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September 13, 2012

Via Electronic Submission

Alfred M. Pollard
General Counsel
Federal Housing Finance Agency
Eight Floor, 440 Seventh Street, SW
Washington DC 20024
(Comments/RIN 2590-AA53)

RE:
Comments of Professor Dwight M. Jaffee on the Federal Housing Finance Agency's Proposed Rule re: Enterprise Underwriting Standards and Mortgage Assets Affected by PACE Programs (RIN 2590-AA53)

Dear Mr. Pollard:

I am a Professor of Finance and Real Estate at the Haas School of Business, University of California, Berkeley. A copy of my curriculum vitae is attached. I have studied the U.S. mortgage market extensively with a special focus on the safety and soundness of the Government Sponsored Enterprises (GSEs). Indeed, I was employed as an expert by OFHEO, the predecessor to the FHFA, on a legal case brought against a former CEO and a former CFO of Freddie Mac, alleging that they had managed Freddie Mac in an unsafe and unsound manner. Thus, improving the safety and soundness of the GSEs has always been a focus of my research and other professional activities. In recent years, I have also been carrying out research on energy efficiency in U.S. real estate, including participation as a primary researcher on a recent research project sponsored by the U.S. Department of Energy. This led me to study Property-Assessed Clean Energy (PACE) programs. As I will argue in this note, it is my opinion that PACE programs, reasonably regulated, will augment the safety and soundness of the GSEs, with the implication that FHFA should be encouraging, certainly not discouraging, the cooperation of the GSEs with these programs.

I therefore respectfully submits these comments in response to the Proposed Rule published by the Federal Housing Finance Agency ("FHFA"), "Mortgage Assets Affected by PACE Programs," RIN 2590-AA53, 77 Fed. Reg. 3959 (Jan. 26, 2012).

1. Introduction

In a Directive of February 28, 2011, the Federal Housing Finance Agency (FHFA) expressly directed the Enterprises (hereafter the Government Sponsored Enterprises, GSEs) “not to purchase mortgages affected by first-lien PACE obligations.” This reiterated an earlier FHFA Statement of July 6, 2010 directing the GSEs to "limit their exposure to financial risks associated with first-lien PACE programs."

The underlying assumption in these Statements and Directives is that the PACE programs present a significant risk to the safety and soundness of the GSEs. In my opinion, this assumption is unfounded and inaccurate, and has lead the FHFA to take positions that are adverse both to the safety and soundness of the GSEs and to U.S. national, state, and local policies to improve the energy efficiency of existing single-family homes.

In this note, I will:

i) Explain why PACE programs are critical if the U.S. is to make significant improvements to the energy efficiency of existing U.S. single-family homes.

ii) Explain why the FHFA assumption that PACE programs are risky for the GSEs is inaccurate and unfounded. I will also show that PACE programs actually and dependably increase the safety and soundness of the GSEs.

iii) Suggest reasonable FHFA regulations that would provide further assurance that PACE programs will affirmatively contribute to the safety and soundness of the GSEs.

2. PACE Programs and the Energy Efficiency of Existing Single-Family Homes

This section briefly describes the critical role of PACE programs in expanding the energy efficiency of existing U.S. single-family homes.

Energy-saving investments for existing U.S. single-family homes have two key features:

i) They are highly productive in the sense that the investment costs are far less than the present value of the expected savings in energy bills. For example, McKinsey and Company, in a critically-acclaimed 2009 study of energy-saving investments in the U.S—Unlocking Energy Efficiency in the U.S. Economy—estimates than an aggregate investment of $153 billion in residential U.S. homes would create a present value of aggregate savings of $167 billion. Given that the actual savings would accrue over time, this means that the annual rate of return on the investments would represent a highly productive investment.

ii) The investments entail a significant upfront capital cost, say in the range of $2,000 to $15,000. In my opinion, this explains why the investments have not been carried out.

Facing a significant up-front capital cost, most U.S. homeowners do not carry out the necessary investments, leaving the households with uneconomically high energy bills and creating unnecessary environmental pollution. Funding for the upfront capital cost is not readily available at reasonable interest rates from traditional consumer or credit card lenders. The problem is that these loan vehicles do not recognize the inherent collateral value that arises because energy-saving investments are necessarily embedded in the home. As seen by consumer and credit lenders, an energy-saving investment has no more collateral value than a family vacation loan.

PACE resolves this collateral problem by allowing the homeowner to tie the commitment to repay the loan to the home itself. The PACE system shares features with “On-Bill” plans, where energy-saving investments are funded by placing the loan repayment obligation on the home’s utility bill. The PACE program has the further advantage, however, that it can be initiated by local communities. The collateral commitment could also be achieved by including the capital cost of the energy-saving investment within the primary mortgage. Indeed, this is done with the mortgages on newly constructed homes, and explains why the energy efficiency of new homes in the U.S. has been steadily rising, as shown in the 2011 Buildings Energy Data Book from the U.S. Department of Energy. For existing homes, however, the mortgage already exists and the homeowner would need to carry out a cumbersome cash-out refinancing to create a new mortgage that covers the investment.

The GSEs and FHFA have not objected to guaranteeing mortgages where there exists an “On-Bill” energy-saving loan, or to new mortgages where the mortgage embeds the costs of energy-saving elements. Indeed, it would be obviously ludicrous for the FHFA to refuse to allow the GSEs to guarantee mortgages on new homes because they embed energy-saving elements. This is noteworthy because in both these cases, the obligation to repay the energy-saving loan is at least equal to, if not ahead, of the GSE claim for mortgage repayment. It is simply inconsistent that the GSEs and FHFA feel so differently about PACE loans. As a simple example, suppose a new home embeds a $10,000 energy-saving investment, and the new mortgage loan guaranteed by a GSE is $10,000 larger, for example, the loan becomes $210,000 instead of $200,000. Suppose now the borrower defaults and the GSE recovers only $200,000. The argument that the lost $10,000 is due to the energy-saving loan is the same for this new mortgage as it would be for an existing $200,000 mortgage in which the GSE recovered only $190,000 because it had first to pay off the $10,000 PACE loan.

The key on all energy-saving loans is that mechanisms exist to ensure that the expected present value of the savings exceed the cost of the energy-saving investments. PACE loans provide three such mechanisms. First, homeowners have every incentive to ensure that the benefits exceed the costs; otherwise, why would they take on the loan payments. Second, sponsoring municipalities will recognize that PACE obligations are parallel with their own property tax receipts, and for this reason all PACE programs require additional steps to ensure the investments are productive. Third, PACE loan payments will generally be sold by the municipality to third-party investors. These investors must expect the investments to be productive and the loans to be repaid. In summary, the incentives of the three participants in a PACE program are fully aligned to insure the projects are productive and the loans will be repaid.

3. PACE Programs Affirmatively Contribute to the Safety and Soundness of the GSEs

The safety and soundness of the GSEs fundamentally depends on the ability and willingness of homeowners with GSE guaranteed mortgages to fulfill their obligation to pay the interest and principal on these mortgages. Borrowers may fail to make these payments for two separate reasons: (1) Borrowers do not have the income resources to make the payment, for example due to unexpected unemployment; (2) Borrowers voluntarily default, for example because the home value becomes less than the mortgage obligation. PACE programs reduce the likelihood of either source of default by (1) reducing the utility bill, thus freeing more income to repay the mortgage, and (2) increasing the home value.

The only condition under which PACE programs would not contribute to the safety and soundness of the GSEs occurs if the energy-saving investments turn out to be unproductive. Given the current inefficiency of most existing U.S. single-family homes and the likely upward trend in energy costs, this is unlikely. Unproductive investments are also unlikely because, as already noted, all the participants in the transaction--the homeowner, the sponsoring municipality, and the PACE investor--have fully aligned interest to make the investment productive. Thus, the highly likely outcome is that PACE investments will fully contribute to the safety and soundness of the GSEs.

Furthermore, the small possibility that a PACE program would detract from the safety and soundness of the GSEs provides no basis for the FHFA to prohibit the GSEs from guaranteeing mortgages with a PACE lien. Virtually all investments have a degree of uncertainty and the proper basis for the investment decision is that the expected benefits provide adequate compensation for any possible downside. In their daily business of guaranteeing home mortgages, the GSEs and their FHFA regulator clearly recognize that no investment can provide a 100 percent guarantee of success.

Indeed, it is ironic that the GSEs and FHFA now propose to require a full-proof guarantee with respect to energy-saving PACE loans, whereas the GSEs and their regulator certainly showed no such concern as the GSEs invested in obviously risk high-risk subprime and ALT-A mortgage positions. To now place regulatory constraints on safe and productive PACE loans would only expand further the losses created by these earlier regulatory errors.

4. Reasonable Regulatory Restrictions on PACE Programs

As an innovative program for energy-saving loans, there is no doubt PACE programs will evolve into more productive forms, and the GSEs and FHFA can play an important and constructive role in encouraging such improvements. Perhaps most importantly, by allowing PACE loans to be made on properties with GSE guaranteed mortgages, more data will become available and research can investigate the specific conditions that could be included within PACE programs to ensure that the loans are as productive as possible.

The FHFA has now offered three alternative means of mitigating the financial risks that it believes PACE programs pose for the GSEs. Alternatives 1 and 2 impose such harsh requirements that they would effectively preclude the practical functioning of PACE programs. Thus, enacting either of these alternatives would have the perverse consequence of putting the GSEs at a future risk from mortgage defaults created by the inability of homeowners to repay their GSE guarantee mortgages due to their inability to afford rising energy costs. Enacting these alternatives would, furthermore, preclude future data and research that would allow the PACE programs to evolve into even more effective forms.

Alternative 3 is more feasible and a number of PACE existing programs believe they could operate within the requirements of this alternative. My own recommendation is that the FHFA proceed with an even simpler condition, namely to require only that PACE sponsors provide adequate documentation to show that the programs require all PACE loans be based on productive energy-saving investments. However, I would still endorse Alternative 3 as an acceptable and feasible plan to allow PACE programs to exist and to develop.

It is also noteworthy that while adopting Alternative 3 or my simpler plan, the FHFA could still later prohibit the GSEs from guaranteeing mortgages on properties that have PACE loans from a particular plan if the accumulated data from that plan indicate the PACE mortgages under that plan have significantly higher default rates than otherwise similar GSE guaranteed mortgages from that same community.

Sincerely,

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Dear Mr. Pollard:

Below is an Index of cited articles from my Comment that was sent to you today as a separate email. Below I show internet links for each item. I will also send you the individual items as PDF files under a separate email:

Dwight Jaffee, Curriculum Vitae, August 2011,
http://faculty.haas.berkeley.edu/jaffee/Papers/DJCVAugust%202011.pdf

McKinsey and Company, Unlocking Energy Efficiency in the U.S. Economy
http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy

U.S Department of Energy 2011 Buildings Energy Data Book
http://buildingsdatabook.eren.doe.gov/docs/DataBooks/2011_BEDB.pdf

Sincerely

Dwight M. Jaffee

DWIGHT M. JAFFEE

Curriculum Vitae

(This version: August 2011)

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Personal Data:
Born: February 7, 1943, Chicago, Illinois (Citizenship: U.S.A.)

Education:
Oberlin College, 1960-61
Northwestern University, Major: Economics, Degree: B.A., 1964
Massachusetts Institute of Technology, Ph.D., 1968
Thesis: "Credit Rationing and the Commercial Loan Market,"
Professor Franco Modigliani, advisor

Academic Positions:
Instructor, Economics Department, MIT, 1967-68
Assistant Professor of Economics, Princeton University, 1968-72
Associate Professor of Economics, Princeton University, 1972-75
Professor of Economics, Princeton University, 1975-1991
Professor of Finance and Real Estate, Walter A. Haas School of Business,
University of California, Berkeley, July 1, 1991--Present
Willis H. Booth Professorship in Banking and Finance II, 1998—present
(reappointed on July 1, 2008 through June 30, 2013).

Recent Teaching:
Asset Backed Securitization (BA230M, Masters in Financial Engineering course)
Graduate Real Estate (Ph.D. Core, BA289A)
Real Estate Research Seminar (Ph.D. BA289S)
Real Estate Finance (MBA Course BA283)
Real Estate Finance (Undergraduate BA183)

Current UC Berkeley University Positions:
Co-chairman, Fisher Center for Real Estate & Urban Economics, Haas School, UC Berkeley
Chairman, Haas School Faculty Committee for Masters in Financial Engineering (MFE)
Board of Directors, Berkeley Center for Law, Business and the Economy, Boalt School of Law
Board of Directors, Center for Built Environment, Berkeley College of Environmental Design

Honors, Fellowships, and Positions:

Northwestern: B.A. with Highest Distinction; Phi Beta Kappa.
MIT: Woodrow Wilson Fellowship; N.D.E.A. IV Fellowship.
Princeton: James Madison Bicentennial Preceptorship, 1971-72 to 1973-74.
Berkeley: Chairman, Haas Finance Group, 2000-2001, Haas Real Estate Group 2005-06.
Other: "Who's Who in Economics", 3rd edition, 1998,"Who's Who in Business Higher Education," 2003.
Recent: *"Literature Contribution for Having a Ten Year Impact in the Field of Risk Management and Insurance*," The American Risk Insurance Association.

Who's Who in America, 65th and 66th editions, 2011 and 2012

Recent Research Grants:

Research Institute for Housing America Trust Fund, "The Impact of Globalization on the US Mortgage Market," $50,000, May 3, 2007.

Berkeley-National University of Singapore Risk Management Institute (joint with Ng Kah Hwa), "Catastrophic Risk and Asian Catastrophe Bond Market," $60,000 funding, March 25, 2007.

Alfred P. Sloan Foundation, Conference funding for "Globalization and the Real Estate Industry," $12,000, February 23, 2007.

Other Academic Positions:

Visiting Professor, Stern School of Business, New York University, Fall 2008.
Distinguished Visiting Professor, National University of Singapore, 2006 to 2008.
Visiting Scholar, Federal Reserve Bank of San Francisco, 1991 to 1999
Acting Director, Inter. Finance Section, Princeton University, '87-88
Associate Editorships: Journal of Economic Perspectives, 1987-1993; Housing Finance Review, 1981- 1991; Journal of Journal of Banking and Finance, 1981-87, Journal of Monetary Economics, 1975-78, Journal of Finance, 73-84, Journal of Money, Credit, and Banking, 73-75.

Recent Consulting, Testimony, and Board Memberships (outside of Universities):

Testimony:
Testified, National Economic Council and Housing and Urban Development, October 26, 2010
Testified, President's Economic Recovery Advisory Board ("Volcker Board"), July 16, 30, 2010.
Testified, Financial Crisis Inquiry Commission, February 28, 2010; video and testimony at: http://fcic.law.stanford.edu/hearings/testimony/forum-to-explore-the-causes-of-the-financial-crisis
Testified as expert witness for U.S. Government in Office of Federal Housing Enterprise Oversight vs. Leland Brendsel (CEO of Freddie Mac) and Vaughn Clark CFO, 2005-2007.

Board Member and Director (outside of UC Berkeley):
Academic Advisory Board, Fitch Ratings, 2006-
Board Member, Global Earthquake Model, http://www.globalquakemodel.org/ , 2011-
Public Interest Director, Contra Fund, Genworth Private Asset Management group, 2004-

Consultant: U.S. Treasury, Federal Reserve Board, Urban Institute, Housing and Urban Development; Federal Home Loan Bank Board, World Bank (Russia/China Missions).

Books

(1) Credit Rationing and the Commercial Loan Market (1971), John Wiley and Sons. Reviewed: Journal of Economic Literature (September 1972, p. 834); Journal of Finance (March 1972); Journal of Political Economy (Nov., Dec., 1973).

(2) Savings Deposits, Mortgages, and Residential Construction, edited with E. Gramlich (1972), Heath, Lexington. Reviewed: Journal of Economic Literature (Dec. 1973).

(3) Economic Implications of an Electronic Monetary Transfer System, with M. Flannery (1973), Heath, Lexington. Reviewed: Journal of Finance (March 1974).

(4) Money, Banking, and Credit, Worth Publishers, 1989.

(5) The Swedish Real Estate Crisis, SNS, Stockholm, 1994.

(6) The Impact of Globalization in a High-Tech Economy, (joint with Ashok Bardhan and Cynthia Kroll), Kluwer Publishers, 2003. Dwight Jaffee directed the project, authored Chapter 2 (Globalization and a High-Tech Economy: A Statistical Overview"), and is a joint author of Chapters 1 (Introduction), 5 (Intra-Firm Trade and Intermediate Inputs), and 8 (Conclusions). Paperback edition and E-editions, Springerlink, 2004.

(7) Oxford Handbook of Offshoring and Global Employment, (joint with Ashok Bardhan and Cynthia Kroll), Oxford University Press, forthcoming 2011-2012.

Current Working Papers/Forthcoming

1) "The Government Sponsored Enterprises: Recovering from a Failed Experiment" (with John Quigley), for presentation NBER November 2011, forthcoming NBER conference volume 2011/2012, and available online from SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1480230

2) "Energy Efficiency and Commercial-Mortgage Valuation," (joint with Richard Stanton and Nancy Wallace), report on Department of Energy Grant and in preparation for journal submission. 2011 presentation schedule includes Blackrock, U.C. Berkeley Entergy Institute, and Carnegie Mellon Finance group.

3) "Energy Factors, Leasing Structure and the Market Price of Office Buildings in the U.S." (with Richard Stanton and Nancy Wallace), Fisher Center Working Paper Series, November 30, 2010. Presented at UC Berkeley, National University of Singapore, Lawrence Berkeley Nation Labs and on program for AREUEA annual meeting, January 2012. Available at: http://escholarship.org/uc/item/9f71t44f

4) "The Impact of Basel III and Solvency 2 on Swedish Banks and Insurers—An Equilibrium Analysis," (with Executive Summary and Appendix, joint with Johan Walden), December 7, 2010, Swedish Institute for Financial Research (SIFR) available at: http://www.sou.gov.se/fmk/rapporter.htm

Published Articles

137. “Bank Regulation and Mortgage Markets”, forthcoming 2011, Berkeley Business Law Journal; available at: http://escholarship.org/uc/item/7b42519c .

136. “How Responsive is Higher Education? The Linkages between Higher Education and the Labor Market” (with Ashok Bardhan and Daniel Hicks), forthcoming Applied Economics 2011, Available as Fisher Center Working Paper Series, May 10, 2010 at: http://escholarship.org/uc/item/6b1889dc

135. “Reforming the U.S. Mortgage Market Through Private Market Incentives”, forthcoming Satya Thallam editor, House of Cards: Reforming Fannie, Freddie and America’s Housing Finance System, 2011. Available at: http://escholarship.org/uc/item/4x0357n0 .

134. “Diversification Disasters,” (joint with Rustam Ibragimov and Johan Walden, Journal of Financial Economics. Volume 99, No. 2, pp. 333-348, (February 2011).

133. “Long-Term Property Insurance” (with Howard Kunreuther and Erwann Michel-Kerjan), Journal of Insurance Regulation, Volume 29, pp. 167-188, 2010.

132. “Pricing and Capital Allocation for Multiline Insurance Firms,” (joint with Rustam Ibragimov and Johan Walden), Journal of Risk and Insurance, Vol. 77, No. 3, pp. 551-578, September 2010.

131. “Housing Policy, Mortgage Policy, and the Federal Housing Administration,” (2010, joint with John Quigley), in Deborah Lucas editor, Measuring and Managing Federal Financial Risk, NBER conference volume, 2010.

130. “Catastrophe Insurance and Regulatory Reform After the Subprime Mortgage Crisis,” in Erwann Michel-Kerjan and Paul Slovic Editors, The Irrational Economist, (Festschrift in Honor of Howard Kunreuther), Public Affairs Books, 2010.

129. “Does the Terrorism Insurance Market Still Need Government Support,” (with Thomas Russell, in Jeffrey R. Brown editor, Public Insurance and Private Markets, American Enterprise Institute, 2010.

128. “Offshoring of Innovation and R&D: Causes and Policy Implications,” (with Ashok Bardhan) in F. Contractor, V. Kumar, S. Kundu, T. Pedersen editors, Global Outsourcing and Offshoring”, Cambridge University Press, November 2010.

127. “The Role of the GSEs and Housing Policy in the Financial Crisis,” submitted paper for the Financial Crisis Inquiry Commission, February 25, 2010, available at: http://fcic-static.law.stanford.edu/cdn_media/fcic-testimony/2010-0227-Jaffee.pdf

126. “Reregulating Fannie Mae and Freddie Mac,” in Robert Kolb editor, Lessons from the Financial Crisis, John Willey and Sons, 2010.

125. “Are Mortgage Backed Securities a Market for Lemons?”, (joint with Chris Downing and Nancy Wallace), Review of Financial Studies, July, 22/7), pp. 2457-2494, 2009.

124. “Mortgage Market and Real Estate Report for the United States 2009,” (joint with Sean Wilkoff) in Hypostat 2009, European Mortgage Federation, 2010, see: http://www.hypo.org/Content/default.asp?pageId=524

123. “Nondiversification Traps in Catastrophe Insurance Markets,” (joint with Rustam Ibragimov and Johan Walden), Review of Financial Studies, 22/3, pp. 959-993, 2009.

122. “The Application of Monoline Insurance Principles to the Reregulation of Investment Banks and the GSEs,” Risk Management and Insurance Review, 2009, Vol. 12, No. 1.

121. “Monoline Regulations to Control the Systemic Risk Created by Investment Banks and GSEs,” B.E. Press Journal of Economic Analysis and Policy, Vol. 9, Issue 3, Article 17, 2009. Available at: http://www.bepress.com/bejeap/vol9/iss3/art17

120. “A Note on Intra-Firm Trade in Manufacturing and Services,” (with Ashok Bardhan), ATDF Journal, Volume 5, Issue 3/4, June 2009.

119. "Show Me The Money," (with Aaron Edlin), 2009, The Economists' Voice: Volume 6, Issue 4, Article 8, 2009. Available at: http://www.bepress.com/ev/vol6/iss4/art8

118. “Comment on ‘‘Rating the Raters’ by Jerome Mathis, James McAndrews, and Jean-Charles Rochet,” Journal of Monetary Economics , Volume 56, Issue 5, pp. 675-677, (July, 2009).

117. “Comment on “Subprime Mortgage Pricing” by Andrew Haughwout, Christopher Mayer, and Joseph Tracy,” Brookings-Wharton Papers on Urban Economics, 2009, pp. 57-58.

116. “The U.S. Subprime Mortgage Crisis: Issues Raised and Lessons Learned,” Chapter 7 in Michael Spence, Patricia Clarke Annex and Robert M. Buckley editors, Urbanization and Growth, World Bank, 2009, available online at http://www.growthcommission.org/storage/cgdev/documents/ebookurbanization.pdf

115. “Mortgage Origination and Securitization in the Financial Crisis (with Anthony Lynch, Matthew Richardson, and Stijn Van Nieuwerburgh), in Viral Acharya and Matthew Richardson editors, Restoring Financial Stability John Wiley and Sons (2009).

114. “What to Do About the Government Sponsored Enterprises,” (with Matthew Richardson, Stijn Van Nieuwerburgh, Lawrence White, and Robert Wright), in Viral Acharya and Matthew Richardson editors, Restoring Financial Stability John Wiley and Sons, (2009).

113. “Responding to WMD Terrorism Threats: The Role of Insurance Markets,” (joint with Thomas Russell,) in Stephen M. Maurer editor, WMD Terrorism: Science and Policy Choices, MIT Press. 2009.

112. “NBCR Terrorism: Who Should Bear the Risk?”, (joint with Thomas Russell), in Harry W. Richardson, Peter Gordon and James E. Moore II, eds., Global Business and the Terrorism Threat, Edward Elgar Publishers, 2009

111. “Mortgage Market and Real Estate Report for the United States 2008,” (joint with Sean Wilkoff) in Hypostat 2008, European Mortgage Federation, November 29, 2009, see: http://www.hypo.org/DocShareNoFrame/docs/1/PAEAKHKCLKBCDFFMPGOFBHIEPDWD9DBYTNTE4Q/EMF/Docs/DLS/2010-00176.pdf

110. “Reforming Fannie and Freddie”, Regulation, Vol. 31, No. 4, Winter 2008-2009.

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108. "Investment Banking Regulation After Bear Stearns," (with Mark Perlow), The Economists' Voice: Vol. 5 : Iss. 5, Article 1, 2008. Available at: http://www.bepress.com/ev/vol5/iss5/art1 ; Also in Joseph Stiglitz, Bradford DeLong, `\ Aaron Edlin editors (2008), The Economists’ Voice, Special Issue: Financial Regulation, Financial Crisis, and Bailouts.

107. “Investment Bank Regulation After the Bear Rescue,” (with Mark Perlow), Central Banking Journal, Vol XVIII. Number 4, May 2008.

106. “Cost of Fannie, Freddie rides on new agency”, San Francisco Chronicle, Sunday, September 21, 2008

105. “Financing Catastrophe Insurance: A New Proposal,” in John M. Quigley and Larry A. Rosenthal editors, Risking House and Home: Disasters, Cities, Public Policy, Berkeley Public Policy Press, 2008.

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103. “Housing Subsidies and Homeowners: What Role for Government-Sponsored Enterprises?”(joint with John Quigley), Brookings-Wharton Papers on Urban Economics, 2007.

102. “Terrorism Insurance: Rethinking the Government’s Role (with Thomas Russell), Issues in Legal Scholarship, Catastrophic Risks: Prevention, Compensation, and Recovery, March 2007: Article 5. Available at: http://www.bepress.com/ils/iss10/art5 . Reprinted in The ICFAI Journal of Insurance Law, Vol. V, No. 4, pp. 34-47, October 2007.

101. “Impact of Global Capital Flows and Foreign Financing on US Interest Rates,” (joint with Ashok Bardhan), Research Institute for Housing America, September 2007, available at: http://housingamerica.org/default.html

100. "The Impact of Foreign Trade in Services on California's White-Collar Employment," California Policy Research Center (University of California) Briefing Paper (joint with Cynthia Kroll and Ashok Bardhan), August 2007; available at: http://www.ucop.edu/cprc/documents/kroll_jaffee.pdf .

99. "Two Key Issues Concerning the Supervision of Bank Safety and Soundness," Economic Review Federal Reserve Bank of Atlanta, Volume 92, #1/2, 2007.

98. "Commentary on Should the Government Provide Insurance for Catastrophes," Federal Reserve Bank of St. Louis Review, Vol. 88, #4, July/August 2006, pp. 381-385.

97. "What to do about Fannie and Freddie" (joint with Edward L. Glaeser), The Economists' Voice, Vol. 3, Issue 7, Article 5, September 2006; Also in Aaron Edlin, J. Bradford DeLong and Joseph Stiglitz, The Economists' Voice: Top Economists Take On Today's Problems, Columbia University Press, 2007. Available at: http://www.bepress.com/ev/vol3/iss7/art5

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95. "Should Governments Provide Catastrophe Insurance," (with Thomas Russell), The Economists' Voice: Vol. 3, No. 5, Article 6 (April 2006), available at: http://www.bepress.com/ev/vol3/iss5/art6 . Also printed in the Journal of Insurance Law, October 2007. . Reprinted in The Icfai Journal of Insurance Law, Vol. V, No. 4, October 2007.

94. "Monoline Restrictions, with Applications to Mortgage Insurance and Title Insurance," Review of Industrial Organization, 28: pp 83-108, March 2006.

93. "Controlling the Interest Rate Risk of Fannie Mae and Freddie Mac, Policy Brief 2006-PB-04, Networks Financial Institute, Indiana State University, April 2006. Available at http://www.networksfinancialinstitute.org/policy-brief-more.asp#Policy8 and http://ssm.com/abstract=923568

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91. "The Role of Government in the Coverage of Terrorism Risk," in Terrorism Risk Insurance in OECD Countries, OECD, 6 July 2005.

90. "On Intra-Firm Trade and Imported Intermediate Inputs" (with Ashok Bardhan), in Edward Graham editor, Multinationals and foreign Investment in Economic Development proceedings (refereed) of the Barcelona meetings of the International Economic Association, Macmillan, April, 2005.

89. “The Interest Rate Risk of Fannie Mae and Freddie Mac,” Journal of Financial Services Research, 24:1 5-29, 2003.

88. “Markets Under Stress: The Case of Extreme Event Insurance,” (with Thomas Russell), in Richard Arnott, Bruce Greenwald, Ravi Kanbur, and Barry Nalebuff editors, Economics for an Imperfect World: Essays in Honor of Joseph E. Stiglitz, MIT Press [2003].

87 “Real Estate and the Internet,” (with Ashok Bardhan), in Hossein Bidgoli editor, The Internet Encyclopedia, Wiley, 2003.

86. “Securitization in European Mortgage Markets (with Bertrand Renaud), E. Mrudula editor, Securitization, ICFAI Press, 2003.

85. “Regulation of Auto Insurance in California (with Thomas Russell), Chapter 5 (pp. 195-236) in J. David Cummins editor, Deregulating Property-Liability Insurance, AEI-Brookings Joint Center for Regulatory Studies, 2002.

84. “The Bubble Has Burst—How will California Fare? (with Cynthia Kroll), Research Report, Fisher Center for Real Estate and Urban Economics, Spring 2001

83. “Real Estate Markets” (with Olga Kaganova), in Lawrence Klein and Marshall Pomer Editors, The New Russia: Transition Gone Awry, pp. 379-392, Stanford Un. Press, 2001.

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McKinsey Global Energy and Materials

Unlocking Energy Efficiency in the U.S. Economy

July 2009

Unlocking Energy Efficiency in the U.S. Economy

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Preface

In 2007, during research on ways to abate greenhouse gas emissions in the United States,[1] we encountered the puzzle of energy efficiency: How is it that so many energy-saving opportunities worth more than $130 billion annually to the U.S. economy can go unrealized, despite decades of public awareness campaigns, federal and state programs, and targeted action by individual companies, non-governmental organizations, and private individuals?

Greater energy efficiency will almost certainly be an important component in comprehensive national – and global – strategies for managing energy resources and climate change in the future. For this reason, we launched an effort in 2008 to investigate opportunities for greater efficiency in the stationary (non-transportation) uses of energy in the U.S. economy. This research confirms what many others have found – that the opportunity is significant. The focus of our effort, however, has been to identify what has prevented attractive efficiency opportunities from being captured in the past and evaluate potential measures to overcome these barriers. Our goal is to identify ways to unlock the efficiency potential for more productive uses in the future. This report is the product of that work.

We hope this report will provide business leaders, policymakers, and other interested individuals a comprehensive fact base for the discussion to come on how to best pursue additional gains in energy efficiency within the U.S. economy.

Our research has been encouraged and challenged by contributions from many participants with many points of view and sometimes differing opinions. They have generously helped our team access data, test emerging findings and potential solutions, and prepare for the release of this report. We especially acknowledge our governmental, non-governmental, and corporate sponsors for sharing their expertise and co-sponsoring this report:

- Austin Energy
- Department of Energy
  - Office of Electricity Delivery and Energy Reliability
  - Office of Energy Efficiency and Renewable Energy
- DTE Energy
- Energy Foundation
- Environmental Protection Agency
- Exelon Corporation
- Natural Resources Defense Council
- PG&E Corporation
- Sempra Energy

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[1] *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?*, McKinsey & Company, 2007.

- Sea Change Foundation
- Southern Company
- U.S. Green Building Council

As part of this work, the team conducted several hundred interviews with representatives of government agencies, public and private companies, academic institutions and research foundations, and a number of independent experts. Though too many to mention by name, these individuals deserve our sincerest thanks for having shared their time and expertise so willingly.

While the work presented in “Unlocking Energy Efficiency in the U.S. Economy” has benefited greatly from these diverse contributions, the views this report expresses are solely the responsibility of McKinsey & Company and do not necessarily reflect the views of our sponsors or any other contributors.

Executive summary

The efficient use of energy has been the goal of many initiatives within the United States over the past several decades. While the success of specific efforts has varied, the trend is clear: the U.S. economy has steadily improved its ability to produce more with less energy. Yet these improvements have emerged unevenly and incompletely within the economy. As a result, net efficiency gains fall short of their full NPV-positive potential. Concerns about energy affordability, energy security, and greenhouse gas (GHG) emissions have heightened interest in the potential for energy efficiency to help address these important issues.

Despite numerous studies on energy efficiency two issues remain unclear: the magnitude of the NPV-positive opportunity, and the practical steps necessary to unlock its full potential. What appears needed is an integrated analysis of energy efficiency opportunities that simultaneously identifies the barriers and reviews possible solution strategies. Such an analysis would ideally link efficiency opportunities and their barriers with practical and comprehensive approaches for capturing the billions of dollars of savings potential that exist across the economy.

Starting in 2008, a research team from McKinsey & Company has worked with leading companies, industry experts, government agencies, and environmental NGOs to address this gap. It reexamined in detail the potential for greater efficiency in non-transportation uses of energy,[2] assessing the barriers to achievement of that potential, and surveying possible solutions. This report is the product of that effort.

The central conclusion of our work: *Energy efficiency offers a vast, low-cost energy resource for the U.S. economy – but only if the nation can craft a comprehensive and innovative approach to unlock it. Significant and persistent barriers will need to be addressed at multiple levels to stimulate demand for energy efficiency and manage its delivery across more than 100 million buildings and literally billions of devices. If executed at scale, a holistic approach would yield gross energy savings worth more than $1.2 trillion, well above the $520 billion needed through 2020 for upfront investment in efficiency measures (not including program costs). Such a program is estimated to reduce end-use energy consumption in 2020 by 9.1 quadrillion BTUs, roughly 23 percent of projected demand, potentially abating up to 1.1 gigatons of greenhouse gases annually.*

Five observations are relevant to a national debate about how best to pursue energy efficiency opportunities of the magnitude identified and within the timeframe considered in this report. Specifically, an overarching strategy would need to:

1. Recognize energy efficiency as an important energy resource that can help meet future energy needs while the nation concurrently develops new no- and low-carbon energy sources
2. Formulate and launch at both national and regional levels an integrated portfolio of proven, piloted, and emerging approaches to unlock the full potential of energy efficiency
3. Identify methods to provide the significant upfront funding required by any plan to capture energy efficiency

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[2] Non-transportation uses of energy exclude fuel used by passenger vehicles, trucks, trains, airplanes, and ships, as well as transport energy used in agriculture, mining, and construction operations. For simplicity of expression, we sometimes refer to the energy covered by our analyses as "stationary energy."

4. Forge greater alignment between utilities, regulators, government agencies, manufacturers, and energy consumers
5. Foster innovation in the development and deployment of next-generation energy efficiency technologies to ensure ongoing productivity gains.

In the body of the report, we discuss the compelling benefits of energy efficiency and why this energy resource warrants being a national priority. We then identify and "map" in detail the complex and persistent set of barriers that have impeded capture of energy efficiency at the level of individual opportunities. We also identify solution strategies, including those proven, piloted, or recently emerged, that could play a role in overcoming these barriers. Finally, we elaborate on the five observations noted above to outline important considerations for the development of a holistic implementation strategy to capture energy efficiency at scale.

We hope that our research and this report will help in the understanding and pursuit of approaches to unlock the benefits of energy efficiency, as the United States seeks to improve energy affordability, energy security, and greenhouse gas reduction.

COMPELLING NATIONWIDE OPPORTUNITY

Our research indicates that by 2020, the United States could reduce annual energy consumption by 23 percent from a business-as-usual (BAU)[3] projection by deploying an array of NPV-positive efficiency measures, saving 9.1 quadrillion BTUs of end-use[4] energy (18.4 quadrillion BTUs in primary energy). This potential exists because significant barriers impede the deployment of energy efficient practices and technologies. It will be helpful to begin by clarifying the size and nature of this opportunity; then we will describe the case for taking action to address the barriers and unlock the energy efficiency potential.

The residential sector accounts for 35 percent of the end-use efficiency potential (33 percent of primary energy potential), the industrial sector 40 percent (32 percent in primary energy), and the commercial sector 25 percent (35 percent in primary energy). The differences between primary and end-use potentials are attributable to conversion, transmission, distribution, and transport losses. We present both numbers throughout as each is relevant to specific issues considered. Capturing the full potential over the next decade would decrease the end-use energy consumption analyzed from 36.9 quadrillion end-use BTUs in 2008 to 30.8 quadrillion end-use BTUs in 2020 (Exhibit A), with potentially profound implications for existing energy provider business models.[5]

This change represents an absolute decline of 6.1 quadrillion end-use BTUs from 2008 levels and an even greater reduction of 9.1 quadrillion end-use BTUs from the projected level of what consumption otherwise would have reached in 2020. Construction of new power plants, gas pipelines, and other energy infrastructure will still be required to address regions of growth, retirement of economically or environmentally obsolete

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[3] The Energy Information Administration's *Annual Energy Outlook, 2008* represents our business-as-usual projection; our analysis focused on the 81 percent of non-transportation energy with end-uses that we were able to attribute.

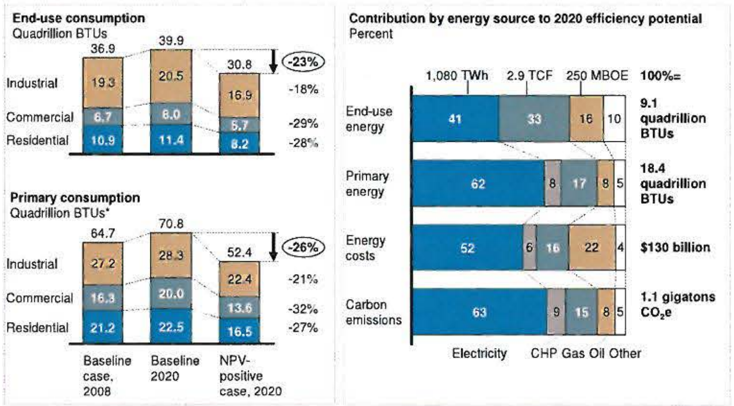
[4] End-use, or "site," energy refers to energy consumed in industrial, business, and residential settings, e.g., providing light, heating and cooling spaces, running motors and electronic devices, and powering industrial processes. By contrast, primary, or "source," energy represents energy in the form it is first accounted (e.g., BTUs of coal, oil, natural gas) before transformation to secondary or tertiary forms (e.g., electricity). From the end-use viewpoint primary energy is lost during transformation to other forms and in transmission, distribution, and transport to end-users; these losses are an important energy-saving opportunity but one that is outside the scope of this report. Unless explicitly defined as primary energy, energy usage and savings values in this report refer to end-use energy.

[5] We examine implications for energy provider business models in Chapter 5 of the full report.

energy infrastructure, and introduction of unaccounted-for consumption, such as electric vehicles. However, energy efficiency could measurably reduce the total new infrastructure investment required during this timeframe.

Beyond the economics, efficiency represents an emissions-free energy resource. If captured at full potential, energy efficiency would abate approximately 1.1 gigatons CO_2e of greenhouse gas emissions per year in 2020 relative to BAU projections, and could serve as an important bridge to a future era of advanced low-carbon supply-side energy options.

Exhibit A: Energy efficiency potential in the U.S. economy



* Includes primary savings from CHP of 490 trillion BTUs in commercial and 910 trillion BTUs in industrial.
Source: EIA AEO 2008, McKinsey analysis

The left side of the exhibit shows total energy consumption, measured in quadrillion BTUs, for the portions of each sector addressed in the report, plus the corresponding consumption if the identified energy efficiency potential were realized. The right side provides different views of the energy efficiency potential in 2020 broken out by fuel type.

In modeling the national potential for greater energy efficiency, we focused our analysis on identifying what we call the "NPV-positive" potential for energy efficiency. We defined "NPV-positive"[6] to include direct energy, operating, and maintenance cost savings over the equipment's useful life, net of equipment and installation costs, regardless of who invests in the efficiency measure or receives the benefits. We used industrial retail rates as a proxy for the value of energy savings in our calculations,[7] applied a 7-percent discount factor as the cost of capital, and assumed no price on carbon. This methodology provides a representation of the potential for net-present-value-positive (NPV-positive) energy efficiency from the perspective of policymakers and business leaders who must make decisions in the broad interests of society. This is in contrast to some studies that report on "technical" potential, which applies the most efficient technology regardless of cost, and differs from reports that project "achievable" potential given historical performance and an implied set of constraints.

We acknowledge, however, that there are different views of future scenarios, societal discount rates, and what constitutes "NPV-positive" from the perspective of individual

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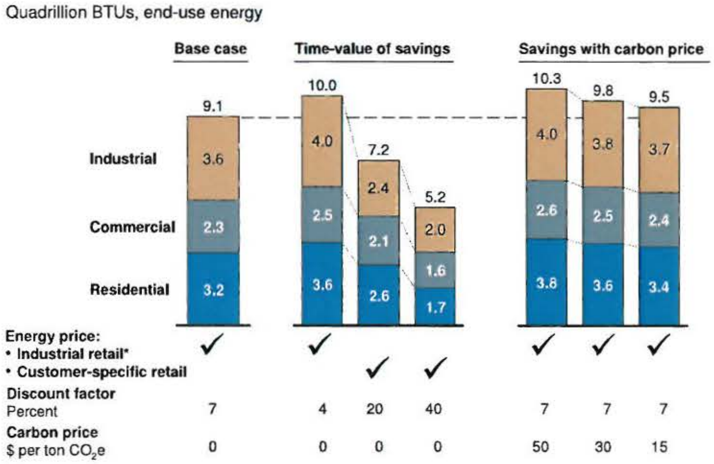
[6] See Appendix B of the full report for more details on this calculation methodology.

[7] Industrial retail rates represent an approximate value of the energy saved as they include generation, transmission, capacity, and distribution costs in regulated and restructured markets. The bulk of the rate is composed of generation cost, with minor contribution from transmission and capacity, and negligible contribution from distribution costs. Though load factor in these rates underestimates the national average, and thus this rate represents a slightly conservative estimate of the value of the energy savings, the other components are closer to the likely savings if significant energy efficiency were to be realized. We computed the avoided cost of gas also using an industrial retail rate, which likewise is close to the wholesale cost of gas plus a small amount of transport cost. A more detailed discussion of the avoided cost of energy is available in Appendix B of the full report.

actors. Thus we tested the resiliency of the NPV-positive opportunities by adjusting the discount rate (expected payback period), the value of energy savings (customer-specific retail prices), and possible carbon price ($0, $15, $30, and $50 per ton CO_2e). We found the potential remains quite significant across all of these sensitivity tests (Exhibit B). Introducing a carbon price as high as $50 per ton CO_2e from the national perspective increases the potential by 13 percent. A more moderate price of $30 per ton CO_2e increases the potential by 8 percent. Applying a discount rate of 40 percent, using customer-class-specific retail rates, and assuming no future cost of carbon, reduces the NPV-positive potential from 9.1 quadrillion to 5.2 quadrillion BTUs – a reduced but still significant potential that would more than offset projected increases in BAU energy consumption through 2020.

Exhibit B: Sensitivity of NPV-positive energy efficiency potential - 2020

The height of each column represents the energy efficiency potential in 2020 associated with non-transportation uses of energy under the conditions defined at the bottom of the exhibit -- energy price, discount factor, and carbon price. The height of each section corresponds to the efficiency potential in that sector, as labeled at the left, under those conditions.



* AEO 2008 industrial energy prices by Census division (national average weighted across all fuels: $13.80/MMBTU) are used as a proxy

Source: EIA AEO 2008, McKinsey analysis

Our methodology is based on detailed examination of the economics of efficiency potential and the barriers to capture of it. Using the Energy Information Administration's National Energy Modeling System (NEMS) and *Annual Energy Outlook 2008* (AEO 2008) as a foundation, for each Census division and building type, we developed a set of "business-as-usual" choices for end-use technology through 2020. Then, to identify meaningful opportunities at this level of detail, we modeled deployment of 675 energy-saving measures to select those with the lowest total cost of ownership, replacing existing equipment and building stock over time whenever doing so was "NPV-positive."[8] We disaggregated national data on energy consumption using some 60 demographic and usage attributes, creating roughly 20,000 consumption micro-segments across which we could analyze potential.

By linking our models with usage surveys and research on user-related barriers, we were able to re-aggregate the micro-segments as clusters of efficiency potential according to sets of shared barriers and usage characteristics. The resulting clusters as shown in Exhibit C are sufficiently homogeneous to suggest a set of targeted solutions.

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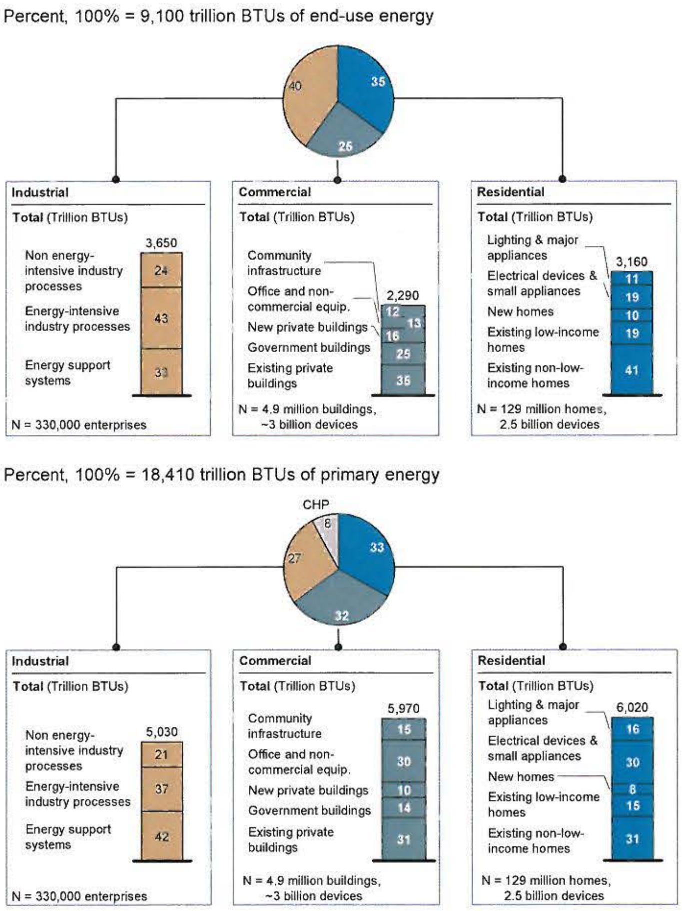
[8] We modeled the energy-savings potential of combined heat and power installations in the commercial and industrial sectors separately from these replacement measures.

Exhibit C: Clusters of efficiency potential in stationary uses of energy – 2020



Source: EIA AEO 2008, McKinsey analysis

The pie charts show the share (in percent) of energy efficiency potential in 2020 in each economic sector, with end-use energy in the upper chart and primary energy in the lower one. Each column chart shows the clusters of potential that make up each sector, with the total potential in the sector (in trillion BTUs) displayed at the top of the column and the share (in percent) in the corresponding segment. Below each column are numbers for relevant end-use settings.

While not all actions that decrease the consumption of energy represent NPV-positive investments relative to alternatives, by definition in our methodology, all the energy efficiency actions included in this report represent attractive investments. The required investment of these NPV-positive efficiency measures ranges upward from $0.40 per MMBTU saved, averaging $4.40 per MMBTU of end-use energy saved (not including program costs). This average is 68 percent below the AEO 2008 business-as-usual forecast price of saved energy in 2020, $13.80 per MMBTU weighted average across all fuel types (Exhibit D), and 24 percent below the projected lowest delivered natural gas price in the United States in 2020, $5.76 per MMBTU. Furthermore, the energy and operational savings from greater efficiency total some $1.2 trillion in present value to the U.S. economy: unlocking this value would require an initial upfront investment of approximately $520 billion (not including program costs).[9] Even the most expensive opportunities selected in this study are NPV-positive over the lifetime of the measure and represent the least expensive way to provide for future energy requirements.

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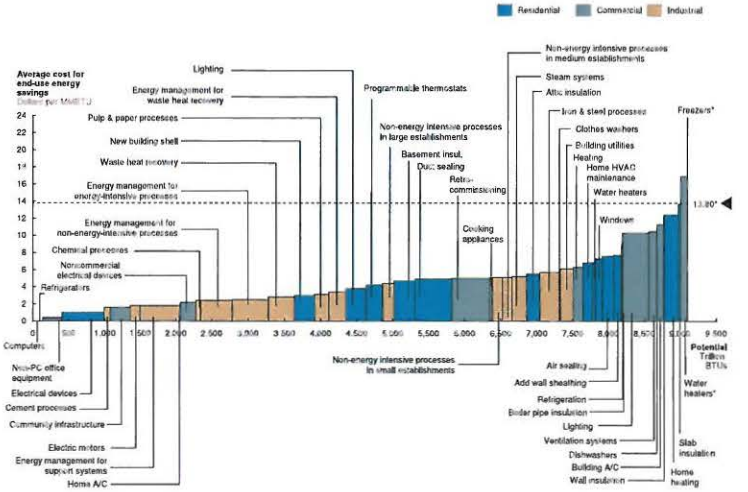
[9] The net present value of this investment therefore would be $1.2 trillion minus $520 billion, or $680 billion.

Exhibit D: U.S. energy efficiency supply curve – 2020

The width of each column on the chart represents the amount of efficiency potential (in trillion BTUs) found in the named group of measures, as modeled in the report. The height of each column corresponds to the average annualized cost (in dollars per million BTUs of potential) of that group of measures.



* Average price of avoided energy consumption at the industrial price; $35.60/MMBTU represents the highest regional electricity price used; new build cost based on AEO 2008 future construction costs

Source: EIA AEO 2008, McKinsey analysis

SIGNIFICANT BARRIERS TO OVERCOME

The highly compelling nature of energy efficiency raises the question of why the economy has not already captured this potential, since it is so large and attractive. In fact, much progress has been made over the past few decades throughout the U.S., with even greater results in select regions and applications. Since 1980, energy consumption per unit of floor space has decreased 11 percent in residential and 21 percent in commercial sectors, while industrial energy consumption per real dollar of GDP output has decreased 41 percent. Though these numbers do not adjust for structural changes, many studies indicate efficiency plays a role in these reductions. As an indicator of this success, recent BAU forecasts have incorporated expectations of greater energy efficiency. For example, the EIA's 20-year consumption forecast shows a 5-percent improvement in commercial energy intensity and 10-percent improvement in residential energy intensity compared to their projections of 4 years ago.[10]

As impressive as the gains have been, however, an even greater potential remains due to multiple and persistent barriers present at both the individual opportunity level and overall system level. By their nature, energy efficiency measures typically require a substantial upfront investment in exchange for savings that accrue over the lifetime of the deployed measures. Additionally, efficiency potential is highly fragmented, spread across more than 100 million locations and billions of devices used in residential, commercial, and industrial settings. This dispersion ensures that efficiency is the highest priority for virtually no one. Finally, measuring and verifying energy not consumed is by its nature difficult. Fundamentally, these attributes of energy efficiency give rise to opportunity-specific barriers that require opportunity-specific solution strategies and suggest components of an overarching strategy (Exhibit E).

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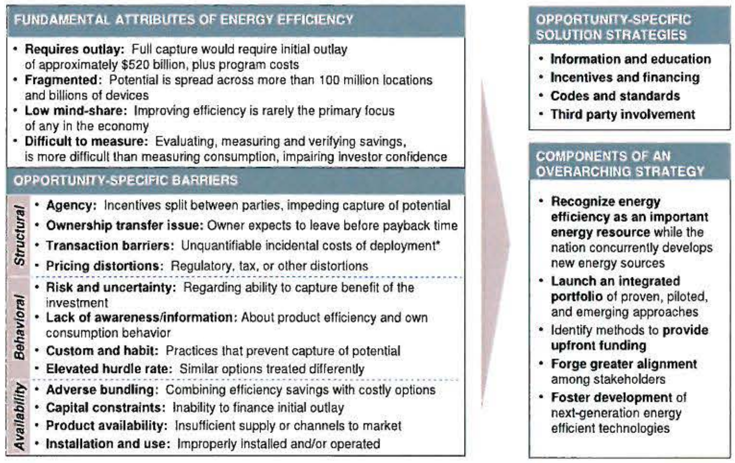
[10] AEO 2004 and 2008.

Exhibit E: Multiple challenges associated with pursuing energy efficiency



FUNDAMENTAL ATTRIBUTES OF ENERGY EFFICIENCY

- **Requires outlay:** Full capture would require initial outlay of approximately $520 billion, plus program costs
- **Fragmented:** Potential is spread across more than 100 million locations and billions of devices
- **Low mind-share:** Improving efficiency is rarely the primary focus of any in the economy
- **Difficult to measure:** Evaluating, measuring and verifying savings, is more difficult than measuring consumption, impairing investor confidence

OPPORTUNITY-SPECIFIC BARRIERS

Structural

- **Agency:** Incentives split between parties, impeding capture of potential
- **Ownership transfer issue:** Owner expects to leave before payback time
- **Transaction barriers:** Unquantifiable incidental costs of deployment*
- **Pricing distortions:** Regulatory, tax, or other distortions

Behavioral

- **Risk and uncertainty:** Regarding ability to capture benefit of the investment
- **Lack of awareness/information:** About product efficiency and own consumption behavior
- **Custom and habit:** Practices that prevent capture of potential
- **Elevated hurdle rate:** Similar options treated differently

Availability

- **Adverse bundling:** Combining efficiency savings with costly options
- **Capital constraints:** Inability to finance initial outlay
- **Product availability:** Insufficient supply or channels to market
- **Installation and use:** Improperly installed and/or operated

OPPORTUNITY-SPECIFIC SOLUTION STRATEGIES

- **Information and education**
- **Incentives and financing**
- **Codes and standards**
- **Third party involvement**

COMPONENTS OF AN OVERARCHING STRATEGY

- **Recognize energy efficiency as an important energy resource** while the nation concurrently develops new energy sources
- **Launch an integrated portfolio** of proven, piloted, and emerging approaches
- Identify methods to **provide upfront funding**
- **Forge greater alignment** among stakeholders
- **Foster development** of next-generation energy efficient technologies

* Financial transaction barriers and actual quality trade-offs are factored into the initial NPV-positive potential calculation as real costs.

Source: McKinsey analysis

On the left, this exhibit summarizes the fundamental difficulties of pursuing greater energy efficiency and the opportunity-specific barriers that affect and help define clusters of efficiency potential. On the right, it shows opportunity-level solution strategies to overcome barriers and suggests the essential elements of an overarching strategy for capturing energy efficiency potential.

Our research suggests that unlocking the full potential of any given opportunity requires addressing all barriers in a holistic rather than piecemeal fashion. To simplify the discussion, we have grouped individual opportunity barriers into three broad categories: structural, behavioral, and availability. Structural barriers prevent an end-user from having the choice to capture what would otherwise be an attractive efficiency option; for example, a tenant in an apartment customarily has little choice about the efficiency of the HVAC system, even though the tenant pays the utility bills.[11] This type of agency barrier affects some 9 percent of the end-use energy efficiency potential. Behavioral barriers include situations where lack of awareness or end-user inertia block pursuit of an opportunity; for example, a facility manager might replace a broken pump with a model having the lowest upfront cost rather than a more energy efficient model with lower total ownership cost, given a lack of awareness of the consumption differences. Availability barriers include situations when an end-user interested in and willing to pursue a measure cannot access it in an acceptable form; for example, a lack of access to capital might prevent the upgrade to a new heating system, or the bundling of premium features with energy efficiency measures in a dishwasher might dissuade an end-user from purchasing a more efficient model.

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[11] We refer to space conditioning systems generically as HVAC systems (heating, ventilation, and air conditioning), whether a building has a heating system, a cooling system, an air exchanger or all three systems.

SOLUTIONS AVAILABLE TO ADDRESS THE BARRIERS

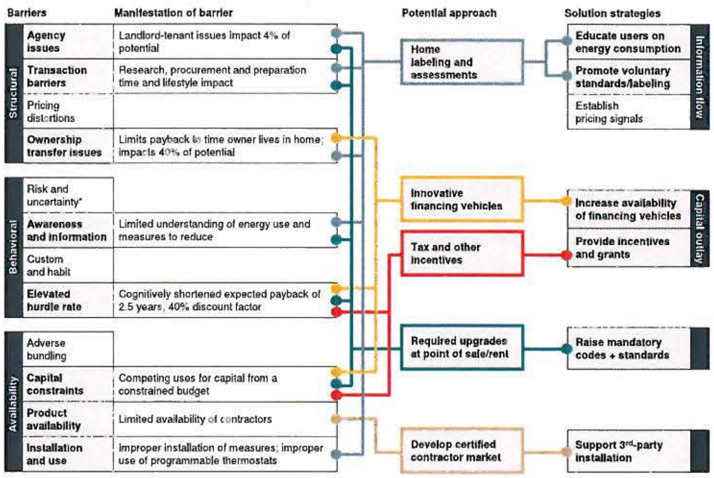
Experience over the past several decades has generated a large array of tools for addressing the barriers that impede capture of attractive efficiency potential, some of which have been proven at a national scale, some have been "piloted" in select geographies or at certain times at a city-scale, and others are emerging and merit trial but are not yet thoroughly tested. The array of proven, piloted, and emerging solutions falls into four broad categories:

- **Information and education.** Increasing awareness of energy use and knowledge about specific energy-saving opportunities would enable end-users to act more swiftly in their own financial interest. Options include providing more information on utility bills or use of in-building displays, voluntary standards, additional device- and building-labeling schemes, audits and assessments, and awareness campaigns.
- **Incentives and financing.** Given the large upfront investment needed to capture efficiency potential, various approaches could reduce financial hurdles that end-users face. Options include traditional and creative financing vehicles (such as on-bill financing), monetary incentives and/or grants, including tax and cash incentives, and price signals, including tiered pricing and externality pricing (e.g., carbon price).
- **Codes and standards.** In some clusters of efficiency potential, some form of mandate may be warranted to expedite the process of capturing the potential, particularly where end-user or manufacturer awareness and attention are low. Options include mandatory audits and/or assessments, equipment standards, and building codes, including improving code enforcement.
- **Third-party involvement.** A private company, utility, government agency, or non-governmental organization could support a "do-it-for-me" approach by purchasing and installing energy efficiency improvements directly for the end-user, thereby essentially addressing most non-capital barriers. When coupled with monetary incentives, this solution strategy could address the majority of barriers, though some number of end-users might decline the opportunity to receive the efficiency upgrade, preventing capture of the full potential.

For most opportunities, a comprehensive approach will require multiple solutions to address the entire set of barriers facing a cluster of efficiency potential. Through an extensive review of the literature on energy efficiency and interviews with experts in this and related fields, we have attempted to define solutions that can address the various barriers under a variety of conditions. Exhibit F illustrates how we mapped alternative solutions against the barriers for a cluster.

We do not believe it is possible to empirically prove that a particular combination of measures will unlock the full potential in any cluster, because the level of impact being considered has never previously been attained. However, we do believe that a holistic combination of solutions that address the full-range of barriers and system-level issues is a prerequisite for attaining energy-productivity gains anywhere near those identified in our analysis.

Exhibit F: Addressing barriers in existing non-low-income homes



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

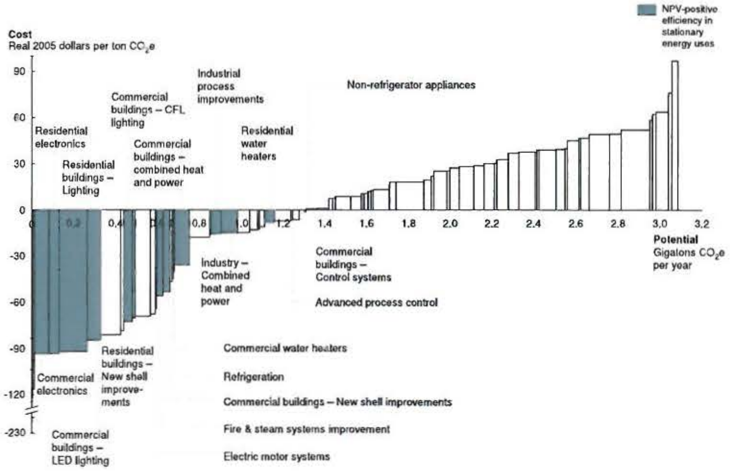
ELEMENTS OF A HOLISTIC IMPLEMENTATION STRATEGY

Capturing the full efficiency potential identified in this report would require an additional investment of $50 billion per year (in present value terms), four- to five-times 2008 levels of investment, sustained over a decade. Even the fastest-moving technologies of the past century that achieved widespread adoption, such as cellular telephones, microwaves, or radio, took 10 to 15 years to achieve similar rates of scale-up. Without an increase in national commitment, it will remain challenging to unlock the full potential of energy efficiency. As noted previously, there are five important aspects to incorporate into the nation's approach to scale-up and capture the full potential of energy efficiency. An overarching strategy would need to:

1. **Recognize energy efficiency as an important energy resource that can help meet future energy needs, while the nation concurrently develops new no- and low-carbon energy sources.** Energy efficiency is an important resource that is critical in the overall portfolio of energy solutions. Likewise, as indicated in our prior greenhouse gas abatement work, new sources of no- and low-carbon generation are also important components of the portfolio. While it may seem counterintuitive initially given the magnitude of the energy efficiency potential available over the next decade, there are important reasons for continuing to develop new no- and low-carbon options for energy supply. First, as described in our original report on U.S. greenhouse gas abatement (Exhibit G), energy efficiency in stationary uses of energy represents less than half of the potential abatement available to meet any future reduction targets. In addition, some areas of the country will continue to experience growth, and some may need to retire and replace aging existing assets. The uncertain growth of electric vehicles could further complicate these requirements. Finally, pursuing energy efficiency at this scale will present a set of risks related to the timing and magnitude of potential capture. Consequently, there remains a strong rationale to diversify risk across supply and demand resources.

Exhibit G: U.S. mid-range greenhouse gas abatement curve – 2030

This exhibit shows greenhouse gas abatement potential as depicted in the mid-range case in McKinsey's greenhouse gas report (2007), with energy efficiency opportunities associated with stationary uses of energy highlighted. The height of each bar represents the incremental cost in dollars to abate one ton of carbon dioxide (or its equivalent); the width shows the gigatons of such emissions that could be abated per year.



Source: McKinsey analysis

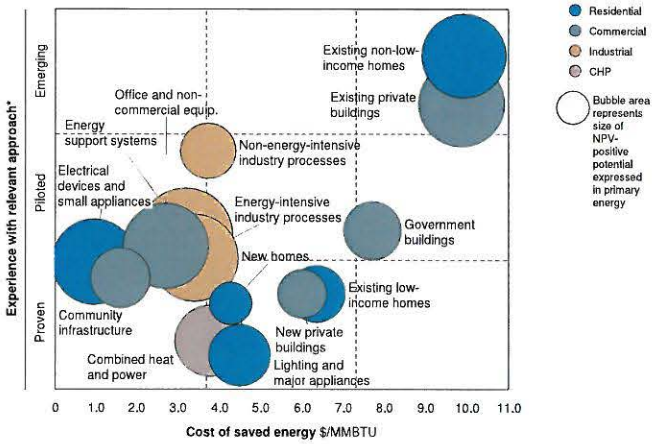
2. **Formulate and launch at both national and regional levels an integrated portfolio of proven, piloted, and emerging approaches to unlock the full potential of energy efficiency.** There are multiple combinations of approaches the nation could take to support the scaled-up capture of energy efficiency. In addition to seeking the impact of national efforts, this portfolio should effectively and fairly reflect regional differences in energy efficiency potential. Any approach would need to make the following three determinations:

   - The extent to which government should mandate energy efficiency through the expansion and enforcement of codes and standards
   - Beyond codes and standards, the extent to which government (or other publicly funded third parties) should directly deploy energy efficiency measures
   - The best methods by which to further stimulate demand and enable capture of the remaining energy efficiency potential.

   Exhibit H illustrates one example of a portfolio of solution strategies focusing on the most proven solution strategies deployed to date. Such a tool facilitates evaluation of a portfolio against the relevant parameters of cost, risk (i.e., experience), and return (i.e., size of potential).

3. **Identify methods to provide the significant upfront funding required by any plan to capture energy efficiency.** End-user funding for energy efficiency by consumers has proved difficult. Partial monetary incentives and supportive codes and standards increase direct funding by end-users: the former by reducing initial outlays and raising awareness, the latter by essentially requiring participation. Enhanced performance contracting or loan guarantees are relatively untested but could facilitate end-user funding. Alternatively, the entire national upfront investment of $520 billion (not including program costs) could be recovered through a system-benefit charge on energy on the order of $0.0059 cents per kWh of electricity and $1.12 per MMBTU of other fuels over 10 years. This would represent an increase in average customer energy costs of 8 percent, which would be more than offset by the eventual average bill savings of 24 percent. Different solution strategies and policies would result in different administrative cost structures. For example, codes and standards have been shown to typically incur program costs below 10 percent, whereas low-income weatherization

Exhibit H: Portfolio representing cost, experience, and potential of clusters possible with specified solution strategies



* Drawing an analogy to our work with business transformation; piloted solutions represent those tried on the scale of a state or major city (i.e., over 1 million points of consumption), emerging are untested at that level, and proven have broad success at a national scale

Source: EIA AEO 2008, McKinsey analysis

The bubbles depict the NPV-positive efficiency potential in each cluster, measured in primary energy, with the area of the circle proportional to the potential. The position of the bubble's center on the horizontal axis indicates the cost of capturing this potential with the measures modeled in this report (excluding program costs) in dollars per million BTUs per year. The center's position on the vertical axis represents the weighted average of the national experience with the approaches outlined for the cluster.

programs have averaged between 20 and 30 percent.[12] Federal energy legislation under discussion at the time of this report will likely offer flexibility as to the level of energy efficiency each state and energy provider chooses to pursue. It will therefore be incumbent on states and local energy providers to undertake a rigorous analysis to assess the role of efficiency in the context of their overall regional energy strategy.

4. **Forge greater alignment across utilities, regulators, government agencies, manufacturers, and energy consumers.** Designing and executing a scaled-up national energy efficiency program will require collaboration among many stakeholders. Three tasks in particular will need to be addressed to achieve the necessary level of collaboration. First, aligning utility regulation with the goal of greater energy efficiency is a prerequisite for utilities to fully support the pursuit of efficiency opportunities while continuing to meet the demands of their public or private owners. Second, setting customer expectations that energy efficiency will reduce energy bills, but not necessarily rates, will be important to securing their support. Finally, measuring energy efficiency requires effective evaluation, measurement, and verification to provide assurance to stakeholders that programs and projects are achieving the savings claimed for them. Rather than attempting to provide "perfect" information, such programs can provide "sufficient" assurance by focusing on consistency, simplicity of design, and addressing both inputs and impact.

5. **Foster innovation in the development and deployment of next-generation energy efficiency technologies to ensure ongoing productivity gains.** Finally, having launched a significant national campaign to pursue energy efficiency, part of the national strategy must address sustaining the innovation required to ensure future productivity gains can be realized. By design, given the near-term focus of this report, technology development plays a minor role in the potential identified in this report. However, we expect that innovative and cost-effective energy-saving technology will continue to emerge. Ongoing funding and support of energy efficiency research and development can help keep the U.S. on a trajectory toward even greater productivity gains than those presented in this report.

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[12] Further discussion of program costs is included in Chapter 5 of the full report.

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In the nation's pursuit of energy affordability, climate change mitigation, and energy security, energy efficiency stands out as perhaps the single most promising resource. In the course of this work, we have highlighted the significant barriers that exist and must be overcome, and we have provided evidence that none are insurmountable. We hope the information in this report further enriches the national debate and gives policymakers and business executives the added confidence and courage needed to take bold steps to formulate constructive ways to unlock the full potential of energy efficiency.

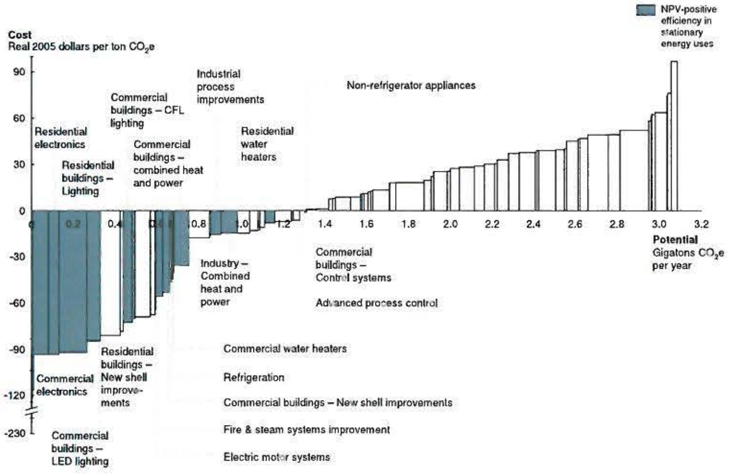
Contents

Sidebars

Introduction

Energy has reemerged as an issue of national concern as the United States confronts the challenges of economic recovery, energy affordability, climate change, and energy security. In November 2007, McKinsey & Company published a report entitled "Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?" and produced what has become a well-recognized abatement curve illustrating the sources, potential magnitudes, and incremental costs of options to abate greenhouse gases (Exhibit 1).

Exhibit 1: U.S. mid-range greenhouse gas abatement curve – 2030



Source: McKinsey analysis

This exhibit shows greenhouse gas abatement potential as depicted in the mid-range case in McKinsey's greenhouse gas report (2007), with energy efficiency opportunities associated with stationary uses of energy highlighted. The height of each bar represents the incremental cost in dollars to abate one ton of carbon dioxide (or its equivalent); the width shows the gigatons of such emissions that could be abated per year.

The colored bars in this exhibit identify the potential impact of greater efficiency in stationary uses (i.e., non-transportation-related) of energy, the focus of this report. It is important to note that to achieve the aggressive goals being discussed nationally for greenhouse gas reduction (i.e., on the order of 3.5 to 5.2 gigatons CO_2e by 2030), the nation will need a portfolio of options that includes and goes well beyond energy efficiency. While this report focuses on what has been referred to as the "left-side" of the abatement curve, no one should view energy efficiency as a complete substitute for the "right-side":

sources of renewable energy, such as wind, solar, biomass, geothermal and hydroelectric energy, or low-carbon options like nuclear power and commercialization of carbon capture and storage. It would also be important to consider the transportation sector in detail, including the potential value of electric vehicles and alternatives for conventional motor fuels (gasoline, diesel) such as cellulosic biofuels, as a substitute for less carbon-efficient options. To achieve the nation's goals of energy affordability, climate change mitigation, and energy security, we will need a combination of these energy initiatives.

The reasons to focus on energy efficiency are as simple as the questions are puzzling: If the economics of energy efficiency are so compelling and the technology is available and proven, why has the U.S. economy not captured more of the energy efficiency available to it, particularly given the progression of efforts at federal and state levels, by government and non-government entities alike, over the past three decades? In other words, by what means could the United States realize a much greater portion of the energy efficiency available to it? A number of organizations asked us to examine this issue and consider what actions would enable greater success.

Working with a range of major U.S. based companies and government organizations, industry experts, foundations, and environmental NGOs we designed our analytical approach with this problem in mind. Our methodology identifies important clusters of energy efficiency potential in non-transportation settings, drawing on knowledge of barriers that have impeded capture of this potential in the past. To make our assumptions and modeling more transparent, we relied heavily on publicly available sources of data. Using the Energy Information Administration's National Energy Modeling System and *Annual Energy Outlook 2008* (AEO) as a foundation, we developed a set of "business-as-usual" (BAU) choices for end-use technology through 2020 in line with the AEO for each Census division and building type. Then, to identify meaningful efficiency opportunities at this level of detail, we modeled deployment of more than 675 energy-saving measures to select those with the lowest total cost of ownership, replacing existing stock over time whenever doing so was "NPV-positive."[1] We then disaggregated national data on energy consumption using some 60 demographic and usage attributes, creating more than 20,000 micro-segments of consumption to further granulate our findings. By linking our models with usage surveys and research on user-related barriers, we were able to re-aggregate the micro-segments as clusters of efficiency potential according to sets of shared barriers and usage characteristics. The resulting clusters (14 in all, five each in the residential and commercial sectors, three in the industrial sector, and combined heat and power (CHP) systems in both commercial and industrial settings) are sufficiently homogeneous to suggest a set of targeted solutions.

We focused our exploration of barriers and solutions on 2020 in order to identify near-term opportunities relatively unaffected by technological uncertainty. Our modeling is based on a 2008 baseline, but we recognize that mobilizing to pursue energy efficiency on a national scale will likely take time. Therefore, references throughout this report to 2020 represent the possible outcome of a decade of effort focused on energy efficiency, which would in reality depend on when significant initiatives are launched.

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[1] By "NPV-positive" we mean the present value of energy, operation, and maintenance cost savings that accrue over the life time of the measure are equal to or greater than the upfront investment to deploy that measure when discounted at an appropriate discount rate. We varied assumptions about the value of energy saved and discount rate to reflect different perspectives on the potential.

In defining opportunities within this near-term horizon, we use a stock-and-flow approach and allow accelerated deployment of energy efficiency measures, represented for example by substitution of building shell improvements or lighting prior to end-of-life for the existing stock, whenever the measure minimizes total lifetime cost. By "minimizes total lifetime cost," we mean the full cost of adopting a measure, be it improving a building or replacing an energy-consuming device before the normal end of its useful life, is more than offset by the associated savings over the measure's lifetime.[2] By contrast, the portfolio of opportunities mostly contains measures that generate only enough savings to offset their incremental cost relative to a business-as-usual alternative. These "end-of-life" NPV-positive opportunities represent the majority of the efficiency potential identified in the residential (50 percent) and commercial (70 percent) sectors. In this way, our modeling uses both "accelerated" replacement and standard stock-and-flow "end-of-life" replacement to maximize the net present value of the total cost of energy consumption. This concept is not as applicable in the industrial sector, where we have assumed upgrades coincide with other needed maintenance schedules or deployment of new equipment or processes.

Our central result for energy efficiency potential used a 7 percent real discount rate and regional industrial energy prices to value the energy savings of reduced consumption. In this regard, the efficiency potential identified in this report is a variant of the "economic" potential described in the preexisting literature on energy efficiency and uses a cost test similar to but not the same as the Total Resource Cost test.[3] We have not evaluated a "technical" potential, which would derive from existing technology regardless of incremental technology cost and yield a higher potential. Nor have we identified an "achievable" potential, which would discount the amount of economic potential captured based on demographic, market, and regulatory factors used to approximate the behavior of various economic agents and estimate what could be realistically expected using current approaches.

Using existing literature, primary interviews, our modeling, the underlying data, and judgment, we synthesized and structured the barriers that impede deployment of energy efficiency measures, attributing to each cluster the most significant barriers. We then gathered available information on existing and past programs targeting energy efficiency in these clusters and evaluated their ability to overcome the associated barriers. Finally, we explored the system-level actions the nation would need to take to drive broad demand for and adoption of energy efficiency, analyzing the proposed trade-offs in various policies and market mechanisms.

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[2] Our analysis assigns no residual value to an existing energy-consuming device that is replaced prior to the end of its life. A less conservative calculation might subtract the residual (i.e., undepreciated) value of the existing device from the total cost of the accelerated device. As this requires resale of a piece of equipment that is not cost effective to use, we have taken the more conservative approach of assuming such equipment cannot be resold and assigned it zero residual value.

[3] Our analysis does not include program administration costs, incentives paid to program administrators, costs or benefits of other resources (e.g., water), or non-resource costs or benefits (e.g., productivity) as are sometimes included in the Total Resource Cost test.

Importantly, there are aspects that differentiate this research from other reports on energy efficiency. We have focused on understanding how to pursue energy efficiency on a national scale by connecting the related activities of estimating potential, identifying barriers, reviewing solutions, and discussing policy implications in a single report. Specifically, we:

- Focused on end-use[4] energy to facilitate the conversation among business leaders and policymakers, while noting the importance of primary energy, its technical match to efficiency topics, and making such numbers available where appropriate
- Included only those energy efficiency initiatives that could be "hard-wired," as opposed to relying on sustained behavioral change among end-users (e.g., conservation efforts, such as turning off unnecessary lights)
- Assumed no material change in consumer utility[5] or lifestyle preferences
- Leveraged existing technologies and did not attempt to forecast future technology innovations or incorporate the most "extreme" forms of whole-building redesign, which can further reduce consumption. Accordingly, we have not presented a "technical" potential
- Attempted to identify the most significant barriers and solutions, but not necessarily be exhaustive of all possibilities
- Applied data wherever possible, but recognized that we could not quantitatively map solutions to every barrier in every cluster
- Avoided the temptation to predict how much of the available "economic" potential could or would be realized by adopting new, scaled-up approaches. Nowhere in this report do we calculate an "achievable" potential as is typically done using top-down estimates from an "economic" potential.

Our research suggests the net cost of achieving these levels of energy efficiency would produce energy savings that approximately double the upfront investment on an economy-wide basis. Although these savings are even more attractive for most participating consumers, issues of timing and allocation would likely lead various stakeholders to perceive the costs differently. It is likely that not all energy consumers would benefit equally from pursuit and capture of greater energy efficiency on a national scale. One outcome we discuss in this report is the inverse relationship between energy bills and electric rates: bills and total energy costs would decline, but the per-unit price (i.e., rate) would likely rise from current levels. The impact relative to business-as-usual is less certain, since in absence of energy efficiency investment, rates may rise due to other factors. Details of this effect on rates will vary throughout the country.

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[4] End-use, or "site," energy refers to energy consumed in industrial, business, and residential settings, e.g., providing light, heating and cooling spaces, running motors and electronic devices, and powering industrial processes. By contrast, primary, or "source," energy represents energy in the form it is first accounted (e.g., BTUs of coal, oil, natural gas) before transformation to secondary or tertiary forms (e.g., electricity). From the end-use viewpoint primary energy is lost during transformation to other forms and in transmission, distribution, and transport to end-users; these losses are an important energy-saving opportunity but one that is outside the scope of this report. In addition, we focus on non-transportation uses of energy, excluding fuel used by passenger vehicles, trucks, trains, airplanes, and ships; in line with this focus, we have also excluded transport energy used in agriculture, mining, and construction operations. For simplicity of expression, we sometimes refer to the energy covered by our analyses as "stationary energy."

[5] By "consumer utility" we mean functionality or usefulness for end-users, including level of comfort; in this context, holding consumer utility constant would imply, for example no change in thermostat settings or appliance use; no downsizing of homes or commercial floor space. In a strict economic sense, maintaining constant consumer utility assumes a constant economic surplus for the consumer while delivering against a common benefit. We have not attempted to calculate potential changes in consumer utility that might result from energy price changes associated with pursuing the options outlined in our report.

The intention of this report is not to recommend particular policy solutions; rather, our hope is that this research will aid in the understanding and further pursuit of economically sensible and effective approaches to unlocking the potential of energy efficiency. This report presents the findings of our work in five chapters:

1. A compelling nationwide opportunity
2. Approaches to greater efficiency in the residential sector
3. Approaches to greater efficiency in the commercial sector
4. Approaches to greater efficiency in the industrial sector
5. Developing a holistic implementation strategy.

The report also contains boxed areas with brief treatments of a number of topics related to energy efficiency but not included directly in our analyses. Additional supporting material, covering technical terms and methodology, as well as works cited and consulted, are located in the appendices.

1. A compelling nationwide opportunity

The United States faces an important opportunity to transform how it uses energy in its residential, commercial, and industrial sectors. Capturing energy savings across the U.S. economy, however, will be a daunting challenge for two reasons: first, each opportunity has meaningful and persistent barriers that have prevented it from being captured in the past, and second, a number of complex issues will have to be addressed at the level of local and regional energy markets – as well as at the national level – if the United States is to realize the full potential of its energy efficiency opportunity.

This chapter describes the NPV-positive efficiency potential the nation can pursue in an accelerated manner in the relative near term (through 2020) and explores the multi-level challenge presented by this attractive opportunity.

SIGNIFICANT POTENTIAL AVAILABLE IN THE NEAR TERM

The opportunity for greater efficiency in stationary energy use is substantial. It is less sensitive to discount factors, participant costs of capital, and carbon prices – and could be pursued more quickly – than is typically acknowledged, but only if the United States can find ways to address the associated barriers and unlock the potential.

Business-as-usual (BAU) projections for 2020 suggest U.S. end-use energy consumption addressed in this report[6] will grow by 0.7 percent per year from 2008, reaching 39.9 quadrillion BTUs in 2020. If the nation can overcome the barriers and capture the full NPV-positive efficiency potential in 2020, the U.S. could consume some 23 percent less energy per year, saving more than 9.1 quadrillion BTUs of end-use energy (including 1,080 billion kWh of electricity) relative to the BAU forecast (Exhibit 2). This reduction would require an upfront investment of approximately $520 billion[7] and would yield present-value savings of roughly $1,200 billion. If deployed over 10 years, this annual spend of roughly

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[6] Appendix B discusses the methodology of this report including the scope of energy uses addressed.

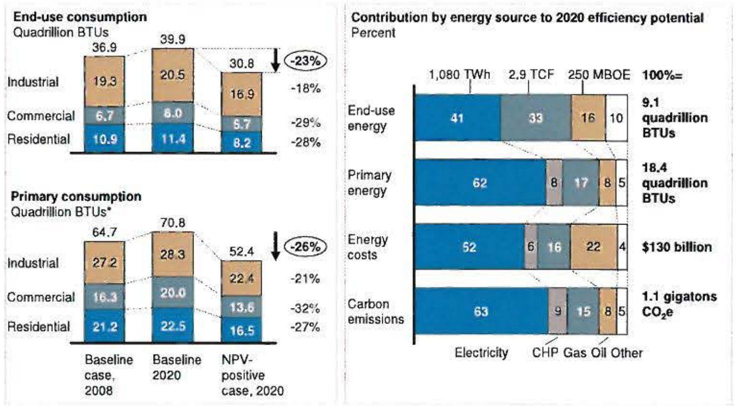
[7] This amount includes $56 billion of upfront investment associated with deploying 50 GW of combined heat and power generation.

$50 billion would represent a four- to five fold increase over current levels of spending on energy efficiency[8] with corresponding annual energy savings valued at $130 billion.[9]

Measured in primary energy,[10] savings would total 18.4 quadrillion BTUs, or 26 percent relative to a BAU baseline. If attained in its entirety, this efficiency potential would reduce annual U.S. GHG emissions in 2020 by 1.1 gigatons CO_2e, some 15 percent of 2005 greenhouse gas emissions and equivalent to 26 percent of non-transportation GHG emissions in the sectors that we modeled.

Exhibit 2: Significant energy efficiency potential in the U.S. economy

The left side of the exhibit shows total energy consumption, measured in quadrillion BTUs, for the portions of each sector addressed in the report, plus the corresponding consumption if the identified energy efficiency potential were realized. The right side provides different views of the energy efficiency potential in 2020 broken out by fuel type.



* Includes primary savings from CHP of 490 trillion BTUs in commercial and 910 trillion BTUs in industrial.
Source: EIA AEO 2008, McKinsey analysis

If the U.S. economy could realize the NPV-positive efficiency potential identified in this report, it would more than fully offset expected consumption growth, leading to an absolute decline in energy use over this period. The nation would see stationary energy use decline equivalent to a rate of 1.5 percent per year, decreasing from 36.9 quadrillion BTUs in 2008 to 30.8 quadrillion BTUs in 2020. This change represents an absolute decline of 6.1 quadrillion end-use BTUs from 2008 levels and an even greater reduction of 9.1 quadrillion end-use BTUs over the projected level of what consumption otherwise would have reached in 2020. This magnitude of change could have profound implications on existing energy provider business models.[11] Construction of new power plants, gas pipelines, and other energy infrastructure will still be required to address selected pockets

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[8] **Annual efficiency spend of $10 billion to $12 billion includes spending on utility programs ($2.5 billion), ESCO efficiency ($3.5 billion), and incremental investment in insulation and devices ($4–6 billion), but excludes business-as-usual insulation spend ($8–$10 billion) to satisfy building codes and** standard practices.

[9] Annual energy savings in 2020 would consist of 3.7 quadrillion end-use BTUs of electricity at $18.72 per MMBTU, 3.0 quadrillion end-use BTUs of gas at $6.88 per MMBTU, 1.5 quadrillion end-use BTUs of oil savings at $20.00 per MMBTU, and 0.9 end-use quads of other energy at $6.35 per MMBTU. The resulting total, 9.1 quadrillion end-use BTUs, has an average savings of $13.80 per MMBTU. CHP offers an additional $7.9 billion per year of energy savings. The total annual energy savings in 2020 of $133 billion has been rounded to $130 billion throughout this report.

[10] Primary energy consumption savings for electricity have been calculated by converting end-use BTUs to primary BTUs at a multiple of 3.1, which includes conversion, transmission, and distribution loss. We convert end use gas consumption to primary use gas consumption by multiplying by 1.039 to include pump energy to move gas through pipelines, and storage and transportation leaks. Data for transport energy of other fuels is not readily available; therefore we use the same as end-use and primary use consumption though some small adjustment would likely be required.

[11] We examine implications for energy provider business models in Chapter 5 of the full report.

of growth, retirement of economically or environmentally obsolete energy infrastructure, and introduction of unaccounted-for consumption such as electric vehicles. However, energy efficiency could measurably reduce the total required investment for additional assets during this timeframe.

The efficiency potential remains significant across scenarios

In modeling the national potential for greater energy efficiency, we calculated net lifecycle benefits less costs, regardless of who invests in measures or receives benefits. For our central result, we used industrial retail rates to value the energy savings and applied a 7 percent discount factor as the cost of capital; we assumed there was no price on carbon. We tested the sensitivity of the NPV-positive opportunities by adjusting the discount rate (expected payback period), value of energy saved (sector-specific retail rates versus industrial retail rates)[12], and possible carbon price ($0, $15, $30, and $50 per ton CO_2e). Exhibit 3 shows the resulting NPV-positive potential beyond business-as-usual levels exploring sensitivity to these three factors:

- **The perspective used to view costs and benefits.** The total potential from a "participant" perspective (i.e., taking the perspective of an end-user with retail energy prices and a 20 percent discount rate)[13] is 7.2 quadrillion BTUs, 21 percent less than potential from the national perspective (using industrial energy prices and a 7 percent discount rate to value the energy savings), indicating significant potential from either perspective.
- **Time-value of savings.** Residential customers' expectation of a 2 to 3 year payback period for household investments is an often-cited barrier to energy efficiency. This expectation of rapid payback limits potential, but still provides considerable opportunities across all sectors. A 40 percent discount rate across sectors with retail power prices reduces potential by 43 percent, but an economy-wide potential of 5.2 quadrillion BTUs remains. By contrast, decreasing the real discount rate from a national perspective from 7 percent to 4 percent increases the potential 10 percent to 10.0 quadrillion BTUs.
- **Value of energy savings through a carbon price.** Introducing a carbon price as high as $50 per ton CO_2e from the national perspective increases the potential by 13 percent. A price of $30 per ton CO_2e would increase the potential by 8 percent. The direct impact of carbon pricing, namely the microeconomic expectation that increasing energy price should reduce energy consumption, is outside the scope of this report.

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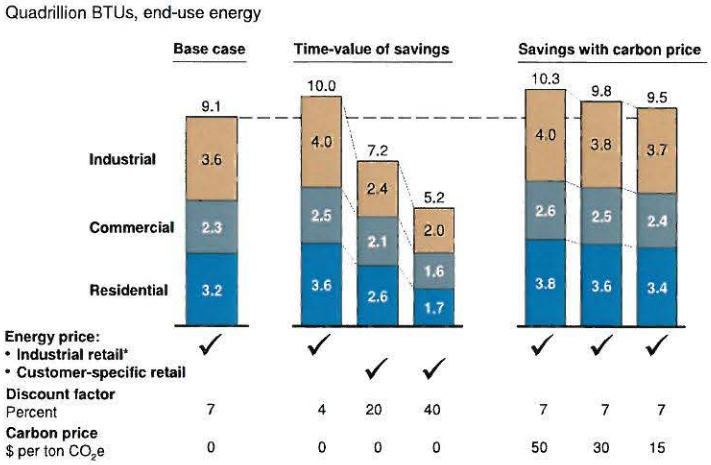
[12] Industrial retail rates represent an approximate value of the energy saved as they include generation, transmission, capacity, and distribution costs in regulated and restructured markets. The bulk of the rate is composed of generation cost, with minor contribution from transmission, capacity, and negligible contribution from distribution costs. Though load factor in these rates underestimates the national average, and thus this rate represents a slightly conservative estimate of the value of the energy savings, the other components are closer to the likely savings if significant energy efficiency were to be realized. We computed the avoided cost of gas also using an industrial retail rate, which likewise is close to the wholesale cost of gas plus a small amount of transport. A more detailed discussion of the avoided cost of energy is available in Appendix B of the full report.

[13] Twenty percent approximates the marginal cost of capital for many unsecured financing sources; though home equity lines or revolving credit lines are available at lower rates, they may be more difficult to obtain.

Exhibit 3: Sensitivity of NPV-positive energy efficiency potential

The height of each column represents the energy efficiency potential in 2020 associated with non-transportation uses of energy under the conditions defined at the bottom of the exhibit -- energy price, discount factor, and carbon price. The height of each section corresponds to the efficiency potential in that sector, as labeled at the left, under those conditions.



* AEO 2008 industrial retail prices by Census division (national average weighted across all fuels: $13.80/MMBTU) are used to value the energy saved

Source: EIA AEO 2008, McKinsey analysis

Opportunities distributed throughout the economy

Because efficiency potential is present in nearly all energy-consuming devices and processes, it is highly fragmented with substantial opportunities in the residential, commercial, and industrial sectors.

- **Residential sector.** The residential sector accounts for 29 percent of 2020 BAU end-use consumption and offers a slightly disproportionate 35 percent of the end-use efficiency potential. The residential opportunity is extremely fragmented, as it is spread across conditioning the space of 129 million households and energizing the dozens of appliances and devices in each household.[14]

- **Industrial sector.** The industrial sector offers the reverse proportion: the sector accounts for 51 percent of 2020 BAU end-use consumption but only 40 percent of end-use efficiency potential. The opportunity is, however, more concentrated: half of the potential is concentrated in 10,000 facilities, with the remainder distributed among 320,000 small and medium-sized enterprises. The relatively smaller proportion of savings potential is likely driven by the sector's historically greater focus (than the residential sector) on capturing energy efficiency opportunities.

- **Commercial sector.** The commercial sector consumes 20 percent of the 2020 BAU end-use energy and offers 25 percent of the efficiency potential across 87 billion square feet of floor space, supporting functions as diverse as retail, education, and warehousing. Electricity represents a larger share of consumption in this sector; as such it offers the largest primary energy opportunity at 35 percent of the total when including commercial CHP opportunities.

Opportunities are indeed scattered across a range of climates, users, end-uses, and fuels. Appliances, building shells, industrial processes, and a wide range of other end-uses offer substantial potential.

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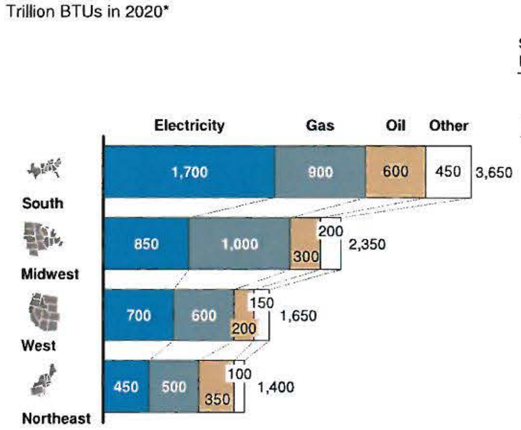
[14] The number of homes, 129 million, is based on EIA's number of occupied homes. In 2020, there will be an additional 10 million to 15 million unoccupied homes counted by the Census. Our analysis, and most products of the EIA, use only the 129 million occupied homes, because unoccupied homes consume little energy and present little, if any, NPV-positive efficiency potential.

Finally, while the nature of efficiency opportunities changes across geographies; substantial potential is present in all areas. Each Census region has efficiency potential equivalent to at least 20 percent of its total energy consumption (Exhibit 4). The South Census region offers the largest absolute potential, more than twice the Northeast Census region, though relative to total consumption its proportion of potential is below the national average. The greatest efficiency potential relative to total consumption is in the Northeast, due to high potential especially in the residential sector.

Exhibit 4: Energy efficiency end-use potential across Census regions



	Savings Percent			
	Total	Resi-dential	Comm-ercial	Indus-trial
South	22	26	29	17
Midwest	23	29	29	19
West	23	25	29	18
Northeast	24	32	28	18

* Numbers rounded to 50 trillion BTUs
Source: EIA AEO 2008, McKinsey analysis

The bars at the left depict the end-use energy efficiency potential in the four Census regions in 2020, by fuel type, and measured in trillion BTUs, with the total for the region at the right end of the bar. The table on the right displays the potential energy savings in the Census region as a percent of BAU consumption in 2020; the total savings in percent is a weighted average of the savings in the three sectors -- residential, commercial, and industrial.

Clusters of opportunity present themselves

In order to accurately represent the potential in these fragments of consumption our modeling uses these characteristics to analyze potential in "micro-segments" of consumption. Aggregating these micro-segments based on common characteristics reveals 14 addressable clusters: five each in residential and commercial sectors, three in the industrial sector, and combined heat and power (CHP) systems across both commercial and industrial settings.

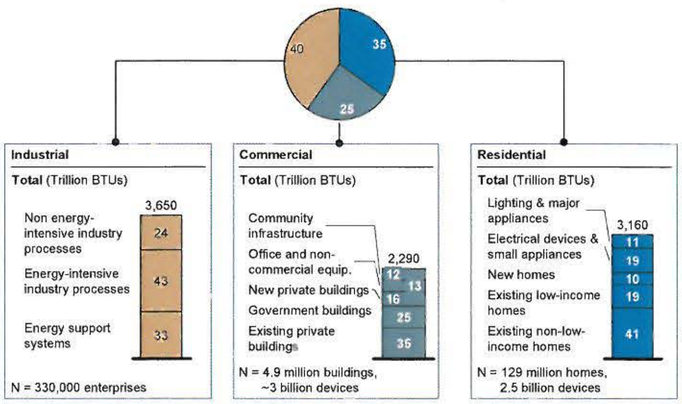
Each cluster represents a sizable and actionable opportunity and is sufficiently homogenous with similar barriers and potential responsiveness to solution strategies. The most relevant characteristics that define these clusters include home owner income, building age (i.e., new versus retrofit buildings), specific end-uses or opportunities (e.g., electrical devices, community infrastructure, waste heat recovery), private versus government ownership structure, and energy intensity. Exhibit 5 shows these clusters and their end-use and primary energy efficiency potential.

New homes, in residential, and new private buildings, in commercial, share similarities both in the barriers that impede the opportunity and the types of solution strategies that address the barriers. Electrical devices and small appliances, in residential, and office and non-commercial devices, in commercial, also exhibit similarities. The combined heat and power cluster, discussed in Chapter 4, differs from other clusters as it offers savings in primary energy but not necessarily in end-use energy, though it is a site-based energy source.

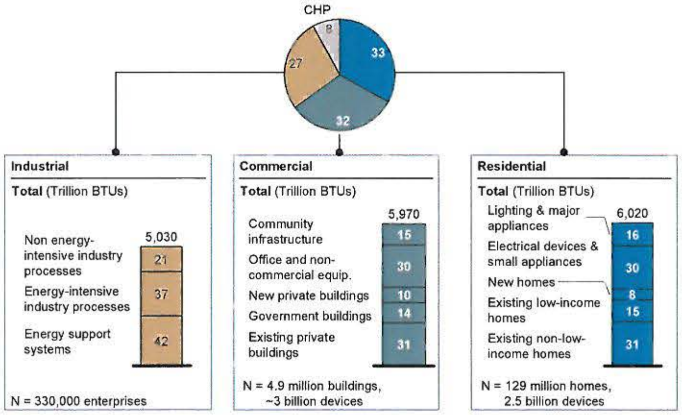
Exhibit 5: Clusters of efficiency potential in stationary uses of energy – 2020

The pie charts show the share (in percent) of energy efficiency potential in 2020 in each economic sector, with end-use energy in the upper chart and primary energy in the lower one. Each column chart shows the clusters of potential that make up each sector, with the total potential in the sector (in trillion BTUs) displayed at the top of the column and the share (in percent) in the corresponding segment. Below each column are numbers for relevant end-use settings.

Percent, 100% = 9,100 trillion BTUs of end-use energy



Percent, 100% = 18,410 trillion BTUs of primary energy

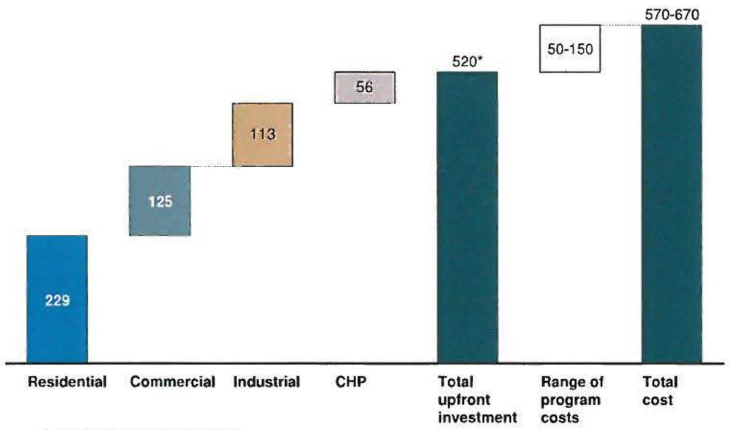


Source: EIA AEO 2008; McKinsey analysis

Exhibit 6: Upfront cost of energy efficiency corresponding to $1.2 trillion savings

The height of each column represents the present value of the cost of NPV-positive energy efficiency measures: the four columns on the left (the sectors, plus CHP) total to the amount shown in the fifth column. The total upfront investment plus the range of program costs totals to the column on the far right, which provides a range for the total cost.

U.S. dollars, billions



* Rounded to the nearest ten billion

Source: EIA AEO 2008, McKinsey analysis

INDIRECT BENEFITS OF ENERGY EFFICIENCY

Improving energy efficiency in residential and commercial space offers a host of non-financial benefits. For example, in the residential sector, energy efficiency upgrades can help reduce exposure to volatility in energy prices, reduce basement water damage (estimated at $1.4 billion annually), decrease food spoilage, and extend clothing life.[1] According to many home performance contractors, the non-financial benefits of efficiency-related upgrades may have greater value to many homeowners than the purely financial ones. Although increased energy efficiency may contribute to such auxiliary benefits as greater reliability and resilience in the electricity grid, this section describes three sets of indirect benefits associated with energy efficiency upgrades: enhanced health and comfort, improved productivity, and increased standard of living, particularly for low-income households.

Impact on comfort and health. Energy efficiency upgrades, including proper insulation and sealing against air infiltration, can address a number of common residential problems, such as drafty rooms, cold floors in the winter, damp basements, dry air, musty odors, and mold. Because people spend up to 90 percent of their time indoors,[2] many of these issues can lead to health risks, contributing to chronic allergies and asthma, as well as periodic illness. Sick building syndrome (SBS), which is associated with poor indoor air quality, can manifest itself in building occupants as irritation of the eyes, nose, throat, or skin, as well as other ailments. Flaws in HVAC systems, emissions from some types of building materials, volatile organic compounds used indoors, and inadequate exhaust systems may be contributing factors. Severe problems with heating or cooling systems, for example, can result in dangerous concentrations of carbon monoxide or radon gas. Air and duct sealing and periodic maintenance of HVAC equipment can mitigate a number of these risks. While quantifying the impact of higher air quality on health is difficult, research suggests that the benefits are significant. Improved indoor air quality can reduce symptoms of SBS by 20 to 50 percent, asthma by 8 to 25 percent, and other respiratory illnesses by 26 to 75 percent.[3]

Impact on productivity. Efficiency-related upgrades in commercial buildings can increase worker productivity directly, as well as indirectly through reduced sick leave. SBS costs the nation an estimated $60 billion annually in sick days, medical costs, and reduced productivity.[4] A study by Lawrence Berkeley National Laboratory suggests higher indoor air quality itself can increase worker productivity by as much as 5 percent. Occupants of green buildings report themselves to be more satisfied with thermal comfort and air quality in the workspace than occupants of non-green buildings,[5] and may also benefit from the additional use of natural light.[6] Furthermore, worker productivity is higher at certain temperatures, which can be maintained more consistently throughout a building with higher-efficiency HVAC systems.[7] In all, improvements in worker health and productivity due to improved air quality may total $37 billion to $210 billion annually according to some sources.[8]

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[1] "Home Energy Saver," LBNL, 2009. <http://hes.lbl.gov>.

[2] "The Inside Story: A Guide to Indoor Air Quality," EPA, April, 2009.

[3] William J. Fisk, "How IEQ Affects Health, Productivity," ASHRAE Journal, May 2002.

[4] William J. Fisk, "Health and Productivity Gains from Better Indoor Environments and their Implications for the U.S. Department of Energy", LBNL, February 2002.

[5] S. Abbaszadeh Fard et al. "Occupant Satisfaction with Indoor Environmental Quality in Green Buildings," Proceedings of Healthy Buildings 2006, Lisbon, Vol. III, 365-370.

[6] Joseph J. Romm., "Successfully Daylighting a Large Commercial Building: A Case Study of Lockheed Building 157," Progressive Architecture, November 1990.

[7] Olli Seppänen et al., "Effect of Temperature on Task Performance in Office Environment," Helsinki University of Technology and LBNL, July 2006.

[8] William J. Fisk, "How IEQ Affects Health, Productivity," ASHRAE Journal, May 2002.

Impact on poverty alleviation. While energy efficiency can result in substantial savings for the average household, these savings can have an even larger impact on the quality of life of low-income households. While the average household spends approximately 5 percent of its income on energy bills, the average low-income household spends about 15 percent, and some households on fixed incomes spend as much as 35 percent. After home weatherization, the average spending for energy drops to 10 percent among low-income households and 21 percent for fixed-income households. These savings materially increase the household standard of living and can be put to other uses, including setting the thermostat to more a comfortable temperature, as well as for food, clothing, or education.

Deploying energy efficiency measures on a national scale will require a significant capital outlay

Deploying NPV-positive energy-saving technologies on a scale commensurate with the savings potential identified in this report, while generating benefits of $1.2 trillion, would require initial, upfront investments totaling $520 billion in present value terms through 2020 (Exhibit 6), representing an investment of $50 billion per year (in present-value terms) for
10 years. Some observers estimate that the U.S. invests $20 billion to $35 billion per year in energy consuming devices and building insulation to support a price "premium" to fund improved efficiency.[15] To compare these investments to the incremental efficiency investments described in this report we subtracted the business-as-usual level purchases of building insulation to meet present building codes and the base cost of less efficient devices to obtain a market size of $10 billion to $12 billion.[16] This implies that capturing the full efficiency potential identified in this report would require a sustained four- to five-fold increase in spending for efficiency improvements beyond today's levels. Overhead and administration costs would be in addition to this amount and would vary by the policy or market mechanism used to capture the potential. Those costs are discussed in Chapter 5.

The cost of the energy efficiency measures, expressed in dollars per million BTUs (MMBTU) saved over their lifetime, varies greatly. Exhibit 7 arrays the most economically attractive solution strategies in each of 49 energy efficiency measures in our central result from least to highest cost per MMBTU of end-use energy saved. The height of each bar shows the average cost per MMBTU saved; its width corresponds to how much energy in trillion BTUs could be saved annually with that strategy for its corresponding end-use in 2020. This chart highlights the diversity of end-uses that would provide savings, but demonstrates that there are few large and simple opportunities to pursue: capturing 80 percent of the opportunity would require deploying 58 percent of the upfront investment.[17]

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[15] Karen Ehrhardt-Martinez and John A. Laitner, ***The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture***, ACEEE, May 2008. Expert interviews.

[16] Annual efficiency spend of $10 billion to $12 billion includes spending on utility programs ($2.5 billion), ESCO efficiency ($3.5 billion), and incremental investment in insulation and devices ($4–6 billion), but excludes business-as-usual insulation spend ($8–$10 billion) to satisfy building codes and standard practices.

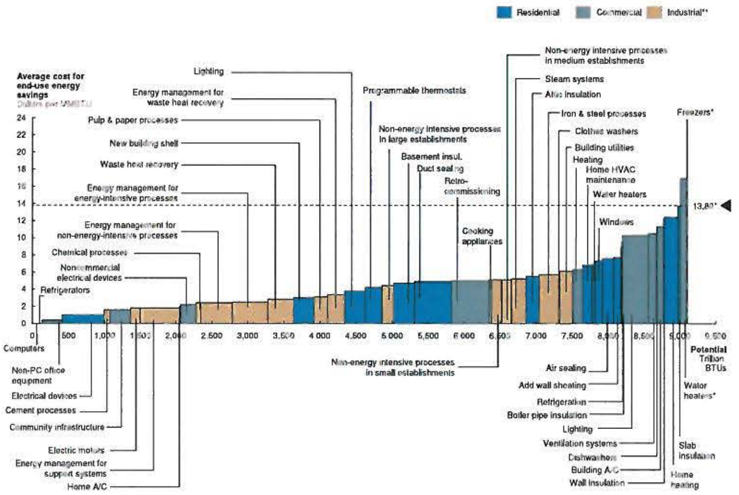
[17] Alternatively, 35 percent of the investment would correspond to 60 percent of the energy efficiency potential.

Financial value of energy savings outweigh its cost

While not all actions that decrease the consumption of energy represent an NPV-positive investment relative to alternatives, by definition of our methodology all the energy efficiency actions included in this report represent NPV-positive investments. The upfront deployment cost of these NPV-positive efficiency measures ranges upward from $0.40 per MMBTU saved, and averages $4.40 per MMBTU saved (not including program costs). This "price" for efficiency is 68 percent below the forecasted price of energy in 2020, $13.80 per MMBTU (Exhibit 7), and 24 percent below the lowest delivered natural gas price in the United States in 2020, $5.76 per MMBTU. Put another way, even the most expensive opportunities selected in this study are attractive over the lifetime of the measure and represent the least expensive way to provide for future energy requirements.

The difference between the average cost of efficiency measures and value of the energy savings represents a conservative view of the financial benefits of energy efficiency because it includes only direct energy savings.[18]

Exhibit 7: U.S. energy efficiency supply curve – 2020



* Average price of avoided energy consumption at the industrial price; $35.60/MMBTU represents the highest regional electricity price used; new build cost based on AEO 2008 future construction costs

** Our 49th source of savings, refining processes, offers no NPV-positive savings

Source: EIA AEO 2008, McKinsey analysis

The width of each column on the chart represents the amount of efficiency potential (in trillion BTUs) found in that group of measures, as modeled in the report. The height of each column corresponds to the average annualized cost (in dollars per million BTUs of potential) of that group of measures.

PREVIOUS EFFORTS HAVE IMPROVED ENERGY EFFICIENCY

Over the past 35 years, national interest in energy efficiency has risen and fallen following changes in energy prices (Exhibit 8). The global oil crises of the 1970s catalyzed substantial action at the federal and state levels: efficiency standards for appliances and buildings, tax credits for investment in efficiency measures, and the creation of the Department of Energy and special-purpose state entities.

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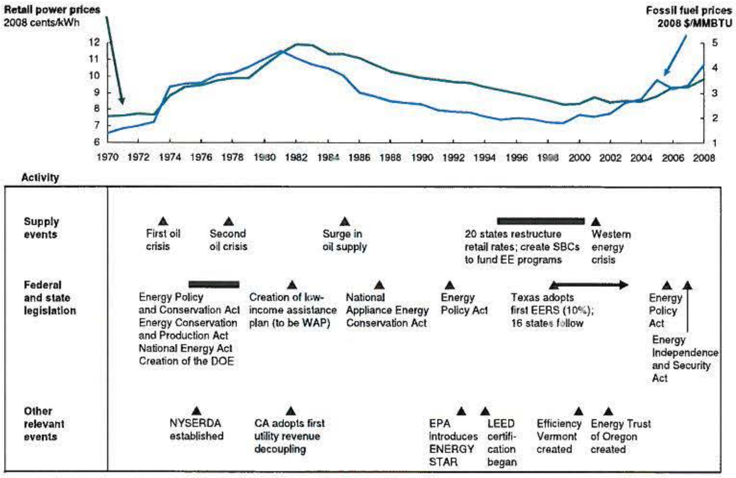
[18] Additional financial benefits include lowered commodity risk, impact on the cost of fuel and improved efficiency of electricity generation, job creation, and health improvements. These benefits are described as special topics in the report where appropriate, but are not included in the calculation of the efficiency potential.

Exhibit 8: Milestones in the pursuit of energy efficiency



Source: DOE, EPA and Alliance to Save Energy; McKinsey analysis

The line chart across the upper portion of the exhibit shows fluctuations in retail power prices (2008 cents per kWh) and fossil fuel prices (2008 dollars per MMBTU) over the past 40 years, with power prices tracking to the vertical axis on the left and fossil fuel prices tracking to the vertical axis on the right. The box across the lower part of the exhibit displays a timeline of key events that have affected the capture of energy efficiency potential in the United States over the same period.

A surge in the global oil supply in the mid-1980s, however, brought a sharp decline in oil and power prices, with relatively stable or declining fossil fuel and power prices following for more than a decade. In this environment, sustaining momentum at the national level for efforts to improve energy efficiency became increasingly difficult.[19] At the same time, national energy policy shifted toward greater reliance on markets to better balance supply and demand of energy resources. Over the past 10 years, however, with an energy crisis in western states, supply disruptions from events overseas and natural disasters domestically, and rising concerns about the effects of climate change, interest in a coordinated approach to capturing energy efficiency has reemerged.

In this period, various government agencies and contractors, non-government agencies, and academics have explored the potential for energy efficiency and the reasons it so often remains an untapped resource. As early as the late 1970s, academics and advocates began identifying the available efficiency potential and the barriers to the capture of that potential. Within the past decade, four efforts stand out at the national level, with more than 20 others at the regional or state level, that generally align with the methodology suggested in the "Guidelines for Conducting Energy Efficiency Potential Studies" published by the EPA. These studies report some subset of technical, economic, or achievable potential, with seven economic potential findings ranging from 10 to 30 percent, presenting an average (and median) value of 21 percent, broadly in line with the results of this report. This report is also in agreement with the finding of our previous work on greenhouse gas abatement in the United States, which identified "mid-range" efficiency savings of 1,284 TWh of electricity and 1,424 trillion BTUs of gas in 2030 with an estimated upfront outlay of $280 billion.[20] Differences in baseline, timing, and nature (i.e., "mid-range" focus on GHG emissions versus focus on NPV-positive energy efficiency) of the reports account for the difference between

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[19] Robert Bamberger, *Energy Policy: Conceptual Framework and Continuing Issues*, Congressional Research Service, March 2007.

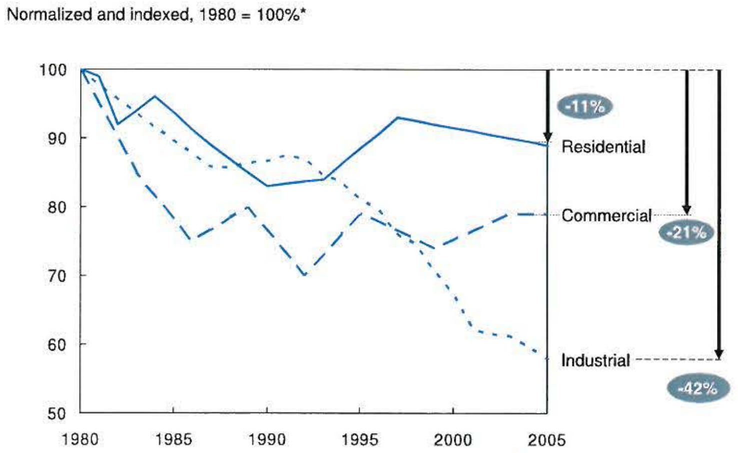
[20] Noteworthy differences between the reports, expressed as the figures to add to the greenhouse gas report's 2030 result to obtain this report's 2020 result include the following: baseline (-$27 billion, -264 TWh, -1,638 end-use TBTUs of gas), timing (-$75 billion, -249 TWh, -303 end-use TBTUs of gas), and methodology, including accelerated retirement (add $200 billion, 235 TWh, and 1,320 end-use TBTUs of gas) and penetration ($150 billion, 74 TWh, 2,210 end-use TBTUs of gas).

the earlier findings and the 1,080 TWh of electricity, 3,010 trillion BTUs of gas savings, and $520 billion in upfront investment in 2020 that is identified in this report.

Efficiency has improved and is expected to accelerate

Energy intensity, expressed as the energy consumption per unit of floor space or per dollar of GDP, has decreased steadily over the past 25 years through 2005 especially in the industrial sector (Exhibit 9). Increased energy efficiency is partly responsible for this decrease in energy intensity. However, decades-long trends toward faster economic growth, national migration toward warmer regions of the country (which require more use of air conditioning), increasing home size, and greater use of electrical appliances and devices in most homes and businesses complicate this picture. The contemporaneous decline in industrial-sector energy intensity derives in large measure from improvements in process efficiency, as well as the shift of some energy-intensive manufacturing activity overseas. Thus one cannot attribute the entire increase in energy productivity to efficiency improvements, though various estimates indicate it plays a significant role in this trend.

Exhibit 9: Change in energy intensity in the U.S. economy – 1980-2005



* Residential and commercial indexing is based on BTUs per square foot; industrial indexing is based on BTUs per real dollar of GDP output

Source: EIA AEO 2008, BEA

The three lines present indexed values of energy intensity for the three sectors in this report, with each year from 1981 through 2005 compared to the value in 1980. Residential and commercial energy intensity are normalized based on BTUs per square foot of space, while industrial intensity is based on BTUs per real dollar of GDP output.

Further, comparing the 20-year intensity forecast from Annual Energy Outlook (AEO) 2004 to AEO 2008 shows accelerating improvements in energy intensity. The AEO 2004 forecasts a 20-year intensity improvement in the residential sector of -5.5 percent while the AEO 2008 forecasts an improvement of -15.7 percent; this change represents a 10 percentage point improvement in energy intensity. Similarly commercial intensity shows a 5 percentage point improvement in intensity as the forecast improved from a 7.4 percent increase to a 2.2 percent increase. Industrial intensity improvements remain high with an expected 23 percent improvement in both forecasts.[21] These facts may indicate both recent progress in driving energy efficiency and renewed national interest in stewardship of our national resources, an observation supported by earlier comments highlighting the annual spend on energy efficiency, which, for example, increased from $1.3 billion in 2003 to $2.1 billion in 2006 in the utility sector.

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[21] We use 20-year expected intensity expressed in primary BTUs per square foot in residential and commercial and primary BTUs per dollar of output for industrial.

Some success stories highlight what is possible

Economic actors as diverse as utilities, government agencies, special purpose entities, and the private sector have driven equally diverse programs targeted at improving energy efficiency. These programs include appliance standards, building codes, financial incentives, financing, and direct installation, to name a few. Several examples of varying scope warrant discussion, as they represent the significant, documented impact of a subset of approaches, namely national mandatory standards, a state's concerted effort, a national labeling program, and a special purpose entity:

Federal Equipment Efficiency Standards. Since 1987, when President Ronald Reagan signed the National Appliance Energy Conservation Act, mandatory national efficiency standards have been an accepted and effective manner for the government to help consumers reduce their energy consumption in a range of household appliances. According to analyses done by the DOE and ACEEE, standards reduced U.S. electricity use by 88 TWh annually and total energy use by 1.2 quadrillion primary BTUs annually in 2000. These savings represent 2.5 percent and 1.3 percent reduction of total electricity and energy use respectively. From 1987 through 2000 appliance standards saved consumers approximately $50 billion in reduced energy bills at an incremental appliance cost of $15 billion. These savings are expected to grow to 250 TWh in 2010 as standards have become more strict since data were last available.[22]

State of California. From 1977 through 2007, per-capita electricity consumption in California remained nearly flat, growing at 0.07 percent annually, compared to 1.3 percent in the nation overall. Adjusting for such structural differences as climate, demographics, and industry and commercial business mix, and incorporating measurement uncertainty,[23] reveals that California consumes approximately 11 to 19 percent[24] less energy per capita than the U.S. average. One notable structural difference is that California's lighter industry mix accounts for 38 percentage points of an apparent 60 percent lower per capita industrial consumption. The state's strategy for energy resources has emphasized utility-led energy efficiency programs, significant building code and appliance standard initiatives, and a range of other innovative efforts. Some observers have identified benefits of this energy efficiency, including gross state product of approximately $1,000 per capita and reduced energy burden on the low-income population.[25] It is worth noting that electricity prices in California are 35 percent higher than the national average, partly due to the public-benefit charge of $0.0054 per kWh (6 percentage points of the difference) to fund energy efficiency. This price difference may play a role in decreasing demand through microeconomic supply-demand dynamics, especially in the industrial sector.

ENERGY STAR®. The United States Department of Energy (DOE) and Environmental Protection Agency (EPA) jointly operate this nationwide voluntary standards and labeling program. Since its inception in 1992, ENERGY STAR has become a leading international brand for energy efficient products. It covers more than 60 product categories across nine broad product classes, including major appliances, office equipment, and consumer electronics. It also addresses new home construction, residential retrofit, and commercial and industrial energy management. Through 2007, the program has helped save 1,790 trillion BTUs of primary energy (159 TWh). There is substantial opportunity,

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[22] "Appliance and Equipment Efficiency Standards: One of America's Most Effective Energy-Saving Policies," ACEEE, 2009.

[23] Anant Sudarshan and James Sweeney, *Deconstructing the Rosenfeld Curve: Understanding California's Low Per Capita Electricity Consumption*, Stanford University, September 30, 2008.

[24] At first glance the relative per capita consumption of 11,900 kWh per capita for the U.S. vs. 6,400 kWh for California shown in this report and the "Rosenfeld Curve" suggests California consumes approximately 40 percent less energy per capita than the U.S. average.

[25] Mark Bernstein, et al., *The Public Benefit of California's Investments in Energy Efficiency*, RAND Corporation, March 2000.

however, with some new products added to the program, such as commercial food service, while many appliances and devices remain unaddressed. Furthermore, the program is only in the early stages of deploying program models to address sizeable needs in the commercial and residential retrofit segments.

Efficiency Vermont. The state legislature and Vermont Public Service Board created Efficiency Vermont in 2000 to help state residents save energy, reduce energy costs, and protect the state's environment. Efficiency Vermont is the nation's first state-wide "energy efficiency" utility. It is funded by a surcharge on customer electricity bills and is operated by an independent, non-profit organization under contract to the Public Service Board. In Efficiency Vermont's first 8 years of operation, businesses and homeowners who worked with the organization saved approximately 398 GWh of electricity. In 2007, Efficiency Vermont's energy savings were approximately 94 GWh, or 1.6 percent of the state's 5,865 GWh of retail sales, completely offsetting business-as-usual electric load growth forecasts in the state.[26] Load-serving entities and other special-purpose and government entities have made similar efforts, notably, but not exclusively, in New England, New York, New Jersey, and the West Coast states.

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[26] *Year 2007 Annual Report*, Efficiency Vermont, October 2008.

DEMAND-SIDE MANAGEMENT

Opportunities in demand-side management (DSM) are prompting utilities to invest in smart grid and advanced metering infrastructure. DSM's main goal is to reduce peak loads, which allows utilities to flatten their power demand curves, shifting load from expensive peaking units to lower-cost base-load plants. Reducing peak consumption increases reliability of the electric grid, reducing outages for customers and operations and maintenance costs for utilities. Furthermore, some DSM measures can decrease total energy consumption while delivering the same value to customers.

Since the 1980s, DSM has focused primarily on commercial and industrial (C&I) customers, with more than 165 utilities in North America having programs for these customers, including direct load control (DLC) and tiered-pricing programs. However, emerging smart grid technology is shifting the focus in DSM from direct load control to dynamic pricing and making programs possible for residential and small-to-medium business segments. Residential DSM programs have so far achieved mixed results: pilots in California and Nevada have demonstrated strong potential, though other high-profile pilots, such as Puget Sound Energy in 2001, reported high implementation costs and insufficient peak reduction. Larger residential DSM deployments will be needed to better understand its actual savings potential.

Four types of DSM programs warrant discussion:

- **Direct load control and incentive-based programs.** DLC programs are one of a range of incentive-based DSM approaches that include interruptible/curtailment rates, demand bidding/buyback programs, emergency demand response programs, and capacity market programs.[1] DLC programs allow utilities to control specific energy-intensive loads, such as air conditioners, in exchange for a billing discount to the customer. DLC programs are wide-spread; about one-third of utilities cycle residential air conditioners, with average participation rates of 15 percent, and roughly 60 percent of utilities offer load-management programs for C&I customers.[2]

  DLC programs have proven cost effective and have yielded substantial savings: A survey of 24 programs showed average peak load savings of 29 percent for participating customers with minimal reduction in total energy consumed.[3] Con Edison, for example, offers its residential and small commercial customers a free programmable thermostat in exchange for the ability to cycle their air conditioning load, although the customer can override the decision if it occurs at an inconvenient time. Con Edison has installed more than 24,000 thermostats with a peak load reduction of 29 MW.[4] Furthermore, Con Ed's DLC program appears to be cost effective, with costs estimated at $455 to 626 per KW saved,[5] compared to $500 to $1,400 per KW for additional peak generation capacity.[6]

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[1] "Assessment of Demand Response and Advanced Metering," Federal Energy Regulatory Commission, Staff Report, August 2006.

[2] "Utility Load Control Programs," Chartwell, March 2006.

[3] "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

[4] New York State Public Service Commission, "Energy Efficiency Portfolio Standard Working Group 2 – Program Summaries: Direct Load Control," September 2005.

[5] New York State Public Service Commission, "Consolidated Edison Company of New York, Inc's Direct Load Control Program," September 2005.

[6] According to World Bank report on equipment prices in the power sector, a gas turbine simple cycle plant costs $530/KW for a 5 MW plant, $970/KW for a 25MW plant and $1380 for a 5 MW plant. "Study of Equipment Prices in the Power Sector." The International Bank for Reconstruction and Development, The World Bank Group. 2008.

Because DLC programs are used primarily for air conditioning loads in the residential sector and inductive loads in C&I, its potential is limited; other programs will be needed to reduce peak loads further. In addition, DLC programs are perceived to be heavy-handed, because they give control of devices inside homes and businesses to utilities.

- Dynamic pricing. Dynamic pricing programs create energy prices that more closely reflect the utility's actual cost of power at the time of consumption. Use of these programs has been limited mostly to large C&I customers; however, residential pilots have emerged recently in many states. Almost one-third of utilities offer dynamic rates,[7] including Time of Use, Critical Peak Pricing (CPP) and Real Time Pricing.[8] Pilots show an average residential reduction in peak consumption due to price signals of approximately 22 percent, although results vary significantly by pilot, with overall consumption dropping by around 4 percent.[9] California's 2,500-participant Statewide Pricing Pilot suggests CPP can reduce California's peak load by 1,500 MW to more than 3,000 MW.[10] Because results have varied significantly by pilot, more large-scale pilots and roll-outs will be necessary to better understand the energy savings potential.
- Consumption information and transparency. Other DSM programs provide customers with greater transparency into their consumption, thereby encouraging them to reduce demand. Methods include bill-related signals, in-home displays, and home automation. Bill-related signals provide more frequent and easier-to-understand billing with clear indications of relative consumption levels. When done monthly, these programs can reduce consumption by up to 6 percent, while weekly or daily billing offers savings of 10 to 13 percent.[11] Early pilots suggest that in-home displays, devices that provide real-time information on home energy consumption, could provide savings of 4 to 15 percent.[12] Home automation, including programmable thermostats and smart appliances, are in the earliest development phase of all DSM programs; however, early results indicate peak reduction of up to 46 percent, with reductions in total consumption of 11 percent.[13]

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[7] "Utility Load Control Programs," Chartwell, March 2006.

[8] Time of Use (TOU) rates: electricity rates are set in tiers for different times of the day and typically do not change more than twice per year. Many large commercial and industrial customers already have TOU pricing. Critical Peak Pricing (CPP): during times of extreme peak, prices will increase dramatically. Real-Time Pricing (RTP): prices change on an ongoing basis to reflect closely the utility's cost of generating or purchasing electricity.

[9] "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

[10] Roger Levy, "California Statewide Pricing Pilot (SPP) Overview and Results 2003-2004," 2005.

[11] Sarah Darby, "The Effectiveness Of Feedback On Energy Consumption," Environmental Change Institute, Oxford University, April 2006.

[12] Sarah Darby, "The Effectiveness of Feedback on Energy Consumption, "Environmental Change Institute, University of Oxford, April 2006.

[13] "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

THE CHALLENGE OF CAPTURING ENERGY EFFICIENCY

Although the U.S. economy has captured measurable and important amounts of energy efficiency since the oil crises of the 1970s, many attractive opportunities remain available. The fundamental challenge for the nation is, therefore, how to bring programs like these to scale and capture the full NPV-positive potential that exists today.

Both the nature of energy efficiency and attributes of consumer behavior present challenges to efficiency capture

The nation's mixed success in improving energy efficiency stems in part from the significant barriers that surround every cluster of potential and in part from system-level challenges associated with pursuing energy efficiency opportunities at scale in our economy. Four fundamental attributes of energy efficiency, some of them the legacy of how we have approached the opportunity over time, make the task of capturing these savings truly challenging:

- **Initial outlay.** Energy efficiency measures will require upfront investment of capital with savings that will accrue over sometimes lengthy periods. Despite the NPV-positive nature of the investments identified in this report, behavioral barriers to upfront capital outlays and historically low savings rates have prevented consumers from capturing substantial amounts of efficiency. Issues of capital allocation and risk of business termination have challenged the commercial and industrial sectors. Access to capital remains an issue in all sectors.
- **Fragmentation.** As mentioned before, energy efficiency opportunities are scattered across the economy: no single industry, building type, population cluster, climate region, or end-use alone can unlock the opportunity nationwide. The dispersion means that while the NPV-positive energy efficiency potential is collectively large, individually each efficiency opportunity is of relatively low priority. The level of penetration needed to capture something approaching the full potential has rarely been achieved by any technological advancement in society, and even less frequently in as short a time frame as a decade.
- **Low awareness and attention.** Improving energy efficiency is rarely the primary focus or responsibility of any major agent in the economy: businesses have other areas of strategic focus, energy providers focus on reliability, and residential end-users typically face competing needs for their funds and attention. Few businesses targeting these opportunities have existed before, apart from the energy services company (ESCOs) industry which represent a small part of the energy industry. Additionally, energy efficiency is often a lower priority in the selection of energy-consuming devices than functionality, form, or reliability.
- **Difficult to measure.** Reduced energy consumption is not a physical product and frequently difficult to measure. Given the diverse factors that affect energy consumption, including weather, economic activity, and consumer behavior, energy savings require measurement and verification methods more challenging than the meter reading required to accurately measure consumption. Furthermore, saving energy is a more abstract concept than consuming energy, because it expresses a difference relative to what would have happened had consumers made different choices.

Since the late 1970s economists have tried to understand why consumers diverge from classical economic decision criteria through a better understanding of behavioral economics. Several heuristics have emerged which may explain from a behavioral standpoint how these attributes arise or why some of the barriers they present persist.

Given the volume of decisions consumers make daily and the time it would take to rationally analyze each and every one, consumers default to avoiding action on less interesting opportunities. This behavior (termed status quo bias) manifests as consumers hesitating to upset their current situation. For example, a study revealed most investors do not adjust the asset allocation of their retirement funds even in the face of significant market fluctuations.[27] In a similar manner, consumers are unwilling to invest money in energy efficiency upgrades that are financially beneficial as it disrupts their current finances.

When consumers do think about the economics of a decision though, there are other apparently "irrational" components to their decision making. Many consumers are prone to value current or short-term value much higher than longer-term value, and thus attach a higher discount rate to investments that pay back more slowly (termed hyperbolic discounting).[28] This is likely one reason the slower payback of energy efficiency manifests as a high discount factor in customer behavior. In addition the context in which consumers make decisions (termed framing) can influence those decisions. Studies have shown that people are much more likely to act when confronted with a potential loss rather than a potential savings.[29] Currently efficiency investments are typically framed as a savings and are thus prone to this effect. Representing them as avoiding a loss may make them more appealing.

Studies have also shown that when consumers must incur a loss to receive a potential gain, that gain must significantly outweigh the loss (termed loss aversion). For example, when placing a bet with even odds most gamblers demand a $200 reward to place a wager of $100.[30] Thus, even if an energy efficiency measure is strongly NPV-positive, consumers may require the reward of future savings to more than double the upfront investment "wager" (i.e., a cost to benefit ratio of 2 or higher). However, this aversion to investing decreases when consumers have already decided to spend money. Consumers become much less sensitive to incremental costs as they become a smaller percentage of the total cost (diminishing sensitivity).[31] The incremental cost of an efficient air conditioner, for example, appears more palatable to consumers when compared to the price of a new home than when compared to the price of an alternative air conditioner.

The nature of energy efficiency and attributes of consumer behavior combine to create a series of opportunity-specific barriers that the market must overcome to unlock energy efficiency on a national scale (Exhibit 10). These barriers require comprehensive, opportunity-specific solution strategies to unlock the potential, as well as system-level actions to address regulatory barriers and enable broader market impact.

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[27] William Samuelson and Richard Zeckhauser, "Status Quo Bias in Decision Making," *Journal of Risk and Uncertainty*, 1988.

[28] George Ainslie, "Specious Reward: A Behavioral Theory of Impulsiveness and Impulse Control," *Psychological Bulletin*, 1975.

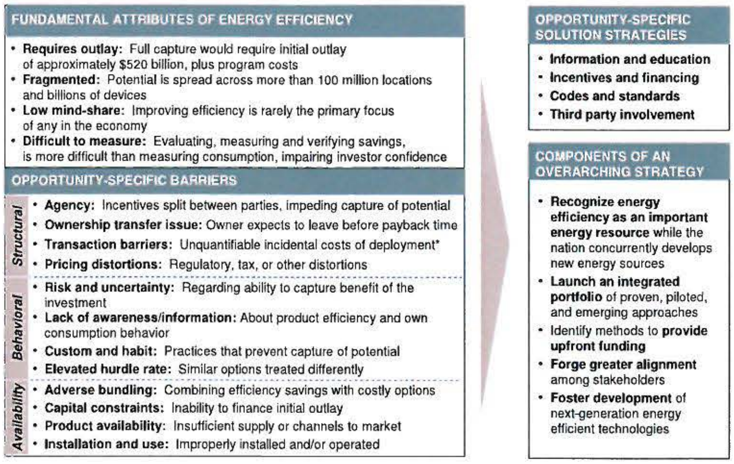
[29] Amos Tversky and Daniel Kahneman, "The Framing of Decisions and the Psychology of Choice," *Science*, 1981.

[30] Amos Tversky and Daniel Kahneman, "Advances in Prospect Theory: Cumulative Representation of Uncertainty," *Journal of Risk and Uncertainty*, 1992.

[31] Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica*, 1979.

Exhibit 10: Multiple challenges associated with pursuing energy efficiency

On the left, this exhibit summarizes the fundamental difficulties of pursuing greater energy efficiency and the opportunity-specific barriers that affect and help define clusters of efficiency potential. On the right, it shows opportunity-level solution strategies to overcome barriers and suggests the essential elements of an overarching strategy for capturing energy efficiency potential.



FUNDAMENTAL ATTRIBUTES OF ENERGY EFFICIENCY

- **Requires outlay:** Full capture would require initial outlay of approximately $520 billion, plus program costs
- **Fragmented:** Potential is spread across more than 100 million locations and billions of devices
- **Low mind-share:** Improving efficiency is rarely the primary focus of any in the economy
- **Difficult to measure:** Evaluating, measuring and verifying savings, is more difficult than measuring consumption, impairing investor confidence

OPPORTUNITY-SPECIFIC BARRIERS

Structural

- **Agency:** Incentives split between parties, impeding capture of potential
- **Ownership transfer issue:** Owner expects to leave before payback time
- **Transaction barriers:** Unquantifiable incidental costs of deployment*
- **Pricing distortions:** Regulatory, tax, or other distortions

Behavioral

- **Risk and uncertainty:** Regarding ability to capture benefit of the investment
- **Lack of awareness/information:** About product efficiency and own consumption behavior
- **Custom and habit:** Practices that prevent capture of potential
- **Elevated hurdle rate:** Similar options treated differently

Availability

- **Adverse bundling:** Combining efficiency savings with costly options
- **Capital constraints:** Inability to finance initial outlay
- **Product availability:** Insufficient supply or channels to market
- **Installation and use:** Improperly installed and/or operated

OPPORTUNITY-SPECIFIC SOLUTION STRATEGIES

- **Information and education**
- **Incentives and financing**
- **Codes and standards**
- **Third party involvement**

COMPONENTS OF AN OVERARCHING STRATEGY

- **Recognize energy efficiency as an important energy resource** while the nation concurrently develops new energy sources
- **Launch an integrated portfolio** of proven, piloted, and emerging approaches
- Identify methods to **provide upfront funding**
- **Forge greater alignment** among stakeholders
- **Foster development** of next-generation energy efficient technologies

* Financial transaction barriers and actual quality trade-offs are factored into the initial NPV-positive potential calculation as real costs.

Source: McKinsey analysis

Opportunity-specific barriers pose significant hurdles to capturing clusters of energy efficiency potential

Achieving meaningful energy savings will require a variety of approaches tailored to the specific barriers that have inhibited capture of individual efficiency opportunities. Identifying and understanding these barriers has been a focus of energy efficiency research for decades; our investigation drew upon the considerable body of work on the topic. Most sources refer to a consistent set of barriers and point to the need for a comprehensive mix of policies, due to the presence of multiple, sometimes overlapping barriers. Our research additionally suggests that unlocking the potential of a given cluster requires addressing all major barriers that affect that cluster. Many traditional approaches (e.g., monetary incentives or awareness campaigns) have focused on removing the most significant or most addressable barriers, but have often fallen short of a holistic solution that comprehensively addresses all barriers.

Barriers to greater efficiency. To simplify the discussion, we have grouped well-known barriers into the following three categories:

- **Structural.** These barriers arise when the market or environment makes investing in energy efficiency less possible or beneficial, preventing a measure that would be NPV-positive from being attractive to an end-user:
  - **Agency issues** (split incentives), in which energy bills and capital rights are misaligned between economic actors, primarily between landlord and tenant
  - **Ownership transfer issues**, in which the current owner cannot capture the full duration of benefits, thus requiring assurance they can capture a portion of the future value upon transfer sufficient to justify upfront investment; this issue also affects builders and buyers

  - **"Transaction" barriers**, a set of hidden "costs" that are not generally monetizable,[32] associated with energy efficiency investment; for example, the investment of time to research and implement a new measure
  - **Pricing distortions**, including regulatory barriers that prevent savings from materializing for users of energy-savings devices.
- **Behavioral.** These barriers explain why an end-user who is structurally able to capture a financial benefit still decides not to:
  - **Risk and uncertainty over the certainty and durability of measures and their savings** generates an unfamiliar level of concern for the decision maker
  - **Lack of awareness**, or low attention, on the part of end-users and decision-makers in firms regarding details of current energy consumption patterns, potential savings, and measures to capture those savings
  - **Custom and habit**, which can create an inertia of "default choices" that must be overcome
  - **Elevated hurdle rates**, which translates into end-users seeking rapid pay back of investments – typically within 2 to 3 years. This expectation equates to a discount rate of 40 percent for investments in energy efficiency, inconsistent with the 7-percent discount rate they implicitly use when purchasing electricity (as embodied by the energy provider's cost of capital). It is beyond the scope of this report to evaluate the appropriate risk-adjusted hurdle rate for specific end-users, though it seems clear that the hurdle rates of energy delivery and energy efficiency are significantly different.
- **Availability.** These barriers prevent adoption even for end-users who would choose to capture energy efficiency opportunities if they could:
  - **Adverse bundling or "gold plating,"** situations in which the energy efficient characteristic of a measure is bundled with premium features, or is not available in devices with desirable features of higher priority, and is therefore not selected
  - **Capital contraints and access to capital**, both access to credit for consumers and firms and (in industry and commerce) competition for resources internally within balance-sheet constraints
  - **Product (and service) availability** in the supply chain; energy efficient devices may not be widely stocked or available through customary purchasing channels, or skilled service personnel may not be available in a particular market
  - **Installation and use issues**, where improper deployment or use eliminates savings.

In practice, nearly all clusters reflect a mix of barriers, with "awareness and information" and "access to capital" the most frequently observed. In fact, 10 of our 14 clusters face both of these barriers. "Product or service availability" is the third-most common, with all three of these barriers impacting six of our 14 clusters. The relative importance of these barriers is broadly in agreement with other work.[33] The mixture of barriers complicates the energy efficiency landscape enormously. We can draw several general conclusions from our analyses:

- **Unlocking the full potential of energy efficiency requires a holistic approach.** Such an approach would address all barriers within a given cluster. None of

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[32] We have included direct transaction costs in our calculation of the NPV-positive potential where present and calculable (e.g., the cost of running a new connection to a gas pipeline, if a user switches from electric to gas heating and piping is not in place at that address).

[33] Steve Sorrell, et al., *The Economics of Energy Efficiency: Barriers to Cost Effective Investment*, Edward Elgar, 2004.

the 14 clusters offers a simple one-step approach as all clusters face at least two barriers, 11 clusters face three or more barriers, and eight clusters face four or more barriers.

- **Agency issues, in the sense of landlord-tenant issues, are not as widespread as often thought.** The industrial sector faces this barrier relatively little. Its effect is only somewhat prevalent in the residential sectors, with 8 percent of residential potential affected. Impact varies in the commercial sector, with roughly 5 to 25 percent of the potential impacted in most commercial subsectors. However, agency issues are concentrated in a few commercial subsectors, with the retail, office, and food service subsectors having up to 75 percent of their energy efficiency potential affected. In total, approximately 9 percent of potential across all sectors is affected by this type of agency issue.
- **Ownership transfer issues, sometimes considered a variant of agency issues, pose a more significant challenge.** Though the benefits of energy efficiency measures in residential homes have an average lifetime of 17 years and pay back within 7 years, 40 percent of households will have moved in that time. This issue is less significant for commercial buildings that have longer tenancy periods, though in some commercial buildings, such as retail or food service, tenancies tend to be significantly shorter than the 15 year average lifetime of commercial-sector energy efficiency measures. Thus current owners are likely to capture only a portion of available savings; for many investments to make financial sense however, owners must be confident they can capture enough of the value of future savings at the time of building sale to warrant the upfront investment.
- **Access to capital and elevated hurdle rates affect 43 percent of the NPV-positive efficiency potential.** These issues tend to cover different segments and technologies than principal-agent issues. If hurdle rates are decreased from the 40 percent typical of residential end-users (equivalent to a 2- to 3-year payback) to 7 percent, 3.9 quadrillion end-use BTUs become NPV-positive. However, even the 5.2 quadrillion end-use BTUs that remain available at a 40-percent discount factor represent an attractive and unseized opportunity.

Opportunity-specific solution strategies can overcome these barriers

Our review of previous and proposed programs designed to encourage greater energy efficiency suggest that four categories of measures can aid in unlocking the clusters of efficiency potential in the residential, commercial, and industrial sectors. To fully overcome the barriers that affect a single cluster of potential, a combination of solution strategies will likely be needed, though in some clusters a single targeted solution strategy may be sufficient.

- **Information and education.** Increasing awareness of energy use and knowledge about specific energy-saving opportunities would enable end-users to act more swiftly in their own financial interest. Options include providing more information on utility bills or through the use of in-building displays, voluntary standards, labeling schemes, audits, assessments, and awareness campaigns. Such solutions will likely prove insufficient to drive broad adoption on their own, but they represent a necessary part of most holistic solutions.
- **Incentives and financing.** Given the large upfront investment needed to capture efficiency potential, various approaches could reduce the financial hurdles that end-users face. Options include traditional and creative financing vehicles (such as energy efficiency mortgages), monetary incentives or grants, including tax and cash incentives, and price signals, including tiered pricing and pricing of externalities (e.g., carbon prices).
- **Codes and standards.** In several clusters, some form of mandate may be warranted to expedite the process of capturing potential, particularly where end-user or manufacturer awareness and attention are particularly low. Options include

equipment standards, building codes (including improving code enforcement), and mandatory audits or assessments. Such mandates can often yield high "adoption" because they bypass the consumer decision-making process, but they can face a challenging political process and must be kept up to date to capture the full potential.

- **Third-party involvement.** A private company, utility, government agency, or non-governmental organization could support a "do-it-for-me" approach by purchasing and installing energy efficient improvements directly for the end user, thereby essentially addressing all non-capital barriers. When coupled with monetary incentives covering potentially the full cost, this solution strategy could address all barriers and unlock almost the entire potential, though some portion of end-users might opt out of such a program, thereby preventing full capture.

The challenge with every cluster of efficiency potential is to identify appropriate solution strategies that will address existing barriers with sufficient force to unlock the savings. Through an extensive review of the literature on energy efficiency and interviews with experts in this and related fields, we have attempted to identify which solution strategies address which barriers within each cluster. Some solution strategies are "proven" to work at the national level; some have been "piloted" at the scale of large cities, counties, or even states but likely need further refinement before being scaled to a national effort; and others are "emerging" and seem plausible enough to warrant a trial or may have been tried on a sub-metropolitan scale. We categorize each of the 47 solution strategies by these three levels of historical experience relative to a nationally scaled deployment: proven, piloted, and emerging.

In addition, continued progress against the full potential would require careful monitoring of strategies to identify unaddressed barriers, refining the approach to address those barriers, and determining when to discontinue a strategy once the NPV-positive potential is exhausted or is on a self-propelling trajectory to full capture.

Our objective is to expose a promising range of solution strategies that could contribute to a more aggressive scaled-up pursuit of the national efficiency potential. In Chapters 2 through 4 we will describe the potential in each cluster based on its distinguishing characteristics, outline the important barriers that challenge the capture of that potential, and map possible solutions against those barriers. We have attempted to quantify the impact of various measures wherever possible; however, that has not been feasible in every case, often due to the qualitative nature of persistent barriers (e.g., information). In Chapter 5 we discuss the importance of developing a holistic implementation strategy that incorporates five observations from this research.

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If the U.S. were to progress through 2020 in line with the EIA's projections for energy consumption – the nation would have expanded substantially the energy infrastructure, captured a relatively low level of energy efficiency above and beyond that legislated in the Energy Independence and Security Act of 2007, and constructed many more inefficient commercial and residential buildings and appliances. If this were to occur, the U.S. will have foregone a significant opportunity to improve its energy productivity and, thus, its international competitiveness.

2. Approaches to greater energy efficiency in the residential sector

The residential sector will consume 29 percent of the baseline energy in the United States in 2020, accounting for 11.4 quadrillion BTUs of end-use energy (Table 1). These tables, present at the introduction to each sector and cluster, show the end-use and primary energy consumption in 2008 and 2020 and potential savings in 2020, each split out by fuel. We provide the same metrics for GHG emissions and abatement. Finally, the boxes at the bottom show the financial impact: the present value of the investment, the present value of the savings, and the annual savings. With an annual growth rate of 0.4 percent, consumption is forecast to reach 11.4 quadrillion end-use BTUs in 2020, driven by population growth, larger homes, and more electronic devices in each household.[34] Relative to the business-as-usual forecast, deploying all NPV-positive energy efficiency improvements in the residential sector would reduce its energy consumption in 2020 by 28 percent, saving the U.S. economy an estimated $41 billion in annual energy costs and avoiding some 360 million tons of CO_2e emissions in that year. Exhibit 11 illustrates energy efficiency measures of a typical household, ranging from improvements in the house's building shell to upgrading to more energy efficient electrical devices. The upfront investment associated with this level of improvement – involving efficiency upgrades for 129 million homes, their appliances and HVAC systems,[35] and 2.5 billion electronic devices – would necessitate some $229 billion in incremental investment and provide present value savings of $395 billion.

Table 1: Overview of energy use in the residential sector

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	**Savings** Percent
END-USE ENERGY	10,880	11,410	3,160	28
Trillion BTUs				
▪ Electricity TWh	1,410	1,510	390	26
▪ Natural gas	4,960	5,200	1,460	28
▪ Other fuels*	1,130	1,060	370	35
PRIMARY ENERGY	21,190	22,480	6,020	27
Trillion BTUs				
▪ Electricity	14,910	16,010	4,130	26
▪ Natural gas	5,150	5,400	1,520	28
EMISSIONS	1,270	1,350	360	27
Megatons CO_2e				

PV of upfront investment – 2009-2020: $229 billion	PV of energy savings – 2009-2020: $395 billion	Annual energy savings – 2020: $41 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

Considering the dominant barriers to energy efficiency and selected attributes of energy consumption, we organized the efficiency potential in the residential sector into five clusters (Exhibit 12). Some 71 percent of the end-use potential (53 percent of primary

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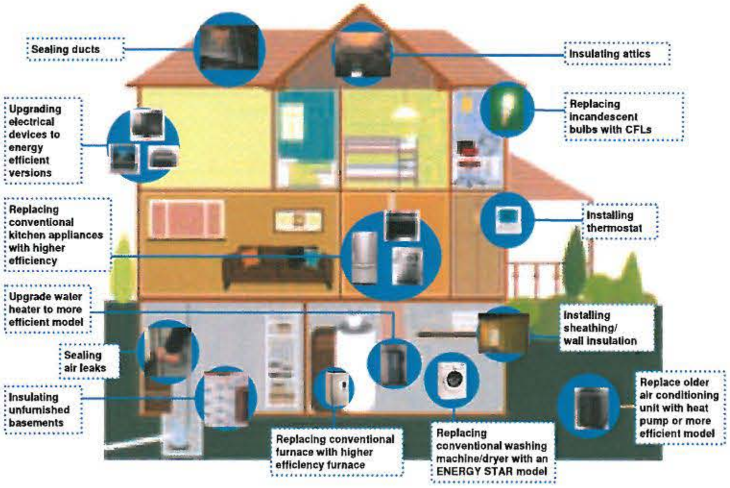
[34] AEO 2008, NEMS.

[35] We refer to home heating and cooling systems generically as HVAC systems (heating, ventilation, and air conditioning), whether a home has a heating system, a cooling system, an air exchanger or all three systems. We group changes to building shell and HVAC systems together because they work in tandem to determine the conditioning of the living space.

energy potential) resides in improving the building shell and heating and cooling equipment, mostly in existing homes. The remaining 29 percent of end-use potential (47 percent of primary energy potential) is split between electrical devices and small appliances, and lighting and appliances.

Exhibit 11: Potential energy efficiency measure for a typical home

Each of the callouts represents some of the measures that are modeled to drive residential energy efficiency in the report.



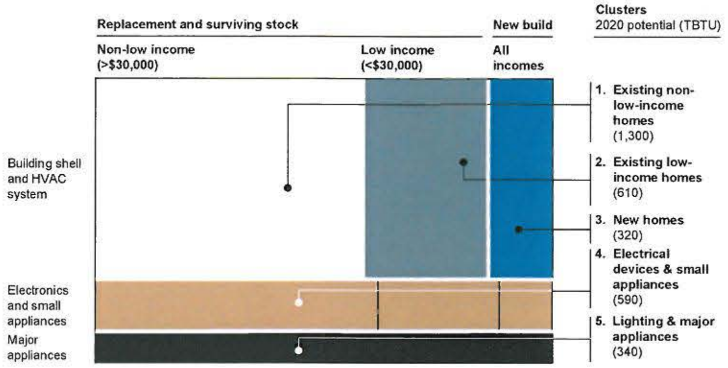
For each cluster, we will outline the energy efficiency potential, describe the barriers that have prevented its capture in the past, and explore possible solution strategies.

1. **Existing non-low-income homes (1,300 trillion end-use BTUs):** Low consumer awareness and demand, fast payback requirements, ownership transfer issues, high transaction costs, and inconsistent installation practices pose the most formidable and persistent barriers. Possible solution strategies to address these barriers include home energy assessments, creative financing solutions, monetary incentives, and mandatory upgrades.
2. **Existing low-income homes (610 trillion end-use BTUs):** This cluster in particular suffers from capital constraints, though the barriers that apply to the previous cluster apply here as well. Low-income weatherization programs scaled up from today's levels are a potentially powerful measure to address all barriers in this cluster, including the capital constraint.
3. **New homes (320 trillion end-use BTUs):** Potential in this cluster reflects the lack of incentives for builders to construct high-efficiency homes. Solution strategies to secure this potential include greater penetration of voluntary building labeling, incentives to builders or home buyers, and improved, standardized, and enforced building codes.
4. **Electrical devices and small appliances (590 trillion end-use BTUs):** Potential is highly fragmented across 2.5 billion consumer electronics devices and small appliances (e.g., computers, televisions, coffee makers, battery chargers). For most device classes, energy efficiency has received little attention from consumers and manufacturers. Promising solution strategies include voluntary labeling and mandatory standards addressing both active and standby consumption.

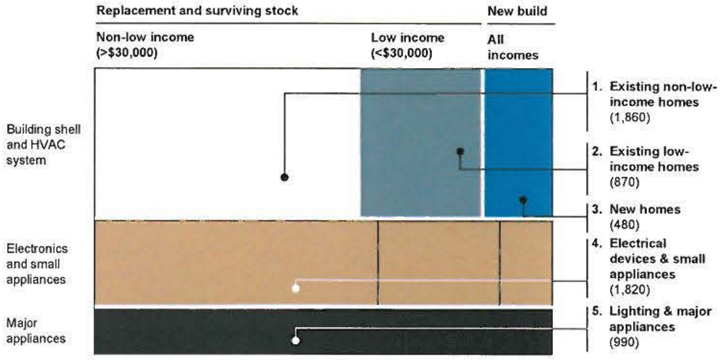
5. **Lighting and major appliances**[36] **(340 trillion end-use BTUs):** Lighting dominates the potential in this cluster, with lack of consumer information and quality trade-offs representing the most significant barriers. Solutions involve voluntary standards and labeling, monetary incentives, and mandatory standards.

Exhibit 12: Clusters of energy efficiency potential in the residential sector

End-use energy, avoided consumption; total = 3,160 trillion BTUs



Primary energy, avoided consumption; total = 6,020 trillion BTUs



Source: EIA AEO 2008, McKinsey analysis

The upper and lower charts break out the energy efficiency potential in 2020 for the residential sector in end-use and primary energy respectively. Each area represents a cluster of efficiency potential: area is proportional to the relative share (of total potential in the sector) associated with that cluster, while the number next to the cluster name provides the efficiency potential, measured in trillion BTUs.

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[36] Appliances include water heater, dishwashers, clothes washers, clothes dryers, refrigerators, freezers, and cooking equipment.

WHOLE-BUILDING DESIGN

By viewing a building as a system that can be optimized within a specific site – rather than as a set of independent end-uses – whole-building design achieves additional energy savings in a cost-effective manner. Though it requires a fundamental change in how end-users interact with energy, this approach offers four opportunities:

- **Optimizing building design for the local environment.** Design decisions, including building orientation, landscaping, and exterior design, can reduce demand for heating and cooling. For example, surface-to-volume ratio of the structure, awning use, day lighting, total window area, roof color and pitch, and even wall color and chemistry of the pigment used will affect a building's energy needs. Optimal designs vary by climate and latitude but typically save 10 percent of energy use and as much as 40 percent in some cases.[1] This approach requires that energy use be included as a parameter in the design and construction processes.

- **Minimizing energy consumption.** Energy consumption can be reduced by modifying the building size, shape, and interior layout, as well as by using passive means for heating, cooling, and water heating. The average size of a new single family home in the U.S., for example, increased from 1,500 square feet in 1970 to 2,480 square feet in 2007[2]—a 65 percent increase—with a parallel increase in energy needed for space conditioning; over this period, the average household shrank from 3.0 to 2.6 persons.[3]

- **Pursuing holistic designs.** Due to specialization in education and building trades, contractors tend to design each mechanical system in isolation. Holistic system design would reduce energy consumption and capital investment by, for example, recovering furnace waste heat for water heating or upgrading the building envelope and using passive heating and cooling systems to reduce space conditioning load, enabling the HVAC system to be reduced by as much as half, or even eliminated.[4]

- **Improving design and installation practices.** Improper design and installation of HVAC equipment and building insulation can reduce their efficiency by as much as 30 percent.

Though many of these measures qualify as NPV-positive, their deployment would require a shift in the way end-users interact with and think about energy use. In some cases, these measures could represent a tradeoff with aesthetics or building use that end-users might find unacceptable, leading to a change in utility.

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[1] Dianna Lopez Barnett and William Browning, A Primer on Sustainable Building, Rocky Mountain Institute, 2007.

[2] "Housing Facts, Figures and Trends", NAHB, 2008. <www.nahb.org>.

[3] U.S. Census Bureau,.<www.Census.gov>.

[4] Right-size heating and cooling equipment," EERE, January 2002.

REBOUND EFFECTS

Rebound effects explain why actual energy savings fall short of expected savings. Studies have confirmed the existence of four effects we classify as rebound:[1]

- **Technical estimation.** "Shortfall" occurs when actual savings fall short of engineering estimates. There are two potential causes: improper installation, which can reduce savings by 20 to 30 percent, and necessary simplifications in engineering models, which can result in overestimating savings by as much as 50 percent, especially for space conditioning.
- **Direct rebound effect.** "Take-back" involves increased energy use concurrent with deployment of an energy efficiency measure. Studies have found average interior temperatures were reset 1 to 3 degrees Fahrenheit higher in homes receiving insulation upgrades, representing a 15 to 30 percent decrease in energy savings.[2,3] This effect can be as much as 50 percent in some settings.
- **Indirect rebound effect.** If end-users redeploy money saved through energy efficiency to purchase (or consume) energy in another form, overall energy consumption will not decrease, though users clearly do more work or capture more utility with the same investment.
- **Macroeconomic effect.** Energy efficiency may paradoxically increase long-term consumption by improving access to energy among populations that previously had limited access to it and by increasing economic growth. Opinions are divided on this point and the impact of increased efficiency on energy prices in regulated and restructured markets remains uncertain.[4]

Our research addressed the issue of technical estimation by matching our building modeling output to consumer survey data. Direct and indirect rebound effects represent improvements in consumer utility (i.e., amount of work or comfort per-unit of energy) and by extension energy productivity. Finally, it is likely that legislative changes or regulatory dynamics will result in price adjustments that offset the potential downward pressure of efficiency on energy prices.

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[1] Steve Sorrell, "The Rebound Effect: An Assessment of the Evidence for Economy-wide Energy Savings from Improved Energy Efficiency," UK Energy Research Centre, October 2007.

[2] Chris Martin and Martin Watson, "Measurement of Energy Savings and Comfort Levels in Houses Receiving Insulation Upgrades," Energy Monitoring Company for Energy Saving Trust, June 2006.

[3] Geoffrey Milne and Brenda Boardman, "Making Cold Homes Warmer: The Effect of Energy Efficiency Improvements in Low-Income Homes" Energy Action Grants Agency Charitable Trust, 2000.

[4] The effect is known as the Khazzoom-Brookes postulate. See, for example, Horace Herring, "Does Energy Efficiency Save Energy: The Implications of accepting the Khazzoom-Brookes Postulate," EERU, 1998.

1. EXISTING NON-LOW-INCOME HOMES

Heating and cooling the 55 million single family, 12 million multi family and 3 million manufactured existing non-low-income homes in the U.S. consumes 3.3 quadrillion end-use BTUs of energy in the 2020 reference case. This cluster offers the largest savings potential in the residential sector, accounting for 41 percent (1,300 trillion BTUs) of total residential end-use potential in 2020 (Table 2). The barriers in this cluster are among the most intractable in the residential sector, and the relevant solution strategies as a set are relatively untested at scale, suggesting that the cluster requires further development of solution strategies. Assuming solutions to the barriers are put in place, capturing this potential would require $153 billion of incremental capital and provide present value savings of $167 billion.

Shell improvements can be either low- or high-capital. Low-capital maintenance, includes installing programmable thermostats, sealing home air leaks and ducts, and performing HVAC equipment maintenance. These measures offer 60 percent of the potential in this cluster for 49 percent of the cost. Higher-capital improvements, including the remaining measures listed in Exhibit 13, provide 40 percent of the potential for 51 percent of the cost.[37] Older homes have significantly greater potential per household. Homes built before 1940 have more than twice the potential per household than homes built after 1970. Sixty-four percent of the retrofit opportunity resides in the 51 percent of homes built before 1970.[38]

Table 2 Existing non-low-income homes

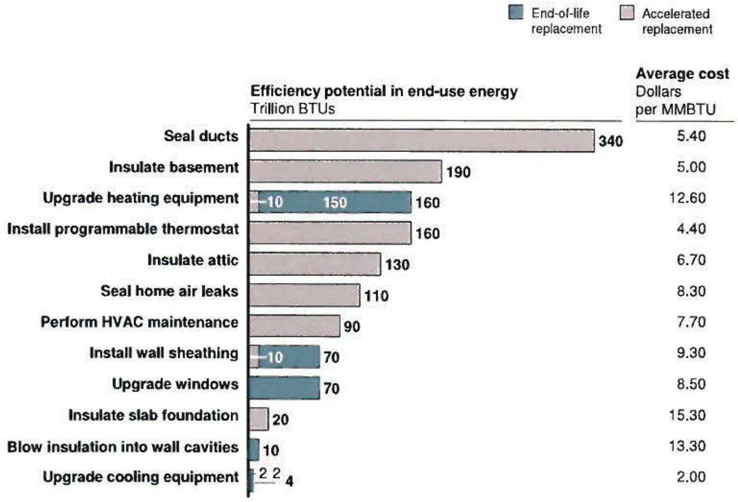
	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	3,830	3,330,	1,300	39
▪ Electricity TWh	220	200	70	38
▪ Natural gas	2,410	2,100	820	39
▪ Other fuels*	670	550	230	41
PRIMARY ENERGY Trillion BTUs	5,510	4,850	1,860	38
▪ Electricity	2,330	2,120	780	37
▪ Natural gas	2,500	2,180	860	39
EMISSIONS Megatons CO_2e	320	280	110	38

PV of upfront investment – 2009-2020: $153 billion	PV of energy savings – 2009-2020: $167 billion	Annual energy savings – 2020: $14 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA, AEO 2008, McKinsey analysis

Exhibit 13: Efficiency opportunities in existing non-low-income homes



Source: McKinsey analysis, EIA AEO 2008, RECS, Home Energy Saver model

The bars represent the energy efficiency potential in 2020, in trillion BTUs, for various measures to improve the performance of the building shell of non-low-income homes, with the savings associated with end-of-life and/or accelerated replacement for each of the measures. The prices on the right represent the respective average cost in dollars per million BTU saved for each of the measures.

Barriers to retrofitting building shells and HVAC systems in most homes

This cluster exhibits the most intractable set of barriers in the residential sector, because it is deeply involved with homeowners' decision-making processes. To organize the discussion, we have divided the process into five stages: awareness, agency and ownership, decision to pursue, ability to pursue, and savings capture:

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[37] The impact and cost of measures were developed and scaled nationally through Lawrence Berkeley National Laboratory's Home Energy Saver, EIA's RECS 2005, RSMeans, U.S. Census, and other publicly available data. These savings and cost estimates represent the average across all households, and savings opportunities vary significantly by household, requiring a personal energy assessment to identify specific opportunities.

[38] Some older homes have been upgraded previously; therefore, opportunities will need to be identified on a per-home basis prior to deployment; these statistics draw on RECS and our modeling of potential as described in Appendix A.

- **Awareness.** Homeowners typically do not understand their home's energy consumption and are unaware of energy-saving measures. Half of homeowners consider recycling and energy efficient appliances as ways to reduce GHG emissions, though only 15 percent indicated that improving insulation would be a preferred means.[39] People also tend to underestimate retrofit savings. A recent survey asked how much consumers expect to save from projects such as adding insulation, caulking and sealing their homes. Although these measures provide savings of 10 to 25 percent nearly three-fourths of respondents underestimated their potential utility bill savings at 10 percent or less.[40] Similarly, fewer than 2 percent of homes in the United States have had an energy efficiency rating or energy assessment to identify savings opportunities in their homes.
- **Agency and ownership.** Both the principal-agent problem in the sense of landlord-tenant issues, and the ownership transfer problem, affect this cluster. Ownership-transfer arises when the payback period on an improvement is longer than the future period of home ownership, as the current owner will not capture savings commensurate with the upfront cost and would be unsure about the increase in home value from the measures implemented. This affects 40 percent of retrofit potential (520 trillion end-use BTUs).[41] The landlord-tenant issue, which arises where renters pay the utility bills, affects 4 percent (50 trillion end-use BTUs) of potential in this cluster.[42]
- **Decision to pursue savings.** Two issues affect the decision itself:
  - **Competing uses for capital** in homeowner budgets inhibit allocation of money to energy-saving investments. Core spending accounts for approximately 90 percent[43] of the average household's budget, forcing retrofit spending to compete for the remaining 10 percent with other categories, including sometimes more appealing options like entertainment and more visible home improvements,[44] such as kitchen and bathroom remodeling.[45] A "typical" residential energy efficiency retrofit costs $1,500 for the average non-low-income single family household, representing approximately 27 percent of their annual discretionary spend (based on a median U.S. household income of $50,740).
  - **Rapid payback**, i.e., inconsistent discount rates, arise from elevated expectations on the use of personal funds. Empirical research suggests U.S. consumers typically expect payback within 2.5 years.[46] This expectation affects 60 percent (780 trillion end-use BTUs) of the potential in this cluster.
- **Ability to pursue savings.** Assuming homeowners decide to pursue the savings, two issues emerge that affect their ability to proceed. **High transaction barriers** arise as consumers incur significant time "costs" in researching, identifying, and

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[39] *2007 Business in Society Survey*, McKinsey & Company, 2007. Number of respondents: 2,002.

[40] "As Energy Costs Rise, Survey Finds Oklahoma Homeowners Are Concerned about Home Energy Efficiency – and Many Are Taking Action to Reduce Heating and Cooling Bills," Johns Manville, *Company News* web site, October 7, 2008.

[41] Inhibited potential includes that not NPV-positive for a home owner's expected stay in their home. This is calculated for each year of expected stay then summed while weighting by the number of people who move after each duration of occupancy (as calculated by the National Association of Home Builders using data from the American Housing Survey) to find the total potential affected.

[42] RECS 2001, NEMS.

[43] Includes food, housing, transportation, health, apparel, education, and insurance (see *Consumer Expenditure Survey 2007*, Bureau of Labor Statistics, Table 2, "Income before taxes: Average annual expenditures and characteristics").

[44] Electrical equipment, kitchen equipment, hardware, painting and flooring provides 78 percent of Home Depot sales, implying that less than 22 percent of sales derive from insulation. "Home Depot 2009 Annual Report." http://www.sec.gov/Archives/edgar/dta/354950/000095014409002875/x17422e10vk.htm#102.

[45] "Special Remodeling Report," NAHB, January 2007.

[46] *Energy Savings Potential of Solid State Lighting in General Illumination Applications: Final Report*, Office of Energy Efficiency and Renewable Energy, Department of Energy, December 2006.

procuring efficiency upgrades, as well as preparing for, and enduring lifestyle disruption during the improvement process.[47] In addition, the **availability of credible, whole house contractors** remains limited. Most contractors do not train in holistic building science, rather they specialize in a single construction procedure (e.g., HVAC or windows). Furthermore, the contractor market is highly fragmented; industry annual revenue of $75 billion is scattered across more than 40,000 businesses consisting mostly of privately held companies with less than $2 million in annual revenue, making it difficult for homeowners to identify which contractors perform relatively well compared to others and have the capabilities to complete the full retrofit.[48]

- **Savings capture.** Even after committing to pursue the savings, challenges remain. **Inconsistent quality of installation** and infrequent retro-commissioning of equipment can increase space conditioning costs by 20 to 30 percent.[49] Experts estimate that contractors install some 90 percent of HVAC equipment and insulation sub-optimally, reducing efficiency by 20 to 30 percent.[50] **Improper use** of programmable thermostats, such as overriding their programming to hold a constant temperature, can reduce or eliminate their savings that, in total, represent 12 percent of retrofit potential.

Solution strategies to unlock potential

Most solutions in this cluster remain unproven, with the exception of financial incentives that have proven successful through tax credits. This suggests the need for more thorough pilots of innovative approaches including labeling, on-bill or property-tax linked financing, retrofit mandates, and whole building contractor training. Exhibit 14 depicts how each of these solution strategies addresses the barriers each cluster faces. Reading from left to right, the first column, "barriers", depicts all barriers discussed in Chapter 1 with the dominant barriers colored and bolded. The next column, "manifestation of barrier", briefly describes how that barrier prevents capture of potential in this cluster. Next, reading right to left, the rightmost column, "solution strategies" depicts all general types of solution strategies discussed in Chapter 1. The boxes shaded and in bold are those most relevant to this cluster. The next column to the left, "potential approach" describes briefly how to apply that solution strategy to this cluster. Finally, the colored lines connect each potential approach to the barriers it can overcome.

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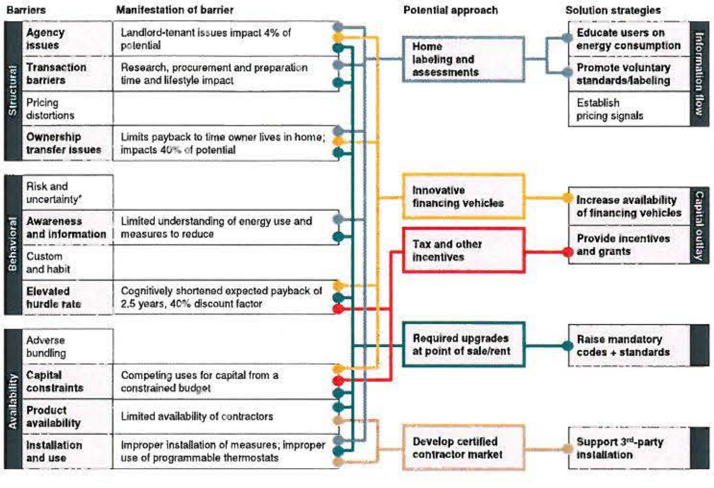
[47] Quantifiable transaction costs including those for refinishing walls after insulation or adding distribution piping for natural gas lines are explicitly included in our efficiency potential calculations.

[48] "HVAC and Plumbing Contractors," First Research, April 2009. <www.firstresearch.com/Industry-Research/HVAC-and-Plumbing-Contractors.html>.

[49] This is mostly in addition to the potential identified in this report; aside from 4 percent savings from retro-commissioning of heating and cooling units our analysis assumes installation continues to proceed as customary practice today.

[50] "A Guide to Heating and Cooling Efficiently," ENERGY STAR web site. <www.energystar.gov>.

Exhibit 14: Addressing barriers in existing non-low-income homes



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

- **Public awareness, home labeling, and voluntary standards** *(piloted).* Rating systems and labeling programs (e.g., Home Energy Rating System (HERS), ENERGY STAR, LEED), combined with broad public awareness campaigns, or campaigns targeted at realtors, could increase transparency of home energy use and catalyze action to capture efficiency opportunities. Labeling and voluntary standards have proven effective in the new home market and may be promising for the existing home market, though full penetration of the market will take years. Fewer than 2 percent of existing U.S. homes have ratings,[51] because most homes are evaluated and rated only at time of construction.[52] Therefore we expect share to increase through the new homes market where, for example, ENERGY STAR captured 17 percent of new construction in 2008 and is expected to grow to 25 percent in 2009. With sufficient penetration through broad market adoption or mandates, this measure overcomes many barriers, with the notable exceptions of capital constraints, rapid payback, and product availability. In addition to increasing awareness, reducing some transaction costs, and instructing in the proper use of thermostats, this measure could address the ownership-transfer barrier: some evidence suggests green home owners expect a market premium, as 73 percent of green homeowners[53] report their expectation of a higher resale value was an important factor during their purchase process.
- **Innovative financing** *(piloted).* New forms of financing can reduce capital constraints and agency issues by tying loan payments to the property or utility meter, instead of the homeowner, and by assuring cash flow from the investment is always positive to the home owner (i.e., monthly energy savings are greater than the loan payment). Mechanisms such as Pay As You Save (PAYS),[54] other utility on-bill

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[51] ENERGY STAR from Environmental Protection Agency and Department of Energy, LEED from U.S. Green Building Council, HERS Index from Residential Energy Services Network.

[52] ENERGY STAR and LEED labeling for new homes have not penetrated the existing home market. However, ENERGY STAR has a program called "Home Performance with ENERGY STAR" to address the market for existing homes, which is discussed later in this chapter.

[53] *The Green Homeowner: Attitudes and Preferences for Remodeling and Buying Green Homes*, McGraw Hill Construction, 2007.

[54] PAYS program is a type of on-bill utility financing that ties the loan payment to the home instead of the homeowner and also ensures that loan payments are less than energy savings from month to month.

financing, or loans tied to property taxes, such as Long Island Green Homes in Babylon, New York or BerkeleyFIRST in Berkeley, California could overcome both the principal-agent and ownership-transfer barriers, high discount rate, and capital constraints. Despite promising local pilots, these mechanisms have not yet achieved high penetration rates or been broadly applied. Conventional forms of financing, such as energy efficient mortgages or home equity lines can also provide funding, however they do not address agency barriers and have not penetrated the market to a significant degree, despite 30 years of availability.

- **Rebates and incentives** *(proven).* Monetary incentives for energy assessments and upgrades to residential customers historically have come through tax incentives or utility-sponsored programs. Under the American Recovery and Reinvestment Act (ARRA), 2009, homeowners can access up to $1,500 – but no more than 30 percent of the total installed cost – in tax credits for energy efficient home improvements, covering a wide array of efficiency measures. If incentive and rebate programs were to be expanded dramatically to reach all homes on a national level and buy down all NPV-positive measures to a 2.5-year payback, the outlay would total approximately $105 billion. Another approach involves programs offered by utilities or other organizations to provide low-cost or no-cost energy assessments. These programs, however, have tended to be on a small scale, providing only gradual impact, due to low funding levels, measurement and verification challenges, and low participation rates.
- **Building mandates** *(emerging).* Mandates can capture a large percentage of the potential, effectively removing all barriers; however, they would be a more significant intervention in the market. Authorities could require prescriptive or performance-based improvements at the point of sale, during a major renovation, or over a specified interval. The City of Berkeley, California's Residential Energy Conservation Ordinance (RECO) mandates minimum energy efficiency upgrades at the point of sale and major renovation. RECO has been in existence since the 1980s and leads to upgrades in approximately 500 homes annually at a typical cost of $400 to $1,300, which is borne by the home seller.[55] Because of changing ownership and inhabitant behavior, performance measurement and enforcement is challenging.

  A similar, but milder mandate would require home assessments, rather than improvements. The City of Austin, Texas, among others, is in the process of implementing such a mandatory assessment program. Such a program should recommend upgrades and provide referrals to approved contractors to address the service availability barrier; however, it would not guarantee savings. In fact, the success of the program would depend entirely on the rate at which participants choose to make the upgrades, because the amount of energy savings must justify the assessment cost, which typically runs between $300 and $600, given current operational scale, in addition to the cost of the energy efficiency measures themselves. In addition, about half of homes would not be covered by a point-of-sale audit by 2020 because they will not have changed ownership.[56] Covering all homes under such a program would likely require an additional mandated inspection within a specified time period. One important design aspect for a mandatory assessment program would be that it provide recommendations, not exact prescriptions, to minimize the possibility that differences in recommendations and savings estimates could cause a homeowner to defer or cancel the upgrade.[57]

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[55] Expert interviews. City of Berkeley, California website. <www.ci.berkeley.ca.us>.

[56] Paul Emrath, "How Long Buyers Remain in Their Homes," NAHB, February 12, 2009. <www.housingeconomics.com>

[57] Interviews with contractors revealed that homes that have been already rated before an assessment by a contractor have a lower chance of being upgraded, likely due to homeowners' confusion from conflicting assessments.

- **Larger market of home performance contractors** *(emerging)*. This solution strategy would overcome existing workforce constraints. Given the current pace of roughly 200,000 retrofits annually,[58] capturing the full efficiency potential of 70 million homes within ten years would require a 30- to 40-fold increase in certified contractors, from approximately 40,000 to 1.5 million. To overcome the barrier of homeowner risk and uncertainty, contractors would likely need training and certification, in building science, potentially combined with certification and facilitated through government-funded training programs. Home Performance with ENERGY STAR (HPwES), where regional managers connect consumers with qualified Building Performance Institute (BPI)-certified contractors,[59] completed 50,000 upgrades from 2001 through 2008[60] and could serve as a potential model. A recent DOE summit recommended using HPwES as the preferred mechanism to deploy BPI certified contractors using RESNET certifications. This is a significant step toward deploying this solution strategy.

2. EXISTING LOW-INCOME HOMES

With 24 million single family, 16 million multifamily, and 5 million manufactured homes, low-income homes (building shells and HVAC) account for 1,540 trillion end-use BTUs of energy consumption in the 2020 reference case (Table 3). Capital constraints and a history of government and policy solutions distinguish this cluster,[61] which represents 19 percent of the residential energy savings potential in 2020 (610 trillion end-use BTUs).[62] Some 92 percent of the opportunity consists of shell upgrades, with the remaining 8 percent in the HVAC system. Capital required to achieve this potential could total an estimated $46 billion and provide present value savings of $80 billion. Sixty-eight percent of the potential is in single family homes, with 23 percent in multifamily and 9 percent in manufactured homes.

Table 3: Existing low-income homes

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	1,770	1,540	610	40
▪ Electricity TWh	100	90	30	37
▪ Natural gas	1,110	970	390	40
▪ Other fuels*	320	260	110	41
PRIMARY ENERGY Trillion BTUs	2,530	2,240	870	39
▪ Electricity	1,060	970	360	37
▪ Natural gas	1,150	1,000	400	40
EMISSIONS Megatons CO_2e	150	130	50	39

PV of upfront investment – 2009-2020: $46 billion	PV of energy savings – 2009-2020: $80 billion	Annual energy savings – 2020: $7 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA, AEO 2008, McKinsey analysis

Per square foot, low-income homes have a higher consumption (29,000 end-use kBTUs per sq. ft) and higher potential (9 end-use kBTUs per sq. ft) than other homes (25 end-use kBTUs per sq. ft and 7 end-use kBTUs per sq. ft respectively). They are also on average smaller: 1,480 square feet compared to 2,462 square feet for the average non-low-income home, driving lower per house consumption.

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[58] Expert interviews.

[59] The Building Performance Institute (BPI) certifies holistic home performance contractors. <www.bpi.org>.

[60] "ENERGY STAR Overview of 2008 Achievements," EPA Climate Protection Partnerships Division, March 2009.

[61] In this report, low-income households are defined as households with less than $30,000 in annual income.

[62] Public housing accounts for approximately 3 percent of all low-income homes and 3 percent of the low-income energy savings potential. There are approximately 1 million public homes in the United States, making up less than 1 percent of total U.S. housing.

Barriers to greater energy efficiency

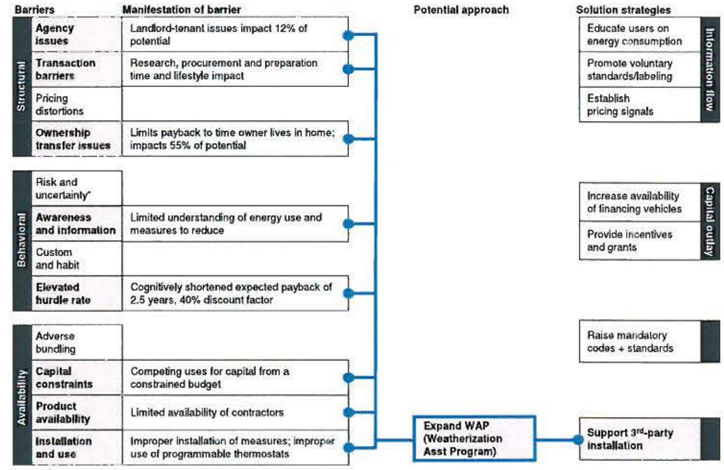
The barriers to improving the efficiency of low-income homes are similar to those in other residential retrofits, though capital concerns are far more pronounced. Allocating capital to a typical shell retrofit, which would cost $910 for the average low-income home ($1,820 for the average low-income single family home), would require spending roughly half of a household's annual non-core budget,[63] making funding through cash savings extremely challenging. Additionally, this cost compares poorly to the value of some older, poorly maintained homes[64] and the savings expected from shortened occupancy. Debt financing, while available, is often at higher interest rates, especially for lower-income households. Financing a retrofit through credit cards, if those were even avaialble to this segment, with an average interest rate of 18 percent,[65] would reduce the NPV-positive energy efficiency potential by 110 trillion end-use BTUs.

Solution strategies to unlock potential

Solutions suitable for the previous cluster (i.e., non-low-income homes) would also be relevant in the low-income retrofit cluster, given the consistency among most of the barriers.

Exhibit 15: Addressing barriers in existing low-income homes

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.



* Represents a minor barrier
Source: McKinsey analysis

The success of the government-sponsored Weatherization Assistance Program (WAP), however, warrants specific attention (Exhbiit 15). Traditionally, WAP has prioritized the lowest income homes with energy-savings potential: 66 percent of homes weatherized have annual household incomes below $8,000, with 90 percent having less than $15,000, but the program could be extended to focus on energy savings more broadly and address higher-income homes. WAP fully funds and deploys energy-saving measures in low-income houses, effectively bypassing all barriers. These programs have weatherized more than 6.2 million homes over the past 32 years, generating annual savings of approximately 100 trillion end-use BTUs. These retrofits typically reduce heating and cooling bills by

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[63] Core expenses include housing, food, apparel, transportation, health care, education, insurance and pensions. Non-core expenses include entertainment, alcohol, tobacco, and miscellaneous expenses (Bureau of Labor Statistics website, <www.bls.gov/cex/2007/Standard/income.pdf>).

[64] In particularly troubled areas housing values can be highly depressed: currently there are several hundred homes available in Detroit for under $2,000 total cost.

[65] "Historical Monthly Credit Card Tables," Carddata Financial Surveillance, 2009.

32 percent and carry a fully loaded cost of approximately $3,200,[66] which includes measures addressing appliance and lighting potential. As with retrofits for other residential buildings, large-scale WAP deployment is constrained by the availability of resources: capturing all cost-effective potential from 45 million homes by 2020 would require increasing the annual output – currently 100,000 homes – by a factor of almost 40. Under the ARRA, 2009, the plan is to weatherize 1 million homes per year – 10 times the current pace – but, even if sustained, this would not be enough to reach all homes by 2020.

3. NEW HOMES

New buildings (i.e., constructed after 2009) are expected to consume 970 trillion end-use BTUs in 2020, representing 10 percent (320 trillion end-use BTUs) of total residential potential (Table 4). The incremental capital associated with this level of improvement would total $16 billion through 2020.

Table 4: New homes

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	n/a	970	320	33
▪ Electricity TWh	n/a	70	20	31
▪ Natural gas	n/a	650	210	33
▪ Other fuels*	n/a	80	30	37
PRIMARY ENERGY Trillion BTUs	n/a	1,510	480	32
▪ Electricity	n/a	750	230	31
▪ Natural gas	n/a	650	210	33
EMISSIONS Megatons CO_2e	n/a	90	30	32

PV of upfront investment – 2009-2020: $16 billion	PV of energy savings – 2009-2020: $41 billion	Annual energy savings – 2020: $4 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

New residential buildings represent a modest portion of the 2020 potential for two reasons: the 21.6 million new homes added to the national stock through 2020 are forecast to account for a relatively small share (17 percent) of all homes in 2020, and homes built after 2009 are expected to be more efficient, consuming only 19.7 end-use kBTUs per sq. ft. – 25 percent lower than the average (26.2 end-use kBTUs per sq. ft) for existing homes. Despite its moderate size in 2020, this cluster is important for two reasons. First, its share of potential grows with time: from 2020 to 2030, the share of homes built after 2009 would grow from 17 to 28 percent of U.S. homes[67] and the NPV-positive reduction potential offered correspondingly increases from 320 to 520 trillion end-use BTUs. Second, upgrades installed when a home is being built save energy at $4.30 per MMBTU, less than half the price of the $8.80 per MMBTU average for retrofit upgrades. This difference exists because all new-build potential comes at an incremental, rather than full deployment cost, unlike costs for many retrofit measures.

Barriers to capturing efficiency potential in new buildings

The new building cluster faces three noteworthy barriers:

- **Ownership transfer concerns between builders and future owners.** Builders are often unsure about their ability to earn a return on efficiency investments. Because builders do not typically benefit from future energy savings, they must cover their incremental costs through a price premium on the efficient home. Home builders perceive high costs[68] as the most important obstacle to building energy efficient homes.

- **Low consideration at time of purchase.** Customers are typically unaware of the savings energy efficient homes offer and value other home attributes, such as location, school district, or home size, above energy efficiency, and it is unclear whether a large population of home buyers will consistently pay a premium for more efficient homes.

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[66] The amount of $3,200 includes approximately $2,500 of installation costs and $700 of administrative costs. Martin Schweitzer, *Estimating the National Effects of the U.S. Department of Energy's Weatherization Assistance Program with State-Level Data: A Metaevaluation Using Studies from 1993 to 2005*, Oak Ridge National Laboratory, U.S. Department of Energy, September 2005; 2005 dollars converted to 2009 dollars.

[67] AEO 2008, NEMS.

[68] Some industry experts indicate that if a builder redesigns his/her business model he or she could construct efficient homes at no additional cost.

- **Inconsistent installation quality.** This issue applies as much to the new building cluster as it does to the existing residential homes cluster. Problems with installation quality stem from incorrect sizing, improper duct sealing and refrigerant charge, and low compliance with building codes, partly due to low code enforcement.
  - **Sizing:** Properly sizing HVAC equipment for a home involves a trade-off between sufficient size to maintain the home at desired temperatures when facing climate extremes (i.e., the hottest and coldest days of the year) and energy savings that come with operating an appropriately sized system. A unit large enough to meet cooling needs in even the most extreme climates will repeatedly cycle on and off on more temperate days significantly reducing efficiency. Furthermore, larger air conditioners tend to be more expensive, more prone to maintenance problems, noisier, and less effective at removing humidity. Reducing air conditioner over-sizing beyond maximum-efficient operation could yield 20-percent savings.[69] The Air Conditioning Contractors of America and the Air Conditioning and Refrigeration Institute have jointly developed guidelines to help contractors properly size air conditioners and heat pumps.
  - **Duct sealing and refrigerant charge:** As many as 90 percent of air conditioning units have incorrectly sized and/or sealed ducts, and 70 percent of homes have inadequate air flow. Over- or undercharging refrigerant can also reduce equipment efficiency: half to three-quarters of air conditioners are estimated to have improper charges.[70] Improper air flow and refrigerant charge together can reduce efficiency by 12 to 32 percent.
  - **Code compliance and enforcement:** Code compliance varies significantly by type of measure, with full compliance ranging by state from 40 percent to 60 percent.[71] Many consumer-advocates report that builders have limited incentive to ensure proper installation, and inspectors may lack proper training to evaluate energy efficiency, because their primary focus is on health and safety. Furthermore, building officials are typically paid less than the market rate for skilled efficiency assessors, making recruitment of the required skill set difficult.

Other barriers affecting this potential include risk and uncertainty about the quality of construction, adverse bundling of efficiency features with uneconomic "green" measures, such as more expensive insulation products with a lower lifecycle carbon content or claims of auxiliary benefits, and unavailability of green homes. Sixty-three percent of homebuyers report that green homes are not available in areas they want to live.[72]

Solution strategies to unlock potential

Three principal solution strategies appear suitable for the new building cluster. Developing and adopting higher performance standards in building energy and HVAC codes on a national scale would raise the floor for energy efficiency in new buildings (Exhibit 16). Voluntary specifications, such as ENERGY STAR and LEED, enable developers to differentiate buildings that exceed the code. However, it has not been fully proven that customers will pay the commensurate price premium necessary to increase builder confidence in the ability to earn a return on the incremental investment. Incentives for builders and HVAC manufacturers or prospective home buyers could stimulate the market for these higher-efficiency buildings.

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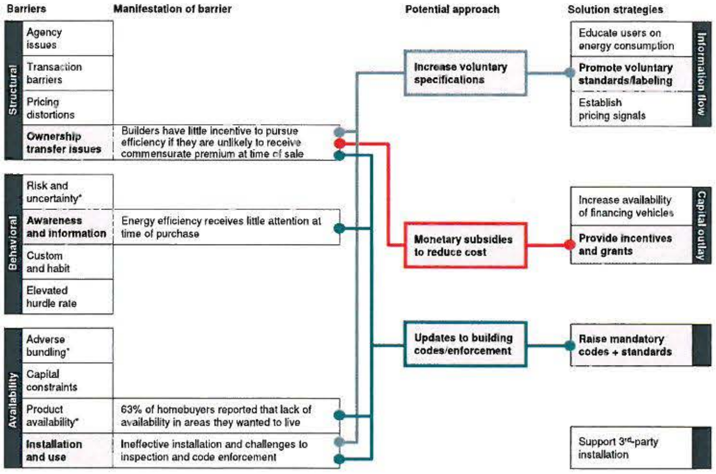
[69] Chris Neme, et al., "National Energy Savings Potential from Addressing Residential HVAC Installation Problems," ACEEE, February, 1999.

[70] "Energy Savings Impact of Improving the Installation of Residential Central Air Conditioners," Cadmus Group, 2005.

[71] Expert interviews.

[72] "The Green Homeowner: Attitudes and Preferences for Remodeling and Buying Green Homes," McGraw Hill Construction, 2007.

Exhibit 16: Addressing barriers in new homes



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

Given the relatively lower cost of capturing energy efficiency in the design and construction of buildings – and the perishability of these options – this cluster merits more immediate attention than its share of 2020 potential suggests.

- **Mandatory building codes** *(proven).* State and local residential building codes are often based on the International Energy Conservation Code (IECC) model code, which is evaluated by the DOE to determine energy savings. If the DOE makes a positive determination, states are required to consider adopting the new code; they are not, however, obligated to adopt it. Codes typically contain prescriptive (i.e., specific measures to include in a home) and performance (i.e., minimum efficiency levels that builders must verify, regardless of measures employed) options. Prescriptive codes may be easier for builders to implement because they provide explicit stipulations. Performance codes allow builders to trade-off between measures, allowing for innovation and lowest-cost compliance, but are more complicated, because a range of measures are possible and savings would need to be quantified. Most analysis indicates that building codes have demonstrated savings over time, though some critics raise concerns about the code-writing process, unintended consequences on builders, and the proper trade-off between regionality and uniformity. Our research suggests solution strategies to capture potential through codes involve three complementary actions: 1) spreading high-efficiency codes to all states, 2) raising efficiency levels in existing codes, and 3) improving code compliance.
  - **Spreading high-efficiency codes to all states:** Since IECC model codes are not mandatory, states and municipalities are free to adopt or not adopt updated codes. As of early 2009, 21 states had adopted the 2006 or 2009 IECC codes or the equivalent; 13 had adopted IECC 1998 or 2003, and 16 had not adopted codes as stringent as IECC 1998 (Exhibit 17). If all states adopted the 2009 IECC code starting in 2009, annual energy savings in 2020 would be approximately 130 trillion end-use BTUs, with cumulative savings through 2020 reaching 850 trillion end-use BTUs.[73]

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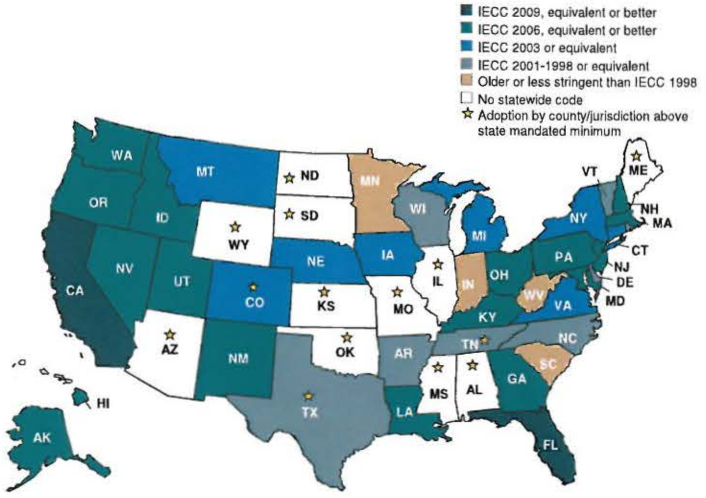
[73] Expert interviews.

Exhibit 17: Inconsistency of residential building codes

The map displays the variation in residential new building codes in place across the United States. In general, darker shades indicate higher standards, and lighter shades indicate less stringent standards, in line with the legend in the top right of the exhibit.



Source: Buildings Energy Databook, US Department of Energy, Office of Energy Efficiency and Renewable Energy

Two interesting options could be used to drive larger code adoption. The first focuses on education for state officials and building departments, e.g., through such mechanisms as the Building Codes Assistance Project (BCAP)[74] or utility-funded code assistance projects. The second method would employ incentives to encourage adoption, such as having the federal government make the accessibility of certain funds contingent on building code stringency. This approach has worked in the past in other contexts: when changing the legal drinking age to 21, the federal government linked highway funding to adoption of that limit, and all fifty states complied within three years.[75] The federal government enacted a similar measure in the February 2009 American Recovery and Reinvestment Act under the State Energy Program; it provides $3.1 billion in grants for state energy efficiency programs on the condition that the state plans to adopt residential and commercial codes that meet or exceed the 2009 IECC and ASHRAE Standard 90.1-2007 and comply with these codes in 90 percent of new and renovated residential and commercial buildings within 8 years.[76]

- **Raising efficiency levels in current codes:** Most of the recent improvements in the IECC code – which is updated every three years – have resulted in 1 to 3 percent improvements; from 1992 to 2006 code efficiency increased approximately 8 percent.[77] However, the 2009 IECC code is estimated to provide a 12 to 16 percent efficiency improvement compared to the 2006 IECC code.[78] In addition, the DOE and others are seeking to improve efficiency in the 2012 IECC code a further

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[74] BCAP was established in 1994, as a joint initiative of the Alliance to Save Energy, ACEEE, and the Natural Resources Defense Council. BCAP is largely funded by the DOE and the Energy Foundation.

[75] "Sanctions are effective," Advocates for Highway and Auto Safety, 2009. <http://www.saferoads.org/sanctions-are-effective>.

[76] "2009 Recovery Act and State Funding," EERE, DOE, 2009. <http://apps1.eere.energy.gov/state_energy_program/recovery_act.cfm>.

[77] "Energy Efficiency Trends in Residential and Commercial Buildings," DOE, October 2008.

[78] The 2009 prescriptive code is estimated to be 12.2 percent more efficient than the 2006 code, and the performance code is estimated to be 15.7 percent more efficient. ICF analysis suggests 2009 IECC could save roughly $235 in energy costs per household per year compared with IECC 2006. "Energy and Cost Savings Analysis of 2009 IECC Efficiency Improvements," ICF International, September, 2008.

15 percent beyond 2009 IECC. This level is very close to the NPV-positive value for new residential buildings calculated in this report.[79] If IECC 2009 were adopted through 2011 and a 30 percent improved code were adopted in 2012, 250 trillion end-use BTUs could be saved in 2020.[80]

- **Improving code compliance:** To increase enforcement of building codes, states and municipalities could consider four complementary measures: 1) managing performance of building inspectors with third-party verifiers to spot-check buildings;[81] 2) hiring more building officials; 3) increasing the pay of building officials and requiring training in building science to attract those with building assessment skills; and 4) increasing the objectivity of performance-based code compliance, particularly for energy modeling.

  The Building Codes Assistance Project estimates that improving code compliance significantly above current levels would cost $210 million per year: $75 million for local building departments to hire and train building officials and $135 million for state governments to increase education and compliance.[82] Other experts have estimated the cost required to increase building code compliance, for new residential and commercial buildings, at a higher level of $1 billion per year.[83] This estimate includes hiring and training officials; adding equipment; creating an inspected building database; training contractors, plumbers, and electricians on code compliance and best practices; and re-inspecting 2 percent of buildings. Even at this higher annual cost, which (if incurred for 10 years and divided equally between commercial and residential sectors) adds $3.5 billion present value to the cost of capturing the new building potential, the energy efficiency potential of the cluster remains over $21 billion NPV-positive (in fact providing a roughly 20 percent rate of return).

- **Voluntary building standards, home labeling, and benchmarking** *(proven)*. Labeling can address builder-buyer agency issues by fostering a market premium for energy efficiency due to increased awareness of efficient buildings. If installation quality receives continued attention, labeling could also circumvent the installation and inspection challenges. While no large-scale study of price premiums for efficient homes has been conducted to date, a number of regional analyses suggest that efficient homes are beginning to command a premium in some markets. In Portland, Oregon and Seattle, Washington, for example, new homes that were certified to be energy efficient were selling at a 3- to 5-percent premium and 10-percent faster rate.[84] (Note: this research was conducted prior to the recent collapse in the housing market). Voluntary standards could also drive builder training and increase use of best practices, indirectly increasing energy efficiency. There are various labeling mechanisms in use today that could address these concerns, if brought to scale:

  - The current ENERGY STAR specification covers total home energy use, including space conditioning and appliances, and is 20 to 30 percent more efficient than

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[79] It should be noted that very few retrospective studies on the energy savings impact of building codes exist and ones that do exist were conducted at the state or local level. Making the case for improving and funding building codes will likely require retrospective studies measuring the energy savings impact on a nationwide level.

[80] Expert interviews.

[81] This could be through utility or federally led programs (such as Austin Energy's), where funding is contingent on documentation of a proper inspection.

[82] "Code Enforcement Cost Estimates," BCAP, 2009. Expert Interviews.

[83] David Goldstein and Cliff Majersik, "NRDC/IMT Proposal for Improved Building Energy Code Compliance through Enhanced Resources and Third-Party Verification," NRDC, 2009. $1 billion is across both residential homes and commercial buildings.

[84] "Green Certified Homes Sell for More in Portland Real Estate Market," Earth Advantage Institute and the Green Building Value Initiative, May 6, 2008.

the average new home.[85] ENERGY STAR homes had a 17 percent share of the new home market in 2008 and together save 2 TWh of electricity and 15 trillion BTUs of natural gas per year.[86]

- The U.S. Green Building Council developed the LEED building certification system that targets energy savings, water efficiency, greenhouse gas emissions reduction, and improved indoor environmental quality. The system allows trade-off between these goals but sets the minimum efficiency level for LEED certification at 15 percent more efficient than the latest IECC code.[87]
- The Energy Efficient Codes Coalition is making its comprehensive package, called "The 30 Percent Solution," available to state and local governments as a code.[88]

- **Builder incentives** *(piloted).* There are various tax incentives for builders written into law, such as those in the Federal Energy Policy Act of 2005. Certain programs run by utilities or other organizations can accelerate adoption of these incentives. Efficiency Vermont, for instance, in its new residential housing program, provides builder training and assistance in securing incentives. For a total cost of $2.8 million in 2007, this program helped 35 percent of all homes qualify for ENERGY STAR rating, double the national average.[89] Incentives to builders are more likely to drive efficiency, because they directly offset incremental costs without requiring buyer awareness.[90]

4. ELECTRICAL DEVICES AND SMALL APPLIANCES

Electrical devices and small appliances, sometimes loosely called "plug load," consist of hundreds of smaller electricity-consuming devices and represent an area of sustained consumption growth: the U.S. consumer electronics industry, for example, grew from revenues of $94 billion in 2001 to $162 billion in 2007.[91] In 2008, the average household spent $330 on energy for these devices, with the expenditure growing at an annual rate of 2 percent. EIA forecasts that increased penetration of electronic devices will drive consumption from 500 TWh of electricity in 2008 to 630 TWh by 2020, rising from 35 percent of end-use residential electricity consumption to 40 percent in 2020. By 2020, there will be 2.5 billion devices consuming power in residential homes. TVs, DVD players and PCs made up 32 percent of electrical device and small appliance consumption in 2008, while another 9 categories tracked by the EIA made up an additional

Table 5: Electrical devices and small appliances

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	1,690	2,140	590	27
▪ Electricity TWh	500	630	170	27
▪ Natural gas	n/a	n/a	n/a	n/a
▪ Other fuels*	n/a	n/a	n/a	n/a
PRIMARY ENERGY Trillion BTUs	5,270	6,640	1,820	27
▪ Electricity	5,270	6,640	1,820	27
▪ Natural gas	n/a	n/a	n/a	n/a
EMISSIONS Megatons CO_2e	330	410	110	27

PV of upfront investment – 2009-2020: $3 billion	PV of energy savings – 2009-2020: $65 billion	Annual energy savings – 2020: $11 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

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[85] "Methodology to Calculate Energy Savings for ENERGY STAR Qualified New Homes," ENERGY STAR, 2007.

[86] "ENERGY STAR market share," EPA, April 2009.

[87] The energy efficiency portion of a LEED certification is based on ENERGY STAR. A new residential building must earn an 85 or lower on the ENERGY STAR scale, which is indexed at 100 to the IECC 2006 code and each percent below 100 indicated 1 percent savings. LEED specifications focus on sustainability of the home, including energy efficiency as well as water and sustainability, and it is therefore difficult to determine the exact efficiency improvement of a LEED home compared to the average home.

[88] "Energy and Cost Savings Analysis of 2009 IECC Efficiency Improvements," ICF International, 2008.

[89] *Year 2007 Annual Report*, Efficiency Vermont, 2008.

[90] One challenge brought on by the recent economic downturn is that tax credits are effective only if builders have taxes to pay.

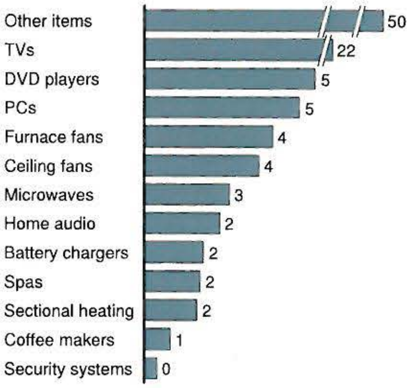
[91] "Consumer electronics market research reports," CEA, April 2006 and 2008.

18 percent. The remaining 50 percent of consumption is divided across hundreds of other electric devices (Exhibit 18).

Electrical devices and small appliances provide 590 trillion end-use BTUs of NPV-positive potential, accounting for 19 percent of residential energy efficiency potential and 44 percent of residential electricity potential in 2020 (Table 5). Incremental capital required to capture this potential in 2020 would be approximately \$3.4 billion,[92] and provide present value savings of \$65 billion, resulting in a per-MMBTU cost of \$1.00. This potential is highly cost effective – 90 percent of this potential would have payback period of less than two years.

Exhibit 18: Energy consumption of electrical devices and small appliances – 2008

Percent of end-use energy; total = 1,690 trillion BTUs*



* Does not equal 100% due to rounding
Source: NEMS 2008

Each bar represents the share of total electrical-device-related energy consumption in 2008 associated with the listed category of devices.

Barriers to capturing potential in plug-load devices

Energy efficiency of plug-load devices has historically received little attention from consumers and manufacturers, giving rise to both demand- and supply-side barriers:

- **Lack of consumer awareness and associated habit and transaction cost barriers.** Each plug-load device occupies an extremely small part of a consumer's electric bill or a device's purchase price. Even TVs, the largest energy consumers in the cluster, cost consumers an average of \$40 per TV per year (\$100 on average per house) – only 5 percent of their total energy bill. Furthermore, consumers tend to underestimate plug-load consumption; residents believe these devices drive 13 percent of electric bills, much lower than their actual 35 percent share.[93] Research shows that many end-users do not know that devices consume electricity even when not in use.[94] Surveys also indicate that consumers tend to value other attributes, including price, features, device size, and warranty quality, above energy efficiency and that only 10 percent of consumers rate energy savings as the most important feature when purchasing a device.[95]

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[92] These costs reflect premiums of energy efficient consumer electronic devices currently in the market and do not account for manufacturer retooling costs, discussed more in detail later.

[93] Based on results from McKinsey / Burke market research; data represents weighted average of responses.

[94] Brahmanand Mohanty, "Perspectives for Reduction of Standby Power Consumption in Electrical Appliances," United Nations Economic and Social Commission for Asia and the Pacific. <www.unescap.org/esd/energy/publications/psec/guidebook-part-two-standby-power.htm>.

[95] "Going Green: An Examination of the Green Trend and What it Means to Consumers and the CE Industry," Consumer Electronics Association, 2008.

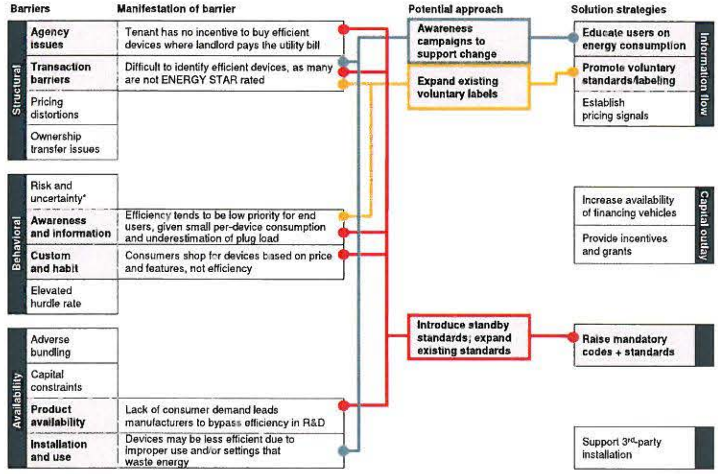
- **Limited technology availability and low manufacturer mindshare.** Lack of demand for energy efficient devices and an absence of mandatory efficiency standards for consumer electronics lead manufacturers to make efficiency improvements a low priority during product development. Because consumer electronics is a competitive market with low margins, manufacturers generally choose to minimize costs over developing features for which they are not sufficiently rewarded.
- **Failure to use efficient settings.** Many consumer devices, such as PCs and TVs, have energy-saving features, for example, entering standby after a period of disuse. A study in 2007 showed that only 15 percent of computers in home offices had power management enabled, as manufacturers don't necessarily enable settings at the point of sale, and consumers sometimes disable settings.[96] Technologies for power management are improving, becoming more user-friendly and less likely to interfere with consumer utility, thus helping to reduce the frequency at which people disable the functions.
- **Agency issues in rented homes.** Where the property owner pays a tenant's utility bill, the tenant has no incentive to choose energy efficient devices, which impedes capture of 19 percent of this cluster's potential.

Solution strategies to unlock potential

Particularly low attention to electrical device and smaller appliance energy consumption among consumers and manufacturers points to solution strategies that either increase consumer awareness of potential savings or bypass consumer and manufacturer awareness and decision-making requirements (Exhibit 19).

Exhibit 19: Addressing barriers in electrical devices and small appliances

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.



* Represents a minor barrier
Source: McKinsey analysis

- **Mandatory standards** *(proven).* Mandatory standards would bypass consumer and manufacturer decision-making, offering a high certainty of capture.
  - **Specific product standards.** For the largest categories, it may be feasible to create specific standards (as there are for battery chargers and power adapters), though other factors including product differentiation and incremental cost are important to consider. As an example, setting mandatory standards at the NPV-

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[96] K. Roth and K. McKenney, "Residential consumer electronics electricity consumption in the United States," European Council for an Energy Efficient Economy Summer Study, June 2007.

positive level identified in this report for the five largest plug-load categories[97] would save 210 trillion end-use BTUs (36 percent of this cluster's potential). To go beyond the most energy-consuming categories and create standards for the hundreds of remaining product classes would be difficult and costly.

— **Standby standard.** A cross-cutting "standby" standard could capture a large portion of the potential across a range of devices, both high consumption devices that have specific product standards and devices that have too little consumption to warrant a specific standard of their own. Standby power consumes an estimated 6 to 8 percent of residential electricity,[98] equivalent to 130 to 170 TWh per year. Standby power accounts for 10 to 90 percent of a device's total consumption, depending on the product.[99] A standby standard could reduce standby consumption by roughly two-thirds,[100] yielding 90 to 110 TWh in savings. Such a standard could produce an additional savings of 80 to 100 TWh in commercial office equipment, which chapter 3 discusses further. In addition, because the U.S. makes up 34 percent of the global consumer electronics market,[101] a U.S. standby standard has the potential to stimulate significant change in global electronics manufacturing. Finally, anecdotal evidence suggests that reducing standby consumption may stimulate design changes that reduce active mode energy consumption.[102] The Federal Energy Management Program (FEMP) is tasked to implement the "1-Watt Standby" plan requiring federal agencies to select products with low-standby energy consumption and has released the FEMP Standby Levels for agencies to follow.[103] While direct impact of this mandate is difficult to measure, it did raise manufacturer awareness of standby power. There are a number of examples from outside the U.S. of standby standards that drive energy savings:

  - Japan's Top Runner program, which reduced annual per-household standby consumption from 437 kWh in 2002 to 308 kWh in 2005.[104]
  - Korea's 1-Watt Program, which will progress from a voluntary program to a mandatory standard in 2010. Average standby power per device is projected to decline from 3.66 Watts in 2003 to 1.54 Watts in 2020, saving 6.8 TWh per year (more than $70 million in electricity cost) by 2020.[105]
  - Australia's standby power regulation, which covers a number of devices, is expected to introduce cross-category regulations for all electric appliances by 2012.

Standby standards do present some concerns:

  - Manufacturers may oppose a standby standard, owing to the incremental cost to their products. However, many plug-load devices could meet a standby standard with little incremental cost, likely to be less than 50 cents per unit.[106]

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[97] The five largest electricity consuming categories in National Energy Modeling System are TVs, PCs, microwaves, ceiling fans, and DVD players.

[98] The majority of the 6 to 8 percent estimate for standby power consumption is from plug-load devices, but it includes some from other appliances. Expert interviews.

[99] "2006 ACEEE Summer Study on Energy Efficiency in Buildings," ACEEE, 2006.

[100] Expert interviews.

[101] "Consumer Electronics Global Statistics," Growth from Knowledge, 2008.

[102] Benoit Lebot, et al., "Global Implications of Standby Power Use," IEA, 2000. Expert interviews.

[103] "U.S. Executive Order 13221 – '1-Watt Standby' Order," Power Integrations, 2001. <www.powerint.com/node/201>.

[104] Joakim Nordqvist, "Evaluation of Japan's Top Runner Programme," Energy Intelligence for Europe Program, 2006.

[105] "Korea's Market Transformation Plan," Korea Energy Management Corporation, October 2008.

[106] Expert interviews.

At that level, the cost of avoided power for all devices would be $2.10 per MWh.[107]

  - ☐ Standards must balance energy savings with delivered functionality, often making it difficult to craft a policy that adequately captures savings while preserving consumer appeal. As a result, there will likely need to be multiple standby standards, because certain devices require higher power levels than others. Set-top boxes, for example, require greater functionality and energy use while in standby and may require a higher minimum level than other products.

- **Voluntary standards and labeling** *(proven).* Voluntary standards can reduce transaction "costs" associated with identifying efficient devices and raise awareness of plug-load consumption. ENERGY STAR has created voluntary standards for nine device categories that fall into residential electrical devices, among them TVs, DVDs, and PCs, which saved 63 TWh of electricity in 2007.[108] Voluntary standards would facilitate implementation of future mandatory standards by developing testing procedures and building manufacturer relationships. Voluntary standards can also be developed and updated faster than mandatory standards, allowing greater flexibility in a rapidly changing marketplace.
- **Education and awareness** *(piloted).* Programs to educate the public about plug-load consumption and how individuals can reduce it could overcome transaction and usage barriers. A representative campaign could 1) encourage people to unplug unused devices and turn off devices when not in use, 2) increase awareness of efficiency settings and passive controls, such as smart switches and power strips, and 3) generate demand for efficient consumer electronic devices. Research shows that 22 percent of residential PC users leave their computers running at night[109] and 64 percent of office PCs run overnight;[110] changing these behaviors alone could unlock significant savings.

5. LIGHTING AND MAJOR APPLIANCES

Lighting and major appliances, which include water heaters, refrigerators, freezers, clothes washers, clothes dryers, dishwashers, stoves and ovens, constitute 30 percent (3,420 trillion end-use BTUs) of 2020 residential consumption (Table 6). Consumption is expected to decline at 0.3 percent over the next ten years, which reflects provisions in EISA 2007 that address lighting consumption, effectively phasing out today's incandescent bulbs in 2012 for more efficient lighting.

The lighting and major appliances cluster accounts for 11 percent of total residential potential in 2020 (340 trillion end-use BTUs). Ninety-six percent of appliance potential are from replacement purchases, with four percent driven by new appliance purchases. Total incremental capital required to purchase higher-efficiency appliances between 2009 and 2020 would be $11 billion and provide present value savings of $42 billion at an average per-MMBTU cost of $4.50 (Table 6).

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[107] Calculated as $0.50 for each of 2.5 billion consumer electronic devices divided by the energy savings of approximately 100 TWh over an average 8-year lifetime.

[108] "Table 8, Consumer Electronic, Residential & Commercial Office Equipment," *2007 Annual Report*, ENERGY STAR, 2007.

[109] K. Roth and K. McKenney, "Residential consumer electronics electricity consumption in the United States," European Council for an Energy Efficient Economy Summer Study, June 2007.

[110] Judy Roberson, et al., "After-hours power status of office equipment and energy use of miscellaneous plug-load equipment," Lawrence Berkeley National Laboratory, LBNL-53729 Rev, May 2004.

Lighting constitutes 15 percent of energy consumption in this cluster but 82 percent of its savings potential, representing 9 percent (80 TWh) of total residential potential (Exhibit 20). Deployment of general use LED lighting, which becomes the lowest cost lighting technology between 2013 and 2017, presents much of this potential. Even today, the average home could save more than $180 per year by switching from incandescent to CFLs,[111] though CFLs become the business-as-usual lighting technology of choice by 2012 in accord with the Energy Independence and Security Act of 2007. Water heating constitutes 50 percent of consumption in this cluster and 13 percent (40 trillion end-use BTUs) of potential. Clothes washers are another 4 percent of consumption and 4 percent (20 trillion BTUs) of cluster potential, with the remaining 31 percent of consumption and 1 percent of potential shared among dryers, dishwashers, refrigerators, freezers, and cooking appliances.[112]

Table 6: Lighting and major appliances

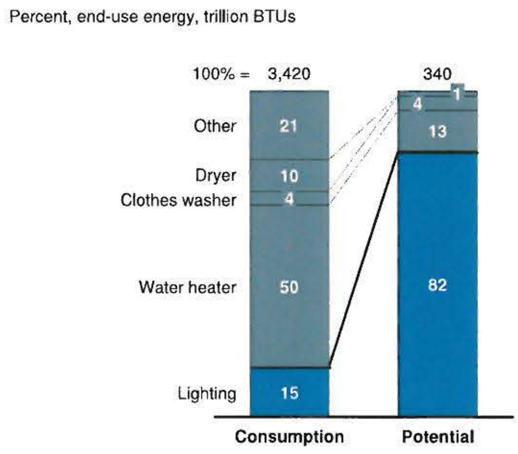
	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	3,540	3,420	340	10
■ Electricity TWh	580	520	90	17
■ Natural gas	1,380	1,490	40	2
■ Other fuels*	180	160	10	6
PRIMARY ENERGY Trillion BTUs	7,770	7,230	990	14
■ Electricity	6,150	5,520	940	17
■ Natural gas	1,430	1,550	40	2
EMISSIONS Megatons CO_2e	470	430	60	14

PV of upfront investment – 2009-2020: $11 billion	PV of energy savings – 2009-2020: $42 billion	Annual energy savings – 2020: $6 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

Exhibit 20: Efficiency opportunities in lighting and major appliances – 2020



Source: EIA AEO 2008, McKinsey analysis

The two columns break out energy consumption and efficiency potential in 2020 for the listed appliance categories modeled in the report.

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[111] Assuming 30 light bulbs per house used 3 hours per day. (Susan Williams and Bill McNary, "Change a Light, Change the World 2007 Facts and Assumptions Sheet," ENERGY STAR, 2007.)

[112] Significant energy efficiency is already included in EIA business-as-usual projections for appliances through inclusion of existing appliance standards as well as assumed penetration of high-efficiency devices above the standard.

Barriers to capturing appliance efficiency potential

Lighting and major appliance efficiency faces barriers common to both electrical devices and new building potential. The most relevant barriers are:

- **Lack of awareness and certainty of savings.** Knowledge of efficient appliances is relatively high among consumers – 93 percent for lighting, 86 percent for kitchen appliances, 84 percent for clothes washers and dryers, and 74 percent for water heaters.[113] However, consumers seem to be less clear about the potential monetary savings. For instance, 75 percent of consumers believed that CFLs had longer than a one year payback or did not know what the payback was.[114]
- **Quality trade-offs.** End-users retain preconceived and often inaccurate ideas about differences in functionality that limit the acceptance of certain products. Forty-two percent of consumers, for example, believe that CFLs have significantly lower-quality light than incandescent bulbs.[115]
- **Supply chain availability.** Sixty-eight percent of water heaters fail before they are replaced, and more than 50 percent are emergency replacements, leaving these consumers dependent on the stock of water heaters available on contractors' trucks. When given purchasing options, however, consumers place the highest importance on energy efficiency, followed by unit size; surprisingly, price ranks fifth of nine possible responses.[116] Thus, if given the time and selection often denied by emergency replacement, consumers would likely select more efficient devices than they are currently able to select.

Other minor barriers include allocation of capital for more costly appliances; adverse bundling in some appliances, such as clothes washers where manufacturers bundle higher efficiency with sophisticated options and cycle settings; ownership transfer issues as home builders have unclear ability to recover their investment in efficient devices; and to a lesser extent transaction barriers associated with identifying efficient devices, which is significantly mitigated by the prevalence of labeling.

Solution strategies to unlock potential

Solutions to capture the energy efficiency potential in appliances include education, voluntary standards and labeling, codes and standards, and incentives and grants (Exhibit 21).

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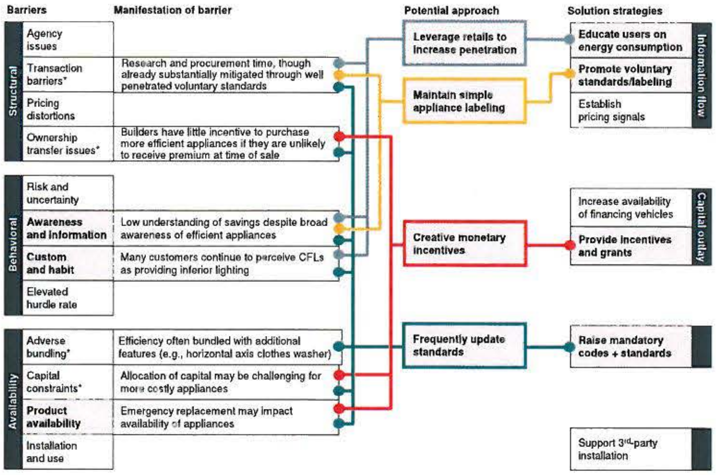
[113] *2007 Business in Society Survey*, McKinsey & Company; Number of respondents: 2,002.

[114] *2007 Business in Society Survey*, McKinsey & Company; Number of respondents: 995.

[115] Note that technologies with real, rather than perceived, quality differences are excluded from substitution in our analysis; we consider CFLs interchangeable for most lighting, as they have overcome most challenges (e.g., slow start up). 2007 Business in Society Survey, McKinsey & Company; Number of respondents: 2,002.

[116] "Residential Water Heater Market," KEMA, July 2006.

Exhibit 21: Addressing barriers in lighting and major appliances



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

- **Mandatory appliance standards** *(proven).* Between 1990 and 2000, mandatory appliance standards saved U.S. consumers roughly $50 billion in energy bills, with consumer savings outpacing additional consumer expenditures by a ratio of 2.5 to 1.[117] Taxpayer funds to support DOE's appliance standards program since 1987 total $200 million to $250 million. According to Lawrence Berkeley National Laboratory, appliance standards will reduce energy consumption in 2020 by 8 percent relative to a scenario with no standards.[118] Refrigerators and clothes washers account for over 50 percent of this savings, followed by water heaters and central air conditioners as the next largest energy saving categories.[119] Challenges to increasing mandatory standards include passing legislation and the speed of implementation. Standards typically take 3 years from inception to implementation.[120] Systematic, periodic reviews to update the standards are essential to their success. Japan's Top Runner program, which includes mandatory labeling, is a case in point. In 21 product categories, the standard is set based on the most efficient model in the market; all products must comply with that standard within 3 to 10 years, depending on the product category. Thus the program eliminates low-efficiency products from the market and encourages manufacturers to develop models with higher efficiency. It is estimated that by 2010, this program will annually save 56 TWh of electricity in Japan's residential and commercial sectors.

- **Voluntary appliance standards and labeling** *(proven).* Voluntary appliance standards have had a significant impact on energy savings in appliances. In 2008, EPA reported savings of 159 TWh through its appliance standards (in both residential and commercial), over a third of which is due to lighting. In 2008, 76 percent of households were aware of the ENERGY STAR brand. ENERGY STAR continues to raise its efficiency bar through a continual updating process. When setting a

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[117] "Appliance and Equipment Efficiency Standards: One of America's Most Effective Energy-Saving Policies," ACEEE, 2009.

[118] Steve Meyers, et al.

[119] Steve Meyers, et al.

[120] The standards process begins with a "Framework Workshop," with an Advanced Notice of Proposed Rulemaking (ANOPR) 18 months later, a Proposed Rule (NOPR) 12 months after that, and a Final Rule an additional 6 months later. "DOE standards due between late 2008 and 2014: Key dates and energy savings," Appliance Standards Awareness Project, 2008.

specification, ENERGY STAR aims to set it to a level that 25 percent of the products on the market can meet, guaranteeing a high level of efficiency but also ensuring that consumers have a variety of products from which to choose. While many factors drive updates in ENERGY STAR specifications, including technological innovation and regulatory changes, having 40 to 50 percent of the market compliant with ENERGY STAR specifications triggers an update of the specification. One factor driving success of ENERGY STAR may be its simple messaging. Finally, voluntary standards can be particularly cost effective: according to National Renewable Energy Laboratory, ENERGY STAR has saved energy at a cost of roughly $0.09 per end-use MMBTU. [121]

- **Monetary incentives and rebates** *(proven).* While incentives to consumers primarily address barriers in capital availability and ownership transfer (i.e., appliances in new buildings), incentives to suppliers can overcome the product availability barrier as well. A number of utilities and other organizations offer rebates, or even free efficient appliances, and the government has offered tax incentives. Many such programs have focused on lighting, due to its high energy-savings potential. For example, the Illinois Department of Commerce and Economic Opportunity Residential ENERGY STAR Lighting Program (2003 to 2004) partnered with over 140 retailers to provide 164,000 instant rebates on CFLs and 60,000 mail-in rebates on ceiling fans and CFLs in the 2 years of the program. In Efficiency Vermont's CFL buy-down program, consumers purchased 580,000 CFLs in 2007 – 74 percent of all CFLs sold in the state. The program reported a cost of about $1.0 million, with savings of approximately 263 GWh, for a per-kWh cost of $0.004.[122] One consumer incentive includes refrigerator and freezer "swap out" programs, where utilities bear the cost of extracting old equipment and replacing it with a new unit, thus encouraging people to accelerate adoption of efficient technology. Providing a financial rebate to contractors to stock efficient water heaters can overcome the technology availability barrier for that appliance.
- **Retailer's role in energy efficiency** *(piloted).* Retailers could play an important role in driving adoption of energy efficient appliances. A flagship example is Wal-Mart's focus on CFLs, with 100 million bulbs sold in 9 months, helping double CFL penetration from 5 percent to 10 percent. ENERGY STAR has effectively partnered with retailers to leverage their relationships with consumers, providing information and advertising material for stores for ENERGY STAR products, as well as promoting efficiency incentives. While still largely unproven, retailers' strong position with consumers make retailers a natural partner for this type of energy efficiency measure.

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[121] "Estimates of Administrative Costs for Energy Efficiency Policies and Programs," NREL, 2000. <www.nrel.gov/docs/fy01osti/29379.pdf>. The ENERGY STAR 2007 Annual Report indicates even higher cost effectiveness recently, with primary energy savings of $0.023 per MMBTU.

[122] *Year 2007 Annual Report,* Efficiency Vermont, 2008.

3. Approaches to greater energy efficiency in the commercial sector

The commercial sector will consume 20 percent of the 2020 baseline end-use energy in the United States, equivalent to 8.0 quadrillion BTUs of end-use energy (Table 7).[123] Consumption is forecast to grow by 1.5 percent per year, from a base of 6.7 quadrillion BTUs of end-use energy in 2008, driven by increases in commercial floor space and consumption intensity of end-use energy per square foot.

Relative to the business-as-usual baseline for 2020, deploying all NPV-positive efficiency improvements in the commercial sector would reduce energy consumption in 2020 by 29 percent, require $125 billion in upfront investment, and provide present-value savings of $290 billion in energy costs while avoiding some 360 million tons of GHG emissions that year.

Although most of the efficiency potential exists in buildings (87 percent, 2,010 trillion end-use BTUs), 13 percent (290 trillion end-use BTUs) is in such community infrastructure as water purification and treatment, water distribution, street and traffic lighting, and telecommunications. The opportunity in the commercial sector is diverse, characterized by 10 types of buildings (4.9 million in total), multiple ownership structures, governmental and private tenants, and more than 100 end-use applications (Exhibit 22).

Table 7: Overview of energy use in the commercial sector

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	6,680	8,010	2,290	29
▪ Electricity TWh	1,330	1,660	510	31
▪ Natural gas	1,930	2,140	510	24
▪ Other fuels*	200	220	50	23
PRIMARY ENERGY Trillion BTUs	16,330	20,010	5,970	30
▪ Electricity**	14,110	17,570	5,390	31
▪ Natural gas	2,010	2,220	530	24
EMISSIONS Megatons CO$_2$e	990	1,220	360	30

PV of upfront investment – 2009-2020: $125 billion	PV of energy savings – 2009-2020: $290 billion	Annual energy savings – 2020: $37 billion

* End-use energy is approximated as equivalent to primary energy

** Does not include CHP savings of 490 trillion BTUs

Source: EIA AEO 2008, McKinsey analysis

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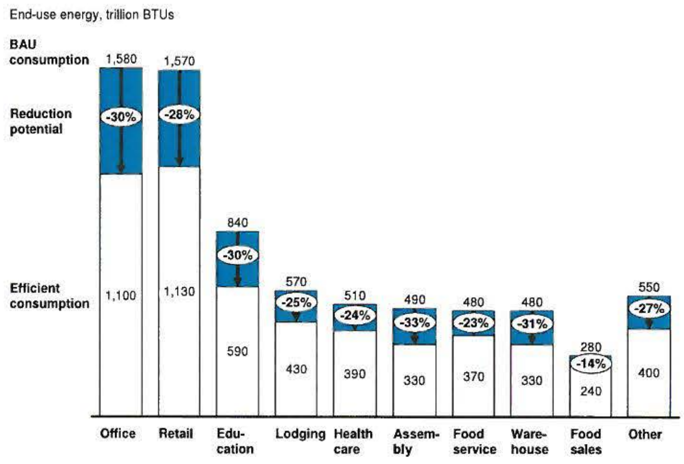
[123] This excludes natural gas and distillate fuel oil consumption (1,350 trillion BTUs in 2020) attributed to miscellaneous load and unspecified sources in *AEO 2008* due to lack of information about the sources of consumption and the efficiency opportunities.

Exhibit 22: Efficiency potential in commercial subsectors – 2020

The exhibit displays energy consumption in 2020 associated with various building types in the commercial sector with and without energy efficiency measures implemented.



Source: EIA AEO 2008, McKinsey analysis

We organized the potential into five clusters, based on shared barriers and attributes (Exhibit 23). Although specific barriers manifest themselves within commercial subsectors (e.g., the relative importance of agency in the food service subsector), we have focused on cross-cutting solutions that can apply with minor modification across subsectors.

For continuity, we will discuss clusters that involve the building shell and HVAC systems, which together provide habitable and conditioned space, then we will examine commercial energy use inside and outside those spaces.

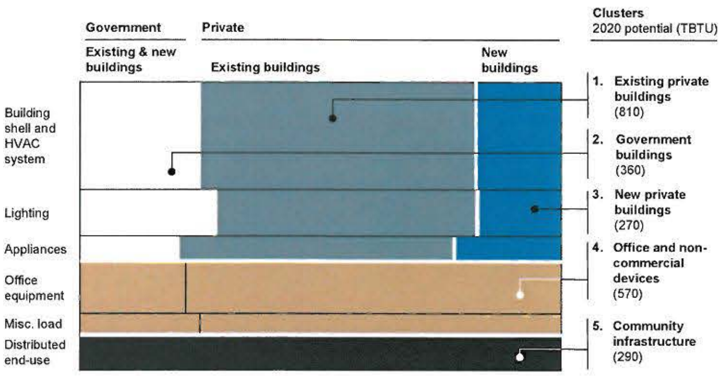
1. **Existing private buildings (810 trillion end-use BTUs):** Notable barriers include split agency, expectations of short payback period, upfront capital constraints, and lack of awareness or information. Solution strategies to address these barriers include requiring energy benchmarking for buildings, establishing a public-private partnership through a government loan guarantee fund, enabling creative financing solutions, and/or introducing mandatory assessments and upgrades.
2. **Government buildings (360 trillion end-use BTUs):** This cluster faces barriers in access to capital, lack of awareness, and regulatory challenges. Possible solution strategies include requiring energy benchmarking for buildings, setting binding energy efficiency targets for state and local jurisdictions, and adjusting regulations to expand access to performance contracting.
3. **New private buildings (270 trillion end-use BTUs):** Barriers resemble those in new residential buildings: lack of incentives for developers to construct high-efficiency buildings, ineffective installation, and limited commissioning. Relevant solution strategies also resemble those for new residential buildings: improving efficiency levels in building codes and greater use of those standards, increasing penetration of voluntary specifications, and linking incentives to developers or buyers through voluntary specifications.
4. **Office and non-commercial devices (570 trillion end-use BTUs):** Potential is spread across a variety of electronic equipment and miscellaneous commercial load, for which energy efficiency has historically been of relatively little concern among both users and manufacturers. As with residential plug-load, the primary

measure appears to be equipment-specific and category-level standards for active and standby power consumption.

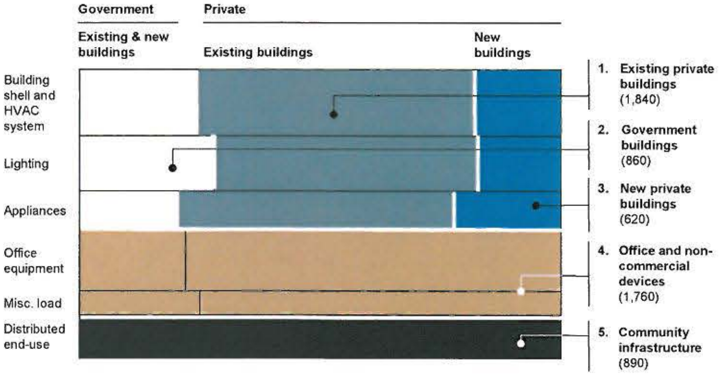
5. **Community infrastructure (290 trillion end-use BTUs):** This cluster suffers from capital constraints, low awareness, and risk aversion. Solution strategies for government-owned facilities could include requiring energy benchmarking, setting binding energy efficiency targets for state and local jurisdictions, and enabling effective performance contracting. Several additional solutions will apply to specific end-uses in this cluster.

Exhibit 23: Clusters of energy efficiency potential in the commercial sector

End-use energy, avoided consumption; total = 2,290 trillion BTUs



Primary energy, avoided consumption; total = 5,970 trillion BTUs



Source: EIA AEO 2008, McKinsey analysis

The upper and lower charts break out the energy efficiency potential in 2020 for the commercial sector in end-use and primary energy respectively. Each area represents a cluster of efficiency potential: the area is proportional to the relative share (of total potential in the sector) associated with that cluster, while the number next to the cluster name provides the efficiency potential, measured in trillion BTUs.

1. EXISTING PRIVATE COMMERCIAL BUILDINGS

Existing privately owned commercial buildings account for 2,860 trillion end-use BTUs of energy consumption in the 2020 reference case (Table 8). These buildings cover a range of types, including educational facilities, office buildings, assembly, retail and service facilities, warehouses, lodging, healthcare, and other buildings. Floor space in this cluster totals approximately 57 billion square feet. This cluster's end-uses include heating, cooling, ventilation, lighting, and water heating, as well as building-related electrical devices including elevators and transformers.[124]

Table 8: Existing private buildings

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	**Savings** Percent
END-USE ENERGY Trillion BTUs	3,560	2,860	810	28
▪ Electricity TWh	560	450	140	31
▪ Natural gas	1,520	1,230	300	24
▪ Other fuels*	140	110	30	27
PRIMARY ENERGY Trillion BTUs	7,630	6,110	1,840	30
▪ Electricity	5,920	4,730	1,500	31
▪ Natural gas	1,580	1,280	310	24
EMISSIONS Megatons CO_2e	460	370	110	30

PV of upfront investment – 2009-2020: $73 billion	PV of energy savings – 2009-2020: $104 billion	Annual energy savings – 2020: $11 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

This cluster offers NPV-positive energy efficiency potential of 810 trillion end-use BTUs, representing 35 percent of the potential in the commercial sector. Retail and office buildings together constitute 44 percent of consumption in this cluster and offer 48 percent of the efficiency potential. Capturing the potential in this cluster would require an investment of approximately $73 billion and provide present-value savings of $104 billion.

Barriers to greater energy efficiency

Capture of NPV-positive potential in existing private buildings is constrained by a wide range of barriers. While different barriers exert themselves to different degrees depending on the context, we have identified several dominant barriers whose removal is essential.

- **Agency issues.** Agency issues affect approximately half (420 trillion end-use BTUs) of the cluster's potential. In leased buildings, financial incentives for the owner to invest in energy efficiency are uncertain, because the owner will likely not capture the energy savings. Owners may benefit from efficiency investments, if lower operating costs increase the rate of tenant renewals and/or command a rental premium.[125]
- **Elevated hurdle rate.** The average payback period expected by commercial customers is 3.6 years.[126] This expectation creates a hurdle for deeper retrofits that typically have longer payback periods. This barrier affects an estimated 170 trillion end-use BTUs or 21 percent of this cluster's potential.
- **Capital constraints.** Capital constraints exist for energy users and their upstream lenders. For the energy end-user, raising and allocating capital for efficiency projects is often confounded by a desire not to increase debt, concern about the opportunity cost of this capital against alternative uses (particularly projects that impact revenue growth), and a reluctance to outsource energy solutions to companies that may charge a financing premium. Upstream financiers may incur increased credit risk when providing capital to privately owned buildings compared to the municipal-university-school-hospital (MUSH) market, because of elevated default risk. In all markets they face difficulty in establishing collateral for the loan, as projects often involve

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[124] We discuss the energy efficiency potential in lighting and appliances in the cluster consisting of new privately owned buildings, though the solutions are equally applicable for lighting and appliances in this and the government buildings clusters.

[125] Based on interviews with commercial building operators.

[126] "Energy Efficiency Indicator, North America," Johnson Controls, March 2008.

specialized equipment, unrecoverable design and installation costs, and high retrieval costs, all of which elevate the financier's risk exposure pending default.[127]

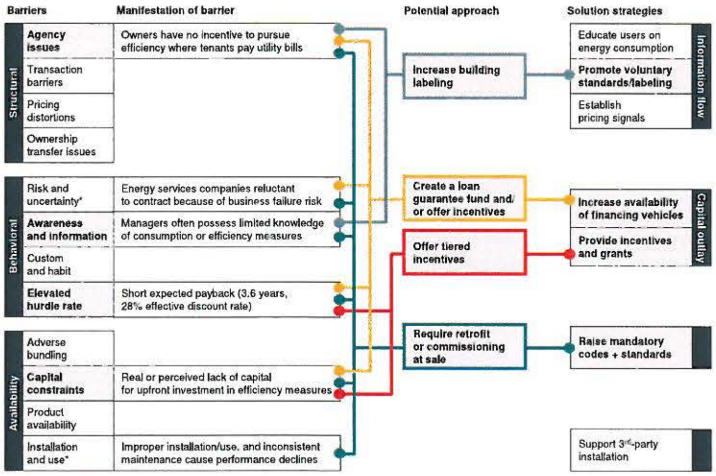
- **Lack of awareness or information.** Many facility managers are unaware of energy efficiency potential with the belief that the building is already energy efficient. Furthermore, they often possess limited knowledge of energy efficiency measures and ways to deploy them within their facilities, including the critical role that proper design and installation play in capturing the savings.[128]

Other barriers affect this cluster to a lesser degree: risk and uncertainty about the financial health and longevity of customers is a barrier for ESCOs considering this market; risk may also take the form of quality tradeoffs (e.g., unwillingness to incur perceived compromises to consumer experiences in retail or food service); and improper installation and inconsistent maintenance of HVAC equipment can lead to suboptimal performance and incomplete realization of efficiency potential.

Solution strategies to unlock potential

A number of solution strategies could help overcome the principal barriers while addressing many of the additional barriers discussed above (Exhibit 24).

Exhibit 24: Addressing barriers in existing private buildings



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

- **Mandate efficiency at time of retrofit** *(emerging).* Local, state, or federal governments could require private buildings to meet an efficiency benchmark at point of sale, major retrofit, or a specified time interval. Such mandates represent a solution that could address all barriers by circumventing the end-user. Creating such a requirement could prove difficult to achieve politically, though recent actions in New York City suggest it may be possible.[129] Results from these programs are as yet unclear as annual turnover is relatively small (2.2 percent of building stock),[130] limiting the speed of improvement.

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[127] *Developing Financial Intermediation Mechanisms for EE Projects in Brazil, China and India*, Econoler International, January 2006. < http:// 3countryee.org/public/angraworkshop.pdf>.

[128] *Sector Collaborative on Energy Efficiency Accomplishments and Next Steps*, EPA, July 2008.

[129] *The Power of Information to Motivate Change: Communicating the Energy Efficiency of Today's Commercial Buildings*, EPA, February 2009. The City of New York's PLANYC Initiative 5. <www.nyc.gov/html/planyc2030>.

[130] "US Commercial Building Ownership Turnover," CoStar Group, February 2008.

In addition, point of sale standards do not create a natural opportunity for retrofits, as change in building ownership does not always accompany turnover of tenants; further, some stakeholders are concerned that point of sale regulation could slow transactions. Hence, variants of this approach that link enforcement to changes in tenancy (rather than ownership) may prove more effective. Enforcement of the regulations presents additional concern and would incur added costs.

- **Create value with voluntary standards** *(emerging).* Buildings meeting an efficiency standard show a 6 percent premium in effective rent and a 16 percent premium in valuation over similar non-energy efficient buildings.[131] The benefits provided by adherence to a voluntary standard, applied to both buildings and commercial equipment, could help manage agency issues by offering financial returns for investments through increased rent and raising awareness of the benefits of efficient buildings.
- **Finance through a public-private partnership** *(piloted).* Interviews[132] suggest that creating a credit-enhancement fund that, for a modest premium, shares the risk of default with the lender could enable private capital to flow into the energy efficiency market. Such an approach has proven successful in other markets, namely student loans and mortgages. According to the Congressional Budget Office, federal credit guarantees on student loans cost the government approximately 3 to 5 percent of the capital deployed.[133] At similar subsidy rates, it would cost $2 billion to $4 billion to provide credit guarantees for the $73 billion of capital needed for this cluster. Furthermore, combining this approach with alternative financing solutions, such as on-bill or tax-district financing, would also overcome agency barriers and provide a vehicle for monetary incentives through tax cuts or offsets to the principal amount. Load-serving entities and local distribution companies and utilities may face challenges internally with billing systems and with regulatory involvement in bill design, and it may not be appropriate in all service territories.
- **Provide monetary incentives** *(proven).* Government and non-government entities could provide monetary incentives to owners in several forms – tax credits, tax deductions, rebates, or accelerated depreciation. The federal government offers a tax deduction of up to $1.80 per square foot for new or renovated commercial buildings that are 50 percent more efficient than the ASHRAE 90.1-2001 standard.[134] Providing tiered incentives – a greater percent of initial investment for deeper retrofits – would help make the economics of deeper retrofits more attractive to building owners. Incentives for commercial equipment should be easy to access contemporaneously with building incentives given the connectedness of the decision process.

  Incentives may be effective within an organization as well. The retail chain JC Penney has begun communicating each store's energy performance rating across the management chain. The company ranks each store and region by energy use, sharing this information with store and regional managers, as well as corporate managers. The company has also begun to link management incentives to energy performance.[135]

A number of additional solution strategies could supplement the approaches outlined above but are not proven to work at scale in the market. Benchmarking would increase awareness by revealing relative performance of buildings of similar type, age, and

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[131] *Program on Housing and Urban Policy*, University of California, Berkeley, January 2009.

[132] Expert interviews.

[133] "Subsidy Estimates for Guaranteed and Direct Student Loans," Congressional Budget Office (CBO), November 2005. "Estimating the Value of Subsidies for Federal Loans and Loan Guarantees," CBO, August 2004.

[134] Energy Policy Act of 2005, subsequent legislation in 2008 extended the tax deduction until 2013.

[135] *The Power of Information to Motivate Change: Communicating the Energy Efficiency of Today's Commercial Buildings*, EPA, February 2009.

geography, as well as indicating sources of energy loss. Tools exist that can provide voluntary or mandatory ratings with or without public disclosure. For example, the EPA provides a free-of-charge benchmarking tool called the Portfolio Manager, which allows building owners or managers to track and benchmark several types of commercial buildings. Several utilities have also developed capabilities to directly upload building energy consumption information into the Portfolio Manager to enable benchmarking.[136] The District of Columbia and California currently require benchmarking and public availability of the results.[137]

Establishing policies or business models that encourage ESCOs to aggregate small building retrofits (i.e., less than 5,000 square feet) could address a particularly challenging 10 percent of overall commercial space. Commercial costs (e.g., administration, sales, EM&V) associated with performance contracting for small projects can be high, as much as 20 to 30 percent of project costs.[138] Aggregating smaller buildings under a single performance contract and/or verifying impact with random sampling across a portfolio rather than directly measuring all improved buildings could reduce these expenses to 5 to 10 percent of project costs[139] for MUSH-market or government owners. This approach might face additional challenges with small privately owned buildings due to disparate ownership. Direct-install programs managed by utilities or other third-party providers, for example, could provide a channel for this aggregation.

2. GOVERNMENT BUILDINGS

With 21.2 billion square feet of floor space, government buildings account for 1,180 trillion end-use BTUs of energy consumption in the 2020 reference case (Table 9). Offices and educational facilities together make up 63 percent of the space and 53 percent of total consumption in the cluster.

The incremental efficiency potential is greatest in local-level government buildings (260 trillion end-use BTUs), principally because local government buildings, which include a subset of schools, libraries, and administrative offices, hold 62 percent of government floor space. State buildings contain 100 trillion end-use BTUs of efficiency potential (Exhibit 25). Federal buildings, by contrast, offer the least efficiency potential, because they are the smallest in overall size and because the reference case includes a 30 percent reduction in their energy consumption by 2020, as mandated for all federal buildings by The Energy Independence and Security Act (EISA, 2007).[140] Unlocking the potential in local buildings would require $19 billion of upfront investment and provide present value savings of $36 billion. Unlocking the potential in state buildings would require $7 billion of upfront investment and provide present value savings of $13 billion.

Table 9: Government buildings

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	**Savings** Percent
END-USE ENERGY Trillion BTUs	1,080	1,180	360	31
▪ Electricity TWh	180	190	70	35
▪ Natural gas	420	450	120	26
▪ Other fuels*	70	70	10	22
PRIMARY ENERGY Trillion BTUs	2,360	2,590	860	33
▪ Electricity	1,870	2,050	730	35
▪ Natural gas	430	470	120	26
EMISSIONS Megatons CO_2e	140	160	50	33

PV of upfront investment – 2009-2020: $26 billion	PV of energy savings – 2009-2020: $49 billion	Annual energy savings – 2020: $5 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

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136 *Utility Best Practices Guidance for Providing Business Customers with Energy Use and Cost Data*, EPA, November 2008.

137 The State of California's AB 1103, 2007 legislation: <www.info.nse.ca.gov>. District of Columbia's Clean and Affordable Energy Act of 2008: <www.dccouncil.washington.dc.us>.

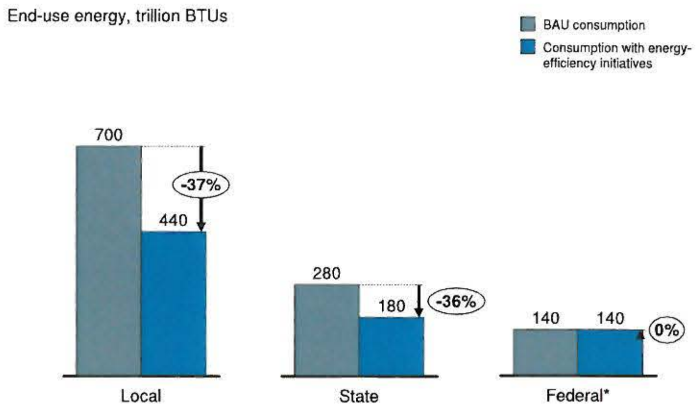
138 Expert interviews.

139 Expert interviews; based on aggregating 100 buildings of 5,000 square feet each in one contract.

140 Energy Independence and Security Act of 2007. Though several state and some local governments have set energy efficiency targets, the reference case does not reflect those targets.

Exhibit 25: Energy potential in government buildings – 2020

The height of the columns represents energy consumption associated with local, state, and federal government buildings in 2020. The left column in each pair shows the BAU consumption forecast for 2020, and the right column displays the possible energy efficient consumption in 2020.



* Federal savings built into BAU
Source: EIA AEO 2008, McKinsey analysis

Barriers to greater energy efficiency

Though significant efficiency potential exists in state and local government buildings, a few dominant barriers have limited the achievement of this potential:

- **Access to capital.** Public facilities often suffer from inadequate capital budgets for infrastructure improvements.[141] In some cases, demand for capital from state agencies can outweigh the ability of state governments to raise debt.[142] In other cases, administrators refuse to access debt due to concerns about debt ratings, because rating agencies may not provide credit for the savings generated through energy efficiency measures. [143] To warrant such treatment rating agencies require assurance that savings flow to the credit market rather than increased spending.
- **Impediments to performance contracting.** Many states limit the use or effectiveness of building retrofit solutions through performance contracting due to inconsistent regulatory support. Challenges range from constraints on the financial treatment of lifecycle benefits – which can inhibit capture of the full potential,[144,145] to accounting rules that limit debt payments from operational savings, to inadequate administrative support or expertise to evaluate or manage pursuit of the opportunity.
- **Lack of awareness.** Many facility managers are unaware of current energy consumption, because centralized departments often pay utility bills. Furthermore, they often possess limited knowledge of energy efficiency measures and ways to deploy them within their facilities.[146]

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[141] Nicole Hopper, et al., *Public and Institutional Markets for ESCO Services: Comparing Programs, Performances and Practices*, LBNL, March 2005.

[142] Ranjit Bharvirkar, et al., *Performance Contracting and Energy Efficiency in the State Government Market*, LBNL, November 2008.

[143] Expert interviews.

[144] Nicole Hopper, et al., *Public and Institutional Markets for ESCO Services: Comparing Programs, Performances and Practices*, LBNL, March 2005.

[145] Ranjit Bharvirkhar, et al., *Performance Contracting and Energy Efficiency in the State Government Market*, LBNL, November 2008. In a sample of 12 states, 8 had maximum contract periods less than the federal maximum allowed length of 25 years.

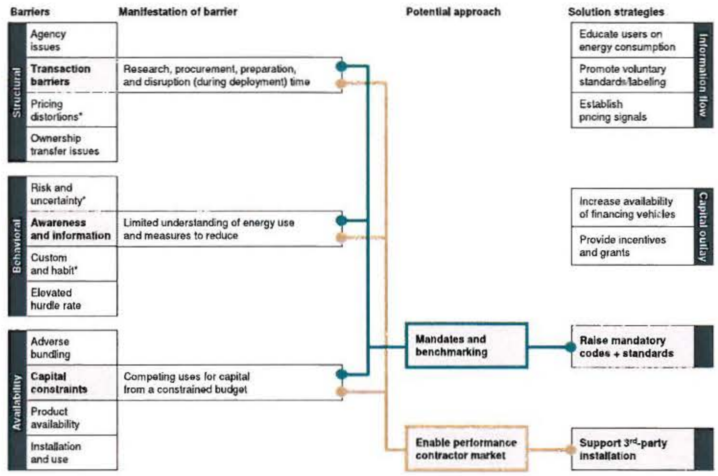
[146] Ranjit Bharvirkar, et al.

Additional barriers include perceptions of risk or uncertainty associated with behavior change or equipment substitution; pricing distortions due to the more favorable rates that are enjoyed by schools and government buildings, making energy efficiency less cost-effective despite its availability; and institutional, allocation, or bureaucratic challenges that limit the ability to act, even when a decision is made to move forward.

Solution strategies to unlock potential

Addressing the major barriers within this cluster will require increasing the focus on and resources deployed toward energy efficiency at all levels of government, while partnering with the private sector to assist in its capture (Exhibit 26).

Exhibit 26: Addressing barriers in government buildings



* Represents a minor barrier
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

- **Mandate benchmarks or standards** *(piloted).* Benchmarking performance and setting mandatory standards are a means to increase institutional focus on efficiency capture. To date, twenty-eight[147] state governments have mandated efficiency targets for state government buildings that target up to a 35 percent reduction in energy use over the next decade in an attempt to "lead by example." Drawing on energy performance benchmarking, for example, Council Rock School District in Pennsylvania was able to improve its average EPA energy performance rating from a 16 (fourth quartile) to 55 (second quartile) within 2 years.[148] The District of Columbia has begun requiring that commercial buildings rate their energy performance and disclose their performance to the public.[149]

  Nonetheless, translating these state aspirations to local governments is often a challenge. A process used in Texas could serve as a useful model: bills passed in 2001 and 2007 require all state agencies and "all political sub-divisions" – including counties, public school districts, and higher education institutions – to reduce energy consumption by 5 percent annually for 6 years. Results so far are inconclusive; however, a sampling of sub-divisions suggests an average consumption decrease of

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[147] Expert interviews.

[148] *The Power of Information to Motivate Change: Communicating the Energy Efficiency of Today's Commercial Buildings*, EPA, February 2009.

[149] The District of Columbia's Clean and Affordable Energy Act of 2008: <www.dccouncil.washington.dc.us>.

14 percent.[150] A second model, effectively used by the U.S. Department of Transportation with highway funding, could make the receipt of federal funding (e.g., Weatherization Assistance Program) contingent on state or local action on efficiency targets for government buildings.

- **Address regulations that inhibit performance contracting** *(emerging)*. In capturing the full potential of energy efficiency available, state and local governments will benefit from effectively partnering with the private sector. Potential actions include developing a streamlined process for performance contracting, allowing aggregation of multiple buildings in a single contract, clarifying accounting rules, and creating an approved list of eligible service providers. Details of this approach lie in the above cluster's description. In addition, state and local governments could require procurement departments to evaluate bids based on lifecycle costs rather than initial costs. Finally, they could designate champions of performance contracting to provide strong executive support, an approach proven to increase penetration of energy efficiency solution strategies.[151]

Additional solution strategies could play an important enabling role. Collaborating with rating agencies to convey the impact of debt incurred for energy efficiency improvements on the credit ratings of participating governments could facilitate allocation of capital, as would earmarking capital for energy efficiency projects. Further opportunities exist to leverage federal allocations (e.g., State Energy Plan and Energy Efficiency Conservation Block Grants) to maximize the impact of collective funding. Finally, federal matching grants could reduce capital requirements and enable state and local governments to pursue this opportunity.

3. PRIVATELY OWNED NEW BUILDINGS

New buildings (i.e., constructed in 2009 and later) will add an average of 1.3 billion square feet per year to the stock of privately owned commercial floor space, representing 27 percent of all privately owned commercial floor space in 2020 and 41 percent in 2030.

Table 10: New private buildings

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	n/a	1,060	270	25
▪ Electricity TWh	n/a	160	50	30
▪ Natural gas	n/a	460	90	21
▪ Other fuels*	n/a	40	10	25
PRIMARY ENERGY Trillion BTUs	n/a	2,260	620	28
▪ Electricity	n/a	1,750	520	30
▪ Natural gas	n/a	470	100	21
EMISSIONS Megatons CO_2e	n/a	140	40	28

PV of upfront investment – 2009-2020: $15 billion	PV of energy savings – 2009-2020: $35 billion	Annual energy savings – 2020: $4 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

Privately owned new buildings offer NPV-positive energy efficiency potential of 270 trillion end-use BTUs (Table 10). The incremental capital cost of capturing this potential is $15 billion but would provide present-value savings of $35 billion. This cluster offers only 12 percent of the commercial-sector efficiency potential in 2020, because buildings constructed between 2009 and 2020 are forecast to account for only 27 percent of all floor space in 2020 and are expected to be more efficient than existing buildings. Nonetheless, new construction will be an increasingly important opportunity through 2030 and beyond, as the share of building stock constructed after 2009 grows. Furthermore, incorporating

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[150] Half the subdivisions showed an increase in energy consumption and half showed a decrease. Median value was an increase in consumption of 3 percent; weighted average value was a decrease in consumption of 14 percent; range in percentage change in consumption was +1,514 percent to -77 percent. These results were not normalized for floor space or other changes.

[151] Ranjit Bharvirkar, et al., ***Performance Contracting and Energy Efficiency in the State Government Market,*** LBNL, November 2008.

energy efficiency measures into new buildings during initial design is attractive as it costs five times as much ($3.83 per square foot compared to $0.76 per square foot) to incorporate the same measures as a retrofit. If the nation ignored the opportunity to capture efficiency potential in "new" buildings through 2020, retrofitting the buildings after they are built, capturing the same potential would cost an additional $48 billion and would likely not be cost effective.

Deployment of more energy efficient lighting and appliances accounts for 110 trillion end-use BTUs of potential in this cluster. Though such building codes as ASHRAE 90.1 specify the range of code-compliant HVAC and lighting equipment, developing federal standards for such equipment would facilitate the capture of energy efficiency potential in two ways: it would address the new-build market in states with no building codes and address the replacement (natural end-of-life or accelerated replacement) in existing buildings in all states.

Barriers to capturing efficiency potential in new buildings

There are two noteworthy barriers that solutions must address:

- **Lack of incentives for developers to build energy efficient buildings.** Because developers do not receive the future energy savings from energy efficient buildings and are often unaware or uncertain of the market premium energy efficient buildings can command, developers have little financial incentive to invest in energy efficiency above the required minimum level.[152] As a result, inclusion of energy efficient options in new buildings may be undermined by tradeoffs in favor of more visible features (e.g., granite flooring, upgraded facilities).
- **Ineffective installation and lack of commissioning.** Developers have little incentive to ensure that contractors install equipment optimally or commission buildings properly. As a result, some buildings perform below the levels called for in building codes: research has found that as many as 20 to 30 percent of buildings designed to meet the ASHRAE 1999 standard did not meet building shell and lighting requirements. However, most buildings designed to meet 1989 standards met or exceeded those specifications.[153] Similarly, non-compliance rates in California for more stringent codes have been reported to be greater than 40 percent.[154]

A range of minor barriers can also inhibit capture of these opportunities. Limited market information to help inform equipment purchasing decisions or floor space selection, concerns over quality of building practices, and limited supply of efficient commercial floor space represent the most encountered minor barriers.

Solution strategies to unlock potential in new buildings

Given the relative cost-benefit of capturing energy efficiency in the design and construction phases and the perishability of these options, this cluster is among the most important for near-term action (Exhibit 27).

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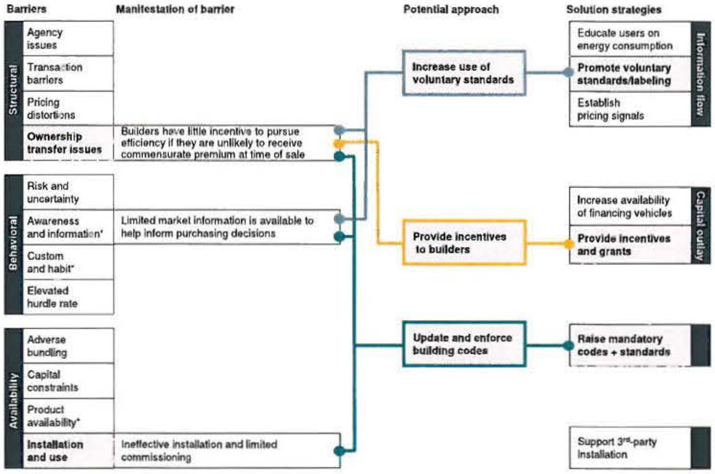
[152] Jens Lausten, *Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings*, International Energy Agency, March 2008.

[153] Eric Richman, et al., "National Commercial Construction Characteristics and Compliance with Building Energy Codes: 1999-2007," *Summer Study on Energy Efficiency in Buildings*, ACEEE, 2008.

[154] M. Sami Khawaja et al., "Statewide Codes and Standards Market Adoption and Noncompliance Rates," Southern California Edison, May 2007.

Exhibit 27: Addressing barriers in new private buildings

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.



* Represents a minor barrier
Source: McKinsey analysis

- **Mandatory building codes** *(proven).* As is true within the residential sector, mandatory codes for new buildings can overcome all barriers by circumventing the end-user's decision-making process. Three complementary actions would increase building code impact:
  - **Adopting the latest energy efficiency building codes.** Only two states have adopted the latest commercial building code, while 13 states have either not adopted a statewide code or continue to use codes that are three or more generations behind (Exhibit 28).[155] The 2007 ASHRAE standard represents a 32 percent efficiency improvement over the 1980 level. States adopting the most recent ASHRAE Standard, 90.1-2007, would reduce energy consumption in new buildings by 11 percent relative to current code levels. In 2020, capturing this improvement would produce 110 trillion end-use BTUs of energy savings, 5 percent of the annual commercial-sector potential that year. Furthermore, if ASHRAE Standard 90.1-2007 were adopted through 2011 and a 30 percent improved code were adopted in 2012, 270 trillion end-use BTUs could be saved in 2020, or 12 percent of annual commercial-sector potential that year.[156] As discussed in the residential section, two options emerge that can overcome the challenge of getting states to adopt the latest codes. Focusing on education for state officials and building departments, and making accessibility of some federal funds contingent on building code stringency could enable increased state adoption of the latest building codes.

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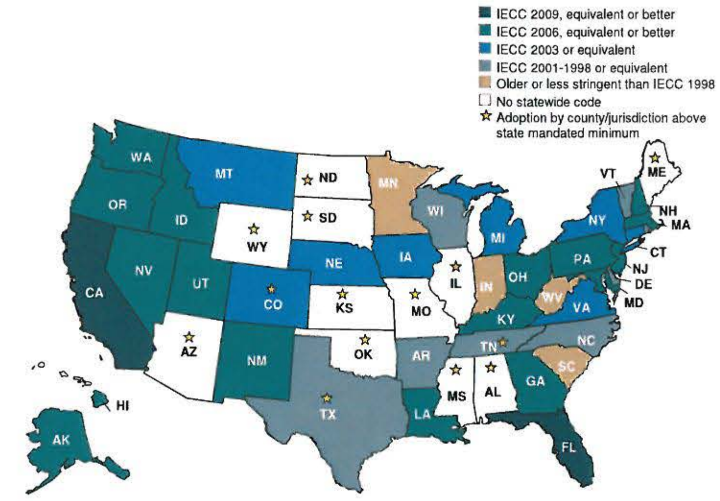
[155] "Building Energy Data Book, Table 5.1.5," EERE, March 2009. < http://buildingsdatabook.eren.doe.gov>.

[156] Expert interviews.

Exhibit 28: Inconsistency of commercial building codes



Source: Buildings Energy Databook, US Department of Energy, Office of Energy Efficiency and Renewable Energy

The map displays the variation in commercial new building codes in place across the United States. In general, darker shades indicate higher standards, and lighter shades indicate less stringent standards, in line with the legend in the top right of the exhibit.

- **Developing more energy efficient codes:** Opportunities exist to advance codes beyond their 2009 levels while maintaining use of cost-effective technology. Current efforts are underway to redesign the ASHRAE code to achieve a 30 percent reduction over 2004 levels – a reduction thought to be cost-effective using existing technologies at current costs.

- **Improving compliance with mandatory codes:** Improving code compliance is an important lever in enabling the effectiveness of mandatory building codes. State support for increased enforcement through various actions as discussed in the residential section would ensure that adopted codes are effective. Experts estimate the incremental annual cost of sufficient enforcement to assure compliance at $1 billion.[157]

- **Broaden mandatory appliance standards** *(proven).* Similar to building codes, equipment standards can overcome all barriers. The Department of Energy provides federal standards for 20 commercial equipment categories, with standards for another seven categories in development.[158] There are no federal energy performance standards, however, for some types of HVAC equipment and some other commonly used appliances.

- **Drive market change through voluntary standards** *(piloted).* Market penetration of voluntary standards in new buildings directly increases awareness and can overcome the agency barrier by increasing the likelihood that a building will gain a premium. Though penetration has been limited,[159] recent trends suggest it is increasing. Targeted awareness programs to educate developers and buyers of commercial buildings would accelerate this process. Universal adoption of these

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[157] David Goldstein and Cliff Majersik, "NRDC/IMT Proposal for Improved Building Energy Code Compliance through Enhanced Resources and Third-Party Verification," NRDC, 2009. The $1 billion is the total for both residential homes and commercial buildings.

[158] Appliance Standard Awareness Project <www.standardsASAP.org>

[159] USGBC has awarded LEED certifications to 14.3 million square feet of commercial building space since 2003 (0.1 percent of the space constructed over this period), while in 2008, 130 new buildings (0.1 percent) achieved the "Designed to earn ENERGY STAR" label.

standards would yield energy savings of 260 trillion end-use BTUs in 2020, some 11 percent of overall commercial-sector potential that year.[160]

- **Provide education and monetary incentives** *(proven).* Builder subsidies would overcome agency issues by allowing builders to recover costs other than through the buyer. The incremental cost of constructing energy efficient buildings is approximately $1.08 per square foot, a 0.5 percent increase over standard practices. Educating developers on the actual incremental costs and the associated building techniques could increase the rate of adoption at relatively low cost. Alternatively, if the government or another agent provides an incentive of $1.08 per square foot to developers, it would cost $1.9 billion annually to capture the full potential.

4. OFFICE AND NON-COMMERCIAL DEVICES

Electricity consumption from office and non-commercial devices is growing at a rate of 3.6 percent per year. This cluster is forecast to consume 1,980 trillion end-use BTUs in 2020, consisting entirely of 580 TWh of electricity (Table 11).

The efficiency potential in this cluster is highly fragmented across hundreds of device categories. At $2.70 per MMBTU of end-use energy, however, the opportunity is among the most cost effective. This cluster could contribute 570 trillion end-use BTUs of NPV-positive potential, assuming an estimated upfront investment of $8 billion and provide present-value savings of $57 billion. Equipment groups fall into three broad categories: office equipment, miscellaneous commercial load, and data centers:

Table 11: Office and non-commercial devices

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	1,290	1,980	570	29
▪ Electricity TWh	380	580	170	29
▪ Natural gas	n/a	n/a	n/a	n/a
▪ Other fuels*	n/a	n/a	n/a	n/a
PRIMARY ENERGY Trillion BTUs	4,010	6,160	1,760	29
▪ Electricity	4,010	6,160	1,760	29
▪ Natural gas	n/a	n/a	n/a	n/a
EMISSIONS Megatons CO_2e	250	380	110	29

PV of upfront investment – 2009-2020: $8 billion	PV of energy savings – 2009-2020: $57 billion	Annual energy savings – 2020: $11 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

- Office equipment includes dozens of device categories, in broad terms, PCs (including desktop computers, laptop computers) and non-PCs (such as servers, printers, fax machines, multi-function devices, and phones).
- Miscellaneous commercial load includes some 100 equipment categories, with two broad sub-groups:
  - Commercial equipment including specialized devices such as MRI machines, X-ray machines, other medical and laboratory equipment, cash registers and surveillance systems.
  - Residential devices present in commercial settings including equipment categories such as refrigerators, coffee makers and water coolers.
- Data-centers consist of servers, auxiliary data equipment, and supporting power systems (e.g., uninterruptable power supplies); potential associated with energy efficient cooling and lighting is contained in the private and government building clusters. However they bear special attention as data center energy use is expected to

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[160] ENERGY STAR labeled buildings perform on average 35 percent better than the average building in CBECS 2003 from expert interviews. New buildings are better than CBECS average by 13 percent from B. Griffith et al., *Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector*, NREL, 2007. This leads to net benefits of 24 percent.

grow 9.6 percent per year from a base of 200 trillion end-use BTUs in 2008 to 600 trillion end-use BTUs in 2020.[161]

Barriers to capturing efficiency potential

The energy consumed by each device in this cluster is small and therefore of relatively little concern to consumers and manufacturers. While there are necessarily many barriers of lesser importance that impact this cluster, we have elevated three for particular consideration:

- **Low awareness.** This cluster may account for as much as 25 percent of total electricity consumption in the commercial sector in 2020; however, each category of devices represents a tiny share of an enterprise's overall electric bill. As a result, the efficiency potential in this cluster receives little attention, as discussed in the section on residential plug-load. Lack of attention is compounded by insufficient or buried information about the energy consumption of these devices, often making the transaction "cost" of identifying lifecycle benefits prohibitively large relative to the savings. Additionally, proper usage of energy efficiency settings presents a minor barrier similar to that facing the electrical devices and small appliances cluster in the residential sector.
- **Manufacturer limitations.** Consumers and businesses tend to value other attributes (e.g., price, screen resolution, print quality) above energy efficiency, thus affecting end-user purchasing processes.[162] This makes manufacturers' ability to receive compensation for energy efficient devices unclear (a type of ownership transfer barrier), which impacts design decisions.
- **Practical availability.** Restricted procurement selection, consumer focus on acquisition rather than lifecycle costs, and distributed budget responsibility within an organization (e.g., separation of upfront purchasing concerns from long-term energy budget responsibility) limit availability of efficient technology. Adverse bundling of efficiency with other features can also present a barrier for some devices.

Data centers face a similar set of barriers. Low awareness of energy usage (and the expertise to capture substantial efficiency potential) persists among operators of smaller data centers, though operators of enterprise-class centers are increasingly focusing on managing power consumption.[163] Furthermore, data centers tend to focus on acquisition cost rather than total lifetime cost, and they may be concerned about perceived quality trade-offs, such as concerns about reliability, due to risk aversion. With this mind-set, developers and data center operators tend to over-invest in servers, resulting in low server utilization, with as many as 30 percent of servers consuming electricity but serving a limited useful business purpose with less than 3 percent average daily utilization.[164]

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[161] "Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431", EPA, Aug 2007. Expert interviews.

[162] "Going Green: An Examination of the Green Trend and What it Means to Consumers and the CE Industry," Consumer Electronics Association, 2008.

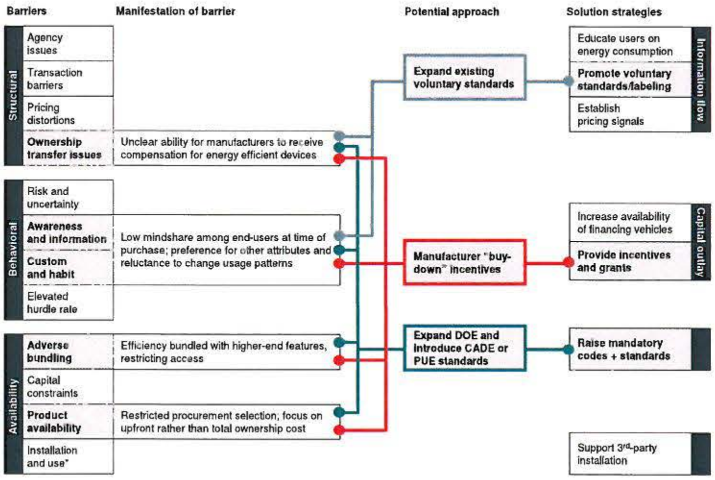
[163] Expert interviews.

[164] "Revolutionizing Data Center Energy Efficiency," McKinsey & Company, 2008.

Solution strategies to unlock potential in office and non-commercial devices

Capturing the potential opportunity from a distributed group of actors where energy efficiency is only a minor factor in the decision-making process may require a certain degree of intervention, but it may be supplemented by harnessing competitive market forces to drive improvements over time. Several solutions emerge as possibilities (Exhibit 29).

Exhibit 29: Addressing barriers in office and non-commercial devices



* Represents a minor barrier
Source: McKinsey analysis

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- **Introduce or expand mandatory minimum standards** *(proven).* Expanding the equipment categories for which the DOE sets standards would enable greater energy efficiency. Within this cluster, three equipment categories have federal mandatory standards, leaving most categories unaddressed.[165] It is important to note that technology in this area advances rapidly, making the task of setting standards without stifling market innovation quite challenging. It is worth noting that a standby standard for electric devices used in residential settings would have further impact in this cluster. However, due to extremely limited data on commercial office equipment, it is difficult to determine impact of such a standby standard.[166]

  For data centers, one potential approach is to set Corporate Average Data-Center Efficiency (CADE) or Power Usage Effectiveness (PUE) standards. In addition, creation of cross-cutting standby standards, as discussed in the residential section, would have a spillover effect to this cluster.

- **Voluntary standards** *(proven).* ENERGY STAR currently covers 12 product categories in this space and reported energy savings in 2008 of 52 TWh.[167] The EPA is developing a benchmarking tool for data centers through its Portfolio Manager.[168] In addition, the impact of solution strategies considered in residential lighting and appliances and electrical devices would also increase potential in this cluster.

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[165] Expert interviews.

[166] Further research would be required to dimensionalize commercial office equipment and determine potential impact of a standby standard.

[167] Expert interviews.

[168] "ENERGY STAR Data Center Infrastructure Rating," EPA, 2008.

Additionally, supporting solution strategies could include providing manufacturers or distributors incentives to decrease the incremental cost of producing energy efficient equipment or providing procurement departments with more information on lifetime costs.

5. COMMUNITY INFRASTRUCTURE

In 2008, 11 percent (750 trillion end-use BTUs) of commercial-sector energy consumption occurred in community infrastructure (Table 12) – settings not normally associated with buildings: street and other outdoor lighting, water services, and telecom infrastructure (including mobile phone base stations).[169] Overall consumption in this cluster is forecast to grow at an annual rate of 1.8 percent.

Community infrastructure could provide 290 trillion end-use BTUs of NPV-positive potential in 2020; unlocking this potential would require upfront investment of $4 billion and provide present-value savings of $45 billion. The potential resides in several sub-categories: street/other lighting (43 percent), water services (12 percent), telecom network (25 percent), and other electricity consumption (20 percent). End-uses and facilities managed by local governments account for 200 trillion end-use BTUs of the potential, while end-uses and facilities managed by private-sector entities make up 90 trillion end-use BTUs of the potential.

Table 12: Community infrastructure

	Energy use – 2008	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	750	930	290	31
■ Electricity TWh	220	270	80	31
■ Natural gas	n/a	n/a	n/a	n/a
■ Other fuels*	n/a	n/a	n/a	n/a
PRIMARY ENERGY Trillion BTUs	2,320	2,890	890	31
■ Electricity	2,320	2,890	890	31
■ Natural gas	n/a	n/a	n/a	n/a
EMISSIONS Megatons CO_2e	150	180	60	31

PV of upfront investment – 2009-2020: $4 billion	PV of energy savings – 2009-2020: $45 billion	Annual energy savings – 2020: $5 billion

* End-use energy is approximated as equivalent to primary energy

Source: EIA AEO 2008, McKinsey analysis

Barriers to capturing the efficiency potential

The prevailing barriers in this cluster vary by ownership category. Local governments typically own water service facilities and often (but not always) own street lighting, while private-sector entities own telecom infrastructure. Water service facilities and street lighting (when owned by government) face barriers typical of government buildings, namely capital availability and inconsistent regulatory support for performance contracting. Street lighting, when owned by the utility, may encounter agency issues. Common barriers affect all three categories of community infrastructure:

- **Risk aversion.** Many operators are risk averse and put a premium on reliability; they may not be inclined to pursue energy efficiency activities for fear of disrupting essential services.[170]
- **Lack of performance awareness or accountability.** Water operators typically manage to such metrics as discharge level and water quality; energy efficiency is not usually a metric for which they are accountable.[171] Similarly, telecom infrastructure is geographically dispersed and budget ownership within an organization is often fragmented, both of which introduce management challenges. As a result, operators often do not have a consolidated view of the energy consumption they manage.[172] Finally, other considerations, such as equipment features (e.g., flexibility, backward compatibility, vendor compatibility), may take precedence over energy efficiency.[173]

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[169] We have excluded natural gas and distillate fuel oil consumption (1,350 trillion end-use BTUs in 2020) attributed to community infrastructure and miscellaneous load in *AEO 2008* due to lack of information about the sources of consumption and the efficiency opportunities.

[170] Expert interviews.

[171] Expert interviews.

[172] Expert interviews.

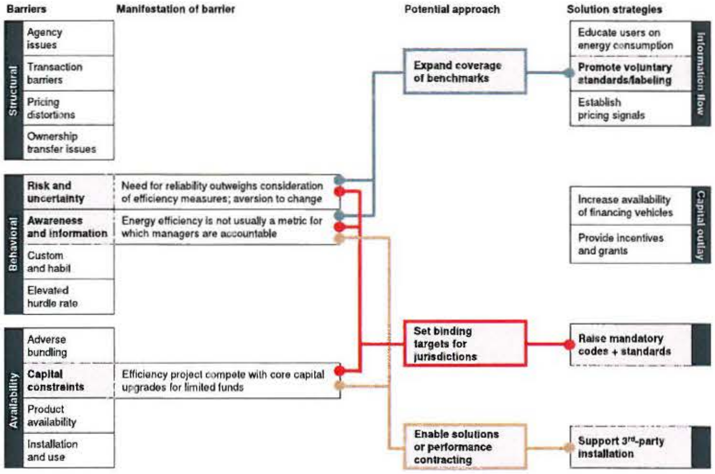
[173] Expert interviews.

- **Competing uses for capital.** Energy efficiency projects may compete for capital with core business projects, such as upgrades to the next-generation mobile technology[174] or new lighting capacity additions.

Solution strategies to unlock potential in community infrastructure

Several solution strategies can address one or more of the barriers affecting community infrastructure efficiency potential (Exhibit 30). The relative emphasis for each measure may differ based on the type of community infrastructure addressed.

Exhibit 30: Addressing barriers in community infrastructure



Source: McKinsey analysis

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- **Benchmark energy consumption** *(piloted).* Expanding existing benchmarking tools, such as the EPS's Portfolio Manager, to include water distribution facilities, street lighting, and distributed telecom infrastructure would help provide a voluntary standard for 230 trillion end-use BTUs of potential or 79 percent of total potential in this cluster. Such benchmarks should normalize for differences, especially if addressing telecom base stations where technology generation, supported bandwidth, voice and data usage, encryption level, and geographical spread of consumers served could significantly impact benchmark definition.
- **Set binding targets** *(piloted).* State and local governments could mandate energy efficiency targets for water services and street lighting, by expanding existing programs.[175] Energy efficiency measures in water services could yield savings of 10 to 30 percent and would include retrofitting facilities with more efficient pumps and motors, incorporating variable frequency motors, installing dissolved oxygen sensors for the aeration process, and installing a system for overall plant monitoring and control.[176]
- **Enable performance contracting** *(emerging).* Water treatment and street lighting would benefit from regulatory changes that would facilitate performance contracting, as discussed for government buildings.

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[174] Expert interviews.

[175] See, for instance, EPA ENERGY STAR Challenge for water systems. <www.energystar.gov>.

[176] Richard Brown, "Energy Efficiency and Renewable Energy Technologies in Wastewater Management," testimony before House Subcommittee on Water Resources and Environment, 4 February, 2009.

Other enabling solution strategies include capturing available funds[177] and improving training by including efficiency within existing EPA guidelines for periodic training and certification. To support these solution strategies, fund regulators could make full access to available funds contingent in part on fulfillment of a training requirement.

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[177] Water treatment facilities can access existing funds for energy efficiency improvements, including State Energy Program, Energy Efficiency Conservation Block Grant, Drinking Water State Revolving Fund, and Clean Water State Revolving Fund.

4. Approaches to greater energy efficiency in the industrial sector

The industrial sector will consume 51 percent of the 2020 baseline end-use energy in the United States, equivalent to 20.5 quadrillion BTUs of end-use energy. The industrial sector offers 3,650 trillion end-use BTUs of NPV-positive energy efficiency potential, equivalent to 18 percent of its forecast energy consumption in 2020 (Table 13).[178] Capturing this potential would save $47 billion per year in energy costs, though between 2009 and 2020 it would require present value investment of $113 billion yielding total present-value savings of $442 billion.[179] It is noteworthy that energy consumption and potential in the industrial sector remains considerably more regionalized than in the residential or commercial sectors: the South, for instance, contains 50 percent of consumption and 49 percent of the efficiency potential.

Energy consumption in the industrial sector (as examined in this report) is forecast to grow by 0.5 percent per year, reaching 20,530 trillion end-use BTUs in 2020. This rate is slower than expected GDP growth because of 3 to 14 percent improvements anticipated in energy-intensive industries (i.e., cement, chemicals, iron and steel, pulp and paper, and refining).[180]

Table 13: Overview of energy use in the industrial sector

	Energy use – 2010***	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY	19,290	20,530	3,650	18
Trillion BTUs				
■ Electricity TWh	1,090	1,050	190	18
■ Natural gas	5,370	5,850	1,040	18
■ Other fuels*	10,200	11,090	1,970	18
PRIMARY ENERGY	27,320	28,320	5,030	18
Trillion BTUs				
■ Electricity**	11,540	11,150	1,980	18
■ Natural gas	5,580	6,080	1,080	18
EMISSIONS	1,660	1,710	300	18
Megatons CO_2e				

PV of upfront investment – 2009-2020: $113 billion	PV of energy savings – 2009-2020: $442 billion	Annual energy savings – 2020: $47 billion

* End-use energy is approximated as equivalent to primary energy

** Does not include CHP savings of 910 trillion BTUs

*** 2010 is used throughout this chapter due to data availability

Source: EIA AEO 2008, McKinsey analysis

The energy intensity of production in industrial subsectors varies widely, from 52.3 end-use BTUs per dollar of value added in cement production to 0.4 end-use BTUs per dollar in

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[178] The industrial sector as a whole is projected to consume 25,820 trillion BTUs of end-use energy in 2010. We excluded transport fuel (1,380 trillion end-use BTUs) and asphalt consumed by the construction sector (1,080 trillion end-use BTUs), as well as chemical feedstock (4,080 trillion end-use BTUs), identifying potential efficiency in the remaining 19,290 trillion BTUs of end-use consumption.

[179] This does not include primary energy potential of 1.4 quadrillion BTUs from industrial and commercial CHP, which is discussed later in the chapter.

[180] For the purposes of this report energy-intensive industries include those requiring intensities above 10 BTUs per dollar of value added: cement, bulk chemicals, refining, iron and steel production, and pulp and paper. See Exhibit 28 for a list of sectors. We excluded aluminum and glass products due to their low total consumption and mining as its consumption is primarily driven by transportation.

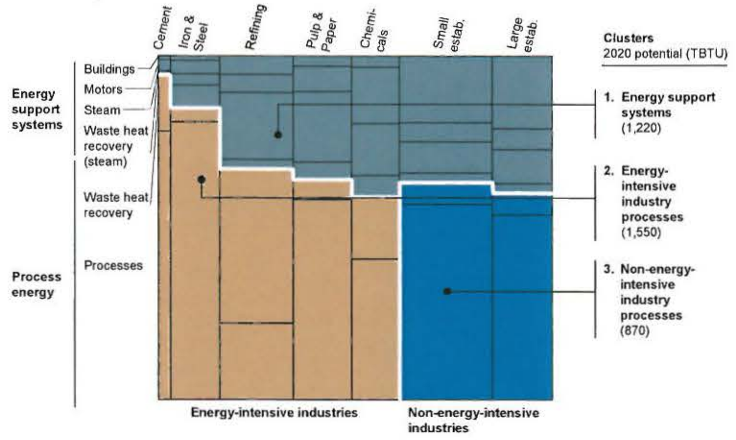
computer assembly. We found that opportunities for energy efficiency are highly fragmented across subsector-specific process steps (e.g., pulping and bleaching in pulp and paper, clinker production in cement, and secondary hot rolling in iron and steel), which represent 67 percent of the potential. Cross-cutting energy support systems, such as steam systems, motors, and buildings, represent the remaining 33 percent of the potential. Sixty-one percent of the total opportunity resides in energy-intensive sectors, with 39 percent in non-energy-intensive sectors. In addition to these energy efficiency initiatives, NPV-positive deployment of combined heat and power systems could increase from 85 GW in 2008 to 135 GW in 2020, representing a substantial opportunity to increase efficiency in primary energy and drive 1,390 trillion BTUs of primary-energy savings, reduce facility-level energy costs by $77 billion, and abate greenhouse gas emissions by 100 megatons of CO_2e.

We have divided the industrial sector into four clusters (Exhibit 31). Unlike the residential and commercial sectors, the three end-use clusters in the industrial sector share similar barriers and solutions, while CHP, which generates electricity and thermal energy from a single fuel source, stands apart. Therefore, we will group the three energy-use clusters into a single discussion and address CHP separately.

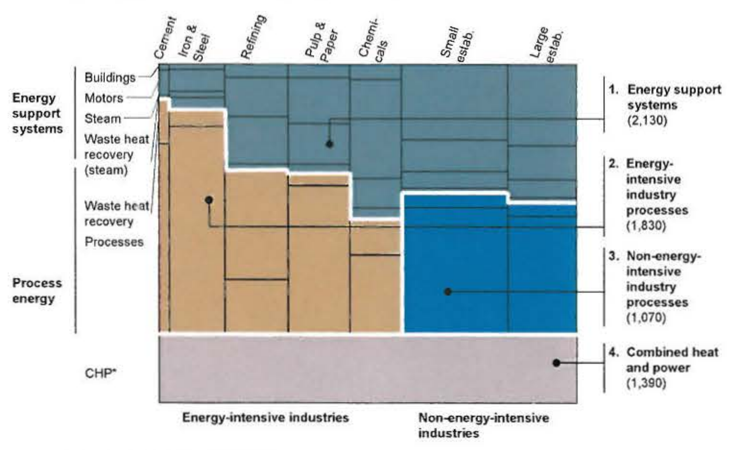
Exhibit 31: Clusters of energy efficiency potential in the industrial sector

The upper and lower charts break out the energy efficiency potential in 2020 for the industrial sector in end-use and primary energy respectively. Each area represents a cluster of efficiency potential: the area is proportional to the relative share (of total potential in the sector) associated with that cluster, while the number next to the cluster name provides the efficiency potential, measured in trillion BTUs.

Enduse energy, avoided consumption; total = 3,650 trillion BTUs



Primary energy, avoided consumption; total = 6,420 trillion BTUs



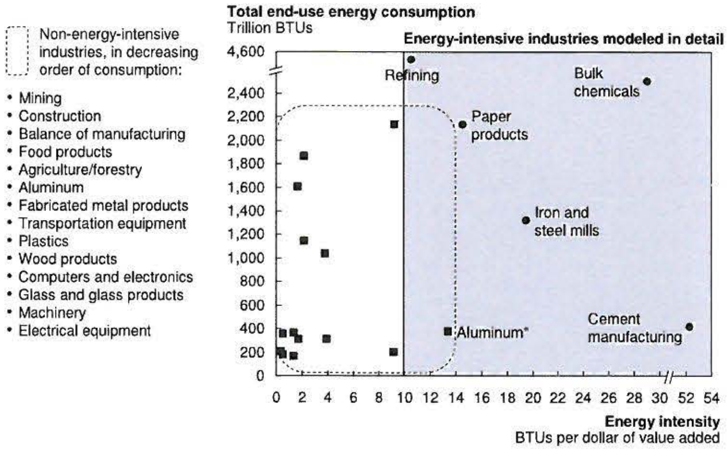
* CHP also includes 490 TBTU of potential from CHP in commercial uses

Source: EIA AEO 2008; McKinsey analysis

EFFICIENCY POTENTIAL IN INDUSTRIAL ENERGY CONSUMPTION

The energy-savings potential in the industrial sector divides into three clusters: energy support systems, process energy in energy-intensive industries (with 10 or more end-use BTUs per dollar of value added), and process energy in non-energy-intensive industries (with less than 10 end-use BTUs per dollar of value added). The energy support systems cluster (1,220 trillion end-use BTUs of potential) consists of steam systems, motor systems, and buildings that support manufacturing processes (but are not core to those processes) across all industrial subsectors; it also includes waste heat recovery from these systems, specifically steam system waste heat. Energy-intensive industry processes (1,550 trillion end-use BTUs of potential) include process energy and process system waste heat recovery. Non-energy-intensive industry processes account for some 870 trillion end-use BTUs of potential (Exhibit 32).[181] Given differences in the nature of the potential, we will describe the potential for each cluster before describing the barriers to greater efficiency and potential solutions to those barriers.

Exhibit 32: Industries modeled for energy efficiency potential



* Despite presenting an energy intensity above 10 BTU per dollar of value added it is modeled with non-energy intensive given its small total energy consumption of only 370 trillion BTUs

Source: EIA AEO 2008, McKinsey analysis

Each dot represents an industry in the U.S., with its position on the horizontal axis corresponding to the energy intensity (measured in BTUs of end-use energy consumed per dollar of value created) for the industry and its position on the vertical axis corresponding to its total end-use energy consumption in 2008. Industries having a dot (as opposed to a square) within the shaded area were modeled in detail for this report.

Energy support systems

Industrial energy support systems consist of steam systems, motor systems, and building infrastructure (i.e., lighting and space conditioning). These systems are forecast to consume 8,540 trillion end-use BTUs of energy in 2010, with consumption forecast to grow at 0.3 percent annually to 8,800 trillion end-use BTUs in 2020 (Exhibit 33). These systems offer 1,220 trillion end-use BTUs of NPV-positive efficiency potential in 2020, requiring an estimated upfront investment of $34 billion and generating present value savings of $164 billion (Table 14).

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[181] Though aluminum requires 13.5 BTUs of energy input per dollar of value added, it represents a small subsector in the U.S. economy (370 trillion end-use BTUs) and is therefore grouped among non-energy-intensive subsectors.

- **Steam systems.** These systems (e.g., steam generation [boilers], distribution, and condensate-recovery systems) are projected to consume 5,360 trillion end-use BTUs of energy and provide 460 trillion end-use BTUs of potential in 2020, with petroleum accounting for 35 percent of the potential, natural gas 35 percent, and other fuels 30 percent. Efficiency measures include waste heat recovery (i.e., from boiler exhaust and waste gases and liquids), which would provide an additional 150 trillion end-use BTUs of potential, steam trap maintenance, insulation of distribution systems, and valve and fitting improvements.

Table 14: Energy support systems

	Energy use – 2010**	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	8,540	8,800	1,220	14
▪ Electricity TWh	870	850	120	15
▪ Natural gas	1,920	2,040	280	13
▪ Other fuels*	3,650	3,870	520	13
PRIMARY ENERGY Trillion BTUs	14,870	14,960	2,130	14
▪ Electricity	9,220	8,970	1,320	15
▪ Natural gas	2,000	2,120	290	13
EMISSIONS Megatons CO_2e	900	910	130	14

PV of upfront investment – 2009-2020: $34 billion	PV of energy savings – 2009-2020: $164 billion	Annual energy savings – 2020: $17 billion

* End-use energy is approximated as equivalent to primary energy

** Table 14, 15 and 16 include a double-count of steam systems of approximately 5,520 trillion BTUs of 2010 consumption due to difficulties in accuately seperating this consumption into each cluster

Source: EIA AEO 2008, McKinsey analysis

- **Motors systems.** Motor-driven systems are projected to consume 2,330 trillion end-use BTUs of energy, all of it electricity, totaling 680 TWh, which represents 65 percent of total industrial electricity consumption. These systems (e.g., pumps, fans, air compressors and motor-driven industrial process systems) provide 250 trillion end-use BTUs (70 TWh) of potential in 2020. Efficiency improvements include matching component size with load requirements, using speed control, and improving maintenance; together, these improvements represent 77 percent of this potential. Motor-drive upgrades beyond EISA 2007 standards[182] and improved motor management offer the remaining 23 percent.

- **Buildings.** Buildings consume energy for HVAC, lighting, and other support functions. By 2020, buildings are projected to consume 1,110 trillion end-use BTUs, including 160 TWh of electricity, 190 trillion end-use BTUs of natural gas, and 360 trillion end-use BTUs of other fuels. Upgrades to lighting and appliances, plus retro-commissioning of HVAC systems and building shells, would provide 360 trillion end-use BTUs of potential.

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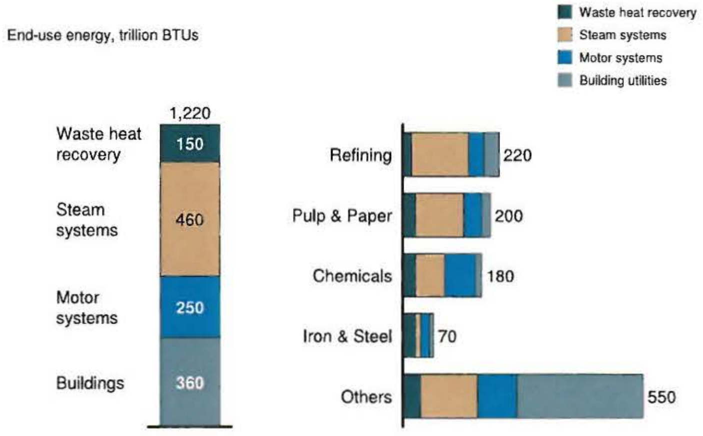
[182] More strict motor efficiency standards included in EISA 2007 address efficiency upgrades for new motors; some potential exists in motors maintained beyond the end of their useful life that should be replaced.

Exhibit 33: Efficiency potential in energy support systems – 2020



Source: EIA AEO 2008; McKinsey analysis

On the left side of the exhibit, the height of each segment and the column itself represent the amount of potential in the industrial support systems modeled, measured in trillion BTUs, with the total at the top of the column and the values for each system in their corresponding segment. The right side of the exhibit displays the amount of potential in select industries for each of these systems.

Energy-intensive industry processes

Energy intensive industry processes are expected to consume 10,440 trillion BTUs of energy in 2020: this would include process heating and cooling, and such highly specialized process steps as clinker production in cement, blast furnaces in iron and steel manufacturing, hydrocracking in refining, and bleaching in pulp and paper.

The savings potential for this cluster is 1,550 trillion end-use BTUs, consisting of 40 TWh of electricity, 490 trillion end-use BTUs of natural gas, and 940 trillion end-use BTUs of other fuels (Table 15). Savings measures include implementing new processes, incrementally improving current processes, upgrading process monitoring and maintenance, and increasing waste heat recovery in specific process systems. Three forms of waste heat recovery offer savings potential:

- High-quality heat recovery, including sinter plants, annealing lines, and top-pressure recovery turbines, which can be harnessed for such uses as process energy, electricity generation, fuel preheating, and steam generation
- Low-quality heat recovery from cooling water and return lines, which can be used for water heating and space conditioning
- Recovering waste streams for fuel, such as hydrogen in refining, basic oxygen furnace gas, blast furnace gas in iron and steel, and black liquor gasification in pulp and paper.[183]

Table 15: Energy-intensive industry processes

	Energy use – 2010**	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	9,930	10,440	1,550	15
▪ Electricity TWh	110	100	40	40
▪ Natural gas	3,300	3,490	490	14
▪ Other fuels*	6,260	6,610	940	14
PRIMARY ENERGY Trillion BTUs	10,810	11,290	1,830	16
▪ Electricity	1,120	1,060	380	36
▪ Natural gas	3,340	3,620	510	14
EMISSIONS Megatons CO_2e	650	680	110	16

PV of upfront investment – 2009-2020: $51 billion	PV of energy savings – 2009-2020: $182 billion	Annual energy savings – 2020: $19 billion

* End-use energy is approximated as equivalent to primary energy

** Tables 14, 15 and 16 include a double-count of steam systems of approximately 5,520 trillion BTUs of 2010 consumption due to difficulties in accuately seperating this consumption into each cluster

Source: EIA AEO 2008, McKinsey analysis

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[183] N. Martin et al., "Opportunities to Improve Energy Efficiency and Reduce Greenhouse Gas Emissions in the U.S. Pulp and Paper industry," LBNL, 2000. Expert interviews.

Measures to capture this potential would require upfront investments of $51 billion, but would generate present value savings of $182 billion; 42 percent of the potential would pay back in less than 2.5 years.

Non-energy-intensive industry processes

Non-energy intensive industry processes (e.g., food products, plastics, electrical equipment) are expected to consume 6,300 trillion end-use BTUs in 2020.[184] Savings measures available in this cluster include improved maintenance, process energy monitoring, and waste heat recovery.[185]

This cluster contains 870 trillion end-use BTUs of efficiency potential, offering $96 billion in present-value savings with an expected upfront investment of $28 billion (Table 16). This opportunity is highly fragmented across some 330,000 plants in 14 industries. The largest 3 percent of plants (9,500), however, consume 41 percent (2,590 trillion end-use BTUs) of the energy and offer 38 percent (330 trillion end-use BTUs) of the efficiency potential, suggesting that these sites would be the most attractive to pursue first.

Barriers to capturing energy efficiency

The industrial sector faces five major barriers that together affect the bulk of the available energy efficiency potential:

Table 16: Non-energy-intensive industry processes

	Energy use – 2010**	BAU energy use – 2020	Savings due to EE – 2020	Savings Percent
END-USE ENERGY Trillion BTUs	6,330	6,300	870	13
■ Electricity TWh	110	110	30	24
■ Natural gas	2,050	2,050	270	13
■ Other fuels*	3,900	3,890	520	13
PRIMARY ENERGY Trillion BTUs	7,220	7,130	1,070	15
■ Electricity	1,200	1,120	270	24
■ Natural gas	2,130	2,130	280	13
EMISSIONS Megatons CO_2e	430	430	60	15

PV of upfront investment – 2009-2020: $28 billion	PV of energy savings – 2009-2020: $96 billion	Annual energy savings – 2020: $11 billion

* End-use energy is approximated as equivalent to primary energy

** Tables 14, 15 and 16 include a double-count of steam systems of approximately 5,520 trillion BTUs of 2010 consumption due to difficulties in accuately seperating this consumption into each cluster

Source: EIA AEO 2008, McKinsey analysis

- **Low awareness and attention.** Energy typically represents a relatively small fraction of operating costs (less than 5 percent), leading to low levels of awareness and attention from senior management at industrial companies.[186] Opportunities often require technical analysis that on-site employees rarely perform because of insufficient training, awareness, or management concern. The savings potential varies considerably by site, ranging from 10 to 40 percent, even for sites within the same subsector, highlighting the need for site-specific analysis.[187] This issue is exacerbated by the lack of focus on energy efficiency by top management, leading to under-prioritization of energy as an important strategic lever or metric to manage, resulting in limited investment in developing the required technical expertise.

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[184] Given the many processes used in these sub-sectors, we created top-down models to identify the key characteristics of the opportunities based on our extensive experience serving these industries.

[185] See the "ENERGY STAR Guide for Energy and Plant Managers" (2008), a series of papers by LBNL's International Energy Studies exploring "Energy Efficiency Improvement and Cost Saving Opportunities" for many industries, including Pharmaceuticals, Wet Corn Milling, Fruit and Vegetable, and Vehicle Assembly; available at <http://ies.lbl.gov/publications>.

[186] Refining (13 percent total savings, 5 percent process energy savings) and to a lesser extent chemicals, (19 percent total savings, 11 percent process energy savings) often represent an exception to this rule.

[187] Expert interviews.

- **Elevated hurdle rate.** Industrial sites generally receive very tight operational budgets, and plant managers are encouraged to maximize production while keeping near-term quarterly costs low. Furthermore, management tends to focus on quarterly targets, potentially at the expense of projects that pay back over longer periods. Forty-three percent of energy managers indicate that they use a payback period of less than 3 years for energy efficiency projects,[188] while under difficult economic conditions anecdotal evidence suggests many companies require a payback period of 18 months or less on all investments.[189] Requiring a 2.5-year payback would reduce identified industrial potential by 46 percent or 1,690 trillion end-use BTUs.
- **Capital allocation and elevated hurdle rate.** Capital allocation from internal sources faces strict capital budget constraints with non-core projects (e.g., energy efficiency) competing for funding against core projects on unlevel ground. Often energy efficiency projects face an elevated hurdle rate compared to core projects. Furthermore, corporations often separate plant operations and maintenance budgets from capital improvement budgets, creating an organizational challenge for energy efficiency efforts, because the costs reside in one budget while the savings reside in another. Finally, even if projects are attractive by internal standards, corporations may remain reluctant to raise debt for energy efficiency projects for fear of adversely affecting their balance sheets and credit ratings.[190]
- **High transaction "cost."** Transaction "costs"[191] associated with implementing efficiency-related process improvements include space constraints, invested resource time, process disruptions, potential effects on product quality, and safety concerns associated with system integration and energy support system maintenance.[192]
- **Procurement and distributor availability constraints.** Lack of product availability can occur within an enterprise's procurement system, with the distributor, or in the marketplace. Many procurement systems contain limited inventory, typically focus on upfront cost rather than total cost of ownership, and require special processes and additional time to procure non-pre-approved parts. Distributor limitations primarily affect replacement of equipment during urgent situations because inventory carrying costs restrict distributors' ability to respond to immediate needs with the most efficient solutions. Marketplace limitations arise from the risk aversion of plant managers: despite continued ability of manufacturers to improve technology, risk aversion frequently creates demand for in-kind rather than more efficient replacements.

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[188] "Johnson Controls Energy Efficiency Indicator, North America," Johnson Controls and the International Facility Management Association, 2008.

[189] Expert interviews.

[190] Expert interviews.

[191] Quantifiable transaction costs including costs for engineering time and system integration are included in the investment sum; transaction costs considered barriers include those with uncertain incremental financial impact given challenges regarding allocation of marginal employee time, and unclear or misperceived impacts on product quality and safety.

[192] Expert interviews.

CLEAN-SHEET REDESIGN OF SELECT INDUSTRIES

Recent studies indicate that the technical potential for efficiency reductions in many energy-intensive industries range from 35 to 71 percent with existing – but not necessarily cost-effective – technology. The "theoretical" potential for efficiency reductions (i.e., as limited by thermodynamics) range from 43 to 95 percent.[1] Capturing this technological potential, however, would require a clean-sheet redesign of operations, because retrofitting these measures into existing facilities would be too costly. Greenfield industrial projects are rare in the U.S., and plants are long-lived assets; as a result, experts have not detailed costs of these measures. Many measures, however, would likely be NPV-positive, if designed into greenfield facilities. The range of technical to thermodynamic potential for each industry analyzed includes:

- Chemicals: 71 to 88 percent, mostly through process-specific changes
- Mining: 60 to 95 percent, mostly related to on-site transportation, reducing what is transported and increasing efficiency of how it is transported
- Pulp and paper: 39 to 43 percent, mostly in paper drying
- Refining: 38 to 73 percent, mostly in improving crude distillation processes
- Steel: 35 to 43 percent, mostly in reducing heating temperatures.

While it would be difficult to achieve the technical limits within the next 5 to 10 years, clean-sheet redesign would enable manufacturers to gradually achieve world-leading levels of energy efficiency as they develop new assets. A long-term industry vision for greater energy efficiency would help direct research and development efforts.

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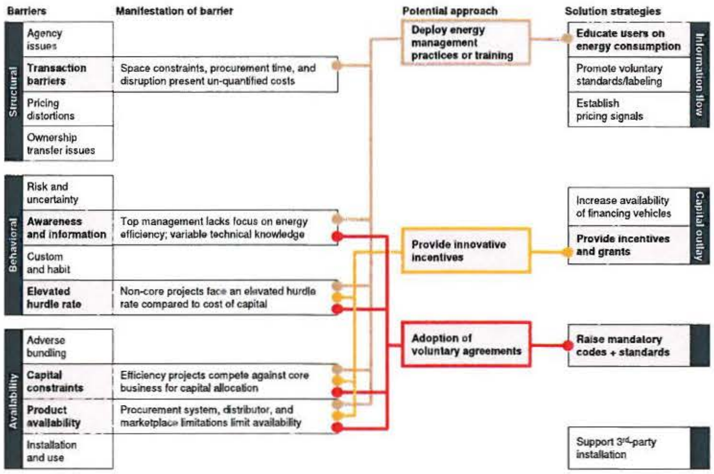
[1] Pulp and Paper Industry Energy Bandwidth Study, prepared by Jacobs Greenville, South Carolina, and Institute of Paper Science and Technology (IPST) at Georgia Institute of Technology Atlanta, Georgia, August 2006; Energy Bandwidth for Petroleum Refining Processes, prepared by Energetics Incorporated, for the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Industrial Technologies Program, October 2006; Steel Industry Energy Bandwidth Study, prepared by Energetics, Inc., for the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Industrial Technologies Program, October 2004; McKinsey analysis

Solution strategies to unlock the potential

Solution strategies to address these barriers cut across consumption clusters and fall into four groups: promoting energy management, providing energy assessments and training tools, offering monetary incentives, and establishing efficiency target agreements or equipment standards (Exhibit 34).

Exhibit 34: Addressing barriers in industrial clusters*



* Energy support systems, energy-intensive industry processes, and non-energy-intensive industry processes
Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

- **Promoting energy-management practices** *(proven/piloted).*[193] Strong company-wide energy-management practices supported by part-time or full-time on-site energy managers have proven effective in achieving greater energy efficiency. Specifically, energy managers can directly play a decisive role in capturing 1,730 trillion BTUs of end-use energy potential (47 percent of the efficiency potential identified in these clusters or 8 percent of total end-use consumption). They target this potential by implementing process and support system measures categorized as improving monitoring and control, improving operating practices, and assuring timely repair and regular maintenance. Implementing these measures will require $39 billion as upfront investment. Furthermore, this solution strategy directly addresses the awareness and attention and product availability barriers by giving primary responsibility to an individual or group. To address the capital allocation and elevated hurdle rate barriers, management could allocate appropriate funds to the energy manager. As of 2002, fewer than 2 percent of facilities had on-site energy managers,[194] despite clear examples of companies that reduced their energy costs by 20 to 30 percent through effective energy management.[195] Effective programs typically include a corporate-level, multi-year planning horizon; designated accountable energy managers and champions; sufficient capital allocation; process and support system energy auditing; and plant or line-level performance goals and performance tracking.[196]
  - EPA's ENERGY STAR Partnership focuses on helping industrial companies develop and refine corporate energy-management programs. In 2007, nearly 500 U.S. manufacturing partners made a commitment to follow the program's energy management guidelines. The guidelines included assessment, benchmarking, energy management planning, and progress evaluation.

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[193] Proven in two clusters (energy support systems and process improvements in energy-intensive industries) and piloted in one cluster (process improvements in the non-energy-intensive industries).

[194] MECS 2002.

[195] Aimee McKane, et al., "Certifying Industrial Energy Efficiency Performance: Aligning Management, Measurement, and Practice to Create Market Value," ACEEE, 2007. Expert interviews.

[196] Christopher Russell, "Strategic Industrial Energy Efficiency: Reduce Expenses, Build Revenues, and Control Risk," Alliance to Save Energy, July 2003.

- Plant certifications, similar to OSHA safety programs, can encourage adoption of energy-management programs. Energy-management certification protocols, such as the emerging ISO 50001 standard,[197] will likely strengthen energy-management practices.

- **Providing energy assessment and training tools** *(proven/piloted).*[198] Subsidized assessments and distribution of training materials can increase awareness of energy-saving opportunities:
  - The DOE Industrial Technology Program "Save Energy Now" represents a national initiative to drive a 25 percent reduction in industrial energy intensity in 10 years. It has already helped 2,100 U.S. manufacturing facilities save an average of 8 percent of total energy costs. They have performed 200 assessments of steam systems and process heat systems across 40 sites in 2006, 257 sites in 2007, and 301 sites in 2008. Surveys 6 months after the assessment showed participants had implemented or were in the process of implementing 60 percent of the recommendations. More than 90 percent of participants found assessments played an influential or highly influential role in their implementation of energy-saving projects.[199] Significant resource requirements would make enlarging programs like this challenging. Assessment of a single establishment costs approximately $10,000, including 2 FTE weeks. Assessing the top 10 percent would require an investment of $300 million, including more than 1,000 FTE-years.
  - EPA's ENERGY STAR Industrial Partnership (through Lawrence Berkeley National Laboratory) and other organizations have created subsector- and technology-focused guidebooks that highlight operational best practices and provide tools for conducting energy-savings assessments. Wisconsin's public benefits program, Focus on Energy, serves as one example of impact: an independent evaluation revealed that their pulp and paper guidebook achieved 67 percent market awareness; 75 percent of those aware of the report consulted the guidebook and 11 percent of those aware of the report implemented identified practices.[200]

- **Monetary incentives** *(piloted/emerging).*[201] Monetary incentives can address capital allocation and availability concerns, shorten payback times, and help overcome product availability barriers by reducing procurement challenges. There are multiple examples of innovations in this area:
  - Companies that have a strong relationship with end-users can improve the energy efficiency of related businesses by requiring greater energy efficiency from them and others in their supply chain. Wal-Mart's "supply chain of the future" initiative, for example, is targeting 20 percent energy savings in its supplier base by 2012, focusing on energy and emissions in seven product categories.[202] Wal-Mart provides suppliers incentives and support (e.g., subsidized energy audits) for

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[197] A consortium of companies and governments (including the U.S. Council for Energy Efficient Manufacturing) are currently developing ISO 50001, in order to make energy management an integral part of industrial operating practices on par with safety, quality, waste reduction and inventory management.

[198] Proven in two clusters (energy support systems and process improvement in energy-intensive industries) and piloted in one cluster (process improvements in the non-energy-intensive industries).

[199] Donald Kazama et al., "California's Industrial Energy Efficiency Best Practices Technical Outreach and Training Program," California Energy Commission, 2007. John Nicol, "Market Impact of the Pulp and Paper Best Practices Guidebook," Science Applications International Corporation, 2007; survey size: 19 customers.

[200] John Nicol, "Market Impact of the Pulp and Paper Best Practices Guidebook," Science Applications International Corporation, 2007; survey size: 19 customers.

[201] Piloted in two clusters (energy support systems and process improvement in energy-intensive industries) and proposed in one cluster (process improvements in the non-energy-intensive industries).

[202] "Supply Chain Sustainability: Wal-Mart's Commitment to the Future," SIF International Working Group, October 2008. <www.socialinvest.org/projects/iwg/documents/Anderson_Presentation_10-08_v2.pdf>.

  energy-saving projects. Similarly, a few manufacturers provide energy efficient equipment at reduced upfront cost, which they finance through shared savings.

  - Direct incentives from manufacturers, distributors, government, or utilities would accelerate the adoption of new technologies. Support system and process system upgrades remain rare, because of the large perceived risk of early adoption. Supporting pilots and providing incentives could help address this problem.

- **Establishing efficiency targets or equipment standards** *(piloted/emerging).*[203] Agreements tailored to a subsector can be effective in raising awareness of energy efficiency among top management. Such agreements can increase capital allocations, lengthen allowed payback times, build awareness at the line level, and increase product availability as management drives the organization to meet targets.

  - **Voluntary agreements.** A variety of commitments are possible with voluntary agreements,[204] including industry covenants, negotiated and long-term agreements, codes of conduct, benchmarking, and monitoring schemes. In return, participants may receive compensation, potential regulatory exemptions, avoidance of stricter regulations, and/or financial rewards. The flexibility, speed of implementation and ease of adjustment appeal to regulators, though concerns over recourse regarding non-compliance persist. Sweden's 2005 program launching 5-year agreements[205] and the Netherlands long-term agreements ("LTA1" and "LTA2") with the chemical industry to implement approved energy-management systems together drove 23 percent energy efficiency improvement from 1998 to 2006.

  - **Efficiency standards for support-system equipment.** Setting high efficiency standards for support-system equipment can help address technology availability by increasing demand (and therefore supply) of efficient equipment. The benefits of standards have to be balanced against implementation challenges arising from system customization, high engineering costs, limited speed of deployment, and long equipment life: for example, of 43,000 industrial, commercial and institutional boilers with heat input greater than 10 million BTUs per hour, 70 percent were more than 40 years old as of 2002,[206] limiting the impact of standards on new equipment. Standards are even more difficult, and possibly not cost-effective, to impose on specialized process equipment given the low volume and case-specific usage characteristics of such equipment.

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[203] Piloted in one cluster (process improvement in energy-intensive industries) and proposed in two clusters (energy support systems and process improvements in the non-energy-intensive industries).

[204] Though participation is usually voluntary, once industry members and regulators reach an agreement, non-compliance typically leads to penalties.

[205] Sweden requests companies to implement an accredited energy management system, carry out an energy audit and implement all identified measures with a payback period less than 3 years. In return the company receives a tax exemption on process-related electricity consumption, dependent on compliance.

[206] "Industrial Boiler MACT Analysis," EPA, 2002.

INDUSTRIAL AND COMMERCIAL COMBINED HEAT AND POWER

Combined heat and power (CHP) systems generate electricity and thermal energy in a single, integrated system. The result is significantly higher overall energy efficiency: engine-driven CHP systems can achieve total thermal efficiencies of 70 to 80 percent. This compares favorably to a net thermal efficiency of 45 percent from the combination of a conventional power plant and an on-site boiler providing comparable benefits.[207] Eliminating transmission and distribution losses and recycling waste heat produce this efficiency improvement.

Industrial CHP typically involves the use of steam or natural gas turbines for electricity generation, with capacities as high as 100 MW or more. Commercial CHP typically uses smaller systems providing some or all on-site thermal and electricity using natural gas reciprocating engines (capacities range from 800 kW to 5 MW). The United States has approximately 75 GW of on-site industrial CHP and 10 GW of installed commercial capacity. Installations are highly concentrated geographically, with 24 GW (28 percent of U.S. capacity) along the Gulf Coast in Louisiana and Texas, 5.8 GW in New York, and 9.2 GW in California.[208] It is worth noting that both California and New York have higher than average energy prices and spark spreads, and stringent air quality requirements, demonstrating that it is possible to achieve high levels of penetration to meet economic and compliance goals.

An additional 50.4 GW of CHP are NPV-positive for deployment by 2020, involving upfront investment of $56 billion (Exhibit 35) and providing a present value savings of $77 billion and an annual savings of 100 million tons of CO_2e emissions. The potential varies markedly by region, system capacity, and sector:

- The South (mostly industrial) and East (mostly commercial) Census regions offer 70 percent (approximately 35 GW) of the NPV-positive potential. Further variation of the potential by region depends on local power prices, space conditioning loads, and the cost and availability of primary fuels, typically natural gas.
- Large CHP systems (greater than 50 MW) represent some 70 percent of the NPV-positive potential in the industrial sector.
- Sectors like chemicals and iron and steel, which together consume 20% of the total industrial end-use energy represent a disproportionate share of the opportunity with 47% of the total industrial CHP potential, owing to their large steam energy requirements.
- Opportunities in the commercial sector represent 24 GW of NPV-positive potential distributed among small-scale installations in thousands of buildings across the country. Large office buildings (14 GW), healthcare facilities (6 GW), and universities (4 GW) comprise the largest opportunities.

Although some additional attractive opportunities may exist in residential or other commercial settings, substantial cost reductions would be necessary to create a broader market for CHP in these applications.

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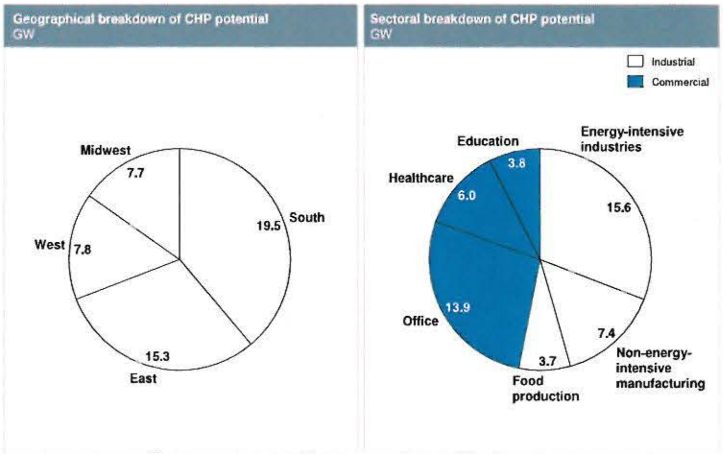
[207] Lauren R. Mattison, "Technical Analysis of the Potential for Combined Heat and Power in Massachusetts," University of Massachusetts, Amherst, May 2006.

[208] "CHP Installation Database," ICF International/EEA, accessed June 2009. < www.eea-inc.com/chpdata/index.html >.

Exhibit 35: Potential for combined heat and power (CHP) – 2020



Source: EIA AEO 2008; McKinsey analysis

The chart on left side of the exhibit shows the total amount of CHP potential (both industrial and commercial) divided among the four Census regions. The chart on the right splits out the potential by the different industries in the commercial and industrial sectors.

Barriers to greater energy efficiency

Over the past two decades, a number of technical and regulatory barriers to wider adoption of CHP have been removed; however, cost, information, and regulatory barriers impede the full capture of CHP potential in the industrial and commercial sectors.

- **Capital constraints.** Installing a CHP system requires significant upfront investment and ongoing operating expense that are recovered through lower energy costs over the life of the equipment.[209] Installation of a typical 10-MW gas turbine system can cost $10 million to $13 million, with annual non-fuel operating and maintenance costs ranging from $200,000 to $700,000.[210] Many industrials do not have the discretionary capital or are hesitant to use it on such a long-term investment.
- **Risk and uncertainty.** Beyond installation costs, developing a CHP system incurs a range of additional project and operational risks that the host company would not bear if it were to rely on a central utility for its power needs. These risks include installation overruns, system integration issues, permitting challenges, lost margin due to system shutdowns, volatility in gas prices, power price uncertainty, and environmental emissions exposure, among others. Additionally, moving to a single source of power exposes companies to higher commodity and disruption risk related to the chosen commodity.
- **Lack of awareness and limited management support.** CHP systems are often seen as fixed cost-centers that require non-core expertise to manage and operate.
- **Pricing distortions.** If rules governing grid connections are not supportive, they can be a significant obstacle to adoption. Operators of CHP systems must pay various tariffs that, while potentially justifiable from a grid operator's point of view, can diminish the attractiveness of CHP:
  - **Interconnection requirements.** Economic use of CHP for most customers requires integration with the utility grid for back-up and supplemental power needs, and, in some cases, sale of excess power. CHP systems must be able to safely, reliably and economically interconnect with the existing utility grid system. To

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[209] "CHP Project Development Handbook," EPA, 2008.

[210] "Catalogue of CHP Technologies," EPA, December 2008. Assumes 6000 annual hours of operation.

ensure safety and reliability of self-generators, grid operators typically need to grant approval for new generation systems prior to interconnection. The current lack of uniformity in interconnection standards makes it difficult for equipment manufacturers to design and produce modular packages;[211] gaining approval can, therefore, be complicated, time consuming, and costly.

  - **Standby rates and exit fees.** Facilities with CHP systems usually require standby or back-up service from the utility to provide power when the CHP system is down for routine maintenance or unplanned outages. The utility must therefore bear a maintenance cost associated with the generation, transmission and distribution capacity (depending on the structure of the utility) required to supply backup power when requested (sometimes on short notice). The level of these charges is often a point of contention between the utility and the consumer, and can, without proper oversight, create unintended and important barriers to CHP. Furthermore, customers that leave the grid may be charged an exit fee to allow a utility to recover future costs already allocated to the support of that customer. In some cases, the charges are prohibitively high, undermining the case for CHP installation.
  - **Site permitting and environmental regulations.** Input-based emissions standards penalize CHP systems that increase on-site emissions while decreasing overall grid emissions. Twelve states have adopted output-based environmental regulations. Output-based regulations are expressed as emissions per unit of useful energy output (e.g., pounds per megawatt-hour [lb/MWh]), and promote clean energy by accounting for the benefits of reduced air pollution effects from energy efficiency in the compliance computation.[212] CHP in ozone non-attainment areas in the 38 states where these regulations have not been enacted may require additional pollution-control equipment and emissions-offset purchases that can affect project economics.

Solution strategies to unlock potential

Overcoming the barriers to CHP deployment would likely require a mix of awareness campaigns, regulatory support (including provisions to align utility and ESCO incentives), and financing support (Exhibit 36).

- **Create CHP-supportive regulations** *(proven).* The United States has used regulations effectively to encourage CHP installation. Installed CHP capacity has increased from about 12 GW in 1980 to more than 52 GW in 1999. The lessons learned from previous legislation can inform development of a new model with similar aims, such as:
  - Target high-efficiency CHP systems that are designed to meet the thermal needs of the site. If this approach to a thermal base-loaded project produces excess electricity, it is important to then ensure means for a reasonable return on this excess electricity
  - Focus on balancing transaction and regulatory barriers, including standby charges, and interconnection requirements, with the need for overall efficiency, reliability, long term planning, and customer costs
  - Assure grid reliability for utilities and market clarity for would-be CHP installers
  - Consider output-based emissions standards and simplified environmental permitting procedures.

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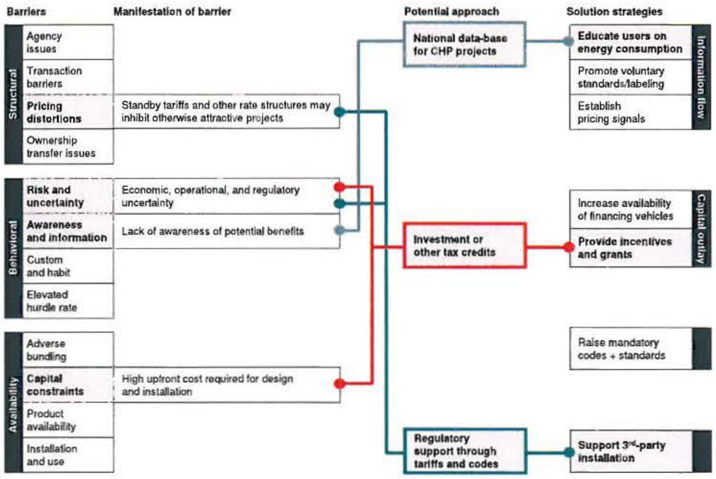
[211] "CHP Effective Energy Solutions for a Sustainable Future," DOE, December 2008.

[212] "Output-based Environmental Regulations Fact Sheet," EPA, 2007.

- **Provide financial incentives** *(proven).* Financial incentives to make CHP economics favorable for third-parties, utilities, and industrials could target upfront capital costs of the system or system installation costs. Tax rebates and direct incentives would help address upfront costs. Although tax rebates are widely recognized as an enabler for CHP systems, they may not be as effective in the commercial sector where some non-profit organizations (e.g., universities) would not be able to take advantage of them. In this case, direct incentives (e.g., grants) may prove to be more effective. Alternatively, an assisted-installation incentive, in which a qualified installer receives an incentive payment once a system is installed successfully and functioning,[213] could help address capital constraints while mitigating project risk and uncertainty.
- **Build awareness** *(proven).* A nation wide survey of industrial and commercial facilities that would be possible candidates for CHP could raise awareness of CHP's potential. A publicly available database of such facilities would decrease risks, uncertainties, and transaction costs for developers willing to support CHP installations and financiers willing to provide upfront financing.

Exhibit 36: Addressing barriers in combined heat and power (CHP)



Source: McKinsey analysis

The left side shows categories of opportunity-specific barriers that can impede capture of energy efficiency potential, with a description of the specific manner in which the barrier is often manifested in the cluster extending toward the right. The far right side of the exhibit lists general solution strategies for pursuing efficiency potential, with the near right column describing how this might be combined into specific approaches to overcome barriers in the cluster. The colored lines map specific solutions to specific barriers.

Additional policy options could support further deployment of CHP. Simplifying interconnection of CHP systems by standardizing grid interconnection guidelines and "fast tracking" approval processes would minimize several development risks and enable manufacturer cost reduction through scale. Implementing output- rather than input-based emission standards would allow CHP to gain full credit for the efficiencies embedded in its integrated design. Finally, aligning utility incentives by including CHP as an eligible resource for Renewable Portfolio Standards (RPS) and/or Energy Efficiency Resource Standards (EERS) could enlist utilities constructively in the development of this resource, an approach used in 13 states today.

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[213] NYSERDA and ConEdison offer $0.10 per kWh plus $750 per kW to a maximum of $2 million, while the federal government offered limited-term investment tax credits of 10 percent when launching PURPA in 1978.

5. Developing a holistic implementation strategy

Although the U.S. economy has improved energy productivity in important ways over the past three decades, significant opportunities remain. The intent of this research effort is to help inform discussion about ways to unlock opportunities for greater energy efficiency, as the nation considers how to ensure energy affordability, promote energy security, and address the issue of climate change. This report does not advocate a specific strategy or set of policies for capturing additional energy efficiency potential, rather it attempts to delineate issues and choices the nation will face. We hope that this report may provide business leaders, policymakers, and other interested parties with a solid fact base and some perspectives on possible approaches for economically sensible strategies for pursuing greater energy efficiency in the U.S. economy.

The central conclusion of our work: *Energy efficiency offers a vast, low-cost energy resource for the U.S. economy – but only if the nation can craft a comprehensive and innovative approach to unlock it. Significant and persistent barriers will need to be addressed at multiple levels to stimulate demand for energy efficiency and manage its delivery across more than 100 million buildings and literally billions of devices. If executed at scale, a holistic approach would yield gross energy savings worth more than $1.2 trillion, well above the $520 billion needed through 2020 for upfront investment in efficiency measures (not including program costs). Such a program is estimated to reduce end-use energy consumption in 2020 by 9.1 quadrillion BTUs, roughly 23 percent of projected demand, potentially abating up to 1.1 gigatons of greenhouse gases annually.*

In 2008 the nation spent an estimated $10 billion to $12 billion on efficiency-related investments;[214] capturing the full efficiency potential identified in this report would require an additional investment of roughly $50 billion per year (in present value terms, four- to five-times this value, sustained over a decade. Even the fastest-moving technologies of the past century that achieved widespread adoption, such as cellular telephones, microwaves, or radio, took 10 to 15 years to achieve similar rates of scale-up. Without an increase in national commitment it will remain challenging to unlock the full potential of energy efficiency.

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[214] Spending on energy efficiency in 2008 included $2.5 billion in utility-sponsored programs, $3.5 billion on energy efficiency in the $5-billion ESCO market, and $4 billion to $6 billion for incremental investment in insulation and efficiency devices. We excluded approximately $8 billion in spend on insulation because it represents standard building practice rather than incremental spend targeted solely at improved energy efficiency.

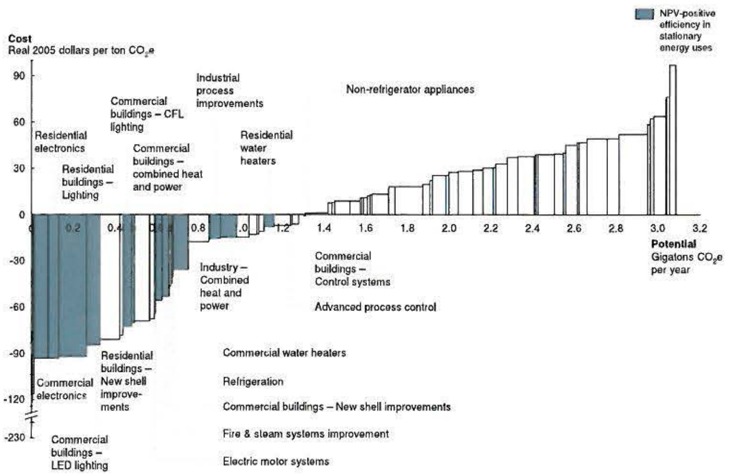
Accomplishing such an increase in scale will require a comprehensive strategy for pursuing opportunities and a coherent approach to system-level issues. Our research suggests five important observations are critical to consider when developing such a comprehensive strategy. Both national and regional strategies will need to:

1. Recognize energy efficiency as an important energy resource that can help meet future energy needs, while the nation concurrently develops new no- and low-carbon energy sources
2. Formulate and launch at both national and regional levels an integrated portfolio of proven, piloted, and emerging approaches to unlock the full potential of energy efficiency
3. Identify methods to provide the significant upfront funding required by any plan to capture energy efficiency
4. Forge greater alignment between utilities, regulators, government agencies, manufacturers, and energy consumers
5. Foster innovation in the development and deployment of next-generation energy efficiency technologies to ensure ongoing productivity gains.

1. RECOGNIZE ENERGY EFFICIENCY AS AN IMPORTANT ENERGY RESOURCE THAT CAN HELP MEET FUTURE ENERGY NEEDS, WHILE THE NATION CONCURRENTLY DEVELOPS NEW NO- AND LOW-CARBON ENERGY SOURCES

Energy efficiency is an important resource that is critical in the overall portfolio of energy solutions. Likewise, as indicated in our prior greenhouse gas abatement work, new sources of no- and low-carbon generation are also important components of the portfolio. While it may seem counterintuitive initially given the magnitude of the energy efficiency potential available over the next decade, there are important reasons for continuing to develop new no- and low-carbon options for energy supply. First, as described in our original report on U.S. greenhouse gas (GHG) abatement (Exhibit 37), energy efficiency in stationary uses of energy represents less than half of the potential abatement available to meet any future reduction targets. Additionally, some areas of the country will continue to experience growth and some may need to retire and replace aging existing assets. The uncertain growth of electric vehicles could further these requirements. Finally, pursuing energy efficiency at this scale will present a set of risks related to the timing and magnitude of potential capture. As such there remains a strong rationale to diversify risk across supply and demand resources.

Exhibit 37: U.S. mid-range greenhouse gas abatement curve – 2030



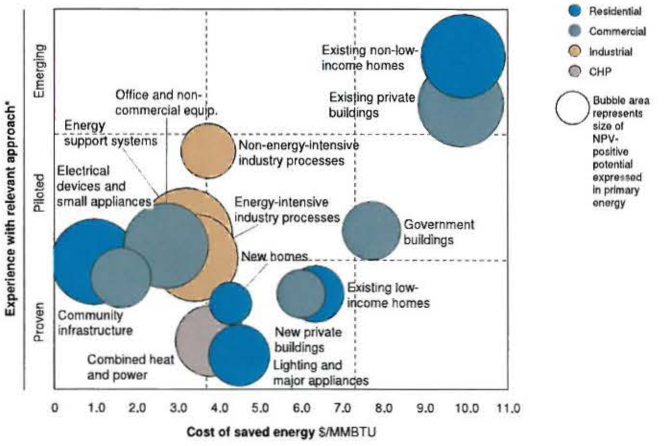
This exhibit shows the mid-range greenhouse gas abatement potential as depicted in McKinsey's greenhouse gas report, with the energy efficiency opportunities from stationary sources highlighted. The height of each bar is the cost in dollars to abate a ton of carbon; the width is the gigatons of carbon emissions equivalent abated per year.

2. FORMULATE AND LAUNCH AT BOTH NATIONAL AND REGIONAL LEVELS AN INTEGRATED PORTFOLIO OF PROVEN, PILOTED, AND EMERGING APPROACHES TO UNLOCK THE FULL POTENTIAL OF ENERGY EFFICIENCY

A range of tools can stimulate demand for energy efficiency, from those with a heavy reliance on market forces (e.g., education and awareness building, greater information transparency, price signals, energy efficiency markets) to those with a more interventionist approach (e.g., mandates, codes, standards, and efficiency performance targets). To capture the magnitude of potential identified in our research within the timeframe it uses, the U.S. will need to establish energy efficiency as a national priority and assemble a portfolio of strong, coordinated policies and market mechanisms drawing from the proven, piloted, and emerging solution strategies discussed in Chapters 2 through 4. Exhibit 38 arrays the clusters of potential (scaled to size of the opportunity) by the required upfront investment (dollars per MMBTU of efficiency gain) along the horizontal axis and the experience with a given solution strategy used to capture that cluster's potential (proven, piloted, or emerging) along the vertical axis. This tool facilitates evaluation of a portfolio against the relevant parameters of cost, risk (i.e., experience), and return (i.e., size of potential). The portfolio depicted focuses on the most proven solution strategies deployed to date. The portfolio focuses on codes and standards for electrical devices and small appliances, lighting and major appliances, office and non-commercial equipment, and new buildings. It looks to government intervention to address existing low-income homes (i.e., WAP). Finally, it employs a blend of voluntary agreements, mandates, and incentives for industrial clusters, government building, community infrastructure, and CHP and a mix of audits, labeling, and incentives for existing private commercial buildings and non-low-income homes.

Exhibit 38: Portfolio representing cost, experience, and potential of clusters possible with specified solution strategies

The bubbles depict the NPV-positive efficiency potential in each cluster, measured in primary energy, with the area of the circle proportional to the potential. The position of the bubble's center on the horizontal axis indicates the cost of capturing this potential with the measures modeled in this report (excluding program costs) in dollars per million BTUs per year. The center's position on the vertical axis represents the weighted average of the national experience with the approaches outlined for the cluster.



* Drawing an analogy to our work with business transformation; piloted solutions represent those tried on the scale of a state or major city (i.e., over 1 million points of consumption), emerging are untested at that level, and proven have broad success at a national scale

Source: McKinsey analysis

In addition to seeking the impact of national efforts this portfolio should effectively and fairly reflect regional differences in energy efficiency potential. Any approach would need to make the following three determinations:

- The extent to which government should mandate energy efficiency through the expansion and enforcement of codes and standards
- Beyond codes and standards, the extent to which government (or other publicly funded third parties) should directly deploy energy efficiency
- The best methods by which to further stimulate demand and enable capture of the remaining energy efficiency potential.

Use of codes and standards

Codes and standards have proven effective at capturing potential at national and state levels. Codes and standards have advantages over other solution strategies in that they match the incremental investment directly to those users who enjoy the reduced consumption benefits; they offer a high level of certainty about execution; and their cost of execution, at $0.15 to $0.30 per MMBTU,[215] is typically lower than other approaches. There would be some disadvantages to codes and standards: these would include costs for effective enforcement; the difficulty of gaining agreement on the level and design of the code, which could slow implementation and reduce impact; and, if not well designed, a forcing of uneconomic measures in some regions or specific situations, even if measures were economic on average. Additionally, some observers have reservations about government intervention, and the corresponding sacrifice of personal liberty, leading them to favor more market- or voluntary-based approaches.

To the extent that legislators pursue codes and standards to capture the full potential in areas where codes and standards currently apply (new buildings, lighting and major appliances, electric devices and small appliances, and office and non-commercial equipment), they would address 2,090 trillion end-use BTUs (23 percent) of the potential energy savings. The required upfront incremental investment associated with deployment

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[215] *Scenarios for a Clean Energy Future*, Interlaboratory Working Group, ORNL/CON-476 and LBNL-44029, November 2000.

of efficiency measures prompted by these codes and standards would total $53 billion and produce approximately $240 billion of present value in energy savings.

There are, however, additional areas where codes and standards could apply. For example, if a broader approach were taken to place codes and standards on government buildings and energy-intensive industries where such measures have been piloted, these figures would grow by an incremental $77 billion in upfront investment, which would yield an additional 1,910 trillion end-use BTUs (21 percent of total potential) in energy savings and offer $231 billion of present-value benefits. An even more expansive application of codes and standards would apply them to existing commercial enterprises and residential buildings. This would offer 2,110 trillion end-use BTUs (23 percent of total potential) of energy savings, requiring an incremental upfront investment of $226 billion and providing an associated $271 billion in present-value savings. This approach would be analogous to requiring emissions inspections on existing vehicles and requiring owners to pay for bringing vehicles up to standard if they fail the emissions test; however, these energy efficiency upgrades would be NPV-positive, returning the owners more savings than the upfront cost.

The design of building codes would need to balance the benefits of uniformity with those of regionality. Uniform codes enable manufacturers to capture economies of scale, reducing the total cost of implementation to society. Regionality allows customization to account for such factors as climate or local energy prices. In addition, administration and enforcement at the state, regional, and federal levels each have advantages and challenges. Codes and standards set at a national or regional level would establish the "floor" for efficiency going forward. Once the strategy for codes has been developed, other aspects of a comprehensive strategy could be layered into place.

Role for government (or other publicly funded third parties)

Select clusters, including low-income existing homes, government buildings, and community infrastructure, may warrant government (or other publicly funded third party) intervention. These clusters present a social imperative or represent a shared resource potentially justifying public intervention.

The DOE's Weatherization Assistance Program (WAP) has been effective with existing low-income homes. Over the past 32 years WAP has retrofitted 6 million of the existing 45 million low-income homes, with an average pace in recent years of approximately 100,000 homes per year. With recent economic stimulus funding of approximately $5 billion, the program is projected to address some 1 million homes per year for the next 3 years, a 10-fold increase in pace. Capturing the full efficiency potential of 610 trillion end-use BTUs available in 2020, however, would require a further eight fold increase in spending to fund the unaddressed approximately $40 billion of upfront investment in this cluster. Government intervention could be expanded in clusters where it is appropriate but less proven, namely government buildings, and community infrastructure. Addressing the entire potential in these clusters, as well as non-low-income homes, offers 1,260 trillion end-use BTUs (14 percent of total potential) with an upfront cost of $76 billion and present value savings of $174 billion. Alternatively, limiting this approach to homes while deepening it to address all households with annual incomes under $50,000 would address 1,090 trillion end-use BTUs (12 percent of total potential) and require $94 billion in upfront investment.

Other means to stimulate demand

Any portfolio of solutions will require approaches for stimulating demand for greater efficiency beyond codes and standards and government intervention. Exhibit 39 outlines six commonly discussed tools for stimulating demand and comments on their relative merits against five criteria. Either market participants or policymakers could use these tools. Manufacturers or distributors, for example, often launch an awareness campaign when marketing products; load-serving entities could approach regulators about adjusting recovery mechanisms to provide more accurate price signals to power customers. A balanced portfolio would seek to capitalize on the strengths of all market participants in the context of activities by other participants. Though these additional approaches may be helpful in pursuing efficiency potential in clusters where codes, standards, and third-party deployment are used (as described above), these additional approaches may be especially useful in the remaining clusters. These otherwise underserved clusters include existing non-low-income homes, existing commercial enterprises, energy support systems, non-energy-intensive industry processes, and combined heat and power which together represent 4,200 trillion end-use BTUs (46 percent of total potential) and have an associated $344 billion in upfront investment providing present value savings of $608 billion.

Exhibit 39: A wide portfolio of approaches will be necessary to capture the full efficiency potential

A portfolio of strategies will be necessary for the full energy efficiency potential to be realized. Each of the strategies is described across a range of factors.

Strategy	Experience to date	Speed of deployment	Complexity of implementation	Source of investment	Administration & other costs
Education and awareness	Varies, depends on message design	Slow. as it requires behavior change	Simple in concept; requires careful message design	End user	Typically 15 percent or less
Transparency of consumption information	Low – only piloted; unclear durability as may rely on conservation	Slow, as it requires behavior change and infrastructure	Challenging, requires incorporation into many devices and simple home display	End user	Unclear, depends on device, with prices ranging from pennies to hundreds of dollars
Price signals	Impact on efficiency not directly evaluated	Fast to implement, time to capture savings will vary	Dependent on rate structure proposed	End user	Limited incremental costs
Energy efficiency resource standards	Unclear	Fast to implement, time to capture savings will vary	Simple to design, can have complicated EM&V	Public	Limited incremental cost; total cost dependent on programs deployed
Energy efficiency credits	Unclear	Fast to implement, time to capture savings will vary	Complex to design, requires complicated EM&V	Public	Unclear
Financial incentives	Moderate to high given success of utility scale programs	Slow, as it requires behavior change	Straight forward	Public	Varies between 10-50% by program type, effectiveness & scale

Source: McKinsey analysis

- **Education and awareness.** Options for improving awareness include expanded labeling of devices and buildings; benchmarking; building audits and disclosures; annual reporting requirements (e.g., an annual energy "10K" from businesses); and education campaigns. Increased education and awareness is widely viewed as a necessary-but-not-sufficient component of a holistic approach, because it relies on end-user activity and provides savings of unclear durability. However, it can be highly cost effective, even at low capture ratios, if well designed.

- **Transparency of consumption information.** A variety of tools would improve transparency of consumption information and relative energy performance, including in-home displays of energy use, similar to a "miles-per-gallon" display in cars; availability of consumption on-line, similar to usage counters for mobile phones; and building control systems that allow for real-time tracking of consumption for major pieces of equipment. Studies in multiple countries have shown that transparency into real-time consumption (e.g., through in-home displays) can result in long-term 4- to 15-percent reductions in demand, while delayed feedback provides lower savings.[216] It seems important to include the context of any numbers provided such as relative performance compared to similar buildings or efficient products currently available commercially. This approach suffers from limitations similar to education and awareness, but represents a policy of limited market intervention.

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[216] Sarah Darby, "The Effectiveness of Feedback on Energy Consumption," Environmental Change Institute, University of Oxford, April 2006.

- **Price signals.** There are several options for price signals, including tiered pricing (e.g., higher rates for higher levels of consumption), general rate increases, and rate adders, such as a cost for carbon. These could increase the price of energy and enhance the financial attractiveness of energy efficiency. While there is undoubtedly some price level that would drive wide-spread adoption of efficiency measures, the challenge will be the political acceptability of achieving – and sustaining – a high enough price to induce significant adoption. Based on EIA estimates of price elasticity, energy prices would need to increase by approximately 20 percent for industrial customers and approximately 50 percent for residential and commercial customers for consumption to decline by the amount identified as NPV-positive potential in this report.[217] There is, however, no guarantee that customers will seek efficiency solutions to reduce demand.
- **Energy Efficiency Resource Standards (EERS) and targets.** Business leaders and policymakers could stimulate demand more directly by establishing energy efficiency targets at the national, state, or local levels. Targets should be set against a forecast consumption that includes growing and emerging applications (plug-load devices, data centers, and electric vehicles, for example) and is regularly re-evaluated to assure accuracy. Targets could also apply to specific segments; for example, new federal government buildings must reduce energy consumption by 30 percent, as mandated by the Energy Independence and Security Act of 2007. Targets should incorporate an assessment of the efficiency potential within a region, with careful attention to differences in climate, energy cost, and prior efficiency measures. California, for example, has made measured progress at capturing energy efficiency for decades and benefits from a mild climate. As such, it may require a different target than regions with less well-established efficiency efforts and different consumption profiles. Some approaches to capturing energy efficiency may result in funds collected in one customer class to be invested for the benefit of another. Regulators may want to make provisions to align funds and investments within a customer-class. EERS offers the advantage of clearly articulating an expected pace and magnitude of efficiency improvements, while leaving the choice of specific actions open. Furthermore, the managers of targets remain responsible for developing a portfolio of solutions to capture the potential.
- **Energy efficiency credits (EEC) and markets.** A market for efficiency could take several forms, though the central objective would be to enable market participants to compete for savings to meet an energy efficiency target. To some extent, this approach operates today in two forward-capacity markets (New England and Pennsylvania-New Jersey-Maryland power markets). Energy efficiency bids captured 26 percent of the 2,550 MW of new and existing demand resource capacity in the ISO New England's February 2008 auction. Ideally, such markets would attempt to deliver the most cost-effective efficiency to meet targets. These markets, however, are relatively untested, potentially complex and expensive at scale, and require well-developed evaluation, measurement and verification (EM&V) systems. Creating an efficiency market at scale would require development of rules to define tradable credits and could be challenging to administer. If pursued such a market would need to be tested thoroughly to understand all implications before being deployed at a national level. Finally, an EEC market requires a target (e.g., EERS) and faces the challenges discussed under that mechanism (above).
- **Financial incentives.** Utilities and governments offer diverse financial incentives in the form of rebates, price subsidies, and tax incentives to participants in the industrial, commercial, and residential sectors. Though a proven method, incentives do rely on end-user participation and are limited to addressing capital barriers,

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[217] AEO 2003 price elasticity study incorporated into the National Energy Modeling System (NEMS) suggests residential price elasticities of -0.41 to -0.60 and commercial elasticities of -0.39 to -0.45 for different fuels; industrial of -1.0. Energy Information Administration: price responsiveness in the AEO 2003 NEMS residential and commercial building sector models.

including elevated discount rates and access to capital. Further, administrative costs (see below) vary with approach, program maturity, and administrative effectiveness. A scaled-up program should identify the most cost effective channel and administrative structure to drive impact.

The magnitude of the effort implied by pursuing such an extensive integrated portfolio should not be underestimated. The pace of deployment will be a significant consideration, given challenges with the legislative process, manufacturing constraints, and human resources.

- **Legislative process.** Crafting legislation, understanding its impact on stakeholders, and moving through the public process to law and rule-making can consume significant time and often require substantial compromise. Codes typically take 3 years to institute, while new legislation takes an unknowable but considerable amount of time and resources (for example, carbon pricing legislation was first introduced in the U.S. Congress in 1998 and is still under consideration in 2009). Creating the necessary administrative structures will also require considerable time.
- **Manufacturing constraints.** Producing hundreds of billions of dollars of merchandise needed for deployment will be challenging. Nonetheless, some manufacturers have indicated that – if demand signals are clear – they can produce the required products within a few years. For example, SEER-13 air conditioners grew from 5 percent of sales to 90 percent in only 3 years with the introduction of a new standard.[218] Others remain concerned about having capacity to increase output to required levels if the nation were to pursue the full savings identified in this report.
- **Human capital requirements.** Limitations in the available workforce and skill base will likely present a significant challenge. Despite a national appetite for new jobs – especially green jobs – identifying, training, and deploying contractors, inspectors, manufacturers, managers, and administrators within the timeframe envisioned in this report represents a considerable effort. Capturing the full potential could require a workforce of roughly 600,000 or more active over the next decade to develop, produce, deploy, administer, and verify efficiency measures.

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[218] Expert interviews.

JOB CREATION

Energy efficiency has been much discussed for its potential to create jobs, particularly in an economic downturn. A full economic analysis of energy efficiency (i.e., general equilibrium analysis) is beyond the scope of this work; however, research suggests that the employment benefits of increased national energy efficiency could be significant. The number of jobs created by unlocking the full efficiency potential identified in this report is difficult to forecast, but research suggests that on a national level jobs created through labor intensive retrofits could total 600,000 to 900,000 on-going jobs that persist through the decade covered by this report. This total includes jobs created though two major initiatives:

- **Labor intensive retrofits.** Assuming roughly $290 billion is invested in deployment of labor-intensive efficiency measures in the residential and commercial sectors between 2009 and 2020, energy efficiency retrofits could generate between 500,000 and 750,000 direct, indirect, and induced jobs through 2020:
  - **Direct jobs.** Physical deployment of efficiency measures would involve construction workers (≈60 percent), trade professionals (≈25 percent), and their managers (≈15 percent), with an average salary of $36,000 to $41,000. In weatherization programs direct jobs represent 30 to 40 percent of the jobs created.[1]
  - **Indirect jobs.** Suppliers of materials used in energy efficiency measures, such as insulation or appliance manufacturers, in the United States and overseas, would see 25 to 40 percent of the jobs created, depending on the measures deployed and country where the jobs are located,[2] with an average salary of $26,000.
  - **Induced jobs.** Local jobs generated by a larger workforce (i.e., where direct workers spend their paychecks, such as grocery stores) represent the remaining 25 to 40 percent of jobs created.[3]
- **Energy efficiency programs and codes and standards.** Other energy efficiency programs could create a range of jobs as well. Improved building codes and equipment standards, plus various other efficiency programs, such as rebate or awareness initiatives, would likely create a range of jobs in manufacturing, engineering, program management, and government roles.[4] Increasing enforcement of building codes nationwide – currently at about 50 percent compliance – would also likely require adding building officials in municipalities across the country. In total these jobs are likely to exceed 100,000.

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[1] Economic Opportunity Studies, "How Many Workers Does the Weatherization Assistance Program Employ Now? What Jobs Will the Recovery Act Offer?", 2009.

[2] Indirect jobs include jobs created in other countries at manufacturers, which research suggests may be even larger than the domestic job creation; Robert Atkinson, "The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America," Information Technology and Innovation Foundation, January 2009. David Swenson and Liesl Eathington , "Determining the Regional Economic Values of Ethanol Production in Iowa Considering Different Levels of Local Investment," Iowa State University, July 2006; Josh Bivens, "Updated Employment Multipliers for the U.S. Economy," Economic Policy Institute, August 2003.

[3] Economic Opportunity Studies; Robert Atkinson; David Swenson and Liesl Eathington; Josh Bivens.

[4] Natalie Hildt, "Appliance and Equipment Efficiency Standards: New Opportunities for States," Appliance Standards Awareness Project, December 2001; David Roland-Holst, "Energy Efficiency, Innovation and Job Creation in California," Center for Energy, Resources and Economic Sustainability, October 2008.

3. IDENTIFY METHODS TO PROVIDE THE SIGNIFICANT UPFRONT FUNDING REQUIRED BY ANY PLAN TO CAPTURE ENERGY EFFICIENCY

Defining a portfolio of policies and mechanisms will require trade-offs among the five characteristics defined in Exhibit 39 – experience to date, speed of deployment, complexity of implementation, source of investment, and administration and other costs. Identifying appropriate and sufficient funding for the upfront investment will be a particular challenge, for which there are two broad approaches. "End-user funding" refers to occasions when end-users pay for energy efficiency investments directly (upfront or over time), even when driven by a building code or appliance standard. "Public funding" refers to monies that are provided through any third-party channel (e.g., state, federal, or local tax revenues, CO_2e allowance receipts, utility rates, or system-benefit charges).

- **End-user funding methods.** End-user funding by consumers has proved difficult for capital-intensive measures, due to the multitude of barriers described in Chapters 2 through 4. Partial monetary incentives and supportive codes and standards increase direct funding by end-users by encouraging participation: the former by reducing initial outlays and raising awareness, the latter by essentially requiring participation.[219] Performance contracting represents another method, one that has begun to find acceptance in commercial and industrial markets. ESCOs fund the upfront investment for efficiency improvements or connect customers with a financier, in order to share in the energy and maintenance savings generated by the investments, while the resulting cash flows remain positive for the end-user at all times. The risk of business failure among ESCO clients, as well as ordinary business churn, and the corresponding repayment exposure presents a significant challenge to ESCOs and has limited their effectiveness to date. With a blend of public and end-user funding mechanisms, a loan guarantee program could help overcome this issue; loan guarantees potentially requiring 3 to 6 percent of the invested amount, could help enable the upfront investment needed.[220]
- **Public funding sources.** Load-serving or government entities typically raise funding for energy-supply requirements, such as new power generation, new power and gas delivery infrastructure, or other public goods, by spreading the costs across all consumers. When pursuing energy efficiency utility or third-party programs typically "stimulate" demand through incentives for only a portion of the investment, because much of the benefit flows to participating end-users through lower bills. As an alternative, programs such as the WAP fully fund and execute efficiency improvements with public funds. Utilities or third parties typically gather program funds through system-benefit charges, though less conventional means, such as proceeds from a carbon price, have been discussed. Funding the entire deployment cost of $520 billion would require a system-benefit charge of $0.0059 per kWh across 4,250 TWh of electricity and $1.12 per MMBTU across 24.5 quadrillion end-user BTUs of other fuel for a period of 10 years, the anticipated implementation period. Alternatively, 10 years of a carbon price of $12.50 per ton on 4.2 gigatons of CO_2e emissions could fund the upfront investment as well. These costs would add approximately $120 to the average annual homeowner's energy bill as well as $2,400 and $75,000 to the average commercial and industrial building annual energy bill. However, as mentioned below, average energy bill reductions would more than offset these investment costs. Savings of 24 percent in average customer energy bill from the efficiency savings would more than offset the 8-percent increase in bills to fund the upfront investment.[220]

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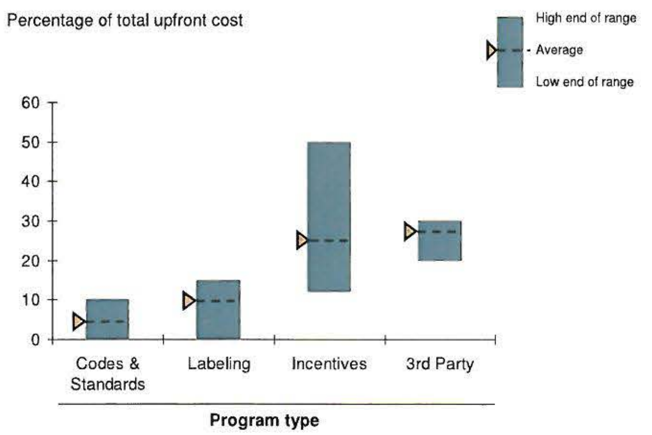
[219] It is worth noting that appliance standards and building codes may reduce the premium required for efficiency measures as manufacturers drive down cost through increased scale; this effect is not incorporated in our analysis.

[220] The student loan model represents the basis of this approach. The insuring agent charges 1 to 2 percent of the credit issuer to guarantee the loan amount and bears the default risk, typically 5 to 6 percent. Applying this model to performance contracting yields a net cost of 3 to 6 percent of the loan amount.

Portfolio designers would also need to consider the efficiency of spending within each solution strategy. Program spending will depend heavily on how programs are designed, the effectiveness of the program and management teams, and many other factors. Nonetheless, different program types do appear to involve different levels of spending. Exhibit 40 shows the average program cost, as well as high and low ranges of typical programs, expressed as a percentage of the upfront investment needed. It is worth noting that codes, standards, and awareness building (i.e., labeling) require the least overhead of the four broad strategies identified. With the scale advantage brought by a national effort, however, program costs for other approaches, namely third-party implementation and provision of incentives, could decrease substantially.

Exhibit 40: Program cost ranges by program type



Source: Scenarios for a Clean Energy Future, Interlaboratory Working Group, 2000;
McKinsey analysis, EIA, ACEEE, From 861 filings

The height of the columns on the chart represent the range of administrative costs of different program types, as a percentage of the total upfront costs.

4. FORGE GREATER ALIGNMENT BETWEEN UTILITIES, REGULATORS, GOVERNMENT AGENCIES, MANUFACTURERS, AND ENERGY CONSUMERS

Designing and executing a coordinated initiative across more than 100 million residential, commercial, and industrial sites will be a major challenge. If such an initiative is to realize a substantial portion of the efficiency potential available, then many parties will participate, including government agencies, utility regulators, manufacturers, utility companies, interested community support organizations, building owners, and end-users. Forging this alignment should address four concerns:

- Overcoming regulatory barriers in utility ratemaking
- Understanding the relationship between bills and rates
- Establishing responsibility in currently unaddressed areas
- Achieving appropriate evaluation, measurement, and verification.

Overcoming regulatory barriers in utility ratemaking

The task of aligning a utility organization with the goal of achieving greater energy efficiency and ensuring its objectivity would have two parts: a financial challenge and a cultural challenge.

Financial challenge. The financial challenge stems from legacy regulatory practices in rate-making, which base utility revenues on the number of units of energy sold. The price of each unit of energy typically covers the variable costs as well as a significant portion of the fixed costs of generating or producing and delivering the unit of energy, on the basis of projected sales volume. If more units are sold than projected, earnings will be higher as the utility over-recovers its investment; if fewer units are sold, earnings will be lower and the utility will not be compensated for its investment. Rates are periodically "trued up," that is, adjusted to more accurately provide for recovery of and return on investments, but in the time between these "rate cases" utilities face both positive and negative exposure to sales volume fluctuations. Variations in volume can result from many factors, including changes in weather, economic activity, increased penetration of devices, and reductions associated with more efficient devices. Under traditional rate mechanisms, utilities typically under-recover on their investments and see a decrease in earnings when electricity load declines due to energy efficiency initiatives. This erosion in finances becomes an even greater concern if utilities are expected to concurrently provide power purchase agreements (PPAs) to developers for renewable energy or undertake significant construction of renewable assets themselves, because constructing new assets, for example, requires balance-sheet strength and the ability to raise capital. Several options can help overcome this potential disincentive to pursue energy efficiency and address the financial risk associated with other energy goals:

- **Decoupling revenues from units sold.** Decoupling is a system of periodic true-ups in base rates that separates the recovery of authorized fixed-cost revenue from sales volume. While units of energy are still priced above their variable cost, decoupling both restores to the utility costs that are under-recovered, and returns to customers costs that were over-recovered. This is because the revenue collected from unit sales is reconciled to an alternative method for determining target revenue. While addressing the concern energy efficiency raises regarding recovery of existing investments, decoupling raises several concerns for utilities, customers, and regulators. First, utilities may be concerned that decoupling carries unknown regulatory exposure. Furthermore, customers may be concerned that decoupling shifts normal business risks such as weather or slumps in economic activity to ratepayers, rather than leaving them with utilities. However, some regulatory mechanisms exist to shift these risks, especially weather, back to the utility. Finally, regulators may be concerned that decoupling does not provide incentive for a utility to actively pursue energy efficiency; at best, it removes a portion of the disincentive associated with lower sales. In high-growth markets, there is also resistance to decoupling, because it could work against the benefit to utilities of regulatory lag; whereas in declining markets, decoupling works against the benefit to customers of regulatory lag. Thus, while decoupling offers some benefits in mitigating the volume exposure faced by utilities, it may not be the best approach in all areas, and may be insufficient on its own to drive energy efficiency.
- **Migrate to true fixed/variable rate structures.** An alternative approach would involve reducing the per-unit cost of energy to the true variable cost and assessing a flat fixed-cost charge to each customer. Incremental sales up or down would not impact utility profits. Some raise a concern that very low unit prices may work against consumers' desire to reduce consumption. However, prices could be set to accurately reflect the intermediate- or long-term costs of investing in fixed infrastructure and potential climate impact. Such a price signal could reduce consumption to levels appropriate to the "real" cost of energy. There is a practical challenge with this mechanism: migrating from the prevailing approach to a true fixed-variable structure could benefit heavy electricity users relative to others within a rate category (and, for example, might increase the burden on low-income and fixed-income populations). Again, this approach does not in itself create an incentive for utilities to pursue energy efficiency.

- **Modifications to traditional regulation.** Modifications to the traditional volumetric approach to revenue offer an additional set of options. These modifications could include ROE caps or sharing mechanisms to distribute "excess" profits back to customers, more frequent rate true-ups, test cases incorporating projected energy efficiency impact, and/or special trackers to capture costs and lost revenues due to energy efficiency. These modifications can reduce – but will likely not fully remove – the alignment challenge associated with volumetric recovery, though they can overcome some of the other disadvantages cited above.

These mechanisms and others might reduce the disincentive for utilities, but they do not create a positive incentive to pursue energy efficiency at scale. There remains a risk that utilities might choose to remain neutral toward energy efficiency, rather than commit and aggressively pursue the full potential. Regulators will likely need to assure utilities of timely cost recovery of program expenses. Additionally, a number of incentives and modifications to existing recovery mechanisms could motivate utilities to promote energy efficiency. Regulators and legislators have proposed or implemented a number of these mechanisms already:

- **Shared savings.** Similar to the ESCO model for the end-user market, this approach allows for the stream of energy savings to be shared with the utility. Generally, the amount expended on energy efficiency is recovered in the same year, minimizing the utility's risk of recovery. This incentive structure links utility compensation to the savings provided for the customer, and requires a clearly defined methodology for calculating the savings.
- **Performance incentive.** This mechanism is typically linked to program spending or the allocated budget, providing a payment based on performance against energy efficiency spending targets. With this approach as well, utilities recover the costs of energy efficiency programs within the year. This incentive structure links utility compensation to the scale of programs undertaken.
- **Capitalization.** This method links energy efficiency with traditional utility earnings-growth mechanisms by allowing capitalization of actual upfront investments for energy efficiency, which are then recovered over future years on a set depreciation schedule. Some markets provide a higher return on equity – a "bonus ROE" – for energy efficiency-related capital to promote the allocation of capital to energy efficiency projects. Capitalization approaches allow for a customer-owned asset to appear on the utility's books. A key risk of the capitalization model, is the ability of a regulator to eliminate one of these "virtual" (regulatory) assets from the utility's balance sheet, destroying cost recovery in the process.
- **Virtual power plant.** This approach links energy efficiency with traditional utility investment mechanisms by allowing the utility to substitute energy efficiency investments for avoided power plant investments. The utility has responsibility for producing an equivalent level of "capacity" from energy efficiency at a reduced cost relative to construction of new supply, plus an incentive to most effectively deploy that capital. The virtual power plant model faces the same risk of regulatory elimination though as the capitalization model.

These incentive mechanisms can provide a wide range of compensation, depending on the specific values chosen and the level of energy efficiency targeted. It is important to note that the incentives are "exchangeable" in value: for any set of incentives, there are values that will make them equivalent in payout for a specific utility. The primary differences relate to both the nature and degree of the risks borne by utilities and ratepayers. The design and selection of the appropriate incentives and regulatory mechanisms should be based on careful analysis of the unique situation in each regulatory jurisdiction.

In summary, various mechanisms could improve the alignment between the utilities' financial incentives and the challenge of aggressively pursuing energy efficiency. There is not one best answer that will work for all utilities, given the differences in markets, regulatory practices, customer preferences, and utility risk profiles. However, in general we find across rate-making mechanisms and the wide range of potential incentives, that:

- To fully align load-serving entities and local distribution companies or utilities with the goals of energy efficiency, they must recover the revenue associated with their lost load, receive timely recovery of program costs, and earn incentives on energy efficiency to assure their financial health.
- Single solutions are generally not enough to make an energy provider financially whole in the face of energy efficiency. Most shareholder-incentive programs do not fully compensate investor-owned utilities. Neither decoupling nor true fixed/variable structures, though they can reverse the effect of energy efficiency on short-term returns, can by themselves compensate an energy provider for long-term growth in many scenarios.
- A combination of shareholder incentives and fixed-cost recovery mechanisms can make energy providers financially whole in most market structures. The appropriate level of incentive and choice of fixed-cost recovery mechanism will vary based on the market structure, growth environment, initial market position, and mix of chosen mechanisms.

Cultural challenges. Beyond the financial challenge of achieving full alignment with greater energy efficiency, many consumers and energy providers will also need to overcome cultural inertia brought on by years of promoting consumption of energy. This mindset is a natural byproduct of the customary business practices, and for many years the growth of energy consumption has brought substantial comfort and benefits to customers. The fundamental challenge will be to change the mindsets and behaviors of employees throughout the energy providers' organizations. The U.S. economy, however, offers many stories of comparable transformations in other industries, be it around such topics as quality control, lean production, innovation, or customer-service mindsets.

Understanding the relationship between bills and rates

One of the most perplexing challenges associated with energy efficiency in the electricity sector is that although it clearly will drive down average energy bills, the integrated effect on rates (i.e., the cost per unit of electricity) can vary across the U.S., based on how various elements in the rate-setting process are treated. It is certain that rates will increase from where they are today as energy efficiency is incorporated into legacy ratemaking structures. It is also possible that under some circumstances these rate increases will outpace rate increases expected in the business-as-usual scenario even though in the energy efficiency case the overall bills paid by ratepayers would decrease. The relative importance of six effects will drive this uncertainty and will cause rates in some areas of the country to increase compared to business-as-usual while other areas experience a decrease:

- **Reallocation of fixed costs.** Reallocation of existing fixed costs across fewer units of consumed energy puts upward pressure on rates. This effect will depend on the market mechanism that determines how those costs are recovered.[221] This effect occurs, however, regardless of who drives energy efficiency programs or funds the costs, and regardless of any utility incentive payments. Fixed-cost reallocation is an effect of legacy systems of rate-making that charge fixed costs on a variable basis; decoupling and proposed rate designs other than true fixed/variable will not address this issue, as discussed above.

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[221] Fixed costs include generation, transmission, distribution and other non-variable support costs. In regulated markets, prudent fixed costs would be reallocated over remaining sales though there could be a timing lag. In restructured markets, generation costs are recovered through market prices and would likely not be recovered resulting in effectively a transfer of value from merchant generators to rate payers.

- **Avoided new generation and load-serving infrastructure.** Reducing or avoiding investments in additional generation and distribution capacity would place downward pressures on future rates relative to the increases that would have occurred, because energy efficiency is a lower-cost alternative to building new assets. The relative importance of this effect compared to the reallocation effect depends on the size of the existing rate base and the scale of planned new investments.
- **Improvements in the marginal dispatch cost of generation.** Though much more complex, this factor is likely to put downward pressure on rates, particularly in restructured markets. Two effects drive the downward pressure: first is the potential to reduce output from marginally less-efficient generation units (i.e., improve system heat rates); and second is the change in the marginal fuel being burned (e.g., less gas-fired generation and more coal-fired generation as the price-setting mechanism). Though coal-fired generation would set the price more often, carbon output would not increase (as coal generally runs already when gas is setting the price). Carbon prices would dampen this second benefit, because they tend to bring the generation costs of coal closer to generation costs of gas. Potential upward price impacts that could partially offset the downward pressure on rates would include any loss to efficiency of baseload assets with increased cycling, as well as in the near-term, the delayed construction of more efficient assets that could displace older, less-efficient ones.
- **Commodity fuel prices.** Fuel prices could decline due to reduced overall demand (e.g., reduced natural gas or coal consumption). We estimate, however, that the overall impact on rates is likely negligible relative to the range of other factors beyond energy efficiency that impact commodity prices.
- **Carbon prices.** Similarly, if legislators put a price on carbon emissions, deploying energy efficiency could place downward pressure on that cost. This effect will depend on many unknown factors including the price setting mechanism, targets, and allowances.
- **Upfront energy efficiency investments and program costs.** If these outlays are recovered through a public-benefit charge or other rate-based mechanism, they will likewise put upward pressure on rates. Incentive payments to load-serving entities or special-purpose energy efficiency entities would also be included, though they are typically a fraction of the program cost.

Assessing the net impact of these factors requires detailed modeling of load characteristics, economics, and regulatory treatments region by region. In addition, numerous other market effects would occur simultaneously, such as responses to renewable portfolio standards or other environmental requirements, which in combination could lead to very different results. In general, our models suggest that regions with higher levels of purchased and passed-through generation would tend to see decreases in rates, because value would transfer from generators to ratepayers. Regions with higher levels of full-cost recovery on generation assets, and with little or no projected need for capital investment in generation, would see an increase in rates relative to the business-as-usual approach.

Establishing responsibility in currently unaddressed areas

Certain elements of a program will have natural owners, such as government entities for designing and legislating codes and standards. A key issue, however, will be deciding who should have responsibility (i.e., the authority and accountability) for deploying energy efficiency measures with less clear ownership. The right choice will likely be a topic of debate within each state, involving trade-offs of strengths and weaknesses of different entities against a number of attributes, as illustrated in Exhibit 41. Expertise in the economics of energy consumption, for example, would be important so that the design of a program accounts for such factors as regional climate, rates, existing building stock, prior programs, and the cumulative effect of initiatives. Local energy brand recognition and trust would foster acceptance of programs. An integrated view and responsibility for supply and demand would help ensure coordinated planning and accountability for overall reliability of the energy system. This responsible party would also need a proven ability to organize and manage large-scale programs. Ideally they could be held financially accountable for the delivery of results on time and on budget.

For each type of entity that might lead comprehensive energy efficiency programs, the coloration of the circles represents an estimated starting position relative to various attributes. More color indicates a relatively higher starting position.

Exhibit 41: Overview of entities managing comprehensive energy efficiency programs

● High starting position
○ Low starting position

Attributes	Load-serving entities	Special-purpose entities*	Government entities	Energy service companies	Product manufacturers
• Expertise in energy consumption and efficiency	●	◑	◑	●	●
• Local energy brand recognition	●	◑	◑	◑	◑
• Integrated supply and demand accountability	●	○	○	○	○
• Integration with pricing /and metering technologies	●	○	○	◑	○
• Financial accountability /for program management	●	◑	◑	●	●
• Integration across fuel opportunities	◑	●	●	●	●
• Procurement and hiring capabilities	◑	●	○	●	●
• Objectivity and alignment toward energy efficiency	○	●	●	◑	○

* Similar to NYSERDA, Efficiency Vermont; dedicated entities for energy efficiency program management

Source: McKinsey analysis

Based on these attributes, three likely candidates emerge: utilities, special-purpose entities, such as Efficiency Vermont and Oregon's Energy Trust, and government entities, such as NYSERDA and those used in other countries. For completeness, we also profiled ESCOs and product manufacturers against these criteria, though their likely roles will be to support implementation of energy-service programs that they initiate directly with end-users or as part of a larger program coordinated and to some extent funded through the party with overall responsibility. Utilities emerge with the strongest starting position because they have the natural information-gathering, management, and delivery systems in place through metering and billing functions. Furthermore, their extensive experience managing energy delivery provides skills that will facilitate management of programs and integrated resource planning. They do, however, face several challenges: principally, there are substantial concerns that most current regulatory structures encourage utilities to increase electricity sales and build new assets rather than aggressively pursue a strategy of reducing consumption as discussed above. Additionally, in many service territories, homes with multiple fuels are served by different utilities, complicating delivery of energy efficiency measures.

By contrast, it would be straightforward to align special-purpose and government entities against the goal of driving efficiency and enable them to address all fuels and energy users in a region. Creating special-purpose entities, however, would separate the responsibility for demand- and supply-side planning and accountability. Load-serving entities would retain responsibility for system reliability and likely be reluctant to trust aggressive promises of demand reduction asserted by another organization. Also, this split responsibility would likely adversely impact coordination of energy-pricing and metering technologies needed to reinforce behaviors and monitor consumption.

If governments choose to designate special-purpose or government entities as responsible parties, they should take care to properly design incentives, regulations, and management structures to foster efficient and effective operation. Doing so would be a reasonably straightforward procedure, because it could be a clean-sheet exercise and well worth the time invested to address these issues.

Achieving appropriate evaluation, measurement, and verification

The difficulty of measuring energy efficiency requires effective evaluation, measurement and verification (EM&V) to provide assurance to stakeholders that programs and projects are achieving the savings claimed for them. EM&V can also provide feedback for program and project design, and assist in attributing savings to participants. If significant levels of energy efficiency are to be pursued and supported by significant levels of public funding, the need for a clear, consistent, and widely accepted EM&V system will be even more important than it is today.

Energy efficiency is hard to measure because it focuses on avoiding consumption rather than on actively producing something; verifying savings is an intrinsically difficult task. Actual consumption may be affected by weather, customer growth, usage differences, device penetration, and economic growth; all of these issues must be considered in determining actual savings impact.

Measuring these attributes exactly and providing a "perfect" EM&V system is not possible; instead, a "sufficient" EM&V system should reflect three key qualities:

- **Consistency.** If investments are to be made with the expectation of future returns that are contingent on the EM&V system, it will be critical that the rules for EM&V-associated rewards and penalties are internally consistent and remain fairly stable over time. This consistency is important for all parties, if they are to plan investments in energy efficiency.
- **Simple in design.** While a more complex EM&V system might permit more precise and accurate measurements and approximations of energy savings, as well as more detailed ways to attribute the drivers of those energy savings, the value of such a system must be considered in the context of the complexity and cost it will drive.
- **Address both inputs and impact.** Measurement methods should incorporate the activities undertaken by the responsible party, to ensure that activities are undertaken in an appropriate manner, and the measurement of energy consumption to determine the impact of those activities.

As California's efforts to improve energy efficiency have shown, even in a state that has taken a relatively aggressive approach to capturing energy efficiency, the issues surrounding attribution can be complex. Detailed EM&V programs that cause a slowdown in the pursuit of energy efficiency are unlikely to merit their expense. For example, in some California programs, discussions of attribution sought to resolve differences of $70 million in incentives, of a total program spend of $2.1 billion – with benefits that exceed $4 billion. A detailed EM&V program that risks disrupting the pursuit of energy efficiency is unlikely to deliver savings equal to the opportunity cost. For example, slowing the capture of the $4 billion in benefits by four months decreases their present value by $70 million.

The International Performance Measurement and Verification Protocol (IPMVP) provides a basis for analyzing project-level savings from energy efficiency measures. Though the IPMVP primarily addresses project savings in commercial and industrial sectors, it could provide the basis for broader measurement of energy efficiency programs. Development of this protocol has been supported by the Department of Energy and provides the basis for measurement in federal Energy Services Performance Contracts. A shared foundation for EM&V of this sort might provide the consistent methodology upon which energy efficiency program managers can build.

ELECTRIC VEHICLES

Electric vehicles (EVs) hold the potential to offer U.S. consumers a practical alternative to gasoline-powered vehicles by 2020. A variety of electric vehicles, including electric-only vehicles (or battery electric vehicles, BEVs), as well as plug-in hybrid electric vehicles (PHEVs), due to reach the market in the next several years could offer a battery-only driving range sufficient for many urban and suburban commutes.

If electric vehicles reach significant penetration levels, electric load levels could increase substantially. The table at right shows the impact that various levels of electric vehicle penetration could have on the total load levels in the economy.

Vehicle electrification impact[3]

Electrical vehicle penetration Percent of fleet	Load increase TWh
1%	8
5%	41
10%	84
15%	126
20%	168
100%	840

Challenges

Even at relatively low levels of market penetration, electric vehicles will pose a challenge to the electricity grid. Highly localized energy assessments will be needed to ensure that peak and non-peak generation capacity and the transmission and distribution system can meet expected load requirements of PHEVs and BEVs. Although generation capacity available during non-peak hours could accommodate electrification of up 73 percent of the current vehicle population,[1] vehicle charging would have to be timed to avoid peak usage; otherwise, additional generation capacity will be needed. If EV charging were not timed around the peak in California, for example, peak load could increase by 10 percent (3,700 MW).[2] Requirements for charging points, such as the build out of infrastructure and the actual power demand of each charging point (220-volt/60-amp versus 120-volt/15-amp), could strain local power grids and require changes to distribution capacity. This requirement could limit the creation of "rapid charging" stations and restrict the number of cars that can be charged at any one time.

Beyond the challenges posed to utilities and the electricity infrastructure, end-users will need to learn new behaviors, such as remembering to plug in their car for charging, limiting use of other vehicle options (e.g., the air conditioner or radio) to optimize range, and perhaps learning a different way of interacting with their cars (e.g., swapping batteries). Consumers will also need to be aware of the availability of charge points during daily trips, with competition for these charge points arising if demand outstrips supply.

Approaches

Emerging smart grid technologies are expected to increase the connectivity, coordination, and automation of the electricity grid, addressing some of the energy usage and capacity concerns, though new capacity for generation, transmission, and distribution will eventually be required. Smart grid applications could allow utilities to increase the price of electricity at peak hours, for example, encouraging off-peak charging. A smart grid may eventually have the ability to precisely reduce load, notifying a customer that charging will not occur or will take longer, perhaps allowing the customer to opt-in or opt-out, depending on the price they are willing to pay. Local dynamics in power markets will affect the degree to which new generation comes from renewable sources and what T&D investments are needed (especially relevant for isolated parts of the electricity grid).

In addition to changes in the energy infrastructure, building out the charging infrastructure and ensuring consumer acceptance will need attention. Possible solutions could include municipality-built public charging stations, addition of battery-swap stations to gasoline stations, and marketing campaigns by public and private entities to educate the public and promote EVs to potential customers.

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[1] Pacific NorthWest National Lab/U.S. DOE; Wirtschaftswoche.

[2] Cal ISO website, McKinsey.

[3] Estimated impact to load based on 12,000 annual miles per vehicle, 280 million vehicles in the U.S. passenger and light truck fleet by 2020, and 4 miles traveled per kWh.

5. FOSTER INNOVATION IN THE DEVELOPMENT AND DEPLOYMENT OF NEXT-GENERATION ENERGY EFFICIENCY TECHNOLOGIES TO ENSURE ONGOING PRODUCTIVITY GAINS

Technology development plays a small role in the potential identified in the near term targets of this report. However, we expect that innovative and cost-effective energy-saving technology will continue to emerge. It will likely be cost effective to fund its research and development in order to accelerate its path to market.

The Inventions and Innovation (I&I) Program run by EERE demonstrates that fostering innovation can be cost effective and have substantial impact. I&I was established in 1976 as the Energy-Related Inventions Program (ERIP); through 2000, it received cumulative funding of $117 million. More than 25 percent of I&I grantees successfully entered the marketplace, delivering a cumulative 973 trillion end-use BTUs of energy savings since I&I's inception. The $117 million investment has saved $4.92 billion in cumulative energy costs to date. As of 1995, administrative costs represented $2.20 per MMBTU of end-use energy savings and grants represented $1.40 per MMBTU.[222] A challenge in evaluating impact arises from the inability to know how such technology would have emerged without assistance. Nonetheless, the attractive leverage and cost structure of this program suggests that fostering innovation warrants ongoing investment.

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In the nation's pursuit of energy affordability, climate change mitigation, and energy security, energy efficiency stands out as perhaps the single most promising resource. In the course of this work, we have highlighted the significant barriers that exist and must be overcome, and we have provided evidence that none are insurmountable. We hope the information provided in this report further enriches the national debate and gives policymakers and business executives the added confidence and courage needed to take bold steps to formulate constructive ways to unlock the full potential of energy efficiency.

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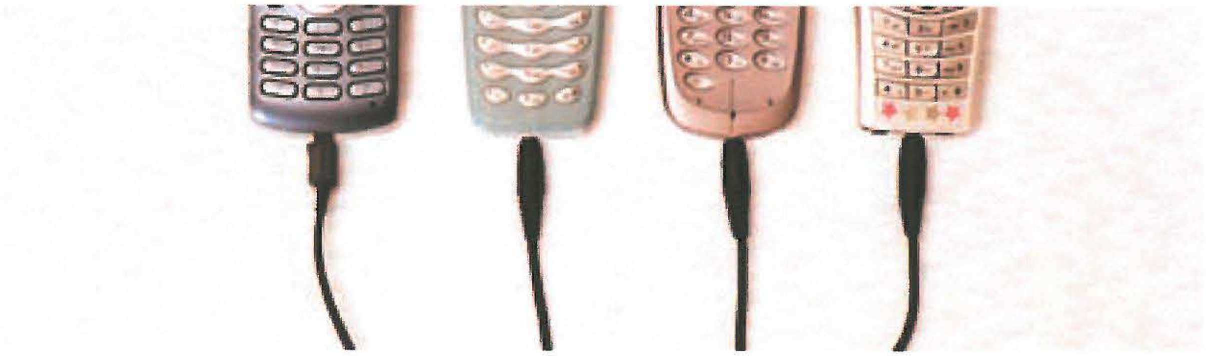
[222] *Scenarios for a Clean Energy Future*, Interlaboratory Working Group, ORNL/CON-476 and LBNL-44029, November 2000.

Appendices



A. Glossary

Abatement. The purposeful reduction of greenhouse gas emissions or their rate of growth.

Accelerated deployment. The deployment of new technologies before the end-of-life of the existing stock. Accelerated deployment is NPV-positive when the lifetime cost savings of the more efficient technology more than exceed the present value of the total (rather than incremental) upfront investment. See also "Stock and flow methodology."

ASHRAE. The American Society of Heating, Refrigerating and Air Conditioning Engineers, which publishes a series of standards for heating, cooling, and ventilation systems in commercial buildings that often serve as the basis for commercial building codes.

BTU. British Thermal Unit, the quantity of heat energy required to raise the temperature of one pound of water from 60° to 61° Fahrenheit at a constant pressure of one atmosphere. BTUs are used throughout this report as a standardized measure of energy output and consumption.

Building shell. The exterior structure of a building that protects the interior space, facilitating control of the interior climate. The shell consists of the roof, exterior walls, exterior windows and doors, the foundation, and the basement slab or lowest level floor.

BAU baseline. The reference-case forecast for U.S. energy consumption in 2020, used in this report as a standard against which incremental energy efficiency potential is calculated. The business-as-usual forecast derives from the U.S. Energy Information Administration's Annual Energy Outlook 2008 and other public sources. Although the AEO baseline contains some energy efficiency improvement, the baseline projects energy consumption in future years without a concerted, economy-wide effort to improve energy efficiency.

CHP. Combined heat and power, also known as "co-generation," is the use of a heat engine or a power station to generate electricity and useful heat energy from a single fuel at a facility near the consumer.

CO_2e. Carbon-dioxide equivalent, a standardized measure of greenhouse gas emissions developed to account accurately for the differing global warming potentials of various gases. Emissions are measured in metric tons of CO_2e per year, usually in millions of tons (megatons) or billions of tons (gigatons).

Consumer utility. Functionality, such as a level of comfort, garnered from a specific energy end-use. Adjusting a thermostat or reducing the number of hours an electronic device is used in a day represent changes in utility. In a strict economic sense, maintaining consumer utility assumes a constant economic surplus for the consumer while delivering against a common benefit. Modeling of efficiency potential and energy use in this report assumed no change in consumer utility.

Community infrastructure. Energy-consuming devices not directly associated with a specific building. These end-uses would include municipal infrastructure (e.g., water treatment and distribution systems) and telecommunications infrastructure.

EISA. Energy Independence and Security Act (2007), passed by Congress to move the United States toward greater energy independence principally through greater energy efficiency and increased use of renewable fuels. It also directs the federal government to be a model in its own energy usage.

Energy intensity. The number of BTUs of energy consumed for each dollar of economic value created.

EM&V. Steps to evaluate, measure, and verify that implementation of an energy efficiency measure has produced the expected energy savings. It may include ensuring those savings are properly attributed.

ESCO. An energy services company is a for-profit or not-for-profit entity dedicated to providing energy solutions to business and/or residential customers, including such services as energy efficiency audits, implementation of efficiency measures, evaluation of the performance of measures, or leading energy conservation efforts.

Existing stock. Technologies in use in the business-as-usual baseline at the beginning of 2009, which serves as a starting point for all modeling. See also "Stock and flow methodology."

Gt. Gigaton, a unit of weight equivalent to 1 billion metric tons or 2.2 trillion pounds.

GW. Gigawatt, a unit of electrical power equivalent to 1 billion watts.

GWh. Gigawatt hour, a unit of electrical energy equivalent to the work done by 1 billion watts acting for 1 hour.

Heat rate. Efficiency of a power plant, measured by calculating the number of BTUs of energy input per kilowatt-hour of power output.

HERS. Home Energy Rating System, measurement of a home's energy efficiency that provides a score of 0 (net zero energy building) through 100 (based on the 2006 IECC) and higher. A 1-point decrease in score represents a 1 percent decrease in energy consumption.

HVAC. Heating, ventilation, and air conditioning, also known as space conditioning; end-uses of energy to heat, cool, and circulate the air of the interior of a building. This report uses the term "HVAC" generically to refer to space conditioning systems, whether a building has a heating system, a cooling system, an air exchanger or one, two or three of those systems.

KWh. Kilowatt hour, a unit of electrical energy equivalent to the work done by 1 thousand watts acting for 1 hour. Standard unit of residential electricity pricing; for example, a 100-watt light bulb burning for 10 hours would consume 1 kilowatt hour.

Load-serving entity. Load serving entities provide electricity to end users, and include investor-owned utilities, municipal utilities, cooperatives, among other entities.

LEED. Leadership in Energy and Environmental Design, a widely recognized certification given to buildings for excellence in sustainable building design. Based on a whole-building approach, different tiers of LEED certification are granted by the U.S. Green Building Council, based on the performance of the building in various areas of human and environmental health, with energy efficiency an important criterion.

Life-cycle benefits. The energy savings of an energy efficient device that accrue over the useful life of the device. This does not include energy to create the device.

MUSH. Municipal, university, school, and hospital; these public-sector buildings are typically able to realize the potential of attractive energy efficiency measures, because they do not change ownership at the rate of private enterprises and thus do not need accelerated payback of the capital invested in energy efficiency measures.

MMBTU. 1 million BTUs.

MWh. 1 megawatt hour, a unit of electrical energy equivalent to the work done by 1 million watts acting for 1 hour.

NPV-positive. Net-present-value-positive, in which the discounted future cash flows from future energy savings outweigh the initial upfront capital investment needed to implement the measure.

PAYS. Pay-as-you-save, a loan made or administered by an energy provider to cover an upfront investment in energy efficiency measures. The end-user repays via the utility bill with money saved through reduced energy usage such that no initial investment is required of the end user.

Performance contracting. An agreement between an energy services company (ESCO) and another entity in which the ESCO assumes responsibility for reducing energy consumption on the premises in specified ways for the period of the contract. The ESCO installs agreed-on energy efficiency measures and recoups its investment through contracted payments, which represent a portion of the energy savings that the entity receives from the efficiency measures.

Plug load. Energy consumed by electrical devices that plug into the wall, typically various electronics products and small appliances. Examples include TVs, PCs, hairdryers, coffee machines, and thousands of other similar products. Consumption in this category is highly fragmented across an average of 20 devices per household.

PBC. Public benefit charge, a fee added to energy bills to pay for public goods.

RPS. Renewable Portfolio Standards, a government mandate requiring that a certain amount of energy generated or sold in a given area, or a certain amount of energy capacity in a given area, derive from renewable energy sources, such as geothermal, wind, biomass, or solar.

Retro-commissioning. Process by which HVAC and other building systems are tested and adjusted to ensure proper configuration and operation for optimal efficiency. This may involve installing correctly sized motors, sealing ducts, repairing leaks in and recharging the refrigeration system, among a wide variety of measures.

Retrofit. Changes made after initial construction and before the expected end-of-life of the asset, typically the building shell.

Space conditioning. Energy consumed in the heating, cooling and ventilation of interior spaces in buildings.

Standby losses. Energy consumed by electrical devices while plugged in to a socket but not in active use.

Stationary use of energy. Energy consumed by the U.S. economy in a year, except for that used in transportation (i.e., the movement of vehicles, including transportation in mining, construction, and agriculture) and in the production of asphalt or chemical feedstock. This report analyzed approximately 81 percent of the stationary energy consumed in the U.S.

Stock-and-flow model. This methodology calculates energy savings potential relative to the business-as-usual (BAU) case. The model projects BAU energy consumption for future years by replacing equipment stock according to current customer preferences. In calculating the efficient scenario it substitutes energy efficiency measures for those technologies when it is NPV-positive to do so. These substitutions include upgrades in new buildings, as well as replacement of technologies contained in existing buildings.

- Accelerated deployment. The deployment of new technologies before the end-of-life of existing stock. Accelerated deployment is NPV-positive when the lifetime cost savings of the more efficient technology more than exceed the present value of the total (rather than incremental) upfront investment.
- NPV-positive choice. Technology in a specific building-Census division category that has the lowest annualized cost, taking into account such factors as energy cost, annualized capital cost (over the lifetime of the technology), and other operating expenses.
- Existing stock. Technologies used in the BAU case at the beginning of 2009, which serves as a starting point for efficiency modeling.

TBTU. Trillion BTUs.

TW. Terawatt, a unit of electrical power equivalent to 1 trillion watts.

TWh. Terrawatt-hour, a unit of electrical energy equivalent to the work done by 1 trillion watts acting for 1 hour.

Waste heat recovery. Capturing and using heat for productive work that is a byproduct of energy-intensive processes or steam systems that would otherwise be ejected into the environment.

Weatherization. Modifying a building to increase its energy efficiency, usually through measures to decrease infiltration of outside air and minimize the loss of heated or cooled interior air.

B. Methodology

The purpose of our research has been to evaluate the barriers that impede capture of energy efficiency today and to provide perspectives on how potential solutions map to individual and broader system-level barriers to unlocking the potential available in the U.S. economy. We have analyzed a multitude of energy efficiency opportunities to determine how much of the potential is NPV-positive, thereby providing a fact base for our assessment of barriers and potential solutions.

This research differs from other reports on energy efficiency in a number of important ways. Specifically, we would like to note four points about our scope:

- We did not attempt to conduct a technical analysis on future energy efficiency technologies.
- We do not predict how much energy efficiency potential can or will be achieved.
- We attempted to be comprehensive – but not necessarily exhaustive – of all barriers and solutions.
- We did not assess second-order effects (e.g., impact on natural gas prices) or broader GDP impacts.

As noted previously, we focused on stationary uses of energy. We, therefore, excluded energy used in all modes of transportation, such as motor vehicles, trains, ships, and aircraft; with this focus, we also excluded energy used in agriculture, construction, and mining operations.

This appendix covers three aspects of our methodology:

1. Assumptions and methodology for calculating NPV-positive energy efficiency potential, including the micro-segmentation process and subsequent re-aggregation of micro-segments into addressable clusters of potential
2. Our approach to structuring the barriers and attributing them to clusters
3. Means of mapping solutions to address the major barriers in these clusters.

1. CALCULATING NPV-POSITIVE POTENTIAL

Data sources for the National Energy Modeling System (NEMS) served as the foundation of our residential and commercial potential analysis. The *Annual Energy Outlook 2008*, Table 2, supplemental tables 24-34, and unpublished AEO data serve as the foundation for the industrial potential analysis. Where insufficient data were available, we drew on public or private sources to supplement the NEMS database and provide the necessary resolution for our analysis.[1] In aggregate, this analysis addresses 36.9 quadrillion of the 45.5 quadrillion BTUs (81 percent) of end-use energy in 2008.

There are six essential components to our analysis of NPV-positive potential:

- Baseline consumption
- Stock and flow methodology
- NPV-positive selection criteria
- Technology characteristics
- Bursting of data into micro-segments
- Re-aggregation of data into addressable clusters.

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[1] In the commercial sector, 2.1 quadrillion BTUs of consumption rely on other public sources; in the industrial sector, 15.3 quadrillion BTUs of consumption rely on public sources and 4.0 quadrillion BTUs rely on private sources.

Baseline consumption

Our baseline consumption matches the *Annual Energy Outlook 2008* for 2008 and 2020 to within 1.2 percent. Furthermore, these data match the *AEO 2008* when cut by fuel or Census division (Census region, in the case of industrial, represents the finest degree of geographic resolution). Note that this baseline incorporates no price for carbon and includes only legislation that has passed into law (i.e., the Energy Independence and Security Act of 2007, but not the American Recovery and Relief Act of 2009).

Stock and flow methodology

We used slightly different methodologies across the sectors, depending on the availability of data and the nature of the opportunities.

Residential and commercial sectors. Our residential and commercial modeling considered almost 500 technologies deployed against 24 end-uses. Each technology is characterized by a working life time, upfront capital spend, annual maintenance spend, and energy efficiency impact. Current energy consumption by end-use is provided by NEMS through the Renewable Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS). We further characterized this consumption by the ratio of technologies deployed in the existing equipment stock.

We modeled the deployment of newer, more energy efficiency technologies in two ways: at end of life and on an accelerated basis.

- **End-of-life replacement.** As each technology reaches the end of its useful life, our model calculates the total levelized cost of all equivalent technologies that could replace it. The "NPV-positive," potential is calculated based on deployment of the technology with the lowest levelized cost.
- **Accelerated replacement.** To more accurately calculate the opportunity in retrofitting buildings, we also considered accelerated deployment. If the total levelized cost of a new technology is less than the levelized energy cost of an existing technology in the current stock, then the model replaces the current stock with the new technology immediately. This occurs in two ways: when technological advances reduce the levelized cost of a technology (as is the case with general-use LED lighting in 2017) or in the first year of the calculation (as is the case with a number of technologies that could be retrofit into buildings remain undeployed today).

Industrial sector. Such detailed data is unavailable for the industrial sector. Instead our model evaluates opportunities using an internal rate-of-return (IRR) calculation for potential measures available in a given year, adjusted to avoid double counting opportunities incorporated in the baseline assumptions through 2020. We separated out the five largest energy-intensive industries – those with 10 or more BTUs of energy input per dollar of output (pulp and paper, cement, refining, chemicals, and iron and steel) – and, using expert interviews and more than 15 secondary industry resources, analyzed in detail the efficiency potential in these industries. To accurately assess the efficiency potential in their manufacturing processes, we calculated the NPV-postitive efficiency potential for more than 150 measures across these five industries. The savings percentage for each industry was calculated against its consumption, and these percentages were averaged (11 percent across the five industries). We used the resulting savings percentage as a baseline to identify the energy efficiency potential for process energy in non-energy-intensive industries. Interviews with industry experts revealed that on a percentage basis, the opportunity to improve efficiency was greater in these industries, varying by business size (large businesses, 13 percent; medium-sized businesses, 14 percent; small businesses, 15 percent), because less attention has been paid to energy efficiency in these businesses.

We calculated most of the potential in energy support systems (i.e., waste heat recovery, steam systems, electric motors) for each energy-intensive industry using more than 50 measures that the team had identified through expert interviews and industry reports. We determined the savings potential, as well as capital costs, identifying the NPV-positive potential for these meausres. Waste heat recovery measures, which do not consume energy but decrease the energy required system-wide by helping to pre-heat fuel, provide incremental energy for other processes or supply energy to support systems. The team calculated the average energy efficiency savings potential across the energy-intensive industries and used this to calculate the efficiency potential for non-energy-intensive industries by multiplying it by the energy consumed in these industries for energy support systems. For building systems, the team used the more detailed commercial model and the savings rate calculated across appropriate commercial building types to find the efficiency potential across all industrial building systems (those pertaining to the building itself, rather than its industrial functions), both for energy- and non-energy-intensive industries.

Combined heat and power. We modeled industrial and commercial combined heat and power (CHP) applications separately, primarily because a CHP system increases on-site fuel consumption while increasing the efficiency of system-wide heat and electricity production (including off-site generation).

- **Industrial applications.** We estimated the potential for industrial CHP based on the EIA's projected steam demand supplied by "non-CHP" sources, by region and industry. We grouped this potential into five sizes of CHP systems (from less than 1 MW to greater than 50 MW) based on plant sizes and steam demand, across six industry groups and the four Census regions of the country. Each of the modeled CHP systems were sized to the thermal load and matched to the power-to-steam ratio of the specific industry. We cross-checked these results against estimates for generation potential from Oak Ridge National Laboratory and the Department of Energy. By comparing the economics of a CHP system to the installed traditional system using AEO 2008 supplemental data, we calculated the total potential for CHP for each region and industry subgroup.
- **Commercial.** There has been limited use of CHP in the commercial sector to date, with roughly 10 GW of generation capacity installed. Our model, therefore, looked at the full potential of expanding CHP in this sector. We analyzed each building type for CHP suitability (based on expert interviews, case studies, and cost analysis) across three sized-based building groups: 1,000-10,000 sq feet, 10,000-100,000 sq feet, and more than 100,000 sq ft. If a building type was suitable for CHP, we calculated opportunities for retrofit CHP systems against the full replacement cost of central energy plants, taking into consideration thermal heating, water heating, cooling and electrical capacity and demand. For new buildings, we compared these costs to the incremental cost of installing a CHP system in place of a standard boiler. Drawing on information from NEMS for capacity factors (the ratio of annual equipment output to output of the equipment at 100 percent utilization) for each building system (e.g., water heating, HVAC, miscellaneous electricity demand) in each type of building, we calculated the full economic potential for energy generation for each building type subgroup by Census division.

NPV-positive selection criteria

We used three criteria to define the "NPV-positive" energy efficiency potential of each efficiency measure:

- **Technology costs.** These include incremental capital (or in the case of accelerated depreciation, total capital cost), installation, and additional operation and maintenance cost. This report uses the DOE's Technology Report as used by NEMS. It specifies for each end-use a set of available technology-vintage combinations that define these parameters (discussed in greater detail below).

- **Value of energy saved.** The value of energy saved is more challenging to quantify. A full treatment of avoided energy costs would require detailed consideration of primary energy savings and lies beyond the scope of this report. There is, however, a range of energy values to draw on. Each unit of energy saved will draw from this range as specified by end-use, supply assets for the selected geography, the regulatory environment, timing, and business-as-usual forecasts. This report values energy saved at Census-division industrial retail rates from AEO 2008, because it serves as a central value that is publically available and well understood. The full range of avoided costs, from lowest to highest, includes:
  - **Cost of generation.** This cost attempts to identify the variable component of generation cost through fuel and operations of impacted plants and early plant retirements (with or without regulated asset recovery). It does not capture impact of energy efficiency on capacity, transmission, or distribution.
  - **Wholesale price.** The wholesale price represents the average generation price, including utility cost recovery, of existing assets. It serves as a useful proxy for the average value of existing energy, but it does not capture the impact of energy efficiency on capacity, transmission, or distribution.
  - **Industrial retail rate.** The industrial retail rate includes the benefits of the wholesale price approach while also attributing system value of avoided capacity, transmission, and distribution. It is worth noting the industrial load factor underestimates the system load factor.
  - **Customer-specific retail rates.** These rates serve as the best tool for applying a participant "lens" to the efficiency potential, when attempting to understand when a retail customer should act to reduce their energy bills. These rates may overvalue the savings from transmission and distribution, because many fixed costs are embedded in customer-specific retail rates.
  - **Least-cost avoided new build.** This value presents an attractive option, because unlocking energy efficiency is likely to defer or eliminate construction of some new assets. Given the uncertainties in the business-as-usual forecast and the amount of efficiency unlocked, however, calculating scenarios accurately is a significant challenge, which could call into question the accuracy of results relying on the necessary assumptions.
  - **Avoided carbon-free build.** This option resembles least-cost avoided new build, except that it focuses on carbon-free sources of energy. It suffers from similar modeling challenges.
- **Discount factor.** The discount factor (or rate) represents the relative value of savings over time. Similar to discounted cash flow analysis, future energy savings in a given year, "Y," are discounted to present-day values by the amount $(1+ DF)^{-y}$ where DF is the discount factor in percent.

By selecting a cost of avoided power and a discount factor from among the available options, it possible to construct a cost test to determine whether – and for whom – energy efficiency potential is NPV-positive. Specifying industrial retail rates and a 7-percent discount factor creates a total-resource cost test (provided all deployment and program costs are included, regardless of funding source). Alternatively, combining customer-specific retail rates and a customer's discount factor (which many argue can be as high as 20 percent) create a participant-focused cost test.

Technology characteristics

The technology characteristics derive from the DOE's Technology Reports, as used by NEMS. This set of characteristics includes limited innovation, an issue that could become a concern when attempting to model efficiency potential over longer timeframes. The characteristics do include expected technology improvements and cost compression in existing technologies. We further tested the sensitivity of our results to these assumptions by considering the more aggressive scenario in the Technology Report.

Characteristics of building shell technologies came from other sources. Lawrence Berkeley National Laboratory's Home Energy Saver provides publicly available energy-consumption modeling for homes, with recommended cost-effective upgrades. This report categorizes all 4,822 residential homes in the RECS survey by their energy use per square foot into five or six classes for each of five climate zones, depending on the climate zone, in order to understand likely characteristics of existing stock and identify cost-effective upgrades. It includes such relevant variables as square footage, resident income, and year of construction, to further identify these opportunities. We also drew upon work by the National Renewable Energy Laboratory (NREL) on zero-net-energy building potential and retro-commissioning to understand commercial existing and new build opportunities.[2]

Bursting of data into micro-segments

Bursting of data into micro-segments to identify and address barriers drew upon the EIA's energy consumption surveys, Census data, and other sources to generate tens of thousands of consumption segments across the three sectors. While not statistically significant at this level of resolution, the data allowed us to identify relevant characteristics to multiple levels of depth that, when combined, produced samples that drove key findings in this report and could be used for further research. Our modeling accomplishes this by "bursting" the demographic characteristics into the lower resolution data (similar to an outer product of two vectors). This does represent an approximation of energy consumption within such a "micro-segment" of the population, provided that data remain aggregated at a high enough level of depth to remain statistically significant as discussed above.

Exhibit B-1 shows characteristics that we used to burst the residential, commercial, and industrial sectors into micro-segments. The result was 75,000 micro-segment and end-use combinations in the residential sector, which allowed us to see the important differences across regions, and across different building types, as well as understand the potential agency barriers, and conduct other important analyses. We burst the commercial sector into 39,000 micro-segment and end-use combinations, which enabled comparisons between public and government micro-segments and the split across the multiple types of buildings, each with very different energy needs. Our micro-segmentation in the industrial sector was less detailed, due to limited availability of data; the industry and geographic splits proved to be the important factors for identifying efficiency potential in the sector.

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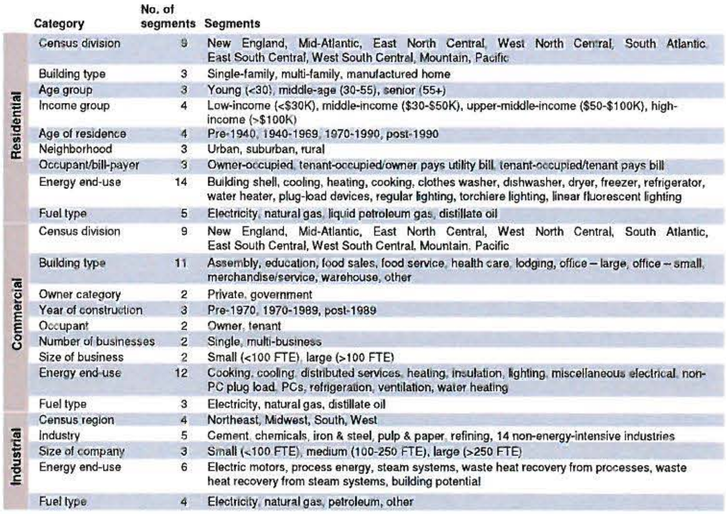
[2] B. Griffith et al., "Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector", NREL, December 2007. Evan Mills et al., "The Cost-Effectiveness of Commercial-Buildings Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States," LBNL, Portland Energy Conservation Inc, Texas A&M University, December 2004.

Exhibit B-1: Segmentation of energy use



	Category	No. of segments	Segments
Residential	Census division	9	New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific
	Building type	3	Single-family, multi-family, manufactured home
	Age group	3	Young (<30), middle-age (30-55), senior (55+)
	Income group	4	Low-income (<$30K), middle-income ($30-$50K), upper-middle-income ($50-$100K), high-income (>$100K)
	Age of residence	4	Pre-1940, 1940-1969, 1970-1990, post-1990
	Neighborhood	3	Urban, suburban, rural
	Occupant/bill-payer	3	Owner-occupied, tenant-occupied/owner pays utility bill, tenant-occupied/tenant pays bill
	Energy end-use	14	Building shell, cooling, heating, cooking, clothes washer, dishwasher, dryer, freezer, refrigerator, water heater, plug-load devices, regular lighting, torchiere lighting, linear fluorescent lighting
	Fuel type	5	Electricity, natural gas, liquid petroleum gas, distillate oil
Commercial	Census division	9	New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific
	Building type	11	Assembly, education, food sales, food service, health care, lodging, office – large, office – small, merchandise/service, warehouse, other
	Owner category	2	Private, government
	Year of construction	3	Pre-1970, 1970-1989, post-1989
	Occupant	2	Owner, tenant
	Number of businesses	2	Single, multi-business
	Size of business	2	Small (<100 FTE), large (>100 FTE)
	Energy end-use	12	Cooking, cooling, distributed services, heating, insulation, lighting, miscellaneous electrical, non-PC plug load, PCs, refrigeration, ventilation, water heating
	Fuel type	3	Electricity, natural gas, distillate oil
Industrial	Census region	4	Northeast, Midwest, South, West
	Industry	5	Cement, chemicals, iron & steel, pulp & paper, refining, 14 non-energy-intensive industries
	Size of company	3	Small (<100 FTE), medium (100-250 FTE), large (>250 FTE)
	Energy end-use	6	Electric motors, process energy, steam systems, waste heat recovery from processes, waste heat recovery from steam systems, building potential
	Fuel type	4	Electricity, natural gas, petroleum, other

Re-aggregation of data into addressable clusters

In re-aggregating data into addressable clusters of efficiency potential, we used available consumption characteristics and/or demographics to organize the micro-segments into clusters that solutions could address. Fourteen clusters of consumption emerged as relevant, as described in the body of this report. The most significant traits used to define these clusters represent an amalgamation of criteria that reflect the existence of similar barriers, responsiveness to particular solutions, and/or common traits relevant for consumption or efficiency potential. The most relevant characteristics that define these clusters include home owner income, building age (i.e., new versus retrofit buildings), specific end-uses or opportunities (e.g., electrical devices, community infrastructure, waste heat recovery), private versus government ownership structure, and energy intensity.

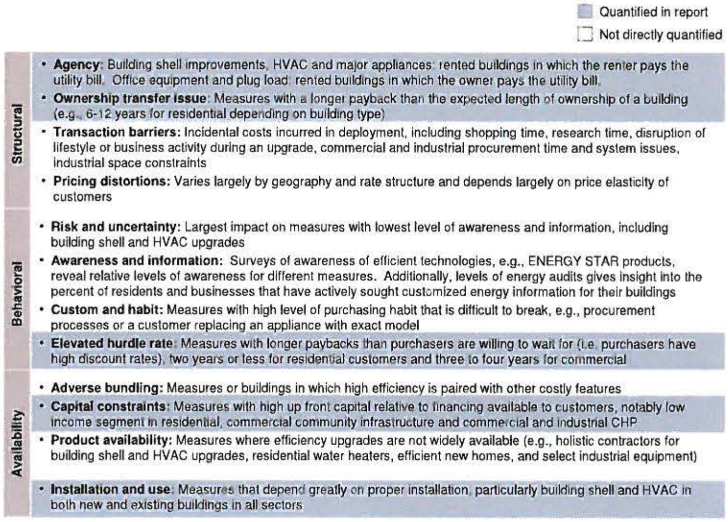
2. BARRIER STRUCTURE AND ATTRIBUTION

Though it is tempting to address the barriers to energy efficiency improvements using a customer purchasing funnel, such an approach would provide too limited a view of the barriers. Specifically, it would omit barriers outside the end-user's control, such as pricing distortions, adverse bundling, and technology availability. Our approach to these opportunity-specific barriers instead captures dozens of barriers identified in a large body of research dating back decades[3] and structures them into twelve barriers, which align with three discrete gates through which efficiency measures must pass to deliver energy savings:

- **Structural.** Is the opportunity available to the end-user, or are there structural limitations to the end-user's ability to capture the benefits?
- **Behavioral.** Will the end-user choose to behave in a manner consistent with pursuing the savings?
- **Availability.** Are the savings available to an end-user who can structurally capture them and who chooses to pursue them?

Some of these barriers are quantifiable; for example, it is possible to assert that agency barriers arise if and only if the building or appliance owner and the payor of energy costs are different economic agents (e.g., a tenant and a landlord). Our demographic data indicates that, for example, agency issues inhibit the capture of 8 percent of the retrofit potential in the residential sector and 5-25 percent of private building retrofit potential dependent on building type in the commercial sector. Other barriers are less quantifiable. Exhibit B-2 arrays the 12 barriers and describes the means used to attribute and, where possible, quantify their impact against the clusters.

Exhibit B-2: Quantification of opportunity-specific barriers



▨ Quantified in report
☐ Not directly quantified

Structural	▨	**Agency:** Building shell improvements, HVAC and major appliances: rented buildings in which the renter pays the utility bill. Office equipment and plug load: rented buildings in which the owner pays the utility bill.
	▨	**Ownership transfer issue:** Measures with a longer payback than the expected length of ownership of a building (e.g., 6-12 years for residential depending on building type)
	☐	**Transaction barriers:** Incidental costs incurred in deployment, including shopping time, research time, disruption of lifestyle or business activity during an upgrade, commercial and industrial procurement time and system issues, industrial space constraints
	☐	**Pricing distortions:** Varies largely by geography and rate structure and depends largely on price elasticity of customers
Behavioral	☐	**Risk and uncertainty:** Largest impact on measures with lowest level of awareness and information, including building shell and HVAC upgrades
	☐	**Awareness and information:** Surveys of awareness of efficient technologies, e.g., ENERGY STAR products, reveal relative levels of awareness for different measures. Additionally, levels of energy audits gives insight into the percent of residents and businesses that have actively sought customized energy information for their buildings
	☐	**Custom and habit:** Measures with high level of purchasing habit that is difficult to break, e.g., procurement processes or a customer replacing an appliance with exact model
	▨	**Elevated hurdle rate:** Measures with longer paybacks than purchasers are willing to wait for (i.e. purchasers have high discount rates), two years or less for residential customers and three to four years for commercial
Availability	☐	**Adverse bundling:** Measures or buildings in which high efficiency is paired with other costly features
	▨	**Capital constraints:** Measures with high up front capital relative to financing available to customers, notably low income segment in residential, commercial community infrastructure and commercial and industrial CHP
	☐	**Product availability:** Measures where efficiency upgrades are not widely available (e.g., holistic contractors for building shell and HVAC upgrades, residential water heaters, efficient new homes, and select industrial equipment)
	▨	**Installation and use:** Measures that depend greatly on proper installation, particularly building shell and HVAC in both new and existing buildings in all sectors

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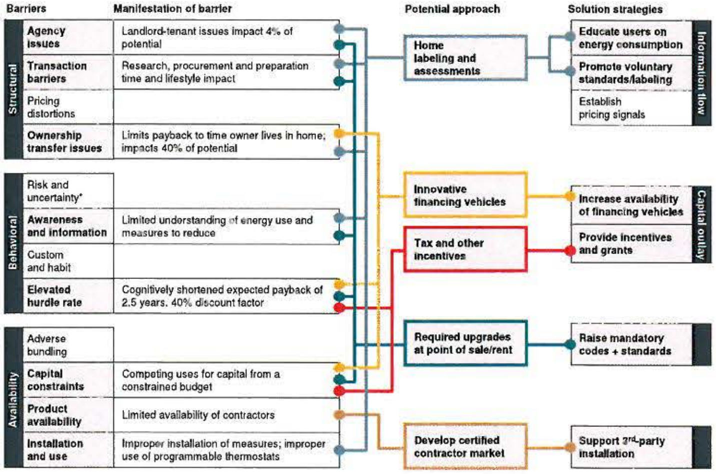
[3] William Golove and Joseph Eto, "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency", LBNL, March 1996. C. Blumstein, "Overcoming Social and Institutional Barriers to Energy Efficiency," 1980. S. DeCanio, "Barriers Within Firms to Energy Efficient Investments," *Energy Policy*, 1993. Amory Lovins, *Energy Efficient Buildings: Institutional Barriers and Opportunities*, E Source Inc, 1992.

3. MAPPING OF SOLUTIONS TO CLUSTERS AND BARRIERS

We conducted an extensive survey of measures that would unlock energy efficiency in the residential, commercial, and industrial sectors. These solution measures broadly fall into three categories: those that have proven successful on a national scale, those piloted and promising but not yet proven at national scale, and those emerging but not yet thoroughly tested. We used available empirical evidence or descriptions to understand which solutions could address which barriers. For example, on-bill financing can address ownership-transfer issues, inconsistent discount rates, and capital constraints by transferring unpaid investment and benefits to future owners while providing necessary capital at a discount rate consistent with other options for energy consumption. Though the barriers addressed by each measure can vary among clusters, Exhibit B-3 provides an example of how we mapped measures to barriers in one cluster in the residential sector, in this case the existing non-low-income homes cluster.

Exhibit B-3: Addressing barriers in existing non-low-income homes



* Represents a minor barrier
Source: McKinsey analysis

Given the limited quantitative data on the barriers and the impact of solutions, this approach faces some limitations: it cannot quantitatively map solutions to every barrier, and it cannot evaluate the relative strength of different solutions. Furthermore, we did not attempt to ascertain what fraction of the potential is achievable with a given measure. However, the approach can highlight what portion of the potential is addressable with a given measure. Our research suggests that a measure or combination of measures will be needed to address all major barriers affecting a cluster, if the efficiency potential is to be captured fully. For example, the limited penetration of on-bill financing in the residential retrofit cluster is likely because this approach fails to address transaction barriers, lack of awareness, contractor availability, and installation concerns. A combination of on-bill financing with a home labeling or awareness campaign, plus direct referrals to qualified contractors could address all barriers and unlock the potential of this cluster.

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  - Department of General Services
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NOTES

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Energy Efficiency & Renewable Energy

2011 Buildings Energy Data Book

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Foreword

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy has developed this *Buildings Energy Data Book* to provide a current and accurate set of comprehensive buildings-related data, and to promote the use of such data for consistency throughout DOE programs.

Data is organized into nine chapters; Chapter 1 – Buildings Sector, Chapter 2 – Residential Sector, Chapter 3 – Commercial Sector, Chapter 4 – Federal Sector, Chapter 5 – Envelope and Equipment, Chapter 6– Energy Supply, Chapter 7 – Energy Codes, Standards, and Laws, Chapter 8 – Water Data, and Chapter 9 – Market Transformation. New data tables on commercial building energy benchmarks were added to their relevant sections. New data tables were also developed from an updated report on commercial refrigeration. You will also find updated market transformation data from the ENERGY STAR program and the U.S. Green Building Council. We continue to refine and provide water data.

We hope you find the *2011 Buildings Energy Data Book* useful. You are encouraged to comment on errors, omissions, emphases, and organization of this report to the person listed below. Requests for additional copies of this report, additional data, or information on an existing table should be referred to D&R International.

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The *2010 Buildings Energy Data Book* can be found on the web at:

http://buildingsdatabook.eere.energy.gov/

Introduction

The *2010 Buildings Energy Data Book* is a statistical compendium prepared and published under contract with the Pacific Northwest National Laboratory (PNNL) with support from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). PNNL first published the predecessor to the annual *Buildings Energy Data Book* in 1986. PNNL published these through 2004; Oak Ridge National Laboratory 2005-2006, and National Energy Technology Laboratory 2007-2009.

The Department of Energy's Office of Energy Efficiency and Renewable Energy has developed this *2010 Buildings Energy Data Book* to provide a current and accurate set of comprehensive buildings-related data and to promote the use of such data for consistency throughout DOE programs. Additional data (e.g., more current, widely accepted, and/or better documented data) and suggested changes should be submitted to D&R International. Please provide full source references along with all data.

The *Buildings Energy Data Book* is a compendium of data and does not provide original data. Much of the data gathered is from government documents, models, and analysis. All data sources are included with each data table.

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Glossary

AAMA	American Architectural Manufacturers Association
ACEEE	American Council for an Energy Efficient Economy
AEO	EIA's Annual Energy Outlook
AFEAS	Alternative Fluorocarbons Environmental Acceptability Study
AFUE	Annual Fuel Utilization Efficiency
AHAM	Association of Home Appliance Manufacturers
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BTS	DOE's Office of Building Technology, State and Community Programs
CBECS	EIA's Commercial Building Energy Consumption Survey
CDD	Cooling Degree Days
CF	Cubic feet
CFC	Chlorofluorocarbon
CHP	Combined Heat and Power
CO	Carbon monoxide
CO2	Carbon dioxide (CO_2)
COP	Coefficient of Performance (dimensionless, heating/cooling capacity: (Btu) over electric input (Btu))
CPS	Bureau of the Census' Current Population Survey
Delivered	Refers to energy used on site (including purchased electricity)
DG	Distributed Generation
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
EER	Energy Efficiency Ratio (Btu/watt-hour)
EERE	DOE’s Energy Efficiency and Renewable Energy Office
EF	Energy Factor
EIA	DOE's Energy Information Administration
EPA	U.S. Environmental Protection Agency
FEMP	DOE's Federal Energy Management Program
FT2	Square Feet
FY	Fiscal Year
GAMA	Gas Appliance Manufacturers Association

Glossary

GDP	Gross Domestic Product
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HHS	U.S. Department of Health and Human Services
HSPF	Heating Season Performance Factor (Btu/watt-hour)
HUD	U.S. Department of Housing and Urban Development
HVAC/R	Heating, ventilating, and air-conditioning/refrigeration
IEA	International Energy Agency
LBNL	Lawrence Berkeley National Laboratory
LIHEAP	HHS' Low Income Home Energy Assistance Program
LPG	Liquid Petroleum Gas
MEF	Modified Energy Factor
MMT CO2	Million metric tons of carbon dioxide (includes only energy consumption effects, unless otherwise noted)
N.A.	Not Available
N/A	Not Applicable
NAHB	National Association of Home Builders
NCES	National Center for Educational Statistics
NEMS	National Energy Modeling System
NIST	National Institute of Standards and Technology
NWWDA	National Wood Window and Door Association
NOx	Nitrogen oxide (NO_x)
OBE	BTS's Office of Building Equipment
OBT	DOE's Office of Building Technology, State and Community Programs (formerly the Office of Building Technologies)
ODP	Ozone Depletion Potential
ORNL	Oak Ridge National Laboratory
OWIP	Office of Weatherization and Intergovernmental Program
PM-2.5	Particulate matter of aerodynamic diameter less than 2.5 microns
PM-10	Particulate matter of aerodynamic diameter less than 10 microns
PNNL	Pacific Northwest National Laboratory

Glossary

Primary	Refers to energy used at the source (including fuel input to electric power plants)
PV	Photovoltaic
PY	Program Year
Quad	Quadrillion Btu (10^15 Btu)
R-value	Thermal resistance measured in $(\text{Btu/Hr-SF-}^{o}\text{F})^{-1}$
RECS	EIA's Residential Energy Consumption Survey
SEDS	State Energy Data System
SEER	Seasonal Energy Efficiency Ratio (Btu/watt-hour)
SEF	Solar Energy Factor
SF	Square feet
SHGC	Solar heat gain coefficient
SIC	Standard Industrial Classification
Site	Refers to energy used on site (i.e., delivered)
SO2	Sulfur dioxide (SO_2)
SRCC	Solar Rating and Certification Corporation
U-Factor	Thermal conductance measured in $(\text{Btu/Hr-SF-}^{o}\text{F})$
VOC	Volatile organic compounds

Chapter 1: Buildings Sector

Chapter 1 provides an overview of energy use in the U.S. buildings sector, which includes single- and multi-family residences and commercial buildings. Commercial buildings include offices, stores, restaurants, warehouses, other buildings used for commercial purposes, and government buildings. Section 1.1 presents data on primary energy consumption, as well as energy consumption by end use. Section 1.2 focuses on energy and fuel expenditures in U.S. buildings. Section 1.3 provides estimates of construction spending, R&D, and construction industry employment. Section 1.4 covers emissions from energy use in buildings, construction waste, and other environmental impacts. Section 1.5 discusses key measures used throughout the Data Book, such as a quad, primary vs. delivered energy, and carbon emissions. Section 1.6 provides estimates of embodied energy for various building assemblies. The main points from this chapter are summarized below.

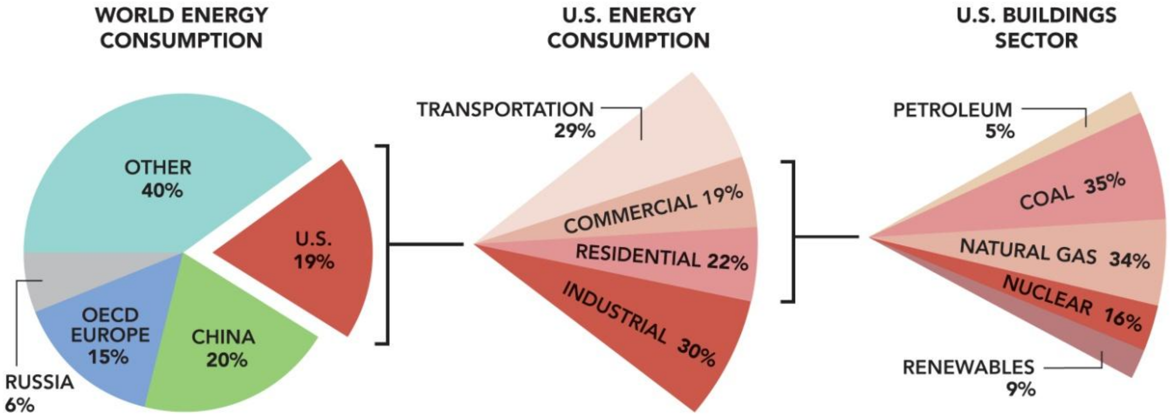
- The 97.8 quads of energy the U.S. consumed in 2010 represented 19% of global consumption—the second largest share of world energy consumption by any country; only China consumed more. (1.1.13) The U.S. buildings sector alone accounted for 7% of global primary energy consumption in 2010. (1.1.3)
- In the United States, the buildings sector accounted for about 41% of primary energy consumption in 2010, 44% more than the transportation sector and 36% more than the industrial sector. (1.1.3)
- Total building primary energy consumption in 2009 was about 48% higher than consumption in 1980. (1.1.8) Space heating, space cooling, and lighting were the dominant end uses in 2010, accounting for close to half of all energy consumed by the buildings sector. (1.1.4)

New building construction also took a big hit in 2010 and was valued at 55% less than at its peak in 2006. (1.3.2) The number of people employed in architecture and construction has decreased 27% from 2006 levels. (1.3.7)

In 2010, China took the United States' place as the largest consumer of energy in the world. Between 2008 and 2010, energy consumption in the U.S. decreased by 2% to 97.8 quads, whereas China's energy consumption increased by 22.9% to 104.6 quads. (1.1.13) Meanwhile, China's carbon dioxide emissions continued to rise at a notable rate, 21% between 2008 and 2010. The U.S.'s carbon dioxide emissions decreased 3% over the same period. U.S. buildings have come to represent an increasing portion of the country's carbon dioxide emissions—40% in 2009, compared to 33% in 1980; yet, the fast growth rate of global emissions means that emissions from U.S. buildings have become a declining percentage of the global total—8.5% in 1980, compared to 7.1% in 2009. (1.4.1)

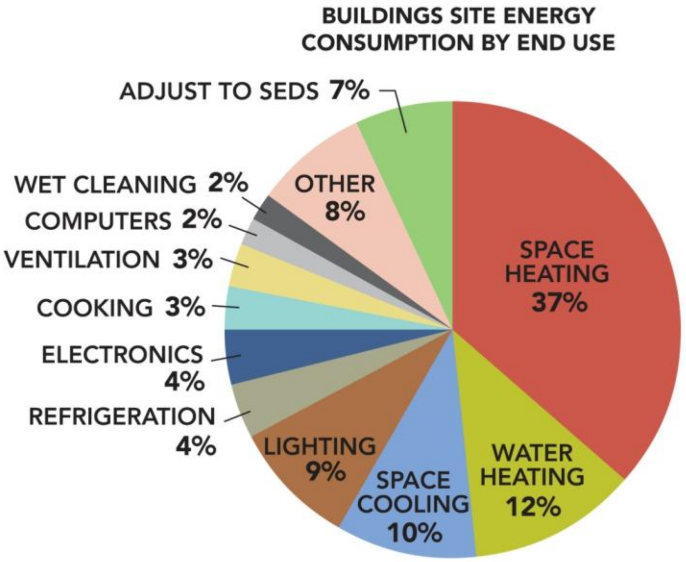
The decline in U.S. energy consumption can be attributed to the economic recession, which has had a particularly hard impact on the building sector. Total energy expenditures in the building sector decreased 8% to 417.8 billion from 2008 to 2009, the largest percent drop in the last 30 years. (1.2.3) The value of new building construction dropped again for the fourth year in a row and was valued at 377.4 billion, 55% less than at its peak in 2006, where new building construction was valued at 843.6 billion. (1.3.2) As expected, the number of people employed in architecture and construction has also decreased since 2006. More than 7.9 million people were employed in the two industries then, compared to 5.7 million in 2010, a 27% drop. (1.3.7)

Forty-one percent of U.S. primary energy was consumed by the buildings sector, compared to 30% by the industrial sector and 29% by the transportation sector. Of the 39 quads consumed in the buildings sector, homes accounted for 54% and commercial buildings accounted for 46% (1.1.3). Of the energy sources used by the U.S. buildings sector, 75% came from fossil fuels, 16% from nuclear generation, and 9% from renewables. (1.1.8)



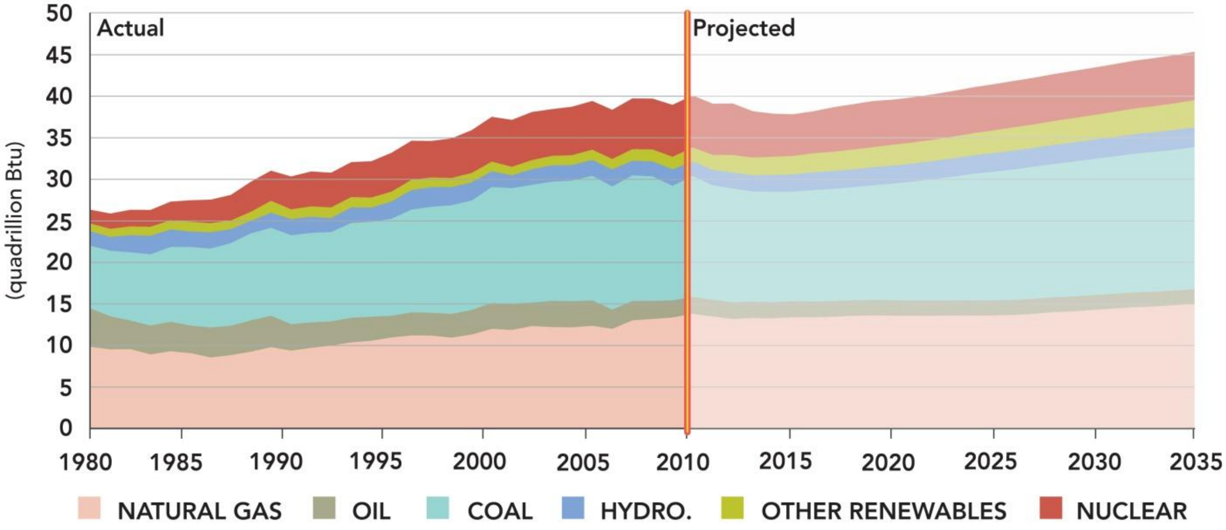
The buildings sector consumed 20 quads of delivered (site) energy in 2010. Delivered energy does not include energy lost during production, transmission, or distribution to customers. The top four end uses—space heating, space cooling, water heating, and lighting—accounted for close to 70% of site energy consumption. Other end uses, such as consumer electronics, kitchen appliances, and ventilation, made up the remainder. (1.1.4)

U.S. building primary energy consumption increased by 48% between 1980 and 2009. The Energy Information Administration (EIA) projects that this growth will stagnate due to the recession until 2016, when steady growth is predicted through 2035. Total primary energy consumption is expected to reach more than 45 quads by 2035, an 17% increase over 2009 levels.



This growth in buildings sector energy consumption is fueled primarily by the growth in population, households, and commercial floorspace, which are expected to increase 27% (2.2.1), 31% (2.1.4), and 28% (3.2.1), respectively, between 2009 and 2035. The use of coal is projected to increase by 11% over the same period, while natural gas consumption will increase by 17%. Use of non-hydroelectric renewable resources, including wind, solar, and biofuels, is expected to increase 109%. (1.1.8)

BUILDINGS SECTOR PRIMARY ENERGY CONSUMPTION



1.1.1 U.S. Residential and Commercial Buildings Total Primary Energy Consumption (Quadrillion Btu and Percent of Total)

									Electricity						Growth Rate
	Natural Gas		Petroleum (1)		Coal		Renewable(2)		Sales	Losses	Total		TOTAL (2)		2010-Year
1980	7.42	28.2%	3.04	11.5%	0.15	0.6%	0.87	3.3%	4.35	10.47	14.82	56.4%	26.29	100%	-
1990	7.14	23.6%	2.36	7.8%	0.15	0.5%	0.74	2.5%	6.01	13.81	19.82	65.6%	30.22	100%	-
2000	8.30	22.1%	2.32	6.2%	0.10	0.3%	0.63	1.7%	8.02	18.15	26.17	69.8%	37.52	100%	-
2005	8.01	20.3%	2.18	5.5%	0.10	0.3%	0.62	1.6%	8.99	19.55	28.53	72.3%	39.44	100%	-
2010	**8.35**	**20.7%**	**1.94**	**4.8%**	**0.07**	**0.2%**	**0.59**	**1.5%**	**9.49**	**19.90 (3)**	**29.39**	**72.9%**	**40.33**	**100%**	**-**
2015	8.40	21.4%	1.71	4.3%	0.06	0.2%	0.66	1.7%	9.43	19.03	28.46	72.4%	39.29	100%	-0.5%
2020	8.43	20.6%	1.63	4.0%	0.06	0.2%	0.69	1.7%	9.95	20.10	30.05	73.6%	40.86	100%	0.1%
2025	8.39	19.7%	1.57	3.7%	0.06	0.2%	0.69	1.6%	10.53	21.24	31.77	74.8%	42.48	100%	0.3%
2030	8.42	19.1%	1.53	3.5%	0.06	0.1%	0.70	1.6%	11.20	22.11	33.31	75.7%	44.03	100%	0.4%
2035	8.41	18.5%	1.50	3.3%	0.06	0.1%	0.71	1.6%	11.83	23.00	34.83	76.5%	45.52	100%	0.5%

Note(s): 1) Petroleum includes distillate and residual fuels, liquefied petroleum gas, kerosene, and motor gasoline. 2) Includes site-marketed and non-marketed renewable energy. 3) 2010 site-to-source electricity conversion = 3.10.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.2 U.S. Buildings Site Renewable Energy Consumption (Quadrillion Btu) (1)

	Wood (2)	Solar Thermal (3)	Solar PV (3)	GSHP (4)	Total	Growth Rate 2010-Year
1980	0.867	0.000	N.A.	0.000	0.867	-
1990	0.675	0.056	N.A.	0.008	0.739	-
2000	0.549	0.060	N.A.	0.016	0.625	-
2005	0.532	0.058	N.A.	0.029	0.620	-
2010	**0.534**	**0.038**	**0.016**	**0.006**	**0.593**	**-**
2015	0.536	0.049	0.052	0.012	0.648	1.8%
2020	0.542	0.051	0.064	0.019	0.675	1.3%
2025	0.543	0.052	0.066	0.022	0.684	1.0%
2030	0.545	0.053	0.069	0.024	0.692	0.8%
2035	0.546	0.057	0.074	0.027	0.703	0.7%

Note(s): 1) Does not include renewable energy consumed by electric utilities (including hydroelectric). 2) Includes wood and wood waste, municipal solid waste, and other biomass used by the commercial sector to cogenerate electricity. 3) Includes only solar energy. 4) GHP = Ground-

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables,Table A17, p. 34-35 for 2010-2035.

1.1.3 Buildings Share of U.S. Primary Energy Consumption (Percent)

	Buildings						
	Residential	Commercial	Total	Industry	Transportation	Total	Total Consumption (quads)
1980(1)	20.1%	13.5%	**33.7%**	41.1%	25.2%	100%	78.1
1990	20.0%	15.7%	**35.8%**	37.7%	26.5%	100%	84.5
2000	20.6%	17.4%	**38.0%**	35.1%	26.9%	100%	98.7
2005	21.5%	17.8%	**39.3%**	32.4%	28.3%	100%	100.3
2010	**22.5%**	**18.6%**	**41.1%**	**30.8%**	**28.1%**	**100%**	**98.2**
2015	21.5%	18.6%	**40.2%**	31.4%	28.4%	100%	97.8
2020	21.4%	19.0%	**40.4%**	32.0%	27.6%	100%	101.1
2025	21.7%	19.5%	**41.2%**	31.8%	27.0%	100%	103.1
2030	21.9%	19.9%	**41.8%**	31.5%	26.8%	100%	105.4
2035	21.9%	20.2%	**42.1%**	31.1%	26.8%	100%	108.1

Note(s): 1) Renewables are not included in the 1980 data.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.4 2010 U.S. Buildings Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	*Site* Electric	*Site*		Primary Electric (4)	Primary	
							Total	Percent		Total	Percent
Space Heating (5)	5.14	0.76	0.30	0.10	0.54	0.72	7.56	37.0%	2.24	9.07	22.5%
Space Cooling	0.04					1.92	1.96	9.6%	5.94	5.98	14.8%
Lighting						1.88	1.88	9.2%	5.82	5.82	14.4%
Water Heating	1.73	0.13	0.07		0.04	0.54	2.51	12.3%	1.67	3.63	9.0%
Refrigeration (6)						0.84	0.84	4.1%	2.62	2.62	6.5%
Electronics (7)						0.81	0.81	3.9%	2.49	2.49	6.2%
Ventilation (8)						0.54	0.54	2.6%	1.66	1.66	4.1%
Computers						0.38	0.38	1.9%	1.19	1.19	2.9%
Cooking	0.39		0.03			0.21	0.63	3.1%	0.64	1.06	2.6%
Wet Cleaning (9)	0.06					0.33	0.38	1.9%	1.01	1.06	2.6%
Other (10)	0.30	0.01	0.30	0.05	0.02	0.89	1.58	7.7%	2.76	3.45	8.6%
Adjust to SEDS (11)	0.68	0.25				0.44	1.37	6.7%	1.35	2.28	5.7%
Total	**8.35**	**1.14**	**0.70**	**0.15**	**0.59**	**9.49**	**20.43**	100%	**29.39**	**40.33**	100%

Note(s): 1) Includes distillate fuel oil (1.06 quad) and residual fuel oil (0.08 quad). 2) Kerosene (0.04 quad) and coal (0.07 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of wood space heating (0.42 quad), biomass (0.11), solar water heating (0.04 quad), geothermal space heating (less than 0.01 quad), solar photovoltaics (PV) less than 0.02 quad), and wind (less than 0.01 quad). 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.10. 5) Includes furnace fans (0.42 quad). 6) Includes refrigerators (2.36 quad) and freezers (0.26 quad). Includes commercial refrigeration. 7) Includes color television (1.02 quad) and other office equipment (0.81 quad). 8) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 9) Includes clothes washers (0.10 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.60 quad) and dishwashers (0.31 quad). Does not include water heating energy. 10) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 11) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the residential and commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, Table A4, Table A5, and Table A17; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Supplement to the Annual Energy Outlook 2012 Early Release, Jan. 2012, Table 32; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A for residential electric end-uses; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2 and 5-25 - 5-26; EIA, Annual Energy Outlook 1998, Dec. 1997, Table A5, p. 108-109 for 1995 ventilation; and BTP/Navigant Consulting, U.S. Lighting Market Characterization, Volume I, Sept. 2002, Table 8-2, p. 63.

1.1.5 2015 U.S. Buildings Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	*Site*	*Site*		Primary	Primary	
	Gas	Oil (1)	LPG	Fuel(2)	En.(3)	Electric	Total	Percent	Electric (4)	Total	Percent
Space Heating (5)	5.10	0.68	0.26	0.09	0.55	0.59	7.27	35.9%	1.77	8.45	21.5%
Lighting						1.52	1.52	7.5%	4.65	4.65	11.8%
Space Cooling	0.04					0.54	0.57	2.8%	4.60	4.63	11.8%
Water Heating	1.79	0.10	0.05		0.05	0.57	2.55	12.6%	1.71	3.70	9.4%
Refrigeration (6)						0.81	0.81	4.0%	2.43	2.43	6.2%
Electronics (7)						1.54	1.54	7.6%	1.94	1.94	4.9%
Ventilation (8)						0.14	0.14	0.7%	1.62	1.62	4.1%
Computers						0.38	0.38	1.9%	1.14	1.14	2.9%
Wet Cleaning (9)	0.06					0.64	0.70	3.5%	0.98	1.04	2.7%
Cooking	0.41		0.03			0.33	0.76	3.8%	0.41	0.85	2.2%
Other (10)	0.33	0.01	0.31	0.05	0.06	1.76	2.52	12.4%	5.30	6.06	15.4%
Adjust to SEDS (11)	0.68	0.19				0.63	1.50	7.4%	1.90	2.77	7.1%
Total	**8.40**	**0.98**	**0.65**	**0.14**	**0.66**	**9.43**	**20.26**	100%	**28.46**	**39.29**	100%

Note(s): 1) Includes distillate fuel oil (0.90 quad) and residual fuel oil (0.08 quad). 2) Kerosene (0.03 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of wood space heating (0.43 quad), biomass (0.11), solar water heating (0.05 quad), geothermal space heating (0.01 quad), solar photovoltaics (PV) (0.05 quad), and wind (less than 0.01 quad). 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 5) Includes furnace fans (0.14 quad). 6) Includes refrigerators (2.18 quad) and freezers (0.25 quad). Includes commercial refrigeration. 7) Includes color television (0.99 quad). 8) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 9) Includes clothes washers (0.10 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.59 quad) and dishwashers (0.30 quad). Does not include water heating energy. 10) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 11) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the residential and commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A4, p. 9-10, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

1.1.6 2025 U.S. Buildings Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	*Site*	*Site*		Primary	Primary	
	Gas	Oil (1)	LPG	Fuel(2)	En.(3)	Electric	Total	Percent	Electric (4)	Total	Percent
Space Heating (5)	4.96	0.57	0.24	0.09	0.57	0.63	7.05	33.2%	1.89	8.31	19.6%
Space Cooling	0.03					1.64	1.67	7.9%	4.94	4.97	11.7%
Lighting						1.55	1.55	7.3%	4.68	4.68	11.0%
Water Heating	1.84	0.08	0.04		0.05	0.62	2.63	12.4%	1.86	3.88	9.1%
Refrigeration (6)						0.82	0.82	3.9%	2.47	2.47	5.8%
Electronics (7)						0.78	0.78	3.7%	2.34	2.34	5.5%
Ventilation (8)						0.60	0.60	2.8%	1.80	1.80	4.2%
Computers						0.44	0.44	2.0%	1.31	1.31	3.1%
Wet Cleaning (9)	0.06					0.30	0.37	1.7%	0.91	0.98	2.3%
Cooking	0.43		0.03			0.15	0.61	2.9%	0.46	0.92	2.2%
Other (10)	0.48	0.01	0.34	0.05	0.08	2.32	3.28	15.5%	7.00	7.96	18.7%
Adjust to SEDS (11)	0.58	0.18				0.69	1.46	6.9%	2.09	2.85	6.7%
Total	**8.39**	**0.84**	**0.65**	**0.15**	**0.69**	**10.53**	**21.25**	100%	**31.77**	**42.48**	100%

Note(s): 1) Includes distillate fuel oil (0.76 quad) and residual fuel oil (0.08 quad). 2) Kerosene (0.03 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of wood space heating (0.443quad), biomass (0.11 quad), solar water heating (0.05 quad), geothermal space heating (0.02 quad), solar photovoltaics (PV) (0.07 quad), and wind (0.01 quad). 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 5) Includes furnace fans (0.44 quad). 6) Includes refrigerators (2.21 quad) and freezers (0.26 quad). Includes commercial refrigeration. 7) Includes color television (1.12 quad). 8) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 9) Includes clothes washers (0.08 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.54 quad) and dishwashers (0.30 quad). Does not include water heating energy. 10) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 11) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the residential and commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A4, p. 9-10, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012,and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

1.1.7 2035 U.S. Buildings Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	*Site* Electric	*Site* Total	*Site* Percent	Primary Electric (4)	Primary Total	Primary Percent
Space Heating (5)	4.84	0.49	0.22	0.09	0.57	0.66	6.87	30.5%	1.93	8.15	17.9%
Space Cooling	0.03					1.79	1.82	8.1%	5.27	5.30	11.7%
Lighting						1.63	1.63	7.3%	4.81	4.81	10.6%
Water Heating	1.81	0.07	0.03		0.06	0.63	2.60	11.6%	1.86	3.83	8.4%
Electronics (6)						0.90	0.90	4.0%	2.66	2.66	5.8%
Refrigeration (7)						0.88	0.88	3.9%	2.60	2.60	5.7%
Ventilation (8)						0.65	0.65	2.9%	1.91	1.91	4.2%
Computers						0.49	0.49	2.2%	1.43	1.43	3.1%
Wet Cleaning (9)	0.07					0.32	0.39	1.7%	0.95	1.01	2.2%
Cooking	0.45		0.02			0.17	0.65	2.9%	0.50	0.98	2.2%
Other (10)	0.81	0.01	0.38	0.06	0.08	2.94	4.28	19.0%	8.65	9.99	21.9%
Adjust to SEDS (11)	0.40	0.18				0.77	1.36	6.0%	2.28	2.86	6.3%
Total	**8.41**	**0.75**	**0.66**	**0.15**	**0.71**	**11.83**	**22.52**	100%	**34.83**	**45.52**	100%

Note(s): 1) Includes distillate fuel oil (0.67 quad) and residual fuel oil (0.08 quad). 2) Kerosene (0.03 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of wood space heating (0.44 quad), biomass (0.11 quad), solar water heating (0.06 quad), geothermal space heating (0.03 quad), solar photovoltaics (PV) (0.07 quad), and wind (0.01 quad). 4) Site-to-source electricity conversion (due to generation and transmission losses) = 2.94. 5) Includes furnace fans (0.45 quad). 6) Includes color television (1.29 quad) and other office equipment (1.37 quad). 7) Includes refrigerators (2.33 quad) and freezers (0.26 quad). Includes commercial refrigeration. 8) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 9) Includes clothes washers (0.07 quad), natural gas clothes dryers (0.07 quad), electric clothes dryers (0.55 quad) and dishwashers (0.33 quad). Does not include water heating energy. 10) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 11) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the residential and commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A4, p. 9-10, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012,and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

1.1.8 Shares of U.S. Buildings Generic Quad (Percent) (1)

	Natural Gas	Petroleum	Coal	Renewables (2) Hydroelectric	Renewables (2) Other	Renewables (2) Total	Nuclear	Total
1980	37%	18%	29%	7%	3%	10%	6%	100%
1990	31%	11%	36%	6%	4%	10%	13%	100%
2000	32%	8%	37%	5%	3%	8%	14%	100%
2005	31%	8%	38%	5%	3%	8%	15%	100%
2010	**35%**	**6%**	**36%**	**5%**	**4%**	**9%**	**16%**	**100%**
2015	37%	5%	31%	5%	5%	11%	16%	100%
2020	35%	5%	32%	5%	6%	11%	17%	100%
2025	34%	4%	33%	5%	7%	12%	17%	100%
2030	34%	4%	33%	5%	7%	12%	17%	100%
2035	34%	4%	33%	5%	7%	13%	16%	100%

Note(s): 1) A generic quad is primary energy apportioned between the various primary fuels according to their relative consumption. 2) Electric imports included in renewables.

Source(s): EEIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.9 Buildings Share of U.S. Electricity Consumption (Percent)

	Buildings						*Delivered Total*
	Residential	Commercial	**Total**	Industry	Transportation	Total	(quads)
1980	34%	27%	**61%**	39%	0%	100%	7.15
1990	34%	31%	**65%**	35%	0%	100%	9.26
2000	35%	34%	**69%**	31%	0%	100%	11.67
2005	37%	35%	**72%**	28%	0%	100%	12.49
2010 (1)	**39%**	**35%**	**74%**	**26%**	**0%**	**100%**	**12.79**
2015	37%	36%	**73%**	27%	0%	100%	12.88
2020	37%	36%	**73%**	26%	0%	100%	13.58
2025	38%	37%	**74%**	25%	0%	100%	14.13
2030	38%	38%	**76%**	24%	0%	100%	14.75
2035	39%	38%	**77%**	22%	1%	100%	15.32

Note(s): 1) Buildings accounted for 73.6% (or $301.6 billion) of total U.S. electricity expenditures.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.10 Buildings Share of U.S. Natural Gas Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Natural Gas Total
	Buildings	Industry	Electric Gen.	Transportation	**Buildings**	Industry	Transportation	(quads)
1980	**37%**	41%	19%	3%	**48%**	49%	3%	20.22
1990	**36%**	43%	17%	3%	**47%**	49%	4%	19.57
2000	**35%**	40%	22%	3%	**50%**	47%	3%	23.66
2005	**36%**	35%	27%	3%	**55%**	42%	3%	22.49
2010 (1)	**34%**	**33%**	**31%**	**3%**	**56%**	**41%**	**3%**	**24.71**
2015	**32%**	33%	32%	3%	**56%**	41%	3%	25.99
2020	**32%**	34%	31%	3%	**55%**	42%	3%	26.13
2025	**33%**	34%	30%	3%	**55%**	42%	3%	25.80
2030	**32%**	33%	32%	3%	**56%**	40%	3%	26.49
2035	**31%**	32%	34%	3%	**57%**	40%	3%	27.11

Note(s): 1) Buildings accounted for 64.2% (or $86.0 billion) of total U.S. natural gas expenditures.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.11 Buildings Share of U.S. Petroleum Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Petroleum Total
	Buildings	Industry	Electric Gen.	Transportation	**Buildings**	Industry	Transportation	(quads)
1980	**9%**	28%	8%	56%	**14%**	31%	56%	34.2
1990	**7%**	25%	4%	64%	**10%**	26%	64%	33.6
2000	**6%**	24%	3%	67%	**8%**	25%	67%	38.4
2005	**5%**	24%	3%	68%	**8%**	25%	68%	40.7
2010 (1)	**5%**	**22%**	**1%**	**72%**	**6%**	**22%**	**72%**	**37.2**
2015	**5%**	21%	1%	73%	**5%**	22%	73%	36.9
2020	**4%**	22%	1%	73%	**5%**	22%	73%	37.1
2025	**4%**	22%	1%	73%	**5%**	22%	73%	37.0
2030	**4%**	22%	1%	73%	**5%**	22%	73%	37.3
2035	**4%**	22%	1%	73%	**5%**	22%	73%	38.0

Note(s): 1) Buildings accounted for an estimated 5.4% (or $39.1 billion) of total U.S. petroleum expenditures.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

1.1.12 Buildings Share of U.S. Petroleum Consumption (Million Barrels per Day)

	Buildings					
	Residential	Commercial	**Total**	Industry	Transportation	Total
1980	2.62	2.01	**4.63**	10.55	19.01	34.19
1990	1.81	1.38	**3.20**	8.73	21.63	33.55
2000	1.92	1.19	**3.11**	9.47	25.82	38.40
2005	1.88	1.18	**3.07**	10.02	27.65	40.73
2010	**1.37**	**0.85**	**2.22**	**8.15**	**26.88**	**37.25**
2015	1.20	0.73	**1.93**	8.00	26.96	36.89
2020	1.13	0.73	**1.86**	8.29	27.00	37.15
2025	1.08	0.74	**1.82**	8.30	26.92	37.04
2030	1.04	0.74	**1.78**	8.29	27.24	37.31
2035	1.01	0.75	**1.76**	8.34	27.90	38.00

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 5.13a for 1980-2009 buildings, Table 5.13b for 1980 to 2009 industry, Table 5.13c for 1980-2009 transportation, and Table 5.13d for 1980-2009 electricity generators; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 consumption; EIA, State Energy Consumption Database, June 2011 for 1980-2009

1.1.13 World Primary Energy Consumption and Population, by Country/Region

									Annual Growth Rate			
	Energy Consumption (Quad)				Population (million)				1990-2000		2000-2010	
Region/Country	1990	2000	2010		1990	2000	2010		Energy	Pop.	Energy	Pop.
United States	85.0	99.8	97.8	18.7%	250	282	311	4.6%	1.6%	1.2%	-0.2%	1.0%
China	27.0	36.4	104.6	20.0%	1,148	1,264	1,343	20.0%	3.0%	1.0%	11.1%	0.6%
OECD Europe	69.9	76.8	79.6	15.2%	402	522	550	8.2%	0.9%	2.6%	0.4%	0.5%
Other Non-OECD Asia	12.5	20.6	31.3	6.0%	781	1,014	1,086	16.2%	5.1%	2.6%	4.2%	0.7%
Russia (1)	61.0	27.2	29.9	5.7%	288	147	140	2.1%	-7.7%	-6.5%	0.9%	-0.5%
Central & S. America	14.5	20.8	28.1	5.4%	359	422	462	6.9%	3.7%	1.6%	3.0%	0.9%
Middle East	11.2	17.3	27.6	5.3%	135	173	213	3.2%	4.5%	2.5%	4.8%	2.1%
Japan	18.8	22.4	20.8	4.0%	124	127	127	1.9%	1.8%	0.3%	-0.8%	0.0%
India	7.9	13.5	23.8	4.6%	838	1,006	1,214	18.1%	5.5%	1.8%	5.9%	1.9%
Canada	11.0	13.1	14.3	2.7%	28	31	34	0.5%	1.8%	1.1%	0.9%	0.9%
Oth. Non-OECD Europe	6.4	17.6	19.4	3.7%	154	128	199	3.0%	10.7%	-1.8%	1.0%	4.5%
Africa	9.5	12.0	19.5	3.7%	631	804	1,001	14.9%	2.4%	2.4%	4.9%	2.2%
South Korea	3.8	7.8	10.2	2.0%	43	47	49	0.7%	7.4%	0.9%	2.7%	0.5%
Mexico/Chile (2)	4.7	6.4	8.5	1.6%	85	100	128	1.9%	3.1%	1.6%	2.9%	2.5%
Australia & N. Zealand	4.4	5.7	6.9	1.3%	20	23	26	0.4%	2.5%	1.2%	2.0%	1.3%
Total World	**348.4**	**397.4**	**522.0**	100%	**5,287**	**6,089**	**6,701**	100%	1.3%	1.4%	2.8%	1.0%

Note(s): 1) 1990 Values for Russia approximated by Former USSR. 2) Before 2010, Mexico/Chile category only included Mexico.

Source(s): EIA, International Energy Outlook 2011, Sept. 2011, Table A1, p.157; EIA, Country Profiles http://www.eia.gov/country/index.cfm

1.2.1 Building Energy Prices, by Year and Major Fuel Type ($2010 per Million Btu)

	Residential Buildings				Commercial Buildings				Building
	Electricity	Natural Gas	Petroleum (1)	Avg.	Electricity	Natural Gas	Petroleum (2)	Avg.	Avg. (3)
1980	36.40	8.35	16.77	17.64	37.22	7.70	13.06	18.52	17.99
1990	35.19	8.63	13.27	18.64	32.49	7.20	9.31	18.62	18.63
2000	30.13	9.54	14.18	18.06	26.86	8.19	10.44	17.66	17.89
2005	30.64	13.66	18.93	21.50	28.11	12.15	15.14	20.92	21.25
2010	**33.69**	**11.08**	**23.75**	**22.42**	**29.73**	**9.10**	**20.28**	**20.99**	**21.80**
2015	33.22	10.28	28.73	22.24	28.07	8.59	24.07	20.11	21.30
2020	32.46	11.06	29.90	22.58	27.78	9.21	25.46	20.46	21.62
2025	32.31	12.11	31.22	23.36	27.74	10.12	26.73	21.07	22.32
2030	31.76	12.66	32.40	23.69	26.98	10.53	27.97	21.01	22.45
2035	32.47	13.86	33.86	24.92	27.99	11.55	28.94	22.14	23.62

Note(s): 1) Residential petroleum products include distillate fuel, LPG, and kerosene. 2) Commercial petroleum products include distillate fuel, LPG, kerosene, motor gasoline, and residual fuel. 3) In 2010, buildings average electricity price was $30.47/MMBtu or ($0.10/kWh), average natural gas price was $10.611/MMBtu ($1.06/therm), and petroleum was $22.66/ MMBtu ($3.14/gal.). Averages do not include wood or coal.

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, June 2011, for 1980-2009 and prices for note, Tables ET3-ET4, p. 27-28 for 1980-2009 consumption; EIA, Annual Energy Outlook 20112 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8, Table A12, p. 25-26, and Table A13, p. 27-28 for 2010-2035 consumption and prices; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

1.2.2 Building Energy Prices, by Year and Fuel Type ($2010)

	Residential Buildings				Commercial Buildings			
	Electricity (¢/kWh)	Natural Gas (¢/therm)	Distillate Oil ($/gal)	LPG ($/gal)	Electricity (¢/kWh)	Natural Gas (¢/therm)	Distillate Oil ($/gal)	Residual Oil ($/gal)
1980	12.42	83.51	1.53	2.24	12.70	77.01	1.43	2.05
1990	12.01	86.28	1.40	1.69	11.08	72.04	0.78	1.26
2000	10.28	95.36	1.51	1.70	9.17	81.85	0.84	1.28
2005	10.45	136.59	1.90	2.36	9.59	121.45	1.24	2.07
2010	**11.50**	**110.79**	**2.29**	**2.92**	**10.14**	**90.95**	**1.66**	**2.86**
2015	11.33	102.80	2.60	3.74	9.58	85.91	2.41	3.28
2020	11.08	110.57	2.64	3.96	9.48	92.13	2.63	3.49
2025	11.02	121.07	2.74	4.15	9.47	101.25	2.73	3.69
2030	10.84	126.62	2.82	4.34	9.20	105.25	2.85	3.89
2035	11.08	138.62	2.93	4.55	9.55	115.50	2.82	4.06

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, June 2011, p. Tables ET3-ET4, p. 27-28 for 1980-2009; EIA, Annual Energy Outlook 2011, April 2011, Table G1, p. 225 for fuels' heat content; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A3, p. 6-8 for 2010-2035; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

1.2.3 Buildings Aggregate Energy Expenditures, by Year and Major Fuel Type ($2010 Billion) (1)

	Residential Buildings				Commercial Buildings				Total Building
	Electricity	Natural Gas	Petroleum (2)	Total	Electricity	Natural Gas	Petroleum (3)	Total	Expenditures
1980	89.1	40.5	28.9	158.5	70.9	20.5	17.2	108.6	267.2
1990	110.9	39.0	18.2	168.2	92.9	19.4	9.2	121.5	289.7
2000	122.6	48.6	21.6	192.8	106.3	26.6	8.3	141.2	334.0
2005	142.1	67.7	26.9	236.7	122.3	37.4	11.4	171.2	407.9
2010	**166.8**	**56.1**	**29.0**	**251.8**	**134.8**	**29.9**	**14.5**	**179.2**	**431.1**
2015	159.3	51.3	31.1	241.7	130.0	29.3	15.0	174.4	416.0
2020	163.1	54.7	30.1	247.9	136.9	32.1	15.7	184.8	432.7
2025	171.3	59.1	29.8	260.3	145.0	35.5	16.6	197.0	457.3
2030	178.9	61.3	29.5	269.7	150.1	37.7	17.3	205.1	474.9
2035	193.0	66.0	29.6	288.6	164.8	42.2	18.0	225.0	513.6

Note(s): 1) Expenditures exclude wood and coal. 2009 U.S. energy expenditures were 1.06 trillion. 2) Residential petroleum products include distillate fuel oil, LPG, and kerosene. 3) Commercial petroleum products include distillate fuel oil, LPG, kerosene, motor gasoline, and residual fuel.

Source(s): EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A3, p. 6-8 for 2010-2035; and EIA, Annual Energy Review 2011, Oct. 2011, Appendix D, p. 353 for price deflators.

1.2.4 FY 2007 Federal Buildings Energy Prices and Expenditures, by Fuel Type ($2010)

Fuel Type	Average Fuel Prices ($/million BTU)		Total Expenditures ($ million) (2)
Electricity	23.68 (1)		4009.39
Natural Gas	9.37		1138.21
Fuel Oil	15.25		419.30
Coal	3.62		62.87
Purchased Steam	24.30		318.35
LPG/Propane	17.06		43.87
Other	16.19		36.64
Average	17.05	**Total**	6028.63

Note(s): Prices and expenditures are for Goal-Subject buildings. 1) $0.0776/kWh. 2) Energy used in Goal-Subject buildings in FY 2007 accounted for 33.8% of the total Federal energy bill.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table A-4, p. 93 for prices and expenditures, and Table A-9, p. 97 for total energy expenditures; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

1.2.5 2010 Buildings Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity	Total	Percent
Space Heating (3)	53.7	14.2	0.9	8.0	0.6	23.7	0.1	23.2	100.7	23.4%
Space Cooling	0.4							61.3	61.7	14.3%
Lighting								59.3	59.3	13.8%
Water Heating	18.3	2.6		2.0		4.6		17.8	40.7	9.4%
Refrigeration (4)								26.9	26.9	6.2%
Electronics (5)								26.1	26.1	6.1%
Ventilation (6)								15.9	15.9	3.7%
Cooking	4.0			0.8		0.8		8.8	13.6	3.2%
Computers								12.1	12.1	2.8%
Wet Cleaning (7)	0.6							11.0	11.6	2.7%
Other (8)	2.7	0.3		7.7	1.2	9.2		27.3	39.2	9.1%
Adjust to SEDS (9)	6.2	5.2				5.2		11.9	23.4	5.4%
Total	**86.0**	**22.3**	**0.9**	**18.5**	**1.8**	**43.5**	**0.1**	**301.6**	**431.2**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.6 billion) and motor gasoline other uses ($1.2 billion). 3) Includes furnace fans ($4.5 billion). 4) Includes refrigerators ($24.1 billion) and freezers ($2.8 billion). 5) Includes color televisions ($11.0 billion) and other electronics ($15.0 billion). 6) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 7) Includes clothes washers ($1.1 billion), natural gas clothes dryers ($0.6 billion), electric clothes dryers ($6.5 billion) and dishwashers ($3.4 billion). 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial services station equipment, ATMs, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, manufacturing performed in commercial buildings. 9) Expenditures related to an energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential and commercial buildings sectors, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, Table A4, p. 9-10 for residential energy consumption, and Table A5, p. 11-12 for commercial energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, State Energy Data 2009: Prices and Expenditures, June 2011, p. 24-25 for coal prices; EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A for residential Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2, 5-25 and 5-26 for commercial ventilation; and BTP/Navigant Consulting, U.S. Lighting Market Characterization, Volume I, Sept. 2002, Table 8-2, p. 63 for commercial lighting.

1.2.6 2015 Buildings Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity	Total	Percent
Space Heating (3)	49.5	15.9	1.3	8.1	0.7	25.9	0.2	18.7	94.3	22.7%
Space Cooling	0.3							48.0	48.3	11.6%
Lighting								45.9	45.9	11.0%
Water Heating	17.6	2.6		1.5		4.1		18.3	40.0	9.6%
Refrigeration (4)								24.9	24.9	6.0%
Electronics (5)								19.8	19.8	4.7%
Ventilation (6)								15.1	15.1	3.6%
Computers								11.6	11.6	2.8%
Wet Cleaning (7)	0.6							10.8	11.4	2.7%
Cooking	3.9			0.9		0.9		4.4	9.1	2.2%
Other (8)	2.9	0.3		8.9	1.4	10.6		54.1	67.6	16.3%
Adjust to SEDS (9)	5.8	4.5				4.5		17.7	28.1	6.7%
Total	**80.6**	**23.3**	**1.3**	**19.4**	**2.1**	**46.1**	**0.2**	**289.3**	**416.2**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.7 billion) and motor gasoline other uses ($1.4 billion). 3) Includes furnace fans ($4.6 billion). 4) Includes refrigerators ($22.6 billion) and freezers ($2.8 billion). 5) Includes color televisions ($10.9 billion). 6) Commercial only; residential fan proportionately in space heating and cooling. 7) Includes clothes washers ($1.1 billion), natural gas clothes dryers ($0.6 billion), electric clothes dryers ($6.5 billion) and dishwashers ($3.3 billion). 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial services station equipment, ATMs, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 9) Expenditures related to an energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential and commercial buildings sectors, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, Table A4, p. 9-10 for residential energy consumption, and Table A5, p. 11-12 for commercial energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, State Energy Data 2009: Prices and Expenditures database.

1.2.7 2025 Buildings Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity	Total	Percent
Space Heating (3)	56.7	14.3	1.5	7.8	0.7	24.3	0.2	19.5	100.7	22.0%
Space Cooling	0.3							50.5	50.9	11.1%
Lighting								45.2	45.2	9.9%
Water Heating	21.3	2.3		1.3		3.6		19.6	44.4	9.7%
Refrigeration (4)								24.9	24.9	5.4%
Electronics (5)								23.2	23.2	5.1%
Computers								13.2	13.2	2.9%
Wet Clean (6)	0.8							9.8	10.5	2.3%
Cooking	4.8			0.8		0.8		4.9	10.5	2.3%
Ventilation (7)								16.6	16.6	3.6%
Other (8)	4.8	0.4		10.6	1.7	12.7		69.8	87.4	19.1%
Adjust to SEDS (9)	5.9	4.9				4.9		19.2	30.0	6.6%
Total	**94.6**	**21.9**	**1.5**	**20.6**	**2.5**	**46.4**	**0.2**	**316.3**	**457.4**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.7 billion) and motor gasoline other uses ($1.7 billion). 3) Includes furnace fans ($4.7 billion). 4) Includes refrigerators ($22.3 billion) and freezers ($2.6 billion). 5) Includes color televisions ($12.0 billion). 6) Includes clothes washers ($0.8 billion), natural gas clothes dryers ($0.8 billion), electric clothes dryers ($5.8 billion) and dishwashers ($3.2 billion). 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial services station equipment, ATMs, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 9) Expenditures related to an energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential and commercial buildings sectors, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, Table A4, p. 9-10 for residential energy consumption, and Table A5, p. 11-12 for commercial energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, State Energy Data 2009: Prices and Expenditures database.

1.2.8 2035 Buildings Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity	Total	Percent
Space Heating (3)	63.4	13.0	1.6	7.7	0.8	23.1	0.2	20.6	107.2	20.9%
Water Heating	23.8	2.2		1.2		3.4		35.8	63.0	12.3%
Space Cooling	0.4							55.7	56.1	10.9%
Lighting								47.8	47.8	9.3%
Electronics (4)								27.2	27.2	5.3%
Refrigeration (5)								27.0	27.0	5.3%
Computers								14.8	14.8	2.9%
Cooking	5.8			0.8		0.8		5.4	12.1	2.3%
Wet Clean (6)	0.9							10.4	11.3	2.2%
Ventilation (7)								2.4	2.4	0.5%
Other (8)	9.3	0.4		12.6	2.0	15.0		88.8	113.2	22.0%
Adjust to SEDS (9)	4.6	5.3				5.3		21.7	31.6	6.2%
Total	**108.2**	**21.0**	**1.6**	**22.3**	**2.8**	**47.6**	**0.2**	**357.8**	**513.8**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.8 billion) and motor gasoline other uses ($2.0 billion). 3) Includes furnace fans ($4.8 billion). 4) Includes color televisions ($14.2 billion). 5) Includes refrigerators ($24.1 billion) and freezers ($3.0 billion). 6) Includes clothes washers ($0.8 billion), natural gas clothes dryers ($0.9 billion), electric clothes dryers ($6.0 billion) and dishwashers ($3.6 billion). 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial services station equipment, ATMs, telecommunications equipment, medical equipment, pumps, lighting, emergency electric generators, manufacturing performed in commercial buildings. 9) Expenditures related to an energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential and commercial buildings sectors, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, Table A4, p. 9-10 for residential energy consumption, and Table A5, p. 11-12 for commercial energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, State Energy Data 2009: Prices and Expenditures database.

1.2.9 Implicit Price Deflators (2005 = 1.00)

Year	Implicit Price Deflator	Year	Implicit Price Deflator	Year	Implicit Price Deflator
1980	0.48	1990	0.72	2000	0.89
1981	0.52	1991	0.75	2001	0.91
1982	0.55	1992	0.77	2002	0.92
1983	0.58	1993	0.78	2003	0.94
1984	0.60	1994	0.80	2004	0.97
1985	0.62	1995	0.82	2005	1.00
1986	0.63	1996	0.83	2006	1.03
1987	0.65	1997	0.85	2007	1.06
1988	0.67	1998	0.86	2008	1.09
1989	0.70	1999	0.87	2009	1.10
				2010	1.11

Source(s): EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353.

1.3.1 Estimated Value of All U.S. Construction Relative to the GDP ($2010)

- 2007 estimated value of all U.S. construction was $1.82 trillion (including renovation; heavy construction; public works; residential, commercial, and industrial new construction; and non-contract work).
- Compared to the $14.6 trillion 2007 U.S. gross domestic product (GDP), all construction held a 12.4% share.
- In 2007, residential and commercial building renovation (valued at $496 billion) and new building construction (valued at $759 billion) was estimated to account for 69% (approximately $1.26 trillion) of the $1.81 trillion.

Source(s): National Science and Technology Council, Construction & Building: Interagency Program for Technical Advancement in Construction and Building, 1999, p. 5; DOC, 1997 Census of Construction Industries: Industry Summary, Jan. 2000, Table 7, p. 15; DOC, Annual Value of Construction Put in Place, August 2010; DOC, Expenditures for Residential Improvements and Repairs by Property Type, Table S2, May 2008; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators and GDP.

1.3.2 Value of New Building Construction Relative to GDP, by Year ($2010 Billion)

	Value of New Construction Put in Place				Bldgs. Percent of
	Residential	Commercial (1)	All Bldgs. (1)	GDP	Total U.S. GDP
1980	166.0	159.8	325.8	6,461	5.0%
1985	213.5	226.3	439.8	7,579	5.8%
1990	208.4	227.2	435.6	8,890	4.9%
1995	238.0	203.8	441.8	10,063	4.4%
2000	334.6	312.7	647.3	12,423	5.2%
2005	538.3	302.2	840.4	13,986	6.0%
2006	508.9	334.7	843.6	14,359	5.9%
2007	376.2	383.3	759.5	14,639	5.2%
2008	242.1	399.6	641.7	14,639	4.4%
2009	143.2	328.5	471.8	14,254	3.3%
2010	129.8	247.7	377.4	14,660	2.6%

Note(s): 1) New buildings construction differs from Table 1.3.2 by excluding industrial building construction.

Source(s): DOC, Current Construction Reports: Value of New Construction Put in Place, C30, Aug. 2003, Table 1 for 1980-1990; DOC, Annual Value of Private Construction Put in Place, August 2008 for 1995-2000; DOC, Annual Value of Private Construction Put in Place, February 2012 for 2002-2010; DOC, Annual Value of Public Construction Put in Place, August 2008 for 1995-2000; DOC, Annual Value of Public Construction Put in Place, February 2012 for 2002-2010; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

1.3.3 Value of Building Improvements and Repairs Relative to GDP, by Year ($2010 Billion) (1)

	Value of Improvements and Repairs				Bldgs. Percent of
	Residential	Commercial	All Bldgs.	GDP	Total U.S. GDP
1980	107.4	N.A.	N.A.	5,894.6	N.A.
1985	147.6	140.2 (2)	287.8	6,914.5	4.2%
1990	176.9	142.3 (3)	319.2	8,110.4	3.9%
1995	169.6	150.9	320.5	9,180.3	3.5%
2000	198.0	136.4	334.4	11,332.9	3.0%
2006	244.6	224.6	469.2	13,099.8	3.6%
2007	235.7	259.8	495.5	13,354.9	3.7%

Note(s): 1) Improvements includes additions, alterations, reconstruction, and major replacements. Repairs include maintenance. 2) 1986. 3) 1989.

Source(s): DOC, Expenditures for Residential Improvements and Repairs by Property Type, Quarterly, May 2005 for 1980-1990; DOC, Expenditures for Residential Improvements and Repairs by Property Type, Table S2, May 2008 for 1994-2007; DOC, Current Construction Reports: Expenditures for Nonresidential Improvements and Repairs: 1992, CSS/92, Sept. 1994, Table A, p. 2 for 1986-1990 expenditures; DOC, 1997 Census of Construction Industries: Industry Summary, Jan. 2000, Table 7, p. 15; DOC, Annual Value of Private Construction Put in Place, July 2008 and DOC, Annual Value of Public Construction Put in place, July 2008 for 1995-2000; DOC, Annual Value of Private Construction Put in Place, August 2010 and DOC, Annual Value of Public Construction Put in Place, August 2010 for 2003-2007; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for GDP and price deflators.

1.3.4 2003 U.S. Private Investment into Construction R&D

Sector	Percent of Sales
Average Construction R&D (1)	**1.2**
Heavy Construction	2.0
Special Trade Construction	0.2
U.S. Average of All Private R&D (2)	**3.2**
Manufacturing Average	3.1
Service Industry Average	3.3

Building Technology	Percent of Sales
Appliances	2.0
Lighting	1.2
HVAC	1.5
Fans, Blowers, & Air Cleaning Equipment	1.6
Lumber and Wood Products	0.3
Commercial Building Operations	2.2

Note(s): 1) Includes all construction (e.g., bridges, roads, dams, buildings, etc.).

Source(s): National Science Foundation, Research and Development in Industry: 2003, Table 27, p. 76-77; and Schonfeld & Associates, R&D Ratios & Budgets, June 2003, p. 219-222.

1.3.5 2007-2010 Investment into Construction and Energy R&D, by Selected Country

	Year	Construction Percent of Private R&D to Total Private R&D	Electricity, Gas, and Water Percent of Private R&D to Total Private R&D
United States	2007	0.1	0.6
Australia	2010	5.2	1.8
China	2009	1.3	2.5
France	2007	0.4	1.6
Germany	2008	0.1	0.3
Italy	2010	0.9	0.8
Japan	2009	1.0	0.5
Norway	2008	1.4	2.2
Portugal	2008	1.7	6.0
South Africa	2007	0.1	16.2
South Korea	2008	2.5	1.0
United Kingdom	2008	0.1	0.2

Note(s): Includes all construction (e.g., bridges, roads, dams, buildings, etc.).

Source(s): National Science Board, Science and Engineering Indicators 2012, Volume 1, Jan. 2012, Appendix Table 4-46; National Science Board, Science and Engineering Indicators: 2010, Volume 1, Jan. 2010, Appendix Table 4-53.

1.3.6 FY2003-2005 Green Building R&D, as Share of Federal Budget and by Organization

Budget Function	Percent of U.S. Federal Budget
National Defense	57.2%
Health	23.1%
Other energy, general science, natural resources, and environment	**8.0%**
Space research and technology	6.3%
Transportation	1.5%
Agriculture	1.5%
Veterans' benefits and services research	0.7%
Green building	**0.2%**
Other functions (2)	1.6%
Total	100%

Organization	Average Annual Funding ($1,000s)
DOE	123,170
EPA	25,317
NSF	22,940
PIER (1)	11,100
DOC-NIST	7,500
NYSERDA	5,800
HUD	5,000
GSA	3,000
ASHRAE	2,400

Note(s): 1) PIER = Public Interest Energy Research. 2) Includes education, training, employment, and social services; income security; and commerce.

Source(s): U.S. Green Building Council, Green Building Research Funding: An Assessment of Current Activity in the United States, 2006, Chart 1, p. 3, Chart 2, p. 3.

1.3.7 Buildings Design and Construction Trades, by Year

	Employees, in thousands	
	Architects	Construction (1)
1980	N.A.	3,065
1990	N.A.	3,861
2000 (4)	215	5,183
2005	235	7,336
2006	221	7,691
2007	240	7,630
2008	233	7,162
2009	204	6,016
2010	184	5,526

	Number of Residential Builder Establishments with Payrolls, in thousands (2)			
	New Construction	Remodeling	Both	Total (3)
1982	14.4	21.7	57.5	93.6
1987	38.4	32.8	48.1	119.3
1992	36.3	43.3	51.0	130.6
1997	46.6	33.6	52.1	134.1
2002	95.4	28.0	47.7	167.4
2007	52.4	49.8	69.8	163.1

Note(s): 1) Does not include industrial building or heavy construction (e.g., dam and bridge building). In 1999, 76% of the employment shown is considered for "production." The entire U.S. construction industry employs an estimated 10 million people, including manufacturing. 2) In 2000, NAHB report having 200,000 members, one-third of which were builders. 3) Excludes homebuilding establishments without payrolls, estimated by NAHB at an additional 210,000 in 1992. 4) NAHB reports that 2,448 full-time jobs in construction and related industries are generated from the construction of every 1,000 single-family homes and 1,030 jobs are created from the construction of every 1,000 multi-family units.

Source(s): DOC, Statistical Abstract of the U.S. 2001, May 2002, Table 593, p. 380 for 2000 architect employment, Table 609, p. 393 for construction employment; Statistical Abstract of the U.S. 2007, 2006, Table 602, p. 388 for 2005 architect employment; DOC, Statistical Abstract of the U.S. 2008, 2007, Table 598, p. 388 for 2006 architect employment; DOC, Statistical Abstract of the U.S. 2009, 2008, Table 596, p. 384 for 2007 architect employment; DOC, Statistical Abstract of the U.S. 2010, 2009, Table 603 for 2008 architect employment; DOC, Statistical Abstract of the U.S. 2011, 2010, Table 629 for 2005-2008 construction employment and Table 615, p. 393 for architect employment; DOC, Statistical Abstract of the U.S. 2012, 2011, Table 632 for 2009-2010 construction employment; DOC, 1992 Census of Construction Activities: U.S. Summary, CC92-I-27, Jan. 1996, p. 27-5 for construction employees; DOC, 1997 Economic Census: Construction - Industry Summary, EC97C23IS, Jan. 2000, Table 2, p. 8 for industrial builders; DOC, 1997 Economic Census: Construction - Single-Family Housing Construction, EC97C-2332A, Nov. 1999, Table 10, p. 14 for 1997 builder establishments; DOC, 2002 Economic Census: Construction - New Single-Family Housing Construction, EC02-231-236115, Dec. 2004, New Housing Operatives, ECO2-231-236118, Dec. 2004, Residential Remodelers, EC02-231-236119, Dec. 2004, Industrial Building Construction, 231-236210, Dec. 2004; DOC, 2007 Economic Census: Construction – New Single-Family Housing Construction, EC0723SG08, Oct. 2010, for 2007 number of residential builder establishments; NAHB, Housing Economics, May 1995, Table 2, p. 14 for 1982-1992 builder establishments; National Science and Technology Council, Construction & Building: Federal Research and Development in Support of the U.S. Construction industry for construction employees in Note 1; NAHB, Housing at the Millennium: Facts, Figures, and Trends, May 2000, p. 21 for Note 2; and NAHB, 1997 Housing Facts, Figures and Trends, 1997, p. 35 for Note 3, and p. 13 for Note 4.

1.3.8 Number of Construction Employees and Total Employees for Select Building Envolope Industries (Thousand Employees)

	2002	2004	2006	2008	2010
Poured Concrete Foundation and Structure Contractors (NAICS 238110)					
-Total Employment	197.5	221.5	254.0	236.2	154.3
-Construction/Extraction Occupations	165.5	187.3	213.1	198.2	127.3
-Construction/Extraction % of Total	83.8%	84.5%	83.9%	83.9%	82.5%
Masonry Contractors (NAICS 238140)					
-Total Employment	228.9	238.4	255.1	229.4	145.2
-Construction/Extraction Occupations	199	208	224	198	123
-Construction/Extraction % of Total	87.0%	87.1%	87.8%	86.4%	84.9%
Roofing Contractors (NAICS 238160)					
-Total Employment	183.2	188.0	201.5	196.1	166.8
-Construction/Extraction Occupations	145.2	152.7	161.9	155.9	130.4
-Construction/Extraction % of Total	79.2%	81.2%	80.4%	79.5%	78.2%
Drywall and Insulation Contractors (NAICS 238310)					
-Total Employment	321.4	342.8	367.7	329.9	213.9
-Construction/Extraction Occupations	279.5	299.2	322.0	286.1	182.4
-Construction/Extraction % of Total	87.0%	87.3%	87.6%	86.7%	85.3%
Painting and Wall Covering Contractors (NAICS 238320)					
-Total Employment	223.1	224.6	245.1	233.6	171.5
-Construction/Extraction Occupations	191.0	193.7	213.0	202.4	146.2
-Construction/Extraction % of Total	85.8%	86.2%	86.9%	86.7%	85.8%

Source(s): Bureau of Labor Statistics, Occupational Employment and Wage Estimates: 2002 OES Estimates for 2002 Data, November 2004 OES Estimates for 2004 Data, May 2006 Estimates for 2006 Data, May 2008 Estimates for 2008 Data, May 2010 Estimates for 2010 Data. Available at http://www.bls.gov/oes/oes_data.htm.

1.3.9 Number of Construction Employees and Total Employees for Select Building Equipment Industries (Thousand Employees)

	2002	2004	2006	2008	2010
Electrical Contractors and Other Wiring Installation Contractors (NAICS 238210)					
-Total Employment	894.3	852.7	890.4	915.2	724.9
-Construction/Extraction Occupations	585.7	562.1	601.1	620.7	478.5
-Construction/Extraction % of Total	65.5%	65.9%	67.5%	67.8%	66.0%
Plumbing, Heating, and Air-Conditioning Contractors (NAICS 238220)					
-Total Employment	837.7	896.8	977.7	996.2	806.4
-Construction/Extraction Occupations	495.6	505.1	542.6	543.0	422.4
-Construction/Extraction % of Total	59.2%	56.3%	55.5%	54.5%	52.4%
Other Building Equipment Contractors (NAICS 238290)					
-Total Employment	107.0	106.8	119.4	132.2	119.8
-Construction/Extraction Occupations	46.4	49.0	54.0	59.7	55.0
-Construction/Extraction % of Total	43.3%	45.8%	45.2%	45.2%	45.9%

Source(s): Bureau of Labor Statistics, Occupational Employment and Wage Estimates: 2002 OES Estimates for 2002 Data, November 2004 OES Estimates for 2004 Data, May 2006 Estimates for 2006 Data, May 2008 Estimates for 2008 Data, May 2010 Estimates for 2010 Data. Available at http://www.bls.gov/oes/oes_data.htm.

1.4.1 Carbon Dioxide Emissions for U.S. Buildings, by Year (Million Metric Tons) (1)

	Buildings				U.S.			
	Site Fossil	Electricity	Total	Growth Rate 2010-Year	Total	Growth Rate 2010-Year	Buildings % of Total U.S.	Buildings % of Total Global
1980	630	933	1562	-	4723	-	33%	8.5%
1990	566	1190	1756	-	5039	-	35%	8.1%
2000	619	1588	2207	-	5867	-	38%	9.3%
2005	591	1739	2330	-	5996	-	39%	8.2%
2010 (3)	**584**	**1684**	**2268**	**-**	**5634**	**-**	**40%**	**7.4%**
2015	570	1493	2063	-1.3%	5434	-0.5%	38%	6.5%
2020	566	1566	2132	-0.5%	5549	-0.1%	38%	6.3%
2025	560	1664	2224	-0.1%	5618	0.0%	40%	6.1%
2030	558	1755	2313	0.1%	5695	0.0%	41%	5.9%
2035	556	1840	2396	0.1%	5806	0.1%	41%	5.7%

Note(s): 1) Excludes emissions of buildings-related energy consumption in the industrial sector. Emissions assume complete combustion from energy consumption and exclude energy production activities such as gas flaring, coal mining, and cement production. 2) Carbon emissions calculated from EIA, Assumptions to the AEO 2010 and difffers from EIA, AEO 2012 Early Release, Table A18. Buildings sector total varies by -0.7% from EIA, AEO 2012 Early Release. 3) U.S. buildings emissions approximately equal the combined carbon emissions of Russia and Canada.

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 2009, Feb. 2011, Tables 8-11 for 1990-2009 greenhouse gas emissions; EIA, Assumptions to the Annual Energy Outlook 2010, May 2010, Table 1.2, p. 12 for carbon coefficients; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2011, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 energy consumption and Table A18, p. 36 for 2010-2035 emissions; EIA, International Energy Outlook 2011, Sept. 2011, Table A10 for 2010-2035 global emissions; and EIA, Country Energy Profiles for global emissions (1980-2009), available at http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm, accessed 2/10/2012 for 1980-2009 global emissions.

1.4.2 2010 Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	272.9	49.0	6.7	18.7	2.6	77.0	6.2	128.2	484.3	21.3%
Space Cooling	2.3							340.5	342.8	15.1%
Lighting								334.1	334.1	14.7%
Water Heating	91.9	9.2		4.6		13.7		98.5	204.1	9.0%
Refrigeration (5)								149.8	149.8	6.6%
Electronics (6)								143.0	143.0	6.3%
Ventilation (7)								95.2	95.2	4.2%
Computers								68.2	68.2	3.0%
Wet Cleaning (8)	2.9							57.8	60.8	2.7%
Cooking	20.9			1.9		1.9		36.5	59.4	2.6%
Other (9)	15.8	0.9		19.1	3.8	23.9		158.4	198.1	8.7%
Adjust to SEDS (10)	36.2	18.4				18.4		75.4	129.9	5.7%
Total	**442.9**	**77.5**	**6.7**	**44.3**	**6.4**	**134.8**	**6.2**	**1685.7**	**2269.6**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. Carbon emissions calculated from EIA, Assumptions to the AEO 2011 and differs from EIA, AEO 2012 Early Release, Table A18. Buildings sector total varies by 0.1% from EIA, AEO 2012 Early Release. 2) Includes kerosene space heating (2.6 MMT) and motor gasoline other uses (3.8 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (23.9 MMT). 5) Includes refrigerators (135.2 MMT) and freezers (14.6 MMT). 6) Includes color television (58.2 MMT) and other office equipment. 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes clothes washers (5.8 MMT), natural gas clothes dryers (2.9 MMT), electric clothes dryers (34.3 MMT), and dishwashers (17.8 MMT). Does not include water heating energy. 9) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 10) Emissions related to a discrepancy between data sources and that results from energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A for residential electric end-uses; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2; BTP/Navigant Consulting, U.S. Lighting Market Characterization, Volume I, Sept. 2002, Table 8-2, p.63; and EIA, AEO 1999, Dec. 1998, Table A4, p. 118-119 and Table A5, p. 120-121 for 1996 data.

1.4.3 2015 Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	270.4	43.9	6.2	16.6	2.1	68.8	6.2	93.0	438.4	21.3%
Lighting								243.7	243.7	11.8%
Space Cooling	1.9							241.0	242.9	11.8%
Water Heating	95.0	7.2		3.1		10.3		89.6	194.9	9.4%
Refrigeration (5)								127.5	127.5	6.2%
Electronics (6)								101.9	101.9	4.9%
Ventilation (7)								85.0	85.0	4.1%
Computers								59.9	59.9	2.9%
Wet Cleaning (8)	3.2							51.6	54.7	2.7%
Cooking	21.7			1.8		1.8		21.4	44.9	2.2%
Other (9)	17.6	0.9		19.2	3.5	23.6		277.9	319.1	15.5%
Adjust to SEDS (10)	36.0	13.9				13.9		99.8	149.8	7.3%
Total	**445.8**	**65.8**	**6.2**	**40.8**	**5.5**	**118.4**	**6.2**	**1492.5**	**2062.9**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (2.1 MMT) and motor gasoline other uses (3.5 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (22.1 MMT). 5) Includes refrigerators (114.3 MMT) and freezers (13.3 MMT). 6) Includes color television (52.2 MMT) and other office equipment (49.9 MMT). 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes clothes washers (5.0 MMT), natural gas clothes dryers (3.2 MMT), electric clothes dryers (31.0 MMT), and dishwashers (15.6 MMT). Does not include water heating energy. 9) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 10) Emissions related to a discrepancy between data sources and that results from energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients.

1.4.4 2025 Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	263.3	35.5	6.3	15.2	2.0	59.0	6.1	98.9	427.3	19.2%
Space Cooling	1.8							258.7	260.5	11.7%
Lighting								245.4	245.4	11.0%
Water Heating	97.7	5.7		2.5		8.3		97.6	203.7	9.2%
Refrigeration (5)								129.5	129.5	5.8%
Electronics (6)								122.6	122.6	5.5%
Ventilation (7)								94.4	94.4	4.2%
Computers								68.8	68.8	3.1%
Wet Cleaning (8)	3.3							47.9	51.2	2.3%
Cooking	22.7			1.6		1.6		24.3	48.7	2.2%
Other (9)	25.3	0.9		21.7	3.8	26.4		366.6	418.3	18.8%
Adjust to SEDS (10)	30.9	13.4				13.4		109.4	153.7	6.9%
Total	**445.0**	**55.6**	**6.3**	**41.1**	**5.8**	**108.7**	**6.1**	**1664.0**	**2223.8**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (2.0 MMT) and motor gasoline other uses (3.8 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (22.9 MMT). 5) Includes refrigerators (115.8 MMT) and freezers (13.6 MMT). 6) Includes color television (58.7 MMT) and other office equipment (63.8 MMT). 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes clothes washers (3.9 MMT), natural gas clothes dryers (3.3 MMT), electric clothes dryers (28.5 MMT), and dishwashers (15.5 MMT). Does not include water heating energy. 9) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 10) Emissions related to a discrepancy between data sources and that results from energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients.

1.4.5 2035 Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	257.1	29.5	6.6	14.1	1.9	52.1	6.0	102.1	417.3	17.4%
Space Cooling	1.7							278.5	280.3	11.7%
Lighting								253.9	253.9	10.6%
Water Heating	96.0	5.1		2.1		7.3		98.1	201.4	8.4%
Electronics (5)								140.4	140.4	5.9%
Refrigeration (6)								137.1	137.1	5.7%
Ventilation (7)								100.7	100.7	4.2%
Computers								75.5	75.5	3.1%
Wet Cleaning (8)	3.5							50.0	53.4	2.2%
Cooking	24.1			1.5		1.5		26.5	52.2	2.2%
Other (9)	42.8	1.0		23.9	4.2	29.0		456.9	528.7	22.1%
Adjust to SEDS (10)	21.3	13.1				13.1		120.5	154.9	6.5%
Total	**446.5**	**48.7**	**6.6**	**41.6**	**6.0**	**103.0**	**6.0**	**1840.3**	**2395.8**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (1.9 MMT) and motor gasoline other uses (4.2 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (23.1 MMT). 5) Includes color television (68.1 MMT) and other office equipment (72.3 MMT). 6) Includes refrigerators (123.2 MMT) and freezers (13.9 MMT). 7) Commercial only; residential fan and pump energy use included proportionately in space heating and cooling. 8) Includes clothes washers (3.8 MMT), natural gas clothes dryers (3.5 MMT), electric clothes dryers (28.8 MMT), and dishwashers (17.4 MMT). Does not include water heating energy. 9) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 10) Emissions related to a discrepancy between data sources and that results from energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients.

1.4.6 World Carbon Dioxide Emissions

	Emissions (million metric tons)				Annual Growth Rate	
Nation/Region	1990	2000	2010		1990-2000	2000-2010
China	2270	2850	8262	26%	2.3%	11.2%
United States	5041	5862	5644	18%	1.5%	-0.4%
OECD Europe	4128	4191	4094	13%	0.2%	-0.2%
Other Non-OECD Asia	827	1339	1872	6%	4.9%	3.4%
Russia (1)	3821	1556	1632	5%	-8.6%	0.5%
Middle East	730	1094	1692	5%	4.1%	4.5%
India	579	1003	1602	5%	5.7%	4.8%
Central & S. America	716	992	1150	4%	3.3%	1.5%
Japan	1047	1201	1090	3%	1.4%	-1.0%
Africa	726	887	1107	4%	2.0%	2.2%
Oth. Non-OECD Europe	417	1038	1127	4%	9.5%	0.8%
Canada	471	573	569	2%	2.0%	-0.1%
South Korea	242	439	528	2%	6.1%	1.9%
Australia & N. Zealand	296	391	456	1%	0.0%	0.0%
Mexico/Chile (2)	302	383	480	2%	2.4%	2.3%
Total World	**21616**	**23804**	**31305**	**100%**	**1.0%**	**2.8%**

Note(s): 1) 1990 value is for the former USSR. 2) Values before 2010 do not include Chile.

Source(s): EIA, Country Energy Profiles, available at http://www.eia.gov/country/index.cfm, accessed 2/3/2012; EIA, International Energy Outlook 2011, September 2011, Table A10, p. 167

1.4.7 2009 Methane Emissions for U.S. Buildings Energy Production, by Fuel Type (MMT CO2 Equivalent) (1)

Fuel Type	Residential	Commercial	Buildings Total
Petroleum	1.0	0.5	1.6
Natural Gas	41.0	26.8	67.8
Coal	0.0	0.3	0.3
Wood	2.6	0.4	3.0
Electricity (2)	52.8	50.5	103.3
Total	**97.4**	**78.5**	**176.0**

Note(s): 1) Sources of emissions include oil and gas production, processing, and distribution; coal mining; and utility and site combustion. Carbon Dioxide equivalent units are calculated by converting methane emissions to carbon dioxide emissions (methane's global warming potential is 23 times that of carbon dioxide). 2) Refers to emissions of electricity generators attributable to the buildings sector.

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 2009, Mar. 2011, Table 18, p. 37 for energy production emissions; EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, April 2011, Table 3-10, p. 3-9 for stationary combustion emissions; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for energy consumption.

1.4.8 2010 Carbon Dioxide Emission Coefficients for Buildings (MMT CO2 per Quadrillion Btu) (1)

	All Buildings	Residential Buildings	Commercial Buildings
Coal			
Average (2)	95.35	95.35	95.35
Natural Gas			
Average (2)	53.06	53.06	53.06
Petroleum Products			
Distillate Fuel Oil/Diesel	73.15	-	-
Kerosene	72.31	-	-
Motor Gasoline	70.88	-	-
Liquefied Petroleum Gas	62.97	-	-
Residual Fuel Oil	78.80	-	-
Average (2)	69.62	68.45	71.62
Electricity Consumption (3)			
Average - Primary (4)	57.43	57.43	57.43
Average - Site (5)	178.3	179.1	177.9
New Generation			
Gas Combined Cycle - Site (6)	112.5	112.5	112.5
Gas Combustion Turbine - Site (6)	171.4	171.4	171.4
Stock Gas Generator - Site (7)	133.9	133.9	133.9
All Fuels (3)			
Average - Primary	56.23	55.79	56.77
Average - Site	111.4	105.6	118.7

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. The combustion of fossil fuels produces carbon in the form of carbon dioxide and carbon monoxide; however, carbon monoxide emissions oxidize in a relatively short time to form carbon dioxide. 2) Coefficients do not match total emissions reported in the AEO 2011 Early Release and were adjusted using Assumptions to the AEO 2010. 3) Excludes electricity imports from utility consumption. Includes nuclear and renewable (including hydroelectric) generated electricity. 4) This coefficient is used to estimate CO2 emissions resulting from the consumption of energy by electric generators. 5) This coefficient is used to estimate CO2 emissions resulting from the consumption of electricity by end-users. 6) This coefficient is used to estimate emissions of the next-built (2010) natural gas-fired, electric generator resulting from the consumption of electricity by end-users. 7) This coefficient is used to estimate emissions of existing natural gas-fired, electric generators resulting from the consumption of electricity by end-users.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A8, p. 18-19, Table A17, p. 34-35 for consumption and Table A18, p. 36 for emissions; EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for coefficients and Table 8.2, p. 97 for generator efficiencies; EIA, Annual Energy Review 2010, Oct. 2011, Diagram 8.0, p. 233 for Transmission and Distribution (T&D) losses.

1.4.9 Average Carbon Dioxide Emissions from a Generic Quad in the Buildings Sector with Stock Fuel Mix and Projected Fuel Mix of New Marginal Utility Capacity and Site Energy Consumption (Million Metric Tons) (1)

	Stock		
	2010		
	Resid.	Comm.	Bldgs.
Electricity (2)	39.81	44.10	41.75
Petroleum	3.78	2.81	3.34
Natural Gas	12.17	9.55	10.98
Renew. En. (3)	0.00	0.00	0.00
Coal	0.03	0.30	0.15
Total	**55.79**	**56.77**	**56.23**

Note(s): 1) Electricity imports from utility consumption were not included since this energy was produced outside of the U.S. "Average" means the weighted average of different fuels (e.g., petroleum is the average of residual and distillate fuel oils, LPG, kerosene, and motor gasoline). The combustion of fossil fuels produces carbon in the form of carbon dioxide and carbon monoxide; however, carbon monoxide emissions oxidize in a relatively short time to form carbon dioxide. 2) Includes renewables. 3) Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A17, p. 34-35 for energy consumption and Table A18, p. 36 for carbon emissions; and EIA, Assumptions to the AEO 2011, June 2011, Table 1.2, p. 14.

1.4.10 2010 Emissions Summary Table for U.S. Buildings Energy Consumption (Thousand Short Tons) (1)

	Buildings				Buildings Percent
	Wood/SiteFossil	Electricity	Total	U.S. Total	of U.S. Total
SO2	433	3,814 (2)	4,247	7,938	54%
NOx	656	1,554	2,210	12,914	17%
CO	2,926	540	3,466	67,790	5%
VOCs	219	34	253	13,443	2%
PM-2.5	378	294	672	4,495	15%
PM-10	383	318	701	10,778	7%

Note(s): 1) VOCs = volatile organic compounds; PM-10 = particulate matter less than 10 micrometers in aerodynamic diameter. PM-2.5 = particulate matter less than 2.5 micrometers in aerodynamic diameter. CO and VOCs site fossil emissions mostly from wood burning. 2) Emissions of SO2 are 28% lower for 2002 than 1994 estimates since Phase II of the 1990 Clean Air Act Amendments began in 2000. Buildings Energy Consumption related to SO2 emissions dropped 27% from 1994 to 2002.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5; and EPA, 1970-2010 National Emissions Inventory, Average Annual Emissions, All Criteria Pollutants, October 2011.

1.4.11 EPA Criteria Pollutant Emissions Coefficients
(Million Short Tons/Delivered Quadrillion Btu, unless otherwise noted)

All Buildings

	Electricity (1)	*Site Fossil Fuel (2)*		Electricity (per primary quad) (1)
SO2	0.402	0.041	|	0.130
NOx	0.164	0.062	|	0.053
CO	0.057	0.275	|	0.018

Note(s): 1) Emissions of SO2 are 28% lower for 2002 than 1994 estimates since Phase II of the 1990 Clean Air Act Amendments began in 2000. Buildings energy consumption related SO2 emissions dropped 65% from 1994 to 2011. 2) Includes natural gas, petroleum liquid fuels, coal, and wood.

Source(s): EPA, 1970-2010 National Emissions Inventory, Average Annual Emissions, All Criteria Pollutants, October 2012; and EIA, Annual Energy Outlook 2011 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for energy consumption.

1.4.12 Characteristics of U.S. Construction Waste

- Two to seven tons of waste (a rough average of 4 pounds of waste per square foot) are generated during the construction of a new single-family detached house.
- 15 to 70 pounds of hazardous waste are generated during the construction of a detached, single-family house. Hazardous wastes include paint, caulk, roofing cement, aerosols, solvents, adhesives, oils, and greases.
- Each year, U.S. builders produce between 30 and 35 million tons of construction, renovation, and demolition (C&D) waste.
- Annual C&D debris accounts for roughly 24% of the municipal solid waste stream.
- Wastes include wood (27% of total) and other (73% of total, including cardboard and paper; drywall/plaster; insulation; siding; roofing; metal; concrete, asphalt, masonry, bricks, and dirt rubble; waterproofing materials; and landscaping material).
- As much as 95% of buildings-related construction waste is recyclable, and most materials are clean and unmixed.

Source(s): First International Sustainable Construction Conference Proceedings, Construction Waste Management and Recycling Strategies in the U.S., Nov. 1994, p. 689; Fine Homebuilding, Construction Waste, Feb./Mar. 1995, p. 70-75; NAHB, Housing Economics, Mar. 1995, p. 12-13; and Cost Engineering, Cost-Effective Waste Minimization for Construction Managers, Vol. 37/No. 1, Jan. 1995, p. 31-39.

1.4.13 "Typical" Construction Waste Estimated for a 2,000-Square-Foot Home (1)

Material	Weight (pounds)		Volume (cu. yd.) (2)
Solid Sawn Wood	1,600	20%	6
Engineered Wood	1,400	18%	5
Drywall	2,000	25%	6
Cardboard (OCC)	600	8%	20
Metals	150	2%	1
Vinyl (PVC) (3)	150	2%	1
Masonry (4)	1,000	13%	1
Hazardous Materials	50	1%	-
Other	1,050	13%	11
Total (5)	**8,000**	100%	**50**

Note(s): 1) See Table 2.2.7 for materials used in the construction of a new single-family home. 2) Volumes are highly variable due to compressibility and captured air space in waste materials. 3) Assuming 3 sides of exterior clad in vinyl siding. 4) Assuming a brick veneer on home's front facade. 5) Due to rounding, sum does not add up to total.

Source(s): NAHB's Internet web site, www.nahb.org, Residential Construction Waste: From Disposal to Management, Oct. 1996.

1.4.14 2003 Construction and Demolition Debris Generated from Construction Activities

	Debris (million tons)			Debris (percent of total buildings sector)		
	Residential	Commercial	Buildings	Residential	Commercial	Buildings
Construction	10.0	5.0	15.0	6%	3%	9%
Demolition	38.0	33.0	71.0	22%	19%	42%
Renovation	19.0	65.0	84.0	11%	38%	49%
Total	**67.0**	**103.0**	**170.0**	**39%**	**61%**	**100%**

Note(s): 170 million tons of construction and demolition debris represents approximately 3.2 pounds of debris per person per day in the U.S.

Source(s): EPA/OSW, Estimating 2003 Building-Related Construction and Demolition Materials Amounts, March 2009, Table 2-7, p. 17.

1.4.15 Disposal and Recovery of Construction and Demolition (C&D) Materials in 2003

Reporting State (1)	**Tons of C&D Materials** Disposed	 Recovered	(2) (3)	**Recovery Rate**
Florida	5,277,259	1,998,256		27%
Maryland	1,913,774	2,270,100		54%
Massachusetts	720,000	3,360,000		82%
New Jersey	1,519,783	5,582,336		79%
North Carolina	1,844,409	20,002		1%
Utah	1,054,296	46,461		4%
Virginia	3,465,548	95,131		3%
Washington	1,780,356	2,640,560		60%
Total	17,575,425	16,012,846		48%

Note(s): 1) Only eight states reported recovery and disposal amounts 2003, representing approximately 21% of the US population. 2) State definitions vary regarding what constitutes C&D materials. Some states may include concrete, asphalt pavement, and metals from non-building sources. 3) Recovered materials may include those used for purposes that do not meet state definitions for recycling, such as landfill cover and energy generation.

Source(s): EPA, Estimating 2003 Building-Related Construction and Demolition Materials Amounts, Table 3-1

1.5.1 Key Definitions

Quad: Quadrillion Btu (10^15 or 1,000,000,000,000,000 Btu)

Generic Quad for the Buildings Sector: One quad of primary energy consumed in the buildings sector (includes the residential and commercial sectors), apportioned between the various primary fuels used in the sector according to their relative consumption in a given year. To obtain this value, electricity is converted into its primary energy forms according to relative fuel contributions (or shares) used to produce electricity in the given year.

Electric Quad (Generic Quad for the Electric Utility Sector): One quad of primary energy consumed at electric utility power plants to supply electricity to end-users, shared among various fuels according to their relative contribution in a given year. (Note: The consumption of an electric quad results in the delivery of just under 1/3 the electric quad due to generation and transmission losses.)

Primary Energy: The total energy consumed by an end-user, including the energy used in the generation and transmission of electricity. Also referred to as "source" energy.

Delivered Energy: The energy consumed by an end-user on site, not including electricity generation and transmission losses.

1.5.2 Consumption Comparisons in 2010

One quad equals:

- 50.2 million short tons of coal
    = enough coal to fill a train of railroad cars 4,123 miles long (about one and a half times across the U.S.)
- 974.7 billion cubic feet natural gas
- 8.2 billion gallons of gasoline = 21.2 days of U.S. gasoline use
    = 22.89 million passenger cars each driven 12,400 miles
    = 20.12 million light-duty vehicles each driven 12,200 miles
    = all new passenger cars sold, each driven 50,000 miles
    = 13.69 million stock passenger cars, each driven 11,500 miles = 10% of all passenger cars, each driven 11,500 miles
    = all new passenger cars each making 9 round-trips from New York to Los Angeles
- 172.4 million barrels of crude oil = 14.45 days of U.S. imports = 245 days of oil flow in the Alaska pipeline at full capacity
    = the amount of crude oil transported by 483 supertankers
- 16.8 hours of world energy use
- the electricity delivered from 258 coal-fired power plants (200-MW each) in one year
- the electricity delivered from 37 nuclear power plants (1000-MW each) in one year
- average annual per capita consumption of 3.17 million people in the U.S.
- the approximate annual primary consumption of any one of the following states: Arkansas, Mississippi, Kansas, Oregon (1)

Note(s): 1) All states listed have annual energy consumption that is within 20% of one quad. Consumption numbers for states are from 2009.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A1, p. 1-2, Table A2, p. 3-5, Table A7, p. 34-35, Table A8, p. 18-19, Table A9, p. 20-21, and Table A11, p. 23-24 for consumption; EIA, Annual Energy Outlook 2011, April 2011, Table G1, p. 235 for heat rates; EIA, State Energy Consumption Database, June 2011; EIA, Electric Power Annual 2010, Nov. 2011, Table 1.1, p. 14; DOC, Statistical Abstract of the United States 2008, May 2008, No. 1080, p. 690; DOC, Statistical Abstract of the United States 2012, 2011, No. 1060, p. 666, and No. 1096, p. 688; and Newport News Shipbuilding Web site.

1.5.3 Carbon Emission Comparisons

One million metric tons of carbon dioxide-equivalent emissions equals:

- the combustion of 530 thousand short tons of coal
- the coal input to 1 coal plant (200-MW) in about 1 year
- the combustion of 18 billion cubic feet of natural gas
- the combustion of 119 million gallons of gasoline = the combustion of gasoline for 7 hours in the U.S.
  - = 323 thousand new cars, each driven 12,400 miles
  - = 282 thousand new light-duty vehicles, each driven 12,200 miles
  - = 274 thousand new light trucks, each driven 11,000 miles
  - = 0.14 million new passenger cars, each making 5 round trips from New York to Los Angeles
- the combustion of 192 million gallons of LPG
- the combustion of 107 million gallons of kerosene
- the combustion of 102 million gallons of distillate fuel
- the combustion of 87 million gallons of residual fuel
- 17 minutes of world energy emissions
- 90 minutes of U.S energy emissions
- 3.9 hours of U.S. buildings energy emissions
- 7 hours of U.S. residential energy emissions
- 8 hours of U.S. commercial energy emissions
- 1.2 days of U.S. buildings lighting energy emissions
- average annual per capita emissions of 53,000 people in the U.S.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2010, Summary Reference Case Tables, Table A2, p. 3-5, Table A7, p. 16-17 for consumption and Table A18, p. 36 for emissions; EIA, Annual Energy Outlook 2011, Apr. 2011, Table G1, p. 235 for heat rates; EIA, Electric Power Annual 2010, Feb. 2012, Table 1.2; EIA, International Energy Outlook 2011, Table A10; EIA, Assumptions to the Annual Energy Outlook 2011, July 2010, Table 1.2, p. 14 for carbon coefficients; DOC, Statistical Abstract of the United States 2012, Jan. 2012, No. 1, p. 8; and Statistical Abstract of the United States 2008, Jan. 2008, No. 1084, p. 715

1.5.4 Average Annual Carbon Dioxide Emissions for Various Functions

	Annual Unit Energy Consumption		Carbon Emissions	
			(MMT CO2)	(lb CO2)
Stock Refrigerator (1)	1,359	kWh - Electricity	0.8	1,800
Stock Electric Water Heater	2,814	kWh - Electricity	1.7	3,800
Stock Gas Water Heater	24	million Btu - Natural Gas	1.3	2,800
Stock Oil Water Heater	32	million Btu - Fuel Oil	2.3	5,100
Single-Family Home	108	million Btu	11.4	25,200
Mobile Home	70	million Btu	7.4	16,400
Multi-Family Unit in Large Building	54	million Btu	5.7	12,700
Multi-Family Unit in Small Building	85	million Btu	9.0	19,800
School Building	2,125	million Btu	252.2	556,200
Office Building	1,376	million Btu	163.3	360,200
Hospital, In-Patient	60,152	million Btu	7,140.2	15,744,200
Stock Vehicles				
Passenger Car	530	gallons - Gasoline	4.6	10,094
Van, Pickup Truck, or SUV	615	gallons - Gasoline	5.3	11,718
Heavy Truck	1,956	gallons - Diesel Fuel	17.4	38,447
Tractor Trailer Truck	10,749	gallons - Diesel Fuel	95.8	211,312

Note(s): 1) Stock refrigerator consumption is per household refrigerator consumption, not per refrigerator.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for consumption and Table A18, p. 36 for emissions; EIA, Annual Energy Outlook 2010, Apr. 2011, Table G1, p. 235 for gasoline heat rate; EIA, A Look at Residential Energy Consumption in 2005, Jan. 2009, Tables WH6 and WH7 for water heater energy consumption, Table AP2 for refrigerator energy, and Table US9 for household consumption; EIA, 2003 Commercial Buildings Energy Consumption Survey, June 2006, Table C3, p. 247 for commercial buildings; ORNL, Transportation Energy Data Book: Edition 30, 2011, Table 4.1, p. 4-2, Table 4.2, p. 4-3, Table 5.1, p. 5-2 and Table 5.2, p. 5-3 for vehicles; and EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for carbon coefficients.

1.5.5 Cost of a Generic Quad Used in the Buildings Sector ($2010 Billion) (1)

	Residential	Commercial	**Buildings**
1980	10.45	10.30	**10.39**
1990	10.12	9.17	**9.70**
2000	9.57	8.26	**8.97**
2005	11.10	9.62	**10.43**
2010	**9.98**	**9.84**	**9.94**
2015	9.88	9.60	**9.78**
2020	9.91	9.66	**9.82**
2025	10.09	9.84	**10.00**
2030	10.06	9.82	**9.97**
2035	10.57	10.35	**10.49**

Note(s): 1) See Table 1.5.1 for generic quad definition. This table provides the consumer cost of a generic quad in the buildings sector. This table may be used to estimate the average consumer cost savings resulting from the savings of a generic (primary) quad in the buildings sector.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A17, p. 34-35 for energy consumption and Table A3, p. 6-8 for 2010-2035 energy prices; EIA, State Energy Consumption Estimates 1960-2009, June 2011, Tables C5-C6, p. 8-9 for 1980-2009; EIA, State Energy Data 2009: Prices and Expenditures, June 2011, Tables CT4 and CT5 (1980-2009); and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

1.5.6 Shares of U.S. Buildings Generic Quad (Percent) (1)

				Renewables				
	Natural Gas	Petroleum	Coal	Hydro.	Other	Total	Nuclear	Total
1980	39%	12%	31%	7%	4%	11%	7%	100%
1990	32%	8%	36%	7%	4%	10%	13%	100%
2000	32%	6%	38%	5%	3%	8%	15%	100%
2005	32%	6%	39%	5%	3%	8%	15%	100%
2010	**32%**	**5%**	**38%**	**5%**	**4%**	**9%**	**17%**	**100%**
2015	34%	4%	33%	6%	5%	11%	18%	100%
2020	32%	4%	34%	6%	6%	12%	18%	100%
2025	31%	4%	35%	6%	7%	12%	18%	100%
2030	31%	3%	35%	6%	7%	12%	18%	100%

Note(s): 1) See Table 1.5.1 for generic quad definition. 2) The total 2010 Buildings sector primary energy consumption was 40.33 quads.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A17, p. 34-35 for energy consumption; and EIA, State Energy Data 2009 Consumption Database

1.6.1 Embodied Energy of Commercial Windows in the U.S.

Window Type	Embodied Energy (MMBtu/SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Aluminium	0.973	190.1
PVC-clad Wood	0.447	88.3
Wood	0.435	90.9
Vinyl (PVC)	0.557	111.7
Curtainwall Viewable Glazing	0.233	66.1

Note(s): 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material. Assumptions: Low rise building. Values are general estimations for the U.S. 60 year building lifetime. Low-e, double-pane, argon-filled glazing. All assemblies are insulated to IECC 2009 minimums for zones 3 and 6.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.2 Embodied Energy of Commercial Studded Exterior Walls in the U.S.

Exterior Wall Type	Embodied Energy (MMBtu/SF) (1)		CO2 Equivalent Emissions (lbs/SF)	
	U.S. North (2)	U.S. South (3)	U.S. North (2)	U.S. South (3)
2x4 Steel Stud Wall (4)				
16" OC with brick cladding	0.10	0.10	14.46	14.04
24" OC with brick cladding	0.10	0.09	13.47	13.03
16" OC with wood cladding	0.07	0.07	8.71	8.27
24" OC with wood cladding	0.06	0.06	7.69	7.28
16" OC with steel cladding (26 ga)	0.24	0.24	38.65	38.23
2x6 Wood Stud Wall (5)				
16" OC with brick cladding	0.09	0.09	11.29	10.91
16" OC with PVC cladding	0.09	0.08	7.98	7.61
24" OC with steel cladding	0.23	0.23	36.29	35.91
24" OC with stucco cladding	0.07	0.07	8.66	8.29
24" OC with wood cladding	0.05	0.05	5.34	4.96
Structural Insulated Panel (SIP) (6)				
with brick cladding	0.15	0.14	15.98	15.06
with steel cladding	0.30	0.29	41.18	40.23
with stucco cladding	0.14	0.13	13.58	12.63
with PVC cladding	0.14	0.13	12.70	11.75
with wood cladding	0.12	0.11	10.23	9.30

Note(s): Assumptions: Low rise building. 60 year building lifetime. All assemblies are insulated to IECC 2009 minimums for zones 3 and 6. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material. 2) Northern values represent ASHRAE climate zone 6. 3) Southern Values represent ASHRAE climate zone 3. 4) Includes cladding, continuous insulation sheathing, cavity insulation, polyethylene membrane, gypsum board, and latex paint. 5) Includes cladding, wood structural panel (WSP) sheathing, cavity insulation, polyethylene membrane, gypsum board, and latex paint. 6) Includes cladding, builder's paper, gypsum board, and latex paint.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.3 Embodied Energy of Commercial Concrete Exterior Walls in the U.S.

	Embodied Energy (MMBtu/SF) (1)		CO2 Equivalent Emissions (lbs/SF)	
	U.S. North (2)	U.S. South (3)	U.S. North (2)	U.S. South (3)
8" Concrete Block (4)				
Brick Cladding	0.26	0.26	42.59	42.37
Stucco Cladding	0.25	0.25	40.17	39.95
Steel Cladding	0.41	0.41	67.77	67.57
2x4 Steel Stud Wall (16" OC)	0.24	0.24	39.46	39.24
6" Cast-In-Place Concrete (3)				
Brick Cladding	0.13	0.13	24.43	24.21
Stucco Cladding	0.11	0.11	22.00	21.78
Steel Cladding	0.28	0.27	49.60	49.41
2x4 Steel Stud Wall (16" OC)	0.11	0.11	21.30	21.08
8" Concrete Tilt-Up (4)				
Brick Cladding	0.14	0.14	28.26	28.04
Stucco Cladding	0.12	0.12	25.84	25.62
Steel Cladding	0.29	0.28	53.44	53.24
2x4 Steel Stud Wall (16" OC)	0.12	0.12	25.13	24.91
Insulated Concrete Forms (5)				
Brick Cladding	0.16	0.16	29.45	29.45
Stucco Cladding	0.14	0.14	27.03	27.03
Steel Cladding	0.30	0.30	54.63	54.63

Note(s): Assumptions: 60 year building lifetime. Low rise building. Values are general estimations for the U.S. All assemblies are insulated to IECC 2009 minimums for zones 3 and 6. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material. 2) Northern values represent ASHRAE climate zone 6. 3) Southern Values represent ASHRAE climate zone 3. 4) Includes continuous insulation, polyethylene membrane, gypsum board, and latex paint. 5) Includes gypsum board and latex paint.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.4 Embodied Energy of Commercial Wood-Based Roof Assemblies in the U.S.

	Embodied Energy (MMBtu/SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Glulam Joist with Plank Decking		
with EPDM membrane	0.16	11.05
with PVC membrane	0.25	20.70
with Modified bitumen membrane	0.25	21.78
with 4-Ply built-up roofing	0.43	41.49
with Steel Roofing	0.10	10.05
Wood I-Joist with WSP Decking		
with EPDM membrane	0.14	10.10
with PVC membrane	0.23	19.75
with Modified bitumen membrane	0.24	20.81
with 4-Ply built-up roofing	0.42	40.54
with Steel Roofing	0.09	9.11
Solid Wood Joist with WSP Decking		
with EPDM membrane	0.15	10.36
with PVC membrane	0.24	20.02
with Modified bitumen membrane	0.24	21.10
with 4-Ply built-up roofing	0.43	40.81
with Steel Roofing	0.10	9.39
Wood Chord/Steel Web Truss with WSP Decking		
with EPDM membrane	0.17	14.09
with PVC membrane	0.26	23.74
with Modified bitumen membrane	0.26	24.80
with 4-Ply built-up roofing	0.44	44.53
with Steel Roofing	0.11	13.10
Wood Truss (Flat) with WSP Decking		
with EPDM membrane	0.15	10.71
with PVC membrane	0.24	20.37
with Modified bitumen membrane	0.24	21.43
with 4-Ply built-up roofing	0.42	41.16
with Steel Roofing	0.09	9.72
Wood Truss (4:12 Pitch) with WSP Decking		
with 30-yr. fiberglass shingles	0.11	7.80
with 30-yr. organic shingles	0.12	8.38
with Clay tile roof	0.16	19.36
with Steel roof	0.09	9.19

Note(s): Assumptions: 60 year building lifetime. Low rise building. Values are general estimations for the U.S. All roof assemblies include R-20 continuous insulation, polyethylene membrane, latex paint, and gypsum board. All assemplies are insulated to IECC 2009 minimums for zones 3 and 6. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.5 Embodied Energy of Other Commercial Roof Assemblies in the U.S.

	Embodied Energy (MMBtu/SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Precast Hollow-Core Concrete		
EPDM Membrane	0.17	21.23
PVC Membrane	0.26	30.89
Modified Bitumen Membrane	0.26	31.94
4-Ply Built-Up Roofing System	0.44	51.68
Steel Roofing System	0.11	20.24
Precast Double-T		
EPDM Membrane	0.15	17.42
PVC Membrane	0.24	27.05
Modified Bitumen Membrane	0.25	28.13
4-Ply Built-Up Roofing System	0.43	47.86
Steel Roofing System	0.10	16.42
Suspended Concrete Slab		
EPDM Membrane	0.24	37.32
PVC Membrane	0.33	46.96
Modified Bitumen Membrane	0.33	48.04
4-Ply Built-Up Roofing System	0.51	67.75
Steel Roofing System	0.18	36.33
Open-Web Steel Joist, Steel Decking (2)		
EPDM Membrane	0.17	15.28
PVC Membrane	0.26	24.93
Modified Bitumen Membrane	0.26	26.01
4-Ply Built-Up Roofing System	0.45	45.72
Steel Roofing System	0.12	14.29

Note(s): Assumptions: 60 year building lifetime. Low rise building. Values are general estimations for the U.S. All roof assemblies include R-20 continuous insulation, polyethylene membrane, and latex paint. All assemblies are insulated to IECC 2009 minimums for zones 3 and 6. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material. 2) Includes

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.6 Embodied Energy of Commercial Interior Wall Assemblies in the U.S.

Interior Wall Type (2)	Embodied Energy (MMBtu/SF) (1)	CO2 Equivalent Emissions (lbs/SF)
2x4 wood stud (16" OC) + gypsum board (3)	0.03	2.84
2x4 wood stud (24" OC) + gypsum board (3)	0.03	2.78
2x4 wood stud (24" OC) + 2 gypsum boards (4)	0.04	4.45
Steel stud (16" OC) + gypsum board (4)	0.04	3.99
Steel stud (24" OC) + gypsum board (4)	0.04	3.64
Steel stud (24" OC) + 2 gypsum boards	0.05	5.31
6" Concrete block + gypsum board	0.21	34.02
6" Concrete block	0.19	32.34
Clay brick (4") unpainted	0.05	6.97

Note(s): Assumptions: Values are general estimations for the U.S. 60 year building lifetime. Low rise building. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material. 2) All interior walls include two coats of latex paint unless noted otherwise. 3) Rounding obscures difference in embodied energy figures: wood stud with 16" OC is 3.6% higher than wood stud with 24" OC. 4) Rounding obscures difference in embodied energy figure: wood stud wall is 19.9% higher than steel stud wall with 16" OC and 27.6% higher than steel stud wall with 24" OC.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.7 Embodied Energy of Floor Structures in the U.S.

Floor Structure with Interior Ceiling Finish of Gypsum Board, Latex Paint	Embodied Energy (MMBtu/SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Glulam joist and plank decking	0.04	3.06
Precast Hollowcore	0.05	13.43
Wood I-joist	0.02	2.03
Open-web Steel Joist	0.06	7.94
Open-web Steel Joist with concrete topping	0.07	12.30
Precast Double-T	0.04	11.38
Precast Double-T with concrete topping	0.06	16.45
Steel Joist	0.06	8.82
Steel Joist with plywood decking	0.06	9.28
Suspended Concrete Slab	0.12	29.19
Wood Joist	0.02	1.65
Wood Joist with plywood decking	0.03	2.38
Wood Chord and Steel Web truss	0.05	5.91
Wood Truss	0.03	2.71
Floor Structure without Interior Ceiling Finish		
Glulam joist and plank decking	0.05	4.32
Precast Hollowcore	0.06	14.68
Wood I-joist	0.04	3.26
Open-web Steel Joist	0.07	9.19
Open-web Steel Joist with concrete topping	0.09	13.54
Precast Double-T	0.05	12.61
Precast Double-T with concrete topping	0.07	17.70
Steel Joist	0.07	10.08
Steel Joist with plywood decking	0.08	10.54
Suspended Concrete Slab	0.13	30.42
Wood Joist	0.04	2.91
Wood Joist with plywood decking	0.05	3.64
Wood Chord and Steel Web truss	0.06	7.17
Wood Truss	0.04	3.95

Note(s): Assumptions: Values are general estimations for the U.S. 60 year building lifetime. Low rise building. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

1.6.8 Embodied Energy of Column and Beam Assemblies in the U.S.

Assumes Non-Load-Bearing Exterior Wall:

Column Type	Beam Type	Embodied Energy (MMBtu SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Concrete	Concrete	0.101	17.57
Concrete	Steel I-beam	0.091	11.24
Hollow structural steel	Glulam	0.022	2.07
Hollow structural steel	Laminated veneer lumber	0.019	1.81
Glulam	Glulam	0.019	1.68
Glulam	Laminated veneer lumber	0.016	1.39
Steel I-beam	Steel I-beam	0.054	5.51
Steel I-beam	Laminated veneer lumber	0.018	1.61
Built-up softwood	Glulam	0.019	0.62
Built-up softwood	Laminated veneer lumber	0.016	0.49

Assumes Load-Bearing Exterior Wall:

Column Type	Beam Type	Embodied Energy (MMBtu SF) (1)	CO2 Equivalent Emissions (lbs/SF)
Concrete	Concrete	0.076	13.49
Concrete	Steel I-beam	0.069	8.31
Hollow structural steel	Glulam	0.017	1.63
Hollow structural steel	Laminated veneer lumber	0.015	1.41
Glulam	Glulam	0.015	1.34
Glulam	Laminated veneer lumber	0.013	1.15
Steel I-beam	Steel I-beam	0.044	4.48
Steel I-beam	Laminated veneer lumber	0.014	1.28
Built-up softwood	Glulam	0.015	1.34
Built-up softwood	Laminated veneer lumber	0.013	1.12

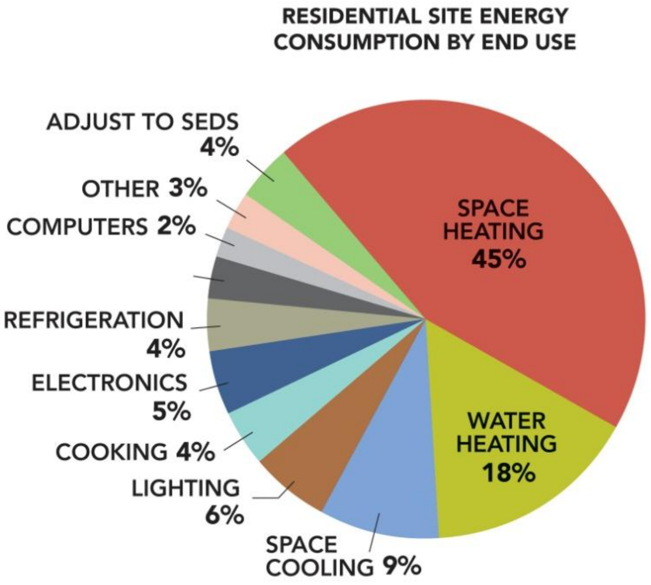
Note(s): Assumptions: Values are general estimations for the U.S. Low rise building. 60 year building lifetime. Bay size: 30 by 30 feet. Column Height: 10 feet. 1) Embodied Energy: Energy use includes extraction, processing, transportation, construction, and disposal of each material.

Source(s): Athena Institute. Athena EcoCalculator for Assemblies v.3.5.2. 2010. Available at www.athenasmi.org/tools/ecoCalculator/index.html

Chapter 2: Residential Sector

Chapter 2 focuses on energy use in the U.S. residential buildings sector. Section 2.1 provides data on energy consumption by fuel type and end use, as well as energy consumption intensities for different housing categories. Section 2.2 presents characteristics of average households and changes in the U.S. housing stock over time. Sections 2.3 and 2.4 address energy-related expenditures and residential sector emissions, respectively. Section 2.5 contains statistics on housing construction, existing home sales, and mortgages. Section 2.6 presents data on home improvement spending and trends. Section 2.7 describes the industrialized housing industry, including the top manufacturers of various manufactured home products. Section 2.8 presents information on low-income housing and Federal weatherization programs. The main points from this chapter are summarized below:

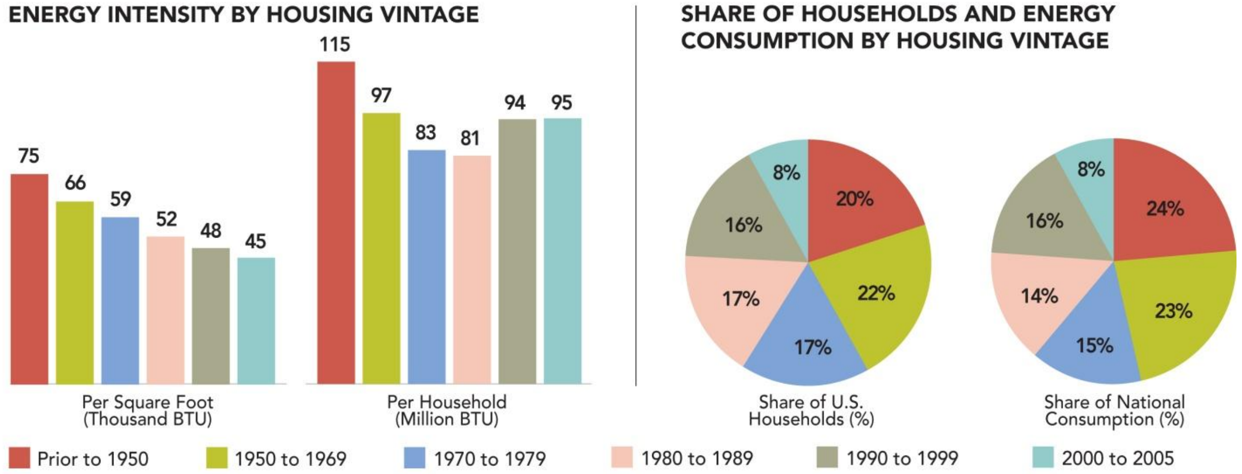
- The recession continues to affect the construction and real estate industry. About 700,000 new residential units were constructed in 2010, representing a 66% drop from 2006. Housing prices have also continued to decrease since 2007.
- Residential energy expenditures decreased 7%, or $18 billion, from 2008 to 2009, the largest percent decrease in the last 30 years. At the same time, carbon dioxide emissions from residential buildings decreased 5%.
- Space heating and cooling – which combined account for 54% of site energy consumption and 43% of primary energy consumption – drive residential energy demand.
- Homes built between 2000 and 2005 used 14% less energy per square foot than homes built in the 1980s and 40% less energy per square foot than homes built before 1950. However, larger home sizes have offset these efficiency improvements.



Primary energy consumption in the residential sector totaled 20.99 quadrillion Btu (quads) in 2009, equal to 54% of consumption in the buildings sector and 22% of total primary energy consumption in the U.S. Nearly half (49%) of this primary energy was lost during transmission and distribution (T&D). Energy consumption increased 24% from 1990 to 2009. However, because of projected improvements in building and appliance efficiency, the Energy Information Administration’s 2012 Annual Energy Outlook forecast a 13% increase from 2009 to 2035. (2.1.1)

As illustrated above, space heating demanded the greatest share of on-site energy consumption at 5.23 quads, or 45%. Forty-three percent of site energy was consumed as natural gas. All the energy used for space cooling, lighting, electronics, and refrigeration was consumed as electricity. Electricity accounted for 70% of total primary energy consumption, but only 4.95 quads of electricity were actually delivered to U.S. households due to T&D losses. (2.1.5)

There is a clear trend toward increasing efficiency in residential housing. Homes built between 2000 and 2005 used 44,700 Btu per heated square foot of heated floor space—14% less than homes built in the 1980s and 40% less than homes built before 1950. (2.1.12)



ENERGY INTENSITY BY HOUSING VINTAGE

SHARE OF HOUSEHOLDS AND ENERGY CONSUMPTION BY HOUSING VINTAGE

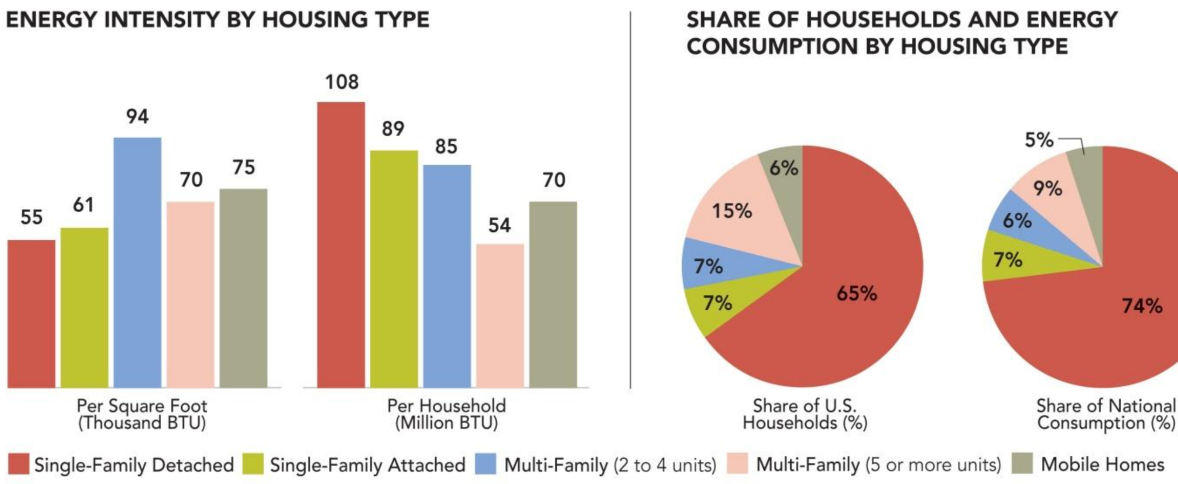
ENERGY INTENSITY BY HOUSING TYPE

SHARE OF HOUSEHOLDS AND ENERGY CONSUMPTION BY HOUSING TYPE

There has also been a trend toward larger home sizes. Specifically, single-family homes built between 2000 and 2005 are 29% larger on average than those built in the 1980s and 38% larger than those built before 1950. However, among all housing types, homes built before 1950 are 11% larger on average than those built between 1950 and 1979. (2.2.5) As shown in the figure above, the oldest homes—which generally have less efficient systems and little or no insulation—have the highest per-household energy consumption of all home vintages. Despite better building practices and newer systems, the greater average floor space of new homes has offset their improved efficiency.

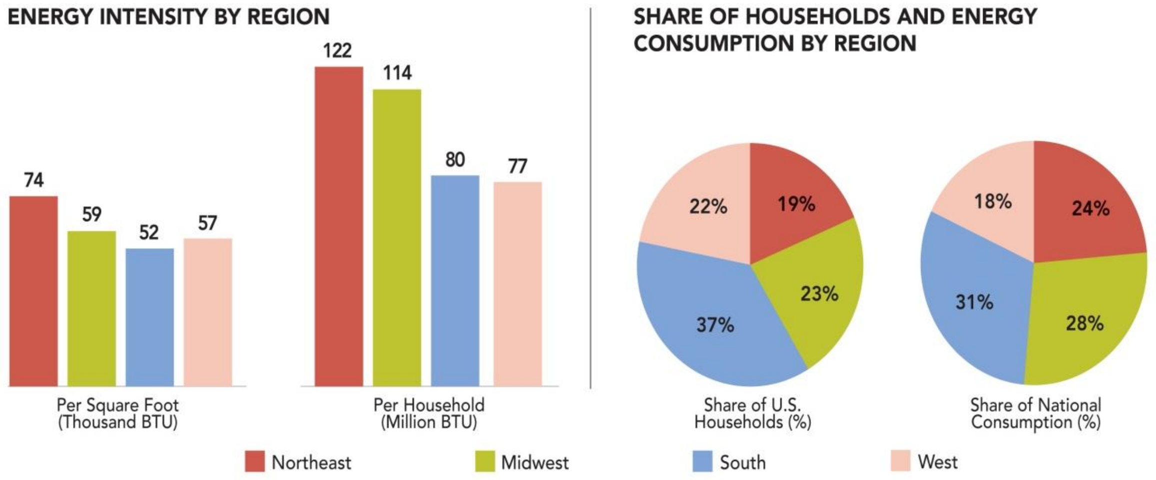
The energy consumption profiles of single-family homes and multi-family homes (apartments) are very different. On average, multi-family homes used 64.1 million Btu per household, which was 9% less than mobile homes and 40% less than single-family homes. The difference was most pronounced for multi-family homes in buildings with 5 or more units, which consumed about half as much energy as the average single-family home. One reason is that new multi-family homes built since 1990 have about half the floor space, on average, as new single-family homes. (2.5.1)

Although multi-family homes used the least energy per household, they consumed the most energy per square foot of heated floor space, at 78,300 Btu. Mobile homes used 5% less energy per square foot than multi-family homes, and the average single-family home used 26% less. (2.1.11) Energy demand for water heating, cooking, and refrigeration is mostly independent of floor space, thus leading to higher consumption per square foot in smaller households.


ENERGY INTENSITY BY HOUSING TYPE

SHARE OF HOUSEHOLDS AND ENERGY CONSUMPTION BY HOUSING TYPE

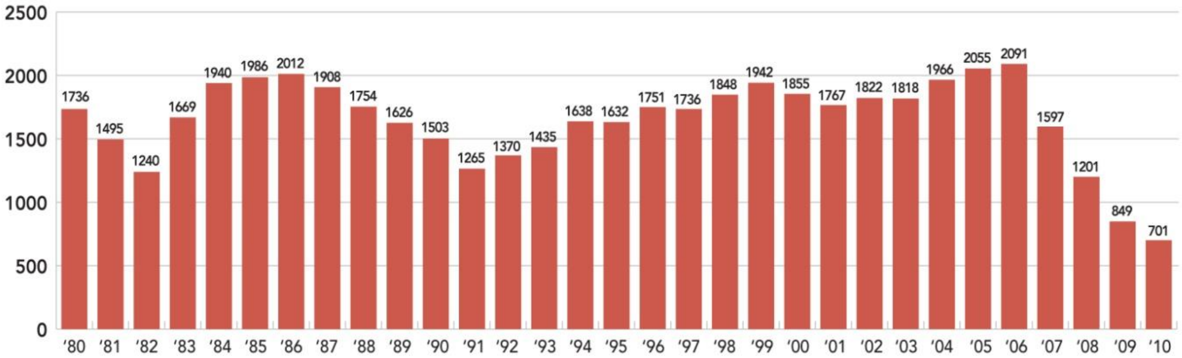
The greatest energy consumption intensities per household were in the Northeast and Midwest. (2.1.10) This is partly because the average household size is largest in the Midwest at 2,566 square feet, while the Northeast has the largest share of homes built before 1950 and the smallest share of homes built between 1990 and 2005. (2.2.3), (2.2.4)


ENERGY INTENSITY BY REGION

SHARE OF HOUSEHOLDS AND ENERGY CONSUMPTION BY REGION

Space heating made up the largest share of delivered energy consumption in both regions. On the other hand, the average household in the South required only 20.4 million Btu for space heating, less than one-third the energy required for space heating in the average household in the Northeast. Households in the West also required less energy for space heating on average—23.8 million Btu per household—and required only 4 million Btu per household for space cooling, compared to 13.9 million Btu per household in the South. Other end uses were fairly consistent across all four regions. (2.1.9)

The characteristics of the residential sector have changed in response to the economy and other factors. For example, new construction grew steadily from 1.8 million homes in 2001 to 2.1 million homes in 2006, but it has declined since, with just over 700,000 new homes built in 2010. (2.5.1) In that year, 52% of single-family homes were constructed and 68% of mobile homes were placed in the South. (2.5.4) In fact, the South has accounted for the largest share of home construction for the past 30 years. (2.2.3) This trend is significant because of the lower energy consumption intensities associated with homes in that region.



NEW HOMES CONSTRUCTED, 1980-2010 (THOUSANDS)
(INCLUDES SINGLE-FAMILY, MULTI-FAMILY, AND MOBILE HOMES)

The geographical distribution of new housing has contributed to greater electricity consumption in the residential sector—from 53% of total primary energy in 1980 to 69% in 2009—as more homes come with electricity-intensive heating and cooling equipment installed. (2.1.1) The percentage of new single-family homes with air conditioning has increased from 62% in 1980 to 79% in 1995 and 88% in 2010. Recently, heat pump heating systems have also gained market share, from 23% in 2001 to 38% in 2010. Warm-air furnaces still represent the most common type of heating system—56% of new homes had one in 2010. (2.2.8)

During the recession, sales of existing homes fell from 6.5 million in 2006 to a low of 4.9 million in 2010, the lowest number of sales since 1997. (2.5.9) All regions saw decreased sales in 2010 and home values continued to fall nationwide. Sales prices and appraisal data showed a 14.8% decrease in 3rd quarter Home Price Index (HPI) values between 2007 and 2011 for the country as a whole. (2.5.10)

Reduced home values corresponded with less spending on energy efficiency-related home improvements. In 2009, Americans spent $169 billion on home improvements compared to $237 billion in 2007. Of the $173 billion, $13 billion was for HVAC systems, $12 billion was for doors and windows, and $1.8 billion was for insulation. (2.6.3), (2.6.4)

Aggregate energy expenditures in the residential sector have increased by more than 50% between 1980 and 2009, from $158.5 billion in 1980 to $241.6 billion in 2009, as expressed in 2010 dollars. (2.3.3) This increase is largely due to the growing housing stock, and less caused by rising energy prices which have increased 11% over the same period. (2.3.4) On average, households in the Northeast spent the most on energy in 2005—$2,554 per year; households in the West spent the least—$1,975 per year. (2.3.13) Though regional variation in energy prices exists, much of the difference in energy expenditures among regions can be explained by climate and housing stock characteristics.

2.1.1 Residential Primary Energy Consumption, by Year and Fuel Type (Quadrillion Btu and Percent of Total)

									Electricity						Growth Rate
	Natural Gas		Petroleum (1)		Coal		Renewable(2)		Sales	Losses	Total		TOTAL (2)		2010-Year
1980	4.79	30%	1.72	11%	0.03	0%	0.85	5%	2.45	5.89	8.33	53%	15.72	100%	-
1990	4.47	26%	1.37	8%	0.03	0%	0.64	4%	3.15	7.24	10.39	61%	16.91	100%	-
2000	5.07	25%	1.52	7%	0.01	0%	0.49	2%	4.07	9.20	13.27	65%	20.36	100%	-
2005	4.94	23%	1.42	7%	0.01	0%	0.49	2%	4.64	10.08	14.72	68%	21.58	100%	-
2010	**5.06**	**23%**	**1.22**	**6%**	**0.01**	**0%**	**0.45**	**2%**	**4.95**	**10.39**	**15.34**	**69%**	**22.07**	**100%**	
2015	4.99	24%	1.08	5%	0.01	0%	0.51	2%	4.79	9.68	14.47	69%	21.06	100%	-0.9%
2020	4.95	23%	1.01	5%	0.01	0%	0.54	2%	5.02	10.15	15.17	70%	21.66	100%	-0.2%
2025	4.88	22%	0.95	4%	0.01	0%	0.54	2%	5.30	10.70	16.00	71%	22.39	100%	0.1%
2030	4.84	21%	0.91	4%	0.01	0%	0.55	2%	5.63	11.12	16.76	73%	23.06	100%	0.2%
2035	4.76	20%	0.87	4%	0.01	0%	0.55	2%	5.94	11.56	17.50	74%	23.69	100%	0.3%

Note(s): 1) Petroleum includes distillate oil, LPG, and kerosene. 2) Includes site-marketed and non-marketed renewable energy. 3) 2008 site-to-source electricity conversion = 3.16.

Source(s): EIA, State Energy Data 2009: Consumption, 2011, Table 8 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables,Table A2, p. 3-5 for 2010-2035 consumption and Table A17, p. 34-35 for non-marketed renewable energy.

2.1.2 Shares of U.S. Residential Buildings Generic Quad (Percent) (1)

				Renewables				
	Natural Gas	Petroleum	Coal	Hydro.	Other	Total	Nuclear	Total (quad)
1980	41%	12%	28%	7%	6%	13%	6%	14.84
1990	34%	8%	34%	6%	5%	11%	13%	16.54
2000	34%	8%	35%	5%	4%	9%	14%	20.06
2005	34%	7%	36%	5%	4%	9%	14%	21.28
2010	**37%**	**6%**	**33%**	**4%**	**4%**	**9%**	**15%**	**21.52**
2015	39%	6%	28%	5%	6%	11%	15%	19.98
2020	38%	5%	30%	5%	7%	12%	16%	20.59
2025	36%	5%	31%	5%	7%	12%	16%	21.14
2030	36%	5%	31%	5%	7%	12%	16%	21.63
2035	39%	5%	29%	5%	8%	13%	14%	18.87

Note(s): 1) See Table 1.5.1 for generic quad definition.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5 and Table A17, p. 34-35 for energy consumption; and EIA, State Energy Data Report 2009, Jun. 2011, Tables 8 and 12.

2.1.3 Residential Site Renewable Energy Consumption (Quadrillion Btu) (1)

	Wood	Solar Thermal	Solar PV	GSHP	Total	Growth Rate 2010-Year
1980	0.846	0.000	N.A.	0.000	0.846	-
1990	0.582	0.056	N.A.	0.006	0.643	-
2000	0.430	0.060	N.A.	0.009	0.499	-
2005	0.428	0.058	N.A.	0.016	0.502	-
2010	**0.424**	**0.010**	**0.009**	**0.006**	**0.449**	
2015	0.426	0.017	0.045	0.012	0.500	2.2%
2020	0.432	0.018	0.056	0.019	0.525	1.6%
2025	0.434	0.018	0.058	0.022	0.531	1.1%
2030	0.435	0.018	0.059	0.024	0.537	0.9%
2035	0.436	0.018	0.062	0.027	0.542	0.8%

Note(s): 1) Does not include renewable energy consumed by electric utilities (including hydroelectric).

Source(s): EIA, State Energy Data 2009: Consumption, 2011, Table 8 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A17, p. 34-35 for 2010-2035.

2.1.4 Residential Delivered and Primary Energy Consumption Intensities, by Year

	Number of Households (millions)	Percent Post-2000 Households (1)	*Delivered Energy Consumption* Total (10^15 Btu)	Per Household (10^6 Btu/Hhold)	Primary Energy Consumption Total (10^15 Btu)	Per Household (million Btu/Hhold)
1980	79.6	N.A.	9.83	123.5	15.72	197.4
1990	94.2	N.A.	9.68	102.7	16.92	179.5
2000	105.7	N.A.	11.17	105.6	20.37	192.7
2005	108.8	9.0%	11.51	105.7	21.59	198.4
2010	**114.2**	**13.6%**	**11.66**	**102.1**	**22.07**	**193.3**
2015	118.8	17.9%	11.30	95.1	21.06	177.3
2020	126.0	24.8%	11.42	90.6	21.66	171.9
2025	132.7	30.7%	11.58	87.3	22.39	168.7
2030	139.3	36.1%	11.83	84.9	23.06	165.6
2035	145.6	40.8%	12.02	82.6	23.69	162.7

Note(s): 1) Percent of houses built after Dec. 31, 2000.

Source(s): EIA, State Energy Data 2009: Consumption, Jun. 2010, Table 8 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10, Table A17, p. 34-35 for 2010-2035, and Table A20, p. 37-38 for households; DOC, Statistical Abstract of the United States 2007, Jan. 2007, Table No. 948, p. 606 for 1980-2004 households; DOC, Statistical Abstract of the United States 2010; 2010, Table 982 for 2005-2009 households.

2.1.5 2010 Residential Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil	LPG	Other Fuel(1)	Renw. En.(2)	*Site* Electric	*Site* Total	Percent	Primary Electric (3)	Primary Total	Percent
Space Heating (4)	3.50	0.53	0.30	0.04	0.43	0.44	5.23	44.7%	1.35	6.15	27.8%
Water Heating	1.29	0.10	0.07		0.01	0.45	1.92	16.4%	1.38	2.86	12.9%
Space Cooling	0.00					1.08	1.08	9.2%	3.34	3.34	15.1%
Lighting						0.69	0.69	5.9%	2.13	2.13	9.7%
Refrigeration (6)						0.45	0.45	3.9%	1.41	1.41	6.4%
Electronics (5)						0.54	0.54	4.7%	1.68	1.68	7.6%
Wet Cleaning (7)	0.06					0.33	0.38	3.3%	1.01	1.06	4.8%
Cooking	0.22		0.03			0.18	0.43	3.7%	0.57	0.81	3.7%
Computers						0.17	0.17	1.5%	0.53	0.53	2.4%
Other (8)	0.00		0.16		0.01	0.20	0.37	3.2%	0.63	0.80	3.6%
Adjust to SEDS (9)						0.42	0.42	3.6%	1.29	1.29	5.8%
Total	**5.06**	**0.63**	**0.56**	**0.04**	**0.45**	**4.95**	**11.69**	100%	**15.34**	**22.07**	100%

Note(s): 1) Kerosene and coal are assumed attributable to space heating. 2) Comprised of wood space heating (0.42 quad), solar water heating (0.01 quad), geothermal space heating (less than 0.01 quad), and solar PV (0.01 quad). 3) Site-to-source electricity conversion (due to generation and transmission losses) = 3.10. 4) Includes furnace fans (0.13 quad). 5) Includes color television (0.33 quad). 6) Includes refrigerators (0.37 quad) and freezers (0.08 quad). 7) Includes clothes washers (0.03 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.19 quad), and dishwashers (0.10 quad). Does not include water heating energy. 8) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. 9) Energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 2-5 and Table A4, p. 9-12; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A, for residential electric end-uses.

2.1.6 2015 Residential Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	*Site*	*Site*		Primary	Primary	
	Gas	Oil	LPG	Fuel(1)	En.(2)	Electric	Total	Percent	Electric (3)	Total	Percent
Space Heating (4)	3.40	0.48	0.26	0.03	0.44	0.42	5.03	44.2%	1.27	5.88	27.9%
Water Heating	1.31	0.07	0.05		0.02	0.48	1.92	16.9%	1.44	2.88	13.7%
Space Cooling	0.00					1.02	1.02	8.9%	3.07	3.07	14.6%
Lighting						0.53	0.53	4.6%	1.60	1.60	7.6%
Refrigeration (5)						0.45	0.45	4.0%	1.37	1.37	6.5%
Electronics (6)						0.33	0.33	2.9%	0.99	0.99	4.7%
Wet Cleaning (7)	0.06					0.33	0.39	3.4%	0.98	1.04	5.0%
Cooking	0.22		0.03			0.11	0.36	3.1%	0.34	0.59	2.8%
Computers						0.19	0.19	1.7%	0.57	0.57	2.7%
Other (8)	0.00		0.17		0.05	0.94	1.17	10.2%	2.85	3.07	14.6%
Total	**4.99**	**0.55**	**0.51**	**0.03**	**0.51**	**4.79**	**11.38**	100%	**14.47**	**21.06**	100%

Note(s): 1) Kerosene and coal are assumed attributable to space heating. 2) Comprised of wood space heating (0.43 quad), solar water heating (0.02 quad), geothermal space heating (0.01 quad), and solar PV (0.05 quad). 3) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 4) Includes furnace fans (0.14 quad). 5) Includes refrigerators (0.37 quad) and freezers (0.08 quad). 6) Includes color television (0.33 quad). 7) Includes clothes washers (0.03 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.20 quad), and dishwashers (0.10 quad). Does not include water heating energy. 8) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 2-5 and Table A4, p. 9-12.

2.1.7 2025 Residential Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	*Site*	*Site*		Primary	Primary	
	Gas	Oil	LPG	Fuel(1)	En.(2)	Electric	Total	Percent	Electric (3)	Total	Percent
Space Heating (4)	3.28	0.38	0.24	0.03	0.46	0.46	4.85	41.5%	1.40	5.78	25.8%
Water Heating	1.32	0.05	0.04		0.02	0.53	1.96	16.8%	1.60	3.03	13.5%
Space Cooling	0.00					1.12	1.12	9.6%	3.38	3.38	15.1%
Lighting						0.47	0.47	4.0%	1.42	1.42	6.3%
Refrigeration (5)						0.48	0.48	4.1%	1.45	1.45	6.5%
Electronics (6)						0.37	0.37	3.2%	1.12	1.12	5.0%
Wet Cleaning (7)	0.06					0.30	0.37	3.1%	0.91	0.98	4.4%
Cooking	0.22		0.03			0.13	0.38	3.2%	0.40	0.64	2.9%
Computers						0.24	0.24	2.0%	0.72	0.72	3.2%
Other (8)	0.00		0.20		0.07	1.20	1.46	12.5%	3.61	3.87	17.3%
Total	**4.88**	**0.43**	**0.50**	**0.03**	**1.00**	**5.30**	**11.69**	100%	**16.00**	**22.39**	100%

Note(s): 1) Kerosene and coal are assumed attributable to space heating. 2) Comprised of wood space heating (0.43 quad), solar water heating (0.02 quad), geothermal space heating (0.02 quad), and solar PV (0.06 quad). 3) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 4) Includes furnace fans (0.14 quad). 5) Includes refrigerators (0.39 quad) and freezers (0.09 quad). 6) Includes color television (0.37 quad). 7) Includes clothes washers (0.02 quad), natural gas clothes dryers (0.06 quad), electric clothes dryers (0.18 quad), and dishwashers (0.10 quad). Does not include water heating energy. 8) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 2-5 and Table A4, p. 9-12.

2.1.8 2035 Residential Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	*Site*	*Site*		Primary	Primary	
	Gas	Oil	LPG	Fuel(1)	En.(2)	Electric	Total	Percent	Electric (3)	Total	Percent
Space Heating (4)	3.20	0.31	0.22	0.03	0.46	0.49	4.72	38.9%	1.45	5.67	23.9%
Water Heating	1.27	0.04	0.03		0.02	0.54	1.90	15.6%	1.60	2.96	12.5%
Space Cooling	0.00					1.25	1.25	10.3%	3.68	3.68	15.5%
Lighting						0.48	0.48	3.9%	1.41	1.41	5.9%
Refrigeration (5)						0.52	0.52	4.3%	1.54	1.54	6.5%
Electronics (6)						0.44	0.44	3.6%	1.29	1.29	5.4%
Wet Cleaning (7)	0.07					0.32	0.39	3.2%	0.95	1.01	4.3%
Cooking	0.23		0.02			0.15	0.40	3.3%	0.44	0.69	2.9%
Computers						0.27	0.27	2.2%	0.79	0.79	3.3%
Other (8)	0.00		0.22		0.07	1.48	1.77	14.6%	4.35	4.64	19.6%
Total	**4.76**	**0.35**	**0.51**	**0.03**	**0.55**	**5.94**	**12.14**	100%	**17.50**	**23.69**	100%

Note(s): 1) Kerosene and coal are assumed attributable to space heating. 2) Comprised of wood space heating (0.44 quad), solar water heating (0.02 quad), geothermal space heating (0.03 quad), solar PV (0.06 quad), and wind (0.01 quad). 3) Site-to-source electricity conversion (due to generation and transmission losses) = 2.94. 4) Includes furnace fans (0.15 quad). 5) Includes refrigerators (0.43 quad) and freezers (0.09 quad). 6) Includes color television (0.44 quad). 7) Includes clothes washers (0.02 quad), natural gas clothes dryers (0.07 quad), electric clothes dryers (0.19 quad), and dishwashers (0.11 quad). Does not include water heating energy. 8) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 2-5 and Table A4, p. 9-12.

2.1.9 2005 Delivered Energy End-Uses for an Average Household, by Region (Million Btu per Household)

	Northeast	Midwest	South	West	National
Space Heating	70.3	56.6	20.4	23.8	38.7
Space Cooling	3.6	5.6	13.9	4.0	7.9
Water Heating	21.1	20.4	15.8	21.2	19.0
Refrigerator	5.4	7.0	6.6	5.7	6.3
Other Appliances & Lighting	23.0	25.9	25.0	24.1	24.7
Total (1)	**122.2**	**113.5**	**79.9**	**77.4**	**95.0**

Note(s): 1) Due to rounding, sums do not add up to totals.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008, Table US-14.

2.1.10 2005 Residential Delivered Energy Consumption Intensities, by Census Region

Region	Per Square Foot (thousand Btu) (1)	Per Household (million Btu)	Per Household Members (million Btu)	Percent of Total Consumption
Northeast	**73.5**	**122.2**	**47.7**	**24%**
New England	77.0	129.4	55.3	7%
Middle Atlantic	72.2	119.7	45.3	17%
Midwest	**58.9**	**113.5**	**46.0**	**28%**
East North Central	61.1	117.7	47.3	20%
West North Central	54.0	104.1	42.9	8%
South	**51.5**	**79.8**	**31.6**	**31%**
South Atlantic	47.4	76.1	30.4	16%
East South Central	56.6	87.3	36.1	6%
West South Central	56.6	82.4	31.4	9%
West	**56.6**	**77.4**	**28.1**	**18%**
Mountain	54.4	89.8	33.7	6%
Pacific	58.0	71.8	25.7	11%
U.S. Average	**58.7**	**94.9**	**37.0**	**100%**

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008.

2.1.11 2005 Residential Delivered Energy Consumption Intensities, by Housing Type

Type	Per Square Foot (thousand Btu) (1)	Per Household (million Btu)	Per Household Members (million Btu)	Percent of Total Consumption
Single-Family:	**55.4**	**106.6**	**39.4**	**80.5%**
Detached	55.0	108.4	39.8	73.9%
Attached	60.5	89.3	36.1	6.6%
Multi-Family:	**78.3**	**64.1**	**29.7**	**14.9%**
2 to 4 units	94.3	85.0	35.2	6.3%
5 or more units	69.8	54.4	26.7	8.6%
Mobile Homes	**74.6**	**70.4**	**28.5**	**4.6%**
All Housing Types	**58.7**	**95.0**	**37.0**	**100%**

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008.

2.1.12 2005 Residential Delivered Energy Consumption Intensities, by Vintage

Year Built	Per Square Foot (thousand Btu) (1)	Per Household (million Btu)	Per Household Member (million Btu)	Percent of Total Consumption
Prior to 1950	74.5	114.9	46.8	24%
1950 to 1969	66.0	96.6	38.1	23%
1970 to 1979	59.4	83.4	33.5	15%
1980 to 1989	51.9	81.4	32.3	14%
1990 to 1999	48.2	94.4	33.7	16%
2000 to 2005	44.7	94.7	34.3	8%
Average	58.7	95.0	40.0	

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008.

2.1.13 2005 Residential Delivered Energy Consumption Intensities, by Principal Building Type and Vintage

	Per Square Foot (thousand Btu) (1)		Per Household (million Btu)		Per Household Member (million Btu)	
Building Type	Pre-1995	1995-2005	Pre-1995	1995-2005	Pre-1995	1995-2005
Single-Family	**38.4**	**44.9**	**102.7**	**106.2**	**38.5**	**35.5**
Detached	37.9	44.7	104.5	107.8	38.8	35.4
Attached	43.8	55.5	86.9	85.1	34.2	37.6
Multi-Family	**63.8**	**58.7**	**58.3**	**49.2**	**27.2**	**24.3**
2 to 4 units	69.0	55.1	70.7	59.4	29.5	25.0
5 or more units	61.5	59.6	53.6	47.2	26.3	24.2
Mobile Homes	**82.4**	**57.1**	**69.6**	**74.5**	**29.7**	**25.2**

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, 2005 Residential Energy Consumption Survey,

2.1.14 2005 Residential Delivered Energy Consumption Intensities, by Ownership of Unit

Ownership	Per Square Foot (thousand Btu) (1)	Per Household (million Btu)	Per Household Members (million Btu)	Percent of Total Consumption
Owned	**54.9**	**104.5**	**40.3**	**78%**
Rented	**77.4**	**71.7**	**28.4**	**22%**
Public Housing	75.7	62.7	28.7	2%
Not Public Housing	77.7	73.0	28.4	19%
				100%

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, 2005 Residential Energy Consumption Survey.

2.1.15 Aggregate Residential Building Component Loads as of 1998 (1)

	Loads (quads) and Percent of Total Loads			
Component	Heating		Cooling	
Roof	-0.65	12%	0.16	14%
Walls	-1.00	19%	0.11	10%
Foundation	-0.76	15%	-0.07	-
Infiltration	-1.47	28%	0.19	16%
Windows (conduction)	-1.34	26%	0.01	1%
Windows (solar gain)	0.43	-	0.37	32%
Internal Gains	0.79	-	0.31	27%
Net Load	**-3.99**	100%	**1.08**	100%

Note(s): 1) "Loads" represents the thermal energy losses/gains that when combined will be offset by a building's heating/cooling system to maintain a set interior temperature (which then equals site energy).

Source(s): LBNL, Residential Heating and Cooling Loads Component Analysis, Nov. 1999, Figure P-1 and Appendix C: Component Loads Data Tables.

2.1.16 Operating Characteristics of Electric Appliances in the Residential Sector

	Power Draw (W) (1)			Annual Usage (hours/year)			Annual Consumption (kWh/year)	Annual Cost ($) (2)
	Active	Idle	Off	Active	Idle	Off		
Kitchen								
Coffee Maker	1,000	70	0	38	229	8,493	58	5.6
Dishwasher (3)				365 (4)			120	11.6
Microwave Oven	1,500		3	70		8,690	131	12.6
Toaster Oven	1,051			37			54	5.2
Refrigerator-Freezer							660	63.1
Freezer							470	45.0
Lighting								
18-W Compact Fluorescent	18			1,189			20	2.1
60-W Incandescent Lamp	60			672			40	3.9
100-W Incandescent Lamp	100			672			70	6.4
Torchiere Lamp-Halogen	300			1,460			440	42.0
Bedroom and Bathroom								
Hair Dryer	710			50			40	3.4
Waterbed Heater	350			3,051			1,070	102.7
Laundry Room								
Clothes Dryer				359 (4)			1,000	96.0
Clothes Washer (3)				392 (4)			110 (3)	10.4
Home Electronics								
Desktop PCs	75	4	2	2,990	330	5,440	237	22.8
Notebook PCs	25	2	2	2,368	935	5,457	72	6.9
Desktop Computer Monitors	42	1	1	1,865	875	6,020	85	8.2
Stereo Systems	33	30	3	1,510	1,810	5,440	119	11.4
Televisions	97		4	1,860		6,900	222 (7)	21.3
Analog, <40"	86			1,095 (5)			184	17.7
Analog, >40"	156			1,825 (5)			312	30.0
Digital, ED/HD TV, <40"	150			1,095 (5)			301	28.9
Digital, ED/HD TV, >40"	234			1,825 (5)			455	43.7
Set-top Boxes	20	0	20	6,450	0	2,310	178	17.1
DVD/VCR	17	13	3	170	5,150	3,430	78	7.5
Video Game Systems	36	36	1	405	560	7,795	41	3.9
Heating and Cooling								
Dehumidifier	600			1,620			970	93.3
Furnace Fan	295			1,350			400	38.2
Ceiling Fan (only fan motor)	35			2,310			81	7.8
Space Heater	1,320	1		584			314	30.1
Water Heating								
Water Heater-Family of 4	4,500			64 (6)			4,770	458.3
Water Heater-Family of 2	4,500			32 (6)			2,340	224.3
Portable Spa	4,350	275		25	8,735		2,525	242.4

Note(s): 1) Power draw will vary due to appliance components and modes of operation. 2) $0.096/kWh. 3) Excludes electricity for water heating and drying. 4) Cycles/year. 5) TVs <40" are estimated on 3 hours/day and TVs >40" are estimated on 5 hours/day. 6) Gallons/day. 7) Power, usage and annual consumption values for televisions are weighted averages of multiple usage types and screen sizes.

Source(s): BTS/A.D. Little, Electricity Consumption by Small End Uses in Residential Buildings, Aug. 1998, Exhibit 6-8, p. 6-10 for clothes washer, computer, dehumidifier, dishwasher, furnace fan, pool pump, torchiere lamp-halogen, waterbed heater, and well pump; LBNL, Energy Data Sourcebook for the U.S. Residential Sector, LBNL-40297, Sept. 1997, p. 100-102 for clothes dryers, Table 10.2, p. 108 for lighting, and p. 62-67 for water heaters; LBNL, Miscellaneous Electricity Use in the U.S. Residential Sector, LBNL-40295, Apr. 1998, Appendix D for hair dryers; EIA, Supplement to AEO 2008, June 2008, Table 21 for refrigerator and freezer; GAMA, Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment, Apr. 2000 for water heater power draw; EIA/TIAX, Commercial and Residential Sector Miscellaneous Electricity Consumption: FY2005 and Projections to 2030, Sept. 2006, p. 41-60 for coffee maker, microwave oven, stereo systems, TVs, DVD/VCR, ceiling fan, and portable spa; TIAX, Energy Consumption by Consumer Electronics in U.S. Residences, Final Report to the Consumer Electronics Association, Jan. 2007, p. 69-72 for desktop and notebook PCs, p. 62-63 for monitors, p. 85-90 for TVs, p. 76-81 for set-top boxes, and p. 103-105 for video game systems; and Energy Center of Wisconsin, Electricitiy Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes, May 2010, pp. 52-57 for toaster ovens, spaceheaters, power tools, vacuums, lawn sprinklers, and acquarium equipment.

2.1.17 Operating Characteristics of Natural Gas Appliances in the Residential Sector

	Average Capacity (thousand Btu/hr)	Appliance Usage	Annual Consumption (million Btu/year)	Annual Cost ($) (1)
Range	10		4	48
Clothes Dryer		359 (2)	4	49
Water Heating				
Water Heater-Family of 4	40	64 (3)	26	294
Water Heater-Family of 2	40	32 (3)	12	140

Note(s): 1) $1.139/therm. 2) Cycles/year. 3) Gallons/day.

Source(s): A.D. Little, EIA-Technology Forecast Updates - Residential and Commercial Building Technologies - Reference Case, Sept. 2, 1998, p. 30 for range and clothes dryer; LBNL, Energy Data Sourcebook for the U.S. Residential Sector, LBNL-40297, Sept. 1997, p. 62-67 for water heating; GAMA, Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment, Apr. 2002, for water heater capacity; and American Gas Association, Gas Facts 1998, December 1999, www.aga.org for range and clothes dryer consumption.

2.1.18 2009 Annual Natural Gas Consumption per Appliance by Census Division

Census Division	**Furnaces** million Btu	**Water Heaters** million Btu	**Ranges** million Btu	**Clothes Dryers** million Btu	**Fireplaces** million Btu
New England	72,095	24,853	6,367	4,930	8,216
Middle Atlantic	85,241	24,032	5,238	4,930	9,448
East North Central	72,506	22,902	8,832	8,216	13,248
West North Central	46,831	24,443	4,416	4,622	3,903
South Atlantic	54,226	20,232	4,108	5,135	5,957
East South Central	47,858	20,129	4,416	5,135	9,038
West South Central	33,891	24,648	3,595	3,081	5,135
Mountain	58,334	26,702	3,389	3,389	6,162
Pacific	44,675	20,232	3,286	3,286	29,064
United States					
Average	**61,928**	**23,005**	**5,238**	**5,135**	**10,270**
Total	**515,657**	**208,173**	**43,648**	**42,723**	**90,171**

Source(s): American Gas Association, Residential Natural Gas Market Survey, Table 10-1, January 2011

2.1.19 Residential Buildings Share of U.S. Natural Gas Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Natural Gas Total
	Residential	Industry	Electric Gen.	Transportation	**Residential**	Industry	Transportation	(quads)
1980	**24%**	41%	19%	3%	**30%**	49%	3%	20.22
1990	**23%**	43%	17%	3%	**29%**	49%	4%	19.57
2000	**21%**	40%	22%	3%	**29%**	47%	3%	23.66
2005	**22%**	35%	27%	3%	**32%**	42%	3%	22.49
2010	**20%**	**33%**	**31%**	**3%**	**32%**	**41%**	**3%**	**24.71**
2015	**19%**	33%	32%	3%	**31%**	41%	3%	25.99
2020	**19%**	34%	31%	3%	**30%**	42%	3%	26.13
2025	**19%**	34%	30%	3%	**30%**	42%	3%	25.80
2030	**18%**	33%	32%	3%	**31%**	40%	3%	26.49
2035	**18%**	32%	34%	3%	**31%**	40%	3%	27.11

Note(s): 1) Residential sector accounted for 40% (or $71 billion) of total U.S. natural gas expenditures.

Source(s): EIA, State Energy Data 2009: Consumption, Jun. 2011, Tables 8-12 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5 for 2010-2035.

2.1.20 Residential Buildings Share of U.S. Petroleum Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Petroleum Total
	Residential	Industry	Electric Gen.	Transportation	**Residential**	Industry	Transportation	(quads)
1980	**5%**	28%	8%	56%	**8%**	31%	56%	34.2
1990	**4%**	25%	4%	64%	**5%**	26%	64%	33.6
2000	**4%**	24%	3%	67%	**5%**	25%	67%	38.4
2005	**3%**	24%	3%	68%	**5%**	25%	68%	40.7
2010	**3%**	**22%**	**1%**	**72%**	**4%**	**22%**	**72%**	**37.2**
2015	**3%**	21%	1%	73%	**3%**	22%	73%	36.9
2020	**3%**	22%	1%	73%	**3%**	22%	73%	37.1
2025	**3%**	22%	1%	73%	**3%**	22%	73%	37.0
2030	**2%**	22%	1%	73%	**3%**	22%	73%	37.3
2035	**2%**	22%	1%	73%	**3%**	22%	73%	38.0

Source(s): EIA, State Energy Data 2009: Consumption, Jun. 2011, Tables 8-12, p. 18-22 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5 for 2010-2035.

2.2.1 Total Number of Households and Buildings, Floorspace, and Household Size, by Year

	Households (millions)	Percent Post-2000 Households (1)	Floorspace (billion SF)	U.S. Population (millions)	Average Household Size (2)
1980	80	N.A.	142	227	2.9
1990	94	N.A.	169	250	2.6
2000	106	N.A.	N.A.	282	2.7
2005	109	9%	256	296	2.7
2010	114	14%	N.A.	310	2.7
2015	119	18%	N.A.	326	2.7
2020	126	25%	N.A.	341	2.7
2025	133	31%	N.A.	357	2.7
2030	139	36%	N.A.	374	2.7
2035	146	41%	N.A.	390	2.7

Note(s): 1) Percent built after Dec. 31, 2000. 2) Number of residents. 3) Number of buildings and floorspace in 1997; for comparison, 1997 households = 101.5 million; percentage of floorspace: 85% single-family, 11% multi-family, and 4% manufactured housing. 2001 households = 107.2 million; percentage of floorspace: 83% single-family, 13% multi-family, and 4% manufactured housing.

Source(s): DOC, Statistical Abstract of the U.S. 2008, Oct. 2007, No. 948, p. 626 for 1980-2004 households; DOC, Statistical Abstract of the U.S. 2012, 2011, Table 982 for 2005-2009 households, Tables 2-3 for 1980-2035 population; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A4, p. 9-10 for 2010-2035 households and Table A20, p. 37-38 for housing starts; EIA, Buildings and Energy in the 1980's, June 1995, Table 2.1, p. 23 for residential buildings and floorspace in 1980 and 1990; EIA, 1997 Residential Energy Consumption Survey for 1997 buildings and floorspace; EIA, 2001 Residential Energy Consumption Survey for 2001 households and floorspace; and EIA, 2005 Residential Energy Consuption Survey for 2005 floorspace.

2.2.2 Share of Households, by Housing Type and Type of Ownership, as of 2005 (Percent)

Housing Type	Owned	Rented	Total
Single-Family:	**61.5%**	**10.3%**	**71.7%**
Detached	57.7%	7.2%	64.9%
Attached	3.8%	3.1%	6.8%
Multi-Family:	**3.7%**	**18.3%**	**22.0%**
2 to 4 units	1.6%	5.3%	6.9%
5 or more units	2.1%	13.0%	15.0%
Mobile Homes	**5.1%**	**1.1%**	**6.2%**
Total	**70.3%**	**29.6%**	**100%**

Source(s): EIA, A Look at Residential Energy Consumption in 2005, July 2008, Table HC3-1 and HC4-1.

2.2.3 Share of Total U.S. Households, by Census Region, Division, and Vintage, as of 2005

Region	Prior to 1950	1950 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2005	All Vintages
Northeast	**6.7%**	**5.2%**	**2.4%**	**2.1%**	**1.3%**	**0.8%**	**18.5%**
New England	2.1%	1.2%	0.5%	0.5%	0.3%	0.3%	4.9%
Middle Atlantic	4.6%	4.0%	1.9%	1.6%	1.0%	0.5%	13.6%
Midwest	**5.7%**	**5.8%**	**3.6%**	**2.5%**	**3.7%**	**1.7%**	**23.0%**
East North Central	4.3%	3.9%	2.7%	1.8%	2.1%	1.1%	16.0%
West North Central	1.4%	1.9%	0.9%	0.7%	1.6%	0.6%	7.1%
South	**4.0%**	**6.9%**	**6.4%**	**7.5%**	**7.5%**	**4.3%**	**36.6%**
South Atlantic	2.0%	3.4%	3.5%	4.2%	4.3%	2.2%	17.4%
East South Central	0.9%	1.3%	0.9%	1.0%	1.3%	0.7%	6.2%
West South Central	1.2%	2.3%	4.7%	2.2%	1.8%	1.4%	13.6%
West	**3.4%**	**4.6%**	**4.5%**	**4.6%**	**3.1%**	**1.5%**	**21.8%**
Mountain	0.7%	1.2%	1.3%	1.5%	1.3%	0.9%	6.8%
Pacific	2.8%	3.4%	3.3%	3.1%	1.8%	0.6%	15.0%
United States	**19.9%**	**22.5%**	**17.0%**	**16.7%**	**15.6%**	**8.3%**	**100%**

Source(s): EIA, A Look at Residential Energy Consumption in 2005, July 2008, Table HC10-1.

2.2.4 Characteristics of U.S. Housing by Census Division and Region, as of 2005

Census Division	Share of U.S. Housing Stock	Average Home Size (1) (total square feet)	Average Home Size (heated square feet)
Northeast	**19%**	**2,423**	**1,664**
New England	5%	2,552	1,680
Middle Atlantic	14%	2,376	1,658
Midwest	**23%**	**2,566**	**1,927**
East North Central	16%	2,628	1,926
West North Central	7%	2,424	1,930
South	**37%**	**2,295**	**1,551**
South Atlantic	20%	2,370	1,607
East South Central	6%	2,254	1,544
West South Central	11%	2,184	1,455
West	**22%**	**1,963**	**1,366**
Mountain	7%	2,149	1,649
Pacific	15%	1,878	1,238
Total	**100%**	**2,309**	**1,618**

Note(s): 1) Total Square footage includes attic, garage, and basement square footage.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, July 2008.

2.2.5 Characteristics of U.S. Housing by Vintage, as of 2005

Vintage	Share of US Housing Stock	Average Home Size (square feet) (1) Single Family	Multi-Family	Mobile Home
Prior to 1950	20%	2,677	1,021	775
1950 to 1969	23%	2,433	927	775
1970 to 1979	17%	2,666	869	948
1980 to 1989	17%	2,853	909	1,008
1990 to 1999	16%	3,366	940	1,245
2000 to 2005	8%	3,680	1,047	1,425
Total U.S. Homes (millions)	111.1			
U.S. Average		2,838	941	1,062

Note(s): 1) Average home sizes include both heated and unheated floor space, including garages.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, July 2008.

2.2.6 Residential Floorspace (Heated Square Feet), as of 2005 (Percent of Total Households)

Floorspace	
Fewer than 500	6%
500 to 999	26%
1,000 to 1,499	24%
1,500 to 1,999	16%
2,000 to 2,499	9%
2,500 to 2,999	7%
3,000 or more	11%
Total	100%

Source(s): EIA, A Look at Residential Energy Consumption in 2005, July 2008, Table HC1-3.

2.2.7 Characteristics of a Typical Single-Family Home (1)

Year Built	mid 1970s
Occupants	3
Floorspace	
Heated Floorspace (SF)	1,934
Cooled Floorspace (SF)	1,495
Garage	2-Car
Stories	1
Foundation	Concrete Slab
Total Rooms (2)	6
Bedrooms	3
Other Rooms	3
Full Bathroom	2
Half Bathroom	0
Windows	
Area (3)	222
Number (4)	15
Type	Double-Pane
Insulation: Well or Adequate	

Building Equipment	Type	Fuel	Age (5)
Space Heating	Central Warm-Air Furnace	Natural Gas	12
Water Heating	49 Gallons	Natural Gas	8
Space Cooling	Central Air Conditioner		8

Appliances	Type / Fuel / Number	Size	Age (5)
Refrigerator	2-Door Top and Bottom	19 Cubic Feet	8
Clothes Dryer	Electric		
Clothes Washer	Top-Loading		
Range/Oven	Electric		
Microwave Oven			
Dishwasher			
Color Televisions	3		
Ceiling Fans	3		
Computer	2		
Printer			

Note(s): 1) This is a weighted-average house that has combined characteristics of the Nation's stock homes. Although the population of homes with similar traits may be few, these are likely to be the most common. 2) Excludes bathrooms. 3) 11.5% of floorspace. 4) Based on a nominal 3' X 5' window. 5) Years.

Source(s): EIA, 2005 Residential Energy Consumption Survey: Characteristics, April 2008, Tables HC 1.1.1, HC1.1.3, HC 2.1, HC 2.2, HC 2.3, HC 2.4,

2.2.8 Presence of Air-Conditioning and Type of Heating System in New Single-Family Homes

Year	Total Homes (thousands)	Type of Primary Heating System: Warm-Air furnace	Heat pump	Hot Water or steam (1)	Other or none (2)	Air-Conditioning
1980	957	57%	24%	4%	15%	62%
1981	819	56%	25%	3%	16%	65%
1982	632	53%	26%	4%	17%	66%
1983	924	56%	29%	4%	12%	69%
1984	1,025	55%	30%	4%	11%	71%
1985	1,072	54%	30%	5%	11%	70%
1986	1,120	54%	29%	7%	10%	69%
1987	1,123	57%	27%	7%	9%	71%
1988	1,085	60%	26%	7%	8%	75%
1989	1,026	63%	24%	6%	7%	77%
1990	966	64%	23%	6%	6%	76%
1991	838	65%	22%	6%	7%	75%
1992	964	66%	24%	6%	5%	77%
1993	1,039	67%	24%	5%	5%	78%
1994	1,160	67%	24%	5%	4%	79%
1995	1,066	66%	25%	5%	4%	79%
1996	1,129	70%	23%	5%	2%	81%
1997	1,116	70%	23%	5%	2%	82%
1998	1,160	72%	21%	4%	3%	83%
1999	1,270	72%	22%	4%	2%	84%
2000	1,242	71%	23%	4%	2%	85%
2001	1,256	71%	23%	4%	1%	86%
2002	1,325	71%	23%	4%	2%	87%
2003	1,386	71%	24%	3%	2%	88%
2004	1,532	70%	26%	3%	1%	90%
2005	1,636	67%	29%	3%	1%	89%
2006	1,654	63%	33%	3%	2%	89%
2007	1,218	62%	34%	2%	2%	90%
2008	819	60%	34%	3%	3%	89%
2009	520	56%	37%	3%	4%	88%
2010	496	56%	38%	2%	3%	88%

Note(s) 1) Includes both air source and geothermal (ground source) versions. 2) Includes electric baseboard, panel, radiant heat, space heater, floor or wall furnace, solar, and other types.

Source(s): DOC, 2010 Characteristics of New Housing, June 2010, Type of Heating System Used in New Single-Family Houses Completed, and Presence of Air-Conditioning in New Single-Family Houses Completed.

2.3.1 Residential Energy Prices, by Year and Major Fuel Type ($2010 per Million Btu)

	Electricity	Natural Gas	Petroleum (1)	Avg.
1980	36.40	8.35	16.77	17.64
1990	35.19	8.63	13.27	18.64
2000	30.13	9.54	14.18	18.06
2005	30.64	13.66	18.93	21.50
2010	**33.69**	**11.08**	**23.75**	**22.42**
2015	33.22	10.28	28.73	22.24
2020	32.46	11.06	29.90	22.58
2025	32.31	12.11	31.22	23.36
2030	31.76	12.66	32.40	23.69
2035	32.47	13.86	33.86	24.92

Note(s): 1) Residential petroleum products include distillate fuel, LPG, and kerosene.

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, Jun. 2011, Table 2 for 1980-2009 prices, Table 8 for 1980-2009 consumption; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A3, p. 6-8 for 2010-2035 consumption and prices; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

2.3.2 Residential Energy Prices, by Year and Fuel Type ($2010)

	Electricity (cents/kWh)	Natural Gas (cents/therm)	Distillate Oil ($/gal)	LPG ($/gal)
1980	12.42	83.51	1.53	2.24
1990	12.01	86.28	1.40	1.69
2000	10.28	95.36	1.51	1.70
2005	10.45	136.59	1.90	2.36
2010	**11.50**	**110.79**	**2.29**	**2.92**
2015	11.33	102.80	2.60	3.74
2020	11.08	110.57	2.64	3.96
2025	11.02	121.07	2.74	4.15
2030	10.84	126.62	2.82	4.34
2035	11.08	138.62	2.93	4.55

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, Jun. 2011, Table 2, p. 24-25 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A3, p. 6-8 for 2010-2035 and Table G1, p. 215 for fuels' heat content; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

2.3.3 Residential Aggregate Energy Expenditures, by Year and Major Fuel Type ($2010 Billion) (1)

	Electricity	Natural Gas	Petroleum (2)	Total
1980	89.1	40.5	28.9	158.5
1990	110.9	39.0	18.2	168.2
2000	122.6	48.6	21.6	192.8
2005	142.1	67.7	26.9	236.7
2010	**166.8**	**56.1**	**29.0**	**251.8**
2015	159.3	51.3	31.1	241.7
2020	163.1	54.7	30.1	247.9
2025	171.3	59.1	29.8	260.3
2030	178.9	61.3	29.5	269.7
2035	193.0	66.0	29.6	288.6

Note(s): 1) Residential petroleum products include distillate fuel oil, LPG, and kerosene.

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, Jun. 2011, Table 2 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table 2, p. 3-5 and Table 3, p. 6-8 for 2010-2035; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

2.3.4 Cost of a Generic Quad Used in the Residential Sector ($2010 Billion) (1)

	Residential
1980	10.45
1990	10.12
2000	9.57
2005	11.10
2010	**9.98**
2015	9.88
2020	9.91
2025	10.09
2030	10.06
2035	10.57

Note(s): 1) See Table 1.5.1 for generic quad definition. This table provides the consumer cost of a generic quad in the buildings sector. Use this table to estimate the average consumer cost savings resulting from the savings of a generic (primary) quad in the buildings sector. 2) Price of

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5 and Table A17, p. 34-35 for energy consumption and Table A3, p. 6-8 for energy prices (2010-2035). EIA, State Energy Data Report 2009, June 2011, Tables 8-12, p. 22-24 and EIA, State Energy Prices and Expenditures 2009, Tables 2 and 3 (1980-2009); EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.3.5 2010 Residential Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural Gas	Petroleum				Coal	Electricity	Total	Percent
		Distil.	LPG	Kerosene	Total				
Space Heating (2)	38.7	11.2	8.0	0.5	19.8	0.0	14.7	73.2	29.1%
Space Cooling (3)	0.0						36.3	36.3	14.4%
Water Heating (4)	14.3	2.1	2.0		4.0		14.2	32.6	12.9%
Lighting							23.9	23.9	9.5%
Refrigeration (5)							19.7	19.7	7.8%
Electronics (6)							17.9	17.9	7.1%
Cooking	2.4		0.8		0.8		7.8	11.0	4.4%
Wet Cleaning (7)	0.6						11.0	11.6	4.6%
Computers							5.8	5.8	2.3%
Other (8)	0.0		4.4		4.4		6.5	10.9	4.3%
Adjust to SEDS (9)							-1.3	-1.3	-0.5%
Total	**56.1**	**13.3**	**15.2**	**0.5**	**29.0**	**0.0**	**166.8**	**251.8**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes furnace fans ($4.5 billion). 3) Fan energy use included. 4) Includes residential recreational water heating ($1.4 billion). 5) Includes refrigerators ($15.3 billion) and freezers ($4.4 billion). 6) Includes color televisions ($11.0 billion) and other electronics ($7.4 billion). 7) Includes clothes washers ($1.1 billion), natural gas clothes dryers ($0.6 billion), electric clothes dryers ($6.5 billion), and dishwashers ($3.4 billion). 8) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. 9) Expenditures related to an energy adjustment that EIA uses to relieve discrepancies between data sources. Refers to energy attributable to the residential building sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A4-A5, p. 9-10 for energy consumption, Table A3, p. 6-8 for prices; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A for residential electric end-uses.

2.3.6 2015 Residential Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural Gas	Petroleum				Coal	Electricity	Total	Percent
		Distil.	LPG	Kerosene	Total				
Space Heating (2)	35.0	13.0	8.1	0.6	21.6	0.0	14.0	70.6	29.2%
Space Cooling (3)	0.0						33.8	33.8	14.0%
Water Heating	13.5	1.9	1.5		3.4		15.8	32.7	13.5%
Lighting							17.6	17.6	7.3%
Refrigeration (4)							15.0	15.0	6.2%
Electronics (5)							10.9	10.9	4.5%
Wet Cleaning (6)	0.6						10.8	11.4	4.7%
Cooking	2.2		0.9		0.9		3.8	6.8	2.8%
Computers							6.3	6.3	2.6%
Other (7)	0.0		5.2		5.2		31.3	36.5	15.1%
Total	**51.3**	**14.9**	**15.7**	**0.6**	**31.1**	**0.0**	**159.3**	**241.7**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes furnace fans ($4.6 billion). 3) Fan energy use included. 4) Includes refrigerators ($12.3 billion) and freezers ($2.8 billion). 5) Includes color televisions ($10.9 billion). 6) Includes clothes washers ($1.1 billion), natural gas clothes dryers ($0.6 billion), electric clothes dryers ($6.5 billion), and dishwashers ($3.3 billion). 7) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A4-A5, p. 9-10 for energy consumption, Table A3, p. 6-8 for prices

2.3.7 2025 Residential Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural Gas	Petroleum				Coal	Electricity	Total	Percent
		Distil.	LPG	Kerosene	Total				
Space Heating (2)	39.7	11.5	7.8	0.6	19.9	0.0	15.0	74.5	28.6%
Space Cooling (3)	0.0						36.2	36.2	13.9%
Water Heating	16.0	1.4	1.3		2.7		17.1	35.9	13.8%
Lighting							15.2	15.2	5.8%
Refrigeration (4)							15.5	15.5	6.0%
Electronics (5)							12.0	12.0	4.6%
Wet Cleaning (6)	0.8						9.8	10.5	4.1%
Cooking	2.7		0.8		0.8		4.3	7.8	3.0%
Computers							7.7	7.7	2.9%
Other (7)	0.0		6.4		6.4		38.7	45.0	17.3%
Total	**59.1**	**12.9**	**16.3**	**0.6**	**29.8**	**0.0**	**171.3**	**260.3**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes furnace fans ($4.7 billion). 3) Fan energy use included. 4) Includes refrigerators ($12.7 billion) and freezers ($2.8 billion). 5) Includes color televisions ($12 billion). 6) Includes clothes washers ($0.8 billion), natural gas clothes dryers ($0.8 billion), electric clothes dryers ($5.8 billion), and dishwashers ($3.2 billion). 7) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A4-A5, p. 9-10 for energy consumption, Table A3, p. 6-8 for prices

2.3.8 2035 Residential Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural Gas	Petroleum				Coal	Electricity	Total	Percent
		Distil.	LPG	Kerosene	Total				
Space Heating (2)	44.3	10.3	7.7	0.6	18.6	0.0	16.0	79.0	27.4%
Space Cooling (3)	0.0						40.6	40.6	14.1%
Water Heating	17.6	1.2	1.2		2.3		17.7	37.6	13.0%
Lighting							15.5	15.5	5.4%
Refrigeration (4)							17.0	17.0	5.9%
Electronics (5)							14.2	14.2	4.9%
Wet Cleaning (6)	0.9						10.4	11.3	3.9%
Cooking	3.2		0.8		0.8		4.8	8.9	3.1%
Computers							8.7	8.7	3.0%
Other (7)	0.0		7.7		7.7		47.9	55.7	19.3%
Total	**66.0**	**11.5**	**17.5**	**0.6**	**29.6**	**0.0**	**193.0**	**288.6**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes furnace fans ($4.8 billion). 3) Fan energy use included. 4) Includes refrigerators ($14.1 billion) and freezers ($2.9 billion). 5) Includes color televisions ($14.2 billion). 6) Includes clothes washers ($0.8 billion), natural gas clothes dryers ($0.9 billion), electric clothes dryers ($6.0 billion), and dishwashers ($3.6 billion). 7) Includes small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A4-A5, p. 9-10 for energy consumption, Table A3, p. 6-8 for prices

2.3.9 Average Annual Energy Expenditures per Household, by Year ($2010)

Year	Average Expenditure
1980	1,991
1990	1,785
2000	1,824
2005	2,175
2010	**2,201**
2015	2,030
2020	1,963
2025	1,957
2030	1,932
2035	1,978

Source(s): EIA, State Energy Data 2009: Prices and Expenditures, Jun. 2011 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10 for consumption, Table A3, p. 6-8 for prices 2010-2035; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators; and DOC, Statistical Abstract of the United States Historical Data for 1980-2009 occupied units.

2.3.10 2005 Energy End-Use Expenditures for an Average Household, by Region ($2010)

	Northeast	Midwest	South	West	National
Space Heating	1,050	721	371	352	575
Air-Conditioning	199	175	456	262	311
Water Heating	373	294	313	318	320
Refrigerators	194	145	146	154	157
Other Appliances and Lighting	827	665	715	716	725
Total (1)	**2,554**	**1,975**	**1,970**	**1,655**	**2,003**

Note(s): 1) Due to rounding, end-uses do not sum to totals.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008, Table US-15; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

2.3.11 2005 Energy Expenditures per Household, by Housing Type and Square Footage ($2010)

	Per Household	Per Square Foot (1)
Single-Family	**2,230**	**1.16**
Detached	2,280	1.16
Attached	1,768	1.20
Multi-Family	**1,359**	**1.66**
2 to 4 units	1,722	1.90
5 or more units	1,192	1.53
Mobile Home	**1,661**	**1.76**
All Homes	**2,003**	**1.12**

Note(s): 1) Energy expenditures per square foot were calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, Oct. 2008, Table US-1 part1; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.3.12 2005 Household Energy Expenditures, by Vintage ($2010)

Year	Per Square Foot (1)	Per Household	Per Household Member	Percent of Residential Sector Expenditures
Prior to 1950	1.42	2,177	887	22%
1950 to 1969	1.34	1,956	771	22%
1970 to 1979	1.31	1,831	736	16%
1980 to 1989	1.18	1,865	741	16%
1990 to 1999	1.07	2,110	752	16%
2000 to 2005	1.02	2,147	777	9%
				Total 100%
Average	**1.24**	**2,003**	**780**	

Note(s): 1) Energy expenditures per square foot were calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, October 2008 for 2005 expenditures; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.3.13 2005 Average Household Expenditures, by Census Region ($2010)

Item	Northeast	Midwest	South	West	United States
Energy (1)	2,554	1,975	1,970	1,655	2,003
Shelter (2)	11,144	8,727	7,931	12,545	9,744
Food	7,187	6,367	6,076	7,015	6,563
Telephone, water and other public services	1,434	1,475	1,627	1,667	1,565
Household supplies, furnishings and equipment (3)	2,408	2,598	2,456	3,146	2,631
Transportation (4)	8,556	8,579	8,842	11,141	9,233
Healthcare	2,856	3,144	2,884	2,929	2,948
Education	1,535	1,104	746	1,025	1,040
Personal taxes (5)	2,390	2,574	2,506	3,251	2,665
Other expenditures	13,178	13,238	12,009	14,242	13,008
Average Annual Income	**69,790**	**62,640**	**58,993**	**72,966**	**64,970**

Note(s): 1) Average household energy expenditures are calculated from the Residential Energy Consumption Survey (RECS), while average expenditures for other categories are calculated from the Consumer Expenditure Survey (CE). RECS assumed total US households to be 111,090,617 in 2005, while the CE data is based on 117,356,000 "consumer units," which the Bureau of Labor Statistics defines to be financially independent persons or groups of people that use their incomes to make joint expenditure decisions, including all members of a particular household who are related by blood, marriage, or other legal arrangements. CE calculated average annual energy expenditures for the United States to be $1,943. 2) Shelter includes both owned and rented dwellings, including any expenses for mortgage interest, property taxes, maintenance, repairs, insurance, and other expenses. 3) Household supplies, furnishings and equipments includes the following: laundry and cleaning supplies, postage and stationary, household textiles, furniture, floor coverings, appliances, and other household equipment. 4) Transportation expenditures include public transportation as well as the following vehicle-related expenses: net outlay of vehical purchases, gasoline and motor oil, vehicle finance, maintenance and repairs, insurance, licenses, rental fees, and other charges. CE estimated public transportation to comprise 5.4% of total transportation spending. 5) Personal taxes include federal, state and local income taxes, as well as $177 per year for "other taxes."

Source(s): EIA, A Look at Residential Energy Consumption in 2005, Oct. 2008, Tables US-1 part 1 for energy expenditures; Bureau of Labor Statistics, Consumer Expenditure Survey 2005, Table 8, Oct. 2010; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.3.14 2005 Average Household Expenditures as Percent of Annual Income, by Census Region ($2010)

Item	Northeast	Midwest	South	West	United States
Energy (1)	3.7%	3.2%	3.3%	2.3%	3.1%
Shelter (2)	16.0%	13.9%	13.4%	17.2%	15.0%
Food	10.3%	10.2%	10.3%	9.6%	10.1%
Telephone, water and other public services	2.1%	2.4%	2.8%	2.3%	2.4%
Household supplies, furnishings and equipment (3)	3.5%	4.1%	4.2%	4.3%	4.1%
Transportation (4)	12.3%	13.7%	15.0%	15.3%	14.2%
Healthcare	4.1%	5.0%	4.9%	4.0%	4.5%
Education	2.2%	1.8%	1.3%	1.4%	1.6%
Personal taxes (5)	3.4%	4.1%	4.2%	4.5%	4.1%
Average Annual Expenditures	76.0%	79.5%	79.7%	80.2%	79.0%
Average Annual Income	**69,230**	**62,136**	**58,519**	**72,380**	**64,448**

Note(s): 1) Average household energy expenditures are calculated from the Residential Energy Consumption Survey (RECS), while average expenditures for other categories are calculated from the Consumer Expenditure Survey (CE). RECS assumed total US households to be 111,090,617 in 2005, while the CE data is based on 117,356,000 "consumer units," which the Bureau of Labor Statistics defines to be financially independent persons or groups of people that use their incomes to make joint expenditure decisions, including all members of a particular household who are related by blood, marriage, or other legal arrangements. CE calculated average annual energy expenditures for the United States to be $1,943 while RECS calculated it to be $1,987. 2) Shelter includes both owned and rented dwellings, including any expenses for mortgage interest, property taxes, maintenance, repairs, insurance, and other expenses. 3) Household supplies, furnishings and equipments includes the following: laundry and cleaning supplies, postage and stationary, household textiles, furniture, floor coverings, appliances, and other household equipment. 4) Transportation expenditures include public transportation as well as the following vehicle-related expenses: net outlay of vehical purchases, gasoline and motor oil, vehicle finance, maintenance and repairs, insurance, licenses, rental fees, and other charges. CE estimated public transportation to comprise 5.4% of total transportation spending. 5) Personal taxes include federal, state and local income taxes, as well as $177 per year for "other taxes."

Source(s): EIA, A Look at Residential Energy Consumption in 2005, Oct. 2008, Tables US-1 part 1 for energy expenditures; Bureau of Labor Statistics, Consumer Expenditure Survey 2005, Table 8; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.3.15 2005 Households and Energy Expenditures, by Income Level ($2010)

Household Income	Households (10^6)		Energy Expenditures by Household	Energy Expenditures by Household Member	Mean Individual Energy Burden (1)
Less than $10,000	9.9	9%	1,497	778	24%
$10,000 to $14,999	8.5	8%	1,568	757	13%
$15,000 to $19,999	8.4	8%	1,602	731	9%
$20,000 to $29,999	15.1	14%	1,753	715	7%
$30,000 to $39,999	13.6	12%	1,852	707	5%
$40,000 to $49,999	11.0	10%	1,995	750	4%
$50,000 to $74,999	19.8	18%	2,129	771	3%
$75,000 to $99,999	10.6	10%	2,431	847	3%
$100,000 or more	14.2	13%	2,774	909	3%
Total	**111.1**	100%			**7%**

Note(s): 1) See Table 2.3.15 for more on energy burdens. 2) A household is defined as a family, an individual, or a group of up to nine unrelated individuals occupying the same housing unit.

Source(s): EIA, A Look at Residential Energy Consumption in 2005, Oct. 2008, Table US-1 part 2; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price inflators.

2.4.1 Carbon Dioxide Emissions for U.S. Residential Buildings, by Year (million metric tons) (1)

	Residential				U.S.			
	Site Fossil	Electricity	Total	Growth Rate 2010-Year	Total	Growth Rate 2010-Year	Res.% of Total U.S.	Res.% of Total Global
1980	385	525	909	-	4723	-	19%	4.9%
1990	340	624	963	-	5039	-	19%	4.5%
2000	380	805	1185	-	5867	-	20%	5.0%
2005	364	897	1261	-	5996	-	21%	4.4%
2010	**353**	**879**	**1231**	**-**	**5634**	**-**	**22%**	**3.9%**
2015	339	759	1098	-2.3%	5434	-0.7%	20%	3.3%
2020	332	791	1122	-0.9%	5549	-0.2%	20%	3.2%
2025	324	838	1163	-0.4%	5618	0.0%	21%	3.1%
2030	319	883	1202	-0.1%	5695	0.1%	21%	3.0%
2035	312	925	1236	0.0%	5806	0.1%	21%	2.9%

Note(s): 1) Excludes emissions of buildings-related energy consumption in the industrial sector. Emissions assume complete combustion from energy consumption and exclude energy production activities such as gas flaring, coal mining, and cement production. 2) U.S. buildings emissions approximately equal the combined carbon emissions of Japan, France, and the United Kingdom.

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 1998, Oct. 1999, Tables E1-E2 for 1980-1989 greenhouse gas emissions; EIA, Emissions of Greenhouse Gases in the U.S. 2009, Feb. 2011, Tables 8-11 for 1990-2009 greenhouse gas emissions; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients; EIA, AEO 2012 Early Release, Jan. 2012, Table A2, p. 3-5 for 2010-2035 energy consumption and Table A18, p. 36 for 2010-2035 emissions; EIA, International Energy Outlook 2011, Sept. 2011, Table A10 for 2010-2035 global emissions; and EIA, Country Energy Profiles for global emissions (1980-2009), available at http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm, accessed 2/10/2012 for 1980-2009 global emissions.

2.4.2 2005 End-Use Carbon Dioxide Emissions Splits for an Average Household, by Region (Pounds of CO2)

	Northeast	Midwest	South	West	National
Space Heating	9,980	7,522	3,853	3,735	5,834
Space Cooling	2,066	2,851	6,648	3,252	4,373
Water Heating	3,500	3,458	3,901	3,401	3,636
Refrigerator	2,488	3,261	3,084	2,663	2,922
Other Appliances & Lighting	8,673	10,421	10,722	9,219	9,945
Total	**26,707**	**27,513**	**28,208**	**22,271**	**26,711**

Source(s): EIA, A Look at Residential Energy Consumption in 2005, Jul. 2008, Tables CE(2-5)-(9-12)c; EIA, Assumptions to the AEO 2011, July 2011, Table 2, p. 12 for coefficients; EIA, AEO 2012 Early Release, Jan. 2012, Tables 2 and 18.

2.4.3 2010 Residential Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	185.5	38.8		18.7	2.2	59.7	0.7	77.6	323.5	26.3%
Space Cooling	0.0							210.2	210.2	17.1%
Water Heating	68.7	7.1		4.6		11.7		90.4	170.8	13.9%
Lighting								126.0	126.0	10.2%
Electronics (5)								96.5	96.5	7.8%
Refrigeration (6)								80.7	80.7	6.6%
Wet Cleaning (7)	2.9							57.8	60.8	4.9%
Cooking	11.4			1.9		1.9		42.6	55.9	4.5%
Computers								30.5	30.5	2.5%
Other (8)				10.2		10.2		36.3	46.5	3.8%
Adjust to SEDS (9)								30.1	30.1	2.4%
Total	**268.5**	**45.9**		**35.3**	**2.2**	**83.5**	**0.7**	**878.7**	**1,231.4**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. Carbon emissions calculated from EIA, Assumptions to the AEO 2011. 2) Includes kerosene space heating (2.2 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (23.9 MMT). 5) Includes color television (58.2 MMT) and other office equipment (30.5 MMT). 6) Includes refrigerators (66.1 MMT) and freezers (14.6 MMT). 7) Includes clothes washers (5.8 MMT), natural gas clothes dryers (2.9 MMT), electric clothes dryers (34.3 MMT), and dishwashers (17.8 MMT). Does not include water heating energy. 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting. 9) Emissions related to a discrepancy between data sources and that results from energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption,and Table A18, p. 36 for emissions; EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for emission coefficients; BTS/A.D. Little, Electricity Consumption by Small End-Uses in Residential Buildings, Aug. 1998, Appendix A for residential electric end-uses; EIA, AEO 1999, Dec. 1998, Table A4, p. 118-119.

2.4.4 2015 Residential Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Space Heating (4)	180.5	34.9		16.6	1.8	53.3	0.6	66.6	301.0	27.4%
Space Cooling	0.0							161.1	161.1	14.7%
Water Heating	69.6	5.1		3.1		8.2		75.3	153.1	13.9%
Lighting								83.7	83.7	7.6%
Refrigeration (5)								71.7	71.7	6.5%
Electronics (6)								52.0	52.0	4.7%
Wet Cleaning (7)	3.2							51.6	54.7	5.0%
Cooking	11.5			1.8		1.8		17.9	31.1	2.8%
Computers								30.0	30.0	2.7%
Other (8)				10.6		10.6		149.3	160.0	14.6%
Total	**264.7**	**40.1**		**32.2**	**1.8**	**74.0**	**0.6**	**759.1**	**1,098.4**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (1.8 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (22.1 MMT). 5) Includes refrigerators (58.4 MMT) and freezers (13.3 MMT). 6) Includes color television (52 MMT). 7) Includes clothes washers (5.0 MMT), natural gas clothes dryers (3.2 MMT), electric clothes dryers (31.0 MMT), and dishwashers (15.6 MMT). Does not include water heating energy. 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption,and Table A18, p. 36 for emissions; EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for emission coefficients.

2.4.5 2025 Residential Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural Gas	Petroleum					Coal	Electricity (3)	Total	Percent
		Distil.	Resid.	LPG	Oth(2)	Total				
Space Heating (4)	173.9	27.9		15.2	1.6	44.7	0.6	73.2	292.3	25.1%
Water Heating	70.2	3.5		2.5		6.0		83.7	159.9	13.8%
Space Cooling	0.0							177.2	177.2	15.2%
Lighting								74.1	74.1	6.4%
Refrigeration (5)								75.8	75.8	6.5%
Electronics (6)								58.7	58.7	5.1%
Wet Cleaning (8)	3.3							47.9	51.2	4.4%
Cooking	11.7			1.6		1.6		20.8	34.2	2.9%
Computers								37.6	37.6	3.2%
Other (9)				12.4		12.4		189.1	201.5	17.3%
Total	**259.1**	**31.3**		**31.8**	**1.6**	**64.7**	**0.6**	**838.1**	**1,162.5**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (1.6 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (22.9 MMT). 5) Includes refrigerators (62.2 MMT) and freezers (13.6 MMT). 6) Includes color television (58.7 MMT). 8) Includes clothes washers (3.9 MMT), natural gas clothes dryers (3.3 MMT), electric clothes dryers (28.5 MMT), and dishwashers (15.5 MMT). Does not include water heating energy. 9) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption,and Table A18, p. 36 for emissions; EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for emission coefficients.

2.4.6 2035 Residential Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural Gas	Petroleum					Coal	Electricity (3)	Total	Percent
		Distil.	Resid.	LPG	Oth(2)	Total				
Space Heating (4)	169.7	22.8		14.1	1.5	38.3	0.5	76.7	285.3	23.1%
Water Heating	67.2	2.6		2.1		4.7		84.8	156.7	12.7%
Space Cooling	0.0							194.5	194.5	15.7%
Electronics (5)								68.1	68.1	5.5%
Refrigeration (6)								81.5	81.5	6.6%
Lighting								74.3	74.3	6.0%
Wet Cleaning (7)	3.5							50.0	53.4	4.3%
Cooking	12.2			1.5		1.5		23.2	37.0	3.0%
Computers								41.9	41.9	3.4%
Other (8)				14.1		14.1		229.6	243.7	19.7%
Total	**252.7**	**25.4**		**31.9**	**1.5**	**58.7**	**0.5**	**924.5**	**1,236.4**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (1.5 MMT). 3) Excludes electric imports by utilities. 4) Includes residential furnace fans (23.1 MMT). 5) Includes color television (68.1 MMT). 6) Includes refrigerators (67.6 MMT) and freezers (13.9 MMT). 7) Includes clothes washers (3.8 MMT), natural gas clothes dryers (3.5 MMT), electric clothes dryers (28.8 MMT), and dishwashers (17.4 MMT). Does not include water heating energy. 8) Includes residential small electric devices, heating elements, motors, swimming pool heaters, hot tub heaters, outdoor grills, and natural gas outdoor lighting

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption,and Table A18, p. 36 for emissions; EIA, Assumptions to the AEO 2011, July 2011, Table 1.2, p. 14 for emission coefficients.

2.4.7 2009 Methane Emissions for U.S. Residential Buildings Energy Production, by Fuel Type

Fuel Type	MMT CO2 Equivalent (1)
Petroleum	1.0
Natural Gas	38.8
Coal	0.0
Wood	2.6
Electricity (2)	51.6
Total	**94.0**

Note(s): 1) Sources of emissions include oil and gas production, processing, and distribution; coal mining; and utility and site combustion. Carbon Dioxide equivalent units are calculated by converting methane emissions to carbon dioxide emissions (methane's global warming potential is 23 times that of carbon dioxide). 2) Emissions of electricity generators attributable to the buildings sector.

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 2009, Mar. 2011, Table 18, p. 37 for energy production emissions; EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, April 2011, Table 3-10, p. 3-9 for stationary combustion emissions; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2, p. 3-5 for energy consumption.

2.5.1 Construction Statistics of New Homes Completed/Placed

	Single-Family		Multi-Family		Mobile Homes	Total
Year	Thousand Units	Average SF	Thousand Units	Average SF	Thousand Units	Thousand Units
1980	957	1,740	545	979	234	1,736
1981	819	1,720	447	980	229	1,495
1982	632	1,710	374	N.A.	234	1,240
1983	924	1,725	467	N.A.	278	1,669
1984	1,025	1,780	627	N.A.	288	1,940
1985	1,072	1,785	631	922	283	1,986
1986	1,120	1,825	636	911	256	2,012
1987	1,123	1,905	546	N.A.	239	1,908
1988	1,085	1,995	445	990	224	1,754
1989	1,026	2,035	397	1,000	203	1,626
1990	966	2,080	342	1,005	195	1,503
1991	838	2,075	253	1,020	174	1,265
1992	964	2,095	194	1,040	212	1,370
1993	1,039	2,095	153	1,065	243	1,435
1994	1,160	2,100	187	1,035	291	1,638
1995	1,066	2,095	247	1,080	319	1,632
1996	1,129	2,120	284	1,070	338	1,751
1997	1,116	2,150	284	1,095	336	1,736
1998	1,160	2,190	314	1,065	374	1,848
1999	1,270	2,223	334	1,104	338	1,942
2000	1,242	2,266	332	1,114	281	1,855
2001	1,256	2,324	315	1,171	196	1,767
2002	1,325	2,320	323	1,166	174	1,822
2003	1,386	2,330	292	1,173	140	1,818
2004	1,532	2,349	310	1,173	124	1,966
2005	1,636	2,434	296	1,247	123	2,055
2006	1,654	2,469	325	1,277	112	2,091
2007	1,218	2,521	284	1,300	95	1,597
2008	819	2,519	301	1,250	81	1,201
2009	520	2,438	274	1,227	55	849
2010	496	2,392	155	1,172	50	701

Source(s): DOC, 2010 Characteristics of New Housing, 2010, "Median and Average Square Feet of Floor Area in New Single-Family Houses Completed by Location", "Presence of Air-Conditioning in New Single Family Houses", "Number of Multifamily Units Completed by Number of Units Per Building", "Median and Average Square Feet of Floor Area in Units in New Multifamily Buildings Completed", "Placements of New Manufactured Homes by Region and Size of Home, 1980-2010"; NAHB, Housing Economics, Mar. 1995; NAHB, Facts, Figures and Trends, 1997, Characteristics of New Multi-Family Homes, 1971-1995, p. 7; DOC, Current Construction Reports, Characteristics of New Housing, C25/98-A, Table 18, p. 44.

2.5.2 2010 Five Largest Residential Homebuilders

Homebuilder	Number of Home Closings (1)	Gross Revenue ($million)	Market Share of Total New Home Closings (%) (2)
PulteGroup	17,095	4,420	5.3%
D.R. Horton	18,983	3,955	5.9%
NVR	10,030	2,981	3.1%
Lennar Corporation	10,955	2,631	3.4%
KB Home	7,346	1,575	2.3%
Total of Top Five	**64,409**	**15,563**	**19.9%**
Habitat for Humanity (3)	6,032	402	0.1%

Note(s): 1) 2010 total U.S. new home closings were 323,000 (only single-family). 2) Total share of closings of top 20 builders was 35%. Total share of the top 100 builders was 54%. 3) Habitat for Humanity built more than 400 homes during the week of May 31, 2007; Habitat for Humanity has built over 1,000 homes in the New Orleans area since Hurricane Katrina. Habitat for Humanity's 2,100 worldwide affiliates have completed more than 200,000 homes since 1976, providing more than 1,000,000 with housing.

Source(s): Housing Giants Magazine, May 2011, Professional Builder's 2011 Housing Giants Rankings.

2.5.3 Value of New Building Construction, by Year ($2010 Billion)

	Residential	GDP
1980	166.0	6,461
1985	213.5	7,579
1990	208.4	8,890
1995	238.0	10,063
2000	334.6	12,423
2005	525.5	13,986
2006	387.3	14,359
2007	247.4	14,639
2008	242.1	14,639
2009	143.2	14,254
2010	137.1	14,660

Source(s): DOC, Current Construction Reports: Value of New Construction Put in Place, C30, Aug. 2003, Table 1 for 1980-1990; DOC, Annual Value of Private Construction Put in Place 1993-2001, Annual Value of Private Construction Put in Place 2002-2011, Annual Value of Public Construction Put in Place 1993-2001, Annual Value of Public Construction Put in Place 2002-2011; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.5.4 2010 New Homes Completed/Placed, by Census Region
(Thousand Units and Percent of Total Units)

Region	Single-Family Units		Multi-Family Units		Mobile Homes Units		Total	
Northeast	54	11%	26	17%	4	8%	84	12%
Midwest	82	17%	25	16%	6	11%	113	16%
South	258	52%	59	38%	34	68%	351	50%
West	103	21%	45	29%	6	13%	154	22%
Total	**496**	100%	**155**	100%	**50**	100%	**702**	100%

Source(s): DOC, Manufacturing, Mining and Construction Statistics: New Residential Construction: New Privately Owned Housing Units Completed, 2010; and DOC, Manufacturing, Mining and Construction Statistics: Placements of New Manufactured Homes by Region and Size of Home, 2010.

2.5.5 2010 Construction Method of Single-Family Homes, by Region (Thousand Units and Percent of Total Units)

Region	Stick-Built Units		Modular Units		Panelized/Precut Units		Total
Northeast	49	10%	4	33%	2	18%	54
Midwest	76	16%	3	25%	2	18%	82
South	247	52%	4	33%	6	55%	258
West	101	21%	1	8%	1	9%	103
Total	**473**	100%	**12**	100%	**11**	100%	**497**

Source(s): DOC, Manufacturing, Mining and Construction Statistics, New Residential Construction: Type of Construction Method of New Single-Family Houses Completed, 2010.

2.5.6 2010 Mobile Home Placements, by Census Region and Top Five States (Percent of National Total)

Region		Top Five States	
Northeast	8%	Texas	15.2%
Midwest	11%	Louisiania	8.6%
South	69%	Florida	5.4%
West	13%	Tennessee	4.8%
Total	100%	North Carolina (1)	4.6%
		Kentucky	4.6%

Note(s): 1) North Carolina and Kentucky are tied for fifth with 4.6% of the national total.

Source(s): DOC, Manufactured Housing Statistics, New Manufactured Homes Placed: by Size of Home by State - 2010, Placements of New Manufactured Homes by Region and Size of Home: 1980-2010, 2010.

2.5.7 Materials Used in the Construction of a 2,272 Square-Foot Single-Family Home, 2000

13,837 board-feet of lumber
13,118 square feet of sheathing
19 tons of concrete
3,206 square feet of exterior siding material
3,103 square feet of roofing material
3,061 square feet of insulation
6,050 square feet of interior wall material
2,335 square feet of interior ceiling material
226 linear feet of ducting
19 windows
4 exterior doors (3 hinged, 1 sliding)
2,269 square feet of flooring material
12 interior doors
6 closet doors
2 garage doors
1 fireplace
3 toilets, 2 bathtubs, 1 shower stall
3 bathroom sinks
15 kitchen cabinets, 5 other cabinets
1 kitchen sink
1 range, 1 refrigerator, 1 dishwasher, 1 garbage disposal, 1 range hood
1 washer, 1 dryer
1 heating and cooling system

Source(s): NAHB, 2004 Housing Facts, Figures and Trends, Feb. 2004, p. 7; D&R International for appliances and HVAC.

2.5.8 2009 Sales Price and Construction Cost Breakdown of an Average New Single-Family Home ($2010) (1)

Function	Cost	
Finished Lot	77,320	20%
Construction Cost	224,630	59%
Financing	6,436	2%
Overhead & General Expenses	20,571	5%
Marketing	5,347	1%
Sales Commission	12,937	3%
Profit	33,979	9%
Total	**381,221**	**100%**

Function	Cost	
Building Permit Fees	4,305	2%
Impact Fees	3,195	1%
Water and Sewer Inspection	3,797	2%
Excavation, Foundation, & Backfill	16,029	7%
Steel	1,653	1%
Framing and Trusses	35,136	16%
Sheathing	3,906	2%
Windows	6,295	3%
Exterior Doors	1,948	1%
Interior Doors & Hardware	3,388	2%
Stairs	1,692	1%
Roof Shingles	8,553	4%
Siding	12,980	6%
Gutters & Downspouts	958	0%
Plumbing	11,865	5%
Electrical Wiring	8,388	4%
Lighting Fixtures	2,395	1%
HVAC	8,944	4%
Insulation	3,364	2%
Drywall	11,440	5%
Painting	7,711	3%
Cabinets, Countertops	12,563	6%
Appliances	3,617	2%
Tiles & Carpet	11,545	5%
Trim Material	7,464	3%
Landscaping & Sodding	7,156	3%
Wood Deck/Patio	1,967	1%
Asphalt Driveway	3,112	1%
Other	19,267	9%
Total	224,632	**100%**

Note(s): 1) Based on a NAHB Survey of 54 home builders asked about the average home built by their firm. Average finished area of the home was 2,716 SF and average lot size was 21,879 SF.

Source(s): NAHB, Breaking Down House Price and Construction Costs, 2010, Table 1; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price inflators.

2.5.9 Annual Sales of Existing Homes, by Region

	Existing Home Sales (in thousands)				
	Northeast	Midwest	South	West	United States
1970	251	501	568	292	1,612
1971	311	583	735	389	2,018
1972	361	630	788	473	2,252
1973	367	674	847	446	2,334
1974	354	645	839	434	2,272
1975	370	701	862	543	2,476
1976	439	881	1,033	712	3,065
1977	515	1,101	1,231	803	3,650
1978	516	1,144	1,416	911	3,987
1979	526	1,061	1,353	887	3,827
1980	403	806	1,092	671	2,972
1981	353	632	917	516	2,418
1982	354	490	780	366	1,990
1983	493	709	1,035	481	2,718
1984	511	755	1,073	529	2,868
1985	622	866	1,172	554	3,214
1986	703	991	1,261	610	3,565
1987	685	959	1,282	600	3,526
1988	673	929	1,350	642	3,594
1989	635	886	1,075	694	3,290
1990	583	861	1,090	651	3,185
1991	591	863	1,067	624	3,145
1992	666	967	1,126	674	3,433
1993	709	1,027	1,262	740	3,738
1994	723	1,031	1,321	812	3,887
1995	717	1,010	1,315	810	3,852
1996	772	1,060	1,394	941	4,167
1997	812	1,088	1,474	997	4,371
1998	898	1,228	1,724	1,115	4,965
1999	910	1,246	1,850	1,177	5,183
2000	911	1,222	1,866	1,174	5,173
2001	912	1,271	1,967	1,184	5,334
2002	952	1,346	2,064	1,269	5,631
2003	1,019	1,468	2,283	1,405	6,175
2004	1,113	1,550	2,540	1,575	6,778
2005	1,169	1,588	2,702	1,617	7,076
2006	1,086	1,483	2,563	1,346	6,478
2007	1,006	1,327	2,235	1,084	5,652
2008	849	1,129	1,865	1,070	4,913
2009	868	1,163	1,914	1,211	5,156
2010	817	1,076	1,860	1,154	4,907

Source(s): HUD, US Housing Market Conditions: 3rd Quarter 2011, November 2011, Exhibit 7. Existing Home Sales 1969-Present, p. 73.

2.5.10 Home Price Index (HPI), All-Transactions, by Census Region (1)(2)

	New Eng.	Mid. Atl.	S. Atl.	E-S Centrl	W-S Centrl	E-N Centrl	W-N Centrl	MT	Pacific	United States
1975	63.1	71.8	68.5	68.8	56.0	63.5	62.1	56.5	46.2	61.3
1976	69.2	73.9	71.5	71.7	62.8	68.7	68.1	61.6	54.7	66.6
1977	73.1	78.0	76.0	79.8	69.0	76.8	77.0	70.8	68.4	74.3
1978	86.3	82.7	85.6	90.7	81.6	89.5	88.4	83.9	80.1	85.3
1979	97.9	94.4	94.6	99.3	95.4	99.0	98.7	96.7	93.9	96.4
1980	106.6	106.4	104.1	103.9	104.0	102.3	104.0	105.3	105.8	104.4
1981	114.8	109.9	109.7	109.2	113.9	104.7	101.5	113.8	112.2	109.3
1982	119.6	114.5	113.8	107.9	120.7	100.3	103.2	115.7	113.7	111.0
1983	133.8	123.9	120.4	113.8	124.3	104.2	109.5	118.9	115.8	116.5
1984	155.9	139.0	124.9	116.9	125.0	106.1	114.4	121.7	119.4	121.7
1985	184.0	157.4	131.0	124.0	124.1	110.6	117.4	124.0	125.2	128.3
1986	223.2	182.6	138.9	130.1	124.1	117.9	122.1	127.3	132.0	136.9
1987	265.1	215.5	147.2	136.3	115.3	127.5	126.4	124.9	143.1	145.6
1988	281.1	234.3	156.0	139.3	111.0	136.1	129.0	124.3	162.6	153.3
1989	284.4	239.6	163.3	143.2	113.5	144.5	132.5	127.1	194.2	162.1
1990	269.7	237.5	165.9	144.6	114.1	150.6	135.0	130.5	212.5	166.0
1991	256.3	235.9	167.3	147.4	116.4	156.0	138.0	134.5	213.9	168.1
1992	255.6	242.0	173.3	154.0	121.4	162.8	143.3	142.9	215.6	173.7
1993	255.5	245.0	176.9	159.6	125.7	168.7	148.6	153.0	212.0	177.8
1994	250.4	241.5	179.7	167.2	129.6	178.1	157.6	167.8	207.5	182.2
1995	257.0	244.9	185.8	176.0	133.8	187.3	164.8	178.9	210.0	188.7
1996	259.1	245.5	190.3	183.1	137.0	196.4	171.8	186.1	209.3	193.3
1997	269.5	251.0	197.4	191.0	141.2	206.2	179.6	194.3	218.2	201.0
1998	285.9	261.5	206.8	200.6	148.4	215.8	188.5	203.2	235.5	211.5
1999	309.6	274.7	215.7	206.9	155.5	225.4	199.0	211.7	250.2	222.0
2000	344.4	294.8	228.2	213.6	163.1	237.6	211.0	223.2	276.1	236.4
2001	382.1	320.0	246.4	224.4	172.9	251.1	225.3	238.4	306.1	254.2
2002	425.0	351.1	264.5	231.9	179.7	262.0	237.7	249.9	335.8	270.9
2003	459.9	378.9	280.7	239.6	185.3	271.1	248.1	260.1	365.9	285.8
2004	525.9	433.9	315.0	250.0	192.1	287.1	265.7	290.2	451.4	316.9
2005	577.0	488.3	364.0	266.8	202.9	302.0	282.1	338.4	537.2	351.9
2006	585.3	517.3	395.6	283.5	215.6	304.4	289.3	374.4	590.5	373.1
2007	575.8	521.2	397.9	294.3	225.4	302.0	292.6	379.6	568.3	374.8
2008	548.6	504.6	366.9	294.5	228.4	290.3	287.4	345.7	474.0	353.1
2009	525.8	486.3	343.8	292.0	229.1	279.4	282.7	316.2	430.3	337.1
2010	524.3	484.9	332.4	289.5	229.1	276.3	282.5	300.8	427.8	332.3
2011	512.0	469.0	313.2	282.6	225.6	267.1	275.7	277.1	405.6	319.0

Note(s): (1) The HPI is a broad measure of the movement of single-family house prices. It serves as a timely, accurate indicator of house price trends at various geographic levels (Federal Housing Finance Agency, "Frequently Asked Questions"). The Federal Housing Finance Agency (FHFA) calculated quarterly HPI for each census division using sales prices and appraisal data that were not seasonally adjusted; DOE estimated the average annual HPI for each census region using publicly-available data from FHFA. (2) Third quarter HPI values are listed.

Source(s): Federal Housing Finance Agency, Housing Price Indexes, All-Transactions Indexes, U.S. and Census Divisions through 2011Qr (Not Seasonally Adjusted). Accessed February 28, 2012.

2.5.11 Yearly Average Historic Mortgage Rates

	30-Year Fixed	15-Year Fixed	1-Year ARM (1)
1973	8.04	N/A	N/A
1974	9.19	N/A	N/A
1975	9.05	N/A	N/A
1976	8.87	N/A	N/A
1977	8.85	N/A	N/A
1978	9.64	N/A	N/A
1979	11.20	N/A	N/A
1980	13.74	N/A	N/A
1981	16.63	N/A	N/A
1982	16.04	N/A	N/A
1983	13.24	N/A	N/A
1984	13.88	N/A	11.51
1985	12.43	N/A	10.05
1986	10.19	N/A	8.43
1987	10.21	N/A	7.83
1988	10.34	N/A	7.90
1989	10.32	N/A	8.80
1990	10.13	N/A	8.36
1991	9.25	N/A	7.09
1992	8.39	7.96	5.62
1993	7.31	6.83	4.58
1994	8.38	7.86	5.36
1995	7.93	7.48	6.06
1996	7.81	7.32	5.67
1997	7.60	7.13	5.61
1998	9.64	6.59	5.58
1999	7.44	7.06	5.99
2000	8.05	7.72	7.04
2001	6.97	6.50	5.82
2002	6.54	5.98	4.62
2003	5.83	5.17	3.76
2004	5.84	5.21	3.90
2005	5.87	5.42	4.49
2006	6.41	6.07	5.54
2007	6.34	6.03	5.56
2008	6.03	5.62	5.17
2009	5.04	4.57	4.70
2010	4.69	4.10	3.78

Note(s): 1) To calculate adjustable-rate mortgage (ARM) rates, Freddie Mac indexes the products to US Treasury yields and asks lenders for both the initial coupon rate as well as the margin on the ARM products.

Source(s): US Department of Housing and Urban Development, US Housing Market Conditions: 3rd Quarter 2011, November 2011, Exhibit 14. Mortgage Interest Rates, Average Commitment Rates, and Points: 1973-Present.

2.5.12 Annual Home Improvement Loan Origination Volumes and Values, by Housing Vintage of Loan Applicant

Housing Vintage	Volume (thousands)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1990-2000	N/A	N/A	N/A	N/A	49	74	93	95	74	36	23	20
1980-1989	105	103	95	86	117	190	224	235	196	113	75	65
1970-1979	242	231	214	186	144	270	306	320	277	173	123	107
1960-1969	178	165	153	134	97	172	191	200	168	102	70	62
1950-1959	135	123	113	96	147	249	268	279	234	139	93	81
1949 or earlier	126	113	100	84	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Total Volume	**786**	**735**	**675**	**586**	**553**	**955**	**1,083**	**1,128**	**949**	**563**	**383**	**335**

Housing Vintage	Value (in $2010 billion)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1990-2000	N/A	N/A	N/A	N/A	2.5	7.6	11.8	10.6	7.3	3.1	2.4	1.8
1980-1989	3.5	3.7	3.7	4.0	5.5	16.2	23.2	22.1	16.9	8.1	6.5	4.9
1970-1979	7.0	7.2	7.5	7.7	6.7	21.4	28.9	27.9	21.9	11.3	9.3	7.3
1960-1969	5.3	5.4	5.7	5.9	4.7	15.4	20.3	19.6	15.0	7.3	6.0	4.9
1950-1959	4.0	4.0	4.3	4.3	6.9	22.3	28.0	27.2	21.4	10.2	8.0	6.6
1949 or earlier	3.5	3.5	3.7	3.5	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Total Value	**23.3**	**23.9**	**24.9**	**25.5**	**23.8**	**75.3**	**100.5**	**96.7**	**75.2**	**36.8**	**29.8**	**23.7**

Note(s): 1) After 2002, category represent 1959 and earlier vintage homes.

Source(s): The Federal Financial Institution Examination Council, Home Mortgage Disclosure Act, National Aggregate Report, Years: 1999-2010.

2.6.1 Value of Residential Building Improvements and Repairs, by Sector ($2010 Billion) (1)

		Improvements	Maintenance and Repairs	Total
1980		72.2	35.2	107.4
1985		82.3	65.3	147.6
1990		91.4	85.5	176.9
1995		105.8	63.8	169.6
2000		138.2	52.7	191.0
2003		156.2	51.9	208.0
2004		169.2	57.9	227.1
2005		179.0	59.7	238.6
2006		187.4	57.2	244.6
2007	(2)	178.7	57.0	235.7

Note(s): 1) Improvements includes additions, alterations, reconstruction, and major replacements. Repairs include maintenance. 2) The US Census Bureau discontinued the Survey of Residential Alterations and Repairs (SORAR) after 2007.

Source(s): DOC, Historic Expenditures for Residential Properties by Property Type: Quarterly 1962-2003 (Old structural purposes) for 1980-2000; DOC, Historic Expenditures for Residential Proerties by Property Type: Quarterly 2003-2007 (New structural purposes) for 1995-2007; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.6.2 2007 Professional and Do-It-Yourself Improvements, by Project ($2010)

	Professional Installation			Do-It-Yourself Installation		
Repair/Improvement	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)
Room Additions, Alterations, and Remodelings	**3,957**	**65,635**	**16,587**	**3,986**	**21,802**	**5,470**
Kitchen	1,349	21,583	15,999	1,110	7,605	6,851
Bathroom	1,602	14,620	9,126	1,611	5,016	3,113
Bedroom	276	10,628	38,507	415	3,341	8,050
Other	730	18,803	25,758	850	5,840	6,871
Systems and Equipment	**11,708**	**23,536**	**2,010**	**7,156**	**4,954**	**692**
Plumbing (Pipes and Fixtures)	2,885	4,633	1,606	2,888	1,799	623
Electrical System	1,602	2,836	1,770	936	689	736
HVAC	2,936	12,403	4,224	556	1,298	2,335
Appliance/Major Equipment	4,285	3,664	855	2,776	1,168	421
Exterior Additions and Replacements	**6,216**	**32,576**	**5,241**	**2,986**	**5,791**	**1,939**
Roof	2,707	16,374	6,049	677	1,894	2,797
Siding	776	5,389	6,945	428	1,308	3,055
Windows/Doors	2,733	10,813	3,957	1,881	2,590	1,377
Interior Additions and Replacements	**6,207**	**22,120**	**3,564**	**4,721**	**6,777**	**1,436**
Insulation	727	1,695	2,331	918	800	871
Flooring/Paneling/Ceiling	4,836	16,535	3,419	3,467	4,742	1,368
Other Interior	644	3,890	6,041	336	1,236	3,678
Disaster Repair	**728**	**9,919**	**13,625**	**187**	**3,302**	**17,659**
Other Additions and Replacements (1)	**4,447**	**32,540**	**7,317**	**3,580**	**8,384**	**2,342**
Total (2)	**33,263**	**186,326**		**22,616**	**51,010**	

Note(s): 1) Other additions and replacements include porches, carports, swimming pools and other major improvements or repairs to lot or yard. 2)Total expenditures (professional installation plus do-it-yourself installation) are $1.8 billion higher compared to Table 2.6.1. This discrepancy is due to sampling methods used by HUD for the American Housing Survey and DOC in the Survey of Expenditures for Residential Improvements and Repairs. Individual households may report projects in multiple categories.

Source(s): Joint Center for Housing Studies of Harvard University, The Remodeling Market in Transition: Improving America's Housing 2009, 2009, Table A-2, p. 30; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.6.3 2007 and 2009 Professional Home Improvements, by Project ($2010)

	2007 Professional Installation			2009 Professional Installation		
Repair/Improvement	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)
Room Additions, Alterations, and Remodelings	**3,957**	**65,635**	**16,587**	**3,322**	**50,519**	**15,207**
Kitchen	1,349	21,583	15,999	1,109	16,234	14,639
Bathroom	1,602	14,620	9,126	1,401	12,200	8,708
Bedroom	276	10,628	38,507	255	8,795	34,490
Other	730	18,803	25,758	557	13,289	23,859
Systems and Equipment	**11,708**	**23,536**	**2,010**	**11,262**	**20,863**	**1,852**
Plumbing (Pipes and Fixtures)	2,885	4,633	1,606	2,700	3,779	1,399
Electrical System	1,602	2,836	1,770	1,523	2,075	1,362
HVAC	2,936	12,403	4,224	2,824	11,864	4,201
Appliance/Major Equipment	4,285	3,664	855	4,215	3,146	746
Exterior Additions and Replacements	**6,216**	**32,576**	**5,241**	**6,163**	**28,957**	**4,699**
Roof	2,707	16,374	6,049	2,698	15,266	5,658
Siding	776	5,389	6,945	780	4,221	5,411
Windows/Doors	2,733	10,813	3,957	2,685	9,470	3,527
Interior Additions and Replacements	**6,207**	**22,120**	**3,564**	**5,479**	**14,681**	**2,679**
Insulation	727	1,695	2,331	861	1,256	1,459
Flooring/Paneling/Ceiling	4,836	16,535	3,419	4,081	11,537	2,827
Other Interior	644	3,890	6,041	537	1,888	3,515
Disaster Repair	728	9,919	13,625	806	9,149	11,352
Other Additions and Replacements (1)	**4,447**	**32,540**	**7,317**	**3,732**	**24,493**	**6,563**
Total	**33,263**	**186,326**		**30,764**	**148,662**	

Note(s): 1) Other additions and replacements include porches, carports, swimming pools and other major improvements or repairs to lot or yard.

Source(s): Joint Center for Housing Studies of Harvard University, The Remodeling Market in Transition, 2009, Table A.2, p. 30 for 2007; Joint Center for Housing Studies of Harvard University, A New Decade of Growth for Remodeling: Improving America's Housing, 2011, Table A-2, p. 28 for 2009; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.6.4 2007 and 2009 Do-It-Yourself Home Improvements, by Project ($2010)

	2007 DIY Installation			2009 DIY Installation		
Repair/Improvement	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)	Projects (thousand)	Total Expenditures ($million)	Mean Expenditures ($)
Room Additions, Alterations, and Remodelings	**3,986**	**21,802**	**5,470**	**3,375**	**15,711**	**4,655**
Kitchen	1,110	7,605	6,851	898	5,405	6,019
Bathroom	1,611	5,016	3,113	1,468	3,884	2,646
Bedroom	415	3,341	8,050	299	2,661	8,900
Other	850	5,840	6,871	710	3,761	5,298
Systems and Equipment	**7,156**	**4,954**	**692**	**6,994**	**4,238**	**606**
Plumbing (Pipes and Fixtures)	2,888	1,799	623	2,890	1,348	466
Electrical System	936	689	736	843	389	461
HVAC	556	1,298	2,335	532	1,413	2,657
Appliance/Major Equipment	2,776	1,168	421	2,729	1,088	399
Exterior Additions and Replacements	**2,986**	**5,791**	**1,939**	**2,714**	**4,460**	**1,643**
Roof	677	1,894	2,797	671	1,702	2,537
Siding	428	1,308	3,055	357	672	1,883
Windows/Doors	1,881	2,590	1,377	1,686	2,086	1,237
Interior Additions and Replacements	**4,721**	**6,777**	**1,436**	**4,411**	**4,822**	**1,093**
Insulation	918	800	871	922	569	618
Flooring/Paneling/Ceiling	3,467	4,742	1,368	3,174	3,645	1,149
Other Interior	336	1,236	3,678	315	608	1,929
Disaster Repair	**187**	**3,302**	**17,659**	**257**	**1,459**	**5,676**
Other Additions and Replacements (1)	**3,580**	**8,384**	**2,342**	**3,313**	**7,490**	**2,261**
Total	**22,616**	**51,010**		**21,064**	**38,180**	

Note(s): 1) Other additions and replacements include porches, carports, swimming pools and other major improvements or repairs to lot or yard.

Source(s): Joint Center for Housing Studies of Harvard University, The Remodeling market in Transition, 2009, Table A.2, p. 30 for 2007; Joint Center for Housing Studies of Harvard University, A New Decade of Growth for Remodeling: Improving America's Housing, 2011, Table A-2, p. 28 for 2009; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.6.5 Single-Family Residential Renovations, by Project and Vintage

	Year Home was Built					
	Pre-1946	1946-60	1961-73	1974-80	1981-98	1999 or later
Kitchen Remodeled	60%	57%	54%	60%	44%	8%
Bathroom Remodeled	59%	52%	59%	55%	40%	4%
Add Room(s)	29%	18%	14%	24%	21%	15%
Exterior Improvement	21%	15%	15%	16%	9%	4%
Basement Room Finished	14%	10%	6%	12%	16%	65%
Redesign/Restructure	14%	8%	11%	10%	5%	4%
Bathroom Added	8%	7%	6%	7%	6%	27%
Sun room Added	4%	6%	3%	4%	5%	8%

Note(s): Data based on a nationwide study of 819 consumers who remodeled their homes in the past 12 months or will in the next 12 months.

Source(s): Professional Remodeler, Consumer Research: What Consumers Want, Sept. 2002, p.44-50.

2.6.6 2010-2011 National Professional Remodeling Cost and Amount Recouped in Resale Value

Envelope	Job Cost ($ thousand)	Resale Value ($ thousand)	Cost Recouped
Siding Replacement - Vinyl	11.4	8.2	72%
Window Replacement - Vinyl	11.1	7.9	72%
Window Replacement - Wood	12.0	8.7	72%
Roofing Replacement	21.5	12.8	60%
Entry Door Replacement - Fiberglass	3.6	2.1	60%
Entry Door Replacement - Steel	1.2	1.2	102%
Remodel			
Minor Kitchen Remodel	21.7	15.8	73%
Major Kitchen Remodel	58.4	40.1	69%
Bathroom Remodel	16.6	10.7	64%
Attic Bedroom Remodel	51.4	37.1	72%
Basement Remodel	64.5	45.2	70%
Home Office Remodel	28.9	13.2	46%
Additions			
Deck Addition - Wood	11.0	8.0	73%
Deck Addition - Composite	15.6	10.3	66%
Bathroom Addition	40.7	21.7	53%
Garage Addition	60.6	35.9	59%
Sunroom Addition	75.2	36.5	49%
Family Room Addition	85.7	53.6	63%
Master Suite Addition	108.1	68.1	63%
Two-Story Addition	165.2	107.3	65%
Back-Up Power Generator	14.7	7.1	49%

Note(s): Job cost includes labor, material, subtrades, contractor overhead and profit. Resale value based on a survey of appraisers, sales agents, and brokers. The survey asked for the estimated increase in resale value of standardized remodeling projects. Definitions of remodeling projects are available at costvalue.remodelingmagazine.com.

Source(s): © 2007 Hanley Wood, LLC. Reproduced by permission. Complete regional and city data from the Remodeling 2010-2011 Cost vs. Value Report can be downloaded for free at costvalue.remodelingmagazine.com.

2.6.7 2009 Home Improvement Spending by Household Income ($2010)

Income	Number of Homeowners (thousand)	Homeowners Reporting Projects (thousand)	Average Expenditure ($)	Total Expenditures ($million)
Under $40,000	24,675	6,113	5,697	34,825
$40-79,999	23,178	6,545	6,841	44,772
$80-119,999	14,051	4,299	9,189	39,505
120,000 and Over	13,005	4,097	16,531	67,731

Note(s): Home improvements include room additions, remodeling, replacements of household systems and appliances, porches and garages, additions and replacements of roofing, siding, window/doors, insulation, flooring/paneling/ceiling, and disaster repairs.

Source(s): Joint Center for Housing Studies of Harvard University, A New Decade of Growth for Remodeling, 2011, Table A-3, pg. 29; EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for GDP and price deflators.

2.7.1 Delivered Energy Consumption Intensities of Public Multi-Family Buildings, by Fuel and Region (Thousand Btu/SF)

Region	Electricity	Natural Gas	Fuel Oil	Total
Northeast	27.7	45.9	39.9	71.5
Midwest	22.5	49.9	N.A.	70.3
South	53.5	27.9	N.A.	65.9
West	22.0	25.3	N.A.	46.2
National Average	**33.0**	**43.4**		**68.3**

Source(s): HUD, Benchmarking Utility Usage in Public Housing, December 2007, http://www.hud.gov/offices/pih/programs/ph/phecc/finbnchrpt.doc.

2.7.2 Delivered Energy Consumption Intensities of Public Multi-Family Buildings, by Fuel and Region (Million Btu/Household)

Region	Electricity	Natural Gas	Fuel Oil	Total
Northeast	21.2	34.9	36.2	54.7
Midwest	16.6	36.6	N.A.	51.8
South	39.4	20.0	N.A.	48.5
West	16.6	19.3	N.A.	34.8
National Average	**24.6**	**32.2**		**51.0**

Source(s): HUD, Benchmarking Utility Usage in Public Housing, December 2007, http://www.hud.gov/offices/pih/programs/ph/phecc/finbnchrpt.doc.

2.8.1 2007 Top Five Manufacturers of Factory-Built Housing Units (1)

Company	Units Produced	Gross Sales Volume ($million)	Market Share of Top 25 Company Sales (2)
CMH Manufacturing	31,100	1,327.8	20%
Champion Enterprises, Inc.	21,126	1,286.6	19%
Palm Harbor Homes, Inc.	8,911	679.1	10%
Fleetwood Enterprises, Inc.	15,137	600.0	9%
Skyline Corporation	8,207	376.4	6%

Note(s): 1) Data based on mail-in surveys from manufacturers which may not be entirely complete. 2) Market shares based on total gross sales volume of the factory-built home producers included in the list of the top 25 factory-built producers responding to the survey. In 2007, surveyed factory-built home sales were estimated at $6.6 billion and 133,361 units.

Source(s): HousingZone.com, 2007 Factory Built Housing Results, http://www.housingzone.com/factory.html.

2.8.2 2007 Top Five Manufacturers of Modular/3D Housing Units (1)

Company	Units Produced	Gross Sales Volume ($million)	Market Share of Top 25 Company Sales (2)
Champion Enterprises, Inc.	4,653	438.7	27%
CMH Manufacturing	3,200	228.8	14%
All American Homes, LLC	1,689	165.4	10%
Palm Harbor Homes, Inc.	1,614	162.9	10%
Excel Homes LLC	1,200	110.6	7%

Note(s): 1) Data based on mail-in surveys from manufacturers, which may not be entirely complete. 2) Market shares based on total gross sales volume of the Modular/3D home producers included in the list of the top 25 factory-built producers responding to the survey. In 2007, surveyed Modular/3D home sales were estimated at $1.6 billion and 20,601 units.

Source(s): HousingZone.com, 2007 Factory Built Housing Results, http://www.housingzone.com/factory.html.

2.8.3 2007 Top Five Manufacturers of HUD-Code (Mobile) Homes (1)

Company	Units Produced	Gross Sales Volume ($million)	Market Share of Top 25 Company Sales (2)
CMH Manufacturing	27,900	1,099	23%
Champion Enterprises, Inc.	16,473	848	18%
Fleetwood Enterprises, Inc.	15,137	600	12%
Palm Harbor Homes	7,297	516	11%
Skyline Corporation	8,207	376	8%

Note(s): 1) Data based on mail-in surveys from manufacturers, which may not be entirely complete. 2) Market shares based on total gross sales volume of the HUD-Code home producers included in the list of the top 25 factory-built producers responding to the survey. In 2007, surveyed HUD-Code home sales were estimated at $4.83 billion and 109,320 units.

Source(s): HousingZone.com, 2007 Factory Built Housing Results, http://www.housingzone.com/factory.html.

2.8.4 2004 Top Five Manufacturers of Factory-Fabricated Components (Trusses, Wall Panels, Doors) (1)

Company	Gross Sales Volume ($million)	Market Share of Top 26 Company Sales (2)	Number of Employees (3)
Carpenter Contractors	175.0	26%	1,130
Automated Building Company	102.5	15%	702
Landmark Truss	45.0	7%	425
Southern Building Products	25.9	4%	180
Dolan Lumber & Truss	25.1	4%	260

Note(s): 1) Data based on mail-in surveys from manufacturers, which may not be entirely complete. 2) Market shares based on total gross sales volume of producers of only components included in the list of the top 26 IH producers responding to the survey. In 2004, surveyed component sales was estimated at $665.1 million. 3) The top 26 companies employ over 4,970 people at their plants.

Source(s): Automated Builder Magazine, Sept. 2005, p. 40-41.

2.8.5 2004 Number of Industrialized Housing Manufacturers Versus Production Companies (Stick-Builders)

Type	Number of Companies
Panelized	3,500
Modular (1)	200
HUD-Code	90
Production Builders	7,000
Component Manufacturers	2,200
Special (Commercial) Units	170

Note(s): 1) 170 of these companies also produce panelized homes.

Source(s): Automated Builder Magazine, Mar. 2005, p. 34-35; Automated Builder Magazine, Jan. 2004, p. 16 for Note 1.

2.8.6 Manufactured Home Shipments, Estimated Retail Sales and Average Sales Prices (1980-2009)

Year	Manufactured Home Shipments	Estimated Retail Sales (2010$ Million)	Average Sales Price (2010$)	
			Single Section	Multi-Section
1980	221,091	10,146	$37,079	$66,046
1981	240,313	10,133	$35,385	$61,872
1982	238,808	9,396	$34,349	$56,715
1983	295,079	11,905	$33,811	$58,592
1984	294,993	11,742	$32,772	$56,287
1985	283,489	11,106	$31,989	$54,093
1986	244,660	9,635	$31,297	$54,154
1987	232,598	9,420	$31,439	$55,360
1988	218,429	9,057	$30,726	$55,505
1989	198,254	8,585	$31,199	$56,827
1990	188,172	8,017	$30,347	$56,095
1991	170,713	7,000	$29,456	$54,619
1992	210,787	8,655	$29,786	$53,787
1993	254,276	10,971	$30,981	$56,020
1994	303,932	13,220	$32,558	$58,189
1995	339,601	15,302	$35,015	$60,530
1996	363,411	16,730	$35,959	$61,530
1997	353,377	17,517	$36,513	$62,950
1998	372,843	20,118	$37,270	$64,446
1999	348,671	18,681	$37,368	$65,170
2000	250,550	16,270	$37,699	$66,909
2001	193,229	11,712	$37,110	$67,384
2002	168,491	10,742	$37,119	$67,391
2003	130,937	9,026	$37,514	$70,206
2004	130,802	8,279	$37,622	$72,500
2005	146,744	8,514	$37,735	$76,023
2006	117,373	7,670	$38,688	$76,411
2007	95,769	6,454	$38,831	$77,246
2008	81,889	5,244	$38,816	$77,529
2009	49,717	3,167	$39,977	$75,109

Note(s): Manufactured Housing Institute compiled data from the Institute for Building Technology and Safety (IBTS) and the US Census Bureau.

Source(s): Manufactured Housing Institute, "Manufactured Home Shipments, Estimated Retail Sales amd Average Sales Prices (1980-2009)"; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for GDP and price deflators.

2.9.1 Program Definitions

DOE Weatherization: Department of Energy's Weatherization Assistance Program

DOE Weatherization Eligible Households: Households with incomes at or below 125% of the Federal poverty level, which varies by family size; however, a State may instead elect to use the LIHEAP income standard if its State LIHEAP income standard is at least 125% of the Federal poverty level. Data listed in this chapter include previously weatherized units. DOE Weatherization Eligible Households are a subset of Federally Eligible Households.

DOE Weatherization Recipient Households: Households that have received weatherization under DOE Weatherization funding.

Federally Eligible Households: Households with incomes below the Federal maximum standard of 150% to 200% of the poverty line or 60% of the State median income, whichever is higher.

HHS: Department of Health and Human Services

LIHEAP: HHS's Low-Income Home Energy Assistance Program

LIHEAP Eligible Households: Households with incomes below the Federal maximum poverty income level, i.e., 150% of the Federal poverty guidelines or 75% of State median income, whichever is higher.

LIHEAP Recipient Households: Households that received fuel subsidies for home heating, cooling, or energy crisis benefits in the year previous to a particular household survey.

Source(s): ORNL, Scope of the Weatherization Assistance Program: Profile of the Population in Need, Mar. 1994, p. 1.2 for Weatherization eligible, Weatherization recipient, and LIHEAP eligible households; EIA, Housing Characteristics 1993, June 1995, p. 336 for Federally eligible for weatherization; HHS, LIHEAP Report to Congress FY 2001, Feb. 2003, Table E-1, p. 105 and Figure 1, p. iii for LIHEAP recipient household; Department of Energy, What is the Weatherization Program, p. 2, February 2009; U.S Department of Health and Human Services, Low Income Home Energy Assistance Program Guidance, Policy, and Procedures, February 2009.

2.9.2 Energy Burden Definitions

Energy burden is an important statistic for policy makers who are considering the need for energy assistance. Energy burden can be defined broadly as the burden placed on household incomes by the cost of energy, or more simply, the ratio of energy expenditures to household income. However, there are different ways to compute energy burden, and different interpretations and uses of the energy burden statistics. DOE Weatherization primarily uses mean individual burden and mean group burden since these statistics provide data on how an "average" individual household fares against an "average" group of households (that is, how burdens are distributed for the population). DOE Weatherization (and HHS) also uses the median individual burden which shows the burden of a "typical" individual.

Mean Individual Burden: This statistic is calculated by first computing the energy burden for each household using RECS data and then taking a mean of the household-level energy burden estimates. It furnishes the most complete information about how a burden is distributed for the population.

Mean Group Burden: This statistic calculates energy expenditures for all households in the group and divides by the average of all incomes for the group. This statistic is calculated as the ratio between aggregate energy expenditures of a group (from RECS and CPS) and aggregate group income (from CPS).

Median Individual Burden: This statistic is computed by taking a median of the RECS household-level energy burden estimates (the point at which 50% of households have a higher burden value and 50% have a lower value).

Source(s): HHS, LIHEAP Report to Congress FY 2000, Apr. 2002, p. 45 for energy burden definition; HHS, Characterizing the Impact of Energy Expenditures on Low-Income Households: An Analysis of Alternative National Energy Burden Statistics, Nov. 1994, p. vii and ix for burdens; and ORNL, Scope of the Weatherization Assistance Program: Profile of the Population in Need, Mar. 1994, p. xii for mean individual and mean group burdens.

2.9.3 Households Weatherized and Weatherization Eligibility by Year (Million) (1)

	DOE	Federally Eligible (2)	Federally Ineligible	Below 125% Poverty Line	Below 150% Poverty Line	Total Households
1977	0.025	-	-	-	-	74.8
1980	0.181	-	-	-	-	79.6
1985	0.125	-	-	-	-	87.9
1987	0.100	-	-	-	-	90.5
1990	0.085	27.9	66.1	18.2	-	94.2
1991	0.105	-	-	-	-	95.3
1992	0.105	-	-	-	-	96.4
1993	0.090	30.7	65.9	19.4	-	97.7
1994	0.101	-	-	-	-	98.7
1995	0.103	-	-	-	-	100.0
1996	0.060	-	-	-	-	101.0
1997	0.067	34.1	67.4	19.7	-	102.2
1998	0.068	-	-	-	-	103.5
1999	0.068	-	-	-	-	104.9
2000	0.077	-	-	-	-	105.7
2001	0.078	33.8	73.2	20.1	26.5	107.0
2002	0.104	-	-	-	-	105.0
2003	0.100	-	-	-	-	105.6
2004	0.100	-	-	-	-	106.6
2005	0.093	29.6	81.5	19.4	26.6	108.8
2006	0.104	-	-	-	-	109.9
2007	0.104	-	-	-	-	110.4
2008	0.098	-	-	-	-	110.6
2009	0.075	-	-	-	-	111.2
2010	0.036	-	-	-	-	111.9
1977-2010	**3.42**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Note(s): 1) The number of households weatherized represent the number of units completed during the specified Program Year. 2) Federally eligible for DOE and HHS (LIHEAP) Weatherization. Includes previously weatherized units.

Source(s): DOE for weatherization recipients; EIA, Housing Characteristics 1987, May 1989, Table 9, p. 20 for 1987 data; EIA, Housing Characteristics 1990, May 1992, Table 17, p. 54-55 for 1990 data; EIA, Housing Characteristics 1993, June 1995, Table 3.3a, p. 38-42 for 1993 data; EIA, A Look at Residential Energy Consumption in 1997, Nov. 1999, Table HC1-3a, p. 38-39; EIA, 1997 Residential Energy Consumption Survey for eligible households; EIA, 2001 Residential Energy Consumption Survey, Apr. 2004, Table HC2-3a for 2001 eligible households; National Association for State Community Services programs: Weatherization Assistance Program PY 2005 Funding Survey for 2005 data; DOC, The 2012 Statistical Abstract, Table 982 for 2005-2010 households; DOC, The 2006 Statistical Abstract, Table 945 for 1999-2004 households; DOC, The 2001 Statistical Abstract, Table 947 for 1994-1998 households; DOC, The 1997 Statistical Abstract, Table 1195 for 1990-1993 households; Personal communication, Adam Guzzo, U.S. DOE, Febuary 14, 2012 for 2008-2010 weatherization recipients.

2.9.4 Weatherization Population Facts

- Roughly 25% of Federally eligible households move in and out of poverty "classification" each year.
- The average income of Federally eligible households in FY 2005 was $16,264, based on RECS and Bureau of the Census' Current Population Survey (CPS) data.
- States target the neediest, especially the elderly, persons with disabilities, and families with children.
- Since the inception of the Weatherization Assistance Program in 1976, over 6.3 million households have received weatherization services with DOE and leveraged funding.
- In FY 2009, the energy burden on Federally eligible households was about four times the burden on Federally ineligible households (14% versus 4%).

Note(s): For weatherization eligibility terminology, see Table 7.1.10. For acronyms, see Key Terminology.

Source(s): ORNL, Weatherization Works: Final Report on the National Weatherization Evaluation, Sept. 1994, p. 1 for migrating poor; ORNL, 1996 for targeting; HHS, LIHEAP Home Energy Notebook for FY 2005, May 2007, Table A-2a, p. 59 for Federally eligible average income; EERE, Weatherization and Intergovernmental Program, July 2010 for number households served; HHS, LIHEAP Home Energy Notebook for FY 2009, Sept. 2011, Table A-3b for energy burden.

2.9.5 Weatherization Program Facts

- PY 2010 weatherization funding breakdown: DOE 18.3%, LIHEAP 59.6%, others 22.1%.(1)
- The Federal Government's outlay for fuel subsidies runs from $4.0 to 4.4 billion per year. The major two agencies dispensing fuel subsidies are HUD and HHS (through LIHEAP).
- In 2006, HUD spent over $1.43 billion annually to pay all or part of the total utility bills (including water/sewer) for 1.2 million low-income units. Utilities (including water) made up approximately 23% of public housing authorities' expenditures. In addition, HUD estimates tenant expenditures on utilities (excluding water) at about $421 million in 2007.
- LIHEAP spends 85% of its funding on direct fuel subsidies and weatherization. Up to 15% can be spent for weatherization activities and the remainder is spent on fuel subsidies. A maximum of 25% of funding is available for weatherization activities if HHS approves a waiver. LIHEAP weatherization funding has ranged from 8-19% of total LIHEAP funds. In FY 2008, LIHEAP weatherization funding was 10% of total LIHEAP funds.

Note(s): 1) Program year is Apr. 1 - Mar. 31.

Source(s): National Association for State Community Services, Weatherization Assistance Program Funding Survey PY 2010 for spending; HUD, Implementing HUD's Energy Strategy, Dec. 2008, Table B-2, p. 9 and Table B-5, p. 11 for public housing utility costs and HUD spending; DHHS, LIHEAP Report to Congress for Fiscal Year 2008, Sept. 2011, Table I-7, 16 for LIHEAP weatherized households and cost splits.

2.9.6 Weatherization Costs and Savings

- DOE Weatherization program requires that States spend no more than an average of $6,572 per household in PY 2011. All States are using energy audits or priority lists to determine the most cost-effective weatherization measures.
- DOE weatherization created an average energy savings of $437 per household, reduced household annual annual consumption by 35% and returned savings of $1.80 per every $1 invested.

Source(s): DOE, Weatherization and Intergovernmental Program: Weatherization Assistance Program, June 2010; EERE/OWIP, Weatherization Program Notice 11-1, Dec. 2010, p. 6.

2.9.7 Residential Energy Burdens, by Weatherization Eligibility and Year (1)

	1987	1990		FY 2000 (2)			FY 2009 (3)		
	Mean Group	Mean Indvdl	Mean Group	Mean Indvdl	Mdn Indvdl	Mean Group	Mean Indvdl	Mdn Indvdl	Mean Group
Total U.S. Households	4.0%	6.8%	3.2%	6.1%	3.5%	2.4%	7.2%	4.4%	3.2%
Federally Eligible	**13.0%**	**14.4%**	**10.1%**	**12.1%**	**7.9%**	**7.7%**	**13.8%**	**9.6%**	**10.0%**
Federally Ineligible	4.0%	3.5%	N.A.	3.0%	2.6%	2.0%	3.6%	3.1%	2.6%
Below 125% Poverty Line	13.0%	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Note(s): 1) Energy burden can be defined broadly as the burden placed on household incomes by the cost of energy, or the ratio of energy expenditures to income for a household. DOE Weatherization primarily uses mean individual burden and mean group burden since these statistics provide data on how an "average" individual household fares against an "average" group of households (that is, how burdens are distributed for the population). DOE Weatherization and HHS also use the median individual burden which shows the burden of a "typical" individual. 2) Data are derived from RECS 1997, adjusted to reflect FY 2000 HDD, CDD, and fuel prices. 3) Data are derived from RECS 2005, adjusted to reflect FY 2009 HDD, CDD, and fuel prices.

Source(s): EIA, Household Energy Consumption and Expenditures 1987, Oct. 1989, Table 13, p. 48-50 for 1987 mean group burdens; ORNL, The Scope of the Weatherization Program: Profile of the Population in Need, Mar. 1994, p. xi. for 1990 Federally ineligible mean individual burden; HHS, Characterizing the Impact of Energy Expenditures on Low-Income Households: An Analysis of Alternative National Energy Burden Statistics, Nov. 1994, p. viii for 1990 total U.S. Households and Federally eligible burdens; HHS, LIHEAP Home Energy Notebook for FY 2000, Apr. 2000, Tables A-2a, A-2b, and A-2c, p. 48-50 for FY 2000; and HHS, LIHEAP Home Energy Notebook for FY 2009, Sept. 2011, Tables A-3a, A-3b, and A-3c, p. 71-73.

2.9.8 FY 2009 Residential Energy Burdens, by Region (1)

	Northeast			South			Midwest			West		
	Mean Indvdl	Mdn Indvdl	Mean Group	Mean Indvdl	Mdn Indvdl	Mean Group	Mean Indvdl	Mdn Indvdl	Mean Group	Mean Indvdl	Mdn Indvdl	Mean Group
Total U.S. Households	9.0%	5.4%	3.7%	7.7%	4.7%	3.4%	7.1%	4.4%	3.3%	4.9%	3.0%	2.4%
Federally Eligible	**16.0%**	**10.9%**	**11.9%**	**15.1%**	**10.1%**	**11.2%**	**13.3%**	**10.2%**	**10.3%**	**9.8%**	**6.3%**	**7.3%**
Federally Ineligible	4.4%	3.9%	3.0%	3.9%	3.4%	2.8%	3.5%	3.0%	2.7%	2.8%	2.3%	2.0%

Note(s): 1) Data are derived from RECS 2005, adjusted to reflect FY 2009 HDD, CDD, and fuel prices.

Source(s): DHHS, LIHEAP Home Energy Notebook for FY 2009, Sept. 2011, Tables A-3a, A-3b, and A-3c, p. 70-72.

2.9.9 2005 Housing Unit Ownership, by Income Level and Weatherization Eligibility (in Millions)

	Single-Family		Multi-Family Unit		Mobile Home	
2005 Household Income	Own	Rent	Own	Rent	Own	Rent
Less than $15,000	6.1	2.4	0.3	7.1	1.6	N.A.
$15,000 to $30,000	11.0	3.0	0.4	5.8	2.2	0.3
$30,000 to $49,999	15.7	2.5	N.A	3.9	1.2	N.A.
All Households	68.2	10.7	4.2	20.1	5.7	1.0
Federally Eligible	**10.9**	**4.5**	**1.1**	**9.4**	**2.5**	**0.6**
Federally Ineligible	57.3	6.2	3.1	10.7	3.2	0.4
Below 100% Poverty Line	5.3	2.4	0.7	6.1	1.5	0.3

Source(s): EIA, 2005 Residential Energy Consumption Survey: Housing Characteristics Tables, June 2008, Table HC 3-3 and Table HC 4-3.

2.9.10 2005 Average Energy Expenditures per Household Member and per Square Foot, by Weatherization Eligibility ($2010)

	$ Per Household Member	Members/ Hhold	$ Per Square Foot	Square Feet/ Hhold
Total U.S. Households	780	2.6	0.86	2,309
Federally Eligible	**617**	**2.7**	**1.10**	**1,532**
Federally Ineligible	844	2.5	0.82	2,590
Below 100% Poverty Line	603	2.7	1.14	1,442

Source(s): EIA, 2005 Residential Energy Consumption Survey: Household Energy Consumption and Expenditures Tables, Oct. 2008, Table US1 part2; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

2.9.11 Households Weatherized with ARRA Funds by Grantee (1)

Grantee	Homes	Grantee	Homes
Alabama	6,704	Nebraska	3,590
Alaska	443	Nevada	8,081
Arizona	6,354	New Hampshire	2,742
Arkansas	5,231	New Jersey	11,290
California	41,649	New Mexico	3,201
Colorado	12,782	New York	40,021
Connecticut	8,940	North Carolina	11,671
Delaware	54	North Dakota	3,051
District of Columbia	962	Ohio	37,140
Florida	18,953	Oklahoma	6,165
Georgia	13,449	Oregon	5,626
Hawaii	604	Pennsylvania	29,042
Idaho	4,470	Rhode Island	2,144
Illinois	35,530	South Carolina	5,304
Indiana	18,768	South Dakota	2,458
Iowa	8,794	Tennessee	19,522
Kansas	6,339	Texas	48,065
Kentucky	7,639	Utah	4,516
Louisiana	4,698	Vermont	2,341
Maine	5,130	Virginia	7,104
Maryland	8,108	Washington	12,335
Massachusetts	17,687	West Virginia	3,710
Michigan	29,293	Wisconsin	21,684
Minnesota	18,224	Wyoming	1,012
Mississippi	5,937		
Missouri	17,334	Territories and Reservations	13,189
Montana	3,310	**Total**	**612,390**

Note(s): 1) Includes homes weatherized through November 30, 2011.

Source(s): Energy.gov, 2012, ARRA Homes Weatherized by Grantee, retrieved Feb. 13, 2012, from <http://energy.gov/downloads/arra-homes-weatherized-grantee>.

Chapter 3: Commercial Sector

Chapter 3 focuses on energy use in the commercial sector. Section 3.1 covers primary and site energy consumption in commercial buildings, as well as the delivered energy intensities of various building types and end uses. Section 3.2 provides data on various characteristics of the commercial sector, including floorspace, building types, ownership, and lifetimes. Section 3.3 provides data on commercial building expenditures, including energy prices. Section 3.4 covers environmental emissions from the commercial sector. Section 3.5 briefly addresses commercial building construction and retrofits. Sections 3.6, 3.7, 3.8, 3.9, and 3.10 provide details on select commercial buildings types, specifically office and retail space, medical facilities, educational facilities, and hotels and motels.

In chapter 3, commercial sector floorspace is divided by the intended commercial activity, such as medical facility, office space, and retail space. Buildings owned and/or operated by Federal, state, or municipal governments are included in the commercial building sector and are categorized according to their primary purpose. Energy consumption in Federal buildings is discussed in more detail in chapter 4.

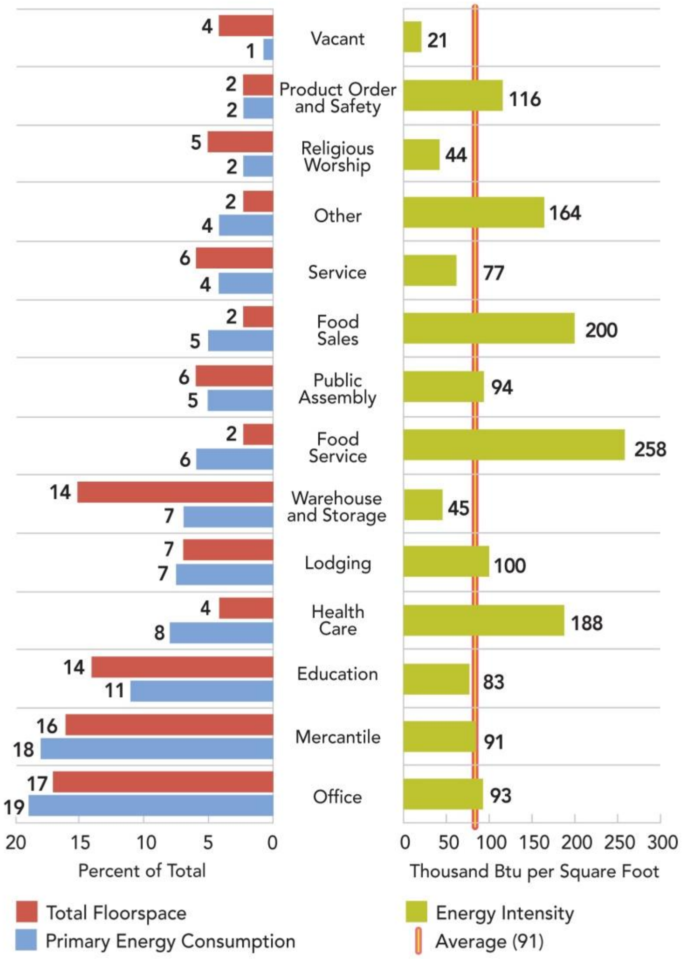
The main points from this chapter are summarized below:

- Commercial buildings represent just under one-fifth of U.S. energy consumption, with office space, retail space, and educational facilities representing about half of commercial sector energy consumption.
- The recession is evidenced by the sharp decrease in energy expenditures in the commercial building sector–a 10% drop. The value of new commercial construction also declined by 22%, the largest percentage drop in the last 30 years. The decline in economic activity had a positive effect on carbon dioxide emissions, which decreased 6%.
- The top three end uses in the commercial sector are space heating, lighting, and space cooling, which represent close to half of commercial site energy consumption.
- Commercial floor space and primary energy consumption grew by 58% and 69%, respectively, between 1980 and 2009. The Energy Information Administration (EIA) projects that they will continue to grow at slower rates between 2009 and 2035, 28% and 22%, respectively. Average energy prices, on the other hand, have been, and are expected to remain, relatively stable.

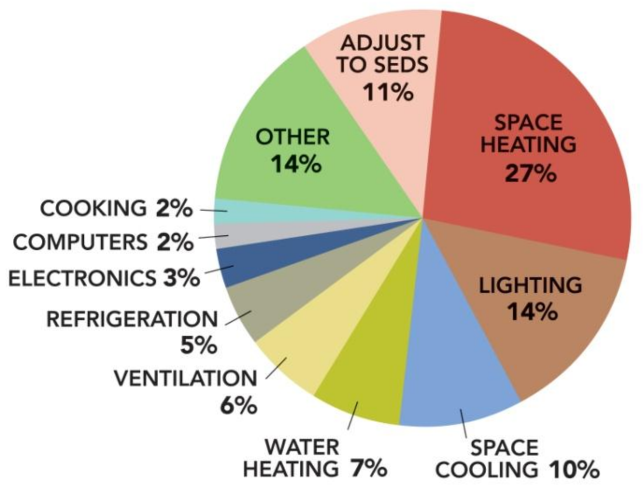
In aggregate, commercial buildings consumed 17.9 quads of primary energy in 2009, representing 46.0% of building energy consumption and 18.9% of U.S. energy consumption. (3.1.1) In comparison, the residential sector consumed 21.0 quads of primary energy, equal to 22.3% of U.S. energy consumption. (2.1.1)

In 2003, the most recent year for which such data are available, office and retail buildings represented the greatest proportions of commercial floor space—17% and 16%, respectively—and 19% and 18%, respectively, of commercial sector energy consumption. Warehouses and storage facilities accounted for 14% of commercial floorspace. (3.2.2) However, the average site energy intensity of these buildings was only 45.2 kBtu per square foot, less than half that of office (92.9 kBtu/ft^2) and retail spaces (73.9 kBtu/ft^2). (3.1.13) As a result, they represent only 7% of commercial sector energy consumption. (3.2.2) Other low-energy-intensity buildings include those used for religious worship and those that are vacant. Medical buildings and food sales and service buildings tend to contain energy-intensive end uses, such as scanning, refrigeration, and cooking, and also tend to be occupied more hours per day and more days per week. Therefore, floorspace devoted to health care, food sales, and food service have high site energy intensities (187,700, 199,700, and 258,300 Btu per square foot, respectively). (3.1.13) Thus, while these buildings represent 8.5% of commercial floor space, they represent close to 19% of commercial primary energy consumption. (3.2.2)

2003 COMMERCIAL BUILDING FLOORSPACE, ENERGY CONSUMPTION, AND ENERGY INTENSITY, BY BUILDING ACTIVITY



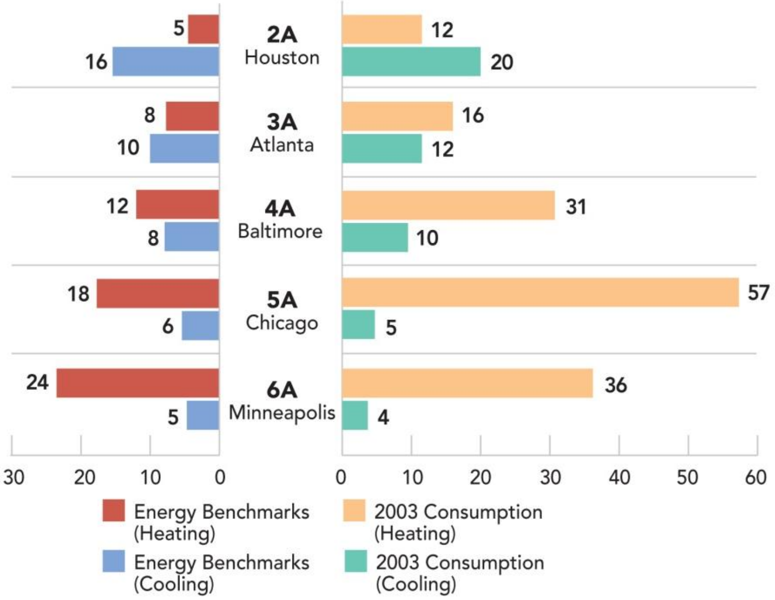
SITE ENERGY CONSUMPTION BY END USE



Space heating consumed 27% of site energy in the commercial sector in 2010, more than any other end use. Other significant end-uses include lighting (14%) and space cooling (10%). Given that the building types that contribute the most to total commercial sector energy consumption, including office, mercantile, education, and lodging, are occupied many hours per day and, in some cases, 24 hours per day, it is not surprising that space conditioning and lighting account for almost half of commercial energy consumption. (3.1.4)

Some of these end-use splits vary considerably by building type. Lighting and space conditioning are the most energy-intensive end uses in mercantile and office buildings. However, in floorspace devoted to food sales, for example, refrigeration requires more energy per square foot than all of the end uses in office space combined—94,800 Btu per square foot for food sales refrigeration compared to 92,900 Btu per square foot for office space end uses in aggregate. (3.1.13) Interestingly, water heating accounts for 31% of the energy consumed in lodging (3.1.13) but only 4% of total commercial energy consumption. (3.1.4)

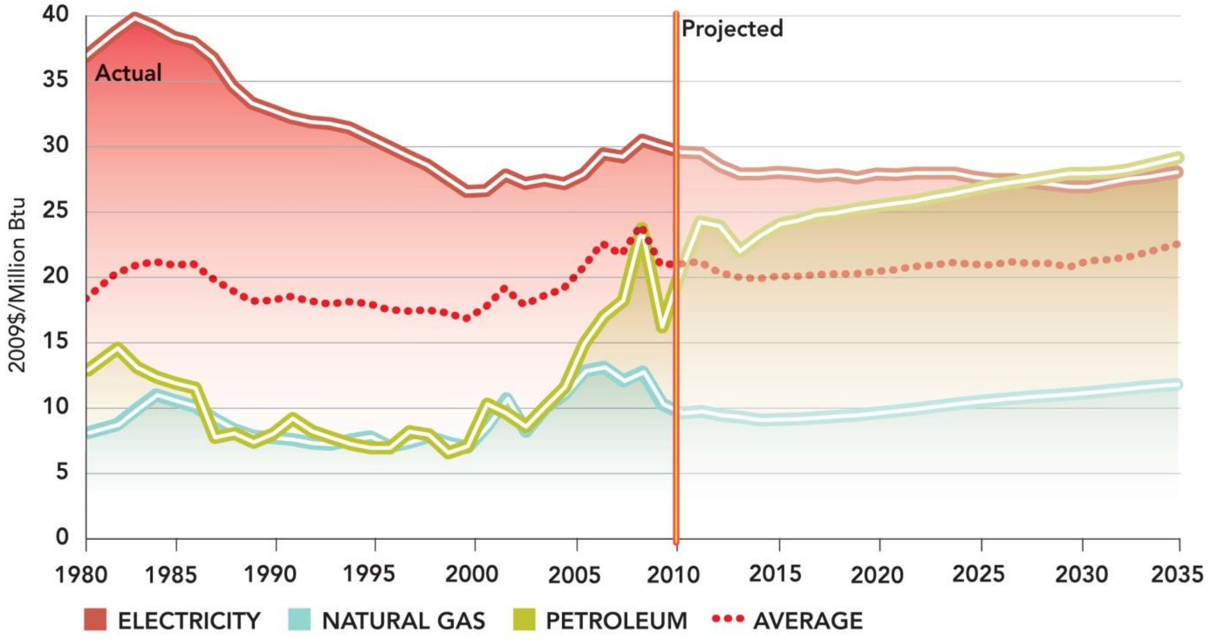
EXISTING MEDIUM OFFICE BUILDINGS, ENERGY BENCHMARKS VS. 2003 CONSUMPTION, BY CLIMATE ZONE



These statistics also indicate that the energy intensity of commercial buildings has remained relatively constant. Between 1980 and 2010, primary energy consumption per square foot increased by 8%. Between 2010 and 2035, EIA actually expects energy intensity to decrease by 6%. (3.1.3) Historical and projected building occupancy rates are currently unavailable, so it is not known how fluctuations in office and retail occupancy rates affect overall consumption and consumption per square foot.

While there has been some change over time in the real prices of specific fuel sources, consumption-weighted average energy prices (fuel-specific energy prices weighted by the amount of each fuel consumed in the commercial sector in a given year) have remained relatively constant. Between 1980 and 2008, electricity prices fell in real terms by 19%, while natural gas prices increased by 27% and petroleum prices increased by 21%. Over this same period, the average price of energy in the commercial sector increased by 14%. This may be misleading, however, as the average price did not experience gradual growth, but rather fluctuated between 1980 and 2009 levels.

EIA projects that average energy prices will decline by 5% between 2009 and 2035. The annual growth rate from 1980 through 2035 is expected to be just under 0.4%. Thus, while the average energy price is expected to fluctuate in the short term, the average energy price is expected to remain relatively constant over the long term. (3.3.1)



COMMERCIAL SECTOR RETAIL ENERGY PRICES

3.1.1 Commercial Primary Energy Consumption, by Year and Fuel Type (Quadrillion Btu and Percent of Total)

									Electricity					Growth Rate
	Natural Gas		Petroleum (1)		Coal		Renewable(2)		Sales	Losses	Total		Total(3)	2010-Year
1980	2.63	24.9%	1.31	12.4%	0.12	1.1%	0.02	0.2%	1.91	4.58	6.49	61.4%	10.57	-
1990	2.67	20.1%	0.99	7.4%	0.12	0.9%	0.10	0.7%	2.86	6.57	9.43	70.9%	13.30	-
2000	3.23	18.9%	0.80	4.7%	0.09	0.5%	0.13	0.7%	3.96	8.95	12.90	75.2%	17.15	-
2005	3.07	17.2%	0.75	4.2%	0.10	0.5%	0.12	0.7%	4.35	9.46	13.81	77.4%	17.85	-
2010	**3.29**	**18.0%**	**0.72**	**3.9%**	**0.06**	**0.3%**	**0.14**	**0.8%**	**4.54**	**9.52**	**14.05**	**77.0%**	**18.26**	**-**
2015	3.41	18.7%	0.62	3.4%	0.06	0.3%	0.15	0.8%	4.63	9.35	13.99	76.7%	18.23	0.0%
2020	3.48	18.2%	0.62	3.2%	0.06	0.3%	0.15	0.8%	4.93	9.95	14.88	77.5%	19.19	0.5%
2025	3.50	17.4%	0.62	3.1%	0.06	0.3%	0.15	0.8%	5.23	10.54	15.77	78.4%	20.10	0.6%
2030	3.58	17.1%	0.62	3.0%	0.06	0.3%	0.16	0.7%	5.57	10.99	16.55	78.9%	20.96	0.7%
2035	3.65	16.7%	0.62	2.9%	0.06	0.3%	0.16	0.7%	5.89	11.45	17.33	79.4%	21.83	0.7%

Note(s): 1) Petroleum includes distillate and residual fuels, liquefied petroleum gas, kerosene, and motor gasoline. 2) Includessite-marketed and non-marketed renewable energy. 3) 2010 commerical site-to-source electricity conversion = 3.10.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2009-2035 and Table A17, p. 34-35 for non-marketed renewable energy.

3.1.2 Commercial Site Renewable Energy Consumption (Quadrillion Btu) (1)

	Wood (2)	Solar Thermal (3)	Solar PV(3)	GHP	Total	Growth Rate 2010-Year
1980	0.021	N.A	N.A.	0.000	0.021	-
1990	0.094	N.A	N.A.	0.003	0.096	-
2000	0.119	N.A	N.A.	0.008	0.126	-
2005	0.104	N.A	N.A.	0.014	0.117	-
2010	**0.110**	**0.028**	**0.006**	**N.A.**	**0.144**	**-**
2015	0.110	0.032	0.007	N.A.	0.148	0.6%
2020	0.110	0.033	0.007	N.A.	0.150	0.4%
2025	0.110	0.034	0.009	N.A.	0.152	0.4%
2030	0.110	0.036	0.010	N.A.	0.155	0.4%
2035	0.110	0.039	0.012	N.A.	0.161	0.4%

Note(s): 1) Does not include renewable energy consumed by electric utilities (including hydroelectric). 2) Includes wood and wood waste, municipal solid waste, and other biomass used by the commercial sector to cogenerate electricity. 3) Includes only solar energy.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables,Table A17, p. 34-35 for 2008-2035.

3.1.3 Commercial Delivered and Primary Energy Consumption Intensities, by Year

				Delivered Energy Consumption		Primary Energy Consumption	
		Floorspace (million SF)	Percent Post-2000 Floorspace (1)	Total (10^15 Btu)	Consumption per SF (thousand Btu/SF)	Total (10^15 Btu)	Consumption per SF (thousand Btu/SF)
1980		50.9	N.A.	5.99	117.7	10.57	207.7
1990		64.3	N.A.	6.74	104.8	13.30	207.0
2000	(2)	68.5	N.A.	8.20	119.7	17.15	250.3
2010	**(2)**	**81.1**	**26%**	**8.74**	**107.7**	**18.22**	**224.6**
2015	(2)	84.1	34%	8.88	105.5	18.19	216.2
2020	(2)	89.1	43%	9.02	101.2	19.15	214.9
2025	(2)	93.9	52%	9.56	101.8	20.06	213.6
2030	(2)	98.2	60%	9.96	101.5	20.92	213.1
2035	(2)	103.0	68%	10.38	100.8	21.78	211.4

Note(s): 1) Percent built after Dec. 31, 2000. 2) Excludes parking garages and commercial buildings on multi-building manufacturing facilities.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; DOE for 1980 floorspace; EIA, Annual Energy Outlook 1994, Jan. 1994, Table A5, p. 62 for 1990 floorspace; EIA, AEO 2003, Jan. 2003, Table A5, p. 127 for 2000 floorspace; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35 for 2008-2035.

3.1.4 2010 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	Site Electric	*Site* Total	*Site* Percent	Primary Electric (4)	Primary Total	Primary Percent
Lighting						1.19	1.19	13.6%	3.69	3.69	20.2%
Space Heating	1.65	0.22		0.06	0.11	0.28	2.33	26.6%	0.88	2.93	16.0%
Space Cooling	0.04					0.84	0.88	10.1%	2.60	2.64	14.5%
Ventilation						0.54	0.54	6.1%	1.66	1.66	9.1%
Refrigeration						0.39	0.39	4.5%	1.21	1.21	6.6%
Water Heating	0.44	0.03			0.03	0.09	0.58	6.7%	0.28	0.78	4.3%
Electronics						0.26	0.26	3.0%	0.81	0.81	4.4%
Computers						0.21	0.21	2.4%	0.66	0.66	3.6%
Cooking	0.18					0.02	0.20	2.3%	0.07	0.25	1.4%
Other (5)	0.30	0.01	0.14	0.05	0.01	0.69	1.20	13.7%	2.13	2.64	14.5%
Adjust to SEDS (6)	0.68	0.25				0.02	0.95	10.9%	0.06	0.99	5.4%
Total	**3.29**	**0.52**	**0.14**	**0.12**	**0.14**	**4.54**	**8.74**	100%	**14.05**	**18.26**	100%

Note(s): 1) Includes (0.43 quad) distillate fuel oil and (0.08 quad) residual fuel oil. 2) Kerosene (0.01 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of (0.11 quad) biomass, (0.03 quad) solar water heating, (less than 0.01 quad) solar PV, and (less than 0.01 quad) wind. 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.10. 5) Includes service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2 and 5-25 - 5-26; EIA, AEO 1998, Dec. 1997, Table A5, p. 108-109 for 1995 ventilation; and DOE/Navigant Consulting, 2010 U.S. Lighting Market Characterization, Jan. 2012, Table 4.8, p. 34; EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.1.5 2015 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	Site Electric	*Site* Total	*Site* Percent	Primary Electric (4)	Primary Total	Primary Percent
Lighting						1.01	1.01	11.4%	3.05	3.05	16.7%
Space Heating	1.69	0.20		0.06	0.11	0.17	2.23	25.2%	0.50	2.57	14.1%
Space Cooling	0.04					0.51	0.54	6.1%	1.52	1.56	8.6%
Ventilation						0.54	0.54	6.1%	1.62	1.62	8.9%
Refrigeration						0.35	0.35	4.0%	1.06	1.06	5.8%
Electronics						0.32	0.32	3.6%	0.95	0.95	5.2%
Water Heating	0.48	0.03			0.03	0.09	0.63	7.1%	0.27	0.81	4.5%
Computers						0.19	0.19	2.1%	0.57	0.57	3.1%
Cooking	0.19					0.02	0.21	2.4%	0.07	0.26	1.4%
Other (5)	0.33	0.01	0.14	0.05	0.01	0.81	1.35	15.2%	2.45	2.99	16.4%
Adjust to SEDS (6)	0.68	0.19				0.63	1.50	16.9%	1.90	2.77	15.2%
Total	**3.33**	**0.43**	**0.14**	**0.11**	**0.15**	**4.63**	**8.88**	100%	**13.99**	**18.23**	100%

Note(s): 1) Includes (0.35 quad) distillate fuel oil and (0.08 quad) residual fuel oil. 2) Kerosene (less than 0.01 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of (0.11 quad) biomass, (0.03 quad) solar water heating, (less than 0.01 quad) solar PV, and (less than 0.01 quad) wind. 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 5) Includes service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.1.6 2025 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	Site	*Site*		Primary	Primary	
	Gas	Oil (1)	LPG	Fuel(2)	En.(3)	Electric	Total	Percent	Electric (4)	Total	Percent
Lighting						1.08	1.08	11.3%	3.27	3.27	16.3%
Space Heating	1.68	0.18		0.06	0.11	0.16	2.20	23.1%	0.49	2.53	12.6%
Ventilation						0.60	0.60	6.2%	1.80	1.80	9.0%
Space Cooling	0.03					0.52	0.55	5.7%	1.56	1.59	7.9%
Electronics						0.40	0.40	4.2%	1.22	1.22	6.1%
Refrigeration						0.34	0.34	3.6%	1.02	1.02	5.1%
Water Heating	0.52	0.03			0.03	0.09	0.67	7.0%	0.27	0.85	4.2%
Computers						0.20	0.20	2.1%	0.60	0.60	3.0%
Cooking	0.21					0.02	0.23	2.4%	0.07	0.27	1.4%
Other (5)	0.48	0.01	0.15	0.05	0.01	1.12	1.82	19.1%	3.39	4.09	20.3%
Adjust to SEDS (6)	0.58	0.18				0.69	1.46	15.3%	2.09	2.85	14.2%
Total	**3.50**	**0.41**	**0.15**	**0.12**	**0.15**	**5.23**	**9.56**	100%	**15.77**	**20.10**	100%

Note(s): 1) Includes (0.33 quad) distillate fuel oil and (0.08 quad) residual fuel oil. 2) Kerosene (less than 0.01 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.05 quad) assumed attributable to other end-uses. 3) Comprised of (0.11 quad) biomass, (0.03 quad) solar water heating, (0.01 quad) solar PV, and (less than 0.01 quad) wind. 4) Site-to-source electricity conversion (due to generation and transmission losses) = 3.02. 5) Includes service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.1.7 2035 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural	Fuel		Other	Renw.	Site	*Site*		Primary	Primary	
	Gas	Oil (1)	LPG	Fuel(2)	En.(3)	Electric	Total	Percent	Electric (4)	Total	Percent
Lighting						1.15	1.15	11.1%	3.40	3.40	15.6%
Space Heating	1.65	0.18		0.06	0.11	0.16	2.16	20.8%	0.48	2.48	11.3%
Ventilation						0.65	0.65	6.2%	1.91	1.91	8.7%
Space Cooling	0.03					0.54	0.57	5.5%	1.59	1.62	7.4%
Electronics						0.46	0.46	4.5%	1.37	1.37	6.3%
Refrigeration						0.36	0.36	3.4%	1.05	1.05	4.8%
Water Heating	0.54	0.03			0.04	0.09	0.70	6.8%	0.25	0.87	4.0%
Computers						0.22	0.22	2.1%	0.64	0.64	2.9%
Cooking	0.22					0.02	0.25	2.4%	0.06	0.29	1.3%
Other (5)	0.81	0.01	0.16	0.06	0.01	1.46	2.51	24.2%	4.30	5.35	24.5%
Adjust to SEDS (6)	0.40	0.18				0.77	1.36	13.1%	2.28	2.86	13.1%
Total	**3.65**	**0.40**	**0.16**	**0.12**	**0.16**	**5.89**	**10.38**	100%	**17.33**	**21.83**	100%

Note(s): 1) Includes (0.32 quad) distillate fuel oil and (0.08 quad) residual fuel oil. 2) Kerosene (0.01 quad) and coal (0.06 quad) are assumed attributable to space heating. Motor gasoline (0.06 quad) assumed attributable to other end-uses. 3) Comprised of (0.11 quad) biomass, (0.04 quad) solar water heating, (0.01 quad) solar PV, and (less than 0.01 quad) wind. 4) Site-to-source electricity conversion (due to generation and transmission losses) = 2.94. 5) Includes service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Tables A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.1.8 Commercial Delivered Energy Consumption Intensities, by Vintage

Year Constructed	Consumption per Square Foot (thousand Btu/SF)	
Prior to 1960	84.4	23%
1960 to 1969	91.5	12%
1970 to 1979	97.0	18%
1980 to 1989	100.0	19%
1990 to 1999	90.3	19%
2000 to 2003	81.6	8%
Average	91.0	

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, Oct. 2006, Table C1a.

3.1.9 2003 Commercial Delivered Energy Consumption Intensities, by Principal Building Type and Vintage (1)

	Consumption (kBtu/SF)				Consumption (kBtu/SF)		
Building Type	Pre-1959	1960-1989	1990-2003	Building Type	Pre-1959	1960-1989	1990-2003
Health Care	178.1	216.0	135.7	Education	77.7	88.3	80.6
Inpatient	230.3	255.3	253.8	Service	62.4	86.0	74.8
Outpatient	91.6	110.4	84.4	Food Service	145.2	290.1	361.2
Food Sales	205.8	197.6	198.3	Religious Worship	46.6	39.9	43.3
Lodging	88.2	111.5	88.1	Public Order & Safety	N.A.	101.3	110.6
Office	93.6	94.4	88.0	Warehouse & Storage	N.A.	38.9	33.3
Mercantile	80.4	91.8	94.4	Public Assembly	61.9	107.6	119.7
Retail (Non-Malls)	74.1	63.7	86.4	Vacant	21.4	23.1	N.A.
Retail (Malls)	N.A.	103.9	99.5	Other	161.3	204.9	125.3

Note(s): 1) See Table 3.1.3 for primary versus delivered energy consumption.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, Oct. 2006, Table C12a.

3.1.10 2003 Commercial Primary Energy Consumption Intensities, by Principal Building Type

Building Type	Consumption (thousand Btu/SF)	Percent of Total Consumption	Building Type	Consumption (thousand Btu/SF)	Percent of Total Consumption
Health Care	345.9	8%	Education	159.0	11%
Inpatient	438.8	6%	Service	151.6	4%
Outpatient	205.9	2%	Food Service	522.4	6%
Food Sales	535.5	5%	Religious Worship	77.0	2%
Lodging	193.1	7%	Public Order and Safety	221.1	2%
Office	211.7	19%	Warehouse and Storage	94.3	7%
Mercantile	223.6	18%	Public Assembly	180.0	5%
Retail (Non-Malls)	172.6	5%	Vacant	33.1	1%
Enclosed & Strip Malls	255.6	13%	Other	318.8	4%

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, Oct. 2006, Table C1a.

3.1.11 2003 Commercial Delivered Energy Consumption Intensities, by Ownership of Unit (1)

Ownership	Consumption (thousand Btu/SF)	
Nongovernment Owned	**85.1**	**72%**
Owner-Occupied	87.3	35%
Nonowner-Occupied	88.4	36%
Government Owned	**105.3**	**28%**
		100%

Note(s): 1) Mall buildings are no longer included in most CBECs tables; therefore, some data is not directly comparable to past CBECs.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, June 2006, Table C3.

3.1.12 Aggregate Commercial Building Component Loads as of 1998 (1)

	Loads (quads) and Percent of Total Loads			
Component	Heating		Cooling	
Roof	-0.103	12%	0.014	1%
Walls (2)	-0.174	21%	-0.008	-
Foundation	-0.093	11%	-0.058	-
Infiltration	-0.152	18%	-0.041	-
Ventilation	-0.129	15%	-0.045	-
Windows (conduction)	-0.188	22%	-0.085	-
Windows (solar gain)	0.114	-	0.386	32%
Internal Gains				
Lights	0.196	-	0.505	42%
Equipment (electrical)	0.048	-	0.207	17%
Equip. (non-electrical)	0.001	-	0.006	1%
People	0.038	-	0.082	7%
NET Load	**-0.442**	100%	**0.963**	100%

Note(s): 1) Loads represents the thermal energy losses/gains that, when combined, will be offset by a building's heating/cooling system to maintain a set interior temperature (which then equals site energy). 2) Includes common interior walls between buildings.

Source(s): LBNL, Commercial Heating and Cooling Loads Component Analysis, June 1998, Table 24, p. 45 and Figure 3, p. 61.

3.1.13 2003 Commercial Buildings Delivered Energy End-Use Intensities, by Building Activity (Thousand Btu per SF) (1)

	Education	Food Sales	Food Service	Health Care	Inpatient	Outpatient	Lodging
Space Heating	39.4	28.9	43.1	70.4	91.8	38.1	22.2
Cooling	8.0	9.8	17.4	14.1	18.6	7.2	4.9
Ventilation	8.4	5.9	14.8	13.3	20.0	3.3	2.7
Water Heating	5.8	2.9	40.4	30.2	48.4	2.5	31.4
Lighting	11.5	36.7	25.4	33.1	40.1	22.6	24.3
Cooking	0.8	8.6	63.5	3.5	5.6	N.A.	3.2
Refrigeration	1.6	94.8	42.1	2.6	2.0	3.5	2.3
Office Equipment	0.4	1.6	1.0	1.2	1.1	1.3	N.A.
Computers	3.4	1.9	1.4	3.4	3.9	2.6	1.3
Other	4.0	9.1	9.5	16.1	18.1	13.2	7.0
Total	83.1	199.7	258.3	187.7	249.2	94.6	100.0

	Mercantile	Service	Retail (No Mall)	Enclosed and Strip Malls	Office	Public Assembly	Public Order and Safety
Space Heating	24.0	35.9	24.8	23.6	32.8	49.7	49.9
Cooling	9.9	3.8	5.9	12.4	8.9	9.6	8.9
Ventilation	6.0	6.0	3.7	7.5	5.2	15.9	9.5
Water Heating	5.1	1.0	1.1	7.7	2.0	1.0	14.0
Lighting	27.5	15.6	25.7	28.6	23.1	7.0	16.5
Cooking	2.3	N.A.	0.6	3.4	0.3	0.8	1.3
Refrigeration	4.4	2.1	5.0	4.0	2.9	2.2	2.9
Office Equipment	0.7	0.3	0.6	0.8	2.6	N.A.	0.6
Computers	1.1	1.0	1.0	1.1	6.1	N.A.	1.6
Other	10.3	11.4	5.6	13.2	9.0	6.5	10.6
Total	91.3	77.0	73.9	102.2	92.9	93.9	115.8

	Religious Worship	Warehouse and Storage	Other	Vacant
Space Heating	26.2	19.3	79.4	14.4
Cooling	2.9	1.3	10.5	0.6
Ventilation	1.4	2.0	6.1	0.4
Water Heating	0.8	0.6	2.1	0.1
Lighting	4.4	13.1	34.1	1.7
Cooking	0.8	N.A.	N.A.	N.A.
Refrigeration	1.7	3.5	6.0	N.A.
Office Equipment	0.1	0.2	N.A.	N.A.
Computers	0.3	0.6	3.0	N.A.
Other	4.9	4.8	18.9	3.1
Total	43.5	45.2	164.4	20.9

Note(s): 1) Due to rounding, end-uses do not sum to total.

Source(s): EIA, 2003 Commercial Building Energy Consumption Survey, Energy End-Uses, Oct 2008, Table E.2A.

3.1.14 Commercial Buildings Share of U.S. Natural Gas Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Natural Gas Total
	Commercial	Industry	Electric Gen.	Transportation	**Commercial**	Industry	Transportation	(quads)
1980	**13%**	41%	19%	3%	**18%**	49%	3%	20.22
1990	**14%**	43%	17%	3%	**19%**	49%	4%	19.57
2000	**14%**	40%	22%	3%	**21%**	47%	3%	23.66
2005	**14%**	35%	27%	3%	**23%**	42%	3%	22.49
2010	**13%**	**33%**	**31%**	**3%**	**24%**	**41%**	**3%**	**24.71**
2015	**13%**	33%	32%	3%	**25%**	41%	3%	25.99
2020	**13%**	34%	31%	3%	**25%**	42%	3%	26.13
2025	**14%**	34%	30%	3%	**25%**	42%	3%	25.80
2030	**14%**	33%	32%	3%	**26%**	40%	3%	26.49
2035	**13%**	32%	34%	3%	**26%**	40%	3%	27.11

Note(s): 1) Commercial buildings accounted for 24% (or $43.4 billion) of total U.S. natural gas expenditures in 2009.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2008-2035 consumption, Table A3, p. 4-6 for 2009 expenditures.

3.1.15 Commercial Buildings Share of U.S. Petroleum Consumption (Percent)

	Site Consumption				Primary Consumption			U.S. Petroleum Total
	Commercial	Industry	Electric Gen.	Transportation	**Commercial**	Industry	Transportation	(quads)
1980	**4%**	28%	8%	56%	**6%**	31%	56%	34.2
1990	**3%**	25%	4%	64%	**4%**	26%	64%	33.6
2000	**2%**	24%	3%	67%	**3%**	25%	67%	38.4
2005	**2%**	24%	3%	68%	**3%**	25%	68%	40.7
2010	**2%**	**22%**	**1%**	**72%**	**2%**	**22%**	**72%**	**37.2**
2015	**2%**	21%	1%	73%	**2%**	22%	73%	36.9
2020	**2%**	22%	1%	73%	**2%**	22%	73%	37.1
2025	**2%**	22%	1%	73%	**2%**	22%	73%	37.0
2030	**2%**	22%	1%	73%	**2%**	22%	73%	37.3
2035	**2%**	22%	1%	73%	**2%**	22%	73%	38.0

Note(s): 1) Commercial buildings accounted for an estimated 2% or $10.7 billion of total U.S. petroleum expenditures in 2009.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for 2009-2035 consumption; and EIA, State Energy Data 2009: Price and Expenditure, June 2011, Tables 2-6 for 2009 expenditures.

3.2.1 Total Commercial Floorspace and Number of Buildings, by Year

	Commercial Sector Floorspace (10^9 square feet)	Percent Post-2000 Floorspace (2)	Buildings (10^6)
1980	50.9 (1)	N.A.	3.1 (3)
1990	64.3	N.A.	4.5 (3)
2000 (4)	68.5	N.A.	4.7 (5)
2008 (4)	78.8	15%	N.A.
2010 (4)	**81.1**	**26%**	N.A.
2015 (4)	84.1	34%	N.A.
2020 (4)	89.2	43%	N.A.
2025 (4)	93.9	52%	N.A.
2030 (4)	98.2	60%	N.A.
2035 (4)	103.0	68%	

Note(s): 1) Based on PNNL calculations. 2) Percent built after Dec. 31, 2000. 3) Actually for previous year. 4) EIA now excludes parking garages and commercial buildings on multi-building manufacturing facilities from the commercial building sector. 5) Data is from 1999. In 1999, commercial building floorspace = 67.3 billion square feet.

Source(s): EIA, Annual Energy Outlook 1994, Jan. 1994, Table A5, p. 62 for 1990 floorspace; EIA, AEO 2003, Jan. 2003, Table A5, p. 127-128 for 2000 floorspace; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A5, p. 11-12 for 2008-2035 floorspace; EIA Commercial Building Characteristics 1989, June 1991, Table A4, p. 17 for 1990 number of buildings; EIA, Commercial Building Characteristics 1999, Aug. 2002, Table 3 for 1999 number of buildings and floorspace; and EIA, Buildings and Energy in the 1980s, June 1995, Table 2.1, p. 23 for number of buildings in 1980.

3.2.2 Principal Commercial Building Types, as of 2003 (Percent of Total Floorspace) (1)

	Total Floorspace	Total Buildings	Primary Energy Consumption
Office	17%	17%	19%
Mercantile	16%	14%	18%
Retail	6%	9%	5%
Enclosed & Strip Malls	10%	4%	13%
Education	14%	8%	11%
Warehouse and Storage	14%	12%	7%
Lodging	7%	3%	7%
Service	6%	13%	4%
Public Assembly	5%	6%	5%
Religious Worship	5%	8%	2%
Health Care	4%	3%	8%
Inpatient	3%	0%	6%
Outpatient	2%	2%	2%
Food Sales	2%	5%	5%
Food Service	2%	6%	6%
Public Order and Safety	2%	1%	2%
Other	2%	2%	4%
Vacant	4%	4%	1%
Total	100%	100%	100%

Note(s): 1) For primary energy intensities by building type, see Table 3.1.13. Total CBECS 2003 commercial building floorspace is 71.7 billion SF.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Consumption and Expenditures Tables, Oct. 2006, Table C1A.

3.2.3 Number of Floors and Type of Ownership, as of 2003 (Percent of Total Floorspace)

Floors	
One	40%
Two	25%
Three	12%
Four to Nine	16%
Ten or More	8%
Total	100%

Ownership	
Nongovernment Owned	**76%**
Owner-Occupied	36%
Nonowner-Occupied	37%
Unoccupied	3%
Government Owned	**24%**
Federal	3%
State	5%
Local	15%
Total	100%

Source(s): EIA, Commercial Building Characteristics 2003, June 2006, Table C1.

3.2.4 Share of Commercial Floorspace, by Census Region and Vintage, as of 2003 (Percent)

Region	Prior to 1960	1960 to 1989	1990 to 2003	Total
Northeast	9%	8%	3%	20%
Midwest	8%	11%	6%	25%
South	5%	18%	14%	37%
West	3%	9%	5%	18%
				100%

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, Oct. 2006, Table A2, p. 3-4.

3.2.5 Commercial Building Size, as of 2003 (Number of Buildings and Percent of Total Floorspace)

Square Foot Range	Number of Buildings (thousands)	
1,001 to 5,000	2,586	10%
5,001 to 10,000	948	10%
10,001 to 25,000	810	18%
25,001 to 50,000	261	13%
50,001 to 100,000	147	14%
100,001 to 200,000 (1)	74	14%
200,001 to 500,000 (1)	26	10%
Over 500,000 (1)	8	11%
Total	**4,859**	100%

Note(s): 1) 35% of commercial floorspace is found in 2.2% of commercial buildings that are larger than 100,000 square feet.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, Oct. 2006, Table A1, p. 1-2.

3.2.6 Commercial Building Vintage, as of 2003

	Percent of Total Floorspace
1919 or Before	5%
1920 to 1945	10%
1946 to 1959	10%
1960 to 1969	12%
1970 to 1979	17%
1980 to 1989	17%
1990 to 1999	20%
2000 to 2003	9%
Total	100%

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, Oct. 2006, Table A1, p. 1-2.

3.2.7 Commercial Building Median Lifetimes (Years)

Building Type	Median (1)	66% Survival (2)	33% Survival (2)
Assembly	55	40	75
Education	62	45	86
Food Sales	55	41	74
Food Service	50	35	71
Health Care	55	42	73
Large Office	65	46	92
Mercantile & Service	50	36	69
Small Office	58	41	82
Warehouse	58	41	82
Lodging	53	38	74
Other	60	44	81

Note(s): 1) PNNL estimates the median lifetime of commercial buildings is 70-75 years. 2) Number of years after which the building survives. For example, a third of the office buildings constructed today will survive 103 years later.

Source(s): EIA, Assumptions for the Annual Energy Outlook 2011, July 2011, Table 5.2, p. 40; EIA, Model Documentation Report: Commercial Sector 'Demand Module of the National Energy Modeling System, May 2010, p. 30-35; and PNNL, Memorandum: New Construction in the Annual Energy Outlook 2003, Apr. 24, 2003 for Note 2.

3.2.8 2003 Average Commercial Building Floorspace, by Principal Building Type and Vintage

	Average Floorspace/Building (thousand SF)			
Building Type	1959 or Prior	1960 to 1989	1990 to 2003	All
Education	27.5	26.9	21.7	25.6
Food Sales	N.A.	N.A.	N.A.	5.6
Food Service	6.4	4.4	5.0	5.6
Health Care	18.5	37.1	N.A.	24.5
Inpatient	N.A.	243.6	N.A.	238.1
Outpatient	N.A.	11.3	11.6	10.4
Lodging	9.9	36.1	36.0	35.9
Retail (Other Than Mall)	6.2	9.3	17.5	9.7
Office	12.4	16.4	14.2	14.8
Public Assembly	13.0	13.8	17.3	14.2
Public Order and Safety	N.A.	N.A.	N.A.	15.4
Religious Worship	8.7	9.6	15.6	10.1
Service	6.1	6.5	6.8	6.5
Warehouse and Storage	19.7	17.2	15.4	16.9
Other	N.A.	N.A.	N.A.	22.0
Vacant	N.A.	N.A.	N.A.	14.1

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, June 2006, Table B8, p. 63-69, and Table B9, p. 70-76.

3.3.1 Commercial Energy Prices, by Year and Major Fuel Type ($2010 per Million Btu)

	Electricity	Natural Gas	Petroleum (1)	Average
1980	37.22	7.70	13.06	18.52
1990	32.49	7.20	9.31	18.62
2000	26.86	8.19	10.44	17.66
2005	28.11	12.15	15.14	20.92
2010 (2)	**29.73**	**9.10**	**20.28**	**20.99**
2015	28.07	8.59	24.07	20.11
2020	27.78	9.21	25.46	20.46
2025	27.74	10.12	26.73	21.07
2030	26.98	10.53	27.98	21.01
2035	27.99	11.55	28.94	22.14

Note(s): 1) Commercial petroleum products include distillate fuel, LPG, kerosene, motor gasoline, and residual fuel. 2) In 2010, buildings average electricity price was $30.47/MMBtu or ($0.10/kWh), average natural gas price was $10.611/MMBtu ($1.06/therm), and petroleum was $22.66/MMBtu ($3.14/gal.). Averages do not include wood or coal prices.

Source(s): EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009 and prices; EIA, State Energy Consumption Database, June 2011 for 1980-2009 consumption; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8, Table A12, p. 25-26, and Table A13, p. 27-28 for 2009-2035 consumption and prices; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

3.3.2 Commercial Energy Prices, by Year and Fuel Type ($2010)

	Electricity (cents/kWh)	Natural Gas (cents/therm)	Distillate Oil ($/gal)	Residual Oil ($/gal)
1980	12.70	77.01	1.43	2.05
1990	11.08	72.04	0.78	1.26
2000	9.17	81.85	0.84	1.28
2005	9.59	121.45	1.24	2.07
2010	**10.14**	**90.95**	**1.66**	**2.86**
2015	9.58	85.91	2.41	3.28
2020	9.48	92.13	2.63	3.49
2025	9.47	101.25	2.73	3.69
2030	9.20	105.25	2.85	3.89
2035	9.55	115.50	2.82	4.06

Source(s): EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009; EIA, Annual Energy Outlook 2010, May 2010, Table G1, p. 221 for fuels' heat content; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A3, p. 6-8 for 2009-2035; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

3.3.3 Commercial Buildings Aggregate Energy Expenditures, by Year and Major Fuel Type ($2010 Billion) (1)

	Electricity	Natural Gas	Petroleum (2)	Total
1980	70.9	20.5	17.2	108.6
1990	92.9	19.4	9.2	121.5
2000	106.3	26.6	8.3	141.2
2005	122.3	37.4	11.4	171.2
2010	**134.8**	**29.9**	**14.5**	**179.2**
2015	130.0	29.3	15.0	174.4
2020	136.9	32.1	15.7	184.8
2025	145.0	35.5	16.6	197.0
2030	150.1	37.7	17.3	205.1
2035	164.8	42.2	18.0	225.0

Note(s): 1) Expenditures exclude wood and coal. 2009 U.S. energy expenditures were 1.06 trillion. 2) Commercial petroleum products include distillate fuel oil, LPG, kerosene, motor gasoline, and residual fuel.

Source(s): EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A3, p. 6-8 for 2010-2035; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

3.3.4 2010 Commercial Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal (3)	Electricity	Total	Percent
Lighting								35.4	35.4	19.7%
Space Heating	15.0	2.9	0.9		0.1	3.9	0.1	8.5	27.5	15.3%
Space Cooling	0.4							25.0	25.3	14.1%
Ventilation								15.9	15.9	8.9%
Refrigeration								11.6	11.6	6.5%
Water Heating	4.0	0.6				0.6		2.7	7.3	4.1%
Electronics								7.8	7.8	4.3%
Computers								6.3	6.3	3.5%
Cooking	1.6							0.7	2.3	1.3%
Other (4)	2.7	0.3		3.3	1.2	4.8		20.4	28.0	15.6%
Adjust to SEDS (5)	6.2	5.2				5.2		0.6	12.0	6.7%
Total	**29.9**	**9.0**	**0.9**	**3.3**	**1.3**	**14.5**	**0.1**	**134.8**	**179.4**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.1 billion) and motor gasoline other uses ($1.2 billion). 3) Coal average price is from AEO 2012 Early Release, all users price. 4) Includes service station equipment, ATMs, medical equipment, telecommunications equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 5) Expenditures related to an energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, and Table A5, p. 11-12 for energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation Oct. 1999, p. 1-2, 5-25 and 5-26 for ventilation; and BTP/Navigant Consulting, DOE/Navigant Consulting, 2010 U.S. Lighting Market Characterization, Jan. 2012, Table 4.8, p. 34; EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.3.5 2015 Commercial Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal (3)	Electricity	Total	Percent
Lighting								28.4	28.4	16.3%
Space Heating	14.6	2.9	1.3		0.1	4.3	0.1	4.7	23.7	13.6%
Ventilation								15.1	15.1	8.6%
Space Cooling	0.3							14.2	14.5	8.3%
Refrigeration								9.9	9.9	5.7%
Electronics								8.8	8.8	5.1%
Water Heating	4.1	0.7				0.7		2.5	7.3	4.2%
Computers								5.3	5.3	3.0%
Cooking	1.7							0.6	2.3	1.3%
Other (4)	2.9	0.3		3.7	1.4	5.4		22.8	31.1	17.8%
Adjust to SEDS (5)	5.8	4.5				4.5		17.7	28.1	16.1%
Total	**29.3**	**8.4**	**1.3**	**3.7**	**1.5**	**14.9**	**0.1**	**130.0**	**174.5**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.1 billion) and motor gasoline other uses ($1.4 billion). 3) Coal average price is from AEO 2012 Early Release, all users price. 4) Includes service station equipment, ATMs, medical equipment, telecommunications equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 5) Expenditures related to an energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, and Table A5, p. 11-12 for energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.3.6 2025 Commercial Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal (3)	Electricity	Total	Percent
Lighting								30.1	30.1	15.2%
Space Heating	17.1	2.8	1.5		0.1	4.4	0.2	4.5	26.1	13.3%
Electronics								11.2	11.2	5.7%
Space Cooling	0.3							14.3	14.6	7.4%
Water Heating	5.2	0.8				0.8		2.5	8.5	4.3%
Computers								5.5	5.5	2.8%
Refrigeration								9.4	9.4	4.8%
Ventilation								16.6	16.6	8.4%
Cooking	2.1							0.6	2.7	1.4%
Other (4)	4.8	0.3		4.3	1.7	6.3		31.2	42.3	21.5%
Adjust to SEDS (5)	5.9	4.9				4.9		19.2	30.0	15.2%
Total	**35.5**	**8.9**	**1.5**	**4.3**	**1.9**	**16.5**	**0.2**	**145.0**	**197.1**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.1 billion) and motor gasoline other uses ($1.7 billion). 3) Coal average price is from AEO 2011 Early Release, all users price. 4) Includes service station equipment, ATMs, medical equipment, telecommunications equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 5) Expenditures related to an energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, and Table A5, p. 11-12 for energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.3.7 2035 Commercial Energy End-Use Expenditure Splits, by Fuel Type ($2010 Billion) (1)

	Natural Gas	Petroleum					Coal (3)	Electricity	Total	Percent
		Distil.	Resid.	LPG	Oth(2)	Total				
Lighting								32.3	32.3	14.4%
Space Heating	19.0	2.7	1.6		0.2	4.5	0.2	4.6	28.2	12.5%
Water Heating	6.3	1.0				1.0		18.1	25.4	11.3%
Space Cooling	0.4							15.1	15.5	6.9%
Electronics								13.0	13.0	5.8%
Refrigeration								10.0	10.0	4.4%
Computers								6.0	6.0	2.7%
Cooking	2.6							0.6	3.2	1.4%
Ventilation								2.4	2.4	1.1%
Other (4)	9.3	0.4		4.9	2.0	7.2		40.9	57.5	25.5%
Adjust to SEDS (5)	4.6	5.3				5.3		21.7	31.6	14.0%
Total	**42.2**	**9.4**	**1.6**	**4.9**	**2.2**	**18.0**	**0.2**	**164.8**	**225.1**	100%

Note(s): 1) Expenditures include coal and exclude wood. 2) Includes kerosene space heating ($0.2 billion) and motor gasoline other uses ($2.0 billion). 3) Coal average price is from AEO 2012 Early Release, all users price. 4) Includes service station equipment, ATMs, medical equipment, telecommunications equipment, pumps, lighting, emergency electric generators, and manufacturing performed in commercial buildings. 5) Expenditures related to an energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A3, p. 6-8 for prices, and Table A5, p. 11-12 for energy consumption; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Supplement to the AEO 2012 Early Release, Jan. 2012, Table 32.

3.3.8 Average Annual Energy Expenditures per Square Foot of Commercial Floorspace, by Year ($2010)

Year	($/SF) (2)
1980(1)	2.12
1990	1.98
2000	2.06
2005	2.30
2010	**2.44**
2015	2.29
2020	2.29
2025	2.32
2030	2.31
2035	2.42

Note(s): 1) End of year 1979. 2) Square footage estimated for years in gray.

Source(s): EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 and Table A5, p. 11-12 for consumption, Table A3, p. 6-8 for prices for 2008-2035; EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators. for price deflators; EIA, AEO 1994, Jan. 1994, Table A5, p. 62 for 1990 floorspace; and PNNL for 1980 floorspace.

3.3.9 2003 Energy Expenditures per Square Foot of Commercial Floorspace and per Building, by Building Type

	Per Square Foot ($2010)	Per Building ($2010 thousand)		Per Square Foot ($2010)	Per Building ($2010 thousand)
Food Service	4.88	27.2	Mercantile	2.23	38.1
Food Sales	4.68	26.0	Education	1.43	36.6
Health Care	2.76	68.0	Service	1.39	9.1
Public Order and Safety	2.07	32.0	Warehouse and Storage	0.80	13.5
Office	2.01	29.8	Religious Worship	0.76	7.8
Public Assembly	1.73	24.6	Vacant	0.34	4.8
Lodging	1.72	61.5	Other	2.99	65.5

Note(s): Mall buildings are no longer included in most CBECs tables; therefore, some data is not directly comparable to past CBECs.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, Oct. 2006, Table 4; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

3.3.10 2003 Energy Expenditures per Square Foot of Commercial Floorspace, by Vintage ($2010)

Vintage	($/SF)
Prior to 1960	1.44
1960 to 1969	1.70
1970 to 1979	1.88
1980 to 1989	2.09
1990 to 1999	1.88
2000 to 2003	1.72
Average	**1.77**

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, Table C4; and EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353 for price deflators.

3.3.11 Energy Service Company (ESCO) Industry Activity ($Million Nominal) (1)

	Estimated Revenue ($Million Nominal) (1)	
	Low	High
1990	143	342
1991	218	425
1992	331	544
1993	505	703
1994	722	890
1995	1,105	1,159
1996	1,294	1,396
1997	1,394	1,506
1998	1,551	1,667
1999	1,764	1,925
2000	1,876	2,186
2001	-	-
2002	-	-
2003	-	-
2004	2,447	2,507
2005	2,949	3,004
2006	3,579	3,627
2007	-	-
2008	4,087	4,171

2008 Revenue Sources

Market Segment	Share
MUSH (2)	69%
Federal	15%
Commercial & Industrial	7%
Residential	6%
Public Housing	3%

2008 Revenues by Project/Technology Type

Market Segment	Share
Energy Efficiency	75%
Onsite Renewables	14%
Engine/Turbine Generators	6%
Consulting/Master Planning	3%
Other	2%

Note(s): 1) Estimates based on surveys of major ESCOs and input from industry experts. 2) Includes municipal and state governments, universities and colleges, K-12 schools, and hospitals.

Source(s): LBNL, Market Trends in the U.S. ESCO Industry: Results from the NAESCO Database Project, LBNL-49601, May 2002 for 1990-2000; LBNL, A Survey of the U.S. ESCO Industry: Market Growth and Development from 2000 to 2006, LBNL-62679, May 2007 for 2004-2006; and LBNL, A Survey of the U.S. ESCO Industry: Market Growth and Development from 2008 to 2011, LBNL-3479E, June 2010 for 2008.

3.4.1 Carbon Dioxide Emissions for U.S. Commercial Buildings, by Year (Million Metric Tons) (1)

	Commercial				U.S.			
	Site Fossil	Electricity	Total	Growth Rate 2010-Year	Total	Growth Rate 2010-Year	Com.% of Total U.S.	Com.% of Total Global
1980	245	409	653	-	4,723	-	14%	3.5%
1990	227	566	793	-	5,039	-	16%	3.7%
2000	239	783	1,022	-	5,867	-	17%	4.3%
2005	227	842	1,069	-	5,996	-	18%	3.8%
2010 (2)	**231**	**805**	**1,036**	-	**5,634**	-	**18%**	**3.4%**
2015	231	734	965	-1.4%	5,434	-0.7%	18%	3.1%
2020	235	776	1,010	-0.3%	5,549	-0.2%	18%	3.0%
2025	235	826	1,061	0.2%	5,618	0.0%	19%	2.9%
2030	240	872	1,111	0.3%	5,695	0.1%	20%	2.8%
2035	244	916	1,159	0.4%	5,806	0.1%	20%	2.7%

Note(s): 1) Excludes emissions of buildings-related energy consumption in the industrial sector. Emissions assume complete combustion from energy consumption and exclude energy production activities such as gas flaring, coal mining, and cement production. 2) Carbon emissions calculated from EIA, Assumptions to the AEO 2010 and differs from EIA, AEO 2011 Early Release, Table A18. Commercial sector total varies by 0.1% from EIA, AEO 2011 Early Release. 3) U.S. commercial buildings emissions approximately equal the combined carbon emissions of

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 2009, Feb. 2011, Tables 8-11 for 1990-2009 greenhouse gas emissions; EIA, Assumptions to the Annual Energy Outlook 2010, May 2010, Table 1.2, p. 12 for carbon coefficients; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2011, Summary Reference Case Tables, Table A2, p. 3-5 for 2010-2035 energy consumption and Table A18, p. 36 for 2010-2035 emissions; EIA, International Energy Outlook 2011, Sept. 2011, Table A10 for 2010-2035 global emissions; and EIA, Country Energy Profiles for global emissions (1980-2009), available at http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm, accessed 2/10/2012 for 1980-2009 global emissions.

3.4.2 2010 Commercial Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Lighting								211.9	211.9	20.4%
Space Heating	87.4	10.2	6.7		0.3	17.3	5.6	50.5	160.7	15.5%
Space Cooling	2.3							149.1	151.3	14.6%
Ventilation								95.2	95.2	9.2%
Refrigeration								69.1	69.1	6.7%
Electronics								46.4	46.4	4.5%
Water Heating	23.2	2.0				2.0		16.2	41.4	4.0%
Computers								37.7	37.7	3.6%
Cooking	9.5							4.1	13.6	1.3%
Other (4)	15.8	0.9		9.0	3.8	13.7		122.0	151.5	14.6%
Adjust to SEDS (5)	36.2	18.4				18.4		2.8	57.3	5.5%
Total	**174.4**	**31.5**	**6.7**	**9.0**	**4.1**	**51.3**	**5.6**	**805.0**	**1,036.3**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. Carbon emissions calculated from EIA, Assumptions to the AEO 2011 and differs from EIA, AEO 2012 Early Release, Table A18. Commercial sector total varies by 0.0% from EIA, AEO 2012. 2) Includes kerosene space heating (0.3 MMT) and motor gasoline other uses (3.8 MMT). 3) Excludes electric imports by utilities. 4) Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 5) Emissions related to a discrepancy between data sources. Energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 1.2, p. 14 for carbon coefficients; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2; OE/Navigant Consulting, 2010 U.S. Lighting Market Characterization, Jan. 2012, Table 4.8, p. 34; and EIA, AEO 1999, Dec. 1998, Table A4, p. 118-119 and Table A5, p. 120-121 for 1996 data.

3.4.3 2015 Commercial Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural Gas	Petroleum					Coal	Electricity (3)	Total	Percent
		Distil.	Resid.	LPG	Oth(2)	Total				
Lighting								160.0	160.0	16.6%
Space Heating	89.9	9.0	6.2		0.3	15.5	5.5	26.4	137.3	14.2%
Space Cooling	1.9							80.0	81.9	8.5%
Ventilation								85.0	85.0	8.8%
Refrigeration								55.8	55.8	5.8%
Electronics								49.9	49.9	5.2%
Water Heating	25.5	2.0				2.0		14.3	41.8	4.3%
Computers								30.0	30.0	3.1%
Cooking	10.2							3.6	13.8	1.4%
Other (4)	17.6	0.9		8.6	3.5	12.9		128.6	159.2	16.5%
Adjust to SEDS (5)	36.0	13.9				13.9		99.8	149.8	15.5%
Total	**181.2**	**25.8**	**6.2**	**8.6**	**3.8**	**44.4**	**5.5**	**733.4**	**964.5**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (0.3 MMT) and motor gasoline other uses (3.5 MMT). 3) Excludes electric imports by utilities. 4) Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 5) Emissions related to a discrepancy between data sources. Energy attributable to the buildings sector, but not directly to specific end uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Assumptions to the Annual Energy Outlook 2011, July 2010, Table 1.2, p. 14 for carbon coefficients.

3.4.4 2025 Commercial Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural Gas	Petroleum					Coal	Electricity (3)	Total	Percent
		Distil.	Resid.	LPG	Oth(2)	Total				
Lighting								171.2	171.2	16.1%
Space Heating	89.4	7.7	6.3		0.4	14.3	5.5	25.7	135.0	12.7%
Ventilation								94.4	94.4	8.9%
Space Cooling	1.8							81.5	83.3	7.8%
Electronics								63.8	63.8	6.0%
Refrigeration								53.7	53.7	5.1%
Computers								31.2	31.2	2.9%
Water Heating	27.5	2.3				2.3		14.0	43.7	4.1%
Cooking	11.0							3.5	14.5	1.4%
Other (4)	25.3	0.9		9.3	3.8	14.0		177.4	216.8	20.4%
Adjust to SEDS (5)	30.9	13.4				13.4		109.4	153.7	14.5%
Total	**185.8**	**24.3**	**6.3**	**9.3**	**4.2**	**44.0**	**5.5**	**825.9**	**1,061.3**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (0.4 MMT) and motor gasoline other uses (3.8 MMT). 3) Excludes electric imports by utilities. 4) Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 5) Emissions related to a discrepancy between data sources. Energy attributable to the buildings sector, but not directly to specific end uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Assumptions to the Annual Energy Outlook 2011, July 2010, Table 1.2, p. 14 for carbon coefficients.

3.4.5 2035 Commercial Buildings Energy End-Use Carbon Dioxide Emissions Splits, by Fuel Type (Million Metric Tons) (1)

	Natural	Petroleum								
	Gas	Distil.	Resid.	LPG	Oth(2)	Total	Coal	Electricity (3)	Total	Percent
Lighting								179.6	179.6	15.5%
Space Heating	87.3	6.7	6.6		0.4	13.7	5.5	25.5	132.0	11.4%
Ventilation								100.7	100.7	8.7%
Space Cooling	1.7							84.1	85.8	7.4%
Electronics								72.3	72.3	6.2%
Refrigeration								55.6	55.6	4.8%
Water Heating	28.8	2.5				2.5		13.3	44.7	3.9%
Computers								33.6	33.6	2.9%
Cooking	11.9							3.4	15.2	1.3%
Other (4)	42.8	1.0		9.8	4.2	14.9		227.3	285.0	24.6%
Adjust to SEDS (5)	21.3	13.1				13.1		120.5	154.9	13.4%
Total	**193.8**	**23.3**	**6.6**	**9.8**	**4.6**	**44.3**	**5.5**	**915.8**	**1,159.3**	100%

Note(s): 1) Emissions assume complete combustion from energy consumption, excluding gas flaring, coal mining, and cement production. Emissions exclude wood since it is assumed that the carbon released from combustion is reabsorbed in a future carbon cycle. 2) Includes kerosene space heating (0.4 MMT) and motor gasoline other uses (4.2 MMT). 3) Excludes electric imports by utilities. 4) Includes commercial service station equipment, ATMs, telecommunications equipment, medical equipment, pumps, emergency electric generators, and manufacturing performed in commercial buildings. 5) Emissions related to a discrepancy between data sources. Energy attributable to the buildings sector, but not directly to specific end-uses.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5, Table A4, p. 9-10 and Table A5, p. 11-12 for energy consumption, and Table A18, p. 36 for emissions; EIA, National Energy Modeling System (NEMS) for AEO 2012 Early Release, Jan. 2012; and EIA, Assumptions to the Annual Energy Outlook 2011, July 2010, Table 1.2, p. 14 for carbon coefficients.

3.4.6 2009 Methane Emissions for U.S. Commercial Buildings Energy Production, by Fuel Type (1)

Fuel Type	MMT CO2 Equivalent
Petroleum	0.5
Natural Gas	26.8
Coal	0.3
Wood	0.4
Electricity (2)	50.5
Total	**78.5**

Note(s):) Sources of emissions include oil and gas production, processing, and distribution; coal mining; and utility and site combustion. Carbon Dioxide equivalent units are calculated by converting methane emissions to carbon dioxide emissions (methane's global warming potential is 23 times that of carbon dioxide). 2) Refers to emissions of electricity generators attributable to the buildings sector.

Source(s): EIA, Emissions of Greenhouse Gases in the U.S. 2009, Mar. 2011, Table 18, p. 37 for energy production emissions; EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, April 2011, Table 3-10, p. 3-9 for stationary combustion emissions; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Summary Reference Case Tables, Table A2, p. 3-5 for energy consumption.

3.5.1 Value of New Commercial Building Construction, by Year ($2010 Billion)

	Value of New Construction Put in Place	U.S. GDP	Comm. Bldgs Percent of Total U.S. GDP
1980	159.8	6,461	2.5%
1985	226.3	7,579	3.0%
1990	227.2	8,890	2.6%
1995	203.8	10,063	2.0%
2000	312.7	12,423	2.5%
2005	302.2	13,986	2.2%
2006	334.7	14,359	2.3%
2007	383.3	14,639	2.6%
2008	399.6	14,639	2.7%
2009	328.5	14,254	2.3%
2010	257.5	14,660	1.8%

Source(s): DOC, Current Construction Reports: Value of New Construction Put in Place, C30, Aug. 2003, Table 1 for 1980-1990; DOC, Annual Value of Private Construction Put in Place, August 2008 for 1995-2000; DOC, Annual Value of Private Construction Put in Place, August 2011 for 2002-2010; DOC, Annual Value of Public Construction Put in Place, August 2008 for 1995-2000; DOC, Annual Value of Public Construction Put in Place, August 2011 for 2002-2010; and EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353 for GDP and price deflators.

3.5.2 Value of Building Improvements and Repairs, by Sector ($2009 Billion) (1)

	Improvements	Maintenance and Repairs	Total	Percent of GDP
1980	N.A.	N.A.	N.A.	N.A.
1985	88.8	51.4	140.2 (2)	2.0%
1990	88.9	53.4	142.3 (3)	1.8%
1995	113.5	37.4	150.9	1.6%
2000	152.8	47.1	200.0	1.8%
2003	127.9	39.4	167.3	1.4%
2004	129.2	39.8	169.1	1.4%
2005	135.4	41.8	177.2	1.4%
2006	141.4	43.6	198.2	1.5%
2007	182.7	56.3	239.0	1.8%
2008	197.4	60.9	258.3	1.9%
2009	163.9	50.6	214.5	1.6%
2010	124.1	38.3	162.4	1.2%

Note(s): 1) Improvements includes additions, alterations, reconstruction, and major replacements. Repairs include maintenance. 2) 1986. 3) 1989.

Source(s): DOC, Current Construction Reports: Expenditures for Nonresidential Improvements and Repairs: 1992, CSS/92, Sept. 1994, Table A, p. 2 for 1986-1990 expenditures; DOC, 1997 Census of Construction Industries: Industry Summary, Jan. 2000, Table 7, p. 15; DOC, Annual Value of Private Construction Put in Place, May 2008 for 1995-2000; DOC, Annual Value of Private Construction Put in Place, August 2011 for 2003-2010; and EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353 for GDP and price deflators.

3.6.1 2009 Energy Consumption per Square Foot of Office Floorspace by Vintage (Thousand Btu/SF) (1)

Vintage	Energy Intensity
2000-2009	81.4
1990-1999	74.1
1980-1989	73.1
1970-1979	102.8
1960-1969	71.4
Pre-1959	75.5

Buildings providing consumption data: 436

Note(s): 1) Commercial office buildings sampled include the following: Class A, B, C.

Source(s): BOMA International, Experience Exchange Report 2010, 2010.

3.6.2 Energy Expenditures per Square Foot of Office Floorspace by Building Age ($2009) (1)

Age (years)	2009	Number of Responses	2006	Number of Responses	2004	Number of Responses
0-9	**2.1**	451	2.1	483	1.8	564
10-19	**1.9**	582	2.3	503	2.0	848
20-29	**2.1**	1,161	2.4	939	2.0	786
30-39	**2.4**	416	2.7	314	2.3	290
40-49	**2.5**	150	3.0	68	2.9	57
50+	**2.5**	187	2.5	128	2.1	164
All Buildings	**2.2**	3,494	**2.4**	2,619	**1.8**	2,939

Note(s): 1) Energy includes electric, gas, fuel oil, purchased steam, purchased chilled water, and water/sewage expenditures. BOMA cautions that any data based on fewer than 25 responses may not be a reliable estimate.

Source(s): BOMA International, The Experience Exchange Report 2010, 2010; BOMA International, The Experience Exchange Report 2007, August 2007; BOMA International, The Experience Exchange Report 2005, August 2005; and EIA, Annual Energy Review 2007, August 2010, Appendix D, p. 383 for price deflators.

3.6.3 Energy Consumption and Expenditures per Square Foot of Office Floorspace, by Function and Class (1)

	2006		2004	
	Energy Intensity (thousand Btu/SF)	Energy Expenditures ($2010/SF)	Energy Intensity (thousand Btu/SF)	Energy Expenditures ($2010/SF)
Medical Offices	90.79	2.56	N.A.	2.36
Financial Offices	N.A.	3.12	N.A.	3.32
Corporate Facilities(2)	96.78	2.74	89.38	2.72
Class A	81.88	2.44	78.84	2.08
Class B	74.87	2.30	N.A.	2.04
Class C	N.A.	2.44	N.A.	1.84
All Buildings	81.1	2.42	77.83	2.09

Note(s): 1) Categories are not mutually exclusive. 2) Coporate Facilities are any building that the owner occupies atleast 75% of the rentable space.

Source(s): BOMA International, The Experience Exchange Report 2007, August 2007; BOMA International, The Experience Exchange Report 2005, August 2005; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price deflators.

3.6.4 2009 Energy Consumption Expenditures by Selected City ($2009/SF) (1)

	Urban	Number of Responses	Suburban	Number of Responses
New York, NY	4.32	33	N.A.	N.A.
Los Angeles, CA	2.84	22	2.47	78
Chicago, IL	1.72	58	N.A.	N.A.
Houston, TX	2.16	27	2.29	149
Phoenix, AZ	2.23	13	1.81	42
Philadelphia, PA	2.81	14	2.87	33
San Antonio, TX	N.A.	N.A.	N.A.	15
San Diego, CA	2.67	14	1.69	75
Dallas, TX	2.27	23	2.19	131
San Jose, CA	N.A.	N.A.	1.88	76
San Francisco, CA	2.55	64	2.19	46
Miami, FL	N.A.	N.A.	2.77	29
Washington, DC	3.29	78	N.A.	N.A.
Seattle, WA	1.51	24	1.75	29
Boston, MA	3.19	32	2.99	47
National Average (2)	**2.33**		**2.08**	

Note(s): 1) Energy includes electric, gas, fuel oil, purchased steam, purchased chilled water, and water/sewage expenditures. "N/A" indicates that the sample size was not large enough to be assumed representative of a given city. BOMA cautions that any data based on fewer than 25 responses may not be a reliable estimate. 2) Averages based on 1,246 urban respondents and 2,942 suburban respondents across 92 US

Source(s): BOMA International, The Experience Exchange Report 2010, 2010.

3.6.5 Top 10 Office Building Owners Globally as of Year End, 2010 (million SF)

Owner	Floorspace Owned
1. RREEF Americas	71.9
2. Brookfield Properties Corp.	69.3
3. The Blackstone Group	65.6
4. CB Richard Ellis Investors	62.7
5. Hines	59.2
6. LaSalleInvestment Management	42.8
7. TIAA-CREF	42.1
8. Boston Properties	38.4
9. Vornado Realty Trust	35.2
10. Duke Realty Corp.	34.7
Total for Top 10:	**521.9**

Source(s): National Real Estate Investor, The 2011 Best of The Best Rankings: 2011 Top 25 Office Owners, June 1, 2011. http://nreionline.com/property/office/real_estate_top_office_owners_9/

3.6.6 Top 10 Property Managers Globally as of Year End, 2010 (million SF)

Managing Company	Floorspace Managed
1. CB Richard Ellis Group	2,900
2. Colliers International	2,000
3. Jones Lang LaSalle	1,800
4. Cushman & Wakefield	723
5. Newmark Knight Frank	445
6. Cassidy Turley	430
7. NAI Global	315
8. Grubb & Ellis	302
9. Lincoln Property Co.	271
10. ProLogis	265
Total for Top 10:	**9,451**

Source(s): National Real Estate Investor, The 2011 Best of The Best Rankings: 2011 Top 25 Property Managers, June 12, 2011. http://nreionline.com/bestofthebest/top_25_property_managers_2011/

3.6.7 Advanced Energy Design Guide for Small Office Buildings (1)

Shell	
Percent Glass (WWR)	20-40%
Window U-Factor	0.33-0.56
SHGC	0.31-0.49
Wall R-Value	7.6-15.2
Roof R-Value	
Attic	30-60
Insulation Above Deck	15-30
Wall Material	Mass (HC > 7 Btu/ft^2)
Lighting	
Average Power Density (Watts/SF)	0.9
System and Plant	
System and Plant	
Packaged Single-Zone	
Packaged Single-Zone w/ Economizer	Cooling Capacity > 54 kBtu
Heating Plant:	
Gas Furnace	80% Combustion Efficiency
Cooling Plant:	
Air conditioner (135-240 thousand Btu*hr.)	10.8 EER/11.2 IPLV - 11.0 EER/11.5 IPLV
Service Hot Water:	
Gas Water Heater	90% Thermal Efficiency

Note(s): 1) Guide provides approximate parameters for constructing a building which is 30% more efficient than ASHRAE 90.1-1999. Ranges are because of climate zone dependencies.

Source(s): ASHRAE, Advanced Energy Design Guide for Small Office Buildings, 2004.

3.6.8 Energy Benchmarks for Existing Large Office Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating		Cooling		Water Heating		Ventilation	
		Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	0.3	0.8	21.9	24.5	0.3	0.2	3.1	3.5
Houston	2A	4.2	4.4	17.7	20.9	0.3	0.3	2.8	3.3
Phoenix	2B	3.0	3.3	16.2	18.3	0.3	0.3	3.2	3.7
Atlanta	3A	6.9	8.5	14.1	17.5	0.4	0.4	2.6	3.2
Los Angeles	3B	2.8	2.9	11.9	13.0	0.4	0.4	2.5	2.7
Las Vegas	3B	4.6	4.7	10.8	13.0	0.3	0.3	2.7	3.3
San Francisco	3C	5.0	6.4	5.6	6.6	0.4	0.4	1.8	2.1
Baltimore	4A	9.8	14.4	12.0	15.5	0.4	0.4	2.4	3.1
Albuquerque	4B	6.6	8.3	6.5	7.6	0.4	0.4	2.3	2.7
Seattle	4C	10.1	15.0	4.5	5.3	0.5	0.4	1.7	2.1
Chicago	5A	14.8	15.1	7.4	7.7	0.5	0.5	2.0	2.1
Boulder	5B	9.5	9.5	4.9	5.0	0.5	0.5	2.0	2.0
Minneapolis	6A	19.6	21.3	6.7	7.0	0.5	0.5	2.0	2.1
Helena	6B	14.2	15.7	3.7	3.8	0.5	0.5	1.8	1.9
Duluth	7	24.3	26.6	3.8	3.6	0.6	0.6	1.8	1.8
Fairbanks	8	45.9	47.9	2.7	2.2	0.7	0.6	2.0	1.7

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 498,407 square feet and 12 floors. Benchmark interior lighting energy = 16.07 thousand Btu/SF. Interior equipment energy consumption = 15.94 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.6.9 Energy Benchmarks for Newly Constructed Large Office Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation (1)
Miami	1A	0.2	18.7	0.2	2.8
Houston	2A	3.2	15.2	0.3	2.5
Phoenix	2B	2.2	13.9	0.3	2.9
Atlanta	3A	3.1	11.1	0.4	2.1
Los Angeles	3B	0.5	8.6	0.4	1.9
Las Vegas	3B	1.4	8.4	0.3	2.2
San Francisco	3C	4.2	5.0	0.4	1.7
Baltimore	4A	6.2	9.8	0.4	2.1
Albuquerque	4B	3.0	5.4	0.4	1.9
Seattle	4C	5.7	3.8	0.4	1.5
Chicago	5A	9.5	6.4	0.5	1.7
Boulder	5B	5.4	4.1	0.5	1.7
Minneapolis	6A	14.4	5.8	0.5	1.7
Helena	6B	10.0	3.1	0.5	1.5
Duluth	7	17.6	3.3	0.6	1.6
Fairbanks	8	31.7	1.7	0.6	1.3

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. The benchmark building had 498,407 square feet and 12 floors. Benchmark interior lighting energy = 10.7 thousand Btu/SF. Interior equipment energy

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012.

3.6.10 Energy Benchmarks for Existing Medium Office Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating		Cooling		Water Heating		Ventilation	
		Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	1.0	0.0	22.0	19.2	0.4	0.4	1.9	13.0
Houston	2A	4.6	1.8	15.5	14.7	0.5	0.5	1.5	12.8
Phoenix	2B	4.0	0.7	17.5	19.4	0.4	0.4	1.9	15.0
Atlanta	3A	7.8	4.3	10.1	10.4	0.6	0.5	1.4	13.9
Los Angeles	3B	4.1	0.3	8.0	3.5	0.5	0.5	1.4	10.9
Las Vegas	3B	5.6	1.4	13.2	14.6	0.5	0.5	1.8	14.5
San Francisco	3C	5.8	1.7	2.9	1.2	0.6	0.6	1.1	8.9
Baltimore	4A	12.1	9.6	8.0	7.8	0.6	0.6	1.3	12.8
Albuquerque	4B	8.0	4.6	6.7	6.9	0.6	0.6	1.6	14.4
Seattle	4C	11.8	7.3	2.5	1.3	0.6	0.6	1.2	11.1
Chicago	5A	17.8	14.2	5.5	4.5	0.7	0.6	1.4	11.4
Boulder	5B	11.6	8.3	4.4	3.9	0.7	0.6	1.5	12.6
Minneapolis	6A	23.6	22.4	4.8	3.8	0.7	0.7	1.4	11.0
Helena	6B	18.1	15.0	2.9	2.3	0.7	0.7	1.4	12.9
Duluth	7	28.9	29.4	2.4	1.7	0.8	0.7	1.4	10.3
Fairbanks	8	52.8	56.4	1.6	1.2	0.8	0.8	1.7	13.2

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 44,985 square feet and 3 floors. Benchmark interior lighting energy = 16.82 thousand Btu/SF. Interior equipment energy consumption = 18.85 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.6.11 Energy Benchmarks for Newly Constructed Medium Office Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation (1)
Miami	1A	0.3	14.9	0.4	1.5
Houston	2A	3.2	11.8	0.5	1.3
Phoenix	2B	2.6	12.8	0.4	1.6
Atlanta	3A	4.5	7.5	0.5	1.2
Los Angeles	3B	0.9	4.8	0.5	1.0
Las Vegas	3B	2.4	9.3	0.5	1.4
San Francisco	3C	5.2	2.5	0.6	1.1
Baltimore	4A	8.5	6.5	0.6	1.2
Albuquerque	4B	4.7	5.3	0.6	1.4
Seattle	4C	7.8	2.0	0.6	1.1
Chicago	5A	12.0	4.4	0.6	1.2
Boulder	5B	7.5	3.6	0.6	1.3
Minneapolis	6A	17.7	3.9	0.7	1.2
Helena	6B	13.3	2.4	0.7	1.2
Duluth	7	21.0	2.0	0.7	1.3
Fairbanks	8	38.6	0.9	0.8	1.1

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. The benchmark building had 53,608 square feet and 3 floors. Benchmark interior lighting energy = 10.7 thousand Btu/SF. Interior equipment energy

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.7.1 2010 Top Retail Companies, by Sales

Chain	2010 Revenues ($billion)	% Change over 2009 Revenues	# Stores 2010	% Change over 2009 Stores
Wal-Mart Stores, Inc.	419.0	3.4%	8,970	6.0%
The Kroger Co.	82.2	7.1%	3,605	-0.4%
Costco	76.3	9.1%	572	1.1%
The Home Depot	68.0	2.8%	2,248	0.2%
Walgreen Co.	67.4	6.4%	8,046	7.3%
Target Corp.	67.4	3.1%	1,750	0.6%
CVS Caremark	57.3	3.6%	7,182	2.2%
Best Buy	50.3	1.2%	4,172	3.7%
Lowes Cos.	48.8	3.4%	1,749	2.3%
Sears Holdings	43.3	-1.6%	4,038	2.2%

Source(s): Chain Store Age. Chain Store Age Top 100: The Nation's Largest Retailers, August/September, 2011.

3.7.2 2010 Top Chain Restaurants, by Sales

Chain	2010 Sales ($billion)	% Change over 2009 Sales	Franchised Stores	Company-owned Stores	Total Stores
McDonald's	32.4	4.5%	12,477	1,550	14,027
Subway (1)	10.6	6.0%	23,850	0	23,850
Burger King (1,2)	8.6	-4.4%	6,380	873	7,253
Wendy's (1)	8.3	-0.6%	5,182	1,394	6,576
Starbucks Coffee (1)	7.6	-9.4%	4,424	6,707	11,131
Taco Bell	6.9	1.5%	4,389	1,245	5,634
Dunkin' Donuts (1)	6.0	5.3%	6,746	26	6,772
Pizza Hut	5.4	8.0%	7,083	459	7,542
KFC	4.7	-4.1%	4,275	780	5,055
Sonic	3.6	-5.7%	3,117	455	3,572

Note(s): 1) Includes figures estimated by Technomic, Inc. 2) Total change in units calculated from data reported in 2010 QSR 50

Source(s): QSR Magazine, 2011 QSR 50 - December, 2011, Available at http://www.qsrmagazine.com/reports/2011-qsr-50?microsite=9341.

3.7.3 2010 Top Supermarkets, by Sales

Supermarket	2010 All Commodity Volume ($millions)	No. of Stores (> $2 million in sales)	Square Feet Selling Area (thousands)
Wal-Mart Stores	143.8	3,001	185,743
Kroger Co.	63.1	2,460	105,777
Safeway, Inc.	35.0	1,461	53,663
Supervalu, Inc.	29.4	1,504	49,826
Ahold USA, Inc. (Stop and Shop, Giant)	25.6	746	31,226
Publix Super Markets, Inc.	22.2	1,035	38,181
Delhaize America, Inc. (Food Lion)	19.0	1,641	48,691
H.E. Butt Grocery Co. (HEB)	12.4	291	14,644
Meijer Inc.	8.8	195	12,498
Great Atlantic & Pacific Tea Co. (Pathmark)	8.1	373	12,385

Note(s): All commodity volume in this example represents the "annualized range of the estimated retail sales volume of all items sold at a retail site that pass through the retailer's cash registers. TDLinx ACV is an estimate based on best available data- a directional measure to be used as an indicator of store and account size, not an actual retail sales report". (Progressive Grocer)

Source(s): Progressive Grocer, 2011 Progressive Grocer Super 50

3.7.4 Advanced Energy Design Guide for Small Retail Buildings (1)

Shell	
Percent Glass	**0.4**
Window (U-Factor	**0.38-0.69**
SHGC	**0.40-0.44**
Wall R-Value (2)	**7.6-15.2 c.i.**
Roof R-Value	
Attic	**30-60**
Insulation Above Deck	**15-25 c.i.**
Lighting	
Average Power Density (W/ft.^2)	**1.3**
System and Plant	
Heating Plant	
Gas Furnace(>225 kBtuh)	**80% Combustion Efficiency**
Cooling Plant	
Air conditioner (>135-240 kBtuh)	**10.8 EER/11.2 IPLV - 11.0 EER/11.5 IPLV**
Service Hot Water	
Gas Storage Water Heater (>75kBtuh)	**90% Thermal Efficiency**

Note(s): 1) Guide provides approximate parameters for constructing a building which is 30% more efficient than ASHRAE 90.1-1999. Ranges are due to climate zone dependencies. 2) Assumes a wall with heat content greaater than 7 Btu/ft^2.

Source(s): ASHRAE, Advanced Energy Design Guide for Small Retail Buildings, 2008.

3.7.5 Energy Benchmarks for Existing Retail Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC	Heating		Cooling		Ventilation	
	Climate Zone	Post	Pre	Post	Pre	Post	Pre
Miami	1A	0.5	0.7	23.0	25.2	14.3	16.1
Houston	2A	11.6	12.4	16.2	18.9	14.6	16.9
Phoenix	2B	8.3	10.2	17.2	21.3	14.2	17.5
Atlanta	3A	24.9	26.2	9.2	11.2	15.1	17.4
Los Angeles	3B	6.9	7.7	3.3	3.9	13.4	14.1
Las Vegas	3B	15.4	17.9	11.6	14.8	12.7	16.9
San Francisco	3C	22.4	22.5	0.7	1.0	10.6	12.1
Baltimore	4A	43.0	46.9	6.2	7.9	13.3	16.2
Albuquerque	4B	30.2	33.8	5.3	6.8	13.7	16.5
Seattle	4C	38.4	42.0	0.9	1.3	11.1	13.7
Chicago	5A	59.5	62.9	4.4	5.3	15.3	18.7
Boulder	5B	43.3	47.2	3.2	4.2	15.2	18.7
Minneapolis	6A	75.5	82.2	3.7	4.3	19.5	21.1
Helena	6B	60.3	66.1	1.9	2.3	20.8	22.2
Duluth	7	92.8	103.7	1.2	1.4	21.1	21.9
Fairbanks	8	156.4	173.4	0.5	0.5	27.1	30.0

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 24,683 square feet and 1 floor. Benchmark interior lighting energy = 37.28 thousand Btu/SF. Interior equipment energy consumption = 7.63 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.7.6 Energy Benchmarks for Newly Constructed Retail Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Ventilation
Miami	1A	0.2	17.0	11.2
Houston	2A	8.1	11.9	10.7
Phoenix	2B	6.4	13.1	10.2
Atlanta	3A	15.3	5.8	9.6
Los Angeles	3B	4.3	1.8	8.0
Las Vegas	3B	11.0	7.5	7.8
San Francisco	3C	16.1	0.4	4.3
Baltimore	4A	28.4	4.3	9.1
Albuquerque	4B	20.2	3.5	8.5
Seattle	4C	28.8	0.6	7.0
Chicago	5A	39.8	2.9	8.9
Boulder	5B	29.7	2.0	8.4
Minneapolis	6A	52.3	2.4	9.0
Helena	6B	45.2	1.1	8.4
Duluth	7	68.9	0.6	5.6
Fairbanks	8	108.9	0.1	9.4

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. The benchmark building had 24,683 square feet and 1 floor. Benchmark interior lighting energy = 19.2 thousand Btu/SF. Interior equipment energy

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.7.7 Energy Benchmarks for Existing Supermarkets, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating		Cooling		Water Heating		Ventilation	
		Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	2.2	2.2	11.8	12.4	0.4	0.4	11.1	11.1
Houston	2A	21.6	21.5	9.7	10.7	0.4	0.4	18.0	18.5
Phoenix	2B	21.4	21.2	11.2	13.2	0.4	0.4	13.6	15.6
Atlanta	3A	41.3	41.1	5.4	6.1	0.5	0.5	21.1	21.7
Los Angeles	3B	22.5	22.3	1.1	1.1	0.5	0.5	12.7	12.3
Las Vegas	3B	32.9	32.6	8.3	10.2	0.4	0.4	18.8	20.1
San Francisco	3C	50.0	48.4	0.3	0.3	0.5	0.5	13.2	13.1
Baltimore	4A	64.7	67.0	3.8	4.5	0.5	0.5	22.3	23.7
Albuquerque	4B	50.7	51.1	3.2	4.1	0.5	0.5	23.7	25.2
Seattle	4C	66.3	68.5	0.4	0.5	0.5	0.5	18.8	20.0
Chicago	5A	81.6	84.5	2.4	2.7	0.5	0.5	27.3	28.6
Boulder	5B	65.3	67.2	1.9	2.3	0.5	0.5	28.3	30.0
Minneapolis	6A	99.9	104.0	2.0	2.3	0.6	0.6	29.9	31.6
Helena	6B	87.3	95.4	1.1	1.3	0.6	0.6	32.1	34.1
Duluth	7	123.5	129.6	0.8	0.6	0.6	0.6	32.1	34.6
Fairbanks	8	188.2	200.6	0.2	0.2	0.7	0.6	40.4	44.6

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 44,985 square feet and 1 floor. Benchmark interior lighting energy = 31.86 thousand Btu/SF. Interior equipment energy consumption = 20.74 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.7.8 Energy Benchmarks for Newly Constructed Supermarkets, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	2.1	7.9	0.4	8.3
Houston	2A	19.1	6.2	0.4	11.2
Phoenix	2B	19.7	8.2	0.4	11.0
Atlanta	3A	34.9	3.0	0.5	11.7
Los Angeles	3B	23.0	0.6	0.5	23.0
Las Vegas	3B	30.7	4.7	0.4	11.4
San Francisco	3C	43.6	0.2	0.5	9.4
Baltimore	4A	53.5	2.4	0.5	12.2
Albuquerque	4B	44.9	1.8	0.5	13.0
Seattle	4C	59.5	0.3	0.5	10.9
Chicago	5A	67.6	1.5	0.5	13.3
Boulder	5B	57.7	1.1	0.5	14.5
Minneapolis	6A	81.4	1.3	0.6	14.4
Helena	6B	74.1	0.7	0.6	18.4
Duluth	7	99.8	0.6	0.6	16.6
Fairbanks	8	145.6	0.3	0.6	20.5

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations.The benchmark building had 44,985 square feet and 1 floor. Benchmark interior lighting energy = 19.7 thousand Btu/SF. Interior equipment energy

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.7.9 Number of Stores and Average Sales in the Grocery Industry as of 2007

Store Type	Number of Stores (1,000s)	US Annual Sales ($Billions)
Supermarket	35.0	535.4
Convenience	145.9	306.6
Grocery (<$2million)	13.7	18.2
Wholesale Clubs	1.2	101.5
Military Convenience Stores	0.4	2.2
Total	**196.2**	**963.9**

Source(s): DOE/EERE/Navigant Consulting, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Sept. 2009, Table 3-2, p. 27.

3.8.1 Medical Offices, Utilities Cost Per Square Foot ($2010)

Expense	Downtown	Suburban	All
HVAC Electricity	2.39	1.81	1.84
Non-HVAC Electricity	N/A	1.51	1.53
Natural Gas	0.52	0.41	0.41
Water/Sewer	0.15	0.22	0.21
Overall Utilities (1)	**2.53**	**2.59**	**2.57**

Note(s): 1) Does not equal sum of the other categories. Can also include purchased steam, purchased chilled water, and fuel oil.

Source(s): BOMA International, The Experience Exchange Report 2010, 2010.

3.8.2 Inpatient Medical Facilities Square Footage, Delivered Energy, Energy Intensity, Selected Years

	Total Square Footage (billion)	Energy Use (quadrillion Btus)	Energy Intensity (thousand Btus/SF)
1999	1.87	0.43	229.0
2003	1.91	0.48	249.3
2008	2.15	0.45	210.1
2010	**2.24**	**0.48**	**213.7**
2015	2.45	0.51	208.2
2020	2.66	0.54	202.9
2025	2.88	0.56	194.8
2030	3.09	0.59	190.9
2035	3.30	0.61	184.6

Source(s): EIA, The Commercial Energy Consumption Survey 2003, Table A2. Census Region, Number of Buildings and Floorspace for All Buildings (Including Malls); EIA, The Commercial Energy Consumption Survey 1999, Table B3. Page 11 Census Region, Number of Buildings and Floorspace; EIA, The Annual Energy Outlook 2012 Early Release supplemental tables for regional detail, Table 32, Jan. 2012.

3.8.3 Energy Benchmarks for Existing Hospitals, by Selected City and End-Use (thousand Btu per square foot)

	IECC	Heating		Cooling		Water Heating		Ventilation	
	Climate Zone	Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	34.6	40.7	88.9	85.4	1.8	1.8	20.0	21.0
Houston	2A	42.1	48.0	89.5	86.9	2.2	2.1	19.6	20.8
Phoenix	2B	42.2	48.6	82.1	80.2	2.0	1.9	20.7	21.9
Atlanta	3A	45.8	53.9	83.7	82.1	2.5	2.5	19.0	20.6
Los Angeles	3B	45.4	46.9	75.4	71.0	2.5	2.4	18.5	18.8
Las Vegas	3B	40.9	48.0	69.5	69.0	2.2	2.2	18.5	21.2
San Francisco	3C	49.2	52.8	66.5	64.1	2.8	2.7	17.1	18.0
Baltimore	4A	49.0	60.3	79.8	79.7	2.8	2.7	18.2	19.8
Albuquerque	4B	36.2	42.6	56.1	55.4	2.8	2.7	18.7	20.1
Seattle	4C	50.5	61.2	65.4	64.6	3.0	2.9	17.5	18.6
Chicago	5A	52.5	55.9	67.3	64.0	3.1	3.0	17.8	18.0
Boulder	5B	39.1	41.1	52.6	50.1	3.0	3.0	18.1	18.2
Minneapolis	6A	55.7	60.5	59.7	56.9	3.3	3.2	17.3	17.5
Helena	6B	45.5	49.4	48.4	46.0	3.3	3.2	17.3	17.4
Duluth	7	59.8	64.0	50.6	47.2	3.6	3.5	16.9	16.5
Fairbanks	8	86.9	91.1	34.3	31.1	4.0	3.9	16.5	15.3

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 241,263 square feet and 5 floors. Benchmark interior lighting energy = 32.89 thousand Btu/SF. Interior equipment energy consumption = 31.03 thousand Btu/SF. Ventilation includes energy used by fans and heat rejection systems.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.8.4 Energy Benchmarks for Newly Constructed Hospitals, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation (1)
Miami	1A	40.6	67.5	1.8	17.4
Houston	2A	47.2	68.1	2.1	17.1
Phoenix	2B	42.5	62.3	1.9	17.4
Atlanta	3A	48.6	62.5	2.5	16.4
Los Angeles	3B	47.6	55.5	2.4	15.7
Las Vegas	3B	41.8	52.0	2.2	16.2
San Francisco	3C	56.6	51.5	2.7	16.1
Baltimore	4A	55.4	60.5	2.7	16.1
Albuquerque	4B	37.9	41.7	2.7	15.5
Seattle	4C	55.1	49.7	2.9	15.2
Chicago	5A	58.2	51.0	3.0	15.6
Boulder	5B	42.3	39.3	3.0	15.1
Minneapolis	6A	62.8	45.5	3.2	15.1
Helena	6B	50.8	36.6	3.2	14.7
Duluth	7	67.0	38.5	3.5	14.7
Fairbanks	8	89.1	25.2	3.9	13.5

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. The benchmark building had 241,263 square feet and 5 floors. Benchmark interior lighting energy = 16.36 thousand Btu/SF. Interior equipment energy consumption = 15.15 thousand Btu/SF. Ventilation includes energy used by fans and heat rejection systems.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>. Version 1.3_5.0, January 2012.

3.8.5 Energy Benchmarks for Existing Outpatient Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC	Heating		Cooling		Water Heating		Ventilation	
	Climate Zone	Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	65.4	60.3	69.6	61.9	0.7	0.7	24.6	23.9
Houston	2A	73.2	76.2	54.0	52.9	0.8	0.8	22.1	24.0
Phoenix	2B	79.1	79.8	54.7	52.9	0.7	0.7	23.8	25.3
Atlanta	3A	83.1	91.1	41.8	42.1	0.9	0.9	22.1	24.6
Los Angeles	3B	87.8	86.3	37.4	35.6	0.9	0.9	22.5	23.1
Las Vegas	3B	76.6	80.5	44.1	44.0	0.8	0.8	23.2	25.5
San Francisco	3C	85.0	93.4	25.0	24.7	1.0	1.0	20.3	22.2
Baltimore	4A	85.9	97.6	34.8	35.3	1.0	1.0	21.0	23.5
Albuquerque	4B	76.5	83.6	30.4	30.9	1.0	1.0	24.1	26.4
Seattle	4C	91.7	103.1	22.8	22.6	1.1	1.0	20.9	22.9
Chicago	5A	92.4	96.0	28.1	26.4	1.1	1.1	21.2	22.1
Boulder	5B	79.9	82.9	24.7	23.3	1.1	1.1	23.4	24.4
Minneapolis	6A	97.1	102.0	24.9	23.5	1.2	1.1	21.1	22.1
Helena	6B	88.6	93.2	19.9	18.8	1.2	1.2	22.3	23.3
Duluth	7	100.6	104.6	17.0	15.5	1.3	1.3	20.8	21.2
Fairbanks	8	129.2	132.6	12.2	10.8	1.5	1.4	20.6	20.3

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 40,932 square feet and 3 floors. Benchmark interior lighting energy = 18.42 thousand Btu/SF. Interior equipment energy consumption = 46.01 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.8.6 Energy Benchmarks for Newly Constructed Outpatient Buildings, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	49.4	49.3	0.7	19.5
Houston	2A	58.9	41.4	0.8	19.4
Phoenix	2B	60.3	40.6	0.7	19.9
Atlanta	3A	66.0	31.9	0.9	19.3
Los Angeles	3B	63.8	26.4	0.9	18.3
Las Vegas	3B	57.7	32.1	0.8	19.6
San Francisco	3C	72.1	19.8	1.0	18.5
Baltimore	4A	72.1	27.4	1.0	19.0
Albuquerque	4B	63.5	23.7	1.0	21.7
Seattle	4C	74.7	17.7	1.0	18.5
Chicago	5A	75.3	21.3	1.1	18.8
Boulder	5B	65.9	19.3	1.1	21.0
Minneapolis	6A	81.3	19.0	1.1	18.9
Helena	6B	74.3	15.6	1.2	20.0
Duluth	7	84.2	13.2	1.3	18.7
Fairbanks	8	99.7	8.8	1.4	17.7

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and are designed to provide a consistent baseline to compare building performance in energy-use simulations. The benchmark building had 40,932 square feet and 3 floors. Benchmark interior lighting energy = 13.02 thousand Btu/SF. Interior equipment energy consumption = 46.01 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.9.1 2003 Delivered Energy End-Use Intensities and Consumption of Educational Facilities, by Building Activity (1)

	(10^12 Btu)		(thousand Btu/SF)
Space Heating	389	47%	39.4
Cooling	79	10%	8.0
Ventilation	83	10%	8.4
Water Heating	57	7%	5.8
Lighting	113	14%	11.5
Cooking	8	1%	0.8
Refrigeration	16	2%	1.6
Office Equipment	4	0%	0.4
Computers	32	4%	3.4
Other	39	5%	4.0
Total	**820**	100%	**83.1**

Note(s): 1) Educational facilities include K-12 as well as higher education facilities. 2) Due to rounding, sum does not add up to total.

Source(s): EIA, 2003 Commercial Building Energy Consumption and Expenditures End-Uses, Sept. 2008, Table E1A and E2A.

3.9.2 Number of Elementary and Secondary Schools in the United States, Enrollment, and Students per School, 2007-2008

	Number of Schools (thousands)	Enrollment (millions)	Average Students per School
Public Schools	98.9	49.2	498
Elementary	67.1		
Secondary	24.6		
Combined	5.9		
Other (1)	1.3		
Private Schools	33.7	6.0	177
Elementary	21.9		
Secondary	2.9		
Combined	8.9		

Note(s): 1) Includes special education, alternative, and other schools not classified by grade span.

Source(s): U.S. Department of Education/National Center for Educational Statistics (NCES), Digest of Education Statistics: 2010, April 2011, Table 2 for enrollment, Table 5 for number of educational institutions.

3.9.3 National Enrollment and Expenditures for Public K-12 Facilities ($2010)

School Year Beginning	Enrollment (millions)	Expenditures ($billion)	Expenditures per Pupil
1986	39.4	272.2	6,904
1990	41.2	330.2	8,011
1995	44.8	255.1	5,689
2000	47.2	348.4	7,380
2005	49.1	449.1	9,145
2010	49.3	523.7	10,621
2015	50.7	567.1	11,193
2018	51.8	610.5	11,784
2020	52.7	638.8	12,129

Source(s): NCES, Projections of Educational Statistics to 2010, Table 18 for 1995-2020; NCES, Projections of Educational Statistics to 2015, Sept. 2006, Table 34, p. 78 for 1990; NCES, Projections of Educational Statistics to 2011, Oct. 2001, Table 33, p. 88 for 1986; and EIA, Annual Energy Review 2010, October 2011, Appendix D, p. 353 for price inflators.

3.9.4 Total Expenditures for K-12 School Plant Operations and Maintenance, by Function ($2010 Billion)

	1995-96		2000-01		2005-06		2006-07		2007-08	
Salaries and Benefits	18.4	53%	21.5	51%	24.2	49%	24.8	49%	25.4	51%
Purchased Services	10.4	30%	12.0	28%	13.2	27%	13.6	27%	13.6	27%
Supplies	5.7	16%	8.6	20%	11.2	23%	11.4	23%	12.0	24%
Other	0.3	1%	0.3	1%	0.4	1%	0.4	1%	0.5	1%
Total	**34.9**	100%	**42.5**	100%	**49.0**	100%	**50.2**	100%	**51.4**	100%

Note(s): 1) Operation and maintenance services include salaries, benefits, supplies, and contractual fees for supervision of operations and maintenance, operating buildings (heating, lighting, ventilating, repair and replacement), care and upkeep of grounds and equipment, vehicle operation and maintenance (other than student transportation), security and other operations and maintenance services.

Source(s): NCES, Digest of Educational Statistics 2010, April 2011, Table 188; EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353 for price inflators.

3.9.5 New Construction and Renovations Expenditures for Public K-12 Schools ($2010 Billion)

	New Schools	Additions	Renovations	Total
2000	11.72	7.65	7.04	26.41
2001	12.70	6.54	5.59	24.83
2002	14.91	6.31	4.76	25.98
2003	13.23	5.95	4.29	23.47
2004	13.98	4.91	4.20	23.09
2005	14.16	5.48	4.29	23.93
2006	13.71	5.31	4.16	23.18
2007	13.32	5.16	4.04	22.52
2008	13.21	3.30	3.36	19.87
2009	12.06	2.14	2.34	16.54
2010	8.67	3.07	2.80	14.54

Note(s): Data includes public school districts only and is presented in calendar years, rather than school years.

Source(s): School Planning & Management, 6th Annual School Construction Report, February 2001 Table 1, p. 28 for 2000; School Planning & Management, 2002 Construction Report, February 2002 Table 1, p. 3 for 2001; School Planning & Management, 2003 Construction Report, February 2003 Table 1, p. 3 for 2002; School Planning & Management, 9th Annual Construction Report, February 2004, Table 1, p. 3 for 2003; School Planning & Management, 10th Annual School Construction Report, February 2005, Table 1, p. C3 for 2004; School Planning & Management, 11th Annual Construction Report, February 2006, Table 1, p. C3 for 2005; School Planning & Management, The 2007 Construction Report, February 2007, Table 1, p. C3 for 2006; School Planning & Management, The 2008 Annual School Construction Report, February 2008, Table 1, p. CR3 for 2007; School Planning & Management, The 2009 Annual School Construction Report, February 2009, Table 1, p. CR3 for 2008; School Planning & Management, 15th Annual School Construction Report, February 2010, Table 1, p. CR3 for 2009; School Planning & Management, 16th Annual School Construction Report, February 2011, Table 1, p. CR3 for 2010; and EIA, Annual Energy Review 2010, August 2011, Appendix D, p. 353 for price inflators.

3.9.6 2010 Regional New Construction and Renovations Expenditures for Public K-12 Schools ($Million)

Region	New Schools	Additions	Renovation	Total
Region 1 (CT, MA, ME, NH, RI, VT)	312.3	94.0	246.6	**652.9**
Region 2 (NJ, NY, PA)	513.3	392.5	588.9	**1,494.7**
Region 3 (DE, MD, VA, WV)	541.2	133.9	154.2	**829.3**
Region 4 (KY, NC, SC, TN)	1,012.6	202.7	115.0	**1,330.3**
Region 5 (AL, FL, GA, MS)	1,338.0	327.6	175.9	**1,841.4**
Region 6 (IN, MI, OH)	359.6	286.3	278.9	**924.8**
Region 7 (IL, MN, WI)	309.3	206.1	135.3	**650.7**
Region 8 (IA, KS, MO, NE)	217.6	231.4	187.8	**636.8**
Region 9 (AR, LA, OK, TX)	1,653.9	479.6	387.8	**2,521.2**
Region 10 (CO, MT, ND, NM, SD, UT, WY)	548.2	130.9	93.3	**772.4**
Region 11 (AZ, CA, HI, NV)	1,605.4	407.3	275.2	**2,287.9**
Region 12 (AK, ID, OR, WA)	258.2	181.8	158.1	**598.1**
Total	**8,669.5**	**3,074.1**	**2,796.8**	**14,540.4**

Source(s): School Planning & Management, 16th Annual School Construction Report, February 2011 p. CR3

3.9.7 Percentage of Public K-12 Schools with Environmental Factors that Interfere with Classroom Instruction (1)

	Permanent Buildings (2)			Temporary Buildings (3)		
	Small	Medium	Large	Small	Medium	Large
Lighting, artificial	5%	6%	6%	11%	3%	10%
Lighting, natural	6%	6%	4%	11%	5%	12%
Heating	14%	11%	12%	11%	6%	12%
Air conditioning	16%	16%	17%	15%	6%	14%
Ventilation	11%	12%	12%	20%	8%	16%
Indoor air quality	8%	11%	9%	12%	9%	14%
Acoustincs or noise control	12%	13%	12%	23%	14%	19%
Physical condition of buildings	10%	11%	10%	15%	12%	15%
Size or configuration of rooms	14%	12%	13%	15%	16%	18%

Note(s): 1) Small school is defined as having 1-349 students, medium 350-699 students, and a large school has 700 or more students. 2) Based on the 99% of public schools with classrooms in permanent buildings. 3) Based on the 33% of public schools with classrooms in temporary

Source(s): National Center for Education Statistics, Digest of Educational Statistics 2010, April 2011, Table 106, for 2005 data.

3.9.8 Advanced Energy Design Guide for Typical Educational Facilities (1)

Shell

Percent Glass	Maximum 35%
Window U-Factor	0.33 - 0.56
Wall R-Value	5.7 - 15.2
Roof R-Value	
Attic	30.0 - 60.0
Insulation Above Deck	25.0
Wall Material	Mass: Heat Capacity > 7 Btu/SF*F

Lighting

Average Power Density(Watts/ft.^2)	
With Daylighting	1.2
Without Daylighting	0.9 - 1.1

System and Plant

System and Plant		
1 Central System		
Packaged Multi-Zone w/ Economizer		Comply with ASHRAE 90.1
Heating Plant:	Gas Boiler	80-85 Combustion Efficiency
Cooling Plant:	Water-Cooled Chiller	Comply with ASHRAE 90.1
Service Hot Water:	Gas Boiler	90 Combustion Efficiency

Note(s): 1) Guide provides approximate parameters for constructing a building which is 30% more efficient than ASHRAE 90.1-1999. Ranges are because of climate zone dependencies.

Source(s): ASHRAE, Advanced Energy Design Guide for K-12 School Buildings, 2008.

3.9.9 Energy Benchmarks for Existing Primary Schools, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating		Cooling		Water Heating		Ventilation	
		Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	0.7	0.7	20.6	22.4	1.4	1.4	3.1	3.4
Houston	2A	6.4	8.3	13.3	17.2	1.7	1.7	2.4	2.9
Phoenix	2B	4.1	6.1	14.2	19.6	1.6	1.5	2.9	3.6
Atlanta	3A	12.5	16.8	7.6	10.6	2.0	2.0	2.1	2.7
Los Angeles	3B	4.4	4.4	6.1	6.6	1.9	1.9	2.2	2.4
Las Vegas	3B	6.6	10.2	10.1	14.5	1.8	1.7	2.6	3.4
San Francisco	3C	10.9	12.6	2.3	3.0	2.2	2.1	1.9	2.2
Baltimore	4A	18.6	29.8	5.4	7.8	2.2	2.2	1.8	2.5
Albuquerque	4B	13.3	19.5	4.7	6.8	2.2	2.1	2.3	3.1
Seattle	4C	17.0	25.8	1.4	2.0	2.3	2.3	1.5	2.0
Chicago	5A	27.0	33.3	3.9	4.5	2.4	2.4	1.9	2.1
Boulder	5B	18.2	24.1	2.7	3.4	2.4	2.3	1.8	2.2
Minneapolis	6A	34.8	43.2	2.9	3.5	2.6	2.5	1.7	2.0
Helena	6B	28.0	33.5	1.6	1.9	2.6	2.5	1.7	1.9
Duluth	7	42.3	51.8	1.2	1.3	2.9	2.8	1.5	1.9
Fairbanks	8	84.2	99.3	0.7	0.8	3.2	3.1	2.0	2.2

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 73,932 square feet and 1 floor. Benchmark interior lighting energy = 23.72 thousand Btu/SF. Interior equipment energy consumption = 18.77 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.9.10 Energy Benchmarks for Newly Constructed Primary Schools, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	0.3	15.9	1.4	2.7
Houston	2A	4.7	11.5	1.7	2.2
Phoenix	2B	3.3	12.4	1.5	2.5
Atlanta	3A	8.3	6.2	2.0	1.8
Los Angeles	3B	2.0	3.6	1.9	1.5
Las Vegas	3B	4.7	8.5	1.7	2.2
San Francisco	3C	8.8	2.0	2.1	1.7
Baltimore	4A	15.8	5.0	2.2	1.7
Albuquerque	4B	10.3	4.2	2.1	2.0
Seattle	4C	12.9	1.1	2.3	1.3
Chicago	5A	21.4	3.6	2.4	1.7
Boulder	5B	15.2	2.6	2.3	1.6
Minneapolis	6A	30.9	2.9	2.5	1.7
Helena	6B	24.0	1.5	2.5	1.4
Duluth	7	37.0	1.2	2.8	1.5
Fairbanks	8	59.6	0.5	3.1	1.4

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations.The benchmark building had 73,932 square feet and 1 floor. Benchmark interior lighting energy = 15.80 thousand Btu/SF. Interior equipment energy

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012.

3.9.11 Energy Benchmarks for Existing Secondary Schools, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating		Cooling		Water Heating		Ventilation	
		Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	1.0	10.2	73.6	17.5	1.2	1.4	6.0	9.1
Houston	2A	9.5	7.0	49.7	20.7	1.5	1.3	5.2	10.9
Phoenix	2B	6.6	20.9	53.9	10.0	1.3	1.7	5.7	8.8
Atlanta	3A	18.7	5.8	31.4	5.2	1.7	1.6	5.0	7.3
Los Angeles	3B	5.7	11.5	25.2	14.4	1.7	1.5	5.0	10.3
Las Vegas	3B	10.5	15.8	34.7	1.7	1.5	1.8	5.3	7.5
San Francisco	3C	16.1	36.2	11.4	7.3	1.9	1.9	4.8	8.4
Baltimore	4A	31.0	22.9	23.8	7.0	2.0	1.9	4.9	8.7
Albuquerque	4B	20.5	35.2	15.1	1.5	1.9	2.0	5.1	7.3
Seattle	4C	30.1	45.1	7.1	4.8	2.0	2.1	4.6	7.2
Chicago	5A	42.3	32.2	17.9	3.7	2.1	2.1	5.0	7.0
Boulder	5B	29.6	61.0	10.1	3.7	2.1	2.3	5.0	7.2
Minneapolis	6A	56.4	48.1	14.7	2.1	2.3	2.3	5.1	7.1
Helena	6B	44.9	74.7	6.6	1.3	2.3	2.5	5.1	7.2
Duluth	7	68.1	130.1	6.6	0.6	2.6	2.8	5.2	8.5
Fairbanks	8	120.1	0.0	3.8	0.0	2.8	0.0	6.0	0.0

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 210,810 square feet and 2 floors. Benchmark interior lighting energy = 18.41 thousand Btu/SF. Interior equipment energy consumption = 11.83 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.9.12 Energy Benchmarks for Newly Constructed Secondary Schools, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	0.7	54.0	1.1	5.5
Houston	2A	8.1	41.0	1.4	5.2
Phoenix	2B	5.8	44.4	1.3	5.6
Atlanta	3A	15.3	25.3	1.7	4.9
Los Angeles	3B	4.1	15.9	1.6	4.7
Las Vegas	3B	8.6	28.2	1.5	5.2
San Francisco	3C	13.9	9.6	1.8	4.7
Baltimore	4A	27.5	20.9	1.9	4.9
Albuquerque	4B	17.9	13.8	1.9	5.1
Seattle	4C	25.8	5.9	2.0	4.5
Chicago	5A	36.7	15.9	2.1	4.9
Boulder	5B	26.3	9.5	2.1	4.9
Minneapolis	6A	50.4	13.4	2.3	5.0
Helena	6B	40.4	6.0	2.3	5.0
Duluth	7	61.0	6.1	2.5	5.3
Fairbanks	8	96.7	2.2	2.8	5.5

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations.The benchmark building had 210,810 square feet and 2 floors. Benchmark interior lighting energy = 15.20 thousand Btu/SF. Interior equipment energy consumption = 11.83 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.10.1 2003 Floorspace and Energy Consumption for Hotels and Motels/Inns (1)

	Hotels	Motels/Inns
Average Electricity Consumption(kBtus/SF):	61.3	40.5
Average Natural Gas Consumption(kBtus/SF):	50.7	42.2
Average Fuel Oil Consumption(kBtus/SF)(2):	5.4	36.6
Total Energy Consumption (quads)	**0.21**	**0.08**
Average Energy Consumption (thousand Btu/SF):	**110.0**	**74.9**
Total Floorspace (billion SF):	**1.90**	**1.05**

Note(s): 1) Averages for fuel souces include only the floorspace that use a given fuel. 2) For Hotels, fuel oil was often used in buildings that used natural gas as well.

Source(s): EIA, Commercial Buildings Energy Consumption Survey 2003 Public Use Data Files, December 2006, Tables 2, 15, and 16.

3.10.2 Lodging Industy, Sales and Occupancy Rates

Year	Properties (1)	Guestrooms (thousand)	Sales ($2010 billion)	Avg. Occupancy Rate	Avg. Room Rate ($2010)
2001	41,393	4,200	126.47	60.3%	107.75
2002	47,040	4,398	123.25	59.1%	100.35
2003	47,584	4,416	123.83	61.1%	97.04
2004	47,598	4,412	130.02	61.3%	98.61
2005	47,590	4,402	135.78	63.1%	100.57
2006	47,135	4,389	142.96	63.3%	104.79
2007	48,062	4,476	145.12	63.1%	108.13
2008	49,505	4,626	143.24	60.4%	108.85
2009	50,800	4,762	128.41	54.7%	98.78
2010	51,015	4,802	127.70	57.6%	98.07

Note(s): 1) Based on properties with 15 or more rooms

Source(s): The American Hotel & Lodging Association, 2002 Lodging Industy Profile, p. 2-3; The American Hotel & Lodging Association, 2003 Lodging Industy Profile, p. 2-3, 2002; The American Hotel & Lodging Association, 2004 Lodging Industy Profile, p. 2-4, 2004; The American Hotel & Lodging Association, 2005 Lodging Industy Profile, p. 2, 4, 2005; The American Hotel & Lodging Association, 2006 Lodging Industy Profile, p. 2, 4, 2006; The American Hotel & Lodging Association, 2007 Lodging Industy Profile, p. 2, 4, 2007; The American Hotel & Lodging Association, 2008 Lodging Industry Profile p. 2, 4, 2008; The American Hotel & Lodging Association, 2009 Lodging Industry Profile, available at: http://www.ahla.com/content.aspx?id=28832; The American Hotel & Lodging Association, 2010 Lodging Industry Profile; The American Hotel & Lodging Association, 2011 Lodging Industry Profile, available at: http://www.ahla.com/content.aspx?id=32567

3.10.3 Lodging Industry Profile (Thousands)

	2004		2006		2008		2010	
Location	Properties	Rooms	Properties	Rooms	Properties	Rooms	Properties	Rooms
Suburban	15.8	1,564	15.9	1,577	16.8	1,668	17.5	1,746
Highway	6.7	446	6.8	452	7.1	480	7.3	498
Urban	4.6	706	4.5	691	4.7	721	4.9	754
Airport	1.9	274	2.0	275	2.1	294	2.2	305
Resort	4.1	595	3.6	567	3.7	584	3.8	595
Small Metro	14.5	826	14.4	827	15.1	878	15.4	904
Rate								
Under $30	0.9	56	0.9	58	1.2	54	0.8	54
$30-44.99	8.0	510	7.1	435	7.3	418	6.6	406
$45-59.99	16.1	1,045	14.8	933	15.0	916	14.5	896
$60-85	14.3	1,368	14.2	1295	14.5	1326	15.8	1386
Over $85	8.3	1,434	10.1	1668	11.4	1913	13.4	2060
Number of Rooms								
Under 75	27.5	1,164	26.9	1147	27.8	1188	28.1	1212
75 - 149	14.3	1,524	14.5	1542	15.8	1668	16.9	1773
150 - 299	4.2	847	4.1	824	4.3	853	4.4	876
300 - 500	1.1	398	1.1	399	1.1	416	1.1	419
Over 500	0.5	479	0.5	478	0.5	502	0.5	522

Source(s): The American Lodging Association, 2007 Lodging Industy Profile, p. 2, 4, 2007; The American Lodging Association, 2008 Profile p. 2, 4, 2008; The American Hotel & Lodging Association, 2009 Lodging Industry Profile, available at: http://www.ahla.com/content.aspx?id=28832; The American Hotel & Lodging Association, 2010 Lodging Industry Profile, available at: http://www.ahla.com/content.aspx?id=30505; The American Hotel & Lodging Association, 2011 Lodging Industry Profile, available at http://www.ahla.com/content.aspx?id=32567

3.10.4 Energy Benchmarks for Existing Large Hotels, by Selected City and End-Use (thousand Btu per square foot)

	IECC	Heating		Cooling		Water Heating		Ventilation	
	Climate Zone	Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	1.4	0.1	155.0	142.0	30.1	29.4	8.9	11.2
Houston	2A	7.1	1.9	119.9	117.9	38.1	37.1	8.8	10.8
Phoenix	2B	4.5	1.1	113.2	111.5	33.5	32.7	9.1	11.4
Atlanta	3A	13.1	3.8	91.3	88.5	45.7	44.6	8.8	10.5
Los Angeles	3B	3.1	0.7	77.5	74.9	44.3	43.1	8.9	10.4
Las Vegas	3B	7.4	2.2	78.9	83.0	39.0	38.0	9.0	11.2
San Francisco	3C	8.0	2.6	48.8	49.6	50.8	49.5	8.7	10.0
Baltimore	4A	20.8	6.9	82.8	74.4	51.8	50.5	8.8	10.1
Albuquerque	4B	13.7	5.4	51.3	54.8	50.6	49.4	9.1	10.9
Seattle	4C	18.2	6.4	46.7	40.4	54.9	53.5	8.9	9.9
Chicago	5A	29.1	9.7	71.1	63.4	57.1	55.6	8.8	9.6
Boulder	5B	20.5	8.0	47.6	44.8	56.8	55.4	9.0	10.1
Minneapolis	6A	37.2	12.6	67.5	59.8	61.6	60.1	8.8	9.6
Helena	6B	30.3	11.5	43.4	37.9	62.5	60.9	9.0	9.8
Duluth	7	45.5	15.9	51.3	40.6	69.2	67.4	8.9	9.3
Fairbanks	8	74.5	24.3	32.3	23.8	78.3	76.3	9.2	9.1

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 122,075 square feet and 6 floors. Benchmark interior lighting energy = 17.56 thousand Btu/SF. Interior equipment energy consumption = 24.77 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

3.10.5 Energy Benchmarks for Newly Constructed Large Hotels, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	1.3	69.1	29.4	8.7
Houston	2A	5.9	53.7	37.1	8.6
Phoenix	2B	3.8	47.4	32.7	8.8
Atlanta	3A	10.2	43.0	44.6	8.7
Los Angeles	3B	3.1	34.7	43.1	8.5
Las Vegas	3B	6.0	35.4	38.0	8.8
San Francisco	3C	6.6	23.2	49.5	8.9
Baltimore	4A	17.2	37.0	50.5	8.6
Albuquerque	4B	12.3	23.9	49.4	8.8
Seattle	4C	15.0	21.1	53.5	8.5
Chicago	5A	24.2	31.6	55.6	8.6
Boulder	5B	18.4	21.7	55.4	8.8
Minneapolis	6A	31.7	29.0	60.1	8.6
Helena	6B	27.1	18.6	60.9	8.7
Duluth	7	39.6	21.9	67.4	8.7
Fairbanks	8	60.9	13.2	76.3	8.4

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations.The benchmark building had 122,075 square feet and 6 floors. Benchmark interior lighting energy = 11.28 thousand Btu/SF. Interior equipment energy consumption = 24.77 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.10.6 Energy Benchmarks for Newly Constructed Small Hotels, by Selected City and End-Use (thousand Btu per square foot)

	IECC Climate Zone	Heating	Cooling	Water Heating	Ventilation
Miami	1A	0.2	17.9	5.4	5.3
Houston	2A	2.5	13.6	6.5	5.0
Phoenix	2B	1.8	14.1	5.9	5.3
Atlanta	3A	4.5	9.7	7.6	4.8
Los Angeles	3B	1.6	7.5	7.4	4.5
Las Vegas	3B	3.0	10.5	6.6	4.9
San Francisco	3C	4.2	5.2	8.3	4.3
Baltimore	4A	8.0	7.8	8.4	4.5
Albuquerque	4B	5.1	7.1	8.2	5.0
Seattle	4C	6.9	4.1	8.8	4.1
Chicago	5A	11.6	6.3	9.1	4.4
Boulder	5B	8.2	5.4	9.1	4.8
Minneapolis	6A	16.3	5.8	9.7	4.4
Helena	6B	12.8	4.0	9.9	4.5
Duluth	7	20.7	3.9	10.8	4.3
Fairbanks	8	36.6	2.7	12.0	3.9

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations.The benchmark building had 43,186 square feet and 4 floors. Benchmark interior lighting energy = 13.79 thousand Btu/SF. Interior equipment energy consumption = 21.98 thousand Btu/SF.

Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/new_construction.html>, January 2012

3.10.7 Energy Benchmarks for Existing Small Hotels, by Selected City and End-Use (thousand Btu per square foot)

	IECC	Heating		Cooling		Water Heating		Ventilation	
	Climate Zone	Post	Pre	Post	Pre	Post	Pre	Post	Pre
Miami	1A	0.2	0.0	25.7	21.2	5.6	5.4	6.7	2.6
Houston	2A	2.8	0.7	17.7	16.1	6.7	6.5	5.6	2.0
Phoenix	2B	2.0	0.2	18.7	17.0	6.0	5.9	6.2	2.3
Atlanta	3A	5.4	1.9	12.0	11.1	7.8	7.6	5.4	1.6
Los Angeles	3B	1.7	0.0	9.5	9.7	7.6	7.4	5.2	1.4
Las Vegas	3B	3.4	0.6	13.6	13.5	6.8	6.6	5.7	1.9
San Francisco	3C	4.4	0.3	5.8	6.1	8.5	8.3	4.5	0.9
Baltimore	4A	9.2	3.7	9.6	8.8	8.6	8.4	4.9	1.3
Albuquerque	4B	5.9	1.8	8.8	8.8	8.4	8.2	5.5	1.4
Seattle	4C	7.6	2.0	4.9	5.0	9.1	8.8	4.6	0.8
Chicago	5A	13.5	5.2	7.8	6.9	9.4	9.1	4.9	1.1
Boulder	5B	9.1	3.2	6.8	6.4	9.3	9.1	5.3	1.1
Minneapolis	6A	18.3	8.8	7.4	6.5	10.0	9.7	4.8	1.1
Helena	6B	14.2	5.8	5.1	5.0	10.1	9.9	5.0	1.0
Duluth	7	22.8	11.6	4.9	4.2	11.1	10.8	4.6	0.9
Fairbanks	8	41.6	26.7	3.9	3.1	12.3	12.0	4.6	1.1

Note(s): Commercial building energy benchmarks are based off of the current stock of commercial buildings and reflect 2004 ASHRAE 90.1 Climate Zones. They are designed to provide a consistent baseline to compare building performance in energy-use simulations. 'Post' refers to buildings construction in or after 1980. 'Pre' refers to buildings construction before 1980. The benchmark building had 43,186 square feet and 4 floors. Benchmark interior lighting energy = 21.51 thousand Btu/SF. Interior equipment energy consumption = 21.98 thousand Btu/SF.

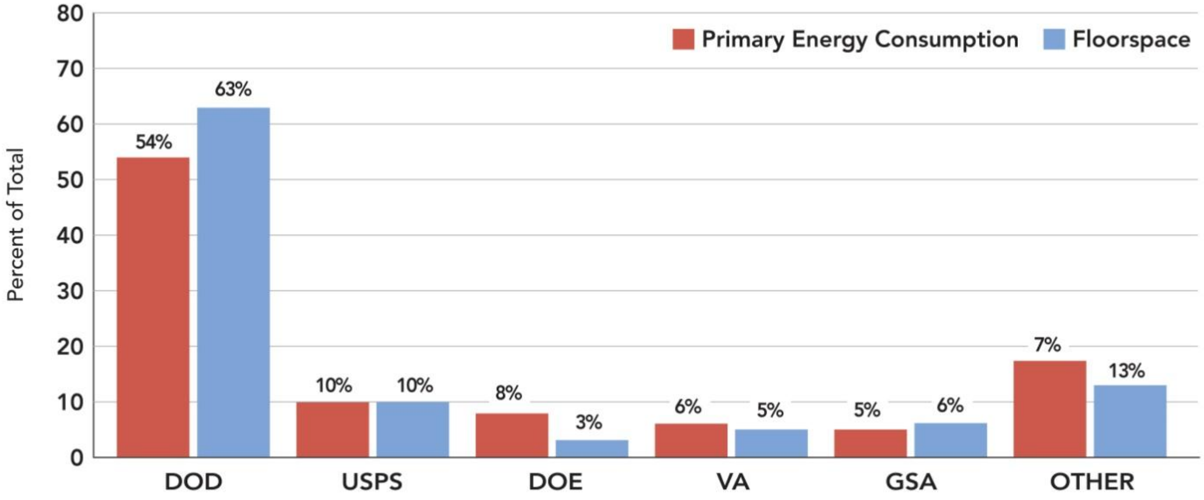
Source(s): DOE/EERE/BT, Commercial Building Benchmark Models, Version 1.3_5.0, November 2010, accessed at <http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html>. Version 1.3_5.0, January 2012.

Chapter 4: Federal Sector

This chapter provides information on Federal building energy consumption, characteristics, and expenditures, as well as information on legislation affecting said consumption. The main points from this chapter are summarized below:

- In FY 2007, Federal buildings accounted for 2.2% of all building energy consumption and 0.9% of total U.S. energy consumption.
- Five Federal agencies were responsible for 83% of all Federal building primary energy consumption in FY 2007. The Department of Defense alone accounted for more than half of this amount.
- From 2006 to 2007, the amount of renewable energy used by Federal agencies as a percentage of total electricity used decreased from 7% to 5%.

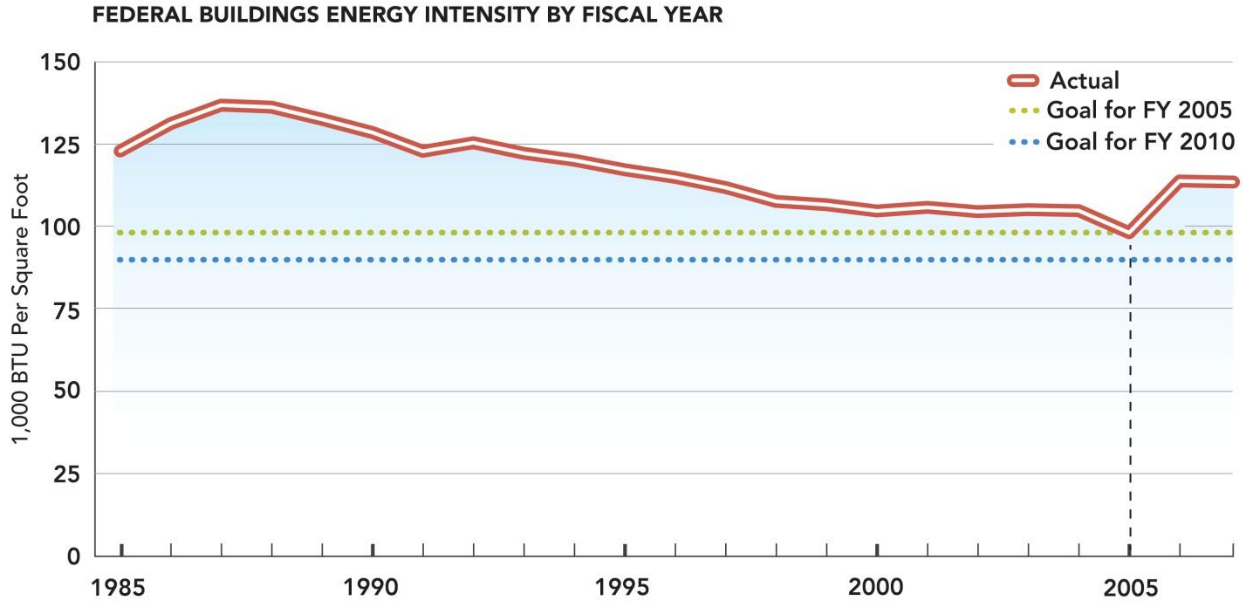
FEDERAL BUILDINGS ENERGY CONSUMPTION BY AGENCY



Federal buildings consumed 0.88 quads of primary energy in fiscal year (FY) 2007, the most recent year for which comprehensive data are available. (4.1.1) This quantity represented 56% of total Federal energy consumption, 2.2% of all building energy consumption, and 0.9% of total U.S. energy consumption. Adjusting for delivery losses, site energy consumption in Federal buildings was 0.39 quads, of which 49% came from electricity. (4.1.2) Other fuels consumed included natural gas (34%), fuel oil (7%), coal (5%), and purchased steam (4%). Overall, Federal agencies spent $6.0 billion ($2010) on energy in FY 2007, a 2.4% decrease from FY 2006 spending. (4.3.1)

Five Federal agencies were responsible for 83% of all Federal building primary energy consumption in FY 2007: the Department of Defense (DOD) (54%), the U.S. Postal Service (USPS) (10%), the Department of Energy (DOE) (10%), the Department of Veterans Affairs (VA) (6%), and the General Services Administration (GSA) (5%). (4.1.2) These five agencies occupied 87% of all Federal building floor space with DOD accounting for 63% of the total, USPS 10%, GSA 6%, VA 5%, and DOE 3%. (4.2.1)

To account for changes in Federal facilities from year to year, the Federal Energy Management Program tracks reductions in energy consumption through energy intensity. Between FY 2003 and FY 2005, Federal building energy intensity fell from 105,200 Btu per square foot to 98,200 Btu per square foot, a decrease of 7%. (4.1.3) However, estimates of energy intensity after FY 2005 are not comparable with estimates before FY 2005. With the passage of the Energy Policy Act, classification of Federal buildings was revised to include energy-intensive facilities not previously considered. This resulted in a higher overall energy intensity of 113,900 Btu per square foot in FY 2006. In FY 2007, energy intensity decreased by only 0.83% compared to the previous year. (4.1.3)



4.1.1 FY 2007 Federal Primary Energy Consumption (Quadrillion Btu)

Buildings and Facilities	**0.88**
Vehicles/Equipment	0.69 (mostly jet fuel and diesel)
Total Federal Government Consumption	1.57

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table A-1, p. 90 for total consumption and Table A-7, p. 95 for vehicle and equipment operations.

4.1.2 FY 2007 Federal Building Energy Use Shares, by Fuel Type and Agency

Fuel Type	*Site* Percent	Primary Percent
Electricity	49.4%	77.3%
Natural Gas	33.5%	14.9%
Fuel Oil	7.3%	3.3%
Coal	5.2%	2.3%
Other	4.9%	2.2%
Total	100%	100%

Agency	Primary Percent
DOD	53.8%
USPS	9.8%
DOE	8.2%
VA	6.4%
GSA	5.1%
Other	16.8%
Total	100%

	FY 2007 (10^15 Btu)
Total Delivered Energy Consumption =	0.39
Total Primary Energy Consumption =	0.88

Note(s): See Table 2.3.1 for floorspace.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table A-4, p. 93 and Table A-6, p. 94 for fuel types, and Table A-1, p. 90 and Table A-7, p. 95 for agency consumption.

4.1.3 Federal Building Delivered Energy Consumption Intensities, by Year (1)

Year	Consumption per Gross Square Foot (10^3 Btu/SF)	Year	Consumption per Gross Square Foot (10^3 Btu/SF)
FY 1985	123.0	FY 1997	111.9
FY 1986	131.3	FY 1998	107.7
FY 1987	136.9	FY 1999	106.7
FY 1988	136.3	FY 2000	104.8
FY 1989	132.6	FY 2001	105.9
FY 1990	128.6	FY 2002	104.6
FY 1991	122.9	FY 2003	105.2
FY 1992	125.5	FY 2004	104.9
FY 1993	122.3	FY 2005	98.2
FY 1994	120.2	FY 2006 (2)	113.9
FY 1995	117.3	FY 2007 (3)	112.9
FY 1996	115.0	FY 2015 (4)	89.5

Note(s): 1) See Table 4.3.1 for floorspace. 2) Increase due to change in categorization of Federal buildings. 3) Adjusted for renewable energy purchases and source savings. 4) Executive Order 13423 goal.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table 1, p. 13; DOE/FEMP, Annual Report to Congress on FEMP, Sept. 2006, Table A-12, p. 158 for 1985-2005 energy consumption; DOE/FEMP, Annual Report on FEMP, Jan. 2001, Table 7-A, p. 55 for 1999, Dec. 2002, Table 8-A, p. 61 for 2000, Feb. 2004, Table 8-A, p. 66 for 2001, Sep. 2004, Table 8-A, p. 65 for 2002, Aug. 2005, Table 6-A, P. A-10 for 2003, Feb. 2006, Table 6-A, p. A-10 for 2004, Sep. 2006, Table 2, p. 13 for 2005, Nov. 2008, Table 1, p. 12 for 2006 and DOE/FEMP for remaining years for floorspace.

4.1.4 Federal Agency Progress Toward the Renewable Energy Goal (Trillion Btu) (1)

	Total Renewable Energy Usage	Total Facility Electricity Use		RE as % of Electricity Use
DOD	5.6	101.2		6%
EPA	0.7	0.4	(2)	154%
DOE	0.7	16.7		4%
GSA	0.8	10.0		8%
NASA	0.2	5.5		4%
DOI	0.4	2.1		18%
Others	1.1	56.5		2%
All Agencies	**9.5**	**192.8**		**5%**

Note(s): 1) In July 2000, in accordance with Section 503 of Executive Order 13123, the Secretary of Energy approved a goal that the equivalent of 2.5 percent of electricity consumption from Federal facilities should come from new renewable energy sources by 2005. 2) EPA's renewable energy use is 154% of its electricity use due to its purchases of renewable electricity for leased space.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table 4, p. 17.

4.2.1 Federal Building Gross Floorspace, by Year and Agency

Fiscal Year	Floorspace (10^9 SF)
FY 1985	3.37
FY 1986	3.38
FY 1987	3.40
FY 1988	3.23
FY 1989	3.30
FY 1990	3.40
FY 1991	3.21
FY 1992	3.20
FY 1993	3.20
FY 1994	3.11
FY 1995	3.04
FY 1996	3.03
FY 1997	3.02
FY 1998	3.07
FY 1999	3.07
FY 2000	3.06
FY 2001	3.07
FY 2002	3.03
FY 2003	3.04
FY 2004	2.97
FY 2005	2.96
FY 2006	3.10
FY 2007	3.01

Agency	2007 Percent of Total Floorspace
DOD	63%
USPS	10%
GSA	6%
VA	5%
DOE	3%
Other	13%
Total	100%

Note(s): The Federal Government owns/operates over 500,000 buildings, including 422,000 housing structures (for the military) and 51,000 nonresidential buildings.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table 1, p. 13; DOE/FEMP, Annual Report to Congress on FEMP, Nov. 2008, Table 1, p. 12 for floorspace by agency. DOE/FEMP, Annual Report on FEMP, Jan. 2001, Table 7-A, p. 55 for 1999, Dec. 2002, Table 8-A, p. 61 for 2000, Feb. 2004, Table 8-A, p. 66 for 2001, Sep. 2004, Table 8-A, p. 65 for 2002, Aug. 2005, Table 6-A, P. A-10 for 2003, Feb. 2006, Table 6-A, p. A-10 for 2004, Sep. 2006, Table 2, p. 13 for 2005, Nov. 2008, Table 1, p. 12 for 2006 and DOE/FEMP for remaining years for floorspace by year.

4.3.1 FY 2007 Federal Buildings Energy Prices and Expenditures, by Fuel Type ($2010)

Fuel Type	Average Fuel Prices ($/million BTU)		Total Expenditures ($ million) (2)
Electricity	23.68 (1)		4,009
Natural Gas	9.37		1,138
Fuel Oil	15.25		419
Coal	3.62		63
Purchased Steam	24.30		318
LPG/Propane	17.06		44
Other	16.19		37
Average	17.05	**Total**	6,029

Note(s): Prices and expenditures are for Goal-Subject buildings. 1) $0.0776/kWh. 2) Energy used in Goal-Subject buildings in FY 2007 accounted for 33.8% of the total Federal energy bill.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table A-4, p. 93 for prices and expenditures, and Table A-9, p. 97 for total energy expenditures; EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

4.3.2 Annual Energy Expenditures per Gross Square Foot of Federal Floorspace Stock, by Year ($2010)

FY 1985	2.13
FY 2000	1.36
FY 2001	1.58
FY 2002	1.49
FY 2003	1.45
FY 2004	1.54
FY 2005	1.59
FY 2006	2.01 (1)
FY 2007	2.01

Note(s): Total Federal buildings and facilities energy expenditures in FY 2006 were $5.79 billion (in $2010). 1) Increase due to change in FEMP categorization of Federal buildings.

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table A-9, p. 97 and Table 1, p. 13; DOE/FEMP, Annual Report to Congress on FEMP, Nov. 2008, Table A-9, p. 78 for energy costs, and Table 1, p. 12 for floorspace for 2006; DOE/FEMP, Annual Report to Congress on FEMP, Sep. 2006, Table A-12, p. 158 for energy costs for 1985-2005; DOE/FEMP, Annual Report on FEMP, Dec. 2002, Table 8-A, p. 61 for 2000; Feb. 2004, Table 8-A, p. 66 for 2001; Sep. 2004, Table 8-A, p. 65 for 2002; Aug. 2005, Table 6-A, P. A-10 for 2003; Feb. 2006, Table 6-A, p. A-10 for 2004; EIA, Annual Energy Review 2009, August 2010, Appendix D, p. 383 for price deflators

4.3.3 Direct Appropriations on Federal Buildings Energy Conservation Retrofits and Capital Equipment ($2010 Million)

FY 1985	522,821	FY 1991	169,061	FY 1997	261,324	FY 2003	201,156
FY 1986	342,653	FY 1992	209,973	FY 1998	340,074	FY 2004	198,588
FY 1987	98,708	FY 1993	170,826	FY 1999	261,784	FY 2005	321,686
FY 1988	108,705	FY 1994	318,739	FY 2000	150,900	FY 2006	301,222
FY 1989	83,340	FY 1995	438,943	FY 2001	162,488	FY 2007	349,350
FY 1990	102,135	FY 1996	238,232	FY 2002	147,895		

Source(s): DOE/FEMP, Annual Report to Congress on FEMP FY 2007, Jan. 2010, Table 11-B, p. 31; DOE/FEMP, Annual Report to Congress on FEMP, Nov. 2007, Table 9-B, p. 26 for 1985, 1990, 1995, 2000-2006. DOE/FEMP, Annual Report to Congress on FEMP, Sep. 2004, Table 4-B, p. 38 for 1986-1989, 1991-1994, 1996-1999. EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

4.4.1 Energy Policy Act of 2005, Provisions Affecting Energy Consumption in Federal Buildings

Energy Management Requirements - Amended reduction goals set by the National Energy Conservation Policy Act, and requires increasing percentage reductions in energy consumption through FY 2015, with a final energy consumption reduction goal of 20 percent savings in FY 2015, as compared to the baseline energy consumption of Federal buildings in FY 2003. (These goals were superseded by Section 431 of the Energy Independence and Security Act of 2007.) [Section 102]

Energy Use Measurement and Accountability - Requires that all Federal buildings be metered to measure electricity use by 2012. [Section 103]

Procurement of Energy Efficient Products - Requires all Federal agencies to procure ENERGY STAR qualified products, for product categories covered by the ENERGY STAR program, or FEMP designated products, unless such products are not available, or if such products are not cost-effective. [Section 104]

Federal Building Performance Standards - Requires that new Federal buildings be designed to achieve savings of at least 30% below ASHRAE Standard 90.1-2004 or 2004 IECC if cost-effective. [Section 109]

Federal Renewable Energy Purchase Requirement - Requires that the Federal government obtain at least 3 percent of electrical energy consumed in FY 2007, 2008 and 2009 from renewable energy sources. This requirement increases to 5 percent in FY 2010, 2011, and 2012, and to 7.5 percent for FY 2013 and all fiscal years after.

Source(s): Energy Policy Act of 2005, Enacted August 8, 2005

4.4.2 Executive Order 13423, Provisions Affecting Energy Consumption in Federal Buildings

-- Requires Federal agencies to improve energy efficiency and reduce greenhouse gas emissions by either 3 percent annual reductions through FY 2015, or by 30 percent by 2015, as compared to FY 2003.

-- Requires Federal agencies to obtain at least half of required renewable energy from new renewable sources.

Source(s): Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, Issued January 24, 2007

4.4.3 Energy Independence and Security Act of 2007, Provisions Affecting Energy Consumption in Federal Buildings

Energy Reduction Goals for Federal Buildings - Amended reduction goals set by the National Energy Conservation Policy Act, and requires increasing percentage reductions in energy consumption through FY 2015, with a final energy consumption reduction goal of 30 percent savings in FY 2015, as compared to the baseline energy consumption of Federal buildings in FY 2003. The goals specified in Section 431 of EISA 2007 supersede those from Section 102 of EPACT 2005. [Section 431]

Management of Energy and Water Efficiency in Federal Buildings - Requires each Federal agency to designate an energy manager, requires that energy manager to evaluate all facilities of that agency for energy and water saving measures once every four years, and requires agencies. Authorizes the Office of Management and Budget to evaluate progress by each agency on energy and water savings measures through semiannual scorecards. [Section 432]

Federal Building Energy Efficiency Performance Standards - Requires that new Federal buildings built after 2010, and Federal building undergoing major renovations after 2010, be designed to reduce fossil fuel consumption, as compared to FY 2003. This reduction requirement increases each 5 years. [Section 433]

Management of Federal Building Efficiency - Requires that Federal agencies select the most energy-efficient designs, systems, equipment, and controls that are life-cycle cost effective, when performing any replacement of installed equipment within a Federal building. [Section 434]

Leasing - Requires that Federal agencies lease space in buildings that have earned the ENERGY STAR label in the most recent year, unless no available space exists. [Section 435]

High Performance Green Federal Buildings - Establishes the Office of Federal High-Performance Green Buildings within the General Services Administration. This office is authorized to coordinate all efforts related to green practices within Federal buildings. [Section 436]

Standard Relating to Solar Hot Water - Requires new Federal buildings, or Federal buildings undergoing major renovations, to meet at least 30 percent of hot water demand through the use of solar hot water heaters, if cost-effective. [Section 523]

Federally-Procured Appliances with Standby Power - Requires all Federal agencies to procure appliances with standby power consumption of less than 1 watt, if available and cost-effective. [Section 524]

Source(s): Energy Independence and Security Act of 2007, Enacted December 19, 2007

Chapter 5: Building Envelope & Equipment

Chapter 5 contains market and technology data on building materials and equipment. Sections 5.1 and 5.2 cover the building envelope, including building assemblies, insulation, windows, and roofing. Sections 5.3 through 5.7 cover equipment used in buildings, including space heating, water heating, space cooling, lighting, thermal distribution (ventilation and hydronics), and appliances. Sections 5.8 and 5.9 focus on energy production from on-site power equipment. The main points from this chapter are summarized below:

- In 2010, shipments of heat pumps and furnaces increased 3% and 12%, respectively, compared to the previous year, reversing a five-year downward trend. (5.3.1).
- New solar photovoltaic capacity in 2010 doubled from the previous year, resulting in cumulative capacity of 2150 MW in the U.S. (5.8.8)
- Residential window sales for new construction dropped 66% from 34.1 million units in 2005 to just 11.4 million units in 2009. (5.2.1) In commercial buildings, low-e glass continued to take market share from clear and tinted glass. (5.2.7)

From 1990 to 2009, the window industry saw major shifts in glazing and framing materials. In the residential market, vinyl frames took a quarter of the market from wood frames, while double-pane sealed insulated glass units took market share from single-pane and unsealed double-pane windows. (5.2.1, 5.2.4, 5.2.5) In the commercial market, tinted and reflective glazing, which together accounted for 47% of the market in 1995, accounted for only 13% in 2009. Low-e coatings increased their share from 17% to 54%, and clear glazing held on to about one-third of the market. (5.2.7)

In the residential HVAC market, heat pumps have been increasing in popularity relative to furnaces, the most commonly purchased type of heating equipment. In 1990, manufacturers shipped only one-third as many heat pumps as furnaces. By 2010, that proportion had increased to nearly three-quarters. (5.3.1)

Seven companies manufactured most of the furnaces, heat pumps, and central air conditioners shipped in 2008 for installation in the United States. UTC/Carrier held the largest market share (32% of gas furnaces and 27% of heat pumps and central air conditioners). (5.3.6, 5.3.7) This equipment was, on the whole, more efficient than the equipment sold in previous years. (5.3.2, 5.3.4) However, the efficiency of the installed base lags behind the efficiency of new equipment due to long service lifetimes, which in the residential sector average between 11 and 20 years, depending on equipment type. (5.3.4, 5.3.8)

In 2005, 52% of households mainly used natural gas to heat their homes. The proportion of households using natural gas changed little over the previous 20 years, while the proportion using electricity increased from 20% to 30%, and the proportion using fuel oil decreased from 12% to 7%. Ten percent of households used other fuels, such as wood and propane. (5.3.11) The proportions were similar for water heating in 2005: 53% used natural gas to heat water, 39% used electricity, and the remainder used other fuels. (5.4.1)

Virtually all U.S. households own a refrigerator and a range or cooktop. Nine out of ten have a microwave oven, four out of ten have a standalone freezer, and three out of ten have one or more room air conditioners. (5.7.3) An estimated 65 million major appliances, including refrigerators, microwaves, ranges, clothes washers and dryers, water heaters, and room air-conditioners were replaced in 2011. (5.7.15)

In 2008, just three companies—A.O. Smith, Rheem Manufacturing, and Bradford-White—manufactured 96% of the water heaters shipped. (5.4.3) Three manufacturers—GE, Electrolux, and Whirlpool—controlled 83% of the refrigerator market and 84% of the range market. (5.7.4, 5.7.10) Whirlpool manufactured nearly two-thirds of the clothes washers and more than two-thirds of the clothes dryers sold in 2008 (5.7.8, 5.7.9). The Korean manufacturer LG Electronics led the room air conditioner and microwave markets, holding one-third of the market of each. (5.7.6, 5.7.11)

A growing number of consumers in the buildings sector generate electricity on site. Excess generation can often be sold back to the grid during times of peak demand. Solar and wind are particularly well suited for this application because they are intermittent, though non-renewable sources are also common. Of the latter, 4,355 MW of combined heat and power capacity were installed by 2011, mostly in colleges and universities (63%) and hospitals (17%). (5.9.3)

Solar power technology consists of solar thermal collectors, which convert solar radiation into thermal energy, and solar PV cells, which convert solar radiation to electric energy. Nearly 14 million square feet of solar thermal collectors were sold domestically in 2009, a 19% drop from 2008 sales. Most of the solar collectors were sold to Florida (27%) and California (26). (5.8.1, 5.8.3) The majority of solar thermal collectors were used for pool heating (71%) and hot water (14%). (5.8.2) The peak capacity of domestic PV sales in 2009 reached more than 600 MW, 84% of which was used in the buildings sector. (5.8.5)

Grid-tied solar PV capacity more than tripled between 2007 and 2010, reaching a total of 2167 MW. Almost 47% of this capacity was located in California. (5.8.9) Small-scale wind power—installations with no more than 100 kW of capacity—also continued to grow. Another 5.2 MW of small wind capacity was added in 2010, bringing the total capacity to 25.6 MW. (5.9.1)

5.1.1 U.S. Insulation Demand, by Type (Million Pounds) (1)

Insulation Type	1992		2001		2006 (1)	
Fiberglass	2,938	55%	3,760	54%	4,085	53%
Foamed Plastic	1,223	23%	1,775	25%	1,955	26%
Cellulose	485	9%	665	9%	730	10%
Mineral Wool	402	8%	445	6%	480	6%
Other	309	6%	370	5%	395	5%
Total	**5,357**	100%	**7,015**	100%	**7,645**	100%

Note(s): 1) Projected.

Source(s): National Insulation Association, www.insulation.org, Aug. 2006.

5.1.2 Industry Use Shares of Mineral Fiber (Glass/Wool) Insulation (1)

	1997	1999	2001	2003	2004	2005
Insulating Buildings (2)	70%	71%	72%	65%	64%	63%
Industrial, Equipment, and Appliance Insulation	27%	26%	25%	28%	30%	31%
Unknown	3%	3%	3%	7%	6%	5%
Total	100%	100%	100%	100%	100%	100%

Note(s): 1) Based on value of shipments. 2) Including industrial.

Source(s): DOC, Annual Survey of Manufacturers: Value of Product Shipments 2005, Nov. 2006, Table 1, p. 54 for 2003-2005; and DOC, 2001 Annual Survey of Manufacturers: Value of Product Shipments, Dec. 2002, p. 65 for 1997-2001.

5.1.3 Thermal Performance of Insulation

	R-Value per Inch (1)			R-Value per Inch (1)
Fiberglass (2)			Perlite/Vermiculite	
Batts	3.1 - 4.3	(3)	Loose-Fill	2.1 - 3.7
Loose-Fill	2.5 - 3.7		Foam Boards	
Spray-Applied	3.7 - 3.9		Expanded Polystyrene	3.9 - 4.4
Rock Wool (2)			Polyisocyanurate/Polyurethane	5.6 - 7.0
Loose-Fill	2.5 - 3.7		Phenolic	4.4 - 8.2
Cellulose			Reflective Insulation	2 - 17
Loose-Fill	3.1 - 3.7		Vacuum Powder Insulation	25 - 30
Spray-Applied	2.9 - 3.5		Vacuum Insulation Panel	20 - 100

Note(s): 1) Hr-SF-F/Btu-in. Does not include the effects of aging and settling. 2) Mineral fiber. 3) System R-Value depends on heat-flow direction and number of air spaces.

Source(s): ASHRAE, 1997 ASHRAE Handbook: Fundamentals, p. 24-4, 22-5; DOE, Insulation Fact Sheet, Jan. 1988, p. 6; Journal of Thermal Insulation, 1987, p. 81-95; ORNL, ORNL/SUB/88-SA835/1, 1990; ORNL, Science and Technology for a Sustainable Energy Future, Mar. 1995, p. 17; and ORNL for vacuum insulation panel.

5.1.4 "Green Roofs" Completed by Year (Thousand SF)

	North America			
	Extensive	Intensive	Mixed	**Total**
2004	917	406	4.9	1,327
2005	1,785	488	198.7	2,472
2006	1,957	1,033	73.8	3,064
2007	-	-	-	2,408
2008	-	-	-	3,182
2009	-	-	-	-
2010	3,109	172	312	4,341
	United States			
	Extensive	Intensive	Mixed	**Total**
2004	777.1	405.8	3.924	1,187
2005	1,570	476.4	102.9	2,150
2006	-	-	-	-
2007	-	-	-	1,953
2008	-	-	-	2,647

Note(s): 1) Extensive: soil depth of less than 6 inches. 2) Intensive: soil depth greater than 6 inches. 3) Mixed: at least 25% break up between extensive and intensive. 4) These data are best used as a gauge of activity in this market rather than actual amount of green roofs.

Source(s): Green Roof Industry Survey, Green Roof Infrastructure Monitor

5.1.5 Properties of Cool Roofing Materials (1)

	Solar Reflectance (2)	Infrared Emittance (3)
Asphalt Shingles		
Shasta White	0.26	0.91
Generic White	0.25	0.91
Generic Grey	0.22	0.91
Light Brown	0.19	0.91
Medium Brown	0.12	0.91
Generic Black	0.05	0.91
White Coatings		
White Coating (1 coat, 8 mil)	0.80	0.91
White Coating (2 coats, 20 mil)	0.85	0.91
Aluminum Coatings		
Aluminum	0.61	0.25
Fibered on Black	0.40	0.56
Membranes		
Gray EPDM (4)	0.23	0.87
White EPDM (4)	0.69	0.87
T-EPDM (4)	0.81	0.92
Light Gravel on Built-Up Roof	0.34	0.90
Metal Roof		
New, Bare Galvanized Steel	0.61	0.04
Tiles		
Red Clay	0.33	0.90
White Concrete	0.73	0.90
Fiber Cement, Pewter Gray	0.25	0.90

Note(s): 1) A good cool-roofing material has high solar reflectance and high infrared emittance. 2) Solar Relectance is the percentage of incident solar radiation that is reflected by the material. 3) A number between 0 and 1 that describes the ability of a material to shed heat. The lower the value, the more heat the material retains. 4) Ethylene propylene diene monomer rubber material.

Source(s): Lawernce Berkley National Laboratory, Cool Roofing Materials Database, http://eetd.lbl.gov/coolroofs/.

5.1.6 ENERGY STAR Cool Roofing Product Shipments (Billion SF) and Penetration Rate

	Commercial Roofing	Residential Roofing	Total	ENERGY STAR Penetration
1999	0.0	0.1	0.1	0.5%
2000	0.0	0.1	0.1	0.4%
2001	0.0	0.1	0.1	0.3%
2002	4.4	0.0	4.5	23.6%
2003	1.0	0.1	1.0	5.4%
2004	1.2	0.3	1.4	7.4%
2005	3.5	0.2	3.7	18.7%
2006	4.1	0.5	4.5	22.5%

Note(s): N/A: Year is before date of ENERGY STAR specification.

Source(s): LBNL, Climate Change Action Plan spreadsheet (updated 2007).

5.2.1 Residential Prime Window Sales, by Frame Type (Million Units) (1)

	Aluminum (2)	Wood (3)	Vinyl	Other	**Total (4)**
New Construction					
1990	5.9	9.4	1.2	0.1	**16.6**
1995	4.7	11.6	4.8	0.3	**21.4**
2000	3.7	12.8	9.0	0.4	**25.8**
2005	6.5	9.2	17.4	1.0	**34.1**
2007	4.4	6.2	13.2	1.0	**24.8**
2009	1.9	2.5	6.3	0.7	**11.4**
Remodeling/Replacement					
1990	3.6	7.6	7.1	0.1	**18.4**
1995	3.9	9.4	9.6	0.2	**23.1**
2000	4.0	10.2	14.8	0.2	**29.2**
2005	2.4	10.0	23.2	0.9	**36.4**
2007	1.9	8.9	22.5	1.0	**34.3**
2009	1.0	6.1	19.1	1.3	**27.5**
Total Construction					
1990	9.5	17.0	8.3	0.2	**35.0**
1995	8.6	21.0	14.4	0.5	**44.5**
2000	7.7	23.0	23.8	0.6	**55.0**
2005	8.9	19.2	40.6	1.9	**70.5**
2007	6.3	15.1	35.7	2.0	**59.1**
2009	2.9	8.6	25.5	1.9	**38.9**

Note(s): 1) Average window life span is 35-45 years. 2) In 1993, 65% of aluminum-framed windows were thermally broken. 3) Includes vinyl-clad and metal-clad units. 4) Due to rounding, sums may not add up to totals.

Source(s): AAMA, Industry Statistical Review and Forecast 1992, 1993 for Note 2; AAMA/NWWDA, Industry Statistical Review and Forecast 1996, 1997, Table 6, p. 6 for 1990; AAMA/WDMA, 2000 AAMA/WDMA Industry Statistical Review and Forecast, Feb. 2001, p. 6 for 1995; 2003 AAMA/WDMA Industry Statistical Review and Forecast, June 2004, p. 6 for 2000 and 2003; and LBNL, Savings from Energy Efficient Windows, Apr. 1993, p. 6 for window life span; AAMA/WDMA, Study of U.S. Market For Windows, Doors, and Skylights, Apr. 2006, p. 41 for 2005; AAMA/WDMA, U.S. Industry Statistical Review and Forecast, Mar. 2008, p. 6 for 2007; AAMA/WDMA, U.S. Industry Statistical Review and Forecast, May 2010, p. 6 for 2009.

5.2.2 Residential Storm Window and Door Shipments, by Frame Type (Million Units)

	Windows				Doors				Total			
Type	1990	2000	2005	2008	1990	2000	2005	2008	1990	2000	2005	2008
Aluminum	10	8	7	N/A	2	4	4	3	12	12	11	N/A
Wood	0	0	0	N/A	0	0	0	0	0	0	0	N/A
Other (1)	1	2	2	N/A	0	1	2	1	1	4	4	N/A
Total (2)	**11**	**11**	**9**	**N/A**	**2**	**6**	**6**	**4**	**13**	**16**	**15**	**N/A**

Note(s): 1) Other includes metal over wood/foam core or vinyl, etc. 2) Due to rounding, sums may not add up to totals.

Source(s): AAMA/NWWDA, Industry Statistical Review and Forecast 1996, 1997, Table 7, p. 7 for 1990; 2003 AAMA/WDMA Industry Statistical Review and Forecast, June 2004, p. 6 for 2000; AAMA/WDMA, Study of U.S. Market for Windows, Doors, and Skylights, Apr. 2006, p. 101, Exhibit G.2 for 2005; AAMA/WDMA, U.S. Industry Statistical Review and Forecast, May 2010, p. 7 for 2008.

5.2.3 Nonresidential Window Sales, by Type and Census Region (Million Square Feet of Vision Area) (1)

	Northeast		Midwest		South		West		Total	
Type	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009
New Construction										
Commercial Windows (2)	4	15	16	22	21	58	13	25	54	120
Curtain Wall	3	10	6	16	16	41	8	18	33	84
Store Front	7	10	11	16	14	41	11	18	43	85
Total (3)	**14**	**36**	**33**	**53**	**51**	**140**	**32**	**60**	**130**	**289**
Remodeling/Replacement										
Commercial Windows (2)	18	12	25	17	46	45	27	19	116	93
Curtain Wall	4	2	6	3	8	7	10	3	28	15
Store Front	12	5	18	8	24	20	22	9	76	41
Total (3)	**34**	**18**	**49**	**27**	**78**	**72**	**59**	**31**	**220**	**148**
Total										
Commercial Windows (2)	22	27	41	40	67	103	40	45	170	213
Curtain Wall	7	12	12	18	24	48	18	21	61	99
Store Front	19	15	29	23	38	61	33	26	119	125
Total (3)	**48**	**54**	**82**	**80**	**129**	**211**	**91**	**91**	**350**	**437**

Note(s): 1) Usage is a good indication of sales. 2) Formerly referred to as Architectural. Includes both shop-fabricated (true architectural) and site-fabricated products. 3) Due to rounding, sums may not add up to totals.

Source(s): AAMA/Ducker Research, Industry Statistical Review and Forecast 1996, Mar. 1997, p. 17 for 1995; AAMA/WDMA, U.S. Industry Statistical Review and Forecast, May 2010, p. 17 for 2009.

5.2.4 Insulating Glass Historical Penetration, by Sector (Percent of New Sales) (1)

Sector	1985	1990	1995	2000	2005	2009
Residential	73%	86%	89%	92%	94%	95%
Nonresidential	63%	80%	84%	86%	88%	89%

Note(s): 1) Usage is a good indication of sales. Includes double- and triple-pane sealed units.

Source(s): Ducker Research, Industry Statistical Review and Forecast 1992-1993 for 1985; AAMA/Ducker Research, Industry Statistical Review and Forecast 1993 for 1990; AAMA/WDMA, 2000 AAMA/WDMA Industry Statistical Review and Forecast, Feb. 2001, p. 12 for 1995; AAMA/WDMA, 2003 AAMA/WDMA Industry Statistical Review and Forecast, June 2004, p.12 for 2000; AAMA/WDMA, U.S. Industry Statistical Review and Forecast, May 2010, p. 12 for 2005 and 2009.

5.2.5 Residential Prime Window Sales, by Glass Type (Million Units)

	Single Pane		Double Pane Sealed IG (1)		Other		Total	
1980	8.6	34%	0.0	0%	16.6	66%	25.2	100%
1990	4.9	14%	12.0	34%	18.7	53%	35.6	100%
1993	2.8	14%	17.2	84%	0.4	2%	20.4	100%
1995	5.5	12%	37.8	85%	1.3	3%	44.5	100%
1999	4.8	8%	55.2	89%	2.0	3%	62.0	100%
2001	3.9	7%	50.9	90%	1.5	3%	56.3	100%
2003	4.7	7%	55.9	89%	2.2	4%	62.8	100%
2005	4.2	6%	63.8	91%	2.5	3%	70.5	100%
2007	2.7	5%	55.0	93%	1.4	2%	59.1	100%
2009	1.6	4%	36.2	93%	1.2	3%	38.9	100%

Note(s): 1) IG = insulated glazing.

Source(s): AAMA/NWWDA, Study of the U.S. Market for Windows and Doors, 1996, Table 22, p.49; AAMA/WDMA, Study of U.S. and Canadian Market for Windows and Doors, Apr. 2000, Exhibit E.7, p. 55; AAMA/WDMA, Study of the Market for U.S. Doors, Windows and Skylights, Apr. 2004, Exhibit D.4, p. 46; AAMA/WDMA, Study of U.S. Market for Windows, Doors, and Skylights, Apr. 2006, Exhibit D.8 Conventional Window Glass Usage, p. 50; AAMA/WDMA, Study of U.S. Market For Windows, Doors, and Skylights, Mar. 2008, Exhibit D.8 Conventional Window Glass Usage, p. 49; AAMA/WDMA/Ducker, Study of the U.S. Market For Windows, Doors, and Skylights, Executive Report, May 2010, Exhibit D.8 Conventional Residential Window Glass Usage, p. 52.

5.2.6 2005 Residential Prime Window Stock (Million Households)

		Double Pane			
Census Division	Single Pane	Without Low-e	With Low-e	Total	Total Households (1)
New England	2.1	2.8	0.4	3.2	5.3
Middle Atlantic	4.7	9.4	0.9	10.3	15.0
East North Central	5.6	9.7	2.0	11.7	17.3
West North Central	2.9	3.9	0.9	4.8	7.7
South Atlantic	12.3	7.9	1.1	9.0	21.3
East South Central	3.4	3.1	0.3	3.4	6.8
West South Central	8.0	3.8	0.3	4.1	12.1
Mountain	2.8	3.6	0.9	4.5	7.3
Pacific	8.9	6.4	1.1	7.5	16.4
United States	**50.7**	**50.6**	**7.9**	**58.5**	**109.2**
Selected States					
New York	2.2	4.2	0.6	4.8	7.0
Florida	5.4	1.3	N.A.	1.3	6.7
Texas	5.1	2.5	N.A.	2.5	7.6
California	7.6	3.7	0.7	4.4	12.0

Note(s): 1) Respondents were shown pictures of different types of window glass and were asked "Which picture best describes the type of glass in the windows of your home/apartment?" 2) An additional 1.3 million households not counted here use other types of windows such as triple-pane

Source(s): EIA, 2005 Residential Energy Consumption Survey, Tables HC 11.5, HC 12.5, HC 13.5, HC 14.5, and HC 15.5, April 2008.

5.2.7 Nonresidential Window Stock and Sales, by Glass Type

	Existing U.S. Stock	Vision Area of New Windows (Million Square Feet)					
Type	(% of buildings)	1995	2001	2003	2005	2007	2009
Single Pane	53%	56	57	48	56	60	48
Insulating Glass (1)	47%	294	415	373	407	476	389
Total	100%	**350**	**472**	**421**	**463**	**536**	**437**
Clear	65%	36%	49%	43%	44%	38%	33%
Tinted	28%	40%	24%	17%	15%	11%	10%
Reflective	7%	7%	8%	6%	4%	3%	3%
Low-e	(2)	17%	19%	34%	37%	48%	54%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Note(s): 1) Includes double- and triple-pane sealed units and stock glazing with storm windows. 2) Included as part of the Tinted category.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, June 2006, Table B1 for stock data; AAMA/NWWDA, 1996 Study of the U.S. Market for Windows and Doors, Table 27, p. 60 for 1995 usage values; 2003 AAMA/WDMA Study of the U.S. Market for Windows, Doors and Skylights, Exhibits D.31 and D.32 for 2001; AAMA/WDMA/Ducker, Study of U.S. Market For Windows, Doors, and Skylights, Apr. 2006, Exhibit D.31 and Exhibit D.32, p. 73 for 2003 and 2005.; AAMA/WDMA/Ducker, Study of U.S. Market For Windows, Doors, and Skylights, Mar. 2008, Exhibit D.31 and Exhibit D.32, p. 72 for 2007; AAMA/WDMA/Ducker, Study of U.S. Market For Windows, Doors, and Skylights, May 2010, Exhibit D.31 and Exhibit D.32, p. 75 for 2009.

5.2.8 Typical Thermal Performance of Residential Windows, by Type

	U-Factor	Solar Heat Gain Coefficient	Visual Transmittance
Single-Glazed Clear	0.84-1.16	0.64-0.76	0.65-0.75
Single-Glazed with Bronze Tint	0.84-1.16	0.54-0.65	0.49-0.56
Double-Glazed Clear	0.44-0.76	0.56-0.68	0.59-0.68
Double-Glazed with grey/Bronze Tint	0.44-0.76	0.47-0.56	0.44-0.51
Double-Glazed with High Performance Tint	0.44-0.76	0.39-0.47	0.50-0.57
Double-Glazed with High-Solar Gain Low-e Glass, Argon/Krypton Gas	0.29-0.61	0.53-0.64	0.54-0.62
Double-Glazed with Moderate-Solar Gain Low-e Glass, Argon/Krypton Gas	0.27-0.60	0.44-0.53	0.55-0.65
Double-Glazed with Low-Solar Gain Low-e (1) Glass, Argon/Krypton Gas	0.26-0.59	0.30-0.37	0.51-0.59
Triple-Glazed (2) with High-Solar Gain Low-e Glass, Argon/Krypton Gas (3)	0.15	0.51	0.65
Triple-Glazed (2) with Low-Solar Gain Low-e (1) Glass, Argon/Krypton Gas (3)	0.14	0.33	0.56

Note(s): 1) Spectrally selective. 2) Includes double glazing with suspended film. 3) Center of glass properties, does not include frame or installation

Source(s): The Efficient Windows Collaborative (http://www.efficientwindows.org)

5.3.1 U.S. Heating and Air-Conditioning System Manufacturer Shipments, by Type (Including Exports)

Equipment Type	2000 (1,000s)	2005 (1,000s)	2007 (1,000s)	2009 (1,000s)	2010 (1,000s)	2005 Value of Shipments ($million) (7)
Air-Conditioners (1)	**5,346**	**6,472**	**4,508**	**3,516**	**3419**	**5,837**
Heat Pumps	**1,539**	**2,336**	**1,899**	**1,642**	**1,748**	**2,226**
Air-to-Air Heat Pumps	1,339	2,114	1,899	1,642	1748	1,869
Water-Source Heat Pumps (2)	200	222	N.A.	N.A.	N.A.	357
Chillers	**38**	**37**	**37**	**25**	**29**	**1,093**
Reciprocating	25	24	30	20	24	462
Centrifugal/Screw	8	6	7	5	5	566
Absorption (3)	5	7	N.A.	N.A.	N.A.	64
Furnaces	**3,681**	**3,624**	**2,866**	**2,231**	**2,509**	**2,144**
Gas-Fired (4)	3,104	3,512	2,782	2,175	2453	2,081
Electric	455	N.A.	N.A.	N.A.	N.A.	N.A.
Oil-Fired (5)	121	111	84	56	56	63
Boilers (6)	**368**	**370**	**N.A.**	**N.A.**	**N.A.**	**N.A.**

Note(s): 1) Includes exports and gas air conditioners (gas units <10,000 units/yr) and rooftop equipment. Excludes heat pumps, packaged terminal air conditioner units, and room air conditioners. Approximately 95% of unitary air conditioners shipped are 5.5 tons or less (65,000 Btu/hr). ~70% residential and ~30% commercial applications. 2) Includes ground-source heat pumps, which numbered around 80,600 units shipped in 2005. 3) DOC did not report absorption chiller shipments for 2007, 2009, and 2010. 4) Gas-fired furnace value of shipments are based on Census unit shipment data, which is about 873,500 units higher than the industry data shown. 5) Oil-fired furnace value of shipments are based on Census unit shipment data, which is approximately 33,600 units lower than the industry data shown. 6) 61% of shipments were gas-fired and 39% were oil-fired. 96% of shipments are cast iron and 4% are steel. 7) Total 2005 value of shipments for heating, ventilation, and air conditioning (HVAC) and refrigeration was $24.7 billion, including industrial and excluding boilers and electric furnaces.

Source(s): ARI, Statistical Profile, Oct. 7, 2004, Table 17, p. 24, Table 18, p. 25, and Table 22, p. 30 for air conditioner, air-to-air heat pump, and 1990 centrifugal/screw chiller shipments; AHRI, ARI Koldfax, Feb. 2005, p. 1 for 2004 air conditioner shipments; GAMA, GAMA Statistical Highlights: Ten Year Summary, 1987-1996; GAMA, GAMA Statistical Highlights: Ten Year Summary, 1994-2000 for furnace and boiler shipments; GAMA, GAMA News Release, Jan. 2005 for 2004 boiler shipments; GAMA, Statistical Highlights, Mar. 2005, p. 4 for 2004 furnace shipments; Appliance Manufacturer, Feb. 1998 for electric furnace; DOC, Current Industrial Reports: Refrigeration, Air Conditioning and Warm Air Heating Equipment, MA333M(06)-1, July 2007, Table 2, for water-source heat pumps, chillers, and value of shipments; Appliance Magazine Appliance Statistical Review, 54th Annual Report, May 2007, p. S1 - S4 for 2005 boiler data; AHRI, "Historical Statistical Data: Central Air Conditioners and Air-Source Heat Pumps," 2010, accessed March 15, 2011 at <http://www.ahrinet.org/historical+data.aspx> for 2007, 2009, and 2010 A/C and heat pump shipments; AHRI, "Historical Statistical Data: Furnaces," 2010, accessed March 15, 2011 at <http://www.ahrinet.org/historical+data.aspx> for 2007, 2009 and 2010 furnace shipments; DOC, Current Industrial Reports, MA333M - Refrigeration, Air Conditioning, and Warm Air Heating Equipment, 2008 Annual report for 2007 and 2010 Annual report for 2009 and 2010 shipments of chillers; and GAMA News Release, Jan. 2007 for note 6.

5.3.2 Residential Furnace Efficiencies (Percent of Units Shipped) (1)

Gas-Fired				Oil-Fired	
AFUE Range	1985	AFUE Range	2006	AFUE Range	1985
Below 65%	15%	75% to 88%	64%	Below 75%	10%
65% to 71%	44%	88% or More	36%	75% to 80%	56%
71% to 80%	10%	Total	100%	More Than 80%	35%
80% to 86%	19%			Total	100%
More than 86%	12%				
Total	100%				

Average shipped in 1985 (2):	74% AFUE	Average shipped in 1985 (2):	79% AFUE
Average shipped in 1995:	84% AFUE	Average shipped in 1995:	81% AFUE
Best Available in 1981:	85% AFUE	Best Available in 1981:	85% AFUE
Best Available in 2007:	97% AFUE	Best Available in 2007:	95% AFUE

Note(s): 1) Federal appliance standards effective Jan. 1, 1992, require a minimum of 78% AFUE for furnaces. 3) Includes boilers.

Source(s): GAMA's Internet Home Page for 2006 AFUE ranges; GAMA News, Feb. 24, 1987, for 1985 AFUE ranges; LBNL for average shipped AFUE; GAMA, Consumer's Directory of Certified Efficiency Ratings, May 2004, p. 12 and 72-73 for 2004 best-available AFUEs; GAMA Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment, May 2007; GAMA Tax Credit Eligible Equipment: Gas- and Oil-Fired Furnaces 95% AFUE or Greater, May 2007; and GAMA AFUE press release 2006: U.S. shipments of gas warm-air central furnaces.

5.3.3 Residential Boiler Efficiencies (1)

Gas-Fired Boilers		Oil-Fired Boilers	
Average shipped in 1985 (2):	74% AFUE	Average shipped in 1985 (2):	79% AFUE
Best Available in 1981:	81% AFUE	Best Available in 1981:	86% AFUE
Best Available in 2007:	96% AFUE	Best Available in 2007:	89% AFUE

Note(s): 1) Federal appliance standards effective Jan. 1, 1992, require a minimum of 80% AFUE (except gas-fired steam boiler, which must have a 75% AFUE or higher). 2) Includes furnaces.

Source(s): GAMA, Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment, Aug. 2005, p. 88 and 106 for best-available AFUE; and GAMA for 1985 average AFUEs; GAMA Tax Credit Eligible Equipment: Gas- and Oil-Fired Boilers 95% AFUE or Greater, May 2007; and GAMA Consumer's Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment, May 2007.

5.3.4 Residential Air Conditioner and Heat Pump Cooling Efficiencies

Equipment Type	Efficiency Parameter	2005 Stock Efficiency	2007 U.S. Average New Efficiency	2007 Best-Available New Efficiency
Air Conditioners	SEER	10.2	13.0	21.0
Heat Pump - Cooling				
Air-Source	SEER	10.0	13.0	17.0
Ground-Source	EER	13.8	16.0	30.0
Heat Pump - Heating				
Air-Source	HSPF	6.8	7.7	10.6
Ground-Source	COP	3.4	3.4	5.0

Source(s): EIA/Navigant Consulting, EIA - Technology Forecast Updates - Residential and Commercial Buildings Technologies Reference Case, Second Edition (Revised), Sept. 2007, p. 26-31.

5.3.5 Commercial Equipment Efficiencies

Equipment Type	Efficiency Parameter	2007 Stock Efficiency	2010 U.S. Average New Efficiency	2010 Best-Available New Efficiency
Chiller				
Screw	COP(full-load / IPLV)	2.80 / 3.05	2.80 / 3.05	3.02 / 4.45
Scroll	COP	2.80 / 3.06	2.96 / 4.40	N.A.
Reciprocating	COP(full-load / IPLV)	2.80 / 3.05	2.80 / 3.05	3.52 / 4.40
Centrifugal	COP(full-load / IPLV)	5.0 / 5.2	6.1 / 6.4	7.3 / 9.0
Gas-Fired Absorption	COP	1.0	1.1	N.A.
Gas-Fired Engine Driven	COP	1.5	1.8	N.A.
Rooftop A/C	EER	10.1	11.2	13.9
Rooftop Heat Pump	EER (cooling)	9.8	11.0	12.0
	COP (heating)	3.2	3.3	3.4
Boilers				
Gas-Fired	Combustion Efficiency	77	80	98
Oil-Fired	Thermal Efficiency	80	84	98
Electric	Thermal Efficiency	98	98	98
Furnace	AFUE	77	80	82
Water Heater				
Gas-Fired	Thermal Efficiency	78	80	96
Oil-Fired	Thermal Efficiency	79	80	85
Electric Resistance	Thermal Efficiency	98	98	98
Gas-Fired Instantaneous	Thermal Efficiency	77	84	89

Source(s): EIA/Navigant Consulting, EIA - Technology Forecast Updates - Residential and Commercial Buildings Technologies - Reference Case, Oct. 2011, p. 58-98.

5.3.6 2008 Unitary Air-Conditioner/Heat Pump Manufacturer Market Shares (Percent of Products Produced)

Total Units Shipped: 5,833,354 (1)

Company	Market Share (%)
UTC/Carrier	27%
Goodman (Amana)	14%
American Standard (Trane)	14%
York	12%
Nordyne	12%
Rheem	9%
Lennox	9%
Others	3%
Total	100%

Note(s): 1) Does not include water-source or ground-source heat pumps.

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturaation Levels, January 2010, p. 5.

5.3.7 2008 Gas Furnace Manufacturer Market Shares (Percent of Products Produced)

Company	Market Share (%)
UTC/Carrier	32%
Goodman (Amana)	15%
Lennox	13%
American Standard (Trane)	13%
Rheem	12%
York	9%
Nordyne	5%
Others	1%
Total	**100%**

Total Units Shipped: 2,300,000

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturaation Levels, January 2010, p. 5.

5.3.8 Major Residential HVAC Equipment Lifetimes, Ages, and Replacement Picture

Equipment Type	Typical Service Lifetime Range	Average Lifetime	2005 Average Stock Age	Units to be Replaced During 2010 (1,000s)
Central Air Conditioners	8 - 14	11	8	5,354
Heat Pumps	9 - 15	12	8	1,260
Furnaces				
Electric	10 - 20	15	11	N.A.
Gas-Fired	12 - 17	15	11	2,601
Oil-Fired	15 - 19	17	N.A.	149
Gas-Fired Boilers (1)	17 - 24	20	17	204

Note(s): Lifetimes based on use by the first owner of the product, and do not necessarily indicate that the product stops working after this period. A replaced unit may be discarded or used elsewhere. 1) 2005 average stock age is for gas- and oil-fired steam and hot water boilers.

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 10 for service and average lifetimes, and units to be replaced; ASHRAE, 1999 ASHRAE Handbook: HVAC Applications, Table 3, p. 35.3 for boilers service lifetimes; and EIA, Housing Characteristics 1990, May 1992, Table 7, p. 24 for 1990 average stock ages.

5.3.9 Major Commercial HVAC Equipment Lifetimes and Ages

Equipment Type	Median Lifetime	
Air Conditioners		
Through-the-Wall	15	
Water-CooledPackage	24	(1)
Roof-Top	15	
Chillers		
Reciprocating	20	
Centrifugal	25	(1)
Absorption	23	
Heat Pumps		
Air-to-Air	15	
Water-to-Air	24	(1)
Furnaces (gas or oil)	18	
Boilers (gas or oil)		
Hot-Water	24 - 35	
Steam	25 - 30	
Unit Heaters		
Gas-Fired or Electric	13	
Hot-Water or Steam	20	
Cooling Towers (metal or wood)		
Metal	22	(1)
Wood	20	

Note(s): 1) Data from 2005. All other data is from 1978.

Source(s): ASHRAE, 2007 ASHRAE Handbook: HVAC Applications, Table 4, p. 36.3 for median service lifetimes.

5.3.10 Main Residential Heating Fuel, by Vintage, as of 2005 (Percent of Total Households)

Heating Fuel	1949 or Before	1950 to 1959	1960 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2005
Natural Gas	56%	57%	55%	46%	45%	45%	45%
Electricity	8%	18%	26%	36%	42%	42%	43%
Fuel Oil	14%	10%	7%	5%	2%	2%	2%
LPG	5%	3%	2%	5%	6%	8%	8%
Other (1)	17%	12%	10%	8%	4%	3%	2%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Note(s): 1) Other includes wood and kerosene.

Source(s): EIA, Residential Energy Consumption Survey 2005 , June 2008, Table HC 5.4.

5.3.11 Main Residential Heating Equipment as of 1987, 1993, 1997, 2001, and 2005 (Percent of Total Households)

Equipment Type	1987	1993	1997	2001	2005
Natural Gas	**55%**	**53%**	**53%**	**55%**	**52%**
Central Warm-Air Furnace	35%	36%	38%	42%	40%
Steam or Hot-Water System	10%	9%	7%	7%	7%
Floor/Wall/Pipeless Furnace	6%	4%	4%	3%	2%
Room Heater/Other	4%	3%	4%	3%	3%
Electricity	**20%**	**26%**	**29%**	**29%**	**30%**
Central Warm-Air Furnace	8%	10%	11%	12%	14%
Heat Pump	5%	8%	10%	10%	8%
Built-In Electric Units	6%	7%	7%	6%	5%
Other	1%	1%	2%	2%	1%
Fuel Oil	**12%**	**11%**	**9%**	**7%**	**7%**
Steam or Hot-Water System	7%	6%	5%	4%	4%
Central Warm-Air Furnace	4%	5%	4%	3%	3%
Other	1%	0%	0%	0%	0%
Other	**13%**	**11%**	**9%**	**8%**	**10%**
Total	100%	100%	100%	100%	100%

Note(s): Other equipment includes wood, LPG, kerosene, other fuels, and none.

Source(s): EIA, A Look at Residential Consumption in 2005, June 2008, Table HC2-4; EIA, A Look at Residential Energy Consumption in 2001, Apr. 2004, 'Table HC3-2a; EIA, A Look at Residential Energy Consumption in 1997, Nov. 1999,Table HC3-2a, p. 55; EIA, Housing Characteristics 1993, June 1995, Table 3.7b, p. 63; and EIA, Housing Characteristics 1987, May 1989, Table 14, p. 33.

5.3.12 Main Commercial Heating and Cooling Equipment as of 1995, 1999, and 2003 (Percent of Total Floorspace) (1)

Heating Equipment	1995	1999	2003 (2)
Packaged Heating Units	29%	38%	28%
Boilers	29%	29%	32%
Individual Space Heaters	29%	26%	19%
Furnaces	25%	21%	30%
Heat Pumps	10%	13%	14%
District Heat	10%	8%	8%
Other	11%	6%	5%

Cooling Equipment	1995	1999	2003 (2)
Packaged Air Conditioning Units	45%	54%	46%
Individual Air Conditioners	21%	21%	19%
Central Chillers	19%	19%	18%
Residential Central Air Conditioners	16%	12%	17%
Heat Pumps	12%	14%	14%
District Chilled Water	4%	4%	4%
Swamp Coolers	4%	3%	2%
Other	2%	2%	2%

Note(s): 1) Heating and cooling equipment percentages of floorspace total more than 100% since equipment shares floorspace. 2) Malls are no longer included in most CBECs tables; therefore, some data is not directly comparable to past CBECs.

Source(s): EIA, Commercial Building Characteristics 1995, Oct. 1998, Tables B34 and B36 for 1995, and EIA, Commercial Building Characteristics 1999, Aug. 2002, Tables B33 and B34 for 1999; and EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, June 2006, Tables B39 and B41 for 2003.

5.3.13 Main Commercial Primary Energy Use of Heating and Cooling Equipment as of 1995

Heating Equipment		Cooling Equipment	
Packaged Heating Units	25%	Packaged Air Conditioning Units	54%
Boilers	21%	Room Air Conditioning	5%
Individual Space Heaters	2%	PTAC (2)	3%
Furnaces	20%	Centrifugal Chillers	14%
Heat Pumps	5%	Reciprocating Chillers	12%
District Heat	7%	Rotary Screw Chillers	3%
Unit Heater	18%	Absorption Chillers	2%
PTHP & WLHP (1)	2%	Heat Pumps	7%
	100%		100%

Note(s): 1) PTHP = Packaged Terminal Heat Pump, WLHP = Water Loop Heat Pump. 2) PTAC = Packaged Terminal Air Conditioner

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume 1: Chillers, Refrigerant Compressors, and Heating Systems, Apr. 2001, Figure 5-5, p. 5-14 for cooling and Figure 5-10, p. 5-18 for heating.

5.3.14 Halocarbon Environmental Coefficients and Principal Uses

Compound	100-Year Global Warming Potential (CO2 = 1)	Ozone Depletion Potential (ODP) (Relative to CFC-11)	Principal Uses
Chlorofluorocarbons			
CFC-11	4,600	1.00	Blowing Agent, Chillers
CFC-12 (1)	10,600	1.00	Auto A/C, Chillers, & Blowing Agent
CFC-113	6,000	0.80	Solvent
CFC-114	9,800	1.00	Solvent
CFC-115 (2)	7,200	0.60	Solvent, Refrigerant
Hydrochlorofluorocarbons			
HCFC-22 (2)	1,700	0.06	Residential A/C
HCFC-123	120	0.02	Refrigerant
HCFC-124	620	0.02	Sterilant
HCFC-141b	700	0.11	CFC Replacement
HCFC-142b	2,400	0.07	CFC Replacement
Bromofluorocarbons			
Halon-1211	1,300	3.00	Fire Extinguishers
Halon-1301	6,900	10.00	Fire Extinguishers
Hydrofluorocarbons			
HFC-23	12,000	0.00	HCFC Byproduct
HFC-125	3,400	0.00	CFC/HCFC Replacement
HFC-134a	1,300	0.00	Auto A/C, Refrigeration
HFC-152a (1)	140	0.00	Aerosol Propellant
HFC-227ea	2,900	0.00	CFC Replacement

Note(s): 1) R-500: 74% CFC-12 and 26% HFC-152a. 2) R-502: 49% HCFC-22 and 51% CFC-115.

Source(s): Intergovernmental Panel for Climate Change, Climate Change 2001: The Scientific Basis, Jan. 2001, Table 3, p. 47 for global warming potentials and uses; EPA for halon ODPs; AFEAS Internet Homepage, Atmospheric Chlorine: CFCs and Alternative Fluorocarbons, Feb. 1997 for remaining ODPs; and ASHRAE, 1993 ASHRAE Handbook: Fundamental, p. 16.3 for Notes 1 and 2; EPA, Emissions of Greenhouse Gases in the U.S. 2005, Table ES-1, p. ES-3 for GWP of HFCs.

5.3.15 Conversion and Replacements of Centrifugal CFC Chillers

	Conversions	Replacements	Total	Cumulative Percent of 1992 Chillers (1)
Pre-1995	2,304	7,208	9,512	12%
1995	1,198	3,915	5,113	18%
1996	1,311	3,045	4,356	24%
1997	815	3,913	4,728	30%
1998	905	3,326	4,231	35%
1999	491	3,085	3,576	39%
2000	913	3,235	4,148	45%
2001	452	3,324	3,776	49%
2002	360	3,433	3,793	54%
2003	334	2,549	2,883	55%
2004	165	2,883	3,048	59%
2005 (2)	155	2,674	2,829	62%
2006 (2)	130	2,860	2,990	66%
2007 (2)	108	3,002	3,110	70%
Total	**9,641**	**48,452**	**58,093**	

Note(s): 1) In 1992, approximately 80,000 centrifugal CFC chillers were in service, 82% of which used CFC-11, 12% CFC-12, and 6% CFC-113, CFC-114, or R-500. 2) Projected.

Source(s): ARI, Replacement and Conversion of CFC for a Decade Chillers Slower Than Expected Assuring Steady Demand for Non-CFC Units, Apr. 25, 2005; ARI, New Legislation Would Spur Replacement of CFC Chillers, Mar. 31, 2004; ARI, Economy Affects CFC Chiller Phase-out, Apr. 2, 2003; ARI, Half way Mark in Sight for Replacement and Conversion of CFC Chiller Used for Air Conditioning of Buildings, Apr. 11, 2001; ARI, Replacement and Conversion of CFC Chillers Dipped in 1999 Assuring Steady Demand for Non-CFC Units for a Decade, Mar. 29, 2000; ARI, Survey Estimates Long Use of CFC Chillers Nearly Two-Thirds of Units Still in Place, Apr. 15, 1999; ARI, CFCs Widely Used to Cool Buildings Despite 28-Month Ban on Production, Apr. 8, 1998; ARI, 1997 Chiller Survey, Apr. 9, 1997; Air Conditioning, Heating and Refrigeration News, Apr. 1996, p. 1; and ARI's web site, www.ari.org, Chiller Manufacturer Survey Confirms Slow Pace of Conversion and Replacements of CFC Chillers, Apr. 12, 1995.

5.4.1 Water Heater Stock for Residential Buildings, By Fuel Type

	Households in 2005 (millions)	Percent
Electric	43.1	39.2%
Natural Gas	58.7	53.4%
Fuel Oil	4.0	3.6%
Propane/LPG	4.0	3.6%
Other	0.2	0.2%
Total (1)	**110.0**	**100.0%**

Note(s): According to RECS, 1.1 million households did not use hot water.The total only includes those households that used hot water.

Souce(s): EIA, Residential Energy Consumption Survey 2005, Table HC 2.8, June 2008.

5.4.2 Water Heater Stock for Residential Buildings, By Storage Type

	Number and Percent of Households in 2005					
	Used by One Unit		Used by Multiple Units		Total	
Small (30 gallons or less)	17.1	17%	1.4	14%	18.5	17%
Medium (31 to 49 gallons)	52.4	53%	2.4	24%	54.8	50%
Large (50 gallons or more)	27.1	27%	2.8	27%	29.9	27%
Tankless water heater	1.1	1%	0.2	2%	1.3	1%
No Separate Water Heater	1.9	2%	3.4	33%	5.3	5%
Total (1)	**99.6**	100%	**10.2**	100%	**109.8**	100%

Note(s): According to RECS, 1.1 million households did not use hot water.The total only includes those households that used hot water.

Souce(s): EIA, Residential Energy Consumption Survey 2005, Table HC 2.8, June 2008.

5.4.3 Water Heater Manufacturer Market Shares

	2006	2008
A.O. Smith/State Industries	23%	46%
Rheem Manufacturing	37%	37%
Bradford-White	14%	13%
American Water Heater	14%	(1)
Others	12%	4%
Total	100%	100%
Total Units Shipped (2)	9,446,076	8,190,043

Note(s): 1) Included in A.O. Smith/State Industries. 2) Excludes exports.

Source(s): Appliance Magazine, A Portrait of the U.S. Appliance Industry, Sept. 2007, p. 63 for 2006; Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 6 for 2008.

5.4.4 Water Heater Stock for Commercial Buildings, By Fuel Type

Fuel Type	Percent of Buildings in 2003 (1)
Electric	41%
Natural Gas	31%
Fuel Oil	2%
Propane/LPG	3%
District Heat	1%
No Water Heating	25%

Note(s): (1) Percentages add to 103% because some buildings use more than one fuel for water heating.

Souce(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Buildings Characteristics, June 2006, Table B31, p. 175.

5.4.5 Water Heater Efficiencies

Residential Type	Efficiency Parameter (1)	2005 Stock Efficiency	Minimum New Efficiency	2010 Best-Available New Efficiency
Electric Storage	EF	0.90	0.90 (2)	0.95 (2)
Electric Instantaneous	EF	0.82	0.82	0.98
Electric Heat Pump	EF	2.00	2.00	2.35
Gas-Fired Storage	EF	0.60	0.59 (3)	0.85 (3)
Gas-Fired Instantaneous	EF	0.82	0.82	0.98
Oil-Fired Storage	EF	0.50	0.53 (4)	0.68 (4)
Solar	SEF	2.50	N.A.	2.50

Commercial Type	Efficiency Parameter (1)	2007 Stock Efficiency	Minimum New Efficiency	2010 Best-Available New Efficiency
Electric Storage	Thermal Efficiency	0.98	0.98 (5)	0.98 (5)
Electric Instantaneous	Thermal Efficiency	0.98	0.98	0.98
Gas-Fired Storage	Thermal Efficiency	0.78	0.80 (6)	0.96 (6)
Gas-Fired Instantaneous	Thermal Efficiency	0.77	0.80	0.85
Oil-Fired Storage	Thermal Efficiency	0.79	0.78 (7)	0.85 (7)

Note(s): 1) EF = energy factor and SEF = solar energy factor, which is the hot water energy delivered by the solar system divided by the electric or gas energy input to the system. 2) Based on a 50-gallon tank. 3) Based on a 40-gallon tank. 4) Based on a 30-gallon tank. 5) Based on a 120-gallon tank. 6) Based on a 100-gallon tank. 7) Based on a 70-gallon tank.

Source(s): EIA, EIA - Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, Oct. 2011.

5.5.1 Market Share of Major HVAC Equipment Manufacturers ($2009 Million)

	Total Market Size
Air-Handling Units	1032
Cooling Towers	533
Pumps	333
Central System Terminal Boxes	192
Classroom Unit Ventilator	160
Fan Coil Units	123

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, Table 4-1, p. 4-4; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

5.5.2 U.S. Commercial Buildings Conditioned Floorspace, Building Type and System Type (Million SF)

	Individual AC	Packaged	Central VAV	Central FCU	Central CAV	Not Cooled	Total
Education	805	2,204	551	466	212	3,522	7,760
Food Sales	0	534	0	0	0	20	554
Food Service	83	1,100	0	0	0	64	1,247
Health Care	134	557	401	334	802	159	2,387
Lodging	1,669	283	85	707	85	779	3,608
Mercantile and Service	333	5,820	1,081	831	249	2,507	10,821
Office	1,257	4,450	2,322	484	1,161	561	10,235
Public Buildings	371	3,337	847	0	741	2,168	7,464
Warehouse/Storage	119	1,482	0	0	102	2,285	3,988
Total	**4,771**	**19,767**	**5,287**	**2,822**	**3,352**	**12,065**	**48,064**

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, Table A2-12, p. B2-1.

5.5.3 Thermal Distribution Design Load and Electricity Intensities, by Building Activity

	Design Load Intensity (W/SF)	End Use Intensity (kWh/SF)
Education	0.5	1.3
Food Sales	1.1	6.4
Food Service	1.5	6.4
Health Care	1.5	5.6
Lodging	0.5	1.9
Mercantile and Service	0.9	2.7
Office	1.3	3.3
Public Assembly	1.2	3.0
Warehouse	0.4	1.8
All Buildings	**1.0**	**2.8**

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, Table 5-11, p. 5-27.

5.5.4 Thermal Distribution Equipment Design Load and Electricity Intensities, by System Type

	Design Load Intensity (W/SF)			End Use Intensity (kWh/SF)		
	Central VAV	Central CAV	Packaged CAV	Central VAV	Central CAV	Packaged CAV
Condenser Fan			0.3			0.2
Cooling Tower Fan	0.2	0.2		0.1	0.2	0.0
Condenser Water Pump	0.2	0.2		0.3	0.3	0.0
Chilled Water Pump	0.2	0.2		0.1	0.2	0.0
Supply & Return Fans	0.7	0.5	0.6	1.2	1.9	1.9
Chiller/Compressor	1.9	1.8	3.3	1.7	2.3	4.0

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, Table 5-11 p. 5-22.

5.5.5 Typical Commercial Building Thermal Energy Distribution Design Load Intensities (Watts per SF)

Distribution System Fans		**Other**	
Central System Supply Fans	0.3 - 1.0	Cooling Tower Fan	0.1 - 0.3
Central System Return Fans	0.1 - 0.4	Air-Cooled Chiller Condenser Fan	0.6
Terminal Box Fans	0.5	Exhaust Fans (2)	0.05 - 0.3
Fan-Coil Unit Fans (1)	0.1 - 0.3	Condenser Fans	0.6
Packaged or Split System Indoor Blower	0.6		
Pumps			
Chilled Water Pump	0.1 - 0.3		
Condenser Water Pump	0.1 - 0.2		
Heating Water Pump	0.1 - 0.2		

Note(s): 1) Unducted units are lower than those with some ductwork. 2) Strong dependence on building type.

Source(s): BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II:Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, Table 3-1, p. 3-6.

5.5.6 1999 Energy Efficient Motors, Replacements and Sales, by Horsepower Class

	Existing		Replacements	
Horsepower Range	Units in Use (thousands)	Horsepower (10^6)	% Retired	Energy Efficient Share of New Motors
1 - 5	20,784	59.6	2.5%	17%
5.1 - 20	6,927	81.8	2.0%	29%
21 - 50	2,376	78.2	1.5%	45%
51 - 100	738	59.6	1.0%	52%
101 - 200	412	56.5	0.8%	65%

Source(s): Electrical Apparatus Service Association, Past Trends and Probable Future Changes in the Electric Motor Industry 1990-1999, 2001, p. 18 for existing stock and retirements and p. 28 for energy efficient motor sales.

5.5.7 1999 AC Adjustable-Speed Drive Population

Horsepower Range	
1 - 5	70%
5.1 - 20	23%
21 - 50	4%
51 - 100	1%
101 - 200	1%
200 +	1%
Total	100%

Source(s): Electrical Apparatus Service Association, Past Trends and Probable Future Changes in the Electric Motor Industry 1990-1999, 2001, p. 30.

5.6.1 Selected Fluorescent and Incandescent Lamp Sales (thousands)

Commercial Trends	2001	2002	2003	2004	2005
T12 Rapid-Start Fluorescent (Mainly 4')	213	206	182	176	163
T8 Medium Bi-Pin Fluorescent (Mainly 4')	164	164	172	196	216
Total (mainly) 4'	**377**	**370**	**354**	**372**	**378**
2' U-Shaped T12	10	9	9	7	9
2' U-Shaped T8	8	7	7	9	9
Total 2' U lamp	**18**	**16**	**16**	**16**	**17**
8' Slimline T12 (Mainly 8')	43	41	37	36	34
8' Slimline T8 (Mainly 8')	4	5	5	6	5
Total Slimline (Mainly 8')	**48**	**47**	**42**	**42**	**39**
8' HO T12 (Mainly 8')	24	24	24	25	25
8' HO T8 (Mainly 8')	1	1	0	1	0
Total HO (Mainly 8')	**25**	**25**	**25**	**25**	**26**
Residential Trends					
Incandescent A-line	1,568	1,526	1,542	1,470	1,410
Screw-Based Compact Fluorescent- Census	69	52	66	93	102
Total Medium Screw-Based Market	**1,637**	**1,577**	**1,608**	**1,563**	**1,512**
Commerical and Residential Trends					
PAR Incandescent	9	7	5	5	15
R Incandescent	89	96	103	112	125
PAR 38 Halogen	41	46	46	50	46
PAR30 and PAR20 Halogen	33	27	31	36	40
Total Reflector Lamps	**172**	**176**	**185**	**203**	**226**

Note(s): 2001-2005 growth rate for A-line Incandescent was -2.62% while Screw-based Compact Fluorescent had a growth rate of 10.17% over the

Source(s): National Electrical Manufactors Association, Special Bulletin for the Lamp Section (2-LL), June 2006, page 1.

5.6.2 Value of Electric Lighting Fixture Shipments ($Million)

Lighting Fixture Type	1985	1990	1995	2000	2001
Residential	786.8	827.6	983.8	1,296.5	983.9
Commercial/Institutional (except spotlight)	1,832.3	2,379.7	2,797.3	3,506.7	3,239.1
Industrial	389.2	529.4	676.3	718.3	628.1
Vehicular (1)	1,001.2	1,620.7	N.A.	N.A.	N.A.
Outdoor	905.5	1,061.5	1,473.0	1,957.4	1,923.2

Note(s): 1) Data for vehicular lighting fixtures was discontinued in 1992.

Source(s): DOC, Electric Lighting Fixtures MA 335L(01)-1, Jan. 2003 for 2000 and 2001; DOC, Current Industrial Reports: Electric Lighting Fixtures, MA335L(99)-1, Dec. 2000, Table 1 for 1990-1999; and DOC, Current Industrial Reports: Electric Lighting Fixtures, MA36L, Oct. 1995, Table 1 for 1985.

5.6.3 Shipments of Fluorescent Lamp Ballasts

	Standard Magnetic Type (1)		Electronic Type		Total		
Year	Quantity (million)	Value ($million)	Quantity (million)	Value ($million)	Quantity (million)	Value ($million)	Electronic Type as a % of Total Units Shipped
1985	70.1	398.9	N.A	N.A.	70.1	398.9	N.A.
1986	69.4	396.1	0.4	11.8	69.8	407.9	1%
1988	74.6	450.9	1.1	25.5	75.7	476.4	1%
1990	78.4	546.3	3.0	69.3	81.4	615.6	4%
1992	83.7	537.7	13.3	274.6	97.0	812.3	14%
1994	83.5	550.0	24.6	390.8	108.1	940.7	23%
1996	67.0	457.8	30.3	451.4	97.3	909.2	31%
1998	63.9	401.4	39.8	512.8	103.7	914.3	38%
2000	55.4	343.0	49.3	555.5	104.8	898.5	47%
2002	40.7	263.3	53.8	573.1	94.5	836.4	57%
2004	30.5	218.4	59.2	579.4	89.7	797.8	66%
2005	22.2	175.1	61.3	594.6	83.5	769.8	73%

Note(s): 1) Standard magnetic type includes uncorrected and corrected power-factor type ballasts.

Source(s): DOC Current Industrial Reports: Fluorescent Lamp Ballasts, MQ335C(05)-5, July 2006 for 2000-2005; DOC, Current Industrial Reports: Fluorescent Lamp Ballasts MQ36C(99)-5, July 2000, Table 1 for 1990-1999; and DOC, Current Industrial Reports: Fluorescent Lamp Ballasts, MQ36C(95), 1996, Table 1 for 1985-1989.

5.6.4 2010 Total Lighting Technology Electricity Consumption, by Sector (TWh per Year) (1)

	Residential		Commercial		Industrial		Other (2)		Total	
Incandescent	**136**	**78%**	**15**	**4%**	**0**	**0%**	**4**	**4%**	**156**	**22%**
General (A-type, Decorative)	112	64%	9	3%	0	0%	-	-	122	17%
Reflector	19	11%	5	2%	0	0%	-	-	24	3%
Miscellaneous	5	3%	0	0%	0	0%	4	4%	9	1%
Halogen	**12**	**7%**	**15**	**4%**	**0**	**0%**	**1**	**1%**	**28**	**4%**
General	1	1%	0	0%	0	0%	-	-	1	0%
Reflector	8	5%	7	2%	0	0%	-	-	15	2%
Low Voltage Display	1	0%	7	2%	-	-	-	-	8	1%
Miscellaneous	2	1%	1	0%	0	0%	1	1%	4	1%
Compact Fluorescent	**15**	**9%**	**16**	**5%**	**0**	**0%**	**1**	**1%**	**32**	**5%**
General (Screw, Pin)	13	7%	13	4%	0	0%	-	-	26	4%
Reflector	1	1%	3	1%	0	0%	-	-	4	1%
Miscellaneous	1	1%	-	-	0	0%	1	1%	2	0%
Linear Fluorescent	**10**	**6%**	**250**	**72%**	**23**	**40%**	**10**	**9%**	**294**	**42%**
T5	0	0%	16	5%	2	4%	-	-	19	3%
T8	1	1%	124	35%	12	21%	-	-	137	20%
T12	7	4%	109	31%	9	15%	-	-	124	18%
Miscellaneous	2	1%	2	0%	0	0%	10	9%	14	2%
High Intensity Discharge	**0**	**0%**	**49**	**14%**	**35**	**60%**	**98**	**83%**	**183**	**26%**
Mercury Vapor	0	0%	1	0%	4	7%	4	3%	9	1%
Metal Halide	0	0%	43	12%	25	42%	29	25%	97	14%
High Pressure Sodium	0	0%	5	1%	6	11%	65	55%	76	11%
Low Pressure Sodium	0	0%	0	0%	0	0%	1	1%	1	0%
Other	**1**	**1%**	**3**	**1%**	**0**	**0%**	**3**	**3%**	**8**	**1%**
LED	0	0%	3	1%	0	0%	2	1%	5	1%
Miscellaneous	1	1%	0	0%	-	-	1	1%	3	0%
Total	**175**	**100%**	**349**	**100%**	**58**	**100%**	**118**	**100%**	**700**	**100%**

Note(s): 1) Lumens-hour is a measure of lighting output; Watt-hour is a measure of electrical input for lighting. A value of zero indicates less than 0.5 billion kWh/year. 2) Accounts for the remainder of lamps not installed inside buildings, including parking lot, stadium, stationary aviation, billboard, and traffic and street lighting.

Source(s): DOE/EERE, 2010 U.S. Lighting Market Characterization, Jan. 2012, Table 4-8, p. 34.

5.6.5 2010 Total Lighting Technology Light Output, by Sector (Trillion Lumen-Hour per Year)(1)

	Residential		Commercial		Industrial		Other (2)		Total	
Incandescent	**1640**	**49%**	**180**	**1%**	**0**	**0%**	**50**	**1%**	**1870**	**5%**
General (A-type, Decorative)	1390	42%	120	0%	0	0%	-	-	1510	4%
Reflector	190	6%	60	0%	0	0%	-	-	250	1%
Miscellaneous	60	2%	0	0%	-	-	50	1%	110	0%
Halogen	**170**	**5%**	**240**	**1%**	**0**	**0%**	**20**	**0%**	**430**	**1%**
General	20	1%	0	0%	0	0%	-	-	20	0%
Reflector	110	3%	100	0%	0	0%	-	-	210	1%
Low Voltage Display	10	0%	130	1%	-	-	-	-	140	0%
Miscellaneous	30	1%	10	0%	0	0%	20	0%	70	0%
Compact Fluorescent	**780**	**23%**	**880**	**4%**	**0**	**0%**	**50**	**1%**	**1710**	**4%**
General (Screw, Pin)	670	20%	760	3%	0	0%	-	-	1430	4%
Reflector	60	2%	130	1%	0	0%	-	-	180	0%
Miscellaneous	50	2%	-	-	-	-	50	1%	100	0%
Linear Fluorescent	**670**	**20%**	**19180**	**79%**	**1800**	**40%**	**750**	**9%**	**22400**	**55%**
T5	0	0%	1480	6%	210	5%	-	-	1700	4%
T8	80	2%	9690	40%	960	21%	-	-	10740	26%
T12	470	14%	7880	32%	640	14%	-	-	8980	22%
Miscellaneous	100	3%	120	0%	10	0%	750	9%	980	2%
High Intensity Discharge	**10**	**0%**	**3720**	**15%**	**2680**	**60%**	**7320**	**87%**	**13720**	**34%**
Mercury Vapor	0	0%	60	0%	150	3%	120	1%	330	1%
Metal Halide	0	0%	3130	13%	1860	42%	1730	21%	6730	17%
High Pressure Sodium	10	0%	520	2%	660	15%	5410	65%	6610	16%
Low Pressure Sodium	0	0%	10	0%	-	-	60	1%	60	0%
Other	**50**	**2%**	**180**	**1%**	**0**	**0%**	**180**	**2%**	**410**	**1%**
LED	0	0%	180	1%	0	0%	80	1%	270	1%
Miscellaneous	50	2%	0	0%	-	-	100	1%	150	0%
Total	**3320**	**100%**	**24380**	**100%**	**4480**	**100%**	**8370**	**100%**	**40550**	**100%**

Note(s): 1) Lumens-hour is a measure of lighting output; Watt-hour is a measure of electrical input for lighting. A value of zero indicates less than 0.5 billion kWh/year. 2) Accounts for the remainder of lamps not installed inside buildings, including parking lot, stadium, stationary aviation, billboard, and traffic and street lighting.

Source(s): DOE/EERE, 2010 U.S. Lighting Market Characterization, Jan. 2012, Table 4-9, p. 36.

5.6.6 2010 Lamp Wattage, Number of Lamps, and Hours of Usage

	Lamp Wattage (Watts per lamp)				Number of Lamps per Building			Hours of Usage per Day			
	Res	Com	Ind	Other (1)	Res	Com	Ind	Res	Com	Ind	Other
Incandescent	**56**	**53**	**46**	**68**	**32**	**14**	**1**	**2**	**10**	**13**	**9**
General (A-type, Decorative) (2)	58	58	46	N/A	27	8	1	2	10	13	N/A
Reflector	69	79	65	N/A	4	4	0 (3)	2	10	12	N/A
Miscellaneous	45	7	0	68	1	3	N/A	2	11	0	9
Halogen	**65**	**68**	**68**	**149**	**2**	**9**	**0**	**2**	**12**	**12**	**11**
General	50	46	36	N/A	0	0	0	2	12	12	N/A
Reflector	68	78	64	N/A	1	4	0	2	12	12	N/A
Low Voltage Display	44	60	0	N/A	0	5	N/A	2	13	0	N/A
Miscellaneous	82	99	145	149	0	0	0	2	10	12	11
Compact Fluorescent	**16**	**19**	**31**	**22**	**12**	**39**	**1**	**2**	**10**	**13**	**9**
General (Screw, Pin)	17	19	36	N/A	10	32	1	2	10	13	N/A
Reflector	17	20	16	N/A	1	7	0	2	10	13	N/A
Miscellaneous	18	0	0	22	1	N/A	N/A	2	0	0	9
Linear Fluorescent	**24**	**37**	**39**	**63**	**5**	**301**	**283**	**2**	**11**	**13**	**14**
T5	19	36	58	N/A	0	20	20	2	12	13	N/A
T8	26	31	32	N/A	1	181	182	2	11	13	N/A
T12	28	50	53	N/A	3	98	79	2	11	12	N/A
Miscellaneous	16	31	42	63	1	2	1	2	11	12	14
High Intensity Discharge	**126**	**350**	**403**	**240**	**0**	**6**	**31**	**2**	**11**	**17**	**12**
Mercury Vapor	193	362	451	219	0	0	3	2	11	17	11
Metal Halide	79	349	434	247	0	6	21	2	11	17	12
High Pressure Sodium	150	356	295	241	0	1	7	2	11	18	13
Low Pressure Sodium	0	185	0	107	N/A	0	N/A	0	11	0	11
Other	**47**	**12**	**11**	**30**	**0**	**7**	**1**	**2**	**21**	**22**	**10**
LED	11	12	11	20	0	7	1	2	21	22	9
Miscellaneous	54	11	0	93	0	0	N/A	1	15	0	13
Total	**46**	**42**	**75**	**151**	**51**	**376**	**317**	**2**	**11**	**13**	**12**

Note(s): 1) Accounts for the remainder of lamps not installed inside buildings, including parking lot, stadium, stationary aviation, billboard, and traffic and street lighting. 2) Values for general incandescent, general compact fluorescent, T5 fluorescent, T8 fluorescent, and T12 fluorescent lamps are weighted-averages calculated using the estimated inventory of different lamps that fit within that category. 3) A value of zero

Source(s): DOE/EERE, 2010 U.S. Lighting Market Characterization, Jan. 2012, Tables 4-1, 4-3, 4-5, 4-7, p. 22, 26, 29, 32.

5.6.7 2003 Lighted Floorspace for the Stock of Commercial Buildings, by Type of Lamp (1)

Total Lighted Floorspace: 62.06 Billion SF

Type of Lamp	Lighted Floorspace (Billion SF) (2)	Percent of Lighted Floorspace
Standard Fluorescent	59.7	96%
Incandescent	38.5	62%
Compact Fluorescent	27.6	44%
High-Intensity Discharge	20.6	33%
Halogen	17.7	29%

Note(s): 1) Mall buildings are no longer included in most CBECs tables; therefore, some data are not directly comparable to past CBECs. 2) The percentages of lighted floorspace total more than 100% since most floorspace is lighted by more than one type of lamp.

Source(s): EIA, 2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables, June 2006, Table B44, p. 220.

5.6.8 2003 Lighting Consumption and Energy Intensities, by Commercial Building Type

Building Type	Percent of Total Lighted Floorspace	Total Annual Lighting Energy (billion KWh)		Annual Lighting End-Use Intensity (kWh/SF)
Education	14%	33.1	8.4%	3.4
Food Sales	2%	13.5	3.4%	10.8
Food Service	2%	12.3	3.1%	7.4
Health Care	5%	30.8	7.8%	9.7
Inpatient	3%	22.3	5.7%	11.8
Outpatient	2%	8.2	2.1%	6.6
Lodging	7%	36.3	9.3%	7.1
Mercantile	16%	90.3	23.0%	8.1
Retail (Other Than Mall)	6%	32.5	8.3%	7.5
Enclosed and Strip Malls	10%	57.7	14.7%	8.4
Office	18%	82.4	21.0%	6.8
Public Assembly	6%	7.9	2.0%	2.1
Public Order and Safety	2%	5.3	1.3%	4.8
Religious Worship	5%	5.0	1.3%	1.3
Service	6%	18.5	4.7%	4.6
Warehouse and Storage	13%	38.7	9.9%	3.8
Other	2%	17.3	4.4%	10.0
Vacant	1%	1.2	0.3%	0.5
Total (1)		**392.4**	**100%**	

Source(s): EIA, 2003 Commericial Buildings Energy Consumption Survey Characteristics and End-Uses, Oct. 2006 and Sept. 2008, Table A1 and Table E1A.

5.6.9 Typical Efficacies and Lifetimes of Lamps (1)

Current Technology	Efficacy (lumens/Watt)	Typical Rated Lifetime (hours)	CRI (2)
Incandescent	10 - 19	750 - 2,500	97
Halogen	14 - 20	2,000 - 3,500	99
Fluorescent - T5	25 - 55	6,000 - 7,500	52 - 75
Fluorescent - T8	35 - 87	7,500 - 20,000	52 - 90
Fluorescent - T12	35 - 92	7,500 - 20,000	50 - 92
Compact Fluorescent	40 - 70	10,000	82
Mercury Vapor	25 - 50	29,000	15 - 50
Metal Halide	50 - 115	3,000 - 20,000	65 - 70
High-Pressure Sodium	50 - 124	29,000	22
Low-Pressure Sodium	18 - 180	18,000	0
Solid State Lighting	20 - 100	15,000 - 50,000	33-97

Note(s): 1) Theoretical maximum luminous efficacy of white light is 220 lumens/Watt. 2) CRI = Color Rendering Index, which indicates a lamp's ability to show natural colors. 3) The DOE Solid State Lighting program has set an efficacy goal twice that of fluorescent lights (160 lumen per Watt).

Source(s): DOE, EERE, Building Technology Program/Navigant Consulting, U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate, Sept. 2002, Appendix A, p. 74; DOE/Navigant Consulting, Solid State Lighting Research and Development Portfolio, Mar. 2006, p 55; ENERGY STAR LED Light Bulb Program, Qualified Product List, Accessed 3/15/2011; LightingFacts.com Product List, accessed March 15, 2011.

5.7.1 Refrigeration System Shipments, by Type (Including Exports)

Appliance Type	1990 (thousands)	2000 (thousands)	2005 (thousands)	2010 (thousands)	2010 Value of Shipments ($million)
Refrigerator-Freezers (1)	7,317	9,462	10,665	9,369 (2)	5,466
Freezers (chest and upright)	1,328	2,007	2,274	1,958	N/A
Refrigerated Display Cases	359	347	177	N/A	N/A
Unit Coolers (3)	178	207	209	N/A	205
Ice-Making Machines (4)	171	385	373	246	636
Water Cooler	253	348	N/A	N/A	N/A
Beverage Vending Machine	229	353	N/A	N/A	N/A

Note(s): 1) Does not include commercial products value. 2) Standard sized refrigerator-freezers 6.5 cubic feet and over. 3) Includes heat transfer coolers (refrigeration), ceiling, wall-mounted, and floor-mounted unit coolers. 4) Includes self-contained and not self-contained ice-making machines and combination ice/drink dispensers.

Source(s): Appliance Magazine, 48th Annual Statistical Review, May 2001, p. 51-54; The Air Conditioning, Heating and Refrigeration News, Nov. 11, 1995, p. 3, 19; Appliance Magazine, 50th Annual Statistical Review, May 2003; DOC, Current Industrial Reports: Air Conditioning and Refrigeration Equipment, MA333M(00)-1, Sept. 2001, Table 2; Appliance Magazine, 54th Annual Statistical Review, May 2007, p. S1-S4; DOC, Current Industrial Reports: Refrigeration, Air Conditioning, and Warm Air Heating Equipment, MA333M(06)-1, July 2007; Appliance Magazine, 2010 U.S. Appliance Shipment Statistics, April 2011, p. 3; DOC, Current Industrial Reports: Refrigeration, Air Conditioning, and Warm Air Heating Equipment, MA333M(10)-1, July 2011, Table 2; DOC, Current Industrial Reports: Major Household Appliances, MA335F(10)-1, May 2011, Table 2.

5.7.2 Other Major Appliance Shipments, by Type (Including Exports)

Appliance Type	1990 (thousands)	2000 (thousands)	2009 (thousands)	2009 Value of Shipments (4) ($million)
Room Air Conditioners	**3,799**	**6,496**	**6,418**	**129**
Ranges (total)	5,873	8,202	5,941	3,158
Electric Ranges	3,350	5,026	3,509	2,041
Gas Ranges	2,354	3,176	2,433	1,117
Microwave Ovens/Ranges	**7,693**	**12,644**	**9,333**	N.A.
Clothes Washers	**5,591**	**7,495**	**7,999**	**4,820**
Clothes Dryers (total)	**4,160**	**6,575**	**6,547**	**N.A. (5)**
Electric Dryers	3,190	5,095	5,261	N.A.
Gas Dryers	970	1,480	1,286	N.A.
Water Heaters (total)	**7,252**	**9,329**	**9,120**	**2,321**
Electric (1)	3,246	4,299	4,017	869
Gas and Oil (1)	4,005	5,006	5,104	1,452
Solar (2)	N.A.	24	N.A.	N.A.
Office Equipment				
Personal Computers (3)	N.A.	47,168	47,073	26,060
Copiers	N.A.	1,989	N.A.	N.A.
Printers	N.A.	27,945	20,627	3,109
Scanners	N.A.	9,400	N.A.	N.A.

Note(s): 1) Includes residential and small commercial units. 2) Shipments and value of shipments of entire systems. 3) Includes workstations, laptops, and notebooks. 4) Value of shipments (except for office equipment and microwaves) are based on Census unit shipment data, which are about 588 thousand units lower than industry data shown. 5) Included in clothes washers value of shipments.

Source(s): AHAM, AHAM Fact Book 2000, 2000, Tables 7 and 8, for 1990 data except water heaters; AHAM, AHAM 2005 Fact Book, 2006, Table 7 for 2000 shipments and Table 6, p. 19 for value of shipments of ranges, microwave ovens, laundry equipment, and room air conditioners; GAMA, Statistical Highlights: Ten Year Summary, 1987-1996; GAMA, Statistical Highlights: Ten Year Summary, 1994- 2003 for water heater shipments; Appliance Magazine, 2010 U.S. Appliance Shipment Statistics, April 2011, p. 3; DOC, Current Industrial Reports: Major Household Appliances, MA335F(10)-1, May 2011, Table 2; DOC, Current Industrial Reports: Refrigeration, Air Conditioning, and Warm Air Heating Equipment, MA333M(10)-1, July 2011, Table 2; DOC, Current Industrial Reports: Major Household Appliances, MA335F(02)-1, July 2003, Table 2 for value of water heater shipments; EIA, 2000 Solar Thermal and Photovoltaic Collector Manufacturing Activities, July 2001, Table 17, p. 20 for solar water heater data; Appliance Magazine, 52nd Annual Statistical Review, May 2005, p. S1-S4 for office equipment shipments; Appliance Magazine, U.S. Appliance Industry Statistical Review: 2000 to YTD 2010, p. 4 and p. 6 for appliance shipments; and Consumer Electronics Association, U.S. Consumer Electronics Sales & Forecasts 2006-2011, July 2010 for 2010 office equipment.

5.7.3 Major Appliance Ownership (Millions of Households and Percent of U.S. Households)

	1990		1996		2001		2005		2008	
Appliance Type	Households		Households		Households		Households		Households	
Room Air Conditioners	30.2	32%	30.4	31%	26.9	26%	27.4	25%	32.7	29%
Refrigerators	91.2	98%	96.8	98%	100.0	96%	104.7	96%	111.6	99%
Freezers	42.4	45%	41.9	42%	42.8	41%	36.1	33%	48.5	43%
Electric Ranges/Cooktops	58.4	63%	65.3	66%	69.2	66%	71.0	65%	68.8	61%
Gas Ranges/Cooktops	36.1	39%	38.3	39%	39.4	38%	42.2	39%	45.1	40%
Microwave Ovens	77.2	83%	89.5	91%	94.6	91%	97.2	89%	102.6	91%
Clothes Washers	86.4	93%	94.3	95%	96.9	93%	90.1	83%	107.1	95%
Electric Clothes Dryers	56.1	60%	60.4	61%	61.8	59%	67.6	62%	69.9	62%
Gas Clothes Dryers	19.1	21%	21.1	21%	19.8	19%	20.7	19%	22.6	20%
Personal Computers	N.A.	N.A.	43.5	44%	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Number of U.S. Households	**94.0**		**98.9**		**107.0**		**108.8**		**112.8**	

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 11; AHAM, AHAM 2005 Fact Book, 2006, Table 93, p. 28 for 1990, 2001 and 2005; AHAM, 2000 Major Home Appliance Industry Fact Book, Nov. 2000, Table 13, p. 21 for 1996; Consumer Electronic Manufacturers Association's Home Page, 1999 for 1997 personal computers; EIA, AEO 2011 Early Release, Table A4, p. 9-10 for 2008 households; EIA, AEO 1995, Jan. 1995, Table B4, p. 104 for 1990 households; EIA, AEO 2004, Jan. 2004, Table A4 for 2001 households.

5.7.4 2008 Refrigerator Manufacturer Market Shares (Percent of Products Produced)

Total Units Shipped: 9,310,000

Company	Market Share (%)
GE	27%
Electrolux (Frigidaire)	23%
Whirlpool	33%
Maytag (Admiral)	(1)
Haier	6%
W.C. Wood	1%
Others	10%
Total	100%

Note(s): 1) Included in Whirpool shipments

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 5.

5.7.5 Refrigerator-Freezer Sizes and Energy Factors (Shipment-Weighted Averages)

	Average Volume (cu. ft.) (1)	Consumption/Unit (kWh/yr)	Best-Available (kWh/yr)
1972	18.2	1726	N.A.
1980	19.6	1278	N.A.
1985	19.5	1058	N.A.
1990	20.5	916	N.A.
1995	20.0	649	555
2000	21.9	704	523
2001	21.9	565	438
2002	22.2	520	428
2003	22.3	514	428
2004	21.5	500	402
2005	20.7	490	417
2006	22.3	506	464
2007	21.9	498	459
2008	21.4	483	N.A.
2009 (2)	21.0	460	334
2010	22.5	462	311

Note(s): The average stock energy uses for refrigerator-freezers was 1,220 kWh/yr in 1990, 1,319 kWh/yr in 1997, and 1,462 kWh/yr in 2001. 1) Represents the average adjusted volume, which is defined as the fresh volume plus 1.63 times the freezer volume. 2) Based on refrigerator-freezer units with adjusted volumes approximately equal to the average adjusted volume.

Source(s): AHAM, Energy Efficiency and Consumption Trends 2010; AHAM, Efficiency and Consumption Trends 2009; AHAM, 2000 Major Home Appliance Industry Fact Book, 2000, Table 25, p. 30 for 1972-1985; AHAM, 2005 AHAM Fact Book, 2006, Table 17, p. 40 for 1990-2004; AHAM, 1991, 1993-1999 Directory of Certified Refrigerators and Freezers for 1993-1999 best-available data (at 19.6 or more cu. ft.); LBNL, Center for Building Science News, Summer 1995, p. 6 for 1990 portion of note; EIA, A Look at Residential Energy Consumption in 2001; Apr. 2004, Table CE5-1c for 2001 portion of note; EIA, A Look at Residential Energy Consumption in 1997, Nov. 1999, Table CE5-2c, p. 205 for 1997 portion of note; and ENERGY STAR certified products lists for 2001-2010 best available, http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel.

5.7.6 2008 Room Air Conditioner Manufacturer Market Shares (Percent of Products Produced)

Total Units Shipped: 9,085,500

Company	Market Share (%)
LG Electronics (Goldstar)	32%
Fedders	12%
Electrolux (Frigidaire)	13%
Whirlpool	13%
Haier	8%
Samsung	5%
Sharp	4%
Friedrich	4%
UTC/Carrier	3%
Matsushita	2%
Others	4%
Total	100%

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 5.

5.7.7 Room Air Conditioner Capacities and Energy Efficiencies (Shipment-Weighted Averages)

	Average Capacity (Btu/hr)	EER	Best-Available (EER)
1972	10227	5.98	N.A.
1980	10,607	7.02	N.A.
1985	10,287	7.70	N.A.
1990	10,034	8.73	N.A.
1995	10,099	9.03	12.0
2000	9,739	9.30	11.7
2001	9,874	9.63	11.7
2002	9,800	9.75	11.7
2003	9,203	9.75	11.7
2004	9,735	9.71	11.7
2005	7,916	9.95	12.0
2006	9,197	10.02	12.0
2007	8,518	9.81	12.0
2008	8,760	9.93	12.0
2009	9,287	10.05	12.0
2010	8,737	10.18	12.0

Source(s): AHAM, Energy Efficiency and Consumption Trends 2010; AHAM, Efficiency and Consumption Trends 2009; AHAM, 1997 Major Appliance Industry Fact Book, Oct. 1997, Table 27, p. 32 for 1972; AHAM, AHAM 2003 Fact Book, 2003, Table 25, p. 45 for 1980-1985 average capacity and EER; AHAM, AHAM 2005 Fact Book, 2006, Table 19, p. 42 for 1990-2004 average capacity and EER; AHAM, 1994-1999 Directory of Certified Room Air Conditioners, Mar. 2000 for 1994-2000 best available; and ENERGY STAR certified products lists for 2001-2010 best available, http://www.energystar.gov/index.cfm?fuseaction=roomac.display_products_excel.

5.7.8 2008 Clothes Washer Manufacturer Market Shares (Percent of Products Produced)

Company	Market Share (%)
Whirlpool	64%
Maytag	(1)
GE	16%
Electrolux (Frigidaire)	6%
LG Electronics	6%
Others	8%
Total	100%

Total Units Shipped: 8,292,000

Note(s): 1) Included in Whirlpool shipments.

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 6.

5.7.9 2008 Clothes Dryer Manufacturer Market Shares (Percent of Products Produced)

Company	Electric Market Share (%)	Gas Market Share (%)
Whirlpool	70%	74%
Maytag	(1)	(1)
GE	16%	10%
Electrolux (Frigidaire)	8%	5%
Others	6%	11%
Total	100%	100%

Total Electric Units Shipped: 5,620,000

Total Gas Units Shipped: 1,353,000

Note(s): 1) Included in Whirlpool shipments.

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 6.

5.7.10 2008 Range Manufacturer Market Shares (Percent of Products Produced)

Company	Electric Market Share (%)	Gas Market Share (%)
GE	47%	37%
Whirlpool	29%	25%
Electrolux (Frigidaire)	8%	23%
Maytag	(1)	(1)
Others	16%	15%
Total	100%	100%

Total Electric Units Shipped: 5,106,000

Total Gas Units Shipped: 2,842,400

Note(s): 1) Included in Whirlpool shipments

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 6.

5.7.11 2008 Microwave Oven Manufacturer Market Shares (Percent of Products Produced)

Company	Market Share (%)
LG Electronics (Goldstar)	33%
Sharp	15%
Samsung	15%
Daewoo	7%
Matsushita	10%
Whirlpool	3%
Sanyo	9%
Others	8%
Total	100%

Total Units Shipped: 11,340,000

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 6.

5.7.12 2007 Copier Machine Manufacturer Market Shares (Percent of Products Produced)

	Copier Market Share (%)
Canon	31%
Konica Minolta	21%
Ricoh	16%
Xerox	10%
Sharp	4%
Kyocera Mita	4%
Others	14%
Total	100%

Total Copier Units Shipped: 247,763

Note(s): Data has not been updated because market share for these products is no longer reported in Appliance Magazine.

Source(s): Appliance Magazine, A Portrait of the U.S. Appliance Industry, Sept. 2008, p. 41.

5.7.13 2007 Personal Computer Manufacturer Market Shares (Percent of Products Produced)

Company	Desktop Computer Market Share (%)	Portable Computer Market Share (%)
Dell	32%	25%
Hewlett-Packard	24%	26%
Gateway	5%	4%
Apple	4%	9%
Acer America	3%	N/A
IBM	1%	N/A
Micron	0%	N/A
Toshiba	N/A	12%
Levono (IBM)	N/A	6%
Sony	N/A	5%
Fujitsu Siemens	N/A	1%
Others	30%	13%
Total	100%	100%

Total Desktop Computer Units Shipped:	34,211,601
Total Portable Computer Units Shipped:	30,023,844

Note(s): Data has not been updated because market share for these products is no longer reported in Appliance Magazine.

Source(s): Appliance Magazine, A Portrait of the U.S. Appliance Industry, Sept. 2008, p. 41.

5.7.14 2007 Printer Manufacturer Market Shares (Percent of Products Produced)

Company	Ink Jet Printer Market Share (%)	Laser Printer Market Share (%)	Dot Matrix Market Share (%)
Hewlett-Packard	58%	56%	N/A
Canon	16%	N/A	N/A
Epson	11%	N/A	27%
Lexmark	15%	10%	11%
Dell	0%	11%	N/A
Samsung	N/A	6%	N/A
Brother	N/A	4%	N/A
Oki Data	N/A	3%	46%
Konica Minolta	N/A	1%	N/A
Panasonic	N/A	N/A	6%
TallyGenicom	N/A	N/A	5%
Others	0%	9%	6%
Total	100%	100%	100%

Total Ink Jet Units Shipped:	6,392,177
Total Laser Units Shipped:	3,356,556
Total Dot Matrix Units Shipped:	231,547

Note(s): Data has not been updated because market share for these products is no longer reported in Appliance Magazine.

Source(s): Appliance Magazine, A Portrait of the U.S. Appliance Industry, Sept. 2008, p. 41.

5.7.15 Major Residential and Small Commercial Appliance Lifetimes, Ages, and Replacement Picture

Appliance Type	Typical Service Lifetime Range (years)	Average Lifetime (years)	2005 Average Stock Age (years)	Units to be Replaced During 2011 (thousands)
Refrigerators (1)	10 - 16	12	7.8	9,217
Freezers	8 - 16	11	11.3	2,215
Microwave Ovens	7 - 10	9	N.A.	14,625
Ranges (2)				
Electric	12 - 19	16	N.A.	4,281
Gas	14 - 22	17	N.A.	2,854
Clothes Washers	7 - 14	11	N.A.	7,362
Clothes Dryers				
Electric	8 - 15	12	N.A.	5,095
Gas	8 - 15	12	N.A.	1,480
Water Heaters				
Electric	4 - 20	13	8.1	4,281
Gas	7 - 15	11	8.1	4,931
Room Air Conditioners	7 - 13	9	6.5	8,216
Facsimile Machines (3)	3 - 5	4	N.A.	3,133
Portable Computers (3)	2 - 4	3	N.A.	31,600

Note(s): Lifetimes based on use by the first owner of the product, and do not necessarily indicate that the product stops working after this period. A replaced unit may be discarded or used elsewhere. 1) Standard-size refrigerators only. 2) Ranges include free-standing, built-in, high-oven and cooktop/oven combination units. 3) Data for facsimile machines and portable computers is from 2010.

Source(s): Appliance Magazine, U.S. Appliance Industry: Market Value, Life Expectancy & Replacement Picture for 2005-2012, Jan. 2011, p. 11-12 for service and average lifetimes and units to be replaced; Appliance Magazine, U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels, January 2010, p. 10 ; EIA, 2005 Residential Energy Consumption Survey, Apr. 2008, Table HC 2.6, Table HC 2.8 and Table HC 2.9 for average stock ages

5.7.16 Other Major Appliance Efficiencies

Residential Appliance Type	Efficiency Parameter (1)	2005 Stock Efficiency	2010 U.S. Average New Efficiency	2010 Best Available New Efficiency
Dishwashers	EF	0.30	0.61	1.13
Clothes Washers (2)	MEF	2.00	2.00	3.88
Clothes Dryers (electric)	EF	3.01	3.10	3.16
Clothes Dryers (gas)	EF	2.67	2.75	3.02
Cooktop (Gas)	Cooking Efficiency	0.38	0.40	0.42

Commercial Appliance Type	Efficiency Parameter (1)	2010 Stock Efficiency	U.S. Average New Efficiency	1992 Best Available New Efficiency
Cooking Equipment:				
Electric Appliances	EF	0.74	N.A.	N.A.
Gas Appliances	EF	0.53	N.A.	N.A.
Laundry Equipment:				
Electric Drying	EF/COP	N.A.	N.A.	0.98
Gas Drying	EF	N.A.	N.A.	0.36
Motors	EF	N.A.	N.A.	0.65
Office Equipment:				
Linear Power Supplies	EF	N.A.	N.A.	0.30 - 0.60
Switching Power Supplies	EF	N.A.	N.A.	0.80 - 0.95
Motors	EF	N.A.	N.A.	0.60 - 0.70

Note(s): 1) EF = Energy Factor. MEF = Modified Energy Factor. COP = Coefficient of Performance. 2) EF does not include remaining moisture content (RMC) of clothes. MEF includes RMC which shows how much the clothes dryer will be needed.

Source(s): EIA/Navigant Consulting, EIA - Technology Forecast Updates - Residential and Commercial Building Technologies - Reference Case, Oct. 2011, p. 46-57 for residential stock; EIA, Supplement to the AEO 2012 - Early Release, Jan. 2012, Table 32 for commercial cooking data; and BTS/OBE, Characterization of Commercial Building Appliances, Aug. 1993 for commercial efficiencies.

5.7.17 Commercial Refrigeration - Annual Primary Energy Consumption

Equipment Type	Percent of Total
Supermarket Refrigeration	56%
Walk-Ins	12%
Reach-Ins	9%
Refrigerated Vending Machines	8%
Ice Machines	7%
Beverage Merchandisers	4%
Food Service Equipment	4%
Total	**1.23 Quad**

Source(s): DOE/EERE/Navigant Consulting, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Sept. 2009, Figure 1-2, p. 17.

5.7.18 Commercial Refrigeration - Installed Base and Total Energy Consumption by Type

Equipment	Installed Base (thousand)	Total Energy Consumption (TWh/yr)
Supermarket Refrigeration Systems		
Display Cases	2,100	214
Compressor Racks	140	373
Condensers	140	50
Walk-Ins	245	51
Walk-In Coolers and Freezers (Non-Supermarket)	755	148
Food Preperation and Service Equipment	1,516	55
Reach-In Refrigerators and Freezers	2,712	106
Beverage Merchandisers	920	45
Ice Machines	1,491	84
Refrigerated Vending Machines	3,816	100
Total		**1225**

Note(s): Energy consumption values have been rounded to the nearest whole number, and therefore the total does not exactly equal the sum of the energy consumption values for each equipment type.

Source(s): DOE/EERE/Navigant Consulting, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Sept. 2009, Table 3-1, p. 26.

5.7.19 Commercial Refrigeration - Unit Inventory and Energy Consumption

Application	Estimated Inventory (thousand)	Unit Energy Consumption (kWh/yr)	Total Energy Consumption (TWh/yr)	Primary Energy Consumption (Tbtu/yr)
Walk-In Coolers and Freezers				
Non-Supermarket, Cooler	468	16,200	7.6	78.9
Non-Supermarket, Freezer	234	21,400	5.0	52.1
Non-Supermarket, Combination	53	30,200	1.6	16.6
Supermarket	245	varies	4.9	51.0
Beverage Merchandisers (1)				
One-Door	460	3,076	1.4	14.7
Two-Door	414	6,080	2.5	26.2
Three-Door	46	8,960	0.4	4.3
Reach-In Refrigerators and Freezers (2)				
Freezers	1,156	4,158	4.8	56.0
Refrigerators	1,556	3,455	5.4	50.0
Ice Machine	1,491	5,429	8.1	84.2
Beverage Vending Machine (3)				
Fully-cooled	496	2,743	1.4	14.2
Zone-cooled	3,320	2,483	8.2	85.8

Note(s): 1) Beverage merchandisers are self-contained, upright, refrigerated cabinets that are designed to hold and/or display refrigerated beverage items for purchase without an automatic vending feature.Typically they have glass doors and bright lighting. These cases are commonly used in convenience stores, aisle locations in supermarkets, and some retail stores.Because the refrigeration system is self-contained, the heat is rejected to the building interior, and their energy use is not included in the supermarket refrigeration sections. 2) Commercial reach-in cabinets are upright, self-contained refrigerated cases with solid or glass doors whose purpose is to hold frozen and/or refrigerated food products. These cases are commonly used in commercial and institutional food-service establishments.These are self-contained units, i.e., the entire refrigeration system is built into the reach-in unit and heat is rejected to the surrounding interior air. 3) In a fully cooled beverage vending machine, all beverages enclosed within the machine are visible to the customer and, therefore, the entire internal volume is refrigerated. The zone-cooled packaged beverage vending machine only cools the beverage that are soon-to-be-vended, meaning only a small portion, or zone, of the internal volume is refrigerated.

Source(s): DOE/EERE/Navigant Consulting, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Sept. 2009, Table 3-5, p. 31 for walk-in coolers and freezers, Table 3-12, p. 37 for beverage merchandiser, Table 3-11, p. 35 for reach-in freezers and refrigerators, Table 3-15, p. 41 for ice machines, and Table 3-16, p. 44 for beverage vending machine.

5.7.20 Commercial Refrigeration - Display Case Shipments

Year	Shipments
1999	340,453
2000	347,262
2001	175,000
2002	183,300
2003	191,549
2004	185,000
2005	170,000
2006	175,500
2007	181,000
2008	185,000

Source(s): DOE/EERE/Navigant Consulting, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Sept. 2009, Table 3-3, p. 28.

5.8.1 Solar Collector Shipments, by Type and Market (Thousand SF, unless noted) (1)

Type	1980	1990	2000	2009
Solar Thermal Collectors (2)	**19,398**	**11,409**	**8,354**	**13,798**
Residential	N.A.	5,851	7,473	10,239
Commercial	N.A.	295	810	974
Industrial	N.A.	(3)	57	634
Utility	N.A.	5,236	5	374
Other	N.A.	26	10	1,577 (4)
Photovoltaics (kW) (5)	(6) 6,897	13,837	88,221	1,282,560

Note(s): 1) Shipments for 1980-2000 include imports and exports; 2008 shipments are domestic only. 2) Solar thermal collectors: receive solar radiation, convert it to thermal energy, and are typically used forspace heating, water heating, and heating swimming pools. 3) Industrial is included in Other. 4) Other includes all exports. 5) Generate electricity by the conversion of solar radiation to electrical energy; shipments for all years include imports and exports. 6) Value from 1982.

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 10.6, p. 305 for total thermal collector shipments 1980-2009, Table 10.7, p. 307 for solar thermal shipments by market, Table 10.8, p. 309 for photovoltaic shipments; EIA, Annual Energy Review 1991, June 1992, Table 111, p. 251 for 1990 collector sector data; EIA, Renewable Energy Annual 2001, Nov. 2002, Table 18, p. 19 for 2000 collector sector data.

5.8.2 Thermal Solar Collector Shipments, by End Use (Thousand SF) (1)

Type	2000	2005	2006	2007	2008	2009
Pool Heating	7,863	15,041	15,362	12,076	11,973	8934
Hot Water	367	640	1,136	1,393	1,978	1992
Space Heating	99	228	330	189	186	150
Space Cooling	0	2	3	13	18	10
Combined Space/Water Heating	2	16	66	73	148	137
Process Heating	20	0	0	27	50	608
Electricity Generation	3	114 (2)	3,847	6	361	389
Total	**8,354**	**16,041**	**20,744**	**15,153**	**16,963**	**13,798**

Note(s): 1) Total shipments include imports and exports for all years.For 2007 to 2009, end-use values only include domestic shipments. 2) 2005 to 2006 increase in electricity generation due to shipment to the Nevada Solar One Project.

Source(s): EIA, Renewable Energy Annual 2010, Oct. 2011, Table 10.6, p. 305 for 2000-2009 total collector shipments, and Table 10.7, p. 307 for 2007-2009 end-use shipments; EIA, Renewable Energy Annual 2001, Nov. 2002, Table 18, p. 19 for 2000 end-use shipments; EIA, Renewable Energy Annual 2003, June 2005, Table 18, p. 10 for 2003 end-use shipments; EIA, Solar Thermal and Photovoltaic Collector Manufacturing Activities 2005, Aug. 2006, Table 38, p. 22 for 2004-2005 end-use shipments; and EIA, Solar Thermal and Photovoltaic Collector Manufacturing Activities 2006, Table 2.10, p. 21 for 2006 end-use shipments.

5.8.3 2009 Top Five Destinations of Thermal Solar Collector Shipments

State	Percent of Domestic U.S. Shipments	Thousand SF
Florida	27%	3,771
California	26%	3,537
Arizona	5%	745
Hawaii	4%	520
Oregon	3%	387

Note(s):

Source(s): EIA, Solar Thermal Collector Manufacturing Activities 2009, Dec. 2010, Table 2.4, p. 10.

5.8.4 Thermal Solar Collector Manufacturer Statistics

-	Number of Manufacturers in 2008:	88
-	Companies with 90% of their revenue coming from solar collector sales:	56
-	Percentage of shipped solar collectors produced by top 5 manufacturers:	79%

Source(s): EIA, Solar Thermal Collector Manufacturing Activities 2009, Dec. 2010, p. 2, Table 2.17, p. 24, Table 2.20, p. 27.

5.8.5 Shipments of Photovoltaic Cells and Modules, by Market (thousand Peak Kilowatts)(1)

	Residential	**Commercial**	Industrial	Transportation	Utility	Government	Other	Total
1995	**6.3**	**8.1**	7.2	2.4	3.8	2.0	1.3	31.1
2000	**24.8**	**13.7**	28.8	5.5	6.3	4.4	4.7	88.2
2002	**29.3**	**20.6**	32.2	12.9	7.6	8.6	0.8	112.1
2003	**23.4**	**32.6**	28.0	11.1	8.5	5.5	0.3	109.4
2004	**53.9**	**74.5**	30.5	1.4	3.2	3.3	14.3	181.1
2005	**75.0**	**89.5**	22.2	1.6	0.1	28.7	9.8	226.9
2006	**95.8**	**180.9**	28.6	2.5	4.0	7.7	17.9	337.3
2007	**68.4**	**140.4**	32.7	3.6	35.3	(2)	0.0	280.5
2008	**174.0**	**253.9**	51.5	9.1	35.8	(2)	0.0	524.3
2009	**221.2**	**282.3**	43.4	0.5	53.6	(2)	0.0	601.1

Note(s): 1) Includes imports and exports for 2000-2006. 2007-2009 only includes domestic shipments. 2) Beginning in 2007, the government sector is included in "Commercial".

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 10.9, p. 311 for 2009; EIA, Renewable Energy Annual 2008, Aug. 2010, Table 3.7, p. 85 for 2007-2008; EIA, Renewable Energy Annual 2006, Aug. 2008, Table 2.23 for 2006; EIA, Solar Thermal and Photovoltaic Collector Manufacturing Activities 2005, Aug.

5.8.6 Annual Shipments of Photovoltaic Cells and Modules (Peak Kilowatts)

Year	Number of Companies	Domestic	Exports	Total
1996	25	13,016	22,448	35,464
1997	21	12,561	33,793	46,354
1998	21	15,069	35,493	50,562
1999	19	21,225	55,562	76,787
2000	21	19,838	68,382	88,220
2001	19	36,310	61,356	97,666
2002	19	45,313	66,778	112,091
2003	20	48,664	60,693	109,357
2004	19	78,346	102,770	181,116
2005	29	134,465	92,451	226,916
2006	41	206,511	130,757	337,268
2007	46	280,475	237,209	517,684
2008	66	524,252	462,252	986,504
2009	101	601,133	681,427	1,282,560

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Tables 10.8 and 10.9, p. 309-311.

5.8.7 2009 Top 10 Destinations of U.S. Photovoltaic Cell and Module Export Shipments, by Country

Country	Peak Kilowatts	Percent of U.S. Exports
Germany	309,147	45%
Italy	108,187	16%
France	47,271	7%
Canada	43,458	6%
Belgium	27,247	4%
Spain	23,460	3%
China	18,297	3%
India	14,806	2%
South Korea	12,581	2%
Australia	8,368	1%
Total U.S. Exports	681,427	100%

Note(s): Total U.S. exports of photovoltaic cells and modules increased by 47% from 2008 to 2009.

Source(s): EIA, Solar Photovoltaic Cell/Module Manufacturing Activities, Dec. 2010, Table 3.14.

5.8.8 Annual New Installations of Grid-Tied Photovoltaic Cells and Modules, by Market (MW)

Peak Capacity by Use	2004	2005	2006	2007	2008	2009	2010
Residential	**23.4**	**26.2**	**36.3**	**55.9**	**74.5**	**150.4**	**260.9**
Non-Residential	**30.6**	**49.0**	**64.2**	**96.5**	**202.4**	**202.4**	**343.8**
Utility	1.8	0.6	0.2	8.7	21.3	66.6	286.0
Unknown	1.8	3.2	4.0	7.7	12.7	17.7	3.7
Total New Capacity	57.6	79.0	104.7	168.8	310.9	437.1	894.4
Cumulative Capacity	155.1	234.2	338.9	507.7	818.6	1256.7	2150.0
Number of Installations	6,873	7,718	9,576	14,597	18,970	34,243	50,314

Source(s): Sherwood, Larry. Interstate Renewable Energy Council. Personal Communication. Febuary, 13, 2012.

5.8.9 Total Grid-Tied PV Capacity, by State

	PV Capacity as of 2007 (MW)				Net Metering Utility (2006)		
State	Total (1)	Residential	Non-Res.	Unknown	Utility Participants (2)	Residential Customers	Non-Res. Customers
California	328.8	118.3	193.7	16.8	19	24,160	1,972
New Jersey	43.6	14.5	27.6	1.5	5	1,789	203
Arizona	18.9	3.2	13.1	2.6	4	185	3
Nevada	18.8	1.2	17.6	-	2	213	23
New York	15.4	9.7	5.2	0.5	5	1,088	119
Colorado	14.6	4.8	9.6	0.2	17	380	25
Massachusetts	4.6	1.5	3.2	-	5	454	104
Hawaii	4.5	1.3	2.4	0.8	4	184	23
Texas	3.2	1.6	1.7	-	9	375	56
All Other States	8.3	9.4	22.6	17.7	180	2,495	617
Total (3)	**475.0**	**164.4**	**283.5**	**22.4**	**232**	**31,323**	**3,146**

Note(s): 1) Projections totals may not add due to rounding. 2) Includes entities with participants in more than one state. 3) Arizona does not have state-wide net metering provisions. 3) Estimated total grid-tied capacity differs from Table 6.3.10.

Source(s): Sherwood, Larry. Interstate Renewable Energy Council (IREC). Personal Communication July, 2008; EIA. Green Pricing and Net Metering Programs, 2006. July 2008. Table 4.2, p. 10.

5.8.10 Annual Installed Capacity of Photovoltaic Cells and Modules, Off-Grid and On-Grid (DC MW)

	On-Grid	Off-Grid	Total
1997	1.4	9.0	10.4
1998	1.8	9.7	11.5
1999	2.6	12.0	14.6
2000	3.7	13.5	17.2
2001	11.1	16.0	27.1
2002	22.5	21.4	43.9
2003	43.4	25.0	68.4
2004	54.7	28.0	82.7
2005	67.4	33.0	100.4
2006	103.2	0.0	103.2
2007	150.1	55.0	205.1
Cumulative (1)	**469.9**	**282.0**	**751.9**

Note(s): 1) Cumulative grid-tied capacity as of 2007 differs from total estimate in Table 6.3.9.

Source(s): Sherwood, Larry. Interstate Renewable Energy Council. Personal Communication. July, 2008.

5.9.1 United States Small Wind Units and Capacity

	Units	On-Grid Units	Off-Grid Units	Capacity kW	On-Grid kW	Off-Grid kW	Sales ($ Million)
2001 (1)	2100	-	-	2,100	-	-	-
2002 (1)	3100	-	-	3,100	-	-	-
2003 (1)	3200	-	-	3,200	-	-	-
2004	4671	-	-	4,878	-	-	17.2
2005	4324	-	-	3,285	-	-	11.1
2006	8330	1	7,876	8,565	4,522	4,043	35.8
2007	9102	1	7,800	9,748	5,720	4,017	43.1
2008	10386	1	7,402	17,374	13,610	3,764	73.5
2009	9820	-	-	20,375	-	-	91.0
2010	7811	-	-	25,618	-	-	139.2

	Remote Off-Grid(2) (< 1 kW)	Residential-Scale (1 - 10 kW)	Commericial Scale (11 - 100 kW)
% 2008 Units	65%	34%	2%
% 2008 Capacity	16%	44%	40%

Note(s): 1) Estimates. 2) Turbines under 1 kW are often used on marine vehicles to charge batteries and to pump water for irrigation or ranching.

Source(s): American Wind Energy Association (AWEA), Stimmel, Ron, 2008 AWEA Small Wind Turbine Global Market Study, June 2008 for 2006 and 2007 detail; AWEA, Stimmel, Ron, 2009 AWEA Small Wind Turbine Global Market Study for 2008 detail; and AWEA, Stimmel, Ron, 2011 AWEA Small Wind Turbine Global Market Study for 2001-2009 units and capacities.

5.9.2 Average Combined Heat and Power Capacity as of 2011, Selected Building Type and Prime Mover (kW)

	Combustion Turbine	Reciprocating Engine	Fuel Cell	Microturbine	Boiler/Steam Turbine	Other
Multifamily Buildings	-	236	365	223	19,000	37,700
Colleges/Univ	15,918	2,039	223	202	18,342	40,659
Restaurants	-	222	-	120	-	-
Hospitals/Healthcare	5,399	1,280	264	298	10,097	22,407
Hotels	5,291	650	444	149	-	400
Justice/Public Order	10,304	1,568	521	58	11,050	28,800
General Merch. Stores	-	2,167	800	360	-	-
Nursing Homes	-	154	-	434	1,000	-
Office	4,533	1,172	440	219	14,025	450
General Gov't	7,957	1,043	285	197	2,686	14,558
Schools K-12	-	322	200	93	1,500	-
Community Services	-	124	200	-	-	-

Source(s): Energy and Environmental Analysis Inc, The Combined Heat and Power Database, http://www.eea-inc.com/chpdata/index.html

5.9.3 Installed Combined Heat and Power Capacity as of 2011, Selected Building Type and Prime Mover (MW)

	Combustion Turbine	Reciprocating Engine	Fuel Cell	Microturbine	Boiler/Steam Turbine	Other	**Total**
Multifamily Buildings	-	35	1	3	38	38	115
Colleges/Univ	828	160	3	4	1009	732	2736
Restaurants	-	2	-	0	-	-	2
Hospitals/Healthcare	184	143	2	2	202	224	757
Hotels	41	57	4	3	-	0	105
Justice/Public Order	52	24	3	0	55	58	191
General Merch. Stores	-	22	1	0	-	-	23
Nursing Homes	-	18	-	3	1	-	22
Office	41	95	2	3	28	0	170
General Gov't	56	28	2	2	19	58	165
Schools K-12	-	64	1	3	2	-	70
Community Services	-	1	0	-	-	-	1
Total	1201	649	18	23	1353	1110	**4355**

Source(s): Energy and Environmental Analysis Inc, The Combined Heat and Power Database, http://www.eea-inc.com/chpdata/index.html

5.9.4 Installed Combined Heat and Power Capacity as of 2011, Selected Building Type and Census Region (MW)

	Northeast	South	Midwest	West	**Total**
Multifamily Buildings	112	-	-	2	115
Colleges/Univ	570	522	1,128	516	2,736
Restaurants	0	2	-	0	2
Hospitals/Healthcare	316	126	108	206	757
Hotels	34	9	0	62	105
Justice/Public Order	59	8	9	115	191
General Merch. Stores	18	-	5	0	23
Nursing Homes	17	0	4	2	22
Office	82	34	15	39	170
General Gov't	3	82	36	44	165
Schools K-12	27	0	21	21	70
Community Services	1	-	-	1	1
Total	**1,238**	**783**	**1,326**	**1,008**	**4,355**

Source(s): Energy and Environmental Analysis Inc, The Combined Heat and Power Database, http://www.eea-inc.com/chpdata/index.html

5.9.5 Installed Combined Heat and Power Capacity as of 2011, Prime Mover and Census Region (MW)

Prime Mover	Northeast	South	Midwest	West	**Total**
Combustion Turbine	359	324	266	251	1,201
Reciprocating Engine	251	121	112	165	649
Fuel Cell	9	0	0	8	18
Microturbine	11	1	1	10	23
Boiler/Steam Turbine	466	182	624	82	1,353
Other	141	156	323	491	1,110
Total	**1,238**	**783**	**1,326**	**1,008**	**4,355**

Source(s): Energy and Environmental Analysis Inc, The Combined Heat and Power Database, http://www.eea-inc.com/chpdata/index.html

5.9.6 Characteristics of Commercial Distributed Generating Technologies, by Plant Type as of 2006

	Efficiency (HHV)		Typicall Installed Capital Costs			Service
New Plant Type	Electrical	Electrical + Thermal	Price ($2010 per kW)	Size (kW)	Cost ($2010 thousand)	Life (years)
Solar Photovoltaic	0.15	N.A.	6,939	32	222	30
Wind	0.13	N.A.	5,274	32	169	30
Fuel Cell	0.42	0.65	7,187	200	1,437	20
Natural Gas Engine	0.30	0.82	1,797	334	600	20
Oil-Fired Engine	0.34	0.73	1,801	300	540	20
Natural Gas Turbine	0.25	0.76	1,908	3510	6,697	20
Natural Gas Microturbine	0.32	0.61	2,437	200	487	20

Source(s): EIA, Assumptions to the Annual Energy Outlook 2011, July 2011, Table 5.3, p. 42 ; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353.

Chapter 6: Energy Supply

Chapter 6 focuses on the U.S. energy supply. Sections 6.1 and 6.2 contain data on electric utilities, including generation capacity, primary fuel consumption, transmission and distribution losses, and electricity prices. Section 6.3 addresses the production, consumption, and storage of natural gas and petroleum. Section 6.4 covers emissions from the utility sector. Section 6.5 provides data on how utilities spend public and system benefit funds. The main points from this chapter are summarized below:

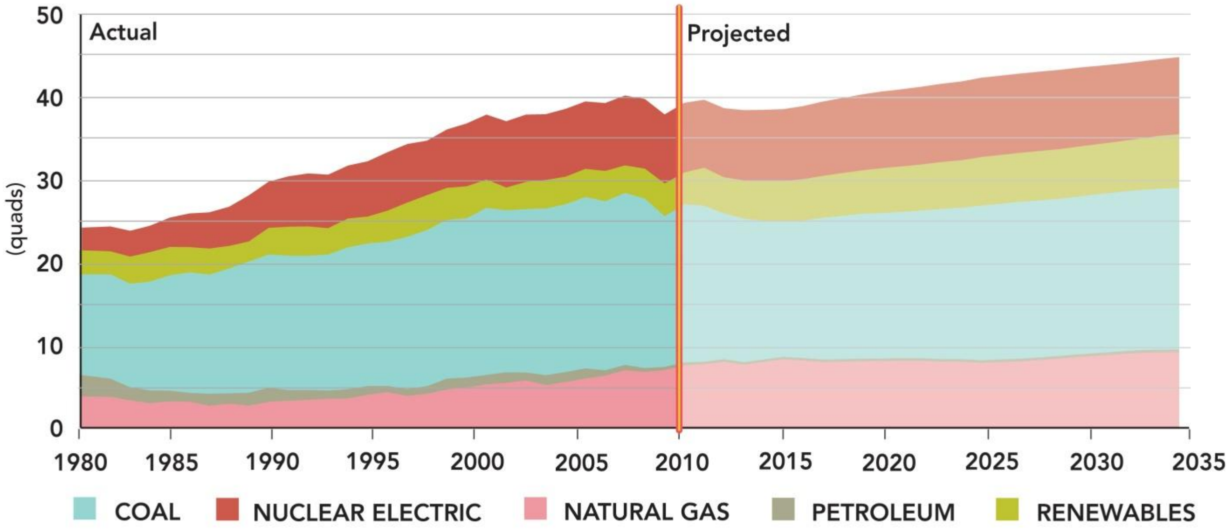
- Total primary energy consumption in the United States increased from 78 quads in 1980 to more than 98 quads in 2010. (1.1.3)
- Electricity consumption in the buildings sector has more than doubled since 1980, increasing from 4.4 quads of delivered energy to 9.5 quads in 2010. (6.1.1)
- The average capacity factor of nuclear plants increased from 66% in 1990 to 91% in 2010, while the average capacity factor for coal plants increased from 59% to only 65%.
- From 2000 to 2010, the number of natural gas wells increased from about 276,000 to 510,000 nationwide, allowing 89% of gas consumed in the United States to be produced domestically in 2010.

Total primary energy consumption in the United States increased from 78 quads in 1980 to more than 98 quads in 2010. (1.1.3) Much of this growth has been driven by a 79% increase in electricity demand, from 7.2 quads of delivered energy in 1980 to 12.8 quads in 2010, or 2.0% annual increase during this period. To meet this demand, primary fuel consumption by electric utilities has increased from 24.3 quads to 39.6 quads over the same period. The Energy Information Administration (EIA) projects energy consumption from electricity will grow at a reduced rate to 15.3 quads of delivered energy and 45.1 quads of primary energy by 2035. (6.1.1), (6.1.3)

In 2010, the buildings sector consumed 40% of total primary energy but 74% of electricity. Electricity demand in the buildings sector has more than doubled since 1980, increasing from 4.4 quads of delivered energy to 9.5 quads in 2010. In comparison, buildings consumed 8.4 quads of natural gas, 1.9 quads of petroleum, and less than 1 quad of coal and renewable sources on site. Electricity accounted for 82% of energy expenditures ($302 billion) in the buildings sector in 2010. (6.1.1), (6.1.3)

Utilities rely on a variety of input fuels to generate electricity, including coal, nuclear, natural gas, petroleum, and renewable sources such as solar, wind, and hydroelectric dams. Coal has accounted for at least half of electricity generation from 1980 through 2008. Coal consumption has declined recently and is projected to continue its decline, accounting for only 43% of utilities' energy consumption in 2035. Nuclear generation also grew from 2.7 quads in 1980 to 8.4 quads, or 21% of total generation, in 2010. The use of natural gas and petroleum is very responsive to price, and use increases when prices become more competitive. As an overall trend, their shares of total generation decreased between 1980 and 1990, from 16% to 11% for natural gas and from 11% to 4% for petroleum. (6.1.2), (6.1.3)

Between 1990 and 2010, petroleum continued to fall as a share of total generation, while generation from natural gas doubled to 8.0 quads. The amount of electricity generated by nuclear power plants remained between 19% and 22% of total generation. As new nuclear capacity increases in the near future, nuclear-generated electricity will increase. After 2030 when nuclear capacity declines, nuclear-generated electricity declines. After 2030, coal's share of total generation is stable, while absolute generation from coal increases by 26% to 20.5 quads. EIA expects renewable sources to increase their share from 10% in 2008 to 14% in 2035, mostly as a result of increased wind capacity. (6.1.2), (6.1.3)



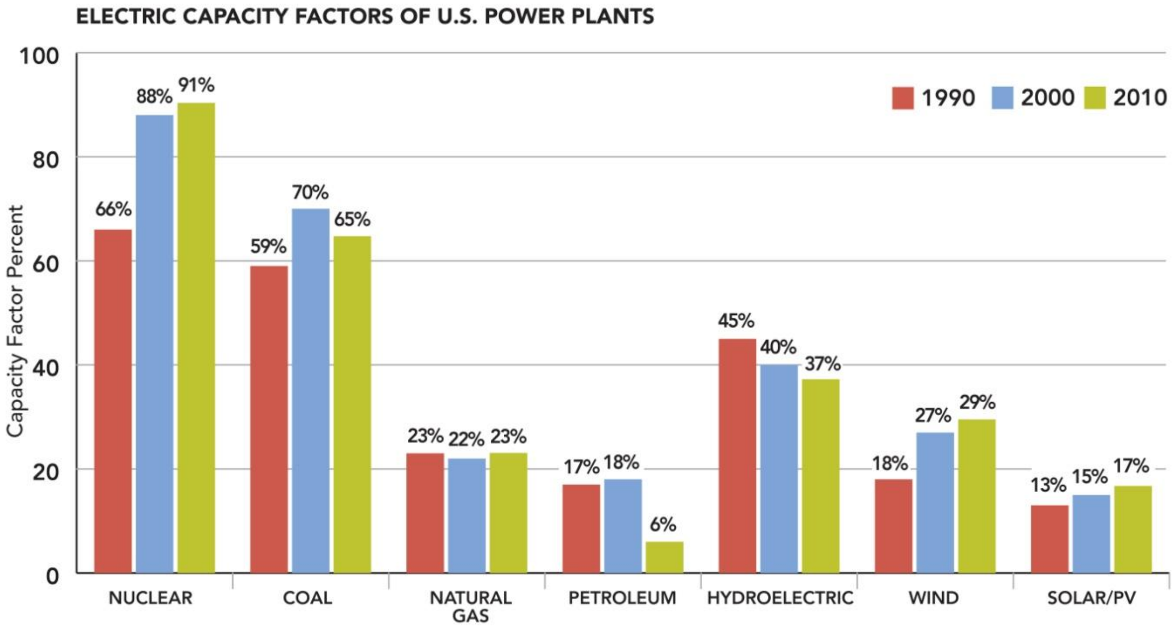
FUELS USED TO GENERATE ELECTRICITY

Electric utilities are major emitters of carbon dioxide and other greenhouse gases. Emissions increased from 1.83 billion metric tons in 1990 to 2.27 billion metric tons in 2010, equal to 40% of total U.S. emissions. (6.4.1) Coal accounted for 81% of emissions, and natural gas accounted for 18%, while petroleum used in electricity generation represents less than 2% of total emissions. A very small amount—about 12 million metric tons of carbon dioxide—can be attributed to geothermal and municipal solid waste. (6.4.2)

As of 2010, there were 18,150 power plants and other sources of electricity generation in the United States. The combined nameplate capacity—the maximum output of a plant operating at full load—of these generators was 1,139 GW. (6.2.1) Meeting the 2035 electricity demand projected by EIA will require an additional 1,041 power plants or 175 GW, including renewable energy power plants. EIA expects new fossil fuel plants to provide 122 GW of this capacity, 43 GW from renewable energy power plants, and 10 GW from nuclear power plants. (6.1.7),

According to EIA, electric capacity factor is a measurement of the electrical energy produced by a generating unit over a period of time as a fraction of its full nameplate capacity. This metric is an indicator of how consistently a generator produces power. Coal and nuclear plants have low fuel costs but cannot be cycled on and off easily, thus most operate continuously at high outputs. On the other hand, petroleum and natural gas are more expensive but can be dispatched quickly if needed; therefore, such plants usually operate only during times of peak demand. This is known as operating in “load-following” mode. Renewable power has the lowest operating costs, but the fuel sources are intermittent. In the case of hydroelectric plants, operators can choose to reduce their capacity factor to provide higher outputs during peak times or to manage ecosystem concerns.

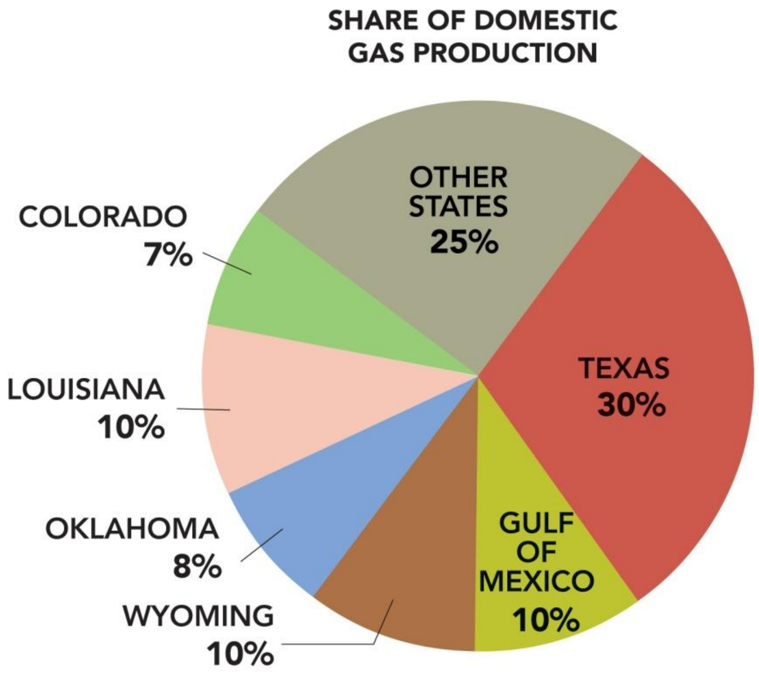
Improvements in fuel design and operating procedures have allowed nuclear plants to run more reliably and with fewer refueling outages. The average capacity factor of nuclear plants increased from 66% in 1990 to 91% in 2010. The average capacity factor for coal plants increased from 59% in 1990 to a high of 72% in 2007. However, since then the capacity factor for coal generation has been falling. (6.2.3) The capacity factor for natural gas plants has remained relatively stable over the last twenty years and is primarily dispatched for peak demand.



Only 32% of the primary energy utilities use is delivered to consumers. The majority (65%) of primary energy is lost as heat during fuel conversion or otherwise consumed by the electric generator. Transmission and distribution losses account for the remaining 3% of primary energy. The average delivery efficiency was only 29% in 1980, and EIA expects it to increase to 34% in 2035 as utilities deploy more efficient generation technologies. (6.2.4) (1.1.4)

The United States consumed 24.1 trillion cubic feet of natural gas in 2010, an increase of 21% over 1980. With the increased capacity of natural gas-fired generators built over the last 20 years, the electric utility sector now consumes twice as much natural gas as it did in 1980. The natural gas consumption now nearly matches the consumption of the buildings sector. In 1980, the buildings sector consumed 7.4 trillion cubic feet on site, while the electric power sector consumed only 3.7 trillion cubic feet. (6.3.5)

From 2000 to 2010, the number of producing wells increased from about 276,000 to 510,000 nationwide, allowing 89% of U.S. gas consumption to be produced domestically. (6.3.3) In 2010, 30% of the nation's natural gas came from Texas, and another 10% came from each of the Gulf of Mexico, Wyoming, and Louisiana. (6.3.6)



6.1.1 Buildings Share of U.S. Electricity Consumption/Sales (Percent)

		Buildings						Delivered Total
		Residential	Commercial	**Total**	Industry	Transportation	Total	(10^15 Btu)
1980		34.3%	26.7%	60.9%	38.9%	0.2%	100%	7.15
1990		34.1%	30.9%	65.0%	34.9%	0.2%	100%	9.26
2000		34.9%	33.9%	68.7%	31.1%	0.2%	100%	11.67
2005		37.1%	34.8%	72.0%	27.8%	0.2%	100%	12.49
2010	(1)	38.7%	35.5%	74.2%	25.7%	0.2%	100%	12.79
2015		37.2%	36.0%	73.2%	26.6%	0.2%	100%	12.88
2020		37.0%	36.3%	73.3%	26.4%	0.2%	100%	13.58
2025		37.5%	37.0%	74.5%	25.2%	0.3%	100%	14.13
2030		38.2%	37.7%	75.9%	23.7%	0.4%	100%	14.75
2035		38.8%	38.4%	77.2%	22.3%	0.5%	100%	15.32

Note(s): 1) Buildings accounted for 82% (or $302 billion) of total U.S. electricity expenditures.

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for 2010-2035 consumption, and Table A3 for expenditures.

6.1.2 U.S. Electricity Generation Input Fuel Shares (Percent)

				Renewables					
	Natural Gas	Petroleum	Coal	Hydro.	Oth(2)	Total	Nuclear	Other (3)	Total
1980	15.7%	10.8%	50.2%	11.8%	0.2%	12.1%	11.3%	(1)	100%
1990	10.7%	4.2%	53.4%	9.9%	1.7%	11.6%	20.0%	(1)	100%
2000	13.9%	3.0%	53.3%	7.3%	1.7%	9.0%	20.7%	(1)	100%
2005	15.1%	3.1%	52.5%	6.8%	1.9%	8.6%	20.7%	(1)	100%
2010	**19.0%**	**1.0%**	**48.3%**	**6.3%**	**3.4%**	**9.7%**	**21.3%**	**0.7%**	**100%**
2015	21.3%	0.8%	42.2%	7.4%	5.2%	12.6%	22.3%	0.8%	100%
2020	19.7%	0.8%	43.0%	7.1%	6.1%	13.3%	22.6%	0.7%	100%
2025	18.4%	0.8%	43.9%	6.9%	6.8%	13.8%	22.5%	0.6%	100%
2030	19.6%	0.8%	43.6%	6.8%	6.9%	13.8%	21.8%	0.6%	100%
2035	20.2%	0.8%	43.4%	6.7%	7.6%	14.4%	20.7%	0.5%	100%

Note(s): 1) Electric imports included in renewables. 2) Includes geothermal, municipal solid waste, biomass, solar thermal, solar PV, and wind. 3)

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for 2010-2035 consumption and Table A17 for renewables.

6.1.3 U.S. Electricity Generation Input Fuel Consumption (Quadrillion Btu)

				Renewables						Growth Rate
	Natural Gas	Petroleum	Coal	Hydro.	Oth(2)	Total	Nuclear	Other (3)	Total	2008-Year
1980	3.79	2.62	12.16	2.87	0.06	2.92	2.74	(1)	24.32	-
1990	3.27	1.29	16.26	3.01	0.51	3.52	6.10	(1)	30.51	-
2000	5.26	1.14	20.22	2.77	0.66	3.43	7.86	(1)	38.08	-
2005	5.96	1.23	20.74	2.67	0.74	3.41	8.16	(1)	39.65	-
2010	**7.54**	**0.38**	**19.13**	**2.49**	**1.36**	**3.85**	**8.44**	**0.29**	**39.63**	**-**
2015	8.27	0.31	16.42	2.88	2.01	4.89	8.68	0.30	38.88	-0.4%
2020	8.06	0.32	17.61	2.93	2.51	5.44	9.28	0.29	40.99	0.3%
2025	7.86	0.32	18.72	2.95	2.91	5.87	9.60	0.27	42.64	0.5%
2030	8.58	0.33	19.11	2.99	3.05	6.04	9.55	0.25	43.86	0.5%
2035	9.13	0.34	19.57	3.04	3.44	6.48	9.35	0.24	45.11	0.5%

Note(s): 1) Electric imports included in renewables. 2) Includes geothermal, municipal solid waste, biomass, solar thermal, solar PV, and wind. 3)

Source(s): EIA, State Energy Consumption Database, June 2011 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for 2010-2035 consumption, and Table A17 for renewables.

6.1.4 U.S. Electricity Net Generation, by Plant Type (Billion kWh)

				Renewables						Growth Rate
	Natural Gas	Petroleum	Coal	Hydr(1)	Oth(2)	Total	Nuclear	CHP (3)	Tot.(4)	2010-year
1980	346	246	1,162	276	6	282	251	N.A.	2,286	-
1990	265	118	1,560	290	35	324	577	61	2,905	-
2000	399	98	1,911	271	45	316	754	165	3,643	-
2005	553	111	1,956	267	53	320	782	180	3,903	-
2010	776	32	1,799	289	100	390	807	165	3,969	**-**
2015	906	26	1,560	297	197	494	830	160	3,977	0.0%
2020	876	27	1,674	298	246	544	887	161	4,169	0.5%
2025	854	28	1,779	298	288	586	917	160	4,325	0.6%
2030	970	28	1,815	299	306	605	913	161	4,492	0.6%
2035	1,068	29	1,857	299	353	652	894	159	4,659	0.6%

Note(s): 1) Electricity used for hydroelectric pumped storage is subtracted from this conventional hydroelectric generation. 2) Includes geothermal, municipal solid waste, wood, biomass, solar thermal, solar photovoltaic, and wind. 3) CHP = Combined heat and Power. Includes CHP plants whose primary business is to sell electricity and heat to the public. 4) Includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, distributed generation, and other miscellaneous technologies that are not listed individually.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A8 for 2010-2035; EIA, Annual Energy Review 2010, Oct. 2011, Table 8.2c, p. 240 for 1990-2009; and EIA, Annual Energy Review 2002, Oct. 2003, Table 8.2b, p. 149 for 1980-1988.

6.1.5 U.S. Electric Utility and Nonutility Net Summer Electricity Generation Capacity (GW)

	Coal Steam	Other Fossil	Combine Cycle	Combustion Turbine	Nuclear	Pumped	Total
1980	N.A.	N.A.	N.A.	N.A.	51.8	0.0	495.9
1990	302.3	N.A.	N.A.	N.A.	99.6	19.5	628.4
2000	310.2	N.A.	N.A.	N.A.	97.9	19.5	693.3
2005	309.0	N.A.	N.A.	N.A.	100.0	21.3	855.6
2010	**308.1**	**107.4**	**171.7**	**134.84**	**101.2**	**22.2**	**845.4**
2015	288.9	97.2	186.5	141.68	103.6	22.2	840.1
2020	286.2	89.9	187.2	145.34	111.2	22.2	842.0
2025	285.6	89.0	194.5	154.88	114.7	22.2	860.8
2030	285.6	87.9	214.1	162.62	114.2	22.2	886.6
2035	285.8	86.7	241.5	167.40	112.0	22.2	915.7

Note(s): 1) Nuclear capacity includes 3 GW of uprates from 2005 to 2030. New nuclear plants are expected to come online 2013-2019.

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 8.11b for 1980-2009; and EIA, AEO 2012 Early Release, Jan. 2012, Table A9 and Table A16 for 2010-2035.

6.1.6 U.S. Renewable Electric Utility and Nonutility Net Summer Electricity Generation Capacity (GW)

	Conv. Hydropower	Geothermal	Municipal Solid Waste	Biomass	Solar Thermal	Solar PV	Wind	Total
1980	81.7	0.9	0.0	0.1	0.0	N.A.	N.A.	82.7
1990	73.3	2.7	2.1	1.2	0.3	N.A.	1.8	81.4
2000	78.2	2.8	3.3	1.7	0.4	N.A.	2.4	88.8
2005	76.9	2.3	3.0	1.6	0.4	N.A.	8.7	92.9
2010	**78.0**	**2.4**	**3.3**	**2.4**	**0.5**	**0.4**	**39.1**	**126.1**
2015	78.4	2.8	3.4	2.7	1.4	2.0	51.6	142.4
2020	78.9	3.6	3.4	2.7	1.4	2.0	51.6	143.8
2025	79.6	4.4	3.4	2.7	1.4	2.3	54.6	148.4
2030	80.5	5.5	3.4	2.7	1.4	3.8	57.5	154.8
2035	81.7	6.4	3.4	2.7	1.4	8.2	65.4	169.2

Source(s): EIA, Annual Energy Review 2011, Oct. 2011, Table 8.11b for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A9 and Table A16 for 2010-2035.

6.1.7 U.S. Electric Power Sector Cumulative Power Plant Additions Needed to Meet Future Electricity Demand (1)

Electric Generator	Typical New Plant Capacity (MW)	Number of New Power Plants to Meet Demand 2015	2020	2025	2030	2035
Coal Steam	1,300	7	8	8	8	8
Combined Cycle	540	28	29	43	79	130
Combustion Turbine/Diesel	148	62	105	174	250	284
Nuclear Power	2,236	1	3	3	3	4
Pumped Storage	147 (2)	0	0	0	0	0
Fuel Cells	10	0	0	0	0	0
Conventional Hydropower	20 (2)	20	47	81	125	185
Geothermal	50	9	26	41	62	81
Municipal Solid Waste	50	1	1	1	1	1
Wood and Other Biomass	50	5	5	5	5	6
Solar Thermal	100	9	9	9	9	9
Solar Photovoltaic	150	11	11	13	23	52
Wind	100	123	124	153	182	262
Total		**277**	**372**	**538**	**760**	**1,041**
Distributed Generation	148 (3)					

Note(s): 1) Cumulative additions after Dec. 31, 2010. 2) Based on current stock average capacity. 3) Combustion turbine/diesel data used.

Source(s): EIA, Annual Energy Outlook (AEO) 2012 Early Release, Jan. 2012, Table A9 and Table A16; EIA, Assumption to the AEO 2011, July 2011, Table 8.2, p. 97; and EIA, Electric Power Annual 2010, Feb. 2012, Table 1.2 for pumped storage and hydroelectric plant capacity.

6.2.1 2010 Existing Capacity, by Energy Source (GW)

Plant Fuel Type	Number of Generators	Generator Nameplate Capacity	Net Summer Capacity	Net Winter Capacity
Coal	1,396	342.3	316.8	319.2
Petroleum	3,779	62.5	55.6	59.6
Natural Gas	5,529	467.2	407.0	438.7
Other Gases	106	3.1	2.7	2.7
Nuclear	104	106.7	101.2	103.0
Hydroelectric Conventional	4,020	78.2	78.8	78.5
Wind	689	39.5	39.1	39.2
Solar Thermal and Photovoltaic	180	0.9	0.9	0.8
Wood and Wood Derived Fuels	346	7.9	7.0	7.1
Geothermal	225	3.5	2.4	2.6
Other Biomass	1,574	5.0	4.4	4.4
Pumped Storage	151	20.5	22.2	22.1
Other	51	1.0	0.9	0.9
Total	**18,150**	**1,138.6**	**1,039.1**	**1,078.7**

Source(s): EIA, Electric Power Annual 2010, Feb. 2012, Table 1.2.

6.2.2 Net Internal Demand, Capacity Resources, and Capacity Margins in the Contiguous United States (GW)

	Net Internal Demand (1)	Capacity Resources (2)	Capacity Margin (3)
1995	589.9	727.5	18.9%
1996	602.4	730.4	17.5%
1997	618.4	737.9	16.2%
1998	638.1	744.7	14.3%
1999	653.9	765.7	14.6%
2000	680.9	808.1	15.7%
2001	674.8	789.0	14.5%
2002	696.4	833.4	16.4%
2003	696.8	856.1	18.6%
2004	692.9	875.9	20.9%
2005	746.5	882.1	15.4%
2006	776.5	891.2	12.9%
2007	766.8	914.4	16.1%
2008	744.2	909.5	18.2%
2009	713.1	916.4	22.2%
2010	**747.8**	**924.9**	**19.1%**
2011	730.4	939.4	22.2%
2012	745.4	957.2	22.1%
2013	757.5	970.1	21.9%
2014	768.5	977.8	21.4%
2015	778.5	980.3	20.6%

Note(s): 1) Net internal demand represents the system demand that is planned for by the electric power industry`s reliability authority and is equal to internal demand less direct control load management and interruptible demand. Direct control load management: Customer demand that can be interrupted at the time of the seasonal peak by direct control of the system operator by interrupting power supply to individual appliances or equipment on customer premises. This type of control usually reduces the demand of residential customers. Interruptible demand: Customer demand that can be interrupted (through contractual agreement) during peak loads by direct control of the system operator or by the customer at direct request of the system operator. This type of control usually reduces the demand of large-volume commercial and industrial consumers. 2) Capacity Resources: Utility- and IPP-owned generating capacity that is existing or in various stages of planning or construction, less inoperable capacity, plus planned capacity purchases from other resources, less planned capacity sales. 3) Capacity Margin is the amount of unused available capability of an electric power system at peak load as a percentage of capacity resources.

Source(s): EIA, Electric Power Annual 2006, Oct. 2007, Table 3.2, p. 34 for 1995-1997; EIA, Electric Power Annual 2009, Nov. 2010, Table 4.2, p. 41 for 1998; and EIA, Electric Power Annual 2010, Nov. 2011, Table 4.3.A and Table 4.3.B for 1999-2015

6.2.3 Electric Capacity Factors, by Year and Fuel Type (1)

		Coal	Petroleum	Natural Gas	Nuclear	Conventional Hydroelectric	Solar/PV	Wind	Total
1990		59%	17%	23%	66%	45%	13%	18%	46%
1995		62%	11%	22%	77%	45%	17%	21%	47%
2000		70%	18%	22%	88%	40%	15%	27%	51%
2001		68%	20%	21%	89%	31%	16%	20%	48%
2002		69%	16%	18%	90%	38%	16%	27%	46%
2003		71%	21%	14%	88%	40%	15%	21%	44%
2004		71%	22%	16%	90%	39%	17%	25%	44%
2005		72%	22%	17%	89%	40%	15%	23%	45%
2006		71%	11%	19%	90%	42%	14%	27%	45%
2007		72%	12%	21%	92%	36%	14%	24%	45%
2008		71%	8%	20%	91%	37%	18%	26%	44%
2009		63%	7%	21%	90%	40%	16%	25%	42%
2010	(2)	65%	6%	23%	91%	37%	17%	29%	43%

Note(s): 1) EIA defines capacity factor to be "the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period. 2) Preliminary.

Source(s) EIA, Annual Energy Review 2010, Oct. 2011, 8.2c, p. 240 and Table 8.11b, p. 273.

6.2.4 Electric Conversion Factors and Transmission and Distribution (T&D) Losses

	Average Utility Delivery Efficiency (1, 2)	Average Utility Delivery Ratio (Btu/kWh) (2, 3)	Growth Rate (2010-year)
1980	29.4%	11,614	-
1990	30.3%	10,754	-
2000	30.7%	10,600	-
2005	31.5%	10,405	-
2010	**32.3%**	**10,570**	**-**
2015	33.1%	10,300	0.5%
2020	33.1%	10,301	0.3%
2025	33.1%	10,294	0.2%
2030	33.6%	10,148	0.2%
2035	34.0%	10,045	0.2%

Transmission and Distribution (T&D) losses as a:

Percent of Electric Generator Fuel Input	2.6%
Percent of Net Electricity Generated (4)	7.4%

Note(s): 1) Use these values to convert primary energy of electric generator fuel input to delivered energy. 2) Accounts for fuel conversion losses, plant use of electricity, and T&D losses. 3) Use these values to convert delivered electric energy to primary energy. 4) After fuel conversion losses and plant use of electricity.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for generator consumption and Table A8 for electricity sales; EIA, Annual Energy Review 2010, Oct. 2011, Figure 8.0, p. 233 for T&D losses; and EIA, State Energy Consumption Database, June 2011 for Electricity Consumption and Generator Fuel Consumption.

6.2.5 2010 Impacts of Saving an Electric Quad (1)

Plant Fuel Type	Utility Fuel Input Shares (%)	Average-Sized Utility Unit (MW) in 2010	Aggregate Number of Units to Provide the Fuel's Share of the Electric Quad (2)
Coal	49%	245	36
Petroleum	1%	17	96
Natural Gas	19%	85	141
Nuclear	22%	1,026	3
Renewable (3)	10%	22	184
Total	100%		**460**

Note(s): 1) This table displays the breakdown of electric power plants that could be eliminated by saving an electric quad, in exact proportion to the actual primary fuel shares for electricity produced nationwide in 2010. Use this table to estimate the avoided capacity implied by saving one electric quad. 2) Based on typical U.S. power plants operating less than full load throughout the year. 3) Includes pumped storage.

Source(s): EIA, Electric Power Annual 2010, Feb. 2012, Table 1.2; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for consumption and Table A8 for electricity supply.

6.2.6 Cost of an Electric Quad Used in the Buildings Sector ($2010 Billion)

	Residential	Commercial	**Buildings Sector**
1980	10.59	10.83	10.70
1990	10.57	9.76	10.19
2000	9.15	8.16	8.66
2005	9.56	8.77	9.18
2010	**11.92**	**10.52**	**11.25**
2015	12.06	10.19	11.14
2020	11.79	10.09	10.94
2025	11.74	10.08	10.91
2030	11.71	9.94	10.83

Note(s): This table provides the consumer cost of an electric quad. Use this table to estimate the savings to consumers when a primary quad is saved in the form of delivered electricity.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 and Table A3; EIA, State Energy Consumption Database, June 2011 for 1980-2009; EIA, State Energy Data Prices and Expenditures Database, June 2011 for 1980-2009; and EIA, Annual Energy Review 2010, Oct. 2011, Appendix D, p. 353 for price deflators.

6.2.7 Characteristics of New and Stock Generating Capacities, by Plant Type

New Plant Type	Heat rate (1) in 2010 (Btu/kWh)	Size (MW)	Overnight Costs (2) (2010 $/kW)	Total Capital Costs of Typical New Plant ($2010 million)
Scrubbed Coal	8,800	1300	2809	3652
Integrated Coal-Gasification Combined Cycle (IGCC)	8,700	1200	3182	3818
IGCC w/Carbon Sequestration	10,700	520	5287	2749
Conv. Gas/Oil Combined Cycle	7,050	540	967	522
Adv. Gas/Oil Combined Cycle	6,430	400	991	396
Conv. Combustion Turbine	10,745	85	961	82
Adv. Combustion Turbine	9,750	210	658	138
Fuel Cell	9,500	10	6752	68
Advanced Nuclear	10,453	2236	5275	11795
Municipal Solid Waste	13,648	50	8237	412
Conventional Hydropower (3)	9,854	500	2221	1111
Wind	9,854	100	2409	241

Stock Plant Type	2010	2015	2020	2025	2030	2035
Fossil Fuel Steam Heat Rate (Btu/kWh)	9,787	9,441	9,509	9,557	9,440	9,341
Nuclear Energy Heat Rate (Btu/kWh)	10,460	10,460	10,460	10,460	10,460	10,460

Note(s): 1) Plant use of electricity is included in heat rate calculations; however, transmission and distribution losses of the electric grid are excluded. 2) Overnight costs represent the capital costs of new projects initiated in 2009. Includes contingency factors and excludes interest charges. 3) Hydro costs and performance characteristics are site-specific. This table provides the cost of the least expensive plant that could be built in the Northwest Power Pool region, where most proposed sites are located.

Source(s): EIA, Assumptions to the AEO 2011, July 2011, Table 8.2. p. 97 for 2010 plant characteristics; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 for consumption and Table A8 for electricity supply.

6.2.8 NERC Regions Map

Source(s): North American Reliability Corporation, NERC Regions Map Feb. 2012, http://www.nerc.com/fileUploads/File/AboutNERC/maps/NERC_Regions_color.jpg

6.2.9 2009 Peak Load and Capacity Margin, Summer and Winter by NERC Region (MW)

	Summer (1)		Winter (2)	
NERC Region	Peak Load	Capacity Margin	Peak Load	Capacity Margin
TRE	63,518	16.7%	56,191	19.1%
FRCC	46,550	6.0%	53,022	2.0%
MRO (U.S.)	37,963	24.6%	35,351	26.8%
NPCC (U.S.)	55,944	29.1%	44,864	43.2%
RFC	161,241	25.2%	143,827	33.3%
SERC	191,032	24.6%	193,135	26.2%
SPP	41,465	16.4%	32,863	34.6%
WECC	128,245	19.4%	109,565	29.6%
U.S. TOTAL	725,958	22.2%	668,818	28.5%

Note(s): 1) Summer Demand includes the months of June, July, August, and September. 2) Winter Demand includes December of the previous year and January-March of the current year. 3) Capacity Margin is the amount of unused available capability of an electric power system at peak load as a percentage of net capacity resources. Net Capacity Resources: Utility- and IPP-owned generating capacity that is existing or in various stages of planning or construction, less inoperable capacity, plus planned capacity purchases from other resources, less planned capacity sales.

Source(s): EIA, Electric Power Annual 2010, Nov. 2011, Table 4.1a for peak load, Table 4.3.a for summer capacity margin, and Table 4.4.a for winter capacity margin.

6.2.10 Top 10 U.S. States by Existing Wind Power Capacities

State	Existing Capacity (MW)	Existing Capacity (%)	Capacity Under Construction (MW)
Texas	9,727	27%	350
Iowa	3,670	10%	0
California	2,739	7%	443
Oregon	2,095	6%	201
Washington	1,964	5%	735
Illinois	1,848	5%	587
Minnesota	1,818	5%	677
New York	1,274	3%	95
Colorado	1,248	3%	552
Indiana	1,238	3%	99
U.S. Total	**36,698**		**6,925**

Note(s): Estimates of existing capacity and capacity under construction are current as of September 2010. Does not include small wind projects, i.e. those with capacities of 100 kW or less. Data provided by AWEA member companies and updated quarterly.

Source(s): American Wind Energy Association (AWEA), U.S. Projects Database, accessed February 2011.

6.3.1 Natural Gas Overview (Trillion Cubic Feet)

	Production	Supplemental Gas	Net Import	Storage Withdrawal	Balancing Item (1)	Consumption (2)
1980	19.40	0.15	0.94	0.02	-0.64	19.88
1990	17.81	0.12	1.45	-0.51	0.31	19.17
2000	19.18	0.09	3.54	0.83	-0.31	23.33
2005	18.05	0.06	3.61	0.05	0.23	22.01
2010	**21.58**	**0.07**	**2.58**	**-0.18**	**0.09**	**24.13**
2015	23.67	0.06	1.70	-0.11	0.05	25.38
2020	25.21	0.06	0.29	-0.08	0.04	25.52
2025	26.00	0.06	-0.84	-0.05	0.03	25.20
2030	26.79	0.06	-0.97	-0.02	0.01	25.87
2035	27.84	0.06	-1.43	0.00	0.00	26.48

Note(s): 1) Quantities lost an imbalances in data due to differences among data sources. Excludes intransit shipments that cross the U.S.-Canada border. 2) Natural gas consumption statistics are compiled from surveys of natural gas production, transmission, and distribution companies and from surveys of electric power generation. Consumption by sector from these surveys is compiled on a national and individual State basis and then balanced with national and individual State supply data.

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 6.1 for 1980-2009; and EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A13 for 2010-2035.

6.3.2 Natural Gas in Underground Storage (Billion Cubic Feet)

	Base Gas	Working Gas	Total	Underground Storage Capacity	
1980	3,642	2,655	6,297	7,434	85%
1981	3,752	2,817	6,569	7,805	84%
1982	3,808	3,071	6,879	7,915	87%
1983	3,847	2,595	6,442	7,985	81%
1984	3,830	2,876	6,706	8,043	83%
1985	3,842	2,607	6,448	8,087	80%
1986	3,819	2,749	6,567	8,145	81%
1987	3,792	2,756	6,548	8,124	81%
1988	3,800	2,850	6,650	8,124	82%
1989	3,812	2,513	6,325	8,120	78%
1990	3,868	3,068	6,936	7,794	89%
1991	3,954	2,824	6,778	7,993	85%
1992	4,044	2,597	6,641	7,932	84%
1993	4,327	2,322	6,649	7,989	83%
1994	4,360	2,606	6,966	8,043	87%
1995	4,349	2,153	6,503	7,953	82%
1996	4,341	2,173	6,513	7,980	82%
1997	4,350	2,175	6,525	8,332	78%
1998	4,326	2,730	7,056	8,179	86%
1999	4,383	2,523	6,906	8,229	84%
2000	4,352	1,719	6,071	8,241	74%
2001	4,301	2,904	7,204	8,415	86%
2002	4,340	2,375	6,715	8,207	82%
2003	4,303	2,563	6,866	8,206	84%
2004	4,201	2,696	6,897	8,255	84%
2005	4,200	2,635	6,835	8,268	83%
2006	4,211	3,070	7,281	8,330	87%
2007	4,234	2,879	7,113	8,402	85%
2008	4,232	2,840	7,073	8,499	83%
2009	4,277	3,130	7,407	8,656	86%
2010	4,305	3,107	7,412	8,710	85%

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 6.6.

6.3.3 Natural Gas Well Productivity

	Gross Withdrawals from Wells (billion cubic feet)	Producing Wells (thousand)	Average Productivity (thousand cubic feet per day)
1980	17,573	182	96,550
1990	16,054	269	59,657
2000	17,726	276	57,964
2001	18,129	373	48,565
2002	17,795	388	45,890
2003	17,882	393	45,463
2004	17,885	406	44,036
2005	17,472	426	41,025
2006	17,996	441	40,851
2007	17,065	453	37,676
2008	15,618	477	32,767
2009	14,839	493	30,094
2010	14,760	510	28,934

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 6.4.

6.3.4 Natural Gas End-Use Deliveries by Type of Distributor for 1996, 2000, and 2006

	1996			2000			2006		
	Volume Delivered		Customers	Volume Delivered		Customers	Volume Delivered		Customers
Type of Distributor	(Tcf)	(Percent)	(millions)	(Tcf)	(Percent)	(millions)	(Tcf)	(Percent)	(millions)
Local Distribution Comp.	14.3	72%	58.7	14.2	67%	57.8	11.1	60%	61.4
Investor-Owned	13.3		54.0	13.2		4.3	0.8		4.9
Municipal	0.8		4.0	0.8		0.5	0.2		0.8
Privately-Owned	0.2		0.7	0.2		0.1	0.0		0.1
Cooperative	0.0		0.1	0.0		62.8	12.0		67.2
Interstate Pipeline	1.6	8%	0.0	2.5	12%	0.0	3.5	17%	0.0
Intrastate Pipeline	3.8	19%	1.4	4.3	20%	1.4	4.3	21%	2.7
Other	0.3	1%	0.0	0.2	1%	0.0	0.2	1%	0.0
Total	20.0	100%	60.2	21.2	100%	64.2	19.9	100%	69.9

Source(s): EIA, Distribution of Natural Gas: The Final Step in the Transmission Process, June 2008, Table 1, p. 6.

6.3.5 Natural Gas Consumption, by Sector (Trillion Cubic Feet)

	Residential	Commercial	Industrial	Transportation	Electric Power	Total
1980	4.75	2.61	8.20	0.63	3.68	19.88
1990	4.39	2.62	8.25	0.66	3.24	19.17
2000	5.00	3.18	9.29	0.65	5.21	23.33
2005	4.83	3.00	7.71	0.61	5.87	22.01
2010	**4.94**	**3.21**	**7.94**	**0.67**	**7.38**	**24.13**
2015	4.87	3.33	8.36	0.73	8.09	25.38
2020	4.82	3.40	8.66	0.76	7.89	25.52
2025	4.76	3.42	8.56	0.77	7.69	25.20
2030	4.72	3.49	8.46	0.80	8.40	25.87
2035	4.65	3.56	8.51	0.83	8.93	26.48

Source(s): EIA, Annual Energy Review 2010, Oct. 2011, Table 6.5 for 1980-2009; and EIA, AEO 2012 Early Release, Jan. 2012, Table A13 for 2010-2035.

6.3.6 Top 10 Natural Gas Producing States, 2009 and 2010 (1)

Gas Production in 2009

State	Marketed Production (2) (billion cubic feet)	Share of U.S. Production
1. Texas	6,819	30%
2. Wyoming	2,335	10%
3. Oklahoma	1,858	8%
4. Louisiana	1,549	7%
5. Colorado	1,499	7%
6. New Mexico	1,383	6%
7. Arkansas	680	3%
8. Utah	444	2%
9. Alaska	397	2%
10. Kansas	354	2%
		77%
Gulf of Mexico	2,429	11%
U.S Total	**21,604**	

Gas Production in 2010

State	Marketed Production (billion cubic feet)	Share of U.S. Production
1. Texas	6,715	30%
2. Wyoming	2,306	10%
3. Louisiana	2,210	10%
4. Oklahoma	1,827	8%
5. Colorado	1,578	7%
6. New Mexico	1,292	6%
7. Arkansas	927	4%
8. Pennsylvania (3)	573	3%
9. Utah	432	2%
10. Alaska	374	2%
		81%
Gulf of Mexico	2,245	10%
U.S. Total	**22,402**	

Note(s): 1) State production includes offshore production in state waters, where applicable. 2) Marketed production equals gross withdrawals less gas used for repressuring, quantities vented and flared, and nonhydrocarbon gases removed in treating or processing operations. Includes all quantities of gas used in field and processing plant operations. 3) Natural gas production in Pennsylvania more than doubled between 2009 and 2010 as a result the significant development of the Marcellus shale formation.

Source(s): EIA, Natural Gas Annual 2009, Dec. 2010, Table 2, p. 4. for gas production in 2009; EIA, Natural Gas Annual 2010, Dec. 2011, Table 2, p. 4. for gas production in 2010.

6.4.1 Emissions of Carbon Dioxide from Electric Utilities (Million Metric Tons)

1990	1,831
2000	2,310
2005	2,417
2010	**2,271**
2015	2,039
2020	2,136
2025	2,234
2030	2,311
2035	2,383

Source(s): EIA, Emissions of Green House Gases in the United States 2009, February 2011 for 1990-2009; EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A18 for 2010-2035.

6.4.2 Electric Quad Average Carbon Dioxide Emissions with Average Utility Fuel Mix (Million Metric Tons) (1)

	Petroleum	Natural Gas	Coal	Nuclear	Renewable	Total
2010	0.83	10.14	46.45	0.00	0.30	57.72
2011	0.00	0.21	0.00	0.00	0.00	0.21
2012	0.00	0.65	0.00	0.00	0.00	0.65
2013	0.00	0.16	0.00	0.00	0.00	0.16
2014	0.00	0.61	0.00	0.00	0.00	0.61
2015	0.00	1.04	0.00	0.00	0.00	1.04
2016	0.00	0.83	0.00	0.00	0.00	0.83
2017	0.00	0.58	0.00	0.00	0.00	0.58
2018	0.00	0.62	0.00	0.00	0.00	0.62
2019	0.00	0.70	0.00	0.00	0.00	0.70
2020	0.00	0.71	0.00	0.00	0.00	0.71
2021	0.00	0.76	0.00	0.00	0.00	0.76
2022	0.00	0.74	0.00	0.00	0.00	0.74
2023	0.00	0.60	0.00	0.00	0.00	0.60
2024	0.00	0.60	0.00	0.00	0.00	0.60
2025	0.00	0.43	0.00	0.00	0.00	0.43
2026	0.00	0.54	0.00	0.00	0.00	0.54
2027	0.00	0.63	0.00	0.00	0.00	0.63
2028	0.00	0.84	0.00	0.00	0.00	0.84
2029	0.00	1.05	0.00	0.00	0.00	1.05
2030	0.00	1.29	0.00	0.00	0.00	1.29
2031	0.00	1.46	0.08	0.00	0.00	1.54
2032	0.00	1.67	0.20	0.00	0.00	1.87
2033	0.00	1.82	0.38	0.00	0.00	2.20
2034	0.00	1.88	0.58	0.00	0.00	2.46
2035	0.00	1.88	0.76	0.00	0.00	2.65

Note(s): 1) This table provides estimates of the carbon emissions resulting from consumption of a primary quad at electric utilities. Projected (2011-2035) new marginal capacity emissions will result from natural gas- and coal-fired power plants. Electric generation capacity is projected to increase for biomass, wind, and nuclear power. Wind power, biomass, and hydroelectric power electric generation will increase 2010-2035. Nuclear electric generation capacity will increase 2014-2035. Electricity imports from utility consumption were ignored since this energy was produced outside of the U.S. "Average" means the weighted average of different fuels (e.g., petroleum is the average of residual and distillate fuel oils). The combustion of fossil fuels produces carbon in the form of carbon dioxide and carbon monoxide; however, carbon monoxide emissions oxidize in a relatively short time to form carbon dioxide. 2) Emissions from renewable energy include emissions released from geothermal power and non-biogenic emissions from municipal solid waste.

Source(s): EIA, Annual Energy Outlook 2012 Early Release, Jan. 2012, Table A2 and Table A18.

6.5.1 2009 Spending by Ratepayer-Funded Electric and Gas Efficiency Programs

Total Program Expenditures in 2009 by Customer Class ($millions)

	Efficiency Programs						
Region (1)	C&I (2)	Residential	Low Income	Other (3)	Total	Load Mgmt.	Grand Total
New England	203	135	49	12	399	8	406
Mid-Atlantic	338	139	139	24	640	13	653
Midwest	224	186	83	89	581	102	683
South Central	50	66	42	13	171	70	241
South Atlantic	37	131	7	30	205	277	481
Pacific NW	132	118	18	78	345	19	364
Pacific West	540	277	210	106	1,133	257	1,390
Southwest	84	143	15	13	255	48	302
Additional (4)	8	22	22	7	58	0	58
United States	1,615	1,217	583	371	3,786	793	4,579

Electric Program Expenditures in 2009 by Customer Class ($millions)

	Efficiency Programs						
Region (1)	C&I (2)	Residential	Low Income	Other (3)	Total	Load Mgmt.	Grand Total
New England	186	99	37	12	333	8	341
Mid-Atlantic	305	82	69	24	479	13	491
Midwest	190	125	26	64	404	102	505
South Central	50	64	42	13	168	70	238
South Atlantic	36	122	5	30	192	277	469
Pacific NW	122	100	15	76	312	19	331
Pacific West	476	239	106	84	904	257	1,161
Southwest	82	91	9	9	191	48	239
United States	1,445	921	308	311	2,983	793	3,776

Gas Program Expenditures in 2009 by Customer Class ($millions)

	Efficiency Programs				
Region (1)	C&I (2)	Residential	Low Income	Other (3)	Total
New England	17	37	12	0	66
Mid-Atlantic	34	57	71	0	162
Midwest	34	61	57	25	177
South Central	1	2	0	0	3
South Atlantic	1	9	2	1	12
Pacific NW	10	19	3	2	33
Pacific West	64	38	104	22	228
Southwest	2	52	6	4	63
Additional (4)	8	22	22	7	58
United States	170	296	276	61	803

Note(s): (1) Regions match Census divisions and Census regions except for "Pacific NW" (ID, MT, OR, WA), "Pacific West" (AK, CA, HI), and "Southwest" (AZ, CO, NV, NM, UT, WY). (2) Commercial and Industrial. (3) In cases in which EM&V is not allocated by customer class, it is included in "other." (4) Total of gas budgets from respondents that did not grant permission to release their data at the state level. This total includes data from CO, ID, IL, KY, MI, NY, OH, PA, TX, and WA.

Source(s): Consortium for Energy Efficiency, State of the Efficiency Program Industry: 2009 Expenditures, Impacts & 2010 Budgets, Dec. 2010, Tables 3, 5, and 8.

6.5.2 Funding Levels of Top 6 and Bottom 5 States with Active Public Benefit Efficiency Programs

	Total EE Budget ($million)		Total EE Budget per Capita ($)	
	2009	2010	2009	2010
Vermont	33	36	52	58
Massachusetts	222	386	34	58
Rhode Island	37	37	35	35
Minnesota	134	200	25	38
California	1,377	1,497	37	40
New York	421	632	22	32
Kansas	4	5	4	5
Mississippi	9	13	9	13
Alabama	0	0	0	0
North Dakota	0	1	0	1
West Virginia	0	0	0	0

Source(s): American Council for an Energy Efficient Economy, A National Survey of State Policies and Practices for the Evaluation of Ratepayer-Funded Energy Efficiency Programs, Feb. 2012, Table B-1, p. 52-53.

6.5.3 Demand-Side Management Funds Collected for Energy Efficiency Programs in 2000 (1)

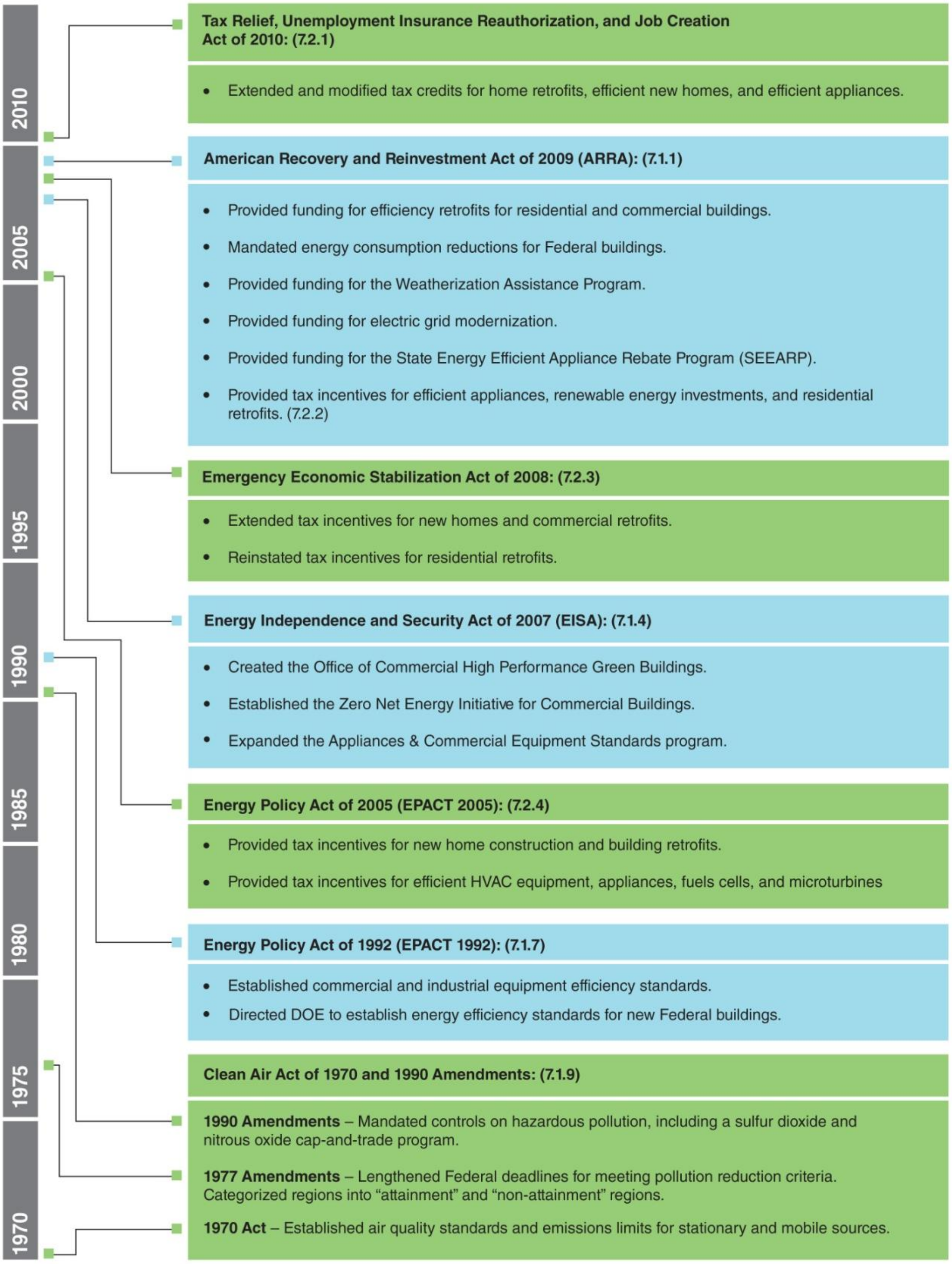
	Total Expenditures ($2009 million)	Per Capita Spending ($2009/person)
Connecticut	82.1	24.08
Massachusetts	122.7	19.29
Rhode Island	17.3	16.48
New Jersey	137.6	16.32
Vermont	7.8	12.74
Maine	15.6	12.21
Wisconsin	60.8	11.32
Hawaii	13.6	11.22
New York	201.3	10.60
California	354.5	10.43
National (2)	**1,354**	**4.80**

Note(s): 1) This table shows demand side management funds(including Public Benefit Funds) collected in 2000 that were spent of energy efficiency programs. 2) The top ten states in spending per capita represent 74.8% of total U.S. funds collected for energy efficiency programs.

Source(s): American Council for an Energy Efficient Economy; Five Years In: An Examination of the First Half Decade of Public Benefit Energy Efficiency Policies, April 2004, Table 3, p. 27; and EIA, Annual Energy Review 2009, August 2010, Appendix D, p. 383 for price inflators.

Chapter 7: Laws, Energy Codes, and Standards

Chapter 7 outlines national climate change legislation, tax incentives, Federal regulations, and State programs that have influenced building energy consumption. Section 7.1 summarizes the past 40 years of national energy legislation beginning with the Clean Air Act of 1970. Section 7.2 describes the energy efficiency-related Federal tax incentives created in the last 5 years. Sections 7.3 through 7.7 describe the energy and water efficiency standards currently or soon to be in effect for residential and commercial HVAC equipment, appliances, lighting, and water-consuming products. Section 7.8 covers building energy codes. Following is a summary of the energy legislation discussed in this chapter:



Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010: (7.2.1)

- Extended and modified tax credits for home retrofits, efficient new homes, and efficient appliances.

American Recovery and Reinvestment Act of 2009 (ARRA): (7.1.1)

- Provided funding for efficiency retrofits for residential and commercial buildings.
- Mandated energy consumption reductions for Federal buildings.
- Provided funding for the Weatherization Assistance Program.
- Provided funding for electric grid modernization.
- Provided funding for the State Energy Efficient Appliance Rebate Program (SEEARP).
- Provided tax incentives for efficient appliances, renewable energy investments, and residential retrofits. (7.2.2)

Emergency Economic Stabilization Act of 2008: (7.2.3)

- Extended tax incentives for new homes and commercial retrofits.
- Reinstated tax incentives for residential retrofits.

Energy Independence and Security Act of 2007 (EISA): (7.1.4)

- Created the Office of Commercial High Performance Green Buildings.
- Established the Zero Net Energy Initiative for Commercial Buildings.
- Expanded the Appliances & Commercial Equipment Standards program.

Energy Policy Act of 2005 (EPACT 2005): (7.2.4)

- Provided tax incentives for new home construction and building retrofits.
- Provided tax incentives for efficient HVAC equipment, appliances, fuels cells, and microturbines

Energy Policy Act of 1992 (EPACT 1992): (7.1.7)

- Established commercial and industrial equipment efficiency standards.
- Directed DOE to establish energy efficiency standards for new Federal buildings.

Clean Air Act of 1970 and 1990 Amendments: (7.1.9)

1990 Amendments – Mandated controls on hazardous pollution, including a sulfur dioxide and nitrous oxide cap-and-trade program.

1977 Amendments – Lengthened Federal deadlines for meeting pollution reduction criteria. Categorized regions into “attainment” and “non-attainment” regions.

1970 Act – Established air quality standards and emissions limits for stationary and mobile sources.

7.1.1 Buildings-Related Funding in the American Recovery and Reinvestment Act of 2009

Department of Education
-- $8.8 billion is provided to fund renovation, repair, and modernization of education facilites through the State Fiscal Stabilization Fund. These measures are to follow the guidelines of one of four recognized green building rating systems.
Department of Housing and Urban Development
--$3 billion to the Public Housing Capital Fund, awarded based on the existing formula to public housing agencies to improve or build new affordable housing.
--$1 billion to the Public Housing Capital Fund "for priority investments, including investments that leverage private sector funding or financing for renovations and energy conservation retrofit investments." This funding is awarded competitively.
--$2.25 billion for the HOME Investment Partnership Program to provide state grants to buy, renovate, and create affordable housing.
--$250 million in grants and loans available to HUD-assisted housing owners for energy retrofits and "green" investments.
General Services Administration (GSA)
--$4.5 billion to convert GSA facilities to high performance green buildings as defined in the Energy Independence and Security Act of 2007. By 2015, existing buildings must use 30% less fossil energy compared to 2005 levels. New buildings and major renovations must use 55% less fossil energy than 2003 levels by 2010, and use no fossil energy by 2030.
Department of Defense
--$3.69 billion for "energy efficiency projects and to repair and modernize" facililites.
Department of Interior
--$884 million to be used for construction activities and energy retrofits at the U.S. National Park Service, U.S. Fish and Wildlife Service, and the Bureau of Land Management.

Source(s): American Recovery and Reinvestment Act of 2009. February 17, 2009. Public Law 111-5; Congressional Research Service, American Recovery and Reinvestment Act of 2009, Public Law 111-5, February 2009; ACEEE, Summary of Energy Efficiency Provisions in ARRA 2009, October 2009.

7.1.2 Buildings-Related DOE Funding in the American Recovery and Reinvestment Act of 2009

Innovative Technology Loan Guarantee Program
--$6.0 billion to provide loans to the commercial sector for renewable energy and transmission projects. This program was originally created under the Energy Policy Act of 2005
Weatherization Assistance Program
--$5.0 billion for grants that are distributed to states and territories. Funding is used to improve the energy efficiency of homes owned by households earning less than 200% of the federal poverty level. Fiscal year 2008 funding was $227.2 million.
Electricity Delivery and Energy Reliability
--$4.5 billion provided to the Office of Electricity Delivery and Energy Reliability to modernize the electric grid, including deployment of smart meters and electricity storage systems.
Energy Efficiency and Conservation Block Grants
--$3.2 billion to be distributed to local governments for energy efficiency programs. Program was established under the Energy Independence and Security Act (EISA) and $2.8 billion will be allocated based on the formula provided in EISA. $400 million is to be allocated on a competitive basis.
State Energy Program
--$3.1 billion is available to states that put in place utility rate decoupling and improved building codes.
Appliance Rebate Program
--$300 million for consumer rebates to replace of old appliances with ENERGY STAR-qualified appliances.

Source(s): American Recovery and Reinvestment Act of 2009. February 17, 2009. Public Law 111-5; Congressional Research Service, American Recovery and Reinvestment Act of 2009, Public Law 111-5, February 2009; ACEEE, Summary of Energy Efficiency Provisions in ARRA 2009, October 2009.

7.1.3 State Energy Efficient Appliance Rebate Program

	2010 Total Rebates (Thousand)	2010 Rebates ($ Million)	2010 Avg Rebate ($)	2011 Total Rebates (Thousand)	2011 Rebates ($ Million)	2011 Avg Rebate ($)
Home Appliances						
Air Conditioners (Room)	28	1.8	65	3	0.3	111
Clothes Washers	480	52.8	110	78	11.2	143
Dishwashers	245	22.2	91	55	5.6	101
Freezers	22	2.0	94	3	0.7	266
Refrigerators	488	64.8	133	104	18.9	182
HVAC						
Air Conditioners (Central)	31	12.4	403	17	13.0	767
Boiler Reset Controls	0	0.0	100	0	0.0	0
Boilers (Gas)	3	1.8	632	1	0.4	500
Boilers (Oil)	2	0.9	425	1	0.5	403
Boilers (Propane)	0	0.0	214	0	0.0	300
Furnaces (Gas)	61	24.2	396	8	3.3	415
Furnaces (Oil)	0	0.2	379	0	0.1	394
Furnaces (Propane)	1	0.3	314	0	0.0	340
Heat Pumps (Air Source)	33	16.2	487	17	9.2	546
Heat Pumps (Ground Source)	2	1.5	912	0	0.0	1,207
Water Heaters						
Electric Heat Pump	3	0.9	278	1	0.2	322
Gas Storage	15	0.0	123	1	0.2	337
Gas Tankless	9	1.8	263	1	0.5	335
Indirect	0	2.4	150	0	0.0	0
Propane Storage	0	0.0	151	0	0.0	25
Propane Tankless	0	0.0	192	0	0.0	300
Solar, Electric Backup	0	0.0	735	0	0.1	1,675
Solar, Gas Backup	0	0.2	1,267	0	0.0	1,262
Solar, Indirect Backup	0	0.1	1,107	0	0.2	2,000
All Products	**1424**	**206.6**	**145**	**291**	**64.7**	**223**

Note(s): Planned program totals based on state plans submitted to the U.S. Department of Energy. Actual results based on state reporting to the U.S. Department of Energy through 12/31/2011. This program was created under the Energy Policy Act of 2005 and received $300 million in funding through the American Recovery and Reinvestment Act of 2009. Under this program, eligible consumers may obtain rebates on the purchase of new energy-efficient appliances when they replace used appliances. Additional information at

Source(s): U.S. Department of Energy

7.1.4 Energy Independence and Security Act 2007, High Performance Commercial Buildings

Create the Office of Commercial High Performance Green Buildings

The Office of Commercial High Performance Green Buildings with The Office of Federal High Performance Green Buildings will establish a High Performance Green Buildings Clearinghouse to disseminate research through outreach, education, and technical assistance

Zero Net Energy Initiative for Commercial Buildings was also included establishing specific goals:

-- Net zero energy use in all new commercial buildings constructed by 2030
-- Net zero energy use in 50% of the United State commercial building stock by 2040
-- Net zero energy use in the entire United States commercial building stock by 2050

Source(s): The 110th Congress of the United States, The Energy Independence and Security Act of 2007, January 2007, Section 422.

7.1.5 Phase Out Schedule of Halocarbons in the U.S. (1)

			Montreal Protocol Reduction		U.S. Clean Air Act Reduction	
Gas	Manufacturing Base Level (2)	Manufacturing Freeze (3)	%	By	%	By
Chlorofluorocarbons (CFCs)	1986	1989	75%	1994	75%	1994
			100%	1996 (4)	100%	1996
Bromofluorocarbons (Halons)	1986	1992	100%	1994 (4)	100%	1994
Hydrochlorofluorocarbons (HCFCs)	1989 HCFC consumption + 2.8 % of 1989 CFC consumption	1996	35.0%	2004	35%	2003
			75.0%	2010	75%	2010
			90.0%	2015	90%	2015
			99.5%	2020	99.5%	2020
			100%	2030 (4)	100%	2030
Hydrofluorocarbons (HFCs)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Note(s): 1) The phase out of halocarbons is consistent with Title VI of the Clean Air Act and is in accordance with the Montreal Protocol and Amendments. 2) The amount of gas produced and consumed in this year is established and defined as the base level. To meet basic domestic needs, levels of production are allowed to exceed the base level by up to 10%. 3) After this year, levels of production are no longer permitted to exceed the base year level. 4) With possible essential use exemptions.

Source(s): Federal Register, Vol. 72, No. 123, June 2007, p. 35230, http://www.epa.gov/ozone/title6/phaseout; United Nations Ozone Environmental Programme, Ozone Secretariat, 2005, http://www.unep.ch/ozone/index.shtml; and Title VI, The Clean Air Act of 1990, S.1630, 101st Congress., 2nd Session.

7.1.6 Energy Policy Act of 1992, Building Energy Codes

--Each State must certify to the Secretary of Energy whether its energy efficiency standards with respect to residential and commercial building codes meet or exceed those of the Council of American Building Officials (CABO) Model Energy Code, 1992, and of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, respectively.

--Requires DOE to provide technical assistance and incentive funding to the States to promote increased use of energy efficiency codes for buildings.

--Directs the Secretary to: (1) establish standards that require energy efficiency measures that are technologically feasible and economically justified in new Federal buildings; and (2) review them every five years. Mandates Federal agency compliance with such standards.

--Prescribes guidelines under which DOE shall support the upgrading of voluntary building energy codes for new residential and commercial buildings.

--The Department of Housing and Urban Development (HUD) and Agriculture are to jointly establish energy efficiency standards for residential housing. Amends Federal law regarding veterans' readjustment benefits to condition a loan for new residential housing upon compliance with such standards.

--DOE is to: (1) issue voluntary building energy code guidelines for use by the private and public sectors to encourage the assignment of energy efficiency ratings for new residential buildings; (2) establish a technical assistance program for State and local organizations to encourage the use of residential energy efficiency rating systems consistent with such guidelines; (3) provide matching grants for the establishment of regional building energy efficiency centers in each of the regions served by a DOE regional support office; and (4) establish an advisory task force to evaluate grant activities.

--HUD is to: (1) assess the energy performance of manufactured housing and make recommendations to the National Commission on Manufactured Housing regarding thermal insulation and energy efficiency improvements; and (2) test the performance and determine the cost effectiveness of manufactured housing constructed in compliance with certain statutory standards. Authorizes the States to establish thermal insulation and energy efficiency standards for manufactured housing if the Secretary of HUD has not issued final regulations by October 1993.

--HUD is to promulgate a uniform affordable housing plan using energy efficient mortgages (mortgages that provide financing incentives either for the purchase of energy efficient homes, or for incorporating the cost of such improvements into the mortgage).

--DOE is to provide financial assistance to support a voluntary national window rating program that will develop energy ratings and labels for windows and window systems. Requires the National Fenestration Rating Council to develop such rating program according to specified procedures. Requires the Secretary to develop specified alternative rating systems if a national voluntary window rating program consistent with this Act has not been developed.

Source(s): U.S. Government, Energy Policy Act of 1992 Conference Report, Oct. 1992.

7.1.7 Energy Policy Act of 1992, Appliance and Equipment Efficiency Standards

--DOE is to: (1) detail energy conservation and labeling requirements for specified commercial and industrial equipment (including lamps and plumbing products); and (2) delineate standards for heating and air-conditioning equipment, electric motors, high intensity discharge lamps, and distribution transformers.

--DOE is to provide financial and technical assistance to support a voluntary national testing and information program for widely used commercial office equipment and luminaries with potential for significant energy savings.

--Requires DOE to report to the Congress on: (1) the potential for the development and commercialization of appliances which are substantially more efficient than required by Federal or State law; and (2) the energy savings and environmental benefits of early appliance replacement programs.

Source(s): U.S. Government, Energy Policy Act of 1992 Conference Report, Oct. 1992.

7.1.8 The Clean Air Act

1970 Amendments

- Established the National Ambient Air Quality Standards (NAAQS) for stationary sources and placed limits on mobile sources.
- Established the New Source Performance Standards (NSPS) which mandated a strict limit on emissions from new pollution sources.
- Expanded on the State Implemenation Plans (SIPs) to carry out mandates.

1977 Amendments

- Categorized regions into attinment and non-attainment regions.
- Non-attainment designation occurred if region emitted in excess of any federal standard.
- If a region complied with federal standards, it was designated as a PSD, which stands for "prevention of significant deterioration."
- Lengthened federal deadlines for meeting pollution reduction, particularly with regards to mobile emissions sources.

1990 Amendments

- Established a sulfur dioxide (Sox) and a nitrous oxide (Nox) cap and trade program. Under this program, an emissions cap is set and permits are issued. An emitter of Sox or Nox must have a permit for each unit of pollutant they release These emissions permits may be trade (bought and sold) amongst polluting parties to minimize cost.
- Mandated the control of 189 hazardous pollutants.
- Updated and expanded provisions of the NAAQS.

Source(s): The United States Congress, Public Law 108-201, The Clean Air Act as amended through February 24, 2004; EPA, The History of the Clean Air Act, accessed February 2011 at <http://www.epa.gov/air/caa/caa_history.html>

7.2.1 Tax Incentives of the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010

Energy Efficient Appliance Credit (modified and extended through 2011)
--$25-75 for efficient dishwashers.
--$175-225 for efficient clothes washers
--$150-200 for efficient refrigerators.

Credit for Efficiency Improvements to Existing Homes (modified and extended through 2011)
--Tax credit equal to 10% of the amount paid or incurred by the taxpayer for a qualifying energy efficiency improvement, up to a maximum of $500.
--This includes up to $50 for any advanced main air circulating fan, $150 for qualifying natural gas, propane, or oil furnaces or hot water boilers, and $300 for "any item of energy-efficient building property."

Efficient New Homes
--Extends the tax credit for new energy efficient homes through 2011.

Source(s): Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010. December 17, 2010. Public Law 111-312; and The United States Senate Committee on Finance, Summary of the Reid-McConnell Tax Relief, Unemployment Insurance Reauthorization and Job Creation Act of 2010. December 10, 2010.

7.2.2 Tax Incentive of the American Recovery and Reinvestment Act of 2009

Envelope Improvements to Existing Homes (1)
--Increases existing tax credit to 30% of costs up to $1,500 to upgrade building envelope to be compliant with codes for new construction. Upgrades to building shell, HVAC system, and windows and doors may qualify. Improvements must be installed between January 1, 2008 and December 31, 2010.

Renewable Energy Production Tax Credits
--Tax credit to 30% of costs for installation of on-site renewable energy equipment, with no caps on total investment. Tax credits for wind energy are available through 2012, while other renewables can receive a tax credit if placed into service through 2013.

Renewable Energy Investment Tax Credits
--Provides the option to take an investment tax credit in lieu of the production tax credit. This allows the full credit to be provided once a system is placed into service, rather than over the production period of the system. The goal of this option is to make financing a project less difficult.

Clean Renewable Energy Bonds
--$1.6 billion to finance renewable energy generation. Funds are to be available in equal proportion to state/local/tribal governments, municipal utilities, and electric cooperatives.

Energy Conservation Bonds
--$2.4 billion issued to states based on population. Bonds can be used to finance a variety of projects that reduce energy use.

Note(s): 1) Based on tax credit from Energy Policy Act of 2005. See the table "Tax Incentive of the Energy Policy Act of 2005."

Source(s): American Recovery and Reinvestment Act of 2009. February 17, 2009. Public Law 111-5; Sissine, et al. "American Recovery and Reinvestment Act of 2009. February 17, 2009. Public Law 111-5." Congressional Research Service. 2009; McDermott Will & Emory. "Energy Tax Provisions Included in American Recovery and Reinvestment Act of 2009." 2009.

7.2.3 Tax Incentives of the Emergency Economic Stabilization Act of 2008 (1)

New Homes
--Extends tax credits for efficient new homes to December 31, 2009.

Envelope Improvements to Existing Homes
--Reinstates 10% tax credit for building shell, HVAC and windows to include installations during 2009.

Commercial Buildings
--Extends tax deductions for efficiency upgrades in commercial buildings to December 31, 2013.

Note(s): 1) Tax incentives detailed are extensions to incentives found in the Energy Policy Act of 2005. See the table "Tax Incentive of the Energy Policy Act of 2005" for details.

Source(s): Emergency Economic Stabilization Act of 2008, Public Law 110-343, October 2008.

7.2.4 Tax Incentives of the Energy Policy Act of 2005

Appliance Manufacturers
--Refrigerator manufactures receive a $75 credit for each unit sold that uses 15-19.9% less energy than required by the 2001 Federal minimum efficiency; $125 for 20-24.9% less; and $175 for at least 25% less.
--Clothes washer manufacturers receive a $100 credit for each unit sold that meeting the 2007 ENERGY STAR criteria.
--Dishwasher manufacturers receive a $3 credit per percentage of energy savings greater than the current ENERGY STAR criteria for each unit sold. For example, a dishwasher is 15% more efficient than the current ENERGY STAR criteria, the credit is $3 X 15 = $45.
--Credits are only available for products manufactured in the U.S.
--Each manufacturer is capped at $75 million for available credits.
Stationary Fuel Cells and Microturbines
--Tax credit of 30%, up to $1000 per kW for fuel cells that at 500 kW or greater and have an efficiency of at least 30%. Residential applications do not have a capacity or efficiency requirement. Units must be put in place between January 1, 2006 and December 31, 2007.
--Tax credit of 10%, up to $200 per kW for microturbines that are less than 2,000 kW and have an efficiency of at least 26%. Units must be put in place between January 1, 2006 and December 31, 2007.

Source(s): ACEEE, The Federal Energy Policy Act of 2005 and its Implications for Energy Efficiency Program Efforts, Sept. 2005, p. 1-7.

7.2.5 Tax Incentives of the Energy Policy Act of 2005

New Homes
--Builders who build homes that use 50% less energy for space heating and cooling than the IECC 2003 are eligible for a $2,000 tax credit per home.
--Manufactured housing builder that either uses 30% less energy than this reference code or that meet the then-current ENERGY STAR criteria are eligible for $1,000 tax credit per home. At least 10% of energy savings must be obtained through building envelope improvements.

Envelope Improvements to Existing Homes
--10% tax credit up to $500 for upgrading building envelope to be compliant with codes for new construction. Window replacement is capped at $200. $500 is the cap for all for envelope and HVAC improvements. Improvements must be installed between January 1, 2006 and December 31, 2007.

Commercial Buildings
--Tax deduction up to $1.80/SF for new commercial buildings which are 50% more efficient than the requirements of ASHRAE 90.1-19XX.
--Tax deduction up to $0.60/SF for existing commercial buildings which upgrade the envelope, lighting, or HVAC building systems to 50% more efficient than ASHRAE 90.1-19XX. The deduction can be combined when improvements are made to two building components.
--Deductions apply to new buildings placed in service and improvements to existing buildings completed between August X, 2005 and December 31, 2007.

Source(s): ACEEE, The Federal Energy Policy Act of 2005 and its Implications for Energy Efficiency Program Efforts, Sept. 2005, p. 1-7.

7.2.6 HVAC Tax Incentives of the Energy Policy Act of 2005

Equipment Type	Qualifying Efficiency	Credit
Central air conditioner	15 SEER and 12.5 EER	300
Central air-source heat pump	15 SEER, 9 HSPF, and 13 EER	300
Ground-source heat pump		
Closed loop	14.1 EER and 3.3 COP	300
Open loop	16.2 EER and 3.6 COP	300
Direct expansion (DX)	15.0 EER and 3.5 COP	300
Gas, oil, or propane furnace or boiler	95% AFUE	150
Furnace Blower	Electricity use <2% of total furnace	50
	site energy consumption	300
Electric heat pump water heater	2.0 EF	300
Gas, oil, or propane water heater	0.80 EF	

Source(s): ACEEE, The Federal Energy Policy Act of 2005 and its Implications for Energy Efficiency Program Efforts, Sept. 2005, Table 1, p. 6.

7.2.7 Federal Energy Efficiency Tax Credits for Individuals and Average Credit Claimed

	2006		2007		2008		2009	
	Count (10^3)	Avg Credit ($)	Count (10^3)	Avg Credit ($)	Count (10^3)	Avg Credit ($)	Count (10^3)	Avg Credit ($)
Nonbusiness Energy Property Credit								
Envelope Improvements	3352	226	3274	215	N/A	N/A	N/A	N/A
Equipment Improvements	676	291	990	291	N/A	N/A	N/A	N/A
Total	4314	222	4292	219	N/A	N/A	6566	788
Residential Energy Efficient Property Credit								
Solar Electric	26	1239	34	1134	92	841	78	N/A
Solar Water Heating	24	859	26	1055	61	911	42	N/A
Small Wind Energy	N/A	N/A	N/A	N/A	5	1526	7	N/A
Geothermal Heat Pump	N/A	N/A	N/A	N/A	59	1330	77	N/A
Fuel Cell	1	729	1	650	9	584	7	N/A
Total	45	963	61	1132	201	1048	210	3078
Grand Total	4344	230	4326	233	201	1048	6705	868

Note(s): N/A = Credit not available.

Source(s): Dept. of the Treasury, Internal Revenue Service, 2006 Estimated Data Line Counts Individual Income Tax Returns, Aug. 2008; Dept. of the Treasury, Internal Revenue Service, 2007 Estimated Data Line Counts Individual Income Tax Returns, Aug. 2009; Dept. of the Treasury, Internal Revenue Service, 2008 Estimated Data Line Counts Individual Income Tax Returns, Aug. 2010; and Dept. of the Treasury, Internal Revenue Service, 2009 Estimated Data Line Counts Individual Income Tax Returns, Aug. 2011.

7.3.1 Efficiency Standards for Residential Central Air Conditioners and Heat Pumps (1)

Type	SEER (3)	HSPF (4)
Split System Air Conditioners	13.0	--
Split System Heat Pumps	13.0	7.7
Single Package Air Conditioners	13.0	--
Single Package Heat Pumps	13.0	7.7
Through-the-Wall Air Conditioners and Heat Pumps:		
-Split System (2)	10.9	7.1
-Single Package (2)	10.6	7.0
Small Duct, High Velocity Systems	13.0	7.7
Space Constrained Products		
-Air Conditioners	12.0	--
-Heat Pumps	12.0	7.4

Note(s): 1) Effective for products manufactured on or after January 23, 2006. 2) Applies to products manufactured prior to January 23, 2010. 3) Seasonal Energy Efficiency Ratio. 4) Heating Seasonal Performance Factor.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.3.2 Efficiency Standards for Residential Furnaces

Effective for products manufactured before November 19, 2015

	AFUE (%) (2)
Furnaces (excluding classes noted below)	78
Mobile Home Furnaces	75
Small Furnaces with input rate < 45,000 Btu/hr (1)	
- Weatherized (outdoor)	78
- Non-Weatherized (indoor)	78

Effective for products manufactured on or after November 19, 2015

	AFUE (%) (2)
Non-Weatherized Gas Furnaces	80
Weatherized Gas Furnaces	81
Mobile Home Oil-Fired Furnaces	75
Mobile home Gas Furnaces	80
Non-Weatherized Oil-Fired Furnaces	82
Weatherized Oil-Fired Furnaces	78

Note(s): 1) Excludes those intended solely for installation in mobile homes. 2) Annual Fuel Utilization Efficiency.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.3.3 Efficiency Standards for Residential Boilers

Effective for products manufactured before September 1, 2012

	AFUE(%) (1)
Boilers (excluding gas steam)	80
Gas Steam Boilers	75

Effective for products manufactured on or after September 1, 2012 (2)

	AFUE (%) (1)	Design Requirements
Gas Hot Water	82	No Constant Burning Pilot Automatic Means for Adjusting Water Temperature
Gas Steam	80	No Constant Burning Pilot
Oil Hot Water	84	Automatic Means for Adjusting Water Temperature
Oil Steam	82	None
Electric Hot water	None	Automatic Means for Adjusting Water Temperature
Electric Steam	None	None

Note(s): 1) Annual Fuel Utilization Efficiency. 2) Boilers manufactured to operate without any need for electricity, an electric connection, electric gauges, electric pumps, electric wires, or electric devices are not required to comply with the revised standards that take effect September 1, 2012. These must, however, meet the standards that were effective prior to September 1, 2012.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.4.1 Efficiency Standards for Commercial Warm Air Furnaces

Effective for products manufactured on or after January 1, 1994

	Thermal Efficiency (1)
Gas-fired, with capacity ≥ 225,000 Btu/hr	Not less than 80%
Oil-fired, with capacity ≥ 225,000 Btu/hr	Not less than 81%

Note(s): 1) Measured at the maximum rated capacity.

Source(s): Title 10, Code of Federal Regulations, Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment, Subpart D - Commercial Warm Air Furnaces. January 1, 2010.

7.4.2 Efficiency Standards for Commercial Packaged Boilers

Effective for products manufactured between January 1, 1994 and March 1, 2012

	Combustion Efficiency (1)
Gas-fired, with capacity ≥ 300,000 Btu/hr	Not less than 80%
Oil-fired, with capacity ≥ 300,000 Btu/hr	Not less than 83%

Effective for products manufactured on or after March 2, 2012

	Size (Btu/hr)	Efficiency Level (1)
Gas-fired, hot water	≥300,000 and ≤2,500,000	80% thermal efficiency
Gas-fired, hot water	>2,500,000	82% combustion efficiency
Oil-fired, hot water	≥300,000 and ≤2,500,000	82% thermal efficiency
Oil-fired, hot water	>2,500,000	84% combustion efficiency
Gas-fired except natural draft, steam	≥300,000 and ≤2,500,000	79% thermal efficiency
Gas-fired except natural draft, steam	>2,500,000	79% thermal efficiency
Gas-fired-natural draft, steam	≥300,000 and ≤2,500,000	77% thermal efficiency
Gas-fired-natural draft, steam	>2,500,000	77% thermal efficiency
Oil-fired, steam	≥300,000 and ≤2,500,000	81% thermal efficiency
Oil-fired, steam	>2,500,000	81% thermal efficiency

Effective March 2, 2022	Size (Btu/hr)	Thermal Efficiency (1)
Gas-fired natural draft, steam	≥300,000 and ≤2,500,000	79%
Gas-fired natural draft, steam	>2,500,000	79%

Note(s): 1) Measured at the maximum rated capacity.

Source(s): Title 10, Code of Federal Regulations, Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment, Subpart E - Commercial Packaged Boilers. January 1, 2010.

7.4.3 Efficiency Standards for Commercial Air Conditioners and Heat Pumps (1)

Type	Cooling Capacity (Btu/hr)	Category (2)	Efficiency Level
Small commercial package air conditioning and heating equipment (air-cooled, three-phase)	<65,000	AC	SEER = 13.0
		HP	SEER = 13.0
Single package vertical air conditioners and single package vertical heat pumps, single-phase and three phase	<65,000	AC	EER = 9.0
		HP	EER = 9.0, COP = 3.0
Single package vertical air conditioners and single package vertical heat pumps	≥65,000 and <135,000	AC	EER = 8.9
		HP	EER = 8.9, COP = 3.0
Single package vertical air conditioners and single package vertical heat pumps	≥135,000 and <240,000	AC	EER = 8.6
		HP	EER = 8.6, COP = 2.9
Small commercial package air-conditioning and heating equipment (air-cooled)	≥65,000 and <135,000	AC	EER = 11.2 (3)
			EER = 11.0 (4)
		HP	EER = 11.0 (3)
			EER = 10.8 (4)
Large commercial package air-conditioning and heating equipment (air-cooled)	≥135,000 and <240,000	AC	EER = 11.0 (3)
			EER = 10.8 (4)
		HP	EER = 10.6 (3)
			EER = 10.4 (4)
Very large commercial package air-conditioning and heating equipment (air-cooled)	≥240,000 and <760,000	AC	EER = 10.0 (3)
			EER = 9.8 (4)
		HP	EER = 9.5 (3)
			EER = 9.3 (4)
Small commercial package air-conditioning heat pump	≥65,000 and <135,000	HP	COP = 3.3
Large commercial package air-conditioning heat pump	≥135,000 and <240,000	HP	COP = 3.2
Very large commercial package air-conditioning heat pump	≥240,000 and <760,000	HP	COP = 3.2

Note(s): EER = Energy Efficiency Ratio, COP = Coefficient of Performance. 1) Effective for products manufactured on or after January 1, 2010, excpet for air-cooled, three-phase small commercial package air-conditioning and heating equipment <65,000 Btu/hr for which standards are effective for products manufactured on or after June 16, 2008. 2) AC = Air Conditioner, HP = Heat Pump. 3) Applies to equipment with electric resistance heating or no heating. 4) Applies to equipment with all other integrated heating-system types.

Source(s): Title 10, Code of Federal Regulations, Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment, Subpart F - Commercial Air Conditioners and Heat Pumps. January 1, 2010.

7.5.1 Efficiency Standards for Residential Room Air Conditioners (1)

Without Reverse Cycle, With Louvered Sides		Without Reverse Cycle, Without Louvered Sides	
Capacity (Btu/hr):	EER (2)	Capacity (Btu/hr):	EER (2)
<6,000	9.7	<6,000	9.0
6,000-7,999	9.7	6,000-7,999	9.0
8,000-13,999	9.8	8,000-13,999	8.5
14,000-19,999	9.7	14,000-19,999	8.5
20,000+	8.5	20,000+	8.5

Note(s): 1) Effective for products manufactured on or after October 1, 2000. 2) EER = Energy Efficiency Ratio.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.5.2 Efficiency Standards for Residential Refrigerators and Freezers (1)

Product Class	Maximum Energy Use (kWh) (2)
1) Refrigerator-freezers, partial automatic defrost	8.82AV + 248.4
2) Refrigerator-freezers, automatic defrost with top-mounted freezer without through-the-door ice service and all refrigerators, automatic defrost	9.80AV + 276.0
3) Refrigerator-freezers, automatic defrost with side-mounted freezer without through-the-door ice service	4.91AV + 507.5
4) Refrigerator-freezers, automatic defrost with bottom-mounted freezer without through-the-door ice service	4.60AV + 459.0
5) Refrigerator freezers, automatic defrost with top-mounted freezer with through-the-door ice service	10.20AV + 356.0
6) Refrigerator-freezers, automatic defrost with side-mounted freezer with through-the-door ice service	10.10AV + 406.0

Note(s): 1) Effective for products manufactured on or after July 1, 2001. Standards do not apply to refrigerators and refrigerator-freezers with total refrigerated volume exceeding 39 cubic feet or freezers with total refrigerated volume exceeding 30 cubic feet. AV = total adjusted volume (ft^3).

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.5.3 Efficiency Standards for Residential Water Heaters (1)

Effective for products manufactured from January 20, 2004 through April 15, 2015

Gas-Fired Storage Water Heaters
EF = 0.67 - (0.0019 x Rated Storage Volume in gallons)

Oil-Fired Water Heaters
EF = 0.59 - (0.0019 x Rated Storage Volume in gallons)

Instantaneous Gas-Fired Water Heaters
EF = 0.62 - (0.0019 x Rated Storage Volume in gallons)

Instantaneous Electric and Table Top Water Heaters
EF = 0.93 - (0.00132 x Rated Storage Volume in gallons)

Electric Storage Water Heaters
EF = 0.97 - (0.00132 x Rated Storage Volume in gallons)

Effective for products manufactured on or after April 16, 2015

Gas-Fired Storage Water Heaters

Rated Storage Volume ≤ 55 gallons	EF = 0.675 - (0.0015 x Rated Storage Volume in gallons)
Rated Storage Volume > 55 gallons	EF = 0.8012 - (0.00078 x Rated Storage Volume in gallons)

Electric Storage Water Heaters

Rated Storage Volume ≤ 55 gallons	EF = 0.960 - (0.0003 x Rated Storage Volume in gallons)
Rated Storage Volume > 55 gallons	EF = 2.057 - (0.00113 x Rated Storage Volume in gallons)

Instantaneous Water Heaters

Gas-Fired	EF = 0.82 - (0.0019 x Rated Storage Volume in gallons)
Electric	EF = 0.93 - (0.00132 x Rated Storage Volume in gallons)

Oil-Fired Storage Water Heaters
EF = 0.68 - (0.0019 x Rated Storage Volume in gallons)

Table Top Water Heaters
EF = 0.93 - (0.00132 x Rated Storage Volume in gallons)

Note(s): 1) EF stands for "Energy Factor," while the Rated Storage Volume is a measure of capacity specified by the manufacturer.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

7.5.4 Efficiency Standards for Wet Cleaning Equipment

Clothes Washers:

Effective from products manufactured from January 1, 2007 through December 31, 2011

	Modified Energy Factor (ft^3/kWh/cycle)	Water Factor (gallons/ft^3)
Top-Loading, Compact (Capacity < 1.6 ft^3)	0.65	--
Front-Loading, Compact (Capacity < 1.6 ft^3)	1.26 (ft^3/kWh/cycle)	--
Top-Loading, Semi-Automatic (1)	--	--
Suds-Saving (1)	--	--

Effective for products manufactured on or after January 1, 2011

	Modified Energy Factor (ft^3/kWh/cycle)	Water Factor (gallons/ft^3)
Top-Loading, Compact (Capacity ≥ 1.6 ft^3)	1.26 (ft^3/kWh/cycle)	9.50
Front-Loading, Compact (Capacity ≥ 1.6 ft^3)	1.26 (ft^3/kWh/cycle)	9.50

Dishwashers:

Effective for products manufactured on or after January 1, 2010 (2)

	Maximum Energy Consumption (kWh/yr)	Maximum Gallons per Cycle
Standard	355	6.5

Note(s): 1) Must have an unheated rinse water option. 2) Size is to be determined by ANSI/AHAM DW-1.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.6.1 Efficiency Standards for General Service Fluorescent Lamps

Effective for products manufactured before July 14, 2012

Lamp Type (1)	Nominal Lamp Wattage (W)	Minimum CRI	Minimum Average Lamp Efficacy (lm/W)	Effective Date
4-Foot Medium Bipin	>35	69	75.0	November 1, 1995
4-Foot Medium Bipin	≤35	45	75.0	November 1, 1995
2-Foot U-Shaped	>35	69	68.0	November 1, 1995
2-Foot U-Shaped	≤35	45	64.0	November 1, 1995
8-Foot Slimline	>65	69	80.0	May 1, 1994
8-Foot Slimline	≤65	45	80.0	May 1, 1994
8-Foot High Output	>100	69	80.0	May 1, 1994
8-Foot High Output	≤100	45	80.0	May 1, 1994

Effective for products manufactured on or after July 14, 2012

Lamp Type	Correlated Color Temperature (K)	Minimum Average Lamp Efficacy (lm/W)
4-Foot Medium Bipin	≤4,500	89
4-Foot Medium Bipin	>4,500 and ≤7,000	88
2-Foot U-Shaped	≤4,500	84
2-Foot U-Shaped	>4,500 and ≤7,000	81
8-Foot Slimline	≤4,500	97
8-Foot Slimline	>4,500 and ≤7,000	93
8-Foot High Output	≤4,500	92
8-Foot High Output	>4,500 and ≤7,000	88
4-Foot Miniature Bipin, Standard Output	≤4,500	86
4-Foot Miniature Bipin, Standard Output	>4,500 and ≤7,000	81
4-Foot Miniature Bipin, High Output	≤4,500	76
4-Foot Miniature Bipin, High Output	>4,500 and ≤7,000	72

Note(s): 1) Do not apply to 4-foot medium bipin lamps or 2-foot U-shaped lamps with rated wattages less than 28W; 8-foot high outputt lamps not defined in ANSI C78.81 or related supplements, or not 0.800 nominal amperes; or 8-foot slimline lamps not defined in ANSI 78.3.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy Conservation Standards and Their Effective Dates. January 1, 2010; and Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule, Federal Register, 74 FR 34080, July 14, 2009.

7.6.2 Efficiency Standards for Incandescent Reflector Lamps (1)

Effective for lamps manufactured after November 1, 1995 and before July 14, 2012

Nominal Lamp Wattage	Minimum Average Lamp Efficacy (lm/W)
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

Effective for lamps manufactured on or after July 14, 2012

Rated Lamp Wattage	Lamp Spectrum	Lamp Diameter (in)	Rated Voltage (V)	Minimum Average Lamp Efficacy (lm/W) (2)
40-205	Standard Spectrum	>2.5	≥125	6.8*P^0.27
40-205	Standard Spectrum	>2.5	<125	5.9*P^0.27
40-205	Standard Spectrum	≤2.5	≥125	5.7*P^0.27
40-205	Standard Spectrum	≤2.5	<125	5.0*P^0.27
40-205	Modified Spectrum	>2.5	≥125	5.8*P^0.27
40-205	Modified Spectrum	>2.5	<125	5.0*P^0.27
40-205	Modified Spectrum	≤2.5	≥125	4.9*P^0.27
40-205	Modified Spectrum	≤2.5	<125	4.2*P^0.27

Note(s): 1) Subject to exclusions, these specified standards apply to ER, BR, and BPAR incandescent refrlector lamps and similar bulb shapes on and after January 1, 2008. Subject to exclusions, these standards apply to incandescent reflector lamps with diameters between 2.25 and 2.75 inches on and after June 15, 2008. These standards do not apply to ER30, BR30, BR40, or ER40 lamps rated at 50W or less, These standards do not apply to BR30, BR40, or ER40 lamps rate at 65W. These standards do not apply to R20 incandescent reflector lamps rated 45W or less. 2) P = rated lamp wattage, in watts.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.6.3 Efficiency Standards for Medium Base Compact Fluorescent Lamps (1)

Factor Lamp Power (W) & Configuration	Requirements Minimum Efficacy: lumens/watt (based upon initial lumen data)
Bare Lamp:	
Lamp Power < 15	45.0
Lamp Power ≥ 15	60.0
Covered Lamp (no reflector):	
Lamp Power < 15	40.0
15 ≤ Lamp Power < 19	48.0
19 ≤ Lamp Power < 25	50.0
25 ≤ Lamp Power	55.0

Note(s): 1) Effective for products manufactured on or after January 1, 2006.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.6.4 Lighting Standards for General Service Incandescent Lamps Prescribed by EISA 2007

General Service Incandescent

Effective Date	Maximum Wattage	Rated Lumen Range	Minimum Life
2012	72	1,490-2,600	1000 hrs.
2013	53	1,050-1,498	1000 hrs.
2014	43	750-1,049	1000 hrs.
2015	29	310-749	1000 hrs.

Modified Spectrum General Service Incandescent

Effective Date	Maximum Wattage	Rated Lumen Range	Minimum Life
2012	72	1,118-1,950	1000 hrs.
2013	53	788-1,117	1000 hrs.
2014	43	563-787	1000 hrs.
2015	29	232-563	1000 hrs.

By 2020, the minimum efficacy for general service incandescent will be 45 lm/W unless the Secretary of Energy has implemented another standard which saves as much or more energy than a 45 lm/W standard.

Source(s): U. S. Government, Energy Independence and Security Act of 2007, January 2007, Section 321.

7.7.1 Water Use Standards for Faucets, Showerheads, and Prerinse Spray Valves (1)

Faucet Type (2)	Maximum Flow Rate
Kitchen Faucets (3)	2.2 gpm
Lavatory Replacement Aerators	2.2 gpm
Kitchen Faucets	2.2 gpm
Kitchen Replacement Aerators	2.2 gpm
Metering Faucets (4)	0.25 gal/cycle
Showerheads (5)	2.5 gpm
Commercial Prerinse Spray Valves (6)	1.6 gpm

Note(s): 1) Effective for products manufactured on or after January 1, 1994. 2) When measured at a flowing water pressure of 60 psi (414 kilopascals). 3) For sprayheads with independently-controlled orifices and manual controls, the maximum flow rate of each manual on/off orifice shall not exceed the maximum flow rate for a lavatory faucet. For those with collectively controlled orifices and manual controls, the maximum flow rate of each manual on/off sprayhead shall be the product of the maximum flow rate for a lavatory faucet and the number of component lavatories. 4) For sprayheads with independently controlled orifices and metered controls, the maximum flow rate of each orifice that delivers a pre-set volume of water before gradually shutting itself off shall not exceed the maximum flow rate for a metering faucet. For sprayheads with collectively-controlled orifices and metered controls, the maximum flow rate of a sprayhead that delivers a pre-set volume of water before gradually shutting itself off shall be the product of the maximum flow rate for a metering faucet and the number of component lavatories. 5) When measured at a flowing water pressure of 80 psi (552 kilopascals). Shall also meet the requirements of ASME/ANSI Standard A112.18.1M-1996, 7.4.4(a). 6) Effective for products manufactured on or after January 1, 2006.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; and Title 10, Code of Federal Regulations, Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment, Subpart O - Commercial Prerinse Spray Valves. January 1, 2010.

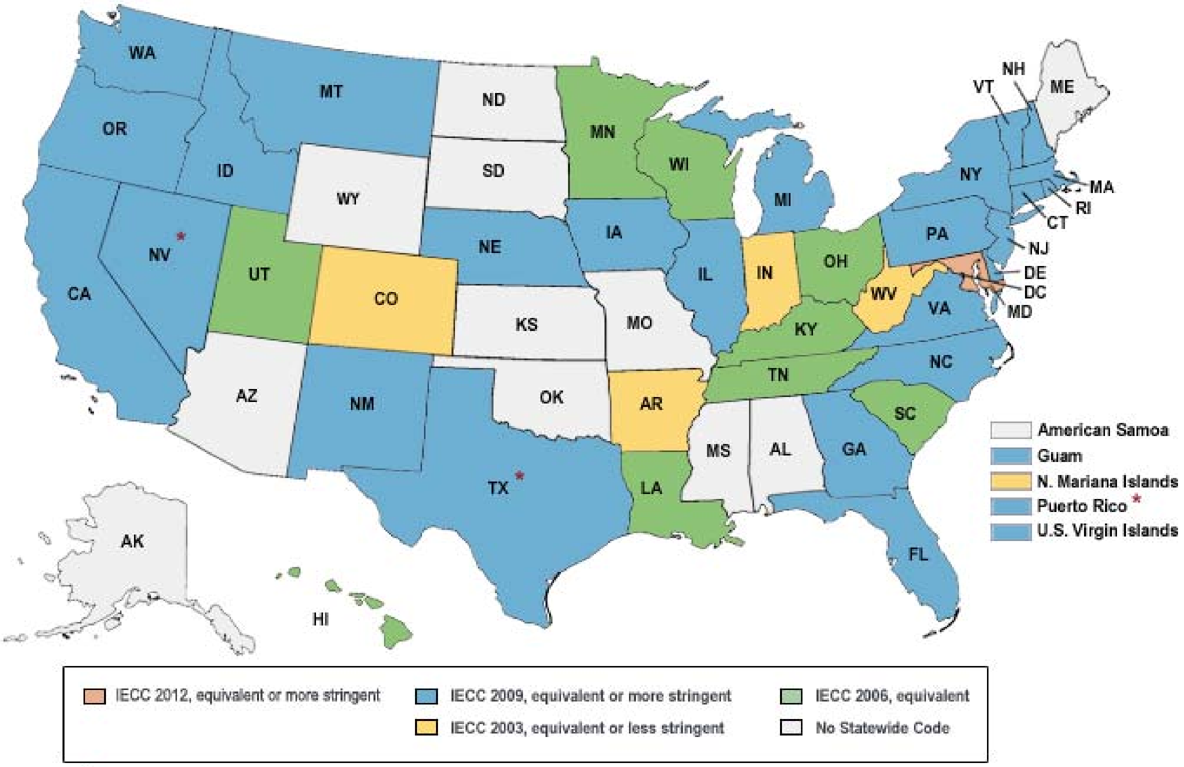
7.7.2 Water Use Standards for Water Closets (1)

Water Closet Type	Maximum Flush Rate (gpf)
Gravity Tank-Type Toilets	1.6
Flushometer Tank Toilets	1.6
Electromechanical Hydraulic Toilets	1.6
Blowout Toilets	3.5
Flushometer Valve Toilets (2)	1.6
Urinals (3)	1.0

Note(s): 1) Effective for products manufactured on or after January 1, 1994, unless otherwise noted. 2) Does not include blowout toilets. Effective for products manufactured on or after January 1, 1997. 3) Except for trough-type urinals. The maximum water use for trough-type urinals should be the product of the maximum flow rate and the length of the urinal in inches divided by 16 inches.

Source(s): Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010.

7.8.1 Status of State Energy Codes: Residential Sector (1)

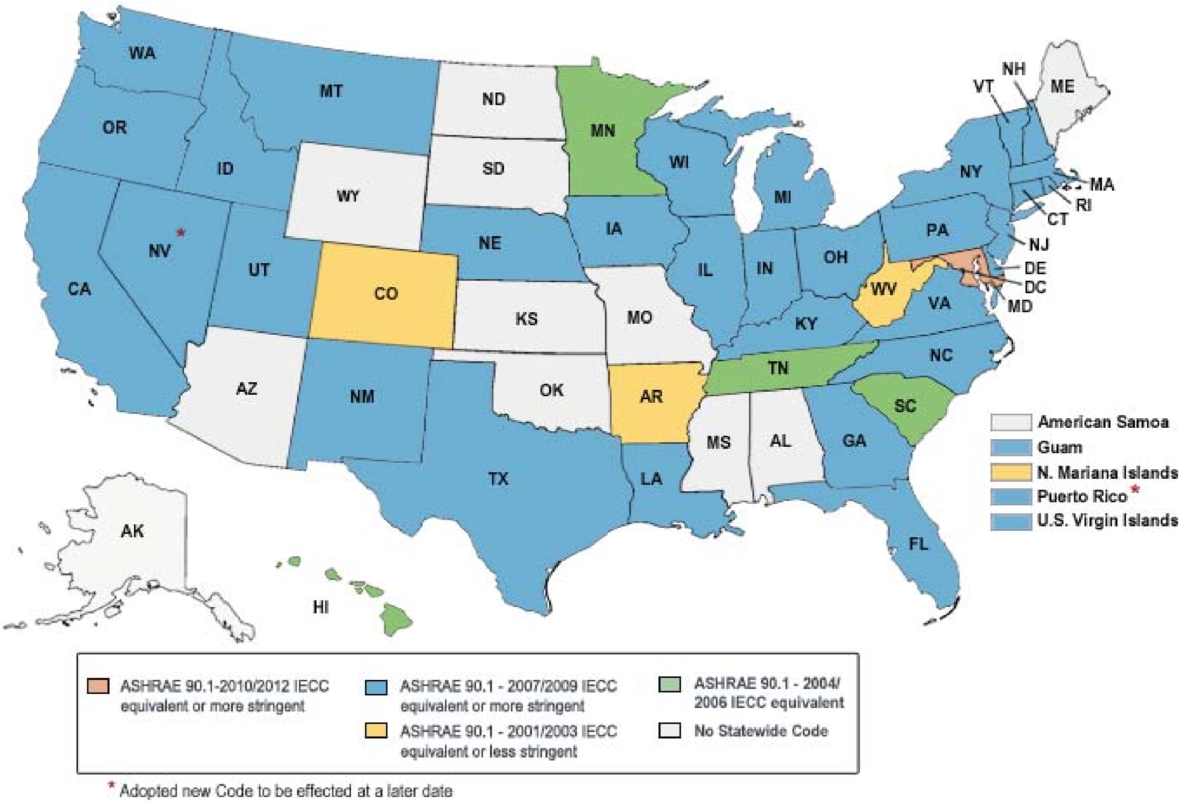


* Adopted new Code to be effective at a later date

Note(s): 1) These are the current residential codes as of March 2012.

Source(s): DOE/EERE, The Status of State Energy Codes, www.energycodes.gov/states/.

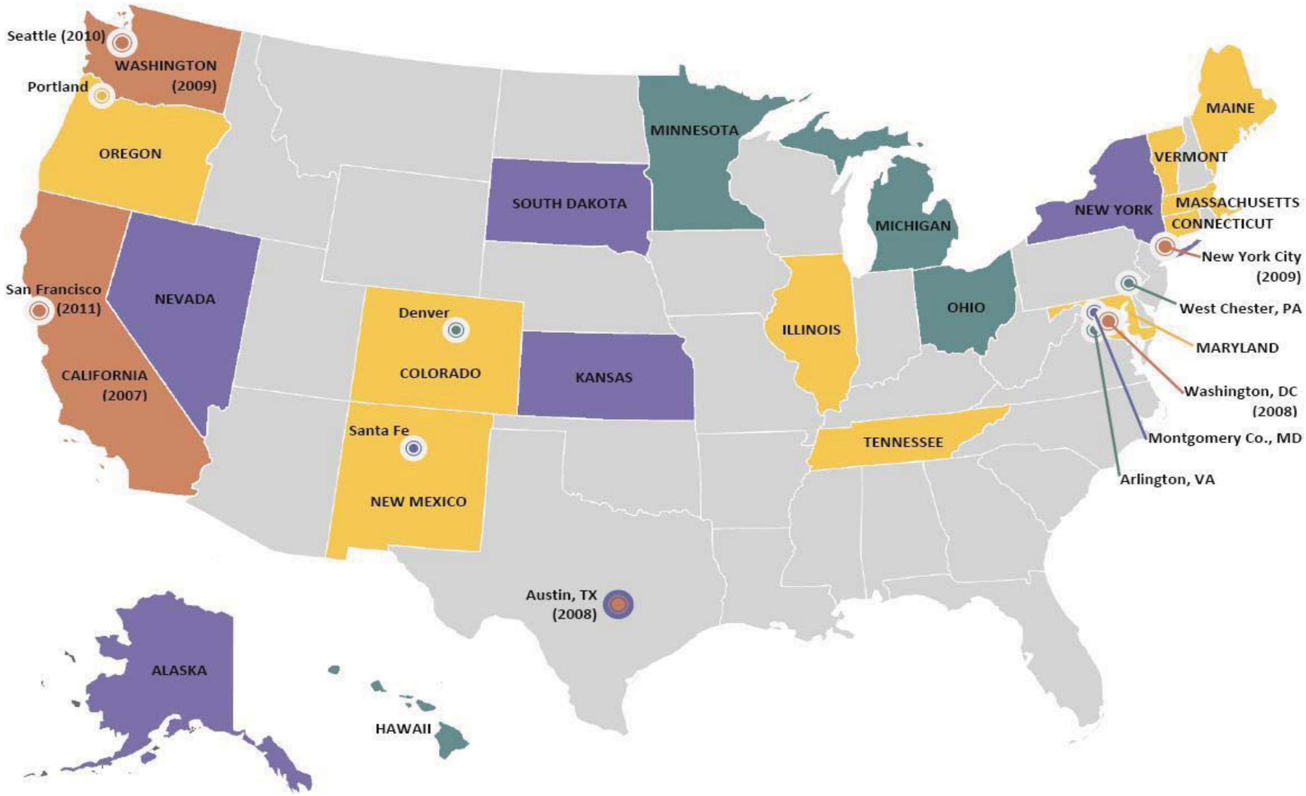
7.8.2 Status of State Energy Codes: Commercial Sector(1)



Note(s): 1) These are the current Commercial codes as of March 2012.

Source(s): DOE/EERE, The Status of State Energy Codes, http://www.energycodes.gov/states/.

7.8.3 Building Energy Rating and Disclosure Policies in the United States



🟫 **Commercial Buildings**
Existing Policy
Austin, TX
California
District of Columbia
New York, NY
San Francisco, CA
Seattle, WA
Washington

🟨 **Commercial Buildings**
Policy Being Considered
Connecticut
Colorado
Illinois
Maine
Maryland
Massachusetts
New Mexico
Oregon
Portland, OR
Tennessee
Vermont

🟦 **Public Buildings**
Rating Requirement
Arlington County, VA
Denver, CO
Hawaii
Michigan
Minnesota
Ohio
West Chester, PA

🟪 **Homes**
Disclosure Requirement
Alaska
Austin, TX
Kansas
Montgomery County, MD
Nevada
New York
Santa Fe, NM
South Dakota

Note(s): Map depicts the policy landscape as of March 17, 2011. More information available at www.BuildingRating.org.
Source(s): Institute for Market Transformation, "Rating Policy Map and Timeline."

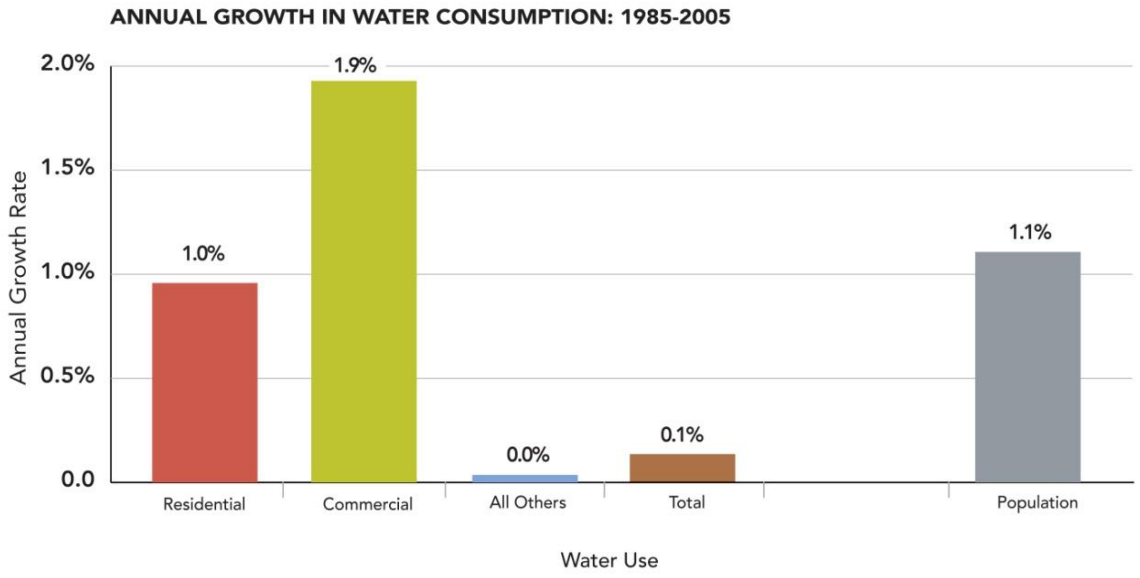
Chapter 8: Water

This chapter includes data on water use in commercial and residential buildings and the energy needed to supply that water. The main points from this chapter are summarized below.

- In 2005, water use in the buildings sector was estimated at 39.6 billion gallons per day, which is nearly 10% of total water use in the United States.
- From 1985 to 2005, water use in the residential sector closely tracked population growth, while water use in the commercial sector grew almost twice as fast.
- In 2005, between 27 billion and 39 billion kWh were consumed to pump, treat, distribute, and clean the water used in the buildings sector, accounting for 0.7% to 1% of net electricity generation.

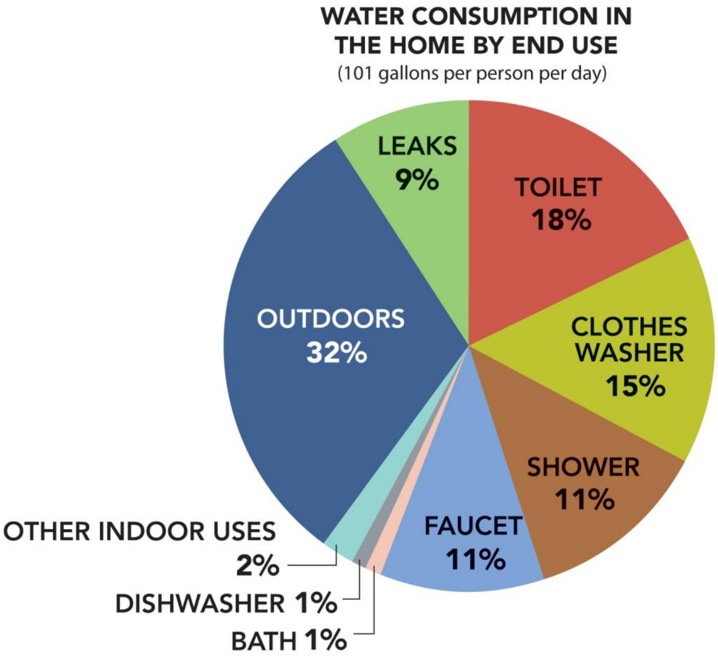
In 2005, an estimated 410 billion gallons per day (bgd) of water were withdrawn for all uses in the United States. This total includes fresh and saline water from ground and surface sources. Domestic (residential) water use was the third largest water use category after thermoelectric power generation and irrigation, with an estimated 29.4 bgd. Another 10.2 bgd were used in commercial buildings, for a total of 39.6 bgd in the buildings sector as a whole. (8.1.1)

From 1985 to 2005, water use in the residential sector closely tracked population growth, while water use in the commercial sector grew almost twice as fast, as shown in the figure. All other water uses taken together were unchanged. As a result, total water use over those two decades increased less than 3%, while water use in the buildings sector increased 27%. The buildings sector's share of total water use increased from 7.8% to 9.7%. (2.2.1, 8.1.1)



In 2005, public and private water suppliers provided 32.7 bgd of water to the buildings sector, representing 87% and 70% of residential and commercial sector water use, respectively. The remainder was supplied by users themselves from wells and surface water sources. (8.2.1, 8.3.1)

Most water used in the buildings sector is pumped, treated, distributed, and cleaned—processes that consume energy in the form of electricity. Two sources estimate the national average energy intensity of public water supplies at 2.3 and 3.3 kWh per thousand gallons. (8.1.2) These two estimates of energy intensity combined with the water use estimates above yield estimates of aggregate energy consumption across all water suppliers in the United States of 27 billion and 39 billion kWh to supply water to the buildings sector in 2005. These values correspond to 0.7% and 1% of the electricity generated by all power plants in that year. (6.1.4)



Water use in the residential sector averages about 100 gallons per person per day. Of this amount, approximately 58 gallons are used indoors, 32 gallons are used outdoors, and 10 gallons are lost to leaks. Based on metering in 1,188 single-family homes in 1999, the leading end uses within the home are toilets (19 gallons), clothes washers (15 gallons), showers (12 gallons), and faucets (11 gallons). (8.2.2) Of the 68 gallons not used outdoors, 25 gallons (37%) are heated. Leading end uses for hot water are faucets (9 gallons), showers (6 gallons), baths (4 gallons), and clothes washers (4 gallons). (8.2.4)

A survey of water suppliers conducted in 2000 found that uniform rates (a set price for each unit of water) are the most common billing rate structure offered to residential consumers. About 56% of suppliers offered this type of rate. Between 18% and 28% of the suppliers surveyed offered increasing block rates, which are designed to encourage conservation. Rate structures that do not encourage conservation were also common. About one-quarter of the suppliers charged a flat fee for some or all of the water they supplied, and between 25% and 35% of suppliers offered declining block rates. (8.2.6)

Water use in the commercial sector varies greatly among establishments based on their size and purpose. One study of water utility billing data for a range of institutions in Southern California and Arizona found that hotels and motels, laundries/laundromats, and car washes were the biggest water users, consuming more than 3,000 gallons per establishment per day, on average. Restaurants, food stores, auto shops, and membership organizations used the least—fewer than 1,000 gallons per establishment per day, on average. (8.3.2)

The study also examined water end uses in several types of establishments and normalized the results to allow for comparison of similar establishments. For example, the normalized total amount of water used varied greatly among the five restaurants in the study, from 2,910 to 15,350 gallons per seat per year and 2.7 to 16.2 gallons per meal per day. Much less variation was observed among supermarkets and hotels. (8.3.3, 8.3.4, 8.3.5)

The WaterSense program, sponsored by the U.S. Environmental Protection Agency (EPA), has set criteria to help consumers identify water-saving products and homes. As of 2010, there were criteria for bathroom sink faucets, toilets, flushing urinals, showerheads, and homes. Products built to these criteria are designed to use between 20% and 50% less water than products that just meet the Federal standards. As of this writing, criteria are under development for pre-rinse spray valves and irrigation control equipment. (8.4.1)

8.1.1 Total Use of Water by Buildings (Million Gallons per Day) (1)

Year	All Buildings	% of Total Water Use	Residential	% of Total Water Use	Commercial	% of Total Water Use
1985	31,260	7.8%	24,320	6.1%	6,940	1.7%
1990	33,580	8.2%	25,290	6.2%	8,290	2.0%
1995	35,670	8.9%	26,090	6.5%	9,580	2.4%
2000 (2)	38,342	9.4%	28,028	6.9%	10,314	2.5%
2005 (3)	39,601	9.7%	29,430	7.2%	10,171	2.5%

Note(s): 1) Includes water from the public supply and self-supplied sources (e.g., wells) for residential and commercial sectors. 2) USGS did not estimate water use in the commercial and residential sectors for 2000. Estimates are based on available data and 1995 splits between domestic and commercial use. 3) USGS did not estimate commercial sector use for 2005. Estimated based on available data and commercial

Source(s): U.S. Geological Survey, Estimated Use of Water in the U.S. in 1985, U.S. Geological Survey Circular 1004, 1988; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1990, U.S. Geological Survey Circular 1081, 1993; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1995, U.S. Geological Survey Circular 1200, 1998; U.S. Geological Survey, Estimated Use of Water in the U.S. in 2000, U.S. Geological Survey Circular 1268, 2004; and U.S. Geological Survey, Estimated Use of Water in the U.S. in 2005, U.S. Geological Survey Circular 1344, 2009.

8.1.2 Average Energy Intensity of Public Water Supplies by Location (kWh per Million Gallons)

Location	Sourcing	Treatment (1)	Distribution	Wastewater	Total
United States (2)	836	627	437	1,363	3,263
United States (3)	2,230	65	(6)	1,649	2,295
Northern California Indoor	2,117	111	1,272	1,911	5,411
Northern California Outdoor	2,117	111	1,272	0	3,500
Southern California Indoor	9,727 (5)	111	1,272	1,911	13,021
Southern California Outdoor	9,727	111	1,272	0	11,110
Iowa	2390	(6)	380	1,570	4,340
Massachusetts	1,500	(6)	(6)	1,750	3,250
Wisconsin Class AB (4)	–	–	–	not included	1,510
Wisconsin Class C (4)	–	–	–	not included	1,850
Wisconsin Class D (4)	–	–	–	not included	1,890
Wisconsin Total (4)	–	–	–	not included	1,601

Note(s): 1) Treatment before delivery to customer. 2) Source: Electric Policy Research Institute (EPRI) 2009. Wastewater estimated based on EPRI 2002. 3) Source: TIAX 2006. 4) Based on water treatment facility size: Class AB >4000 customers, Class C: 1000 to 4000, Class D <1000. Median energy use value reported. 5) Southern California sourcing energy is high because of energy used to pump water from Northern California. 6) Included with Sourcing.

Source(s): Electric Power Research Institute, Program on Technology Innovation: Electric Efficiency Through Water Supply Technologies A Roadmap, Publication 1019360, 2009; EPRI, Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century, 2002; DOE/TIAX LLC, Commercial and Residential Sector Miscellaneous Electricity Consumption: Y2005 and Projections to 2030, 2006; California Energy Commission/Navigant Consulting, Refining Estimates of Water Related Energy Use in California, Public Interest Energy Research Program, CEC-500-2006-118; Iowa Association of Municipal Utilities/Iowa Energy Center, Energy Consumption and Costs to Treat Water and Wastewater in Iowa Part II: Survey Results Tables and Charts, 2002; EPA, Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, 2008; and Energy Center of Wisconsin, Energy Use at Wisconsin's Drinking Water Utilities, 2003.

8.1.3 Energy Use of Wastewater Treatment Plants by Capacity and Treatment Level (kWh per Million Gallons)

	Level Of Treatment				
		Secondary		Tertiary	
Treatment Capacity (Million Gallons per Day)	Less than Secondary	Trickling Filter	Activated Sludge	Advanced	Advanced with Nitrification
1	-	1,811	2,236	2,596	2,951
5	-	978	1,369	1,573	1,926
10	-	852	1,203	1,408	1,791
20	-	750	1,114	1,303	1,676
50	-	687	1,051	1,216	1,588
100	-	673	1,028	1,188	1,558

Note(s): The level of treatment indicates the amount of processing involved before water is released from the treatment facility. Primary treatment removes solids and oils from wastewater. Secondary treatment uses biological processes to remove organic material from the water. Tertiary treatment includes additional processes to further refine the water. Nitrification is a process to remove nitrogen from water.

Source(s): Electric Power Research Institute, Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century, 2002.

8.1.4 Municipal Wastewater Treatment Facilities by Treatment Level and Population Served (Millions) (1)

	Less than Secondary		Secondary		Tertiary		No Discharge		Partial Treatment	
	Facilities	Pop.	Facilities	Pop.	Facilities	Pop.	Facilities	Pop.	Facilities	Pop.
1996	176	17.2	9388	81.9	4428	82.9	2032	7.7	0	-
2000	47	6.4	9156	88.2	4892	100.9	1938	12.3	222	-
2004	40	3.3	9221	96.5	4916	108.5	2188	14.6	218	-
2008	30	3.8	7302	92.7	5071	112.9	2251	16.9	115	-

Note(s): 1) The level of treatment indicates the amount of processing involved before water is released from the treatment facility. Primary treatment removes solids and oils from wastewater. Secondary treatment uses biological processes to remove organic material from the water. Tertiary treatment includes additional processes to further refine the water. No Discharge refers to facilities that do not discharge effluent to surface waters (e.g. groundwater discharge). Partial Treatment facilities perform some treatment before transferring water to another facility for

Source(s): EPA, Clean Watersheds Needs Survey 2008 Report to Congress, 2010; EPA, Clean Watersheds Needs Survey 2004 Report to Congress, 2008.

8.2.1 Residential Water Use by Source (Million Gallons per Day)

Year	Total Residential Water Use	Public Supply (1)	Self-Supply (2)
1980	25,400	22,000	3,400
1985	24,320	21,000	3,320
1990	25,290	21,900	3,390
1995	26,090	22,700	3,390
2000	28,028 (3)	24,438 (3)	3,590
2005	29,430	25,600	3,830

Note(s): 1) Public supply water use: water withdrawn by public and private water suppliers that furnish water to at least 25 people or have a minimum of 15 connections. 2) Self-supply water use: Water withdrawn from a groundwater or surface-water source by a user rather than being obtained from a public supply. 3) USGS did not provide estimates of residential use from public supplies in 2000. This value was estimated based on the residential portion of public supply in 1995 and applied to the total public supply water use in 2000.

Source(s): U.S. Geological Survey, Estimated Use of Water in the U.S. in 1985, U.S. Geological Survey Circular 1004, 1988; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1990, U.S. Geological Survey Circular 1081, 1993; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1995, U.S. Geological Survey Circular 1200, 1998; U.S. Geological Survey, Estimated Use of Water in the U.S. in 2000, U.S. Geological Survey Circular 1268, 2004; and U.S. Geological Survey, Estimated Use of Water in the U.S. in 2005, U.S. Geological Survey Circular 1344, 2009.

8.2.2 1999 Single-Family Home Daily Water Consumption by End Use (Gallons per Capita) (1)

Fixture/End Use	Average gallons per capita per day	Total Use Percent
Toilet	18.5	18.3%
Clothes Washer	15	14.9%
Shower	11.6	11.5%
Faucet	10.9	10.8%
Other Domestic	1.6	1.6%
Bath	1.2	1.2%
Dishwasher	1	1.0%
Leaks	9.5	9.4%
Outdoor Use (2)	31.7	31.4%
Total (2)	**101**	**100%**

Note(s): 1) Based analysis of 1,188 single-family homes at 12 study locations. 2) Total Water use derived from USGS. Outdoor use is the difference between total and indoor uses.

Source(s): American Water Works Association Research Foundation, Residential End Uses of Water, 1999; U.S. Geological Survey, Estimated Use of Water in the U.S. in 2000, U.S. Geological Survey Circular 1268, 2004, Table 6, p. 17; and Vickers, Amy, Handbook of Water Use and Conservation, June 2002, p. 15.

8.2.3 2004 Water Use in Multi-Family Housing Units, In-Rent and Submetered Billing (Gallons per Unit per Day)

	In-Rent	Submetering	Estimated Savings from Submetering	Estimated Potential Range of Savings from Submetering
Indoor Water Use	143	121	-15.3%	6% - 24.6%

Note(s): Based on a regression analysis on a sample of 7,942 properties at 13 sample locations. Results are significant at the 95th percentile.

Source(s): Aquacraft, Inc./East Bay Municipal Utility District W, National Multiple Family Submetering and Allocation Billing Program Study, 2004.

8.2.4 Per Capita Use of Hot Water in Single Family Homes by End Use (Gallons per Capita per Day) (1)

Fixture/End Use	Average gallons per capita per day	Household Use gallons per day	Percent of Total Hot Water Use	Percent of End Use that is Hot Water
Toilet	0.0	0.0	0.0%	0.0%
Clothes Washer	3.9	10.1	15.5%	27.8%
Shower	6.3	16.4	25.1%	73.1%
Faucet	8.6	22.4	34.2%	72.7%
Other	0.0	0.0	0.0%	35.1%
Bath	4.2	10.9	16.7%	78.2%
Dishwasher	0.9	2.3	3.6%	100%
Leaks	1.2	3.1	4.8%	26.8%
Total	**25.1**	**65.2**	**100%**	**39.6%**

Note(s): 1) Based analysis of 10 single-family homes in Seattle, WA. Average number of residents per home: 2.6.

Source(s): Aquacraft, Inc. Residential End Uses of Hot Water in Single-Family Homes from Flow-Trace Analysis, 2000.

8.2.5 2010 Community Water Systems by Size and Type

System Size (1)	Facilities	Population Served (Millions)
Less than 500	29,711	4.9
501 - 3,300	14,031	20.1
3,301 - 10,000	4,914	28.6
10,001 - 100,000	3,801	108.5
More than 100,000	416	138.1
Total	**52,873**	**300.2**

Note(s): 1) Population served by each system. 2) Community water systems provide water to the same population year-round.

Source(s): EPA, Fiscal Year 2010 Drinking Water and Ground Water Statistics, EPA 816-K-09-004, June 2011.

8.2.6 Residential Water Billing Rate Structures for Community Water Systems

	Population Served by System (1)	
Rate Structure	10,001 - 100,000	More than 100,000
Uniform Rates	39.0%	30.0%
Declining Block Rate	15.0%	23.0%
Increasing Block Rate	25.0%	27.0%
Peak Period or Seasonal Rate	0.0%	5.0%
Separate Flat Fee	18.0%	20.0%
Annual Connection Fee	6.0%	3.0%
Combined Flat Fee	4.0%	2.0%
Other Rate Structures	3.0%	9.0%

Note(s): 1) Systems serving more than 10,000 users provide service to 82% of the population served by community water systems. Columns do not sum to 100% because some systems use more than one rate structure. 2) Uniform rates charge a set price for each unit of water. Block rates charge a different price for each additional increment of usage. The prices for each increment is higher for increasing block rates and lower for decreasing block rates. Peak rates and seasonal rates charge higher prices when demand is highest. Flat fees charge a set price for water delivery, with no restrictions on use. Combined flat fees charge one fee for water and other charges, such as rental fees. Separate flat fees bill water and other charges separately.

Source(s): EPA, Community Water System Survey 2006 Volume 1: Overview, p. 24, February 2009.

8.3.1 Commercial Water Use by Source (Million Gallons per Day)

Year	Total Commercial Water Use	Public Supply (1)	Self-Supply (2)
1980	-	-	-
1985	6,940	5,710	1,230
1990	8,290	5,900	2,390
1995	9,580	6,690	2,890
2000 (3)	10,314	7,202	3,111
2005 (3)	10,171	7,102	3,068

Note(s): 1) Public supply water use: water withdrawn by public and private water suppliers that furnish water to at least 25 people or have a minimum of 15 connections. 2) Self-supply water use: Water withdrawn from a groundwater or surface-water source by a user rather than being obtained from a public supply. 3) USGS did not estimate commercial water use in this year. Estimates are based on available data and percentage breakdown of commercial use in the 1995 survey.

Source(s): U.S. Geological Survey, Estimated Use of Water in the U.S. in 1985, U.S. Geological Survey Circular 1004, 1988; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1990, U.S. Geological Survey Circular 1081, 1993; U.S. Geological Survey, Estimated Use of Water in the U.S. in 1995, U.S. Geological Survey Circular 1200, 1998; U.S. Geological Survey, Estimated Use of Water in the U.S. in 2000, U.S. Geological Survey Circular 1268, 2004; and U.S. Geological Survey, Estimated Use of Water in the U.S. in 2005, U.S. Geological Survey Circular 1344, 2009.

8.3.2 Average Water Use of Commercial and Institutional Establishments (Gallons per Establishment per Day)

	Average Daily Use	Variation In Use (1)	% Total CI Use	% of CI Customers	% Seasonal Use (2)
Hotels and Motels	7,113	5.41	5.8%	1.9%	23.1%
Laundries/Laundromats	3,290	8.85	4.0%	1.4%	13.4%
Car Washes	3,031	3.12	0.8%	0.4%	14.2%
Urban Irrigation	2,596	8.73	28.5%	30.2%	86.9%
Schools and Colleges	2,117	12.13	8.8%	4.8%	58.0%
Hospitals/Medical Offices	1,236	78.5	3.9%	4.2%	23.2%
Office Buildings	1,204	6.29	10.2%	11.7%	29.0%
Restaurants	906	7.69	8.8%	11.2%	16.1%
Food Stores	729	16.29	2.9%	5.2%	19.4%
Auto Shops (3)	687	7.96	2.0%	6.7%	27.2%
Membership Organizations (4)	629	6.42	2.0%	5.6%	46.2%
Total	**23,538**		**77.6%**	**83.3%**	

Note(s): Estimated from 24 months of water utility billing data in five Western locations: four locations in Southern California and one in Arizona. 1) Ratio of standard deviation of daily use to average of daily use. 2) Percent seasonal use is the difference between the average monthly use and the lowest monthly use over the average monthly use. 3) Includes auto repair shops, dealers, and service stations. 4) Includes religious organizations and other membership-based organizations.

Source(s): American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water, 2000.

8.3.3 Normalized Annual End Uses of Water in Select Restaurants in Western United States (1)

Fixture/End Use (2)	Range of Water Use (gal/SF)	Range of Water Use (gal/seat)	Range of Water Use (gal/meal/day)
Faucets	68.9 - 250	1225 - 4630	1.1 - 2.6
Dishwashing	54.4 - 183.3	970 - 3000	0.9 - 1.4
Toilets/Urinals	25.6 - 75	455 - 1230	0.4 - 0.5
Ice Making	7.8 - 44.6	140 - 1440	0.1 - 0.9
Total Indoor Use	163.3 - 563.3 (3)	2910 - 15350 (4)	2.7 - 16.2 (4)
Building Size (SF)	1200 - 9800	**Seats:** 73 - 253	**Meals:** 190 - 800

Logged average daily use (thousand gal)	Indoor peak instantaneous demand, gpm (5)
1.5 - 9.7	21.1 - 59.6

Benchmarking Values for Restaurants (6)	N	25th Percentile of Users
Gal./SF/year	90	130 - 331
Gal./meal	90	6 - 9
Gal./seat/day	90	20 - 31
Gal./employee/day	90	86 - 122

Note(s): Familiy-style dine-in establishments. Four restaurants in southern California, one in Phoenix, AZ. 1) Water use data for the buildings was collected over a few days. Estimates of annual use were created by accounting for seasonal use and other variables, billing data, and interviews with building managers. 2) Based on three restaurants. 3) Based on four restaurants. 4) Based on five restaurants. 5) gpm = gallons per minute. 6) The study derived efficiency benchmarks by analyzing measured data and audit data. The benchmark was set at the

Source(s): American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water, 2000.

8.3.4 Normalized Annual End Uses of Water in Select Supermarkets in Western United States (1)

Fixture/End Use	Range of Water Use (gal/SF)
Toilets/Urinals	190 - 320
Other/Misc. Indoor (2)	895 - 1,405
Cooling	2,190 - 3,390
Total	3,560 - 5,075
Building Size (SF)	3,8000 - 66,000

Logged average daily use (thousand gal)	Indoor peak instantaneous demand (gpm)
9.71 - 14.33	29.7 - 58.8

Benchmarking Values for Supermarkets (3)	N	25th Percentile of Users
Indoor Use with Cooling, gal./SF/year	38	52 - 64
Indoor Use with Cooling, gal./SF/daily transaction	38	9 - 16

Note(s): 1) Water use data for the buildings was collected over a few days. Estimates of annual use were created by accounting for seasonal use and other variables, billing data, and interviews with building managers. 2) Includes water for sinks, spraying vegetables, cleaning, etc. 3) The study derived efficiency benchmarks by analyzing measured data and audit data. The benchmark was set at the lower 25th percentile of

Source(s): American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water, 2000.

8.3.5 Normalized Annual End Uses of Water in Select Hotels in Western United States (Gallons per Room per Year) (1)

Fixture/End Use	Budget Hotels Range of Water Use (gal/room)	Luxury Hotel Range of Water Use (gal/room)
Bathtub	986 (2)	2,331
Faucets	2,196 - 2,683	6,297
Showers	10,203 - 13,724	32,453
Toilets	9,493 - 11,986	28,047
Leaks	439 - 8,007	5,351
Laundry	6047 - 12,027	74,480
Ice making	811 - 1,568 (3)	0
Other/misc. indoor	946 - 9,953	0
Total Indoor Use	37,703 - 50,696	82,770
Number of Rooms	140 - 209	297
Logged average daily use, kgal:	18.6 - 29.3	59.3
Peak instantaneous demand, gpm:	40.5 - 106.9	130.7

Benchmarking Values for Hotels	N	25th Percentile of Users
Indoor Use, gal./day/occupied room	98	60 - 115
Cooling Use, gal./year/occupied room	97	7,400 - 41,600

Note(s): Based on four budget hotels and one luxury hotel. Three budget hotels in Southern California, one in Phoenix, AZ. Luxury hotel in Los Angeles, CA. 1) Water use data for the buildings was collected over a few days. Estimates of annual use were created by accounting for seasonal use and other variables, billing data, and interviews with building managers. 2) Based on one hotel. 3) Based on three hotels. 5) The study derived efficiency benchmarks by analyzing measured data and audit data. The benchmark was set at the lower 25th percentile of

Source(s): American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water, 2000.

8.3.6 Normalized Annual End Uses of Water in Two California High Schools

Fixture/End Use	Range of Water Use (gal/room)	Range of Water Use (gal/person)
Toilet	2.9 - 3.2	206 - 271
Urinal	1.2 - 2.6	106 - 186
Faucet	1.0 - 2.3	87 - 165
Shower	0.5 - 0.7	44 - 47
Kitchen	0.7 - 1.0	58 - 58
Misc. uses (2)	0.9	68
Cooling	-	-
Leaks	1.6 - 3.6	112
Swimming Pool	0.4 - 0.9	31
Total Use	**11.1 - 12.3**	**883**

Average Building Size (SF)	Logged average daily use (thousand gal)	Indoor peak instantaneous demand (gpm)
222326	9.1 - 16.4	41 - 60

Benchmarking Values for Schools (3)	N	25th Percentile of Users
Indoor Use, Gal./sq. ft./year	142	8 - 16
Indoor Use, Gal./school day/student	141	3 - 15
Cooling Use, Gal./sq. ft./year	35	8 - 20

Note(s): 1) Water use data for the buildings was collected over a few days. Estimates of annual use were created by accounting for seasonal use and other variables, billing data, and interviews with building managers. 2) One high school. 3) The study derived efficiency benchmarks by analyzing measured data and audit data. The benchmark was set at the lower 25th percentile of users.

Source(s): American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water, 2000.

8.4.1 WaterSense List of Covered Products and Efficiency Specifications

Covered Product	Specification Effective Date	WaterSense Criteria		Federal Standard Level
Lavatory Faucets	October 2007	1.5 gpm	(1)	2.2 gpm
Toilets	January 2007	1.28 gpf	(2)	1.6 gpf
Urinals	October 2009	0.5 gpf		1.0 gpf
Shower Heads	March 2010	2.0 gpm		2.5 gpm
Irrigation Control Equipment	November 2011	Qualitative	(3)	–
Pre-Rinse Spray Valves	In Progress	1.25 gpm	(4)	1.6 gpm
Water Softeners	In Progress	–	(4)	–

WaterSense Landscape Irrigation Partners as of February 2012: 2001 (5)

Note(s): 1) GPM = gallons per minute. 2) GPF = gallons per flush. 3) Mulitiple criteria for irrigation includes requirements for percentage reduction in irrigation adequacy and irrigation excess, as well as conformance to supplemental capability requirements 4) Final criteria for these categories have not been set. These are criteria levels that WaterSense is considering. 5) WaterSense qualifies individuals as partners via private programs certified by WaterSense.

Source(s): EPA, High-Efficiency Lavatory Faucet Specification, October 2007; EPA, Tank-Type High-Efficiency Toilet Specification, January 2007; EPA, Showerheads Specification, March 2010; EPA, High-Efficiency Urinals Specification, October 2009; EPA, Irrigation Controllers Specification, January 2011; and EPA, Meet Our Partners List as of 2/8/2012, http://www.epa.gov/watersense/meet_our_partners.html.

8.4.2 Federal Water Consumption Intensity and Costs (Millions of Gallons)

Agency	Annual Consumption (million gallons)	Annual Cost (thousand $))	Facility Gross SF (thousands)	Gallons per Gross SF
DOD	116,752.0	358,806.6	1,952,056.2	59.8
VA	9,337.3	26,511.4	144,836.1	64.5
Justice	8,990.3	27,928.4	72,917.6	123.3
DOE	6,455.2	13,838.8	111,942.5	57.7
USPS	5,455.9	29,265.8	312,962.7	17.4
Interior	3,624.3	10,905.9	61,724.9	58.7
GSA	2,651.2	18,104.9	176,414.5	15.0
USDA	2,150.9	4,876.0	57,480.9	37.4
NASA	2,036.5	5,085.8	38,896.2	52.4
HHS	1,799.7	11,814.7	31,338.4	57.4
DHS	1,522.8	12,442.9	45,556.7	33.4
Labor	1,029.0	4,816.3	20,335.8	50.6
TVA	733.0	2,248.2	27,969.8	26.2
DOT	464.1	3,002.8	25,722.1	18.0
Treasury	431.1	1,795.5	12,049.6	35.8
Commerce	352.1	1,571.2	13,627.9	25.8
State	169.0	762.2	4,476.7	37.8
EPA	168.1	1,196.0	3,723.3	45.2
SSA	125.0	617.1	9,262.0	13.5
Archives	107.9	552.9	4,062.0	26.6
HUD	21.8	139.1	1,432.0	15.2
RRB	5.5	19.5	346.9	15.9
Total	**164,382.9**	**536,301.9**	**3,129,134.9**	**52.5**

Source(s): FEMP, Annual Report to Congress on Federal Government Energy Management and Conservation Programs FY 2007, Table 9, p. 26, Jan. 2010.

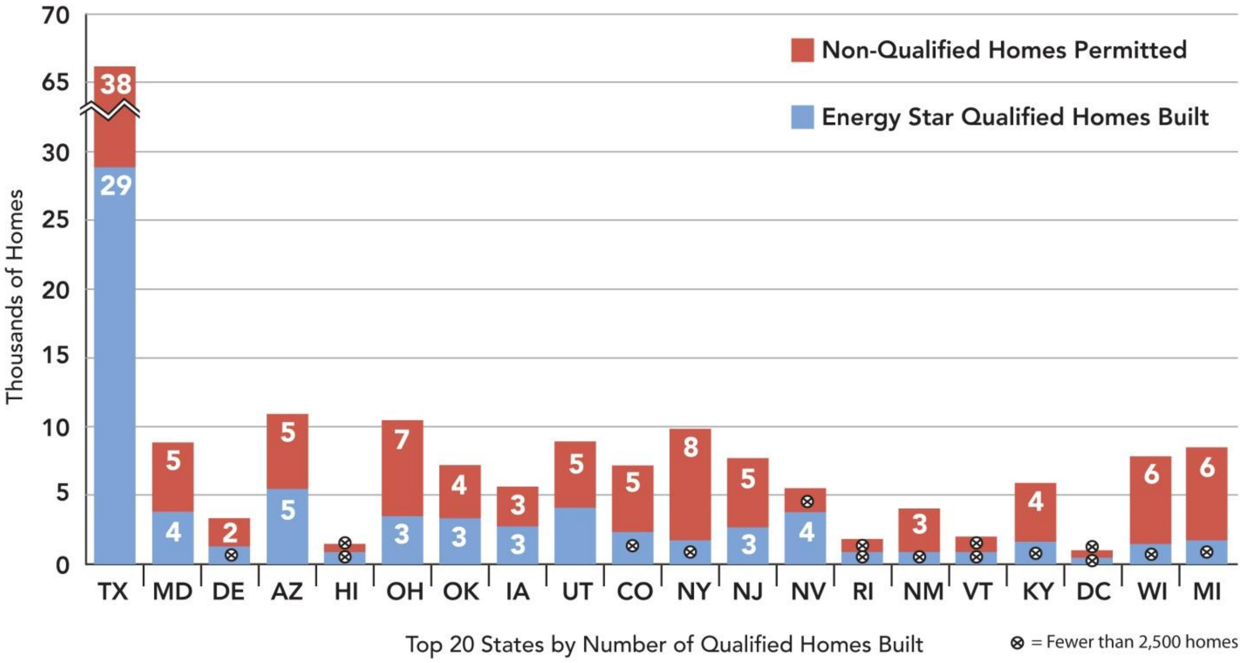
Chapter 9: Market Transformation

This chapter contains data on two market transformation programs that reach across the United States and to other countries: the ENERGY STAR program, jointly administered by the U.S. Environmental Protection Agency and the U.S. Department of Energy, and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system. It also includes data on three professional certifications and five case studies of high performance buildings. The main points from this chapter are summarized below:

- More than 100,000 new homes qualified for the ENERGY STAR label in 2010, almost a quarter of all the single-family homes permitted in the United States that year. (9.1.1)
- Approximately 35,000 homes were retrofitted in 2010 under Home Performance with ENERGY STAR, a 41% increase from 2009 and a 158% increase from 2008. (9.1.2)
- In the commercial sector, the ENERGY STAR label has been awarded to more than 22,000 buildings containing a total of 2.6 billion square feet of floorspace, which represents 3.7% of all commercial floorspace in the United States. (9.1.3), (3.2.2)
- As of February 2012, there were 10,207 LEED-certified projects in the United States, a 58% jump from the number of certified projects in December 2010. (9.2.6)

The number of ENERGY STAR qualified homes continued to increase in 2010, reaching 24% of the single-family home market. ENERGY STAR qualified homes represented more than half of new homes in Hawaii, Nevada, Iowa, and Arizona. (9.1.1)

ENERGY STAR QUALIFIED AND NON-QUALIFIED SINGLE-FAMILY HOMES BUILT/PERMITTED IN 2009

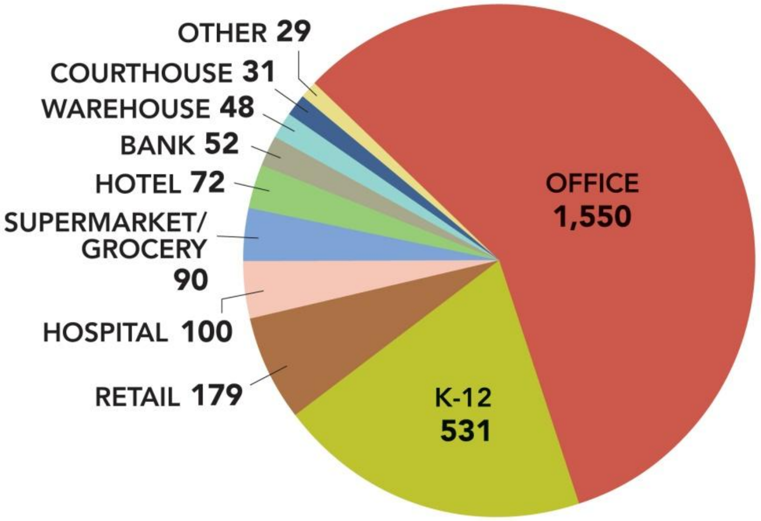


The ENERGY STAR program also helped improve the efficiency of existing homes through Home Performance with ENERGY STAR. Approximately 35,000 homes were retrofitted in 2010, bringing the total number of retrofits completed since program inception to more than 110,000. NYSERDA in New York and National Grid in Massachusetts sponsor the most successful programs in terms of number of homes retrofitted, each with more than 26,000 retrofits completed to date. (9.1.2)

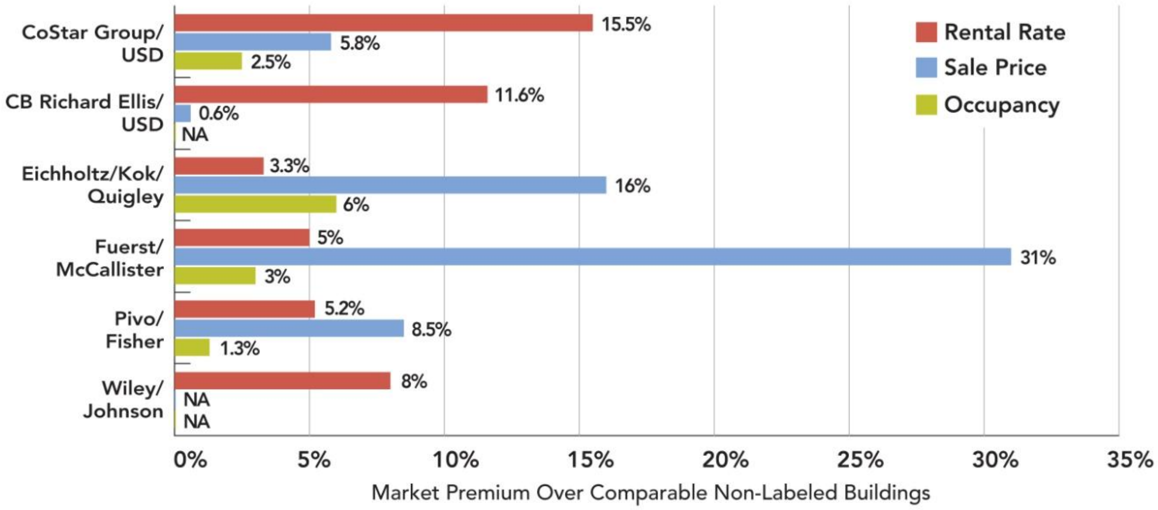
In the commercial sector, the number of ENERGY STAR buildings reached more than 22,000. Office buildings and K-12 schools account for the largest shares of qualified floorspace, with 58% and 20% of the total, respectively. (9.1.3), (3.2.2) Six studies conducted in 2008 and 2009 assessed the value of the ENERGY STAR label for commercial buildings in the United States. They found that labeled buildings fetched quantifiable rental rate, sale price, and occupancy premiums relative to comparable non-labeled buildings. (9.1.4)

ENERGY STAR QUALIFIED COMMERCIAL FLOORSPACE

Total = 2,043 million sq.ft.



MARKET PREMIUMS FOR ENERGY STAR-LABELED COMMERCIAL BUILDINGS



As of February 2012, 10,207 projects in the United States were LEED-certified, 56% of which had been certified under LEED for New Construction (LEED-NC). (9.2.1), (9.2.6) The LEED-NC rating has five levels: Certified, Bronze, Silver, Gold, and Platinum. About 34% of the LEED-NC projects are Silver, 40% are Gold, and 5% are Platinum. (9.2.2) Initially, LEED-NC was the only certification available, but the LEED system has expanded to encompass a greater variety of project types, including core and shell improvements, renovations to commercial interiors, renovation or rehabilitation of existing buildings, and improvements to operations and maintenance practices. (9.2.3), (9.2.4), (9.2.5) Half of certified projects in the United States are owned by for-profit organizations, 19% by state and local governments, 14% by nonprofits, and 16% by other types of organizations, including the Federal Government. (9.2.6) Professional certifications in building science and energy efficiency also rose dramatically in 2011. From December 2010 to February 2012, the number of Building Performance Institute (BPI) certifications in the U.S. increased 79%, reaching a total of 30,541 certifications. Energy Auditor Certifications offered by the Association of Energy Engineers rose by 20%.

9.1.1 2010 ENERGY STAR Qualified New Single-Family Homes, by Selected State

	ENERGY STAR Qualified New Homes	New Single-Family Housing Permits	Market Penetration
Hawaii	1,459	1,919	76%
Nevada	3,514	5,361	66%
Iowa	3,355	5,952	56%
Arizona	5,475	10,755	51%
Ohio	5,275	10,603	50%
Colorado	3,937	8,790	45%
Texas	29,074	66,973	43%
Maryland	3,544	8,489	42%
Oklahoma	2,824	6,866	41%
New Jersey	2,851	7,378	39%
Delaware	940	2,673	35%
Utah	2,308	6,883	34%
Kentucky	1,977	5,983	33%
Rhode Island	229	727	31%
New Mexico	1,152	4,006	29%
Vermont	279	980	28%
District of Columbia	42	177	24%
Wisconsin	1,792	7,687	23%
New York	2,320	9,959	23%
Michigan	1,790	7,755	23%
United States	**108,974**	**447,311**	**24%**

Note(s): The States listed are the top 20 by ENERGY STAR market penetration.

Source(s): Personal communication, Zachary Shadid, U.S. EPA, February 9, 2012; DOC/Census Bureau, Building Permits Survey, 2010, "New Privately Owned Housing Units Authorized".

9.1.2 Home Performance with ENERGY STAR, Completed Jobs

Rank	Program Sponsor	State	2007	2008	2009	2010	Total (2)
1	NY State Energy R&D Authority	NY	4,301	5,206	6,343	6122	26209
2	National Grid	MA	2,536	2,351	6,259	10019	26017
3	Austin Energy	TX	1,950	2,223	2,773	2633	12579
4	Wisconsin Energy Conservation Corp.	WI	840	1,012	1,944	2176	8717
5	New Jersey Board of Public Utilities	NJ	17	163	1,138	4365	5686
6	Energy Trust of Oregon	OR	560	1,040	767	777	3156
7	Sacramento Municipal Utility District (1)	CA	338	417	1,194	155	2104
8	Long Island Power Authority	NY	43	138	703	930	1885
9	Metropolitan Energy Center	MO	-	28	760	843	1631
10	Efficiency Vermont	VT	122	295	494	632	1594
	Total		**11,647**	**13,549**	**24,818**	**35,012**	**110,922**

Note(s): 1) Part of the California Building Performance Contractors Association. 2) Totals include homes completed since program's inception in 2001.

Source(s): Personal communication, Chandler Von Schrader, U.S. EPA, February 10, 2012.

9.1.3 ENERGY STAR Commercial and Institutional Buildings and Industrial Plants (1)

	Qualified Buildings	Floorspace Million SF
1999	87	33
2000	452	73
2001	298	73
2002	486	127
2003	592	150
2004	892	172
2005	1,026	216
2006	1,156	239
2007	1,797	458
2008	3,697	847
2009	4,722	1,035
2010	6,851	1,348
2011	6,049	1,215
Total (2)	**22,056**	**2,682**

Building Type	Floorspace Million SF	% of Total	Buildings
Office	1,550.2	57.8%	5,981
K-12 School	531.3	19.8%	5,453
Retail	179.1	6.7%	2,048
Hospital (General and Surgica	100.5	3.4%	144
Supermarket/Grocery	90.2	3.7%	1,878
Hotel	71.9	2.7%	448
Bank/Financial Institution	51.9	1.9%	257
Warehouse (Unrefrigerated)	47.9	1.2%	179
Courthouse	31.3	1.8%	121
Medical Office	12.0	0.4%	138
Residence Hall/Dormitory	7.9	0.3%	99
Senior Care Facility	3.3	0.1%	45
Data Center	2.5	0.1%	20
Warehouse (Refrigerated)	2.3	0.0%	6
House of Worship	0.7	0.0%	23
Industrial Plants	N/A	N/A	110
Total	**2,683**	**100%**	**16,949**

Note(s): 1) Data as of February 13, 2012. Additional buildings may qualify after applications are reviewed. 2) Totals are less than sum of individual years since some buildings have multiple years listed. Totals include buildings qualified in 2012.

Source(s): EPA, Database of ENERGY STAR Labeled Buildings and Plants, accessed February 13, 2012 (http://www.energystar.gov/index.cfm?fuseaction=labeled_buildings.locator).

9.1.4 Market Premiums for ENERGY STAR-Labeled Commercial Buildings in Six Studies (1)

	Rental Rate Premium	Sale Price Premium	Occupancy Premium (2)
CoStar Group/USD	16%	6%	3%
CB Richard Ellis/USD	12%	1%	N/A (3)
Eichholtz/Kok/Quigley	3%	16%	6%
Fuerst/McCallister	5%	31%	3%
Pivo/Fisher	5%	9%	1%
Wiley/Johnson	8%	N/A (3)	N/A (3)

Note(s): 1) All studies were conducted in 2008 and 2009 and compared ENERGY STAR-labeled buildings in the United States with similar non-labeled buildings. More information at http://www.imt.org/rating-value. 2) Lower vacancy rates. 3) Not reported.

Source(s): Institute for Market Tranformation, "Rating and Disclosing the Energy Performance of Buildings: A Market-Based Solution to Unlock Commercial Energy Efficiency Opportunities" (undated).

9.1.5 Specification Dates for ENERGY STAR-Labeled Consumer Electronics and Office Equipment

Labeled (Covered) Product	Inception - End Date	Dates of updated specification
Computers	1992	1995, 1999, 2000, 2007, 2009
Displays	1992	1995, 1998, 1999, 2005, 2006, 2009
Printers (1)	1993	1995, 2000, 2001, 2007, 2009
Fax Machines (1)	1995	1995, 2000, 2001, 2007, 2009
Copiers (1)	1995	1997, 1999, 2007, 2009
Scanners (1)	1997	2007, 2009
Multi-Function Devices (1)	1997	1999, 2007, 2009
Televisions	1998	2002, 2004, 2005, 2008, 2010, 2011
VCRs	1998-2008	2002, 2004, 2005
Consumer A/V Equipment	1999	2003, 2009, 2010, 2012
Bottled Water Coolers	2000	2004, 2010
Set-Top Boxes	2001-2005, 2009 (2)	2009, 2011
Cordless Phones	2002	2004, 2006, 2008
External Power Adapters	2005-2010	2008
Battery Charging Systems	2006	2011, 2012
Digital-to-Analog Converter Boxes	2007-2010	-

Note(s): 1) Treated together with other products as "Imaging Equipment." 2) Program relaunched in 2009.

Source(s): LBNL, Calendar Year 2007 Program Benefits for ENERGY STAR Labeled Products, October 2008; EPA, Revisions to Existing Standards, energystar.gov, October 2009; EPA, ENERGY STAR Program Specifications for each product listed, energystar.gov, February 2012.

9.1.6 Specification Dates for ENERGY STAR-Labeled HVAC and Residential Appliances

Heating and Cooling Equipment	Inception - End Date	Dates of updated specification
Central AC	1995	2002, 2006, 2009
Air-Source Heat Pumps	1995	2002, 2006, 2009
Oil Furnaces	1995	2006, 2008, 2012, 2013
Gas Furnaces	1995	2006, 2008, 2012, 2013
Programable Thermostats	1995-2009	-
Gas Boilers	1996	2002
Oil Boilers	1996	2002
Gas-Fired Heat Pumps	1995-2000	-
Geothermal Heat Pumps	2001	2009, 2011, 2012
Ventilating Fans	2001	2003, 2009, 2012
Ceiling Fans	2001	2003, 2006, 2009, 2012
Light Commercial HVAC	2002	2004, 2010, 2011
Residential Appliances		
Dishwashers	1996	2001, 2007, 2009, 2011, 2012, 2014
Room AC	1996	2000, 2003, 2005
Refrigerators	1996	2001, 2003, 2004, 2008
Clothes Washers	1997	2001, 2004, 2007, 2009, 2011
Dehumidifiers	2001	2006, 2008
Freezers	2004	2008
Air Cleaners	2004	-
Water Heaters	2009	2010
Other Products		
Insulation	1996-2002	-
Residential Light Fixtures	1997	2001, 2002, 2003, 2005, 2007, 2008, 2011
Windows, Doors, Skylights	1997	2003, 2005, 2010
Roof Products	1999	2005, 2007, 2009
Screw base CFLs	1999	2001, 2004, 2008
Decorative Light Strings	2008	-
Residential LED Lighting	2008	2009, 2011
LED Light Bulbs	2010	-

Source(s): LBNL, Calendar Year 2007 Program Benefits for ENERGY STAR Labeled Products, October 2008; EPA, Revisions to Existing Standards, energystar.gov, October 2009; EPA, ENERGY STAR Program Specifications for each product listed, energystar.gov, February 2012.

9.1.7 Specification Dates for ENERGY STAR-Labeled Commercial and Miscellaneous Products

Commercial Products	Inception - End Date	Dates of updated specification
Commercial Refrigerators and Freezers	2001	2009/2010
Hot Food Holding Cabinets	2003	2011
Commercial Steam Cookers	2003	-
Commercial Fryers	2003	2011
Cold Beverage Vending Machines	2004	2006, 2007
Solid State Lighting	2008	2009
Commercial Dishwashers	2007	-
Commercial Icemakers	2008	-
Commercial Griddles	2009	2011
Commercial Ovens	2009	-
Enterprise Servers	2009	-
Other Products		
Transformers	1995-2007	-
Exit Signs	1996-2008	1999, 2004
Traffic Signals	2000-2007	2003

Source(s): LBNL, Calendar Year 2007 Program Benefits for ENERGY STAR Labeled Products, October 2008; EPA, Revisions to Existing Standards, energystar.gov, October 2009; EPA, ENERGY STAR Program Specifications for each product listed, energystar.gov, February 2012.

9.1.8 Total Appliance Shipments (Millions) and ENERGY STAR Market Share

	Dishwashers		Room AC		Refrigerators		Clothes Washers		Dehumidifiers		Air Cleaners	
1997	5.1	6%	4.1	12%	9.0	25%	7.4	4%	-	N/A	-	N/A
1998	5.1	19%	4.4	13%	8.8	19%	7.0	6%	-	N/A	-	N/A
1999	5.7	12%	6.1	13%	9.1	24%	7.5	9%	-	N/A	-	N/A
2000	5.8	11%	6.5	19%	9.2	27%	7.5	9%	1.0	N/A	-	N/A
2001	5.6	20%	5.6	12%	9.3	17%	7.4	10%	0.8	19%	-	N/A
2002	6.2	36%	6.2	36%	9.7	20%	7.7	16%	0.8	39%	-	N/A
2003	6.4	57%	8.2	29%	10.0	26%	8.1	23%	1.3	74%	-	N/A
2004	7.1	78%	8.8	35%	10.9	33%	8.8	27%	1.7	76%	1.6	5%
2005	7.4	82%	8.0	39%	11.1	33%	9.2	36%	2.0	92%	1.6	13%
2006	7.3	92%	10.1	36%	11.1	31%	9.5	38%	1.5	82%	2.0	17%
2007	7.0	77%	9.5	50%	10.4	30%	8.8	42%	2.0	57%	2.5	14%
2008	6.0	67%	9.1	43%	9.3	31%	8.3	24%	1.6	75%	2.6	15%
2009	5.4	68%	5.8	36%	8.4	35%	7.9	48%	1.6	82%	2.6	19%
2010	5.6	100%	6.4	33%	9.4	50%	8.2	64%	1.6	99%	2.7	21%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): Appliance Magazine, "U.S. Appliance Industry Statistical Review: 2000 to YTD 2010" (July 2010) and "ENERGY STAR Qualified Appliance Retail Sales Data" (2007, 2008, and 2009) for dishwashers, room AC, refrigerators, and clothes washers; LBNL, Climate Change Action Plan spreadsheet (2009); EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2009 Summary (2010) for air cleaners and dehumidifiers; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary (2011); EPA, ENERGY STAR Unit Shipment Data Annual Summary Reports, 2003-2009.

9.1.9 Total Lighting Shipments (Millions) and ENERGY STAR Market Share

	Light Fixtures		Medium Screw-Base Lamps	
1998	221.5	1%	-	N/A
1999	213.2	1%	1,328	0%
2000	210.8	2%	1,026	1%
2001	196.7	2%	1,088	5%
2002	220.5	1%	1,076	4%
2003	225.0	3%	1,161	5%
2004	237.8	2%	1,389	6%
2005	247.4	3%	1,343	7%
2006	248.6	4%	1,302	11%
2007	217.9	6%	1,518	21%
2008	194.6	10%	1,230	22%
2009	174.7	6%	1,681	15%
2010	182.4	15%	1,658	20%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.1.10 Total Cooling Equipment Shipments (Thousands) and ENERGY STAR Market Share

	Central AC		Air-Source Heat Pumps		Geothermal Heat Pumps		Exhaust Fans		Ceiling Fans	
1995	3,300	15%	850	27%	32	N/A	-	N/A	-	N/A
1996	4,251	16%	1,125	30%	31	N/A	-	N/A	-	N/A
1997	4,024	18%	1,110	29%	37	N/A	-	N/A	-	N/A
1998	4,681	18%	1,236	31%	38	N/A	-	N/A	-	N/A
1999	5,011	20%	1,267	30%	42	N/A	-	N/A	-	N/A
2000	5,003	19%	1,310	29%	36	N/A	5,835	N/A	19,500	N/A
2001	4,839	22%	1,442	29%	36	40%	5,909	2%	17,680	18%
2002	5,263	14%	1,484	14%	37	29%	5,975	3%	19,500	8%
2003	5,181	17%	1,626	19%	36	37%	6,036	6%	18,500	17%
2004	5,515	19%	1,886	22%	44	58%	6,102	11%	19,700	14%
2005	6,471	19%	2,137	27%	48	68%	6,199	13%	19,800	18%
2006	4,951	21%	2,118	23%	64	79%	6,285	12%	20,800	15%
2007	4,500	23%	1,900	20%	86	100%	6,354	13%	19,830	14%
2008	3,968	19%	1,865	22%	130	58%	6,432	11%	19,972	13%
2009	3,612	17%	1,622	32%	125	59%	6,511	17%	20,896	7%
2010	3,519	27%	1,652	46%	128	47%	6,823	13%	12,348	15%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.1.11 Total Heating Equipment Shipments (Thousands) and ENERGY STAR Market Share

	Gas Furnaces		Gas Boilers		Oil Boilers		Oil Furnaces	
1995	2,592	22%	109	N/A	156	N/A	146	1%
1996	2,871	24%	198	4%	161	48%	152	1%
1997	2,779	27%	206	6%	160	55%	124	1%
1998	2,977	29%	185	8%	148	67%	128	1%
1999	3,126	31%	201	10%	149	74%	125	1%
2000	3,104	35%	224	15%	144	85%	121	3%
2001	3,063	39%	221	17%	149	89%	122	4%
2002	3,202	40%	214	21%	148	98%	117	6%
2003	3,266	42%	235	21%	167	54%	127	7%
2004	3,519	47%	237	41%	162	71%	130	7%
2005	3,512	37%	224	25%	146	57%	111	7%
2006	3,197	37%	196	38%	121	90%	100	6%
2007	2,782	37%	201	38%	123	80%	84	13%
2008	2,300	43%	192	57%	122	62%	59	12%
2009	2,190	50%	192	46%	123	62%	54	24%
2010	2,197	61%	192	52%	123	61%	56	36%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.1.12 Total Commercial Product Shipments (Thousands) and ENERGY STAR Market Share

	Exit Signs		Commercial Refrigeration		Hot Food Holding Cabinets		Comm. Steam Cookers		Cold Beverage Vending Machines		Bottled Water Coolers	
1996	1,847	10%	-	N/A	-	N/A	-	N/A	-	N/A	-	N/A
1997	2,170	13%	-	N/A	-	N/A	-	N/A	-	N/A	-	N/A
1998	2,493	20%	-	N/A	-	N/A	-	N/A	-	N/A	-	N/A
1999	2,816	27%	-	N/A	-	N/A	-	N/A	-	N/A	-	N/A
2000	3,140	34%	200	N/A	-	N/A	-	N/A	251	N/A	822	1%
2001	3,463	41%	220	14%	-	N/A	-	N/A	249	N/A	822	1%
2002	3,786	44%	226	12%	-	N/A	-	N/A	246	N/A	885	1%
2003	3,831	91%	232	17%	13	8%	35	10%	246	N/A	948	38%
2004	3,877	63%	238	30%	20	62%	35	11%	255	26%	1,012	56%
2005	3,924	50%	244	43%	31	34%	35	12%	246	28%	1,075	68%
2006	3,971	89%	248	49%	31	59%	24	14%	246	31%	1,138	44%
2007	4,019	0%	251	59%	31	64%	23	22%	246	26%	1,201	52%
2008	4,067	0%	292	66%	30	79%	23	23%	246	32%	1,264	41%
2009	-	N/A	292	53%	29	75%	21	28%	246	18%	1,328	43%
2010	-	N/A	317	72%	37	63%	14	35%	243	28%	1,454	43%

	Commercial Dishwashers		Ice Machines		Commercial Fryers	
2003	-	N/A	-	N/A	72	2%
2004	-	N/A	-	N/A	74	10%
2005	-	N/A	-	N/A	77	7%
2006	-	N/A	-	N/A	82	11%
2007	25	0%	-	N/A	85	7%
2008	28	83%	138	40%	90	7%
2009	37	78%	142	42%	91	12%
2010	38	74%	111	63%	84	19%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.1.13 Total Consumer Electronics Shipments (Thousands) and ENERGY STAR Market Share

	TV		Telephony		TV-DVD/VCR		Audio/Video	
1998	28,170	N/A	-	N/A	3,147	17%	13,314	N/A
1999	25,137	39%	-	N/A	4,148	71%	18,279	17%
2000	25,391	46%	40,942	N/A	4,964	76%	23,894	24%
2001	22,773	45%	48,793	N/A	4,630	77%	27,628	38%
2002	23,150	45%	49,686	52%	5,687	82%	29,493	53%
2003	25,574	47%	52,000	59%	4,373	78%	25,438	59%
2004	23,053	83%	54,333	34%	7,169	85%	24,799	29%
2005	26,350	39%	55,967	26%	6,698	55%	24,239	29%
2006	32,310	54%	50,317	29%	3,166	4%	29,732	12%
2007	31,680	53%	42,090	23%	6,683	12%	26,428	36%
2008	32,670	79%	35,127	50%	1,684	67%	32,919	35%
2009	42,562	95%	28,624	74%	-	N/A	-	N/A
2010	42,743	80%	28,656	68%	-	N/A	-	N/A

	External Power Supplies		Battery Charging System	
1998	-	N/A	-	N/A
1999	-	N/A	-	N/A
2000	-	N/A	-	N/A
2001	-	N/A	-	N/A
2002	77,783	N/A	39,357	N/A
2003	79,709	N/A	39,646	N/A
2004	268,717	N/A	40,042	N/A
2005	457,725	3%	40,443	N/A
2006	505,665	30%	40,847	N/A
2007	554,710	56%	41,255	16%
2008	565,704	47%	41,668	15%
2009	668,524	59%	42,085	27%
2010	(1)	N/A	42,674	34%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist or information not available. 1) The ENERGY STAR specification for external power supplies was sunset in 2010.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.1.14 Total Office Equipment Shipments (Millions) and ENERGY STAR Market Share

	Computers		Monitors		Printers		Fascimile		Copiers		Scanners		Multi-Function Devices	
1992	-	N.A.	-	N.A.	-	N.A.	-	N.A.	-	N.A.	-	N.A.	-	N.A.
1993	12.1	41%	12.0	19%	6.9	80%	-	N.A.	-	N.A.	-	N.A.	-	N.A.
1994	14.8	50%	14.6	50%	9.4	98%	-	N.A.	-	N.A.	-	N.A.	-	N.A.
1995	18.4	73%	18.2	93%	11.3	98%	1.3	14%	1.6	24%	-	N.A.	-	N.A.
1996	20.5	79%	20.3	95%	13.2	100%	2.1	57%	1.6	35%	-	N.A.	-	N.A.
1997	25.9	86%	24.6	95%	15.1	100%	3.4	74%	1.7	45%	4.2	30%	0.1	30%
1998	32.4	92%	30.2	95%	18.3	100%	5.6	91%	1.6	65%	5.4	30%	0.4	30%
1999	44.5	47%	33.9	48%	23.0	100%	6.5	99%	1.1	87%	4.9	40%	1.3	91%
2000	49.7	86%	33.4	95%	22.6	100%	7.0	99%	0.9	94%	4.4	50%	1.7	92%
2001	52.9	85%	35.9	95%	28.8	85%	7.2	99%	0.6	90%	3.9	50%	2.2	92%
2002	52.9	83%	36.7	95%	19.7	95%	6.0	99%	0.3	90%	3.4	60%	7.6	98%
2003	58.2	83%	35.1	95%	16.4	98%	4.5	99%	1.4	90%	2.9	70%	13.2	98%
2004	64.1	83%	36.6	95%	16.4	100%	4.2	99%	1.4	90%	2.4	75%	14.9	98%
2005	70.2	83%	38.2	65%	17.5	100%	3.8	99%	1.4	90%	1.9	80%	17.1	98%
2006	71.6	81%	42.0	78%	13.9	100%	3.1	99%	1.4	90%	1.6	85%	18.7	98%
2007	93.0	67%	42.8	92%	10.9	21%	3.9	2%	0.3	27%	1.0	43%	21.2	28%
2008	95.0	21%	32.8	84%	8.8	43%	3.8	4%	0.2	91%	0.6	87%	19.9	49%
2009	66.5	55%	29.4	90%	6.7	67%	3.7	7%	0.2	78%	0.4	97%	19.0	47%
2010	69.5	71%	28.2	43%	7.8	99%	3.7	7%	0.2	79%	0.7	99%	20.2	99%

Note(s): N/A = Not Applicable. ENERGY STAR specification did not exist.

Source(s): LBNL, Climate Change Action Plan spreadsheet, 2009; EPA, ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2010 Summary;

9.2.1 LEED for New Construction, by Selected States

	Certified	Bronze	Silver	Gold	Platinum	Total
California	118	0	216	329	49	712
Texas	65	0	131	112	14	322
Pennsylvania	67	0	110	94	6	278
Washington	40	0	101	121	8	270
Florida	67	0	112	120	10	309
Ilinois	53	0	92	94	15	254
Michigan	92	0	63	53	2	210
Virginia	51	0	99	79	9	238
Oregon	22	1	44	97	23	187
New York	50	0	80	85	23	238
All Other States	560	2	928	1,086	151	2,730
National Totals	**1,185**	**3**	**1,976**	**2,270**	**310**	**5,748**

Note(s): Totals include two buildings (one each in Pennsylvania and Massachusetts) whose certification level was not given, and two buildings whose

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012

9.2.2 LEED for New Construction, by Version

	v1.0	v2.0	v2.1	v2.2	v2009	Retail v2009	Total
Platinum	3	13	70	207	17	0	310
Gold	2	81	416	1,695	76	1	2,271
Silver	1	82	494	1,321	78	1	1,977
Bronze	3	0	0	0	0	0	3
Certified	1	105	429	588	62	0	1,185
Total	**10**	**283**	**1,409**	**3,811**	**233**	**2**	**5,748**

Note(s): Includes only buildings in the United States. Totals include two buildings whose certification level was not given (two at NC 2.0). Pilots are not

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.2.3 LEED for Core and Shell, by Version

	v2.0	v2009	Total
Platinum	34	1	35
Gold	326	5	331
Silver	224	10	234
Certified	61	6	67
Total	**645**	**22**	**667**

Note(s): Includes only buildings in the United States. Pilots are not included.

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.2.4 LEED for Commercial Interiors, by Version

	v2.0	v2009	Retail v2009	Total
Platinum	88	46	0	134
Gold	617	207	1	825
Silver	524	186	3	713
Certified	308	78	2	388
Total	**1,537**	**517**	**6**	**2,060**

Note(s): Includes only buildings in the United States. Pilots are not included.

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.2.5 LEED for Existing Buildings, by Version

	EB v2.0	EB O&M	EB O&M v2009
Platinum	20	22	22
Gold	78	316	195
Silver	92	241	156
Certified	109	103	132
Total	**299**	**683**	**505**

Note(s): Includes only buildings in the United States. Total for EB O&M includes one building whose certification level was not given. Pilots are not

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.2.6 LEED for Schools, by Version

	v2.0	v2009	Total
Platinum	14	1	15
Gold	103	8	111
Silver	78	5	83
Certified	39	3	42
Total	**234**	**17**	**251**

Note(s): Includes only buildings in the United States. Pilots are not included.

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.2.7 LEED Certified Projects, by Ownership Category and Certification Level

	Platinum	Gold	Silver	Bronze	Certified	Unknown	Total
For-Profit Organization	249	2,022	1,809	0	1,082	0	5,164
State or Local Government	88	819	679	2	366	1	1,955
Not-for-Profit Organization	134	586	431	0	286	0	1,437
Federal Government	18	210	237	1	83	0	549
Educational	5	29	22	0	15	0	71
Individual	22	130	94	0	56	0	302
Other	32	259	190	0	109	2	592
Multiple Owner Types	10	66	34	0	27	0	137
Total	**558**	**4,121**	**3,496**	**3**	**2,024**	**3**	**10,207**

Note(s): Includes only buildings in the United States. Pilots and homes are not included.

Source(s): United States Green Building Council, http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx, February 2012.

9.3.1 North American Technician Excellence Program (1)

Individuals Certified:	29,874
Number of Certificates:	36,090

Certifications	**Installation**	**Service (2)**
Air Conditioning	962	5,008
Air Distribution	243	1,481
Heat Pump (3)	864	14,516
Gas Furnace	1,655	9,127
Oil Furnace	43	736
Hydronics Gas	86	550
Hydronics Oil	14	216
Light Commercial Refrigeration	81	283
Commercial Refrigeration	32	129
Senior Technician		64

Census Region	**Percent of**
South	40%
Midwest	26%
West	19%
Northeast	14%
Canada	1%

Note(s): 1)Third party certification program for heating and cooling professionals to ensure knowledge of proper installation and servicing of HVAC/R equipment. 2) All service specialties include their installation counterparts for free. 3) Heat Pump specialties include their Air Conditioning counterparts for free.

Source(s): Personal Communication, Kathy Corr, North American Technical Excellence, February 16, 2012.

9.3.2 Building Performance Institute (BPI) Certifications, by State

State	Certifications (1)	Thousand Residents per Cert. (2)
Alabama	84	57
Alaska	153	5
Arizona	1,035	6
Arkansas	115	26
California	2,782	14
Colorado	914	6
Connecticut	1,041	3
Delaware	152	6
D.C.	84	7
Florida	234	81
Georgia	650	15
Hawaii	2	687
Idaho	71	22
Illinois	1,130	11
Indiana	576	11
Iowa	129	24
Kansas	125	23
Kentucky	369	12
Louisiana	136	34
Maine	321	4
Maryland	798	7
Massachusetts	893	7
Michigan	891	11
Minnesota	333	16
Mississippi	20	149
Missouri	618	10
Montana	32	31
Nebraska	84	22
Nevada	296	9
New Hampshire	294	4
New Jersey	1,982	4
New Mexico	116	18
New York	5,408	4
North Carolina	1,379	7
North Dakota	1	684
Ohio	756	15
Oklahoma	127	30
Oregon	863	4
Pennsylvania	1,548	8
Rhode Island	164	6
South Carolina	409	11
South Dakota	18	46
Tennessee	218	29
Texas	881	29
Utah	113	25
Vermont	317	2
Virginia	636	13
Washington	685	10
West Virginia	283	7
Wisconsin	208	27
Wyoming	67	8
United States	30,541	10
Outside U.S.	28	N/A
Total	30,569	N/A

Note(s): 1) Counts total active certifications in each state as of February 1, 2012. An individual may hold multiple certifications. 2) Based on 2011 Census population estimates as of July 1, 2011.

Source(s): Personal Communication, Leslie McDowell, Building Performance Institute, February 2, 2012; U.S. Census Bureau Population Estimates: State Totals: Vintage 2011, Table 1.

9.3.3 Association of Energy Engineers Energy Auditor Certifications, by State

State	Certified Energy Auditors (1)	Thousand Residents per Auditor (2)
Alabama	78	62
Alaska	50	14
Arizona	31	209
Arkansas	3	979
California	110	343
Colorado	35	146
Connecticut	33	109
Delaware	3	302
D.C.	12	51
Florida	100	191
Georgia	56	175
Hawaii	7	196
Idaho	2	792
Illinois	41	314
Indiana	37	176
Iowa	10	306
Kansas	11	261
Kentucky	15	291
Louisiana	11	416
Maine	17	78
Maryland	38	153
Massachusetts	75	88
Michigan	47	210
Minnesota	37	144
Mississippi	8	372
Missouri	49	123
Montana	1	998
Nebraska	5	369
Nevada	8	340
New Hampshire	14	94
New Jersey	73	121
New Mexico	13	160
New York	117	166
North Carolina	37	261
North Dakota	4	171
Ohio	65	178
Oklahoma	14	271
Oregon	13	298
Pennsylvania	82	155
Rhode Island	7	150
South Carolina	16	292
South Dakota	1	824
Tennessee	20	320
Texas	122	210
Utah	8	352
Vermont	4	157
Virginia	61	133
Washington	15	455
West Virginia	2	928
Wisconsin	19	301
Wyoming	0	N/A
Total U.S.	1,637	189
Outside U.S.	116	N/A
Grand Total	1,753	N/A

Note(s): 1) Counts total active certifications in each state as of February 3, 2012. 2) Based on 2011 Census population estimates as of July 1, 2011.

Source(s): Personal Communication, Jennifer Vendola, Association of Energy Engineers, February 3, 2012; U.S. Census Bureau Population Estimates: State Totals: Vintage 2011, Table 1.

9.4.1 Case Study, The Adam Joseph Lewis Center for Environmental Studies, Oberlin College, Oberlin, Ohio (Education)

Building Design

Floor Area:	13,600 SF	Floors:	2	Footprint:	140 ft. x 45 ft. with attached 100-seat auditorium

3 Classrooms (1)	1 Conference Room	1 Adminstration Office
Auditorium, 100 seats	6 Small Offices	Atrium
Wastewater Treatment Facility		

Shell

Windows Material: Green Tint Triple Pane Argon Fill Insulating Glass
Grey Tint Double Pane Argon Fill Insulating Glass

	Fenestration(square feet)		
	Window	Wall (2)	window/wall
North	1,675	4,372	38%
South	2,553	4,498	58%
East	1,084	2,371	46%
West	350	2,512	14%
Overall	6,063	14,153	43%

Atrium, Triple Pane (3)		Building, Double Pane	
U-Factor	0.34	U-Factor	0.46
SHGC	0.26	SHGC	0.46

Wall/Roof

	Main Material	R-Value
Wall :	Face Brink	19
Roof:	Steel/Stone Ballast	30

HVAC

		COP(4)
Offices/Classrooms:	Individual GSHPs (5)	3.9-4.6
	1 Large GSHP for ventilation	3.8
Atrium:	Radiant Flooring Hydronic Heating System	
Auditorium:	1 Standard Range Water Heat Pump	4.2

Lighting Power Densities (W/SF)

Offices:	0.88	Corridors/Others:	0.45	Total Building:	0.79
Classroom/Lecture Halls:	1.18	Atrium:	0.93		

Energy/Power

PV System:	60 kW grid-tie roof system
Net Annual Energy Usage (thousand Btu/SF*year):	16.4

Note(s): 1) Two classrooms seat 36 and one seats 18. 2) Wall total area includes window area. 3) Atrium has only south, north, and east facing windows. 4) Coefficient of performance ranges due to various sizes; GSHPs have the greatest COP 5) GSHP is Ground water Source Heat

Source(s): NREL, Energy Performance Evaluation of an Educational Facility: The Adam Joseph Lewis Center for Environmental Studies, Oberlin College, Oberlin, Ohio, November 2004, Table 4.1 p. 10 Table 4.2 p.12 and Table 6.5 p. 94; NREL, Lessons Learned from Case Studies of Six High-Performance Buildings, June 2006, p. 5 Table A-2 p. 130

9.4.2 Case Study, The Cambria Department of Environmental Protection Office Building, Ebensburg, Pennsylvania (Office)

Building Design

Floor Area:	34,500 SF	Floors:	2

- Open office space (1)
- Break room
- File storage area
- Storage areas
- Two small labratories
- Two mechanical rooms
- Conference rooms
- Telecom room

Shell

Windows

Material: Triple Pane, low-e with Aluminum Frames and Wood Frames

Triple Pane Aluminum Frames		Triple Pane Wood Frames	
U-Factor	0.24	U-Factor	0.26

Wall/Roof

	Primary Material	R-Value
Wall :	Insulating Concrete Forms	27.0
Roof:	Decking and Insulation	33.0

HVAC

	Total Capacities(thousand Btu/hr)
12 Ground Source Heat Pumps	644 (2)
12 Auxiliary Electric Resistance Heaters	382 (3)

Lighting Power Densities(W/SF)

Open Office Area:	0.75
Office Area Task Lighting(4):	0.5

Energy/Power

PV System:	18.2 kW grid-tie system (5)
Net Annual Energy Usage (thousand Btu/SF*year):	36.0

Note(s): 1) Office space is for 100 people. This accounts for approximately 20,000 SF of the total building floorspace. 2) Cooling capacity 3) Auxiliary heating capacity. 4) Task lighting is in addition to the open office area LPD and is only in select cubicals and offices. 5) Includes 17.2 kW of roof PV array and two 0.5 KW ground level single axis tracking PV arrays.

Source(s): NREL, Analysis of the Design and Energy Performance of the Pennsylvania Department of Enverionmental Proctection Cambria Office Building, March 2005, p. ; NREL, Lessons Learned from Case Studies of Six High-Performance Buildings, June 2006, p. 5 Table A-2 p. 130.

9.4.3 Case Study, The Visitor Center at Zion National Park, Utah (Service/Retail/Office)

Building Design

Vistors Center (1):	8,800 SF	Comfort Station (2):	2,756 SF	Fee Station:	170 SF

Shell

Windows

	Type	U-Factor	SHGC (3)
South/East Glass	Double Pane Insulating Glass, Low-e, Aluminum Frames, Thermally Broken	0.44	0.44
North/West Glass	Double Pane Insulating Glass, Heat Mirror, Aluminum Frames, Thermally Broken	0.37	0.37

Window/Wall Ratio: 28%

Wall/Roof

	Materials	Effective R-Value
Trombe Walls:	Low-iron Patterned Trombe Wall, CMU (4)	2.3
Vistor Center Walls:	Wood Siding, Rigid Insulation Board, Gypsum	16.5
Comfort Station Walls:	Wood Siding, Rigid Insulation Board, CMU (4)	6.6
Roof:	Wood Shingles; Sheathing; Insulated Roof Panels	30.9

HVAC

Heating	Cooling
Trombe Walls	Operable Windows
Electric Radiant Ceiling Panels	3 Cooling Towers

Lighting Power Densities(W/SF)

Main Area:	(5)
Offices:	1.0
Bookstore:	0.9

Energy/Power:

PV System:	7.2 kW grid-tie system
Net Annual Energy Usage (thousand Btu/SF*year):	27.0

Note(s): 1) Includes office, bookstore, and service areas. 2) Restroom complex. 3) Solar heat gain coefficient. 4) Concrete masonry unit. 5) The main vistors center area is handled almost entirely with daylighting. Auxiliary fluorescent lighting is used only occasionally to supplement.

Source(s): NREL, Evaluation of the Low-Energy Design and Energy Performance of the Zion National Park Visitors Center, Feb. 2005, p. 23-37; NREL, Lessons Learned from Case Studies of Six High-Performance Buildings, June 2006, p. 5 Table A-2 p. 130.

9.4.4 Case Study, The Philip Merrill Environmental Center, Annapolis, Maryland (Office)

Building Design

Floor Area:	31,000 SF	Floors:	2	Footprint:	220 ft. x (1)

2 Floors of open office space
Attached pavilion containing: Meeting space Kitchen Staff dining Conference room

Shell

Windows

		U-Factor	SHGC (2)
Type:	Double Pane, Low-e, Argon Filled Insulating Glass	0.244	0.41

Wall/Roof

	Material	Effective R-Value
Interior Wall	plywood, gypsum, SIP foam, and sheathing	28.0
Exterior Wall	gypsum and insulated metal framing	9.3
Roof	plywood, gypsum, SIP foam, and sheathing	38.0

HVAC

18 ground source heat pumps
fin and tube radiators connected to a propane boiler
1 air condtioning unit

Lighting Power Densities (W/SF)

First Floor:	1.2
Second Floor:	1.6
Conference Room:	1.4

Energy/Power

PV System:	4.2 kW thin-film system
Net Annual Energy Usage (thousand Btu/SF*year):	39.9

Note(s): 1) Width varies from about 74 ft. to 59 ft. along different sections of the length. 2) Solar heat gain coefficient.

Source(s): NREL, Analysis of the Energy Performance of the Chesapeake Bay Foundation's Philip Merrill Environmental Center, April 2005, p. 6-24; NREL, Lessons Learned from Case Studies of Six High-Performance Buildings, June 2006, p. 5 Table A-2 p. 130.

9.4.5 Case Study, The Thermal Test Facility, National Renewable Energy Laboratory, Golden, Colorado (Office/Laboratory)

Building Design

Floor Area: 10,000 SF
Floors(1): 2
Aspect Ratio: 1.75

Offices
Laboratories
Conference Room
Mechanical Level

Shell

Windows

	Material	U-factor	SHGC(2)
Viewing Windows:	Double Pane, Grey Tint, Low-e	0.42	0.44
Clerestory Windows:	Double Pane, Clear, Low-e	0.45	0.65

	Window Area(SF)
North	38
South(3)	1,134
East	56
West	56

Wall/Roof

	Material	Effective R-Value
North Wall	Concrete Slab/Rigid Polystyrene	5.0
South/East/West	Steel Studs/Batt Insulation/Concrete	23.0
Roof:	Built-up/Polyisocianurate Covering/Steel Supports	23.0

HVAC

VAV air handling unit
Hot water supply paralell VAV boxes
Direct and Indirect evaporative cooling system
Single zone roof top unit(4)
Hot Water Coil(4)

Lighting Power Densities(W/SF)

Interior Overhead: 0.73
Exterior: 0.05
Emergency: 0.02
Building: 0.80

Energy/Power

Net Annual Energy Usage (kBtu/SF*year): 23.02

Note(s): 1) That second floor is actually and mechanical mezzaine level. 2) Solar heat gain coefficient 3) Includes 492 SF of viewing windows and 642 SF of clerestory windows. 4) Only used to handle the conference room.

Source(s): NREL, Evaluation of the Energy Performance and Design Process of the Thermal Test Facility at the National Renewable Energy Laboratory, February 2005, p. 29-54; NREL, Lessons Learned from Case Studies of Six High-Performance Buildings, June 2006, p. 5 Table A-2 p. 130.

9.4.6 Case Study, The Solaire, New York, New York (Apartments/Multi-Family)

Building Design

Floor Area:	357,000 SF	Units:	293	Maximum Occupancy:	700
Floors:	27	Site Size:	0.38 Acres	Typical Occupancy(1):	578

Black-Water Treatment Facility (2)

Shell

Windows

Material: Double Glazed, Low-e, Thermal Breaks with Insulated Spacers

	Operable Windows	Fixed Windows
Visual Transminttance	0.68	0.68
Solar Heat Gain Coefficient	0.35	0.35
U-Factor	0.47	0.41

Wall/Roof

	Material	R-Value
Exterior Walls:	Insulated brick and concrete block	8.4
Roof:	Roof top garden(green roof)	22.7

HVAC

Two direct-fired natural gas absorption chillers
4-Pipe fan-coil units in individual aparments

Power/Energy(3)

PV System(4): 1,300 SF (76 custom panels) of west facing PV rated for 11 kW . These panels are integrated into the building facade.
151 SF PV located in the entrance canopy. Rated for 662 W.
286 standard PV modules mounted on the south and west walls. Rated for 21 kW.

Unit Average Electricity Consumption(5): 15,681 kBtu/year
Building Natural Gas Consumption(6): 104.1 kBtu/SF*year

Predicted End-Use Consumption(kBtu/SF*year)

Heating	60.8	Plug Loads and Equipment	6.7
Cooling	20.7	Domestic Hot Water	7.9
Lighting	7.4	Cooking, Vertical Transportation, and Other	6.8
Fans/Pumps	11.4	**Total**	**121.7**

Note(s): 1) 84 hours per person weekly, 89 visitors weekly, 8 hours per visitor weekly. 2)30,000 gallon storage tank. Water is used for toilets and cooling tower. 3) Appliances in units are ENERGY STAR qualified. (4) PV system designed to handle 5% of building peak non-residential electrical load (i.e. corridor lighting). 5) Includes only electric that was submetered to each apartment. 6) 2007 building consumption.

Source(s): ASHRAE, High Peformance Buildings, NYC's Living Lesson, p. 56-65, Summer 2008; USGBC, LEED Case Studies, The Solaire, http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=273.

Thermal Conversion Factors

Fuel	Units	Approximate Heat Content
Coal		
Production	million Btu per short ton	20.213
Consumption	million Btu per short ton	19.989
Coke Plants	million Btu per short ton	26.280
Industrial	million Btu per short ton	22.360
Residential and Commercial	million Btu per short ton	21.359
Electric Power Sector	million Btu per short ton	19.726
Imports	million Btu per short ton	25.116
Exports	million Btu per short ton	25.393
Coal Coke	million Btu per short ton	24.800
Crude Oil		
Production	million Btu per barrel	5.800
Imports	million Btu per barrel	5.990
Petroleum Products		
Consumption	million Btu per barrel	5.301
Motor Gasoline	million Btu per barrel	5.128
Jet Fuel	million Btu per barrel	5.670
Distillate Fuel Oil	million Btu per barrel	5.775
Diesel Fuel	million Btu per barrel	5.766
Residual Fuel Oil	million Btu per barrel	6.287
Liquefied Petroleum Gases	million Btu per barrel	3.600
Kerosene	million Btu per barrel	5.670
Petrochemical Feedstocks	million Btu per barrel	5.565
Unfinished Oils	million Btu per barrel	6.118
Imports	million Btu per barrel	5.542
Exports	million Btu per barrel	5.840
Ethanol	million Btu per barrel	3.539
Biodiesel	million Btu per barrel	5.376
Natural Gas Plant Liquids		
Production	million Btu per barrel	3,948
Natural Gas		
Production, Dry	Btu per cubic foot	1,028
Consumption	Btu per cubic foot	1,028
End-Use Sectors	Btu per cubic foot	1,029
Electric Power Sector	Btu per cubic foot	1,027
Imports	Btu per cubic foot	1,025
Exports	Btu per cubic foot	1,009
Electricity Consumption	Btu per kilowatt hour	3,412

Note(s): Conversion factors vary from year to year.

Source(s): DOE, EIA, Annual Energy Outlook 2010, Apr. 2008, Table G1, p. 221.

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