CITY OF PALM DESERT

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March 23, 2012

Alfred M. Pollard, General Counsel
Attention: Comments/RIN 2590-AA53
Federal Housing Finance Agency
Eighth Floor
400 Seventh Street SW
Washington, DC 20024

Re: RIN 2590-AA53 Mortgage Assets Affected by PACE Programs

Dear Mr. Pollard:

Located in the State of California, the City of Palm Desert is the first jurisdiction to adopt a Property Assessed Clean Energy (PACE) program pursuant to California's PACE legislation, enacted through Assembly Bill 811 on July 21, 2008 as an amendment to assessment law that has been in existence since 1911. The City believes that senior lien PACE programs can be implemented in a manner that would not jeopardize the safety or soundness of mortgage loans on the properties participating in PACE programs.

The City of Palm Desert's Energy Independence Program helps its residents (i) to reduce their utility bills by reducing spikes in energy bills during peak months (sometimes completely offsetting a property's power consumption with on-site generation), (ii) to pay for the energy improvement with the energy savings generated by the improvement, and (iii) to achieve the public benefits of reduction of carbon emissions, helping to alleviate global warming, and energy conservation. PACE promotes clean energy jobs and American independence from the helplessness of high bills; conventional, carbon-based generation and fuels; utilizing scarce resources that must be saved for future generations; international tensions over energy supplies; and climate changes due to individual actions.

We believe that the FHFA, in promulgating a rule and policy regarding PACE assessments, should modify the restrictions and conditions set forth in the July 6, 2010 Statement and the February 28, 2011 Directive to stipulate that Fannie Mae, Freddie Mac, and any other mortgage lenders regulated by FHFA be allowed to buy residential mortgages with first lien PACE assessments that are originated by programs that conform to underwriting standards and program guidelines such as those currently proposed in H.R. 2599 (The PACE Assessment Protection Act) to protect the interest of local governments, homeowners, mortgage lenders, and government sponsored enterprises.

The following discussion provides comments to specific questions posited in the notice.

Question 1: Are conditions and restrictions relating to FHFA-regulated entities' dealings in mortgages on properties participating in PACE programs necessary? If so, what specific conditions and/or restrictions may be appropriate?

Conditions and restrictions relating to FHFA-regulated entities' dealing in mortgages on properties participating in PACE programs are not necessary, because local governments such as Palm Desert are motivated to structure their PACE programs in manner that promotes financial responsibility, consumer protection, and improves a property owner's paying ability.

However, we believe that consensus on national underwriting standards and program guidelines that promote priorities such as financial responsibility, consumer protection, and improved property owners' paying ability, would benefit all governments implementing a PACE program, homeowners, mortgage lenders, and government-sponsored enterprises regulated by FHFA, such as Fannie Mae and Freddie Mac.

One important underwriting standard we believe should be included in a national set of underwriting standards is an expected savings-to-investment ratio greater than one. Calculated as estimated savings on the borrower's cash flow due to the energy improvement, divided by the amount financed through the PACE assessment, a projected savings-to-investment ratio of greater than one increases the projected income of the borrower and places a mortgage lender in a more secure position than without the PACE participation.

FHFA and its regulated entities rely heavily on a borrower's stated income in determining whether or not to make a mortgage loan to that borrower, but there is no guarantee that such level of income will continue over the term of a mortgage. In some respects, a projected savings-to-investment ratio for a PACE improvement, while not constituting a guarantee of results, may be more predictable than a borrower's continued level of income over the term of a mortgage. Given the basic tenet of "at will" labor in the United States, an energy improvement affixed to a property may be more likely to remain in place and to provide continued benefit to the property than the borrower may be able to keep his or her job. Further, energy prices have a strong upward trend, which correlate to increasing utility bills over time (see our comments to the fifth bullet point under Question 4, regarding energy prices). Therefore, the borrower's annual energy cost savings would correspondingly increase over time, which translate to greater revenues available over time for the borrower to pay a mortgage loan.

In California, payment of PACE assessments may not be accelerated by the local government if there is a delinquency or default in the payment of the assessment, similar to treatment of other property taxes in California. We believe non-acceleration of PACE assessments is another important condition for the protection of homeowners, mortgage lenders, and government-sponsored enterprises. Non-acceleration is an important mortgage holder protection because liability for the assessment in foreclosure is limited to any amount in arrears at the time; the total outstanding assessed amount is not due in full, therefore greatly mitigating the effect of the "lien-

priming" feature of the PACE assessment upon mortgage lenders and subsequent investors in mortgage interests.

In our view, it is not appropriate to prohibit FHFA-regulated entities from dealing in mortgages on properties with PACE assessments secured by a lien having priority over mortgages. Instead, it is more appropriate for the improvement financed by the PACE assessment to have a projected savings-to-investment ratio greater than one and for the PACE program to include non-acceleration in the event of default or delinquency. Because the PACE improvements are of a nature that they are fixtures to the property, the value of which are greatly diminished if removed from the property, it is entirely appropriate that the PACE assessment also "runs with the land," surviving a sale of the property (unless voluntarily prepaid in connection with the sale) or foreclosure on the property in the event of foreclosure by a junior lienholder. The energy improvement remains part of the property and will benefit the incoming property owner. Accordingly, the new property owner assumes the related responsibility for the tax assessment associated with the energy improvement.

We believe that the term of the PACE assessment should not exceed the reasonably expected useful life of the financed energy improvements, in order to provide a further matching of the benefit of the improvement with the payment obligation on the PACE assessment.

On May 7, 2010, the United States Department of Energy issued its best practice guidelines and underwriting standards for PACE programs (the "DOE Guidelines"). Although Palm Desert's Energy Independence Program predates the DOE Guidelines, its underwriting standards and program requirements are substantially similar to, and in some instances more stringent than, the DOE Guidelines. Moreover, a bill, H.R. 2599, has been introduced in Congress with bipartisan sponsorship to implement national underwriting standards and program guidelines that include the recommendations of the U.S. Department of Energy, as well as additional requirements, such as a minimum 15% equity requirement in the property in order to participate, as well as a requirement for the property owner to allow the mortgage holder to escrow amounts of the PACE assessment for payment to the local government, if required by the mortgage holder. The DOE Guidelines and H.R. 2599 both include the conditions we have recommended specifically in the paragraphs above.

We also believe that the DOE Guidelines and H.R. 2599 include underwriting standards and program guidelines (in addition to those specifically discussed in the preceding paragraphs) that are appropriate to protect the interest of local governments, homeowners, mortgage lenders, and government sponsored enterprises alike. While the FHFA's current position sacrifices the interests of local governments and homeowners in favor of interests of mortgage lenders and government sponsored enterprises, the DOE Guidelines and H.R. 2599 protect mortgage lenders and government sponsored enterprises without sacrificing the interests of local governments and homeowners. We refer to the DOE Guidelines and H.R. 2599, attached to this letter and incorporated herein by reference, for a description of additional appropriate conditions and restrictions relating to FHFA-regulated entities' dealings in mortgages on properties participating in PACE programs.

Additionally, FHFA's July 6, 2010 Statement and February 28, 2011 Directive fly in the face of critical national and local public security and health and safety concerns, relating to energy independence and reduction of greenhouse gases. On December 15, 2009, the United States Environmental Protection Agency published findings in the *Federal Register* and set forth scientific documentation of how elevated concentrations of greenhouse gases and associated climate change endanger public health, increase mortality rates due to increases in average temperatures which increase the likelihood of heat waves, increase energy production needs, and threaten existing U.S. energy infrastructure. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clear Air Act, 74 Fed. Reg. 66,496 (2009).

FHFA's unwillingness to cooperate with other federal agencies and state and local public agencies to approve national underwriting standards and program guidelines that protect the interests of all concerned (local governments, homeowners, mortgage lenders, and government sponsored enterprises) is simply unthinkable. In our great nation of scientists, researchers, highly skilled professionals, and unparalleled financial capital markets, it is irrational and capricious for FHFA to continue to maintain that there is no set of underwriting standards and program guidelines for a first-lien PACE program that could protect the interests of local governments, homeowners, mortgage lenders, and government sponsored enterprises alike.

National underwriting standards and program guidelines can be crafted to protect the interests of those affected by first-lien PACE assessments, whether they be local governments, homeowners, mortgage lenders, or government sponsored enterprises. We recommend that any conditions and requirements adopted by FHFA relating to its regulated entities' dealings in mortgages on properties participating in PACE programs be adopted in a form substantially similar to DOE Guidelines and H.R. 2599.

Question 2: How does the lien-priming feature of first-lien PACE obligations affect the financial risks borne by holders of mortgages affected by PACE obligations or investors in mortgage-backed securities based on such mortgages? To the extent that the lien-priming feature of first-lien PACE obligations increases any financial risk borne by holders of mortgages affected by PACE obligations or investors in mortgage-backed securities based on such mortgages, how and at what cost could such parties insulate themselves from such increased risk?

The lien-priming feature of first-lien PACE obligations does not adversely affect the financial risks borne by holders of mortgages affected by PACE obligations or investors in mortgage-backed securities if appropriate underwriting standards and program design are implemented. Indeed, given proper PACE program design, the financial risks borne by such mortgage holders may actually be decreased.

Specifically, we understand that the borrower's debt-to-income ratio and the property's loan-to-value ratio are among the key criteria and indicators of financial risk utilized by mortgage lenders at the time a mortgage loan is issued.

When the savings-to-investment ratio is greater than one and the term of the PACE assessment does not exceed the reasonably expected useful life of the financed energy improvements, the borrower's debt obligations decrease (i.e., the borrower's energy bills go down), and the borrower's income increases by the amount of energy savings realized. At the very least, when the savings-to-investment ratio is equal to one, the cost of the financed improvements is offset equally by the energy savings, and therefore the mortgage lender is in the same position as before the PACE obligation. When the savings-to-investment ratio is greater than one, the mortgage lender is placed in a better position than before the PACE obligation.

The significance of the loan-to-value ratio as an indicator of financial risk is primarily in the context of a foreclosure. If all of the secured debt on a property may be accelerated and the entire amounts due payable in the event of a default or delinquency, to the extent that the debt on the property exceeds the property's value, the subordinate secured lender is at risk.

However, several features for PACE programs can offset this risk. First, if payment of PACE assessments may not be accelerated by the local government in the event of delinquency or default in the payment of the assessment, liability for the assessment in foreclosure is limited to any amount in arrears at the time, which is a fraction of the total outstanding assessed amount. In other words, mandatory non-acceleration of PACE obligations preserves for the mortgage lender most of the value of the property and means that the practical effect of the lien-priming is relatively small.

Further, while FHFA focuses on the increase of the "loan" component of the loan-to-value ratio occasioned by the addition of the PACE obligation, we note that the "value" component also is increased by the value of the PACE-financed energy improvement. Whether the increased value is determined by cost basis or by appraisal, the "value" side of the equation also increases with the addition of the PACE-financed improvement, therefore offsetting the increase in the "loan" component of the loan-to-value ratio.

Studies have shown that energy efficiency and renewable energy measures increase a home's value. For instance, a 2011 statistical study published in the *Journal of Sustainable Real Estate* of homes with ENERGY STAR® ratings showed purchase prices to be $8.66 higher per square foot than non-ENERGY STAR® homes in the study area. An April 2011 statistical study of 72,000 California homes by the Lawrence Berkeley National Laboratory concludes that there is strong evidence that homes with photovoltaic (PV) systems in California have sold for a premium over comparable homes without PV systems, corresponding to a premium of approximately $17,000 for a 3,100 watt PV system (the average size of the PV systems in the study). Finally, Fannie Mae has implemented an energy efficiency financing program for mortgage lenders participating in Fannie Mae programs, pursuant to which Fannie Mae permits mortgage loan proceeds to be used to finance energy improvements under certain conditions. In determining the loan-to-value ratio for the purposes of such loans by mortgage lenders, Fannie Mae directs lenders to determine the value as the lesser of the "as completed" appraised value of the property or the sum of the purchase price of the property and the cost of the energy improvements. See Fannie Mae Announcement SEL 2010-15.

Adding to these protections, minimum equity requirements for participation in the PACE program, such as the minimum 15% equity requirement proposed in H.R. 2599, provide an additional cushion to protect the mortgage lender from adverse property value changes, which can occur regardless of the existence or non-existence of a PACE assessment on the property.

Finally, an escrow feature such as that proposed in H.R. 2599 to allow the mortgage holder to escrow amounts of the PACE assessment for payment to the local government, if required by the mortgage holder, also offers protection to mortgage lenders from the risk defaults in the property owner's payment of the PACE assessment. The escrow feature essentially allows the mortgage holder to capture energy savings income of the property owner in an amount required for periodic payment of PACE assessments on the property tax bill. If PACE assessments are not delinquent, there is no risk of foreclosure by the local government.

There are very minimal costs attendant to requiring PACE programs to include the protections of a savings-to-investment ratio of greater than one, a maximum term of the PACE assessment not exceeding the reasonably expected useful life of the financed energy improvements, non-acceleration of the PACE assessment, eligibility criteria for improvements that are climate-specific, and a minimum equity requirement such as the 15% requirement in H.R. 2599.

Question 3: How does the lien-priming feature of first-lien PACE obligations affect any financial risk that is borne by holders of mortgages affected by PACE obligations or investors in mortgage-backed securities based on such mortgages and that relates to any of the following:

- *The total amount of debt secured by the subject property relative to the value of the subject property (i.e., Combined Loan to Value Ratio for the property or other measures of leverage);*

Please see our comments to Question 2, above, for our comments regarding the loan to value ratio and borrower's debt-to-income ratio in this context.

- *The amount of funds available to pay for energy-related home-improvement projects after the subtraction of administrative fees or any other program expenses charged or deducted before funds become available to pay for an actual PACE-funded projects (FHFA understand such fees and expenses can consume up to 10% or more of the funds a borrower could be obligated to repay under some PACE programs);*

Please see our comments to Question 4, below, for our comments regarding administrative fees and other program expenses in this context.

- *The timing and nature of advancements in energy-efficiency technology;*

Please see our comments to Question 4, below, for our comments regarding the timing and nature of advancements in energy-efficiency technology in this context.

- *The timing and nature of changes in potential homebuyers' preferences regarding particular kinds of energy-efficiency projects;*

Please see our comments to Question 4, below, for our comments regarding the timing and nature of changes in potential homebuyers' preferences regarding particular kinds of energy-efficiency projects in this context.

- *The timing, direction, and magnitude of changes in energy prices; and*

Please see our comments to Question 4, below, for our comments regarding the timing, direction, and magnitude of changes in energy prices in this context.

- *The timing, direction, and magnitude of changes of property values, including the possibility of downward adjustments in value?*

Please see our comments to Question 2, above, for our comments regarding financial risk borne by mortgage holders in the context of PACE obligations, changes in property values, and protections that can be implemented at minimal costs to insulate parties from such risk.

Question 4: To the extent that the lien-priming feature of first-lien PACE obligations increases any financial risk that is borne by holders of mortgages affected by PACE obligations or investors in mortgage-backed securities based on such mortgages and that relates to any of the following, how and at what cost could such parties insulate themselves from that increase in risk:

- *The total amount of debt secured by the subject property relative to the value of the subject property (i.e., Combined Loan to Value Ratio for the property or other measures of leverage);*

Please see our comments to Question 2, above, for our comments regarding the loan to value ratio and borrower's debt-to-income ratio in this context and protections that can be implemented at minimal costs to insulate parties from financial risk.

- *The amount of funds available to pay for energy-related home-improvement projects after the subtraction of administrative fees or any other programs expenses charged deducted before funds become available to pay for an actual PACE funded project (FHFA understands such fees and expenses can consume up to 10% or more of the funds a borrower could be obligated to repay under some PACE programs);*

Under Palm Desert's Energy Independence Program, very few program or administrative fees are included in, and deducted from the principal amount of the financing to the property owner. The title review and title insurance policy cost (currently $360) is deducted from the disbursement amount for all participants. In the few instances where a property owner elects to have an appraisal conducted to establish a minimum value-to-lien ratio of at least 10:1 (rather than relying on the assessed value of the property), the property owner may include the cost of the appraisal (typically $300-400) in the financing as well, which would be deducted before disbursement. Based on the average size of financings currently participating in Palm Desert's Energy Independence Program of approximately $25,000, title costs are 1.44% of the total amount financed, and appraisal fees (if any) would be 1.6% of the total amount financed, at the

current cost levels. California's assessment laws already include limitations on the costs that may be included in an assessment for the installation or construction of improvements.

- *The timing and nature of advancements in energy-efficiency technology;*

New advancements in technology do not impair the functionality of installed PACE improvements; advancements simply provide additional options. The property owner who is saving money from his or her PACE-financed energy-efficient HVAC system, in comparison to the inefficient system that was replaced, will still continue to save money even if other models of energy-efficient HVAC systems become available. The fact remains that the improvement financed by the PACE obligation still achieves better results than the pre-existing improvement or condition.

If a savings-to-investment ratio greater than one is a requirement to the PACE obligation, a pre-existing lender (who calculated the borrower's debt-to-income ratio before the PACE obligation and the installation of the energy-efficient HVAC system) will continue to be in a better position with respect to the debt-to-income ratio than at the time the lender made the mortgage. If the property is sold, a new lender can (and should) take both the pre-existing PACE lien and current energy expenditures of the property owner into account when the new lender underwrites the mortgage and before any mortgage loan is made.

As discussed in our comments to Question 2, there are very minimal costs attendant to requiring PACE programs to include the protections of a savings-to-investment ratio of greater than one, a maximum term of the PACE assessment not exceeding the reasonably expected useful life of the financed energy improvements, eligibility criteria for improvements that are climate-specific, and other protections such as those set forth in H.R. 2599.

- *The timing and nature of changes in potential homebuyer preferences regarding particular kinds of energy-efficiency projects;*

Changes in homebuyer preferences in particular kinds of energy-efficiency projects do not impair the functionality of installed PACE improvements. The fact remains that the improvement financed by the PACE obligation still achieves better results than the pre-existing improvement or condition.

Protections such as a savings-to-investment ratio of greater than one, eligibility criteria for improvements that are climate-specific, non-acceleration of the PACE assessment, and a minimum equity requirement such as the 15% requirement in H.R. 2599 reduce risks of changes in homebuyer preferences regarding particular kinds of energy-efficiency projects having an adverse effect on the mortgage holders' existing financial risk.

Again, if a savings-to-investment ratio greater than one is a requirement to the PACE obligation, a pre-existing lender (who calculated the borrower's debt-to-income ratio before the PACE obligation and the installation of the energy improvement) will continue to be in a better position with respect to the debt-to-income ratio than at the time the lender made the mortgage. If the property is sold, a new lender can take both the pre-existing PACE lien and current energy expenditures of the property owner into account when the new lender underwrites the mortgage and before any mortgage loan is made.

Further, unlike cosmetic home improvement projects, PACE-financed energy or water efficiency improvements and renewable energy improvements are functional in nature, achieve better results than the old improvement or system that they replace, and continue to hold value for the time that these improvements continue to function. Therefore, assuming underwriting in keeping with the standards set forth in the DOE Guidelines or in H.R. 2599, the property value is no more at risk for fluctuations in the market on account of the PACE-financed improvement than due to real estate market fluctuations generally.

As discussed in our comments to Question 2, there are very minimal costs attendant to requiring PACE programs to include the protections of a savings-to-investment ratio of greater than one, non-acceleration of the PACE assessment, a maximum term of the PACE assessment not exceeding the reasonably expected useful life of the financed energy improvements, eligibility criteria for improvements that are climate-specific, a minimum equity requirement such as the 15% requirement in H.R. 2599, and other protections such as those set forth in H.R. 2599.

- *The timing, direction, and magnitude of changes in energy prices; and,*

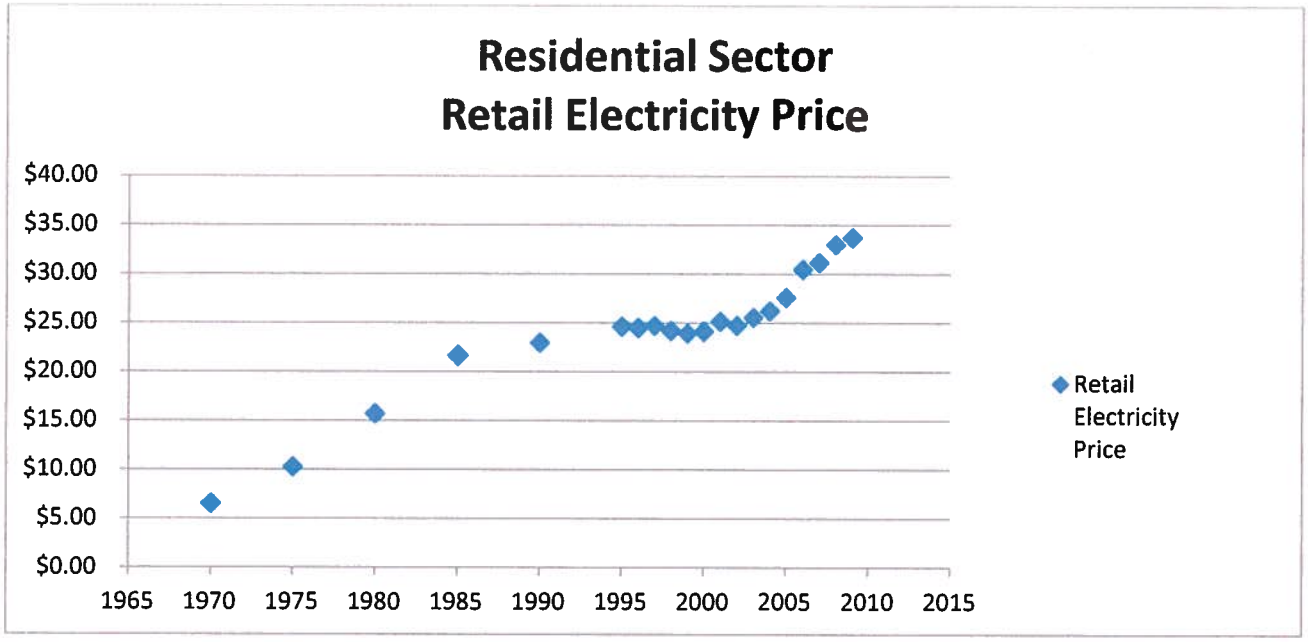
FHFA and its regulated entities rely heavily on a borrower's stated income in determining whether or not to make a mortgage loan to that borrower, but there is no guarantee that such level of income will continue over the term of a mortgage. A projected savings-to-investment ratio for a PACE improvement may be more predictable as a financial risk metric over the term of the PACE obligation than a borrower's continued level of income over the term of a mortgage. Given the basic tenet of "at will" labor in the United States, an energy improvement affixed to a property may be more likely to remain in place and to provide continued benefit to a property than the borrower may be able to keep his or her job.

In calculating the savings-to-investment ratio, an upward change in energy price will increase the projected savings and improve the ratio; conversely, a downward change in energy price will decrease the projected savings and decrease the ratio. Data compiled by the U.S. Energy Information Administration from 1970 through 2009, showing retail electricity prices for the residential sector nationwide by five-year intervals from 1970 through 1995 and every year thereafter, shows that energy prices have a strong upward trend.

This strong upward trend indicates that the risk of changes in energy prices adversely affecting the projected savings-to-investment ratio is relatively low. If anything, this data indicates that the energy prices are likely to change in a way that positively affects the projected savings-to-investment ratio, therefore positively affecting the borrower's cash revenues and the safety and soundness of a mortgage loan.

The study revealed that downward movements in energy prices (which would adversely affect a savings-to-investment ratio) ranged from -0.53% to -2.02% in the four periodic downward changes shown in the data. Upward movements in energy prices (which would positively affect a savings-to-investment ratio) ranged from 0.88% to 58.06% in the fifteen periodic upward changes shown in the data. The greatest magnitude of changes in energy prices that would adversely affect the savings-to-investment ratio is relatively small (-2.02%), compared to the greatest magnitude of changes in energy prices that would positively affect the savings-to-investment ratio (58.06%). The following chart reflects residential sector retail electricity prices

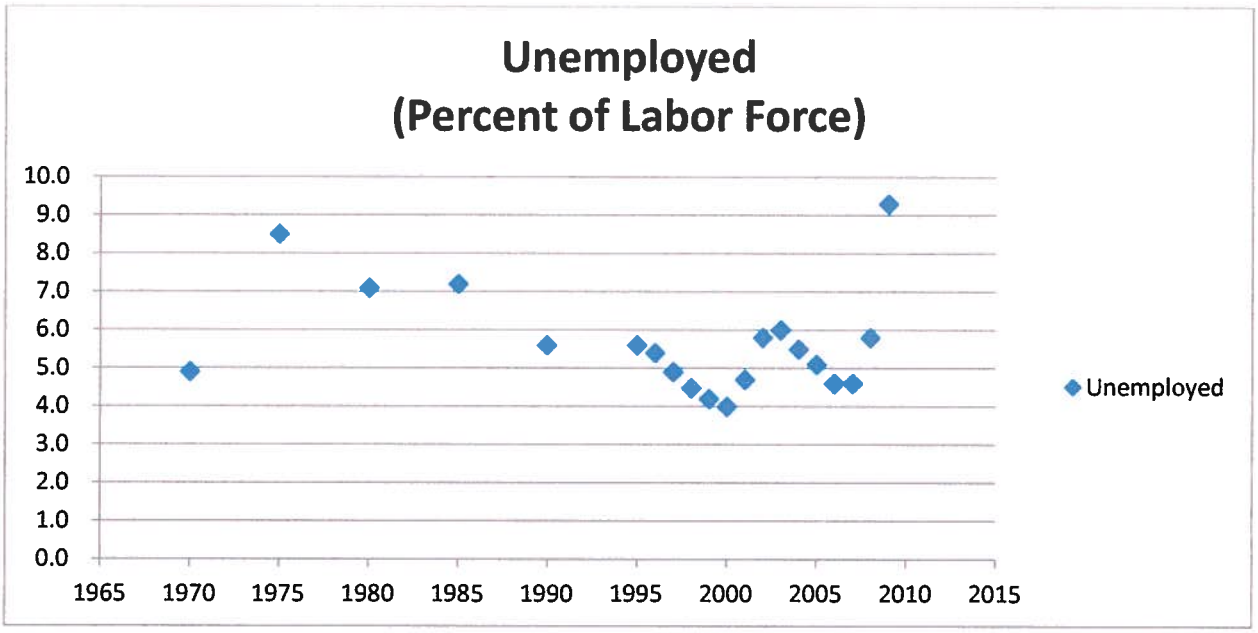
on a nationwide basis from 1970 through 2009, to the extent available and shown in the U.S. Energy Information Administration's report, dated June 2011.



Source: "State Energy Price and Expenditure Estimates, 1970 Through 2009," U.S. Energy Information Administration, DOE/EIA-0376(2009) (June 2011)

On the other hand, data available from the U.S. Department of Labor, Bureau of Labor Statistics, for the same period and intervals (from 1970 through 2009, by five-year intervals from 1970 through 1995 and every year thereafter) shows that unemployment rates are more volatile. Upward movements in unemployment rates correlate with higher risk for adverse changes in the borrower's income; downward movements in unemployment rates correlate with decreased risk for adverse changes in the borrower's income.

The U.S. Department of Labor data revealed that upward movements in the unemployment rate (which would correlate with higher risk for adverse changes in the borrower's income) ranged from 1.41% to 73.47% in the seven periodic unemployment increases shown in the data. Downward movements in the unemployment rate (which would correlate with decreased risk for adverse changes in the borrower's income) ranged from -3.57% to -22.22% in the ten periodic decreases in unemployment shown in the data. (For two periods, there was no increase or decrease in unemployment rates.) The greatest magnitude of changes in unemployment rates that would correlate with higher risk for adverse changes in the borrower's income is relatively large (73.47%), compared to the greatest magnitude of changes in unemployment rates that would correlate with decreased risk for adverse changes in the borrower's income (-22.22%). The following chart reflects unemployment rates for the civilian non-institutional population on a nationwide basis from 1970 through 2009, by five-year intervals from 1970 through 1995 and every year thereafter (to correspond with the periods and intervals for available energy price data, shown above).



Source: "Labor Force Statistics from the Current Population Survey, 1941-2011," U.S. Department of Labor, Bureau of Labor Statistics (March 2012)

As demonstrated by this data, the energy savings-to-investment ratio is a more reliable and stable metric to evaluate financial risk than borrower's debt-to-income ratio.

As discussed in our comments to Question 2, there are very minimal costs attendant to requiring PACE programs to include the protections of a savings-to-investment ratio of greater than one, a maximum term of the PACE assessment not exceeding the reasonably expected useful life of the financed energy improvements, and other protections such as those set forth in H.R. 2599.

- *The timing, direction, and magnitude of changes of property values, including the possibility of downward adjustments in value?*

Please see our comments to Question 2, above, for our comments regarding financial risk borne by mortgage holders in the context of PACE obligations, changes in property values, and protections that can be implemented at minimal costs to insulate parties from such risk.

Question 5: What alternatives to first-lien PACE loans (e.g., self-financing, bank financing, leasing, contractor financing, utility company "on-bill" financing, grants, and other government benefits) are available for financing home-improvement projects relating to energy efficiency? On what terms? Which do and which do not share the lien-priming feature of first-lien PACE obligations? What are the relative advantages and disadvantages of each, from the perspective of (i) The current and any future homeowner-borrower, (ii) the holder of an interest in any mortgage on the subject property, and (iii) the environment?

Mortgage loan or home equity financing options do not share the lien-priming feature of first-lien PACE obligations, and they are personal obligations of the borrower with additional security provided by the property as collateral. Should the collateral be insufficient to cover the

obligation, the property owner has an unsecured debt obligation to the mortgage lender. Property owners are typically required to pay off the mortgage or home equity loan in full from proceeds of a sale of the property; the amount is typically not transferrable to the subsequent property owner, who receives the continuing benefits of the energy improvement. If the existing mortgage lender is the same entity that has extended the mortgage or home equity financing for the energy improvement, the mortgage lender bears the risks of the energy financing, which is disadvantageous to the mortgage lender in comparison to a properly structured PACE obligation including protections such as those stated in H.R. 2599.

Mortgage loan or home equity financing also typically includes the remedy of acceleration in the event of default or delinquency, which is disadvantageous from the property owner's point of view. Moreover, under the traditional mortgage lending or home equity financing model, the individual who installed the energy efficient or renewable energy improvement is personally responsible for the entire cost of the improvement, regardless of whether that individual continues to live on the property or move away. This is a disadvantage in comparison to PACE financing, whereby the new property owner, who receives the continuing benefits of the energy improvement, assumes the related responsibility for the tax assessment associated with the energy improvement. For additional discussion regarding disadvantages of traditional mortgage or home equity financing of energy improvements to the property owner, please see our comments to Question 7.

On-bill financing (i.e., financing of the energy improvement with installments placed on the customer's utility bill on an unsecured basis) has the advantage that the customer will likely pay the utility bill or else face a discontinuation of services. However, the lack of security for this debt means that unpaid amounts will likely be unrecoverable, which is a disadvantage to the governmental entity. If a home becomes and remains vacant for a period of time, there would be no utility use; however, unpaid financing installments for energy improvements would continue to accumulate, with low chances of collection. This is one of the reasons for the inception of PACE.

Contractor financing, whether through a lease or power purchase contract, poses risks attendant to the contractor's continued existence as a going concern, which could be a disadvantage to property owners. Contractor financing, while not having first-lien characteristics, is typically accompanied by the ability to remove the improvement, which may be workable for certain improvements such as solar panels, but which is unworkable for others such as energy efficient insulation or energy efficient windows and doors. If the contractor removes the energy improvement, it also causes damage to the property, which is disadvantageous to a mortgage lender, the property owner, and the governmental entity (to the extent property taxes received by the governmental entity are based on the value of the property). The non-acceleration foreclosure remedies attendant to PACE (as proposed by the DOE Guidelines and H.R. 2599) keep the property and improvements intact and protect the interests of the mortgage lender and governmental entity as well.

If a first-lien PACE obligation has been made pursuant to a program with appropriate underwriting standards and program guidelines, such as those stated in H.R. 2599, mortgage

holders should not see any disadvantage from first-lien PACE financing, as compared to other non-first lien financing options. The H.R. 2599 protections of non-acceleration and a 15% minimum equity requirement, among others, benefit both mortgage holders and property owners. Moreover, with PACE financing, the property owner will see the additional advantage of a matching of the payment obligation to the persons who receive the benefit of the energy improvement, among other benefits.

Assuming the identical improvement and holding all other factors constant, an individual improvement's effect on the environment is not impacted differently by the manner of financing. However, as discussed in our comments to Question 7, the manner of financing impacts the volume of energy-related work performed.

Question 6: How does the effect on the value of the underlying property of an energy-related home-improvement project financed through a first-lien PACE program compare to the effect on the value of the underlying property that would flow from the same project if financed in any other manner?

If an energy improvement is financed by contractor financing, it is possible that the value of the underlying property may realize a less beneficial effect than if the improvement is financed by other means. This is because the improvement is typically owned by the contractor, rather than by the property owner, and the improvement may be removed, which also can lead to damage to the property.

Otherwise, the method of financing should not impact the value of the underlying property differently if the energy improvement is the same and is owned by the property owner. However, as discussed in our comments to Question 7, the manner of financing impacts the volume of energy-related work performed.

Question 7: How does the effect on the environment of an energy-related home-improvement project financed through a first-lien PACE program compare to the effect on the environment that would flow from the same project if financed in any other manner?

Assuming the identical improvement and holding all other factors constant, an individual improvement's effect on the environment is not impacted differently by the manner of financing. However, the manner of financing impacts the volume of energy-related work performed.

With PACE, the fact that the property is responsible for the payments, rather than the individual owners themselves who may move from the property and derive no subsequent benefit from the property, provides an incentive to property owners to install energy efficient or renewable energy improvements. Under the traditional mortgage lending or home equity financing model, the individual who installed the energy efficient or renewable energy improvement is personally responsible for the entire cost of the improvement, regardless of whether that individual continues to live on the property or move away. The property simply serves as collateral for the mortgage or home equity debt, which runs with the person. Traditional mortgage lending or

home equity financing options provide a disincentive to property owners to install energy efficient or renewable energy improvements.

In October 2009, the White House Middle Class Task Force and White House Council on Environmental Quality released a report entitled, "Recovery Through Retrofit," containing a proposal for Federal action to lay the groundwork for a self-sustaining home energy efficiency retrofit industry, including a recommendation in support of "PACE" programs. The recommendations in the report were developed through a broad interagency process with the Office of the Vice President, eleven federal departments and agencies, and six White House Offices, coordinated by the White House Council on Environmental Quality.

As stated in the Recovery Through Retrofit report, a barrier to home energy retrofit is

> "high turnover rate of housing in the United States . . . The debt accrued by a retrofit is tied to the individual making the investment, rather than the home itself, even though the savings are passed on to the next owner of the home. This means that retrofits frequently don't pay for themselves before the homeowner who took the initiative moves . . . [PACE financing] tie[s] the retrofitting loan to the property instead of the individual, permitting the energy retrofit assessment to be paid off in annual installments as part of the property's usual property tax bill." Middle Class Task Force and Council on Envtl. Quality, Exec. Office of the Pres. of the U.S., *Recovery Through Retrofit* 8 (2009)

Question 8: Do first-lien PACE programs cause the completion of energy-related home improvement projects that would not otherwise have been completed, as opposed to changing the method of financing for projects that would have been completed anyway? What, if any, objective evidence exists on this point?

Please see our comments in response to Question 7.

Question 9: What consumer protections and disclosures do first-lien PACE programs mandate for participating homeowners? When and how were those protections put into place? How, if at all, do the consumer protections and disclosures that local first-lien PACE programs provide to participating homeowners differ from the consumer protections and disclosures that non-PACE providers of home-improvement financing provide to borrowers? What consumer protection enforcement mechanisms do first-lien PACE programs have?

Palm Desert currently provides disclosures and a three business day right to rescind consistent with the consumer protections laws, such as the Truth in Lending Act. These disclosures were put in place at the inception of the program. These disclosures are the substantially similar to the disclosures provided by the entities subject to such consumer protection laws, such as mortgage lenders. The DOE Guidelines and H.R. 2599 include requirements for these types of disclosures.

Question 10: What, if any, protections or disclosures do first-lien PACE programs provide to homeowner-borrowers concerning the possibility that a PACE-financed project will cause the value of their home, net of the PACE obligation, to decline? What is the effect on the financial risk borne by the holder of any mortgage interest in a subject property if PACE programs do not provide any such protections or disclosures?

Palm Desert's Energy Independence Program provides disclosures to PACE participants consistent with consumer protection laws, such as the Truth in Lending Act, and the DOE Guidelines and H.R. 2599 require similar disclosures. Protections can be implemented in PACE underwriting standards and program requirements to require only high quality and climate-specific energy improvements to be financed which would mitigate or decrease mortgage holders' financial risks. Please see comments to other questions contained herein, including but not limited to comments to Questions 1-4. Given these types of protections, the type of disclosure proposed in Question 10 does not seem to us to be any more germane than disclosure by mortgage lenders to property owners that the value of the property in general (whether including a PACE obligation or not) may decline.

Further, Question 10 assumes that the PACE-financed project will cause the property value to decline. On the contrary, studies have shown that energy efficiency and renewable energy measures increase a home's value. See comments to Question 2, above.

FHFA's July 6, 2010 rule directs its regulated entities to implement tighter mortgage underwriting standards for properties in a PACE jurisdiction, whether or not PACE financing is actually obtained by the borrower. It is FHFA's irrational rule, not the PACE obligation itself, that causes a discriminatory and unfair result and potential diminished value of the property. Palm Desert currently discloses to participants in its Energy Independence Program the potential adverse consequences of FHFA's July 2010 directives. The savings-to-investment ratio and related underwriting criteria as set forth in the DOE Guidelines and H.R. 2599 can be implemented without such unnecessary harmful effects on real property values.

Question 11: What, if any, protections or disclosures do first-lien PACE programs provide to homeowner-borrowers concerning the possibility that the utility-cost savings resulting from a PACE-financed project will be less than the cost of servicing the PACE obligation? What is the effect on the financial risk borne by the holder of any mortgage interest in a subject property if first-lien PACE programs do not provide any such protections or disclosures?

The publicly available program report and administrative guidelines for Palm Desert's Energy Independence Program, as well as the application form for the program and marketing materials, make these types of disclosures. Protections against the possibility that utility-cost savings resulting from a PACE-financed project will be less than the cost of servicing the PACE obligation such as a savings-to-investment ratio of greater than one, a maximum term of the PACE assessment not exceeding the reasonably expected useful life of the financed energy improvements, and other protections such as those set forth in H.R. 2599, offset the risk of adverse effects on the financial risk borne by the holder of any mortgage interest in a subject property. As discussed in our comments to Question 15 below, analytic tools such as energy

surveys, physical energy audits, climate-specific legislative enactments for energy efficient improvements at the state level, and energy savings calculators also presently exist to assist determinations regarding the savings-to-investment ratio. Further, please see our comments above regarding the fifth bullet point under Question 4 (regarding energy prices).

Question 12: What, if any, protections or disclosures do first-lien PACE programs provide to homeowner-borrowers concerning the possibility that over the service life of a PACE-financed project, the homeowner-borrower may face additional costs (such as costs of insuring, maintaining, and repairing equipment) beyond the direct cost of the PACE obligation? What is the effect on the financial risk borne by the holder of any mortgage interest in a subject property if first-lien PACE programs do not provide any such protections or disclosures?

The publicly available program report and administrative guidelines for Palm Desert's Energy Independence Program, as well as the application form for the program, make these types of disclosures.

Given that energy efficiency improvements typically replace older, less efficient improvements of the same type, and therefore require a similar level of maintenance as the replaced improvement, there is likely little effect on the financing risk borne by the holder of a mortgage interest in a subject property if first-lien programs do not provide any such protections or disclosures in this context. However, we believe that these types of disclosures are appropriate for PACE obligations.

Question 13: What, if any, protections or disclosures do first-lien PACE programs provide to homeowner-borrowers concerning the possibility that subsequent purchasers of the subject property will reduce the amount they would pay to purchase the property by some or all of the amount of any outstanding PACE obligation? What is the effect on the financial risk borne by the holder of any mortgage interest in a subject property if first-lien PACE programs do not provide any such protections or disclosures?

This question ignores that the PACE obligation is accompanied by the PACE-financed improvement, which adds value to the property. Please see our comments to Question 2 and the third and fourth bullet points under Question 4, above, for additional discussion regarding financial risk borne by mortgage holders in the context of PACE obligations, changes in property values, and protections that can be implemented at minimal costs to insulate parties from such risk.

Question 14: How do the credit underwriting standards and processes of PACE programs compare to that of other providers of Home-improvement financing, such as banks? Do they consider, for example: (i) Borrower creditworthiness, including an assessment of total indebtedness in relation to borrower income, consistent with national standards; (ii) total loan to-value ratio of all secured loans on the property combined, consistent with national standards; and (iii) appraisals of property value, consistent with national standards?

Please see the DOE Guidelines and H.R. 2599 for the factors recommended as a national standard for eligible PACE financing, which are substantially similar to the factors considered by Palm Desert's Energy Independence Program. These factors include measures of borrower creditworthiness, and standards governing the maximum financing amount in relation to the value of the property. If an appraisal is used in lieu of the property's assessed value, Palm Desert requires that the appraiser be a certified member of the Appraisal Institute (MAI), which has both national and international appraisal standards.

Question 15: What factors do first-lien PACE programs consider in determining whether to provide PACE financing to a particular homeowner-borrower seeking funding for a particular project eligible for PACE financing? What analytic tools presently exist to make that determination? How, if at all, have the methodologies, metrics, and assumptions incorporated into such tools been tested and validated?

Please see the DOE Guidelines and H.R. 2599, for the factors recommended for eligible PACE financing, which are substantially similar to the factors considered by Palm Desert's Energy Independence Program. Analytic tools such as energy surveys, physical energy audits, climate-specific legislative enactments for energy efficient improvements at the state level, and energy savings calculators presently exist to assist determinations regarding the savings-to-investment ratio. Energy audits are typically conducted in compliance with national standards developed by entities such as the Building Performance Institute, Inc. (BPI) or the Residential Energy Services Network (RESNET) (which developed the Home Energy Rating System (HERS)). Energy savings calculators are available on websites of the U.S. Environmental Protection Agency, the U.S. Small Business Administration, and energy companies such as Southern California Edison, which likely do not make these tools available without significant testing and validation.

Question 16: What factors and information do first-lien PACE programs gather and consider in determining whether a homeowner-borrower will have sufficient income or cash flow to service the PACE obligation in addition to the homeowner-borrower's preexisting financial obligation? What analytic tools presently exist to make that determination? How, if at all, have the methodologies, metrics, and assumptions incorporated into such tools been tested and validated?

Please see our comments in response to Question 15.

Question 17: What specific alternatives to FHFA's existing statements about PACE should FHFA consider? For each alternative, as compared to the Proposed Action, what positive or negative environmental effects would result and how would the level of financial risk borne by holders of any interest in a mortgage on PACE-affected properties change?

FHFA should consider modifying the restrictions and conditions set forth in the July 6, 2010 Statement and the February 28, 2011 Directive to stipulate that Fannie Mae, Freddie Mac, and any other mortgage lenders regulated by FHFA be allowed to buy residential mortgages with first lien PACE assessments that are originated by programs that conform to underwriting standards and program guidelines such as those currently proposed in H.R. 2599 (The PACE Assessment Protection Act). We believe that significant positive environmental effects would result because of greater property owner participation in PACE programs. See, for instance our comments to Question 7, above.

By way of example, Palm Desert's Energy Independence Program has been responsible for the installation of 97 solar systems totaling 700 kilowatts ("kW"). These installations have saved 1.5 million kilowatt hours ("kWh") from the power grid annually. This decrease in the amount of energy drawn from the power grid translates to a reduction of 1,034 metric tons of carbon dioxide ("CO2") emissions or removing 203 cars from the roadway annually.[1] The program has been responsible for the replacement of 182 inefficient air conditioning systems, which equates to a savings of approximately 1.0 million kWh annually.[2] The air conditioning unit replacements have also had a direct benefit to the environment by reducing CO2 emissions by 690 metric tons, equivalent to removing 135 cars from the roadway annually.[3] Several other different types of improvements including, but not limited to, window retrofits, water heaters, insulation and pool pumps have been approved and installed as part of the program. These types of projects also have energy savings and environmental benefits.

From August 28, 2008, to July 6, 2010, Palm Desert received 337 applications for financing improvements under the Energy Independence Program (approximately 14.5 per month) and approved 227 of them (approximately 10 per month). Many of the 227 applications approved included multiple improvements. Subsequent to FHFA's issuance of its July 6, 2010 directive, twelve applications for financing under the program were cancelled by the applicants by June 23, 2011, for a loss of $220,000.00 in energy improvements. In addition, since FHFA's issuance of the July 2010 directive, Palm Desert has only received 34 applications for financing under the program. This translates to a drop from approximately 14.5 to 2 applications per month. Of the

[1] The reduction of CO2 emissions and the removal of the number of cars was calculated by using the EPA Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/cleanenergy/energy-resources/calculator.html (the "EPA Calculator").

[2] This savings was calculated by using the Energy Savings Calculator for HVAC Residential Central Air Conditioning at http://www.sba.gov/content/energy-saving-calculators-energy-star (the "Air Conditioning Calculator"). The City used "CA-Palm Springs" as the applicable city, a 15.0 SEER rating for the Energy Star Qualified Unit, a 10.0 SEER rating for the Conventional Unit, and a 5-ton Cooling Capacity of Air Conditioners for both units. The "Life cycle energy saved" was divided by 14 to obtain an annual savings amount.

[3] The reduction of CO2 emissions and removal of the number of cars was calculated by using the EPA Calculator described in footnote 1, based on the annual savings of 1.0 million kWh.

34 applications, 28 have been approved, which translates to a drop from approximately 10 approved applications to approximately 1.5 approved applications per month.

If the Energy Independence Program had continued to yield approximately 10 approved applications per month since the issuance of the July 2010 FHFA directive, then the program would have yielded 180 approved applications since FHFA's issuance of the July 2010 directive instead of 28 approved applications – meaning the City has lost an estimated 152 approved energy financing applications since FHFA's issuance of the July 2010 directive. Prior to the July 2010 FHFA directive, 60 percent of the projects approved were energy efficiency related projects and 40 percent were solar installations. If this ratio had been maintained in the time following FHFA's issuance of the July 2010 directive, and if the program had continued to yield approximately 10 approved applications per month following FHFA's issuance of the July 2010 directive, then the program has missed capturing approximately 91 energy efficiency retrofits and 61 solar projects (152 total projects) for a total investment of $3.2 million since FHFA's July 2010 directive.[4] These lost energy improvements translate to an estimated 1.4 million kWh lost in energy savings[5] per year and missed environmental benefits of eliminating 965 metric tons of CO2, which is equal to removing 189 cars from the roadway per year.[6]

These lost potential energy savings and environmental benefits are for a relatively small city; the population of Palm Desert is just under 50,000. With peak demand of 62,000 megawatts (MW) at the moment of highest energy consumption during 2008, Cal. Energy Comm'n, *2009 Integrated Energy Policy Report* 55 (2009), a 20% reduction in state-wide consumption at peak demand in 2008 would have reduced peak demand on that day by 12,400 MW - the equivalent of more than twelve 1,000 MW-capacity nuclear reactors.[7]

As discussed throughout this letter, if underwriting standards and program requirements such as those set forth in H.R. 2599 are mandated for PACE programs, the financial risk borne by a holder of any interest in a mortgage on PACE-affected properties would be offset and possibly decreased.

In conclusion, we strongly urge that any rule adopted by FHFA regarding PACE assessments permit Fannie Mae, Freddie Mac, and any other mortgage lenders regulated by FHFA to purchase and deal in residential mortgages with first lien PACE assessments that are originated by programs that conform to underwriting standards and program guidelines such as those

[4] The City assumed an average financing amount of $29,999.00 for solar and $15,000.00 for energy efficiency retrofits.

[5] The kWh lost due to the lost 61 solar projects was calculated using the annual average energy production of solar systems in the Program, which is 15,330 kWh. The kWh lost due to the lost 91 energy efficiency retrofits was calculated using the Air Conditioning Calculator and the assumptions described in footnote 2.

[6] The missed reduction of CO2 emissions and removal of the number of cars was calculated by using the EPA Calculator described in footnote 1, based on the estimated 1.4 million kWh lost in energy savings annually.

[7] As of December 2011, there were 104 nuclear reactors in the United States, which have the combined energy production capacity of 101,351 MW. U.S. Energy Info. Admin., U.S. Dep't of Energy, 2011 Capacity and Generation: Preliminary (March 5, 2012) (http://www.eia.doe.gov/cneaf/nuclear/page/nuc_generation/gensum.html) The average production capacity of each nuclear reactor in the United States is, statistically, approximately 975 MW.

currently proposed in H.R. 2599 (The PACE Assessment Protection Act) to protect the interest of local governments, homeowners, mortgage lenders, and government sponsored enterprises.

Sincerely,

John M. Wohlmuth
City Manager
City of Palm Desert

Attachments: H.R. 2599 (PACE Assessment Protection Act of 2011)
U.S. Department of Energy Guidelines for Pilot PACE Financing Programs (May 7, 2010)
Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clear Air Act, 74 Fed. Reg. 66,496 (2009).
"Recovery Through Retrofit" Report, White House Middle Class Task Force and White House Council on Environmental Quality (October 2009)
Fannie Mae Announcement SEL-2010-15
"An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California," Ernest Orlando Lawrence Berkeley National Laboratory (April 2011)
"Valuing Green Home Designs: A Study of ENERGY STAR® Homes," B. Bloom, M.C. Nobe, and M.D. Nobe, *Journal of Sustainable Real Estate*, Vol. 3, No. 1-2011
"State Energy Price and Expenditure Estimates, 1970 Through 2009," U.S. Energy Information Administration, DOE/EIA-0376(2009) (June 2011) (excerpts)
"Labor Force Statistics from the Current Population Survey, 1941-2011," U.S. Department of Labor, Bureau of Labor Statistics (March 2012)

cc: Mayor Robert A. Spiegel
Mayor Pro Tem William Kroonen
Council Member Jean M. Benson
Council Member Cindy Finerty
Council Member Jan Harnik
Edmund G. Brown Jr., Governor, State of California
Kamala D. Harris, Attorney General, State of California
Barbara Boxer, U.S. Senator
Dianne Feinstein, U.S. Senator
Congresswoman Mary Bono Mack
Congresswoman Nan Hayworth
Congressman Dan Lungren
Congressman Mike Thompson

QUESTION NO. 11: EXAMPLE OF SAVINGS TO INVESTMENT RATIO PROTECTION FOR HOMEOWNER/BORROWER

HVAC Energy Efficiency Upgrade Example (6 SEER to 14 SEER)

OLD HVAC SEER	6
System Cost	$3,500.00
Annual Kwh Consumption	16,736
Annual Cost @ .15/kWh	**$2,510.40**

NEW HVAC SEER	14
System Cost	$7,500.00
Annual Kwh Consupmtion	6,025
Annual Cost @ .15/kWh	**$903.75**

vs. 6 SEER

Annual kWh **Saved** vs. 6 SEER	10,711
Annual Cost **Savings** vs. 6 SEER	$1,606.65
Life Cycle kWh **Saved** (15yrs)	160,665
Life Cycle Cost **Savings** vs. 6 SEER (15yrs)	$26,995.37
Annual Assessment (7% for 15yrs)	$839.67
Life Span Assessment Costs	$12,595.05
Savings to Investment Ratio	1.90

Assumptions:

1. Information based on Energy Savings Calculator developed by EPA and U.S. Department of Energy
2. Life Cycle Cost Savings includes annual energy cost increase of 1.6% based on U.S. Energy Information Administration Annual Energy Outlook 2011
3. Savings to Investment Ratio calculated as net present value of life cycle cost savings divided by net present value of life span assessment costs

QUESTION NO. 11: EXAMPLE OF SAVINGS TO INVESTMENT RATIO PROTECTION FOR HOMEOWNER/BORROWER

Solar Installation Example 6.87 kW System	
System Costs	$41,178.00
CSI Rebate (.64/watt)	$3,896.00
Customer Cost	$37,282.00
30% Federal Tax Credit	$11,184.60
Net Cost	**$26,097.40**
Estimated Annual kWh Produced	11,679
Annual Energy Cost w/o Solar @.18/kWh	$2,547.00
Annual Energy Cost w Solar	$296.00
Annual Energy Cost Savings @ (.18/kWh)	**$2,251.00**
Life Cycle Energy Cost Savings (20yrs.)	**$52,567.02**
Annual Assessment (7% for 20yrs)	$2,516.37
Life Span Assessment Costs	$50,327.40
Savings to Investment Ratio	1.02

Assumptions:

1. Life Cycle Cost Savings includes annual energy cost increase of 1.6% based on U.S. Energy Information Administration Annual Energy Outlook 2011
2. Energy solar production based on actual Palm Desert,CA property installation
3. Savings to Investment Ratio calculated as net present value of life cycle energy cost savings divided by net present value of life span assessment costs

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112TH CONGRESS
1ST SESSION

H. R. 2599

To prevent Fannie Mae, Freddie Mac, and other Federal residential and commercial mortgage lending regulators from adopting policies that contravene established State and local property assessed clean energy laws.

IN THE HOUSE OF REPRESENTATIVES

JULY 20, 2011

Ms. HAYWORTH (for herself, Mr. THOMPSON of California, Mr. DANIEL E. LUNGREN of California, Mr. SENSENBRENNER, Mr. SESSIONS, Mr. FLORES, Mr. COLE, Mr. HANNA, Mr. DOLD, Mr. MANZULLO, Mrs. CAPPS, Ms. WOOLSEY, Mr. PERLMUTTER, Ms. MATSUI, and Mr. POLIS) introduced the following bill; which was referred to the Committee on Financial Services

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A BILL

To prevent Fannie Mae, Freddie Mac, and other Federal residential and commercial mortgage lending regulators from adopting policies that contravene established State and local property assessed clean energy laws.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the ''PACE Assessment Protection Act of 2011''.

SEC. 2. PURPOSE.

It is the purpose of this Act to ensure that those PACE programs which incorporate prudent programmatic safeguards to protect the interest of mortgage holders and property owners remain viable as a potential avenue for States and local governments to achieve the many public benefits associated with energy efficiency, water efficiency, and renewable energy retrofits. In addition, it is essential that the power and authority of State and local governments to exercise their longstanding and traditional powers to levy taxes for public purposes not be impeded.

SEC. 3. DEFINITIONS.

For purposes of this Act the following definitions apply:

(1) The term ''local government'' includes counties, cities, boroughs, towns, parishes, villages, districts, and other political subdivisions authorized under State laws to establish PACE programs.

(2) The term ''PACE agreement'' means an agreement between a local government and a property owner detailing the terms of financing for a PACE improvement.

(3) The term ''PACE assessment'' means a tax or assessment levied by a local government to provide financing for PACE improvements.

(4) The term ''PACE improvements'' means qualified clean energy improvements, qualified energy conservation and efficiency improvements, and qualified water conservation and efficiency improvements.

(5) The term ''PACE lien'' means a lien securing a PACE assessment, which may be senior to the lien of pre-existing purchase money mortgages on the same property subject to the PACE lien.

(6) The term ''PACE program'' means a program implemented by a local government under State law to provide financing for PACE improvements by levying PACE assessments.

(7) The term ''residential property'' means a property with up to 4 private residences.

(8) The term ''non-residential property'' means private property that is—

(A) not used for residential purposes; or

(B) residential property with 5 or more residences.

(9) The term ''clean energy improvements'' means any system on privately owned property for producing electricity for, or meeting heating, cooling, or water heating needs of the property, using renewable energy sources, combined heat and power sys-

tems, or energy systems using wood biomass (but not construction and demolition waste) or natural gas. Such improvements include solar photovoltaic, solar thermal, wood biomass, wind, and geothermal systems. Such term includes the reasonable costs of a study undertaken by a property owner to analyze the feasibility of installing any of the improvements described in this paragraph and the cost of a warranty or insurance policy for such improvements.

(10) The term ''energy conservation and efficiency improvements'' means measures to reduce consumption, through conservation or more efficient use, of electricity, fuel oil, natural gas, propane, or other forms of energy by the property, including air sealing, installation of insulation, installation of heating, cooling, or ventilation systems, building modification to increase the use of daylighting, replacement of windows, installation of energy controls or energy recovery systems, installation of building management systems, and installation of efficient lighting equipment, provided that such improvements are permanently affixed to the property. Such term includes the reasonable costs of an audit undertaken by a property owner to identify potential energy savings that could be achieved through instal-

lation of any of the improvements described in this paragraph.

(11) The term ''water conservation and efficiency improvements'' means measures to reduce consumption, through conservation or more efficient use of water by the property, including installation of low-flow toilets and showerheads, installation of timer or timing system for hot water heaters, and installation of rain catchment systems.

(12) The term ''property owner'' means the owner of record of real property that is subject to a PACE assessment, whether such property is zoned or used for residential, commercial, industrial, or other uses.

(13) The term ''qualified'' means, with respect to PACE improvements, that the improvements meet the criteria specified in section 5.

SEC. 4. TREATMENT OF PACE PROGRAMS BY FNMA AND FHLMC.

(a) LENDER GUIDANCE.—The Director of the Federal Housing Finance Agency, acting in the Director's general supervisory capacity, shall direct the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation to—

(1) issue guidance, within 30 days after the date of enactment of this Act, providing that the levy of a PACE assessment and the creation of a PACE lien do not constitute a default on any loan secured by a uniform instrument of Federal National Mortgage Association or Federal Home Loan Mortgage Corporation and do not trigger the exercise of remedies with respect to any provision of such uniform security instrument if the PACE assessment and the PACE lien meet the requirements of section 5;

(2) rescind any prior issued guidance or Selling and Servicing Guides that are inconsistent with the provisions of paragraph (1); and

(3) take all such other actions necessary to effect the purposes of this Act.

(b) PROHIBITION OF DISCRIMINATION.—The Director of the Federal Housing Finance Agency, the Comptroller of the Currency, the Federal National Mortgage Association, the Federal Home Loan Mortgage Corporation, the Federal Deposit Insurance Corporation, the National Credit Union Administration, the Board of Governors of the Federal Reserve System, and all Federal agencies and entities chartered or otherwise established under Federal law shall not discriminate in any manner

against States or local governments implementing or participating in a PACE program, or against any property that is obligated to pay a PACE assessment or is subject to a PACE lien, including, without limitation, by—

(1) prohibiting lending within such jurisdiction or requiring more restrictive underwriting criteria for properties within such jurisdiction;

(2) except for the escrowing of funds as permitted by section (5)(g)(2), requiring payment of PACE assessment amounts that are not due or that are not delinquent; or

(3) applying more restrictive underwriting criteria to any property that is obligated to pay a PACE assessment and is subject to a PACE lien than any such entity would apply to such property in the event that such property were subject to a State or municipal tax or assessment that was not a PACE assessment.

SEC. 5. PACE PROGRAMS ELIGIBLE FOR PROTECTION.

(a) IN GENERAL.—A PACE program, and any PACE assessment and PACE lien related to such program, are entitled to the protections of this Act only if the Program meets all of the requirements under this section at the time of its establishment, or, in the case of any PACE program in effect upon the date of the enact-

ment of this Act, not later than 60 days after such date of enactment.

(b) CONSUMER PROTECTIONS APPLICABLE TO RESIDENTIAL PROPERTY.—A PACE program shall provide, with respect to residential property, for the following:

(1) PROPERTY OWNER AGREEMENTS.—

(A) PACE ASSESSMENT.—The property owner shall agree in writing to a PACE assessment, either pursuant to a PACE agreement or by voting in the manner specified by State law. In the case of any property with multiple owners, each owner or the owner's authorized representative shall execute a PACE agreement or vote in the manner specified by State law, as applicable.

(B) PAYMENT SCHEDULE.—The property owner shall agree to a payment schedule that identifies the term over which PACE assessment installments will be due, the frequency with which PACE assessment installments will be billed and amount of each installment, and the annual amount due on the PACE assessment. Upon full payment of the amount of the PACE assessment, including all outstanding interest and charges and any penalties that may

become due, the local government shall provide the participating property owner with a written statement certifying that the PACE assessment has been paid in full and the local government shall also satisfy all requirements of State law to extinguish the PACE lien.

(2) DISCLOSURES BY LOCAL GOVERNMENT.—The local government shall disclose to the participating property owner the costs and risks associated with participating in the PACE program, including risks related to their failure to pay PACE assessments and the risk of enforcement of PACE liens. The local government shall disclose to the property owner the effective interest rate of the PACE assessment, including all program fees. The local government shall clearly and conspicuously provide the property owner the right to rescind his or her decision to enter into a PACE assessment, within 3 days of the original transaction.

(3) NOTICE TO LIENHOLDERS.—Before entering into a PACE agreement or voting in favor of a PACE assessment, the property owner or the local government shall provide to the holders of any existing mortgages on the property written notice of the terms of the PACE assessment.

(4) CONFIDENTIALITY.—Any personal financial information provided by a property owner to a local government or an entity administering a PACE program on behalf of a local government shall comply with applicable local, State, and Federal laws governing the privacy of the information.

(c) REQUIREMENTS APPLICABLE ONLY TO NON-RESIDENTIAL PROPERTY.—A PACE program shall provide, with respect to non-residential property, for the following:

(1) AUTHORIZATION BY LIENHOLDERS.—Before entering into a PACE agreement with a local government or voting in favor of PACE assessments in the manner specified by State law, the property owner shall obtain written authorization from the holders of the first mortgage on the property.

(2) PACE AGREEMENT.—

(A) TERMS.—The local government and the owner of the property to which the PACE assessment applies at the time of commencement of assessment shall enter into a written PACE agreement addressing the terms of the PACE improvement. In the case of any property with multiple owners, the PACE agreement shall be signed by all owners or their legally authorized representative or representatives.

(B) PACE IMPROVEMENTS.—The property owner shall contract for PACE improvements, purchase materials to be used in making such improvements, or both, and upon submission of documentation required by the local government, the local government shall disburse funds to the property owner in payment for the PACE improvements or materials used in making such improvements.

(C) PAYMENT SCHEDULE.—The PACE agreement shall include a payment schedule showing the term over which payments will be due on the assessment, the frequency with which payments will be billed and amount of each payment, and the annual amount due on the assessment. Upon full payment of the amount of the assessment, including all outstanding interest and charges and any penalties that may become due, the local government shall provide the participating property owner with a written statement certifying that the assessment has been paid in full and the local government shall also satisfy all requirements of State law to extinguish the PACE lien.

(3) DISCLOSURES BY LOCAL GOVERNMENT.—The local government shall disclose to the participating property owners the costs and risks associated with participating in the program, including risks related to their failure to make payments and the risk of enforcement of PACE liens.

(4) CONFIDENTIALITY.—Any personal financial information provided by a property owner to a local government or an entity administering a PACE program on behalf of a local government shall comply with applicable local, State, and Federal laws governing the privacy of the information.

(d) PUBLIC NOTICE OF PACE ASSESSMENT.—The local government shall file a public notice of the PACE assessment in a manner sufficient to provide notice of the PACE assessment to potential lenders and potential purchasers of the property. The notice shall consist of the following statement or its substantial equivalent: ''This property is subject to a tax or assessment that is levied to finance the installation of qualifying energy and water conservation and efficiency improvements or clean energy improvements. The tax or assessment is secured by a lien that is senior to all private liens.''.

(e) ELIGIBILITY OF RESIDENTIAL PROPERTY OWNERS.—Before levying a PACE assessment on a property,

the local government shall ensure that all of the following are true with respect to the property:

(1) All property taxes and any other public assessments are current and have been current for 3 years or the property owner's period of ownership, whichever period is shorter.

(2) There are no involuntary liens, such as mechanics liens, on the property in excess of $1,000.

(3) No notices of default and not more than one instance of property-based debt delinquency have been recorded during the past 3 years or the property owner's period of ownership, whichever period is shorter.

(4) The property owner has not filed for or declared bankruptcy in the previous 7 years.

(5) The property owner is current on all mortgage debt on the property.

(6) The property owner or owners are the holders of record of the property.

(7) The property title is not subject to power of attorney, easements, or subordination agreements restricting the authority of the property owner to subject the property to a PACE lien.

(8) The property meets any geographic eligibility requirements established by the PACE program.

The local government may adopt additional criteria, appropriate to PACE programs, for determining whether to provide PACE financing to a property.

(f) QUALIFYING IMPROVEMENTS AND QUALIFYING CONTRACTORS FOR RESIDENTIAL PROPERTIES.—PACE improvements for residential properties shall be qualified if they meet the following criteria:

(1) AUDIT.—For clean energy improvements and energy conservation and efficiency improvements, an audit or feasibility study performed by a person who has been certified as a building analyst by the Building Performance Institute or as a Home Energy Rating System (HERS) Rater by a Rating Provider accredited by the Residential Energy Services Network (RESNET); or who has obtained other similar independent certification shall have been commissioned by the local government or the property owner and the audit or feasibility study shall—

(A) identify recommended energy conservation, efficiency, and/or clean energy improvements and such recommended improvements must include the improvements proposed to be

financed with the PACE assessment to the extent permitted by law;

(B) estimate the potential cost savings, useful life, benefit-cost ratio, and simple payback or return on investment for each improvement; and

(C) provide the estimated overall difference in annual energy costs with and without the recommended improvements.

State law may provide that the cost of the audit and the cost of a warranty covering the financed improvements may be included in the total amount financed.

(2) AFFIXED FOR USEFUL LIFE.—The local government shall have determined the improvements are intended to be affixed to the property for the entire useful life of the improvements based on the expected useful lives of energy conservation, efficiency, and clean energy measures approved by the Department of Energy.

(3) QUALIFIED CONTRACTORS.—The improvements must be made by a contractor or contractors, determined by the local government to be qualified to make the PACE improvements. A local government may accept a designation of contractors as

qualified made by an electric or gas utility or another appropriate entity. Any work requiring a license under applicable law shall be performed by an individual holding such license. A local government may elect to provide financing for improvements made by the owner of the property, but shall not permit the value of the owner's labor to be included in the amount financed.

(4) DISBURSEMENT OF PAYMENTS.—A local government must require, prior to disbursement of final payments for the financed improvements, submission by the property owner in a form acceptable to the local government of—

(A) a document signed by the property-owner requesting disbursement of funds;

(B) a certificate of completion, certifying that improvements have been installed satisfactorily; and

(C) documentation of all costs to be financed and copies of any required permits.

(g) FINANCING TERMS APPLICABLE ONLY TO RESIDENTIAL PROPERTY.—A PACE program shall provide, with respect to residential property, for the following:

(1) AMOUNT FINANCED.—PACE improvements shall be financed on terms such that the total energy

and water cost savings realized by the property owner and the property owner's successors during the useful lives of the improvements, as determined by the audit or feasibility study pursuant to subsection (f)(1), are expected to exceed the total cost to the property owner and the property owner's successors of the PACE assessment. In determining the amount that may be financed by a PACE assessment, the total amount of all rebates, grants, and other direct financial assistance received by the owner on account of the PACE improvements shall be deducted from the cost of the PACE improvements.

(2) PACE ASSESSMENTS.—The total amount of PACE assessments for a property shall not exceed 10 percent of the estimated value of the property. A property owner who escrows property taxes with the holder of a mortgage on a property subject to PACE assessment may be required by the holder to escrow amounts due on the PACE assessment, and the mortgage holder shall remit such amounts to the local government in the manner that property taxes are escrowed and remitted.

(3) OWNER EQUITY.—As of the effective date of the PACE agreement or the vote required by State

law, the property owner shall have equity in the property of not less than 15 percent of the estimated value of the property calculated without consideration of the amount of the PACE assessment or the value of the PACE improvements.

(4) TERM OF FINANCING.—The maximum term of financing provided for a PACE improvement may be 20 years. The term shall in no case exceed the weighted average expected useful life of the PACE improvement or improvements. Expected useful lives used for all calculations under this paragraph shall be consistent with the expected useful lives of energy conservation and efficiency and clean energy measures approved by the Department of Energy.

(h) COLLECTION AND ENFORCEMENT.—A PACE program shall provide that—

(1) PACE assessments shall be collected in the manner specified by State law;

(2) notwithstanding any other provision of law, in the event of a transfer of property ownership through foreclosure, the transferring property owner may be obligated to pay only PACE assessment installments that are due (including delinquent amounts), along with any applicable penalties and interest, except that before imposition of any pen-

alties or fees, the PACE program shall provide an opportunity to any holder of a senior lien on the property to assume payment of the PACE assessment;

(3) PACE assessment installments that are not due may not be accelerated by foreclosure except as provided by State law; and

(4) payment of a PACE assessment installment from the loss reserve established for a PACE program shall not relieve a participating property owner from the obligation to pay that amount.

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Department of Energy
Washington, DC 20585

Guidelines for Pilot PACE Financing Programs

May 7, 2010

This document provides best practice guidelines to help implement the Policy Framework for PACE Financing Programs announced on October 18, 2009.[1] Property Assessed Clean Energy (PACE) financing programs allow state and local governments, where permitted by state law, to extend the use of land-secured financing districts to fund energy efficiency and renewable energy improvements on private property.[2] PACE programs attach the obligation to repay the cost of improvements to the property, not to the individual borrower. After consultation within the federal government and with other stakeholders, the Department of Energy has prepared the following Best Practices to help ensure prudent financing practices during the current pilot PACE programs.

These best practice guidelines are significantly more rigorous than the underwriting standards currently applied to land-secured financing districts. Especially in light of the exceptionally challenging economic environment and recovering housing market, the following best practice guidelines for pilot PACE financing programs are important to provide an extra layer of protection to both participants who voluntarily opt into PACE programs, and to lenders who hold mortgages on properties with PACE tax liens. These best practice guidelines may evolve over time as we learn more about the performance of PACE programs and are able to identify new best practices.[3] All pilot PACE financing programs are strongly encouraged to follow these best practice guidelines. This document is divided into two sections: Program Design Best Practice Guidelines and Assessment Underwriting Best Practice Guidelines.

[1] The Policy Framework for PACE Financing Programs is available here: http://www.whitehouse.gov/assets/documents/PACE_Principles.pdf.

[2] For more information on PACE programs, please visit: http://www1.eere.energy.gov/wip/solutioncenter/financialproducts/PACE.html. PACE programs are paid through a tax lien on the property. Lien priority is a matter of state law, and these best practices do not (and cannot) pre-empt state law.

[3] These best practice guidelines are primarily for the residential market. Different standards may be appropriate in non-residential markets.

Program Design Best Practice Guidelines:

Local governments should consider the following program design features to increase the reliability of energy and economic performance for the benefit of program participants, mortgage holders, and investors.

1. Expected Savings-to-Investment Ratio (SIR) Greater Than One[4]

The primary rationale for PACE programs is to pursue a legally-defined "public purpose", which generally includes environmental, health, and energy independence benefits.[5] Although traditional land-secured assessment districts do not require projects to "pay for themselves", PACE financing should generally be limited to cost effective measures to protect both participants and mortgage holders until PACE program impacts become more widely understood.

The financed package of energy improvements should be designed to pay for itself over the life of the assessment. This program attribute improves the participant's debt-to-income ratio, increasing the participant's ability to repay PACE assessments and other debt, such as mortgage payments. Local governments should consider three program design features to ensure that the expected SIR is greater than one:[6]

- An energy audit and modeling of expected savings to identify energy efficiency and renewable energy property improvement measures that are likely to deliver energy and dollar savings in excess of financed costs over the assessment term. Local governments should limit investment to those identified measures.

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[4] SIR = [Estimated savings over the life of the assessment, discounted back to present value using an appropriate discount rate] divided by [Amount financed through PACE assessment]
Savings are defined as the positive impacts of the energy improvements on participant cash flow. Savings can include reduced utility bills as well as any payments for renewable energy credits or other quantifiable environmental and health benefits that can be monetized. Savings should be calculated on an annual basis with an escalator for energy prices based either on the Energy Information Agency (EIA) U.S. forecast or a substantiated local energy price escalator.

[5] Specific public purposes are defined by the state's enabling legislation, which may vary somewhat between states. Existing legislation is available here:
http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=PTFAuth&sh=1

[6] These program options are not mutually exclusive and programs should consider deploying them in concert. In addition, these measures could be coordinated with the proposed HOMESTAR's Silver and Gold guidelines. More Information on HOMESTAR is available here:
http://www.whitehouse.gov/the-press-office/fact-sheet-homestar-energy-efficiency-retrofit-program

- In lieu of audits, programs may choose to limit eligibility to those measures with well-documented energy and dollar savings for a given climate zone. There are a number of energy efficiency and renewable energy investments that are most likely to yield a SIR of greater than one for most properties in a region.
- Encourage energy efficiency before renewable energy improvements. The economics of renewable energy investments can be enhanced when packaged with energy efficiency measures. The SIR should be calculated for the entire package of investments, not individual measures.

2. The Term of the Assessment Should Not Exceed the Useful Life of the Improvements

This best practice guidelines document is intended to ensure that a property owner's ability to repay is enhanced throughout the life of the PACE assessment by the energy savings derived from the improvements. It is important to note that the useful life of the measure often exceeds the assessment term.

3. Mortgage Holder of Record Should Receive Notice When PACE Liens Are Placed

Mortgage holders should receive notice when residential property owners fund improvements using a PACE assessment.[7]

4. PACE Lien Non-Acceleration Upon Property Owner Default

In states where non-acceleration of the lien is standard for other special assessments, it should also be standard for PACE assessments. After a foreclosure, the successor owners are responsible for future assessment payments. Non-acceleration is an important mortgage holder protection because liability for the assessment in foreclosure is limited to any amount in arrears at the time; the total outstanding assessed amount is not due in full.

5. The Assessment Should Be Appropriately Sized

PACE assessments should generally not exceed 10% of a property's estimated value (i.e. a property value-to-lien ratio of 10:1). In addition, because of the administrative requirements of administering PACE programs, assessments should generally not be issued for projects below a minimum cost threshold of approximately $2500. These measures ensure that improvements are "right-sized" for properties and for the administrative costs of piloting PACE programs. PACE programs may also choose to set the maximum assessment relative to median home values.

[7] A different standard may apply to non-residential properties.

6. Quality Assurance and Anti-Fraud Measures

Quality assurance and anti-fraud measures are essential protections for property owners, mortgage holders, investors, and local governments. These measures should include:

- Only validly licensed auditors and contractors that adhere to PACE program terms and conditions should be permitted to conduct PACE energy audits and retrofits. Where feasible or necessary, auditors and contractors should have additional certifications appropriate to the installed measures.
- Inspections should be completed on at least a portion of participating properties upon project completion to ensure that contractors participating in the PACE program are adequately performing work.
- If work is not satisfactorily completed, contractor payment should be withheld until remedied. If not satisfactorily remedied, programs should disqualify contractors from further PACE-related work.
- Property owners should sign-off before payment is issued for the work.

7. Rebates and Tax Credits

The total amount of PACE financing should be net of any expected direct cash rebates for the energy efficiency or renewable energy improvements chosen. However, other non-direct cash incentives can be more difficult to manage. For example, calculating an expected income tax credit can be complicated, as not all participants will have access to the tax credit and there will be time lags between project completion and tax credit monetization. Programs should therefore consider alternative structures for financing this gap, including assignment of rebates and tax credits to repay PACE assessments, short-term assessment additions, and partnering with third party lenders that offer short-term bridge financing. At the minimum, programs should provide full disclosure to participants on the implications and options available for monetizing an income tax credit.

8. Participant Education

PACE may be an unfamiliar financing mechanism to program participants. As such, it is essential that programs educate potential participants on how the PACE model works, whether it is a property owner's most appropriate financing mechanism, and the opportunities and risks PACE program participation creates for property owners. Programs should clearly explain and provide disclosures of the following:

- How PACE financing works

- Basic information on other financing options available to property owners for financing energy efficiency and renewable energy investments, and how PACE compares
- All program fees and how participants will pay for them
- Effective interest rate including all program fees, consistent with the Good Faith Estimate (GFE) of the Real Estate Settlement Procedure Act (RESPA) and the early and final disclosure of the Truth in Lending Act (TILA).
- PACE assessment impact on escrow payments (if applicable)
- Risk that assessment default may trigger foreclosure and property loss
- Information on transferring the assessment at time of sale
- Options for and implications of including tax credits in the financed amount

9. Debt Service Reserve Fund

For those PACE programs that seek third party investors, including investors in a municipal bond to fund the program, an assessment reserve fund should be created to protect investors from late payment or non-payment of PACE assessments.

10. Data Collection

Pilot programs should collect the data necessary to evaluate the efficacy of PACE programs. Examples of typically collected data would include: installed measures, investment amount, default and foreclosure data, expected savings, and actual energy use before and after measures installation. To the extent possible, it's important that programs have access to participant utility bills, ideally for 18 months before and after the improvements are made. The Department of Energy will provide more detailed information on collecting this data, obtaining permission to access utility bills, and how to report program information to enable a national PACE performance evaluation.

<u>Assessment Underwriting Best Practices Guidelines:</u>

Local governments should design underwriting criteria to reduce the risk of default and impairment to the property's mortgage holders. Many best practices for reducing these risks are included in the previous section. In addition, underwriting criteria for individual assessments should include the following:

1. Property Ownership

- Check that applicant has clear title to property and that the property is located in the financing district.

- Check the property title for restrictions such as details about power of attorney, easements, or subordination agreements.

2. Property-Based Debt and Property Valuation

- Estimated property value should be in excess of property owner's public and private debt on the property, including mortgages, home equity lines of credit (HELOCs), and the addition of the PACE assessment, to ensure that property owners have sufficient equity to support the PACE assessment. Local governments should be cautious about piloting the PACE model in areas with large numbers of "underwater" mortgages.
- To avoid placing an additional tax lien on properties that are in distress, have recently been in distress, or are at risk for distress, the following should be verified:
    - There are no outstanding taxes or involuntary liens on the property in excess of $1000 (i.e. liens placed on property for failure of the owner to comply with a payment obligation).
      Property is not in foreclosure and there have been no recent mortgage or other property-related debt defaults.
- Programs should attain estimated property value by reviewing assessed value. This is typically used in assessment districts. If assessed value appears low or high, programs should review comparable market data to determine the most appropriate valuation. If programs believe the estimated value remains inaccurate or there is a lack sufficient comparable market data to conduct an analysis, they should conduct a desktop appraisal.[8]

3. Property Owner Ability to Pay

PACE programs attach the obligation to repay the cost of improvements to the property (not to the individual borrower). The standard underwriting for other special assessments only consists of examining assessed value to public debt, the total tax rate, and the property tax delinquency rate. However, we deem certain precautions important due to the current vulnerability of mortgage lenders and of the housing market in many regions. These precautions include:

- A Savings-to-Investment Ratio (SIR) greater than one, as described above, to maintain or improve the property owner's debt-to-income ratio.
- Property owner is current on property taxes and has not been late more than once in the past 3 years, or since the purchase of the house if less than three years.[9]

[8] A desktop appraisal involves a licensed appraiser estimating the value of a property without a visual inspection. These appraisals cost approximately $100.

[9] Applicants that have purchased the property within 3 years have recently undergone rigorous credit analyses that compensate for the short property tax payment history.

- Property owner has not filed for or declared bankruptcy for 7 years.

These best practice guidelines will evolve over time with continued monitoring of the performance of pilot PACE financing programs.

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Chapter I

[EPA–HQ–OAR–2009–0171; FRL–9091–8]

RIN 2060–ZA14

Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: The Administrator finds that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations. The Administrator also finds that the combined emissions of these greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the greenhouse gas air pollution that endangers public health and welfare under CAA section 202(a). These Findings are based on careful consideration of the full weight of scientific evidence and a thorough review of numerous public comments received on the Proposed Findings published April 24, 2009.

DATES: These Findings are effective on January 14, 2010.

ADDRESSES: EPA has established a docket for this action under Docket ID No. EPA–HQ–OAR–2009–0171. All documents in the docket are listed on the *www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.*, confidential business information (CBI) or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available either electronically through *www.regulations.gov* or in hard copy at EPA's Docket Center, Public Reading Room, EPA West Building, Room 3334, 1301 Constitution Avenue, NW., Washington, DC 20004. This Docket Facility is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742.

FOR FURTHER INFORMATION CONTACT: Jeremy Martinich, Climate Change Division, Office of Atmospheric Programs (MC–6207J), Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460; telephone number: (202) 343–9927; fax number: (202) 343–2202; e-mail address: *ghgendangerment@epa.gov*. For additional information regarding these Findings, please go to the Web site *http://www.epa.gov/climatechange/endangerment.html*.

SUPPLEMENTARY INFORMATION:

Judicial Review

Under CAA section 307(b)(1), judicial review of this final action is available only by filing a petition for review in the U.S. Court of Appeals for the District of Columbia Circuit by February 16, 2010. Under CAA section 307(d)(7)(B), only an objection to this final action that was raised with reasonable specificity during the period for public comment can be raised during judicial review. This section also provides a mechanism for us to convene a proceeding for reconsideration, '' '[i]f the person raising an objection can demonstrate to EPA that it was impracticable to raise such objection within [the period for public comment] or if the grounds for such objection arose after the period for public comment (but within the time specified for judicial review) and if such objection is of central relevance to the outcome of this rule.' '' Any person seeking to make such a demonstration to us should submit a Petition for Reconsideration to the Office of the Administrator, Environmental Protection Agency, Room 3000, Ariel Rios Building, 1200 Pennsylvania Ave., NW., Washington, DC 20004, with a copy to the person listed in the preceding **FOR FURTHER INFORMATION CONTACT** section, and the Associate General Counsel for the Air and Radiation Law Office, Office of General Counsel (Mail Code 2344A), Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20004.

Acronyms and Abbreviations. The following acronyms and abbreviations are used in this document.

ACUS Administrative Conference of the United States
ANPR Advance Notice of Proposed Rulemaking
APA Administrative Procedure Act
CAA Clean Air Act
CAFE Corporate Average Fuel Economy
CAIT Climate Analysis Indicators Tool
CASAC Clean Air Scientific Advisory Committee
CBI Confidential Business Information
CCSP Climate Change Science Program
CFCs chlorofluorocarbons
CFR Code of Federal Regulations
CH_4 methane
CO_2 carbon dioxide
CO_2e CO_2-equivalent
CRU Climate Research Unit
DOT U.S. Department of Transportation
EO Executive Order
EPA U.S. Environmental Protection Agency
FR **Federal Register**
GHG greenhouse gas
GWP global warming potential
HadCRUT Hadley Centre/Climate Research Unit (CRU) temperature record
HCFCs hydrochlorofluorocarbons
HFCs hydrofluorocarbons
IA Interim Assessment report
IPCC Intergovernmental Panel on Climate Change
MPG miles per gallon
MWP Medieval Warm Period
N_2O nitrous oxide
NAAQS National Ambient Air Quality Standards
NAICS North American Industry Classification System
NASA National Aeronautics and Space Administration
NF_3 nitrogen trifluoride
NHTSA National Highway Traffic Safety Administration
NOAA National Oceanic and Atmospheric Administration
NOI Notice of Intent
NO_X nitrogen oxides
NRC National Research Council
NSPS new source performance standards
NTTAA National Technology Transfer and Advancement Act of 1995
OMB Office of Management and Budget
PFCs perfluorocarbons
PM particulate matter
PSD Prevention of Significant Deterioration
RFA Regulatory Flexibility Act
SF_6 sulfur hexafluoride
SIP State Implementation Plan
TSD technical support document
U.S. United States
UMRA Unfunded Mandates Reform Act of 1995
UNFCCC United Nations Framework Convention on Climate Change
USGCRP U.S. Global Climate Research Program
VOC volatile organic compound(s)
WCI Western Climate Initiative
WRI World Resources Institute

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I. Introduction

A. Overview

Pursuant to CAA section 202(a), the Administrator finds that greenhouse gases in the atmosphere may reasonably be anticipated both to endanger public health and to endanger public welfare. Specifically, the Administrator is defining the ''air pollution'' referred to in CAA section 202(a) to be the mix of six long-lived and directly-emitted greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). In this document, these six greenhouse gases are referred to as ''well-mixed greenhouse gases'' in this document (with more precise meanings of ''long lived'' and ''well mixed'' provided in Section IV.A).

The Administrator has determined that the body of scientific evidence compellingly supports this finding. The major assessments by the U.S. Global Climate Research Program (USGCRP), the Intergovernmental Panel on Climate Change (IPCC), and the National Research Council (NRC) serve as the primary scientific basis supporting the Administrator's endangerment finding.[1] The Administrator reached her determination by considering both observed and projected effects of greenhouse gases in the atmosphere, their effect on climate, and the public health and welfare risks and impacts associated with such climate change. The Administrator's assessment focused on public health and public welfare impacts within the United States. She also examined the evidence with respect to impacts in other world regions, and she concluded that these impacts strengthen the case for endangerment to public health and welfare because impacts in other world regions can in turn adversely affect the United States.

The Administrator recognizes that human-induced climate change has the potential to be far-reaching and multi-dimensional, and in light of existing knowledge, that not all risks and potential impacts can be quantified or characterized with uniform metrics. There is variety not only in the nature and potential magnitude of risks and impacts, but also in our ability to characterize, quantify and project such impacts into the future. The Administrator is using her judgment, based on existing science, to weigh the threat for each of the identifiable risks, to weigh the potential benefits where relevant, and ultimately to assess whether these risks and effects, when viewed in total, endanger public health or welfare.

The Administrator has considered how elevated concentrations of the well-mixed greenhouse gases and associated climate change affect public health by evaluating the risks associated with changes in air quality, increases in temperatures, changes in extreme weather events, increases in food- and water-borne pathogens, and changes in aeroallergens. The evidence concerning adverse air quality impacts provides strong and clear support for an endangerment finding. Increases in ambient ozone are expected to occur over broad areas of the country, and they are expected to increase serious adverse health effects in large population areas that are and may continue to be in nonattainment. The evaluation of the potential risks associated with increases in ozone in attainment areas also supports such a finding.

The impact on mortality and morbidity associated with increases in average temperatures, which increase the likelihood of heat waves, also provides support for a public health endangerment finding. There are uncertainties over the net health impacts of a temperature increase due to decreases in cold-related mortality, but some recent evidence suggests that the net impact on mortality is more likely to be adverse, in a context where heat is already the leading cause of weather-related deaths in the United States.

The evidence concerning how human-induced climate change may alter extreme weather events also clearly supports a finding of endangerment, given the serious adverse impacts that can result from such events and the increase in risk, even if small, of the occurrence and intensity of events such as hurricanes and floods. Additionally, public health is expected to be

[1] Section III of these Findings discusses the science on which these Findings are based. In addition, the Technical Support Document (TSD) accompanying these Findings summarizes the major assessments from the USGCRP, IPCC, and NRC.

adversely affected by an increase in the severity of coastal storm events due to rising sea levels.

There is some evidence that elevated carbon dioxide concentrations and climate changes can lead to changes in aeroallergens that could increase the potential for allergenic illnesses. The evidence on pathogen borne disease vectors provides directional support for an endangerment finding. The Administrator acknowledges the many uncertainties in these areas. Although these adverse effects provide some support for an endangerment finding, the Administrator is not placing primary weight on these factors.

Finally, the Administrator places weight on the fact that certain groups, including children, the elderly, and the poor, are most vulnerable to these climate-related health effects.

The Administrator has considered how elevated concentrations of the well-mixed greenhouse gases and associated climate change affect public welfare by evaluating numerous and far-ranging risks to food production and agriculture, forestry, water resources, sea level rise and coastal areas, energy, infrastructure, and settlements, and ecosystems and wildlife. For each of these sectors, the evidence provides support for a finding of endangerment to public welfare. The evidence concerning adverse impacts in the areas of water resources and sea level rise and coastal areas provides the clearest and strongest support for an endangerment finding, both for current and future generations. Strong support is also found in the evidence concerning infrastructure and settlements, as well ecosystems and wildlife. Across the sectors, the potential serious adverse impacts of extreme events, such as wildfires, flooding, drought, and extreme weather conditions, provide strong support for such a finding.

Water resources across large areas of the country are at serious risk from climate change, with effects on water supplies, water quality, and adverse effects from extreme events such as floods and droughts. Even areas of the country where an increase in water flow is projected could face water resource problems from the supply and water quality problems associated with temperature increases and precipitation variability, as well as the increased risk of serious adverse effects from extreme events, such as floods and drought. The severity of risks and impacts is likely to increase over time with accumulating greenhouse gas concentrations and associated temperature increases and precipitation changes.

Overall, the evidence on risk of adverse impacts for coastal areas provides clear support for a finding that greenhouse gas air pollution endangers the welfare of current and future generations. The most serious potential adverse effects are the increased risk of storm surge and flooding in coastal areas from sea level rise and more intense storms. Observed sea level rise is already increasing the risk of storm surge and flooding in some coastal areas. The conclusion in the assessment literature that there is the potential for hurricanes to become more intense (and even some evidence that Atlantic hurricanes have already become more intense) reinforces the judgment that coastal communities are now endangered by human-induced climate change, and may face substantially greater risk in the future. Even if there is a low probability of raising the destructive power of hurricanes, this threat is enough to support a finding that coastal communities are endangered by greenhouse gas air pollution. In addition, coastal areas face other adverse impacts from sea level rise such as land loss due to inundation, erosion, wetland submergence, and habitat loss. The increased risk associated with these adverse impacts also endangers public welfare, with an increasing risk of greater adverse impacts in the future.

Strong support for an endangerment finding is also found in the evidence concerning energy, infrastructure, and settlements, as well ecosystems and wildlife. While the impacts on net energy demand may be viewed as generally neutral for purposes of making an endangerment determination, climate change is expected to result in an increase in electricity production, especially supply for peak demand. This may be exacerbated by the potential for adverse impacts from climate change on hydropower resources as well as the potential risk of serious adverse effects on energy infrastructure from extreme events. Changes in extreme weather events threaten energy, transportation, and water resource infrastructure. Vulnerabilities of industry, infrastructure, and settlements to climate change are generally greater in high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Climate change will likely interact with and possibly exacerbate ongoing environmental change and environmental pressures in settlements, particularly in Alaska where indigenous communities are facing major environmental and cultural impacts on their historic lifestyles. Over the 21st century, changes in climate will cause some species to shift north and to higher elevations and fundamentally rearrange U.S. ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will likely alter ecosystem structure, function, and services, leading to predominantly negative consequences for biodiversity and the provision of ecosystem goods and services.

There is a potential for a net benefit in the near term [2] for certain crops, but there is significant uncertainty about whether this benefit will be achieved given the various potential adverse impacts of climate change on crop yield, such as the increasing risk of extreme weather events. Other aspects of this sector may be adversely affected by climate change, including livestock management and irrigation requirements, and there is a risk of adverse effect on a large segment of the total crop market. For the near term, the concern over the potential for adverse effects in certain parts of the agriculture sector appears generally comparable to the potential for benefits for certain crops. However, The body of evidence points towards increasing risk of net adverse impacts on U.S. food production and agriculture over time, with the potential for significant disruptions and crop failure in the future.

For the near term, the Administrator finds the beneficial impact on forest growth and productivity in certain parts of the country from elevated carbon dioxide concentrations and temperature increases to date is offset by the clear risk from the observed increases in wildfires, combined with risks from the spread of destructive pests and disease. For the longer term, the risk from adverse effects increases over time, such that overall climate change presents serious adverse risks for forest productivity. There is compelling reason to find that the support for a positive endangerment finding increases as one considers expected future conditions where temperatures continue to rise.

Looking across all of the sectors discussed above, the evidence provides compelling support for finding that greenhouse gas air pollution endangers the public welfare of both current and

[2] The temporal scope of impacts is discussed in more detail in Section III.C. The phrase ''near term'' as used in this document generally refers to the current time period from and the next few decades. The phrase ''long term'' generally refers to a time frame extending beyond that to approximately the middle to the end of this century.

future generations. The risk and the severity of adverse impacts on public welfare are expected to increase over time.

The Administrator also finds that emissions of well-mixed greenhouse gases from the transportation sources covered under CAA section 202(a) [3] contribute to the total greenhouse gas air pollution, and thus to the climate change problem, which is reasonably anticipated to endanger public health and welfare. The Administrator is defining the air pollutant that contributes to climate change as the aggregate group of the well-mixed greenhouse gases. The definition of air pollutant used by the Administrator is based on the similar attributes of these substances. These attributes include the fact that they are sufficiently long-lived to be well mixed globally in the atmosphere, that they are directly emitted, and that they exert a climate warming effect by trapping outgoing, infrared heat that would otherwise escape to space, and that they are the focus of climate change science and policy.

In order to determine if emissions of the well-mixed greenhouse gases from CAA section 202(a) source categories contribute to the air pollution that endangers public health and welfare, the Administrator compared the emissions from these CAA section 202(a) source categories to total global and total U.S. greenhouse gas emissions, finding that these source categories are responsible for about 4 percent of total global well-mixed greenhouse gas emissions and just over 23 percent of total U.S. well-mixed greenhouse gas emissions. The Administrator found that these comparisons, independently and together, clearly establish that these emissions contribute to greenhouse gas concentrations. For example, the emissions of well-mixed greenhouse gases from CAA section 202(a) sources are larger in magnitude than the total well-mixed greenhouse gas emissions from every other individual nation with the exception of China, Russia, and India, and are the second largest emitter within the United States behind the electricity generating sector. As the Supreme Court noted, ''[j]udged by any standard, U.S. motor-vehicle emissions make a meaningful contribution to greenhouse gas concentrations and hence, * * * to global warming.'' *Massachusetts* v. *EPA,* 549 U.S. 497, 525 (2007).

[3] Section 202(a) source categories include passenger cars, heavy-, medium and light-duty trucks, motorcycles, and buses.

The Administrator's findings are in response to the Supreme Court's decision in *Massachusetts* v. *EPA.* That case involved a 1999 petition submitted by the International Center for Technology Assessment and 18 other environmental and renewable energy industry organizations requesting that EPA issue standards under CAA section 202(a) for the emissions of carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons from new motor vehicles and engines. The Administrator's findings are in response to this petition and are for purposes of CAA section 202(a).

B. Background Information Helpful To Understand These Findings

This section provides some basic information regarding greenhouse gases and the CAA section 202(a) source categories, as well as the ongoing joint-rulemaking on greenhouse gases by EPA and the Department of Transportation. Additional technical and legal background, including a summary of the Supreme Court's *Massachusetts* v. *EPA* decision, can be found in the Proposed Endangerment and Contribution Findings (74 FR 18886, April 24, 2009).

1. Greenhouse Gases and Transportation Sources Under CAA Section 202(a)

Greenhouse gases are naturally present in the atmosphere and are also emitted by human activities. Greenhouse gases trap the Earth's heat that would otherwise escape from the atmosphere, and thus form the greenhouse effect that helps keep the Earth warm enough for life. Human activities are intensifying the naturally-occurring greenhouse effect by adding greenhouse gases to the atmosphere. The primary greenhouse gases of concern that are directly emitted by human activities include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Other pollutants (such as aerosols) and other human activities, such as land use changes that alter the reflectivity of the Earth's surface, also cause climatic warming and cooling effects. In these Findings, the term ''climate change'' generally refers to the global warming effect plus other associated changes (*e.g.,* precipitation effects, sea level rise, changes in the frequency and severity of extreme weather events) being induced by human activities, including activities that emit greenhouse gases. Natural causes also, contribute to climate change and climatic changes have occurred throughout the Earth's history. The concern now, however, is that the changes taking place in our atmosphere as a result of the well-documented buildup of greenhouse gases due to human activities are changing the climate at a pace and in a way that threatens human health, society, and the natural environment. Further detail on the state of climate change science can be found in Section III of these Findings as well as the technical support document (TSD) that accompanies this action (*www.epa.gov/climatechange/endangerment.html*).

The transportation sector is a major source of greenhouse gas emissions both in the United States and in the rest of the world. The transportation sources covered under CAA section 202(a)—the section of the CAA under which these Findings occur—include passenger cars, light- and heavy-duty trucks, buses, and motorcycles. These transportation sources emit four key greenhouse gases: carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. Together, these transportation sources are responsible for 23 percent of total annual U.S. greenhouse gas emissions, making this source the second largest in the United States behind electricity generation.[4]

Further discussion of the emissions data supporting the Administrator's cause or contribute finding can be found in Section V of these Findings, and the detailed greenhouse gas emissions data for section 202(a) source categories can be found in Appendix B of EPA's TSD.

2. Joint EPA and Department of Transportation Proposed Greenhouse Gas Rule

On September 15, 2009, EPA and the Department of Transportation's National Highway Safety Administration (NHTSA) proposed a National Program that would dramatically reduce greenhouse gas emissions and improve fuel economy for new cars and trucks sold in the United States. The combined EPA and NHTSA standards that make up this proposed National Program would apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016. They proposed to require these vehicles to meet an estimated combined average

[4] The units for greenhouse gas emissions in these findings are provided in carbon dioxide equivalent units, where carbon dioxide is the reference gas and every other greenhouse gas is converted to its carbon dioxide equivalent by using the 100-year global warming potential (as estimated by the Intergovernmental Panel on Climate Change (IPCC). assigned to each gas. The reference gas used is CO_2, and therefore Global Warming Potential (GWP)-weighted emissions are measured in teragrams of CO_2 equivalent (Tg CO_2 eq.). In accordance with UNFCCC reporting procedures, the United States quantifies greenhouse gas emissions using the 100-year time frame values for GWPs established in the IPCC Second Assessment Report.

emissions level of 250 grams of carbon dioxide per mile, equivalent to 35.5 miles per gallon (MPG) if the automobile industry were to meet this carbon dioxide level solely through fuel economy improvements. Together, these proposed standards would cut carbon dioxide emissions by an estimated 950 million metric tons and 1.8 billion barrels of oil over the lifetime of the vehicles sold under the program (model years 2012–2016). The proposed rulemaking can be viewed at (74 FR 49454, September 28, 2009).

C. Public Involvement

In response to the Supreme Court's decision, EPA has been examining the scientific and technical basis for the endangerment and cause or contribute decisions under CAA section 202(a) since 2007. The science informing the decision-making process has grown stronger since our work began. EPA's approach to evaluating the science, including comments submitted during the public comment period, is further discussed in Section III.A of these Findings. Public review and comment has always been a major component of EPA's process.

1. EPA's Initial Work on Endangerment

As part of the *Advance Notice of Proposed Rulemaking: Regulating Greenhouse Gas Emissions under the Clean Air Act* (73 FR 44353) published in July 2008, EPA provided a thorough discussion of the issues and options pertaining to endangerment and cause or contribute findings under the CAA. The Agency also issued a TSD providing an overview of all the major scientific assessments available at the time and emission inventory data relevant to the contribution finding (Docket ID No. EPA–HQ–OAR–2008–0318). The comment period for that *Advance Notice* was 120 days, and it provided an opportunity for EPA to hear from the public with regard to the issues involved in endangerment and cause or contribute findings as well as the supporting science. EPA received, reviewed and considered numerous comments at that time and this public input was reflected in the Findings that the Administrator proposed in April 2009. In addition, many comments were received on the TSD released with the *Advance Notice* and reflected in revisions to the TSD released in April 2009 to accompany the Administrator's proposal. All public comments on the *Advance Notice* are contained in the public docket for this action (Docket ID No. EPA–HQ–OAR–2008–0318) accessible through *www.regulations.gov.*

2. Public Involvement Since the April 2009 Proposed Endangerment Finding

The Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases (Proposed Findings) was published on April 24, 2009 (74 FR 18886). The Administrator's proposal was subject to a 60-day public comment period, which ended June 23, 2009, and also included two public hearings. Over 380,000 public comments were received on the Administrator's proposed endangerment and cause or contribute findings, including comments on the elements of the Administrator's April 2009 proposal, the legal issues pertaining to the Administrator's decisions, and the underlying TSD containing the scientific and technical information.

A majority of the comments (approximately 370,000) were the result of mass mail campaigns, which are defined as groups of comments that are identical or very similar in form and content. Overall, about two-thirds of the mass-mail comments received are supportive of the Findings and generally encouraged the Administrator both to make a positive endangerment determination and implement greenhouse gas emission regulations. Of the mass mail campaigns in disagreement with the Proposed Findings most either oppose the proposal on economic grounds (*e.g.,* due to concern for regulatory measures following an endangerment finding) or take issue with the proposed finding that atmospheric greenhouse gas concentrations endanger public health and welfare. Please note that for mass mailer campaigns, a representative copy of the comment is posted in the public docket for this Action (Docket ID No. EPA–HQ–OAR–2009–0171) at *www.regulations.gov*.

Approximately 11,000 other public comments were received. These comments raised a variety of issues related to the scientific and technical information EPA relied upon in making the Proposed Findings, legal and procedural issues, the content of the Proposed Findings, and the implications of the Proposed Findings.

In light of the very large number of comments received and the significant overlap between many comments, EPA has not responded to each comment individually. Rather, EPA has summarized and provided responses to each significant argument, assertion and question contained within the totality of the comments. EPA's responses to some of the most significant comments are provided in these Findings. Responses to all significant issues raised by the comments are contained in the 11 volumes of the Response to Comments document, organized by subject area (found in docket EPA–HQ–OAR–2009–0171).

3. Issues Raised Regarding the Rulemaking Process

EPA received numerous comments on process-related issues, including comments urging the Administrator to delay issuing the final findings, arguing that it was improper for the Administrator to sever the endangerment and cause or contribute findings from the attendant section 202(a) standards, arguing the final decision was preordained by the President's May vehicle announcement, and questioning the adequacy of the comment period. Summaries of key comments and EPA's responses are discussed in this section. Additional and more detailed responses can be found in the Response to Comments document, Volume 11. As noted in the Response to Comments document, EPA also received comments supporting the overall process.

a. It Is Reasonable for the Administrator To Issue the Endangerment and Cause or Contribute Findings Now

Though the Supreme Court did not establish a specific deadline for EPA to act, more than two and a half years have passed since the remand from the Supreme Court, and it has been 10 years since EPA received the original petition requesting that EPA regulate greenhouse gas emissions from new motor vehicles. EPA has a responsibility to respond to the Supreme Court's decision and to fulfill its obligations under current law, and there is good reason to act now given the urgency of the threat of climate change and the compelling scientific evidence.

Many commenters urge EPA to delay making final findings for a variety of reasons. They note that the Supreme Court did not establish a deadline for EPA to act on remand. Commenters also argue that the Supreme Court's decision does not require that EPA make a final endangerment finding, and thus that EPA has discretionary power and may decline to issue an endangerment finding, not only if the science is too uncertain, but also if EPA can provide ''some reasonable explanation'' for exercising its discretion. These commenters interpret the Supreme Court decision not as rejecting all policy reasons for declining to undertake an endangerment finding, but rather as dismissing solely the policy reasons EPA set forth in 2003. Some commenters cite language in the

Supreme Court decision regarding EPA's discretion regarding ''the manner, timing, content, and coordination of its regulations,'' and the Court's declining to rule on ''whether policy concerns can inform EPA's actions in the event that it makes'' a CAA section 202(a) finding to support their position.

Commenters then suggest a variety of policy reasons that EPA can and should make to support a decision not to undertake a finding of endangerment under CAA section 202(a)(1). For example, they argue that a finding of endangerment would trigger several other regulatory programs—such as the Prevention of Significant Deterioration (PSD) provisions—that would impose an unreasonable burden on the economy and government, without providing a benefit to the environment. Some commenters contend that EPA should defer issuing a final endangerment finding while Congress considers legislation. Many commenters note the ongoing international discussions regarding climate change and state their belief that unilateral EPA action would interfere with those negotiations. Others suggest deferring the EPA portion of the joint U.S. Department of Transportation (DOT)/EPA rulemaking because they argue that the new Corporate Average Fuel Economy (CAFE) standards will effectively result in lower greenhouse gas emissions from new motor vehicles, while avoiding the inevitable problems and concerns of regulating greenhouse gases under the CAA.

Other commenters argue that the endangerment determination has to be made on the basis of scientific considerations only. These commenters state that the Court was clear that ''[t]he statutory question is whether sufficient information exists to make an endangerment finding,'' and thus, only if ''the scientific uncertainty is so profound that it precludes EPA from making a reasoned judgment as to whether greenhouse gases contribute to global warming,'' may EPA avoid making a positive or negative endangerment finding. Many commenters urge EPA to take action quickly. They note that it has been 10 years since the original petition requesting that EPA regulate greenhouse gas emissions from motor vehicles was submitted to EPA. They argue that climate change is a serious problem that requires immediate action.

EPA agrees with the commenters who argue that the Supreme Court decision held that EPA is limited to consideration of science when undertaking an endangerment finding, and that we cannot delay issuing a finding due to policy concerns if the science is sufficiently certain (as it is here). The Supreme Court stated that ''EPA can avoid taking further action only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do'' 549 U.S. at 533. Some commenters point to this last provision, arguing that the policy reasons they provide are a ''reasonable explanation'' for not moving forward at this time. However, this ignores other language in the decision that clearly indicates that the Court interprets the statute to allow for the consideration only of science. For example, in rejecting the policy concerns expressed by EPA in its 2003 denial of the rulemaking petition, the Court noted that ''it is evident [the policy considerations] have nothing to do with whether greenhouse gas emissions contribute to climate change. Still less do they amount to a reasoned justification for declining to form *a scientific judgment*'' *Id.* at 533–34 (emphasis added).

Moreover, the Court also held that ''[t]he statutory question is whether sufficient information exists to make an endangerment finding'' *Id.* at 534. Taken as a whole, the Supreme Court's decision clearly indicates that policy reasons do not justify the Administrator avoiding taking further action on the question here.

We also note that the language many commenters quoted from the Supreme Court decision about EPA's discretion regarding the manner, timing and content of Agency actions, and the ability to consider policy concerns, relate to the motor vehicle standards required in the event that EPA makes a positive endangerment finding, and not the finding itself. EPA has long taken the position that it does have such discretion in the standard-setting step under CAA section 202(a).

b. The Administrator Reasonably Proceeded With the Endangerment and Cause or Contribute Findings Separate From the CAA Section 202(a) Standard Rulemaking

As discussed in the Proposed Findings, typically endangerment and cause or contribute findings have been proposed concurrently with proposed standards under various sections of the CAA, including CAA section 202(a). EPA received numerous comments on its decision to propose the endangerment and cause or contribute findings separate from any standards under CAA section 202(a).

Commenters argue that EPA has no authority to issue an endangerment determination under CAA section 202(a) separate and apart from the rulemaking to establish emissions standards under CAA section 202(a). According to these commenters, CAA section 202(a) provides only one reason to issue an endangerment determination, and that is as the basis for promulgating emissions standards for new motor vehicles; thus, it does not authorize such a stand-alone endangerment finding, and EPA may not create its own procedural rules completely divorced from the statutory text. They continue by stating that while CAA section 202(a) says EPA may issue emissions standards conditioned on such a finding, it does not say EPA may first issue an endangerment determination and then issue emissions standards. In addition, they contend, the endangerment proposal and the emissions standards proposal need to be issued together so commenters can fully understand the implications of the endangerment determination. Failure to do so, they argue, deprives the commenters of the opportunity to assess the regulations that will presumably follow from an endangerment finding. They also argue that the expected overlap between reductions in emissions of greenhouse gases from CAA section 202(a) standards issued by EPA and CAFE standards issued by DOT calls into question the basis for the CAA section 202(a) standards and the related endangerment finding, and that EPA is improperly motivated by an attempt to trigger a cascade of regulations under the CAA and/or to promote legislation by Congress.

EPA disagrees with the commenters' claims and arguments. The text of CAA section 202(a) is silent on this issue. It does not specify the timing of an endangerment finding, other than to be clear that emissions standards may not be issued unless such a determination has been made. EPA is exercising the procedural discretion that is provided by CAA section 202(a)'s lack of specific direction. The text of CAA section 202(a) envisions two separate actions by the Administrator: (1) A determination on whether emissions from classes or categories of new motor vehicles cause or contribute to air pollution that may reasonably be anticipated to endanger, and (2) a separate decision on issuance of appropriate emissions standards for such classes or categories. The procedure followed in this rulemaking, and the companion rulemaking involving emissions standards for light duty motor vehicles, is consistent with CAA section 202(a). EPA will issue final emissions standards for new motor

vehicles only if affirmative findings are made concerning contribution and endangerment, and such emissions standards will not be finalized prior to making any such determinations. While it would also be consistent with CAA section 202(a) to issue the greenhouse gas endangerment and contribution findings and emissions standards for new light-duty vehicles in the same rulemaking, *e.g.,* a single proposal covering them and a single final rule covering them, nothing in CAA section 202(a) requires such a procedural approach, and nothing in the approach taken in this case violates the text of CAA section 202(a). Since Congress was silent on this issue, and more than one procedural approach may accomplish the requirements of CAA section 202(a), EPA has the discretion to use the approach considered appropriate in this case. Once the final affirmative contribution and endangerment findings are made, EPA has the authority to issue the final emissions standards for new light-duty motor vehicles; however, as the Supreme Court has noted, the agency has 'significant latitude as to the manner, timing, [and] content * * * of its regulations . * * *' *Massachusetts v. EPA,* 549 U.S. at 533. That includes the discretion to issue them in a separate rulemaking.

Commenters' argument would also lead to the conclusion that EPA could not make an endangerment finding for the entire category of new motor vehicles, as it is doing here, unless EPA also conducted a rulemaking that set emissions standards for all the classes and categories of new motor vehicles at the same time. This narrow procedural limitation would improperly remove discretion that CAA section 202(a) provides to EPA.

EPA has the discretion under CAA section 202(a) to consider classes or categories of new motor vehicles separately or together in making a contribution and endangerment determination. This discretion would be removed under commenters' interpretation, by limiting this to only those cases in which EPA was also ready to issue emissions standards for all of the classes or categories covered by the endangerment finding. However, nothing in the text of CAA section 202(a) places such a limit on EPA's discretion in determining how to group classes or categories of new motor vehicles for purposes of the contribution and endangerment findings. This limitation would not be appropriate, because the issues of contribution and endangerment are separate and distinct from the issues of setting emissions standards. EPA, in this case, is fully prepared to go forward with the contribution and endangerment determination, while it is not ready to proceed with rulemaking for each and every category of new motor vehicles in the first rulemaking to set emissions standards. Section 202(a) of the CAA provides EPA discretion with regard to when and how it conducts its rulemakings to make contribution and endangerment findings, and to set emissions standards, and the text of CAA section 202(a) does not support commenters attempt to limit such discretion.

Concerns have been raised that the failure to issue the proposed endangerment finding and the proposed emissions standard together preclude commenters from assessing and considering the implications of the endangerment finding and the regulations that would likely flow from such a finding. However, commenters have failed to explain how this interferes in any way with their ability to comment on the endangerment finding. In fact it does not interfere, because the two proposals address separate and distinct issues. The endangerment finding concerns the contribution of new motor vehicles to air pollution and the effect of that air pollution on public health or welfare. The emissions standards, which have been proposed (74 FR 49454, September 28, 2009), concern the appropriate regulatory emissions standards if affirmative findings are made on contribution and endangerment. These two proposals address different issues. While commenters have the opportunity to comment on the proposed emissions standards in that rulemaking, they have not shown, and cannot show, that they need to have the emissions standards proposal before them in order to provide relevant comments on the proposed contribution or endangerment findings. Further discussion of this issue can be found in Section II of these Findings, and discussion of the timing of this action and its relationship to other CAA provisions and Congressional action can be found in Section III of these Findings and Volume 11 of the Response to Comments document.

c. The Administrator's Final Decision Was Not Preordained by the President's May Vehicle Announcement

EPA received numerous comments arguing that the President's announcement of a new ''National Fuel Efficiency Policy'' on May 19, 2009 seriously undermines EPA's ability to provide objective consideration of and a legally adequate response to comments objecting to the previously proposed endangerment findings.

Commenters' conclusion is based on the view that the President's announced policy requires EPA to promulgate greenhouse gas emissions standards under CAA section 202(a), that the President's and Administrator Jackson's announcement indicated that the endangerment rulemaking was but a formality and that a final endangerment finding was a fait accompli. Commenters argue that this means the result of this rulemaking has been preordained and the merits of the issues have been prejudged.

EPA disagrees. Commenters' arguments wholly exaggerate and mischaracterize the circumstances. In the April 24, 2009 endangerment proposal EPA was clear that the two steps in the endangerment provision have to be satisfied in order for EPA to issue emissions standards for new motor vehicles under CAA section 202(a) (74 FR at 18888, April 24, 2009). This was repeated when EPA issued the Notice of Upcoming Joint Rulemaking to Establish Vehicle GHG Emissions and CAFE Standards (74 FR 24007 May 22, 2009) (Notice of Intent or NOI). This was repeated again when EPA issued proposed greenhouse gas emissions standards for certain new motor vehicles (74 FR 49454, September 28, 2009). EPA has consistently made it clear that issuance of new motor vehicle standards requires and is contingent upon satisfaction of the two-part endangerment test.

On May 19, 2009 EPA issued the joint Notice of Intent, which indicated EPA's intention to propose new motor vehicle standards. All of the major motor vehicle manufacturers, their trade associations, the State of California, and several environmental organizations announced their full support for the upcoming rulemaking. Not surprisingly, on the same day the President also announced his full support for this action. Commenters, however, erroneously equate this Presidential support with a Presidential directive that requires EPA to prejudge and preordain the result of this rulemaking.

The only evidence they point to are simply indications of Presidential support. Commenters point to a press release, which unsurprisingly refers to the Agency's announcement as delivering on the President's commitment to enact more stringent fuel economy standards, by bringing ''all stakeholders to the table and [coming] up with a plan'' for solving a serious problem. The plan that was announced, of course, was a plan to conduct notice and comment

rulemaking. The press release itself states that President Obama ''set in motion a new national policy,'' with the policy ''aimed'' at reducing greenhouse gas emissions for new cars and trucks. What was ''set in motion'' was a notice and comment rulemaking described in the NOI issued by EPA on the same day. Neither the President nor EPA announced a final rule or a final direction that day, but instead did no more than announce a plan to go forward with a notice and comment rulemaking. That is how the plan ''delivers on the President's commitment'' to enact more stringent standards. The announcement was that a notice and comment rulemaking would be initiated with the aim of adopting certain emissions standards.

That is no different from what EPA or any other agency states when it issues a notice of proposed rulemaking. It starts a process that has the aim of issuing final regulations if they are deemed appropriate at the end of the public process. The fact that an Agency proposes a certain result, and expects that a final rule will be the result of setting such a process in motion, is the ordinary course of affairs in notice and comment rulemakings. This does not translate into prejudging the final result or having a preordained result that de facto negates the public comment process. The President's press release of May 19, 2009 was a recognition that this notice and comment rulemaking process would be set in motion, as well as providing his full support for the Agency to go forward in this direction; it was no more than that.

The various stakeholders who announced their support for the plan that had been set in motion all recognized that full notice and comment rulemaking was part of the plan, and they all reserved their rights to participate in such notice and comment rulemaking. For example, see the letter of support from Ford Motor Company, which states that ''Ford fully supports proposal and adoption of such a National Program, which we understand will be subject to full notice-and-comment rulemaking, affording all interested parties including Ford the right to participate fully, comment, and submit information, the results of which are not pre-determined but depend upon processes set by law.''

d. The Notice and Comment Period Was Adequate

Many commenters argue that the 60-day comment period was inadequate. Commenters claim that a 60-day period was insufficient time to fully evaluate the science and other information that informed the Administrator's proposal. Some commenters assert that because the comment period for the Proposed Finding substantially overlapped with the comment period for the Mandatory Greenhouse Gas Reporting Rule, as well as Congress' consideration of climate legislation, their ability to fully participate in the notice and comment period was ''seriously compromised.'' Moreover, they continue, because EPA had not yet proposed CAA section 202(a) standards, there was no valid reason to fail to extend the comment period. Several commenters and other entities had also requested that EPA extend the comment period.

Some commenters assert that the notice provided by this rulemaking was ''defective'' because the **Federal Register** notice announcing the proposal had an error in the e-mail address for the docket. At least one commenter suggests that this error deprives potential commenters of their Due Process under the Fifth Amendment of the Constitution, citing *Armstrong* v. *Manzo,* 380 U.S. 545, 552 (1965), and that failure to ''correct'' the minor typographical error in the e-mail address and extend the comment period would make the rule ''subject to reversal'' in violation of the CAA, Administrative Procedure Act (APA), the Due Process clause of the Constitution, and EO 12866.

Finally, for many of the same reasons that commenters argue a 60-day comment period was inadequate, several commenters request that EPA reopen and/or extend the comment period. One commenter requests that the comment period be reopened because there was new information regarding data used by EPA in the Proposed Findings. In particular, the commenter alleges that it recently became aware that one of the sources of global climate data had destroyed the raw data for its data set of global surface temperatures. The commenter argues that this alleged destruction of raw data violates scientific standards, calls into question EPA's reliance on that data in these Findings, and necessitates a reopening of the proceedings. Other commenters request that the comment period be extended and/or reopened due to the release of a Federal government document on the impact of climate change in the United States near the end of the comment period, as well as the release of an internal EPA staff document discussing the science.

The official public comment period on the proposed rule was adequate. First, a 60-day comment period satisfies the procedural requirements of CAA section 307 of the CAA, which requires a 30-day comment period, and that the docket be kept open to receive rebuttal or supplemental information as follow-up to any hearings for 30 days following the hearings. EPA met those obligations here—the comment period opened on April 24, 2009, the last hearing was on May 21, 2009 and the comment period closed June 23, 2009.

Second, as explained in letters denying requests to extend the comment period, a very large part of the information and analyses for the Proposed Findings had been previously released in July 30, 2008, as part of the *Advance Notice of Proposed Rulemaking: Regulating Greenhouse Gas Emissions under the Clean Air Act (ANPR)* (73 FR 44353). The public comment period for the ANPR is discussed above in Section I.C.1 of these Findings. The Administrator explained that the comment period for that ANPR was 120 days and that the major recent scientific assessments that EPA relied upon in the TSD released with the ANPR had previously each gone through their own public review processes and have been publicly available for some time. In other words, EPA has provided ample time for review, particularly with regard to the technical support for the Findings. See, for example, EPA Letter to Congressman Issa dated June 17, 2009, a copy of which is available at *http://epa.gov/climatechange/endangerment.html*.

Moreover, the comment period was not rendered insufficient merely because other climate-related proceedings were occurring simultaneously.

While one commenter suggests that the convergence of several different climate-related activities has ''seriously compromised'' their ability to participate in the comment process, that commenter was able to submit an 89 page comment on this proposal alone. Moreover, it is hardly rare that more than one rule is out for comment at the same time. As noted above, EPA has received a substantial number of significant comments on the Proposed Findings, and has thoroughly considered and responded to significant comments.

EPA finds no evidence that a typographical error in the docket e-mail address of the **Federal Register** notice announcing the proposal prevented the public from having a meaningful opportunity to comment, and therefore deprived them of due process. Although the minor error—which involved a word processing auto-correction that turned a short dash into a long dash—appeared in the FR version of the Proposed Findings, the e-mail address is correct

in the signature version of the Proposed Findings posted on EPA's Web site until publication in the **Federal Register,** and in the ''Instructions for Submitting Written Comments'' document on the Web site for the rulemaking. EPA has received over 190,000 e-mails to the docket e-mail address to date, so the minor typographical error appearing in only one location has not been an impediment to interested parties' e-mailing comments. Moreover, EPA provided many other avenues for interested parties to submit comments in addition to the docket e-mail address, including via *www.regulations.gov,* mail, and fax; each of these options have been utilized by many commenters. EPA is confident that the minor typographical error did not prevent anyone from submitting written comments, by e-mail or otherwise, and that the public was provided ''meaningful participation in the regulatory process'' as mentioned in EO 12866.

Our response regarding the request to reopen the comment period due to concerns about alleged destruction of raw global surface data is discussed more fully in the Response to Comments document, Volume 11. The commenter did not provide any compelling reason to conclude that the absence of these data would materially affect the trends in the temperature records or conclusions drawn about them in the assessment literature and reflected in the TSD. The Hadley Centre/Climate Research Unit (CRU) temperature record (referred to as HadCRUT) is just one of three global surface temperature records that EPA and the assessment literature refer to and cite. National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) also produce temperature records, and all three temperature records have been extensively peer reviewed. Analyses of the three global temperature records produce essentially the same long-term trends as noted in the Climate Change Science Program (CCSP) (2006) report ''Temperature Trends in the Lower Atmosphere,'' IPCC (2007), and NOAA's study [5] ''State of the Climate in 2008''. Furthermore, the commenter did not demonstrate that the allegedly destroyed data would materially alter the HadCRUT record or meaningfully hinder its replication. The raw data, a small part of which has not been public (for reasons described at: *https://www.uea.ac.uk/mac/comm/media/press/2009/nov/CRUupdate*), are available in a quality-controlled (or homogenized, value-added) format and the methodology for developing the quality-controlled data is described in the peer reviewed literature (as documented at *http://www.cru.uea.ac.uk/cru/data/temperature/*).

The release of the U.S. Global Climate Research Program (USGCRP) report on impacts of climate change in the United States in June 2009 also did not necessitate extending the comment period. This report was issued by the USGCRP, formerly the Climate Change Science Program (CCSP), and synthesized information contained in prior CCSP reports and other synthesis reports, many of which had already been published (and were included in the TSD for the Proposed Findings). Further, the USGCRP report itself underwent notice and comment before it was finalized and released.

Regarding the internal EPA staff paper that came to light during the comment period, several commenters submitted a copy of the EPA staff paper with their comments; EPA's response to the issues raised by the staff paper are discussed in the Response to Comments document, Volume 1. The fact that some internal agency deliberations were made public during the comment period does not in and of itself call into question those deliberations. As our responses to comments explain, EPA considered the concerns noted in the staff paper during the proposal stage, as well as when finalizing the Findings. There was nothing about those internal comments that required an extension or reopening of the comment period.

Thus, the opportunity for comment fully satisfies the CAA and Constitutional requirement of Due Process. Cases cited by commenters do not indicate otherwise. The comment period and thorough response to comment documents in the docket indicate that EPA has given people an opportunity to be heard in a ''meaningful time and a meaningful matter.'' *Armstrong* v. *Manzo,* 380 U.S. 545, 552 (1965). Interested parties had full notice of the rulemaking proceedings and a significant opportunity to participate through the comment process and multiple hearings.

For all the above reasons, EPA's denial of the requests for extension or reopening of the comment period was entirely reasonable in light of the extensive opportunity for public comment and heavy amount of public participation during the comment period. EPA has fully complied with all applicable public participation requirements for this rulemaking.

e. These Findings Did Not Necessitate a Formal Rulemaking Under the Administrative Procedure Act

One commenter, with the support of others, requests that EPA undertake a formal rulemaking process for the Findings, on the record, in accordance with the procedures described in sections 556–557 of the Administrative Procedure Act (APA). The commenter requests a multi-step process, involving additional public notice, an on-the-record proceeding (*e.g.,* formal administrative hearing) with the right of appeal, utilization of the Clean Air Scientific Advisory Committee (CASAC) and its advisory proceedings, and designation of representatives from other executive branch agencies to participate in the formal proceeding and any CASAC advisory proceeding.

The commenter asserts that while EPA is not obligated under the CAA to undertake these additional procedures, the Agency nonetheless has the legal authority to engage in such a proceeding. The commenter believes this proceeding would show that EPA is ''truly committed to scientific integrity and transparency.'' The commenter cites several cases to argue that refusal to proceed on the record would be ''arbitrary and capricious'' or would be an ''abuse of discretion.'' The allegation at the core of the commenter's argument is that profound and wide-ranging scientific uncertainties exist in the Proposed Findings and in the impacts on health and welfare discussed in the TSD. To support this argument, the commenter provides lengthy criticisms of the science. The commenter also argues that the regulatory cascade that would be ''unleashed'' by a positive endangerment finding warrants the more formal proceedings.

Finally, the commenter suggests that EPA engage in ''formal rulemaking'' procedures in part due to the Administrative Conference of the United States' (ACUS) recommended factors for engaging in formal rulemaking. The commenter argues that the current action is ''complex,'' ''open-ended,'' and the costs that errors in the action may pose are ''significant.''

EPA is denying the request to undertake an ''on the record'' formal rulemaking. EPA is under no obligation to follow the extraordinarily rarely used formal rulemaking provisions of the APA. First, CAA section 307(d) of the CAA clearly states that the rulemaking provisions of CAA section 307(d), *not* APA sections 553 through 557, apply to certain specified actions, such as this

[5] Peterson, T.C., and M.O. Baringer (Eds.) (2009) State of the Climate in 2008. *Bull. Amer. Meteor. Soc.,* 90, S1–S196.

one. EPA has satisfied all the requirements of CAA section 307(d). Indeed, the commenter itself ''is not asserting that the Clean Air Act expressly requires'' the additional procedures it requests. Moreover, the commenter does not discuss how the suggested formal proceeding would fit into the informal rulemaking requirements of CAA section 307(d) that do apply.

Formal rulemaking is very rarely used by Federal agencies. The formal rulemaking provisions of the APA are only triggered when the statute explicitly calls for proceedings ''on the record after opportunity for an agency hearing.'' *United States* v. *Florida East Coast Ry. Co.,* 410 U.S. 224, 241 (1973). The mere mention of the word ''hearing'' does not trigger the formal rulemaking provisions of the APA. *Id.* The CAA does not include the statutory phrase required to trigger the formal rulemaking provisions of the APA (and as noted above the APA does not apply in the first place). Congress specified that certain rulemakings under the CAA follow the rulemaking procedures outlined in CAA section 307(d) rather than the APA ''formal rulemaking'' commenter suggests.

Despite the inapplicability of the formal rulemaking provisions to this action, commenters suggest that to refuse to voluntarily undertake rulemaking provisions not preferred by Congress would make EPA's rulemaking action an ''abuse of discretion.'' EPA disagrees with this claim, and cases cited by the commenter do not indicate otherwise. To support the idea that an agency decision to engage in informal rulemaking could be an abuse of discretion, commenter cites *Ford Motor Co.* v. *FTC,* 673 F.2d 1008 (9th Cir. 1981). In *Ford Motor Co.,* the court ruled that the FTC's decision regarding an automobile dealership should have been resolved through a rulemaking rather than an individualized adjudication. *Id.* at 1010. In that instance, the court favored ''rulemaking'' over adjudication—not ''formal rulemaking'' over the far more common ''informal rulemaking.'' The case stands only for the non-controversial proposition that sometimes agency use of *adjudications* may rise to an abuse of discretion where a *rulemaking* would be more appropriate—whether formal or informal. The Commenter does not cite a single judicial opinion stating that an agency abused its discretion by following the time-tested and Congressionally-favored informal rulemaking provisions of the CAA or the APA instead of the rarely used formal APA rulemaking provisions.

The commenter also alludes to the possibility that the choice of informal rulemaking may be ''arbitrary and capricious. EPA disagrees that the choice to follow the frequently used, and CAA required, informal rulemaking procedures is arbitrary and capricious. The commenter cites *Vermont Yankee Nuclear Power Corp.* v. *NRDC,* 435 U.S. 519 (1978) for the proposition that ''extremely compelling circumstances'' could lead to a court overturning agency action for declining to follow extraneous procedures. As the commenter notes, in *Vermont Yankee* the Supreme Court overturned a lower court decision for imposing additional requirements not required by applicable statutes. Even if the dicta in *Vermont Yankee* could be applied contrary to the holding of the case in the way the commenter suggests, EPA's decision to follow frequently used informal rulemaking procedures for this action is highly reasonable.

As for the ACUS factors the commenter cites in support of its request, as the commenter notes, the ACUS factors are mere recommendations. While EPA certainly respects the views of ACUS, the recommendations are not binding on the Agency. In addition, EPA has engaged in a thorough, traditional rulemaking process that ensures that any concerns expressed by the commenter have been addressed. EPA has fully satisfied all applicable law in their consideration of this rulemaking.

Finally, as explained in Section III of these Findings and the Response to Comments document, EPA's approach to evaluating the evidence before it was entirely reasonable, and did not require a formal hearing. EPA relied primarily on robust synthesis reports that have undergone peer review and comment. The Agency also carefully considered the comments received on the Proposed Findings and TSD, including review of attached studies and documents. The public has had ample opportunity to provide its views on the science, and the record supporting these final findings indicates that EPA carefully considered and responded to significant public comments. To the extent the commenter's concern is that a formal proceeding will help ensure the *right* action in response to climate change is taken, that is not an issue for these Findings. As discussed in Section III of these Findings, this science-based judgment is not the forum for considering the potential mitigation options or their impact.

II. Legal Framework for This Action

As discussed in the Proposed Findings, two statutory provisions of the CAA govern the Administrator's Findings. Section 202(a) of the CAA sets forth a two-part test for regulatory action under that provision: Endangerment and cause or contribute. Section 302 of the CAA contains definitions of the terms ''air pollutant'' and ''effects on welfare''. Below is a brief discussion of these statutory provisions and how they govern the Administrator's decision, as well as a summary of significant legal comments and EPA's responses to them.

A. Section 202(a) of the CAA—Endangerment and Cause or Contribute

1. The Statutory Framework

Section 202(a)(1) of the CAA states that:

The Administrator shall by regulation prescribe (and from time to time revise) standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in [her] judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.

Based on the text of CAA section 202(a) and its legislative history, the Administrator interprets the two-part test as follows. Further discussion of this two-part test can be found in Section II of the preamble for the Proposed Findings. First, the Administrator is required to protect public health and welfare, but she is not asked to wait until harm has occurred. EPA must be ready to take regulatory action to prevent harm before it occurs. Section 202(a)(1) requires the Administrator to ''anticipate'' ''danger'' to public health or welfare. The Administrator is thus to consider both current and future risks. Second, the Administrator is to exercise judgment by weighing risks, assessing potential harms, and making reasonable projections of future trends and possibilities. It follows that when exercising her judgment the Administrator balances the likelihood and severity of effects. This balance involves a sliding scale; on one end the severity of the effects may be of great concern, but the likelihood low, while on the other end the severity may be less, but the likelihood high. Under either scenario, the Administrator is permitted to find endangerment. If the harm would be catastrophic, the Administrator is permitted to find endangerment even if the likelihood is small.

Because scientific knowledge is constantly evolving, the Administrator may be called upon to make decisions while recognizing the uncertainties and

limitations of the data or information available, as risks to public health or welfare may involve the frontiers of scientific or medical knowledge. At the same time, the Administrator must exercise reasoned decision making, and avoid speculative inquiries. Third, as discussed further below, the Administrator is to consider the cumulative impact of sources of a pollutant in assessing the risks from air pollution, and is not to look only at the risks attributable to a single source or class of sources. Fourth, the Administrator is to consider the risks to all parts of our population, including those who are at greater risk for reasons such as increased susceptibility to adverse health effects. If vulnerable subpopulations are especially at risk, the Administrator is entitled to take that point into account in deciding the question of endangerment. Here too, both likelihood and severity of adverse effects are relevant, including catastrophic scenarios and their probabilities as well as the less severe effects. As explained below, vulnerable subpopulations face serious health risks as a result of climate change.

In addition, by instructing the Administrator to consider whether emissions of an air pollutant cause or contribute to air pollution, the statute is clear that she need not find that emissions from any one sector or group of sources are the sole or even the major part of an air pollution problem. The use of the term ''contribute'' clearly indicates a lower threshold than the sole or major cause. Moreover, the statutory language in CAA section 202(a) does not contain a modifier on its use of the term contribute. Unlike other CAA provisions, it does not require ''significant'' contribution. See, *e.g.,* CAA sections 111(b); 213(a)(2), (4). To be sure, any finding of a ''contribution'' requires some threshold to be met; a truly trivial or de minimis ''contribution'' might not count as such. The Administrator therefore has ample discretion in exercising her reasonable judgment in determining whether, under the circumstances presented, the cause or contribute criterion has been met. Congress made it clear that the Administrator is to exercise her judgment in determining contribution, and authorized regulatory controls to address air pollution even if the air pollution problem results from a wide variety of sources. While the endangerment test looks at the entire air pollution problem and the risks it poses, the cause or contribute test is designed to authorize EPA to identify and then address what may well be many different sectors or groups of sources that are each part of—and thus contributing to—the problem.

This framework recognizes that regulatory agencies such as EPA must be able to deal with the reality that ''[m]an's ability to alter his environment has developed far more rapidly than his ability to foresee with certainty the effects of his alterations.'' See *Ethyl Corp* v. *EPA,* 541 F.2d 1, 6 (DC Cir.), *cert. denied* 426 U.S. 941 (1976). Both ''the Clean Air Act 'and common sense * * * demand regulatory action to prevent harm, even if the regulator is less than certain that harm is otherwise inevitable.' '' See *Massachusetts* v. *EPA,* 549 U.S. at 506, n.7 (citing *Ethyl Corp.*).

The Administrator recognizes that the context for this action is unique. There is a very large and comprehensive base of scientific information that has been developed over many years through a global consensus process involving numerous scientists from many countries and representing many disciplines. She also recognizes that there are varying degrees of uncertainty across many of these scientific issues. It is in this context that she is exercising her judgment and applying the statutory framework. As discussed in the Proposed Findings, this interpretation is based on and supported by the language in CAA section 202(a), its legislative history and case law.

2. Summary of Response to Key Legal Comments on the Interpretation of the CAA Section 202(a) Endangerment and Cause or Contribute Test

EPA received numerous comments regarding the interpretation of CAA section 202(a) set forth in the Proposed Findings. Below is a brief discussion of some of the key adverse legal comments and EPA's responses. Other key legal comments and EPA's responses are provided in later sections discussing the Administrator's findings.

Additional and more detailed summaries and responses can be found in the Response to Comments document. As noted in the Response to Comments document, EPA also received comments supporting its legal interpretations.

a. The Administrator Properly Interpreted the Precautionary and Preventive Nature of the Statutory Language

Various commenters argue either that the endangerment test under CAA section 202(a) is not precautionary and preventive in nature, or that EPA's interpretation and application is so extreme that it is contrary to what Congress intended in 1977, and effectively guarantees an affirmative endangerment finding. Commenters also argue that the endangerment test improperly shifts the burdens to the opponents of an endangerment finding and is tantamount to assuming the air pollution is harmful unless it is shown to be safe.

EPA rejects the argument that the endangerment test in CAA section 202(a) is not precautionary or preventive in nature. As discussed in more detail in the proposal, Congress relied heavily on the en banc decision in Ethyl when it revised section 202(a) and other CAA provisions to adopt the current language on endangerment and contribution. 74 FR 18886, 18891–2. The Ethyl court could not have been clearer on the precautionary nature of a criteria based on endangerment. The court rejected the argument that EPA had to find actual harm was occurring before it could make the required endangerment finding. The court stated that:

> *The Precautionary Nature of ''Will Endanger.''* Simply as a matter of plain meaning, we have difficulty crediting petitioners' reading of the ''will endanger'' standard. The meaning of ''endanger'' is not disputed. Case law and dictionary definition agree that endanger means something less than actual harm. When one is endangered, harm is *threatened;* no actual injury need ever occur. Thus, for example, a town may be ''endangered'' by a threatening plague or hurricane and yet emerge from the danger completely unscathed. A statute allowing for regulation in the face of danger is, necessarily, a precautionary statute. Regulatory action may be taken before the threatened harm occurs; indeed, the very existence of such precautionary legislation would seem to *demand* that regulatory action precede, and, optimally, prevent, the perceived threat. As should be apparent, the ''will endanger'' language of Section 211(c)(1)(A) makes it such a precautionary statute. *Ethyl* at 13 (footnotes omitted).

Similarly, the court stated that ''[i]n sum, based on the plain meaning of the statute, the juxtaposition of CAA section 211 with CAA sections 108 and 202, and the *Reserve Mining* precedent, we conclude that the ''will endanger'' standard is precautionary in nature and does not require proof of actual harm before regulation is appropriate.'' *Ethyl* at 17. It is this authority to act before harm has occurred that makes it a preventive, precautionary provision.

It is important to note that this statement was in the context of rejecting an argument that EPA had to prove actual harm before it could adopt fuel control regulations under then CAA section 211(c)(1). The court likewise rejected the argument that EPA had to show that such harm was ''probable.''

The court made it clear that determining endangerment entails judgments involving both the risk or likelihood of harm and the severity of the harm if it were to occur. Nowhere did the court indicate that the burden was on the opponents of an endangerment finding to show that there was no endangerment. The opinion focuses on describing the burden the statute places on EPA, rejecting *Ethyl's* arguments of a burden to show actual or probable harm.

Congress intentionally adopted a precautionary and preventive approach. It stated that the purpose of the 1977 amendments was to ''emphasize the preventive or precautionary nature of the act, *i.e.,* to assure that regulatory action can effectively prevent harm before it occurs; to emphasize the predominate value of protection to public health.'' [6] Congress also stated that it authorized the Administrator to weigh risks and make projections of future trends, a ''middle road between those who would impose a nearly impossible standard of proof on the Administrator before he may move to protect public health and those who would shift the burden of proof for all pollutants to make the pollutant source prove the safety of its emissions as a condition of operation.'' Leg. His. at 2516.

Thus, EPA rejects commenters' arguments. Congress intended this provision to be preventive and precautionary in nature, however it did not shift the burden of proof to opponents of an endangerment finding to show safety or no endangerment. Moreover, as is demonstrated in the following, EPA has not shifted the burden of proof in the final endangerment finding, but rather is weighing the likelihood and severity of harms to arrive at the final finding. EPA has not applied an exaggerated or dramatically expanded precautionary principle, and instead has exercised judgment by weighing and balancing the factors that are relevant under this provision.

b. The Administrator Does Not Need To Find That the Control Measures Following an Endangerment Finding Would Prevent at Least a Substantial Part of the Danger in Order To Find Endangerment

Several commenters argue that it is unlawful for EPA to make an affirmative endangerment finding unless EPA finds that the regulatory control measures contemplated to follow such a finding would prevent at least a substantial part of the danger from the global climate change at which the regulation is aimed. This hurdle is also described by commenters as the regulation ''achieving the statutory objective of preventing damage'', or ''fruitfully attacking'' the environmental and public health danger at hand by meaningfully and substantially reducing it. Commenters point to *Ethyl Corp.* v. *EPA,* 541 F.2d 1 (DC Cir. 1976) (en banc) as support for this view, as well as portions of the legislative history of this provision.

Commenters contend that EPA has failed to show that this required degree of meaningful reduction of endangerment would be achieved through regulation of new motor vehicles based on an endangerment finding. In making any such showing, commenters argue that EPA would need to account for the following: (1) The fact that any regulation would be limited to *new* motor vehicles, if not the subset of new motor vehicles discussed in the President's May 2009 announcement, (2) any increase in emissions from purchasers delaying purchases of new vehicles subject to any greenhouse gas emissions standards, or increasing the miles traveled of new vehicles with greater fuel economy, (3) the fact that only a limited portion of the new motor vehicle emissions of greenhouse gases would be controlled, (4) the fact that CAFE standards would effectively achieve the same reductions, and (5) the fact that any vehicle standards would not themselves reduce global temperatures. Some commenters refer to EPA's proposal for greenhouse gas emissions standards for new motor vehicles as support for these arguments, claiming the proposed new motor vehicle emission standards are largely duplicative of the standards proposed by the National Highway Traffic Safety Administration (NHTSA), and the estimates of the impacts of the proposed standards confirm that EPA's proposed standards cannot ''fruitfully attack'' global climate change (74 FR 49454, September 28, 2009).

Commenters attempt to read into the statute a requirement that is not there. EPA interprets the endangerment provision of CAA section 202(a) as not requiring any such finding or showing as described by commenters. The text of CAA section 202(a) does not support such an interpretation. The endangerment provision calls for EPA, in its judgment, to determine whether air pollution is reasonably anticipated to endanger public health or welfare, and whether emissions from certain sources cause or contribute to such air pollution. If EPA makes an affirmative finding, then it shall set emissions standards applicable to emissions of such air pollutants from new motor vehicles. There is no reference in the text of the endangerment or cause or contribute provision to anything concerning the degree of reductions that would be achieved by the emissions standards that would follow such a finding. The Administrator's judgment is directed at the issues of endangerment and cause or contribute, not at how effective the resulting emissions control standards will be.

As in the several other similar provisions adopted in the 1977 amendments, in CAA section 202(a) Congress explicitly separated two different decisions to be made, providing different criteria for them. The first decision involves the air pollution and the endangerment criteria, and the contribution to the air pollution by the sources. The second decision involves how to regulate the sources to control the emissions if an affirmative endangerment and contribution finding are made. In all of the various provisions, there is broad similarity in the phrasing of the endangerment and contribution decision. However, for the decision on how to regulate, there are a wide variety of different approaches adopted by Congress. In some case, EPA has discretion whether to issue standards or not, while in other cases, as in CAA section 202(a), EPA is required to issue standards. In some cases, the regulatory criteria are general, as in CAA section 202(a); in others, they provide significantly more direction as to how standards are to be set, as in CAA section 213(a)(4).

As the Supreme Court made clear in *Massachusetts* v. *EPA,* EPA's judgment in making the endangerment and contribution findings is constrained by the statute, and EPA is to decide these issues based solely on the scientific and other evidence relevant to that decision. EPA may not ''rest[] on reasoning divorced from the statutory text,'' and instead EPA's exercise of judgment must relate to whether an air pollutant causes or contributes to air pollution that endangers. *Massachusetts* v. *EPA,* 549 U.S. at 532. As the Supreme Court noted, EPA must ''exercise discretion within defined statutory limits.'' Id. at 533. EPA's belief one way or the other regarding whether regulation of greenhouse gases from new motor vehicles would be ''effective'' is irrelevant in making the endangerment and contribution decisions before EPA. Id. Instead ''[t]he statutory question is

[6] The Supreme Court recognized that the current language in section 202(a), adopted in 1977, is ''more protective'' than the 1970 version that was similar to the section 211 language before the DC Circuit in *Ethyl. Massachusetts* v. *EPA,* 549 U.S. at 506, fn 7.

whether sufficient information exists to make an endangerment finding'' Id. at 534.

The effectiveness of a potential future control strategy is not relevant to deciding whether air pollution levels in the atmosphere endanger. It is also not relevant to deciding whether emissions of greenhouse gases from new motor vehicles contribute to such air pollution. Commenters argue that Congress implicitly imposed a third requirement, that the future control strategy have a certain degree of effectiveness in reducing the endangerment before EPA could make the affirmative findings that would authorize such regulation. There is no statutory text that supports such an interpretation, and the Supreme Court makes it clear that EPA has no discretion to read this kind of additional factor into CAA section 202(a)'s endangerment and contribution criteria. In fact, the Supreme Court rejected similar arguments that EPA had the discretion to consider various other factors besides endangerment and contribution in deciding whether to deny a petition. *Massachusetts* v. *EPA,* 549 U.S. at 532–35.

Commenters point to language from the *Ethyl* case to support their position, noting that the DC Circuit referred to the emissions control regulation adopted by EPA under CAA section 211(c) as one that would ''fruitfully attack'' the environmental and public health danger by meaningfully and substantially reducing the danger. It is important to understand the context for this discussion in *Ethyl.* The petitioner *Ethyl Corp.* argued that EPA had to show that the health threat from the emissions of lead from the fuel additive being regulated had to be considered in isolation, and the threat ''in and of itself'' from the additive had to meet the test of endangerment in CAA section 211(c). EPA had rejected this approach, and had interpreted CAA section 211(c)(1) as calling for EPA to look at the cumulative impact of lead, and to consider the impact of lead from emissions related to use of the fuel additive in the context all other human exposure to lead. The court rejected *Ethyl's* approach and supported EPA's interpretation. The DC Circuit noted that Congress was fully aware that the burden of lead on the body was caused by multiple sources and that it would be of no value to try and determine the effect on human health from the lead automobile emissions by themselves. The court specifically noted that ''the incremental effect of lead emissions on the total body lead burden is of no practical value in determining whether health is endangered,'' but recognized that this incremental effect is of value ''in deciding whether the lead exposure problem can fruitfully be attacked through control of lead additives.'' *Ethyl,* 541 F.2d at 31 fn 62. The court made clear that the factor that was critically important to determining the effectiveness of the resulting control strategy—the incremental effect of automobile lead emissions on total body burden—was irrelevant and of no value in determining whether the endangerment criteria was met. Thus it is clear that the court in *Ethyl* did not interpret then CAA section 211(c)(1)(A) as requiring EPA to make a showing of the effectiveness of the resulting emissions control strategy, and instead found just the opposite, that the factors that would determine effectiveness are irrelevant to determining endangerment.

Commenters also cite to the legislative history, noting that Congress referred to the ''preventive or precautionary nature of the Act, *i.e.,* to assure that regulatory action can effectively prevent harm before it occurs.'' Leg. Hist. at 2516. However, this statement by Congress is presented as an answer to the question on page 2515, ''Should the Administrator act to prevent harm before it occurs or should he be authorized to regulate an air pollutant only if he finds actual harm has already occurred.'' Leg. Hist. at 2515. In this context, the discussion on page 2516 clearly indicates that there is no opportunity for prevention or precaution if the test is one of actual harm already occurring. This discussion does not say or imply that even if the harm has not occurred, you can not act unless you also show that your action will effectively address it. This discussion concerns the endangerment test, not the criteria for standard setting. The criteria for standard setting address how the agency should act to address the harm, and as the *Ethyl* case notes, the factors relevant to how to ''fruitfully attack'' the harm are irrelevant to determining whether the harm is one that endangers the public health or welfare.

As with current CAA section 202(a), there is no basis to conflate these two separate decisions and to read into the endangerment criteria an obligation that EPA show that the resulting emissions control strategy or strategies will have some significant degree of harm reduction or effectiveness in addressing the endangerment. The conflating of the two decisions is not supported in the text of this provision, by the Supreme Court in *Massachusetts* v. *EPA,* by the DC Circuit in *Ethyl,* or by Congress in the legislative history of this provision. It would be an unworkable interpretation, calling for EPA to project out the result of perhaps not one, but even several, future rulemakings stretching over perhaps a decade or decades. Especially in the context of global climate change, the effectiveness of a control strategy for new motor vehicles would have to be viewed in the context of a number of future motor vehicle regulations, as well as in the larger context of the CAA and perhaps even global context. That would be an unworkable and speculative requirement to impose on EPA as a precondition to answering the public health and welfare issues before it, as they are separate and apart from the issues involved with developing, implementing and evaluating the effectiveness of emissions control strategies.

c. The Administrator Does Not Need To Find There Is Significant Risk of Harm

Commenters argue that Congress established a minimum requirement that there be a ''significant risk of harm'' to find endangerment. They contend that this requirement stemmed from the *Ethyl* case, and that Congress adopted this view. According to the commenters, the risk is the function of two variables: the nature of the hazard at issue and the likelihood of its occurrence. Commenters argue that Congress imposed a requirement that this balance demonstrate a ''significant risk of harm'' to strike a balance between the precautionary nature of the CAA and the burdensome economic and societal consequences of regulation.

There are two basic problems with the commenters' arguments. First, commenters equate ''significant risk of harm'' as the overall test for endangerment, however the *Ethyl* case and the legislative history treat the risk of harm as only one of the two components that are to be considered in determining endangerment.—, The two components are the likelihood or risk of a harm occurring, and the severity of harm if it were to occur. Second, commenters equate it to a minimum statutory requirement. However, while the court in the *Ethyl* case made it clear that the facts in that case met the then applicable endangerment criteria, it also clearly said it was not determining what other facts or circumstances might amount to endangerment, including cases where the likelihood of a harm occurring was less than a significant risk of the harm.

In the EPA rulemaking that led to the *Ethyl* case, EPA stated that the requirement to reduce lead in gasoline ''is based on the finding that lead

particle emissions from motor vehicles present a significant risk of harm to the health of urban populations, particularly to the health of city children'' (38 FR 33734, December 6, 1973). The court in *Ethyl* supported EPA's determination, and addressed a variety of issues. First, it determined that the ''will endanger'' criteria of then CAA section 211(c) was intended to be precautionary in nature. It rejected arguments that EPA had to show proof of actual harm, or probable harm. *Ethyl,* 541 F.2d at 13–20. It was in this context, evaluating petitioner's arguments on whether the likelihood of a harm occurring had to rise to the level of actual or probable harm, that the court approved of EPA's view that a significant risk of harm could satisfy the statutory criteria. The precautionary nature of the provision meant that EPA did not need to show that either harm was actually occurring or was probable.

Instead, the court made it clear that the concept of endangerment is ''composed of reciprocal elements of risk and harm,'' *Ethyl* at 18. This means ''the public health may properly be found endangered both by a lesser risk of a greater harm and by a greater risk of lesser harm. Danger depends upon the relation between the risk and harm presented by each case, and cannot legitimately be pegged to 'probable' harm, regardless of whether that harm be great or small.'' The Ethyl court pointed to the decision by the 8th Circuit in *Reserve Mining Co.* v. *EPA,* 514 F.2d 492 (8th Cir, 1975), which interpreted similar language under the Federal Water Pollution Control Act, where the 8th Circuit upheld an endangerment finding in a case involving ''reasonable medical concern,'' or a ''potential'' showing of harm. This was further evidence that a minimum ''probable'' likelihood of harm was not required.

The Ethyl court made it clear that there was no specific magnitude of risk of harm occurring that was required. ''Reserve Mining convincingly demonstrates that the magnitude of risk sufficient to justify regulation is inversely proportional to the harm to be avoided.'' *Ethyl* at 19. This means there is no minimum requirement that the magnitude of risk be ''significant'' or another specific level of likelihood of occurrence. You need to evaluate the risk of harm in the context of the severity of the harm if it were to occur. In the case before it, the Ethyl court noted that ''the harm caused by lead poisoning is severe.'' Even with harm as severe as lead poisoning, EPA did not rely on ''potential'' risk or a ''reasonable medical concern.'' Instead, EPA found that there was a significant risk of this harm to health. This finding of a significant risk was less than the level of ''probable'' harm called for by the petitioner Ethyl Corporation but was ''considerably more certain than the risk that justified regulation in Reserve Mining of a comparably 'fright-laden' harm.'' *Ethyl* at 19–20. The Ethyl court concluded that this combination of risk (likelihood of harm) and severity of harm was sufficient under CAA section 211(c). ''Thus we conclude that however far the parameters of risk and harm inherent in the 'will endanger' standard might reach in an appropriate case, they certainly present a 'danger' that can be regulated when the harm to be avoided is widespread lead poisoning and the risk of that occurrence is 'significant'.'' *Ethyl* at 20.

Thus, the court made it clear that the endangerment criteria was intended to be precautionary in nature, that the risk of harm was one of the elements to consider in determining endangerment, and that the risk of harm needed to be considered in the context of the severity of the potential harm. It also concluded that a significant risk of harm coupled with an appropriate severity of the potential harm would satisfy the statutory criteria, and in the case before it the Administrator was clearly authorized to determine endangerment where there was a significant risk of harm that was coupled with a severe harm such as lead poisoning.

Importantly, the court also made it clear that it was not determining a minimum threshold that always had to be met. Instead, it emphasized that the risk of harm and severity of the potential harm had to be evaluated on a case by case basis. The court specifically said it was not determining ''however far the parameters of risk and harm * * * might reach in an appropriate case.'' *Ethyl* at 20. Also see *Ethyl* fn 17 at 13. The court recognized that this balancing of risk and harm ''must be confined to reasonable limits'' and even absolute certainty of a de minimis harm might not justify government action. However, ''whether a particular combination of slight risk and great harm, or great risk and slight harm constitutes a danger must depend on the facts of each case.'' *Ethyl* at fn 32 at 18.[7]

In some cases, commenters confuse matters by switching the terminology, and instead refer to effects that ''significantly harm'' the public health or welfare. As with the reference to ''significant risk of harm,'' commenters fail to recognize that there are two different aspects that must be considered, risk of harm and severity of harm, and neither of these aspects has a requirement that there be a finding of ''significance.'' The DC Circuit in *Ethyl* makes clear that it is the combination of these two aspects that must be evaluated for purposes of endangerment, and there is no requirement of ''significance'' assigned to either of the two aspects that must instead be evaluated in combination. Congress addressed concerns over burdensome economic and societal consequences in the various statutory provisions that provide the criteria for standard setting or other agency action if there is an affirmative endangerment finding. Those statutory provisions, for example, make standard setting discretionary or specify how cost and other factors are to be taken into consideration in setting standards. However, the issues of risk of harm and severity of harm if it were to occur are separate from the issues of the economic impacts of any resulting regulatory provisions (*see* below).

As is clear in the prior summary of the endangerment findings and the more detailed discussion later, the breadth of the sectors of our society that are affected by climate change and the time frames at issue mean there is a very wide range of risks and harms that need to be considered, from evidence of various harms occurring now to evidence of risks of future harms. The Administrator has determined that the body of scientific evidence compellingly supports her endangerment finding.

B. Air Pollutant, Public Health and Welfare

The CAA defines both ''air pollutant'' and ''effects on welfare.'' We provide both definitions here again for convenience.

Air pollutant is defined as:

[7] Commenters point to *Amer. Farm Bureau Ass'n* v. *EPA,* 559 F.3d 512, 533 (DC Cir. 2009) as supporting their argument. However, in that case the Court made clear that EPA's action was not subject to the endangerment criterion in CAA section 108 but instead was subject to CAA section 109's requirement that the primary NAAQS be requisite to protect the public health with an adequate margin of safety. Under that provision and its case law, the Court upheld EPA's reasoned balancing of the uncertainty regarding the link between non-urban thoracic coarse PM and adverse health effects, the large population groups potentially exposed to these particles, and the nature and degree of the health effects at issue. Citing to EPA's reasoning at 71 FR 61193 in the final PM rule, the court explained that EPA need not wait for conclusive proof of harm before setting a NAAQS under section 109 for this kind of coarse PM. The Court's reference to EPA's belief that there may be a significant risk to public health is not stated as any sort of statutory minimum, but instead refers to the Agency's reasoning at 71 FR 61193, which displays a reasoned balancing of possibility of harm and severity of harm if it were to occur.

''Any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term ''air pollutant'' is used.'' CAA section 302(g). As the Supreme Court held, greenhouse gases fit well within this capacious definition. *See Massachusetts* v. *EPA,* 549 U.S. at 532. They are ''without a doubt'' physical chemical substances emitted into the ambient air. *Id.* at 529.

''Regarding 'effects on welfare', the CAA states that [a]ll language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants.'' CAA section 302(h).

As noted in the Proposed Findings, this definition is quite broad. Importantly, it is not an exclusive list due to the use of the term ''includes, but is not limited to, * * *.'' Effects other than those listed here may also be considered effects on welfare. Moreover, the terms contained within the definition are themselves expansive.

Although the CAA defines ''effects on welfare'' as discussed above, there are no definitions of ''public health'' or ''public welfare'' in the CAA. The Supreme Court has discussed the concept of public health in the context of whether costs of implementation can be considered when setting the health based primary National Ambient Air Quality Standards. *Whitman v. American Trucking Ass'n,* 531 U.S. 457 (2001). In *Whitman,* the Court imbued the term with its most natural meaning: ''the health of the public. *Id.* at 466. In the past, when considering public health, EPA has looked at morbidity, such as impairment of lung function, aggravation of respiratory and cardiovascular disease, and other acute and chronic health effects, as well as mortality. *See, e.g., Final National Ambient Air Quality Standard for Ozone,* (73 FR 16436, 2007).

EPA received numerous comments regarding its proposed interpretations of air pollutant and public health and welfare. Summaries of key comments and EPA's responses are discussed in Sections IV and V of these Findings. Additional and more detailed summaries and responses can be found in the Response to Comments document. As noted in the Response to Comments document, EPA also received comments supporting its legal interpretations.

III. EPA's Approach for Evaluating the Evidence Before It

This section discusses EPA's approach to evaluating the evidence before it, including the approach taken to the scientific evidence, the legal framework for this decision making, and several issues critical to determining the scope of the evaluation performed.

A. The Science on Which the Decisions Are Based

In 2007, EPA initiated its assessment of the science and other technical information to use in addressing the endangerment and cause or contribute issues before it under CAA section 202(a). This scientific and technical information was developed in the form of a TSD in 2007. An earlier draft of this document was released as part of the ANPR published July 30, 2008 (73 FR 44353). That earlier draft of the TSD relied heavily on the IPCC Fourth Assessment Report of 2007, key NRC reports, and a limited number of then-available synthesis and assessment products of the U.S. Climate Change Science Program (CCSP; now encompassed by USGCRP). EPA received a number of comments specifically focused on the TSD during the 120-day public comment period for the ANPR.

EPA revised and updated the TSD in preparing the Proposed Findings on endangerment and cause or contribute. Many of the comments received on the ANPR were reflected in the draft TSD released in April 2009 that served as the underlying scientific and technical basis for the Administrator's Proposed Findings, published April 24, 2009 (74 FR 18886). The draft TSD released in April 2009 also reflected the findings of 11 new synthesis and assessment products under the U.S. CCSP that had been published since July 2008.

The TSD that summarizes scientific findings from the major assessments of the USGCRP, the IPCC, and the NRC accompanies these Findings. The TSD is available at *www.epa.gov/climatechange/endangerment.html* and in the docket for this action. It also includes the most recent comprehensive assessment of the USGCRP, *Global Climate Change Impacts in the United States*,[8] published in June 2009. In addition, the TSD incorporates up-to-date observational data for a number of key climate variables from the NOAA, and the most up-to-date emissions data from EPA's annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks,* published in April, 2009.[9] And finally, as discussed in Section I.B of these Findings, EPA received a large number of public comments on the Administrator's Proposed Findings, many of which addressed science issues either generally or specifically as reflected in the draft TSD released with the April 2009 proposal. A number of edits and updates were made to the draft TSD as a result of these comments.[10]

EPA is giving careful consideration to all of the scientific and technical information in the record, as discussed below. However, the Administrator is relying on the major assessments of the USGCRP, IPCC, and NRC as the primary scientific and technical basis of her endangerment decision for a number of reasons.

First, these assessments address the scientific issues that the Administrator must examine for the endangerment analysis. When viewed in total, these assessments address the issue of greenhouse gas endangerment by providing data and information on: (1) The amount of greenhouse gases being emitted by human activities; (2) how greenhouse gases have been and continue to accumulate in the atmosphere as a result of human activities; (3) changes to the Earth's energy balance as a result of the buildup of atmospheric greenhouse gases; (4) observed temperature and other climatic changes at the global and regional scales; (5) observed changes in other climate-sensitive sectors and systems of the human and natural environment; (6) the extent to which observed climate change and other changes in climate-sensitive systems can be attributed to the human-induced buildup of atmospheric greenhouse gases; (7) future projected climate change under a range of different scenarios of changing greenhouse gas emission rates; and (8) the projected risks and impacts to

[8] Karl, T., J. Melillo, and T. Peterson (Eds.) (2009) Global Climate Change Impacts in the United States. Cambridge University Press, Cambridge, United Kingdom.

[9] U.S. EPA (2009) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007.* EPA–430–R–09–004, Washington, DC.

[10] EPA has placed within the docket a separate memo ''Summary of Major Changes to the Technical Support Document'' identifying where within the TSD such changes were made relative to the draft TSD released in April 2009.

human health, society and the environment.

Second, as indicated above, these assessments are recent and represent the current state of knowledge on the key elements for the endangerment analysis. It is worth noting that the June 2009 assessment of the USGCRP incorporates a number of key findings from the 2007 IPCC Fourth Assessment Report; such findings include the attribution of observed climate change to human emissions of greenhouse gases, and the future projected scenarios of climate change for the global and regional scales. This demonstrates that much of the underlying science that EPA has been utilizing since 2007 has not only been in the public domain for some time, but also has remained relevant and robust.

Third, these assessments are comprehensive in their coverage of the greenhouse gas and climate change problem, and address the different stages of the emissions-to-potential-harm chain necessary for the endangerment analysis. In so doing, they evaluate the findings of numerous individual peer-reviewed studies in order to draw more general and overarching conclusions about the state of science. The USGCRP, IPCC, and NRC assessments synthesize literally thousands of individual studies and convey the consensus conclusions on what the body of scientific literature tells us.

Fourth, these assessment reports undergo a rigorous and exacting standard of peer review by the expert community, as well as rigorous levels of U.S. government review and acceptance. Individual studies that appear in scientific journals, even if peer reviewed, do not go through as many review stages, nor are they reviewed and commented on by as many scientists. The review processes of the IPCC, USGCRP, and NRC (explained in fuller detail in the TSD and the Response to Comments document, Volume 1) provide EPA with strong assurance that this material has been well vetted by both the climate change research community and by the U.S. government. These assessments therefore essentially represent the U.S. government's view of the state of knowledge on greenhouse gases and climate change. For example, with regard to government acceptance and approval of IPCC assessment reports, the USGCRP Web site states that: ''When governments accept the IPCC reports and approve their Summary for Policymakers, they acknowledge the legitimacy of their scientific content.'' [11] It is the Administrator's view that such review and acceptance by the U.S. Government lends further support for placing primary weight on these major assessments.

It is EPA's view that the scientific assessments of the IPCC, USGRCP, and the NRC represent the best reference materials for determining the general state of knowledge on the scientific and technical issues before the agency in making an endangerment decision. No other source of information provides such a comprehensive and in-depth analysis across such a large body of scientific studies, adheres to such a high and exacting standard of peer review, and synthesizes the resulting consensus view of a large body of scientific experts across the world. For these reasons, the Administrator is placing primary and significant weight on these assessment reports in making her decision on endangerment.

A number of commenters called upon EPA to perform a new and independent assessment of all of the underlying climate change science, separate and apart from USGCRP, IPCC, and NRC. In effect, commenters suggest that EPA is either required to or should ignore the attributes discussed above concerning these assessment reports, and should instead perform its own assessment of all of the underlying studies and information.

In addition to the significant reasons discussed above for relying on and placing primary weight on these assessment reports, EPA has been a very active part of the U.S. government climate change research enterprise, and has taken an active part in the review, writing, and approval of these assessments. EPA was the lead agency for three significant reports under the USGCRP [12], and recently completed an assessment addressing the climate change impacts on U.S. air quality—a report on which the TSD heavily relies for that particular issue. EPA was also involved in review of the IPCC Fourth Assessment Report, and in particular took part in the approval of the summary for policymakers for the Working Group II Volume, *Impacts, Adaptation and Vulnerability.*[13] The USGCRP, IPCC, and NRC assessments have been reviewed and formally accepted by, commissioned by, or in some cases authored by, U.S. government agencies and individual government scientists. These reports already reflect significant input from EPA's scientists and the scientists of many other government agencies.

EPA has no reason to believe that the assessment reports do not represent the best source material to determine the state of science and the consensus view of the world's scientific experts on the issues central to making an endangerment decision with respect to greenhouse gases. EPA also has no reason to believe that putting this significant body of work aside and attempting to develop a new and separate assessment would provide any better basis for making the endangerment decision, especially because any such new assessment by EPA would still have to give proper weight to these same consensus assessment reports.

In summary, EPA concludes that its reliance on existing and recent synthesis and assessment reports is entirely reasonable and allows EPA to rely on the best available science.[14] EPA also recognizes that scientific research is very active in many areas addressed in the TSD (*e.g.,* aerosol effects on climate, climate feedbacks such as water vapor, and internal and external climate forcing mechanisms), as well as for some emerging issues (*e.g.,* ocean acidification and climate change effects on water quality). EPA recognizes the potential importance of new scientific research, and the value of an ongoing process to take more recent science into account. EPA reviewed new literature in

[11] *http://www.globalchange.gov/publications/reports/ipcc-reports.*

[12] CCSP (2009) *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [James G. Titus (Coordinating Lead Author), K. Eric Anderson, Donald R. Cahoon, Dean B. Gesch, Stephen K. Gill, Benjamin T. Gutierrez, E. Robert Thieler, and S. Jeffress Williams (Lead Authors)], U.S. Environmental Protection Agency, Washington DC, USA, 320 pp. CCSP (2008) *Preliminary review of adaptation options for climate-sensitive ecosystems and resources.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Julius, S.H., J.M. West (eds.), J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA, 873 pp. CCSP (2008) *Analyses of the effects of global change on human health and welfare and human systems.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Gamble, J.L. (ed.), K.L. Ebi, F.G. Sussman, T.J. Wilbanks, (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA.

[13] IPCC (2007) Climate Change 2007: *Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

[14] It maintains the highest level of adherence to Agency and OMB guidelines for data and scientific integrity and transparency. This is discussed in greater detail in EPA's Response to Comments document.

preparation of this TSD to evaluate its consistency with recent scientific assessments. We also considered public comments received and studies incorporated by reference. In a number of cases, the TSD was updated based on such information to add context for assessment literature findings, which includes supporting information and/or qualifying statements. In other cases, material that was not incorporated into the TSD is discussed within the Response to Comments document.

EPA reviewed these individual studies that were not considered or reflected in these major assessments to evaluate how they inform our understanding of how greenhouse gas emissions affect climate change, and how climate change may affect public health and welfare. Given the very large body of studies reviewed and assessed in developing the assessment reports, and the rigor and breadth of that review and assessment, EPA placed limited weight on the much smaller number of individual studies that were not considered or reflected in the major assessments. EPA reviewed them largely to see if they would lead EPA to change or place less weight on the judgments reflected in the assessment report. While EPA recognizes that some studies are more useful or informative than others, and gave each study it reviewed the weight it was due, the overall conclusion EPA drew from its review of studies submitted by commenters was that the studies did not change the various conclusions or judgments EPA would draw based on the assessment reports.

Many comments focus on the scientific and technical data underlying the Proposed Findings, such as climate change science and greenhouse gas emissions data. These comments cover a range of topics and are summarized and responded to in the Response to Public Comments document. The responses note those cases where a technical or scientific comment resulted in an editorial or substantive change to the TSD. The final TSD reflects all changes made as a result of public comments.

B. The Law on Which the Decisions Are Based

In addition to grounding these determinations on the science, they are also firmly grounded in EPA's legal authority. Section II of these Findings provides an in-depth discussion of the legal framework for the endangerment and cause or contribute decisions under CAA section 202(a), with additional discussion in Section II of the Proposed Finding (74 FR 18886, 18890, April 24, 2009). A variety of important legal issues are also discussed in Sections III, IV, and V of these Findings, as well as in the Response to Comments document, Volume 11. Section IV and V of these Findings explain the Administrator's decisions, and how she exercised her judgment in making the endangerment and contribution determinations, based on the entire scientific record before her and the legal framework structuring her decision making.

C. Adaptation and Mitigation

Following the language of CAA section 202(a), in which the Administrator, in her judgment, must determine if greenhouse gases constitute the air pollution that may be reasonably anticipated to endanger public health or welfare, EPA evaluated, based primarily on the scientific reports discussed above, how greenhouse gases and other climate-relevant substances are affecting the atmosphere and climate, and how these climate changes affect public health and welfare, now and in the future. Consistent with EPA's scientific approach underlying the Administrator's Proposed Findings, EPA did not undertake a separate analysis to evaluate potential societal and policy responses to any threat (*i.e.,* the endangerment) that may exist due to anthropogenic emissions of greenhouse gases. Risk reduction through adaptation and greenhouse gas mitigation measures is of course a strong focal area of scientists and policy makers, including EPA; however, EPA considers adaptation and mitigation to be potential responses to endangerment, and as such has determined that they are outside the scope of the endangerment analysis.

The Administrator's position is not that adaptation will not occur or cannot help protect public health and welfare from certain impacts of climate change, as some commenters intimated. To the contrary, EPA recognizes that some level of autonomous adaptation [15] will occur, and commenters are correct that autonomous adaptation can affect the severity of climate change impacts. Indeed, there are some cases in the TSD in which some degree of adaptation is accounted for; these cases occur where the literature on which the TSD relies already uses assumptions about autonomous adaptation when projecting the future effects of climate change. Such cases are noted in the TSD. We also view planned adaptation as an important near-term risk-minimizing strategy given that some degree of climate change will continue to occur as a result of past and current emissions of greenhouse gases that remain in the atmosphere for decades to centuries.

However, it is the Administrator's position that projections of adaptation and mitigation in response to risks and impacts associated with climate change are not appropriate for EPA to consider in making a decision on whether the air pollution endangers. The issue before EPA involves evaluating the risks to public health and welfare from the air pollution if we do not take action to address it. Adaptation and mitigation address an important but different issue—how much risk will remain assuming some projection of how people and society will respond to the threat.

Several commenters argue that it is arbitrary not to consider adaptation in determining endangerment. They contend that because endangerment is a forward-looking exercise, the fundamental inquiry concerns the type and extent of harm that is believed likely to occur in the future. Just as the Administrator makes projections of potential harms in the future, these commenters contend that the Administrator needs to consider the literature on adaptation that addresses the likelihood and the severity of potential effects. Commenters also note that since adaption is one of the likely impacts of climate change, it is irrational to exclude it from consideration when the goal is to evaluate the risks and harms in the real world in the future, not the risks and harms in the hypothetical scenario that result if you ignore adaptation.

According to commenters, the Administrator must consider both autonomous adaptation and anticipatory adaptation. They contend that literature on adaptation makes it clear there is a significant potential for adaptation, and that it can reduce the likelihood or severity of various effects, including health effects, and could even avert what might otherwise constitute endangerment. Commenters note that EPA considered the adaptation of species in nature, and it is arbitrary to not also consider adaptation by humans. Moreover, they argue that there is great

[15] The IPCC definition of adaptation: ''Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realize new opportunities.'' The IPCC defines autonomous adaptation as ''Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.''

certainty that adaptation will occur, and thus EPA is required to address it and make projections. They recommend that EPA look to historic responses to changes in conditions as an analogue in making projections, recognizing that life in the United States is likely to be quite different 50 or 100 years from now, irrespective of climate change.

Commenters argue that adaption needs to be considered because it is central to the statutory requirements governing the endangerment inquiry. EPA is charged to determine the type and extent of harms that are likely to occur, and they argue that this can not rationally be considered without considering adaptation. Since some degree of adaptation is likely to occur, they continue that such a projection of future actual conditions requires consideration of adaption to evaluate whether the future conditions amount to endangerment from the air pollution.

According to commenters, the issue therefore is focused on human and societal adaptation, which can come in a wide variety of forms, ranging from changes in personal behavioral patterns to expenditures of resources to change infrastructure, such as building and maintaining barriers to protect against sea level rise.

With regard to mitigation, commenters argue that EPA should consider mitigation strategies and their potential to alleviate harm from greenhouse gas emissions. They contend that it is unreasonable for EPA to assume that society will not undertake mitigation.

Section 202(a) of the CAA reflects the basic approach of many CAA sections—the threshold inquiry is whether the endangerment and cause or contribute criteria are satisfied, and only if they are met do the criteria for regulatory action go into effect. This reflects the basic separation of two different decisions—is this a health and welfare problem that should be addressed, and if so what are the appropriate mechanisms to address it? There is a division between identifying the health and welfare problem associated with the air pollution, and identifying the mechanisms used to address or solve the problem.

In evaluating endangerment, EPA is determining whether the risks to health and welfare from the air pollution amount to endangerment. As commenters recognize, that calls for evaluating and projecting the nature and types of risks from the air pollution, including the probability or likelihood of the occurrence of an impact and the degree of adversity (or benefit) of such an impact. This issue focuses on how EPA makes such an evaluation in determining endangerment—does EPA look at the risks assuming no planned adaptation and/or mitigation, although EPA projects some degree is likely to occur, or does EPA look at the risks remaining after some projection of adaptation and/or mitigation?

These two approaches reflect different views of the core question EPA is trying to answer. The first approach most clearly focuses on just the air pollution and its impacts, and aims to separate this from the human and societal responses that may or should be taken in response to the risks from the air pollution. By its nature, this separation means this approach may not reflect the actual conditions in the real world in the future, because adaptation and/or mitigation may occur and change the risks. For example, adaptation would not change the atmospheric concentrations, or the likelihood or probability of various impacts occurring (*e.g.*, it would not change the degree of sea level rise), but adaptation has the potential to reduce the adversity of the effects that do occur from these impacts. Mitigation could reduce the atmospheric concentrations that would otherwise occur, having the potential to reduce the likelihood or probability of various impacts occurring. Under this approach, the evaluation of risk is focused on the risk if we do not address the problem. It does not answer the question of how much risk we project will remain after we do address the problem, through either adaptation or mitigation or some combination of the two.

The second approach, suggested by commenters, would call for EPA to project into the future adaptation and/or mitigation, and the effect of these measures in reducing the risks to health or welfare from the air pollution. Commenters argue this will better reflect likely real world conditions, and therefore is needed to allow for an appropriate determination of whether EPA should, at this time, make an affirmative endangerment finding. However, this approach would not separate the air pollution and its impacts from the human and societal responses to the air pollution. It would intentionally and inextricably intertwine them. It would inexorably change the focus from how serious is the air pollution problem we need to address to how good a job are people and society likely to do in addressing or solving the problem. In addition it would dramatically increase the complexity of the issues before EPA.

The context for this endangerment finding is a time span of several decades into the future. It involves a wide variety of differing health and welfare effects, and almost every sector in our society. This somewhat unique context tends to amplify the differences between the two different approaches. It also means that it is hard to cleanly implement either approach. For example, it is hard under the first approach to clearly separate impacts with and without adaption, given the nature of the scientific studies and information before us. Under the second approach it would be extremely hard to make a reasoned projection of human and societal adaptation and mitigation responses, because these are basically not scientific or technical judgments, but are largely political judgments for society or individual personal judgments.

However, the context for this endangerment finding does not change the fact that at their core the two different approaches are aimed at answering different questions. The first approach is focused on answering the question of what are the risks to public health and welfare from the air pollution if we do not take action to address it. The second approach is focused on answering the question of how much risk will remain assuming some projection of how people and society will respond.

EPA believes that it is appropriate and reasonable to interpret CAA section 202(a) as calling for the first approach. The structure of CAA section 202(a) and the various other similar provisions indicate an intention by Congress to separate the question of what is the problem we need to address from the question of what is the appropriate way to address it. The first approach is clearly more consistent with this statutory structure. The amount of reduction in risk that might be achieved through adaptation and/or mitigation is closely related to the way to address a problem, and is not focused on what is the problem that needs to be addressed. It helps gauge the likelihood of success in addressing a problem, and how good a job society may do in reducing risk; it is not at all as useful in determining the severity of the problem that needs to be addressed.

The endangerment issue at its core is a decision on whether there is a risk to health and welfare that needs to be addressed, and the second approach would tend to indicate that the more likely a society is to solve a problem, the less likely there is a problem that needs to be addressed. This would mask the issue and provide a directionally wrong signal. Assume two different situations, both presenting the same serious risks to

public health or welfare without consideration of adaptation or mitigation. The more successful society is projected to be in solving the serious problem in the future would mean the less likely we would be to make an endangerment finding at the inception identifying it as a problem that needs to be addressed. This is much less consistent with the logic embodied in CAA section 202(a), which separates the issue of whether there is a problem from the issue of what can be done to successfully address it.

In addition, the second approach would dramatically increase the complexity of the issues to resolve, and would do this by bringing in issues that are not the subject of the kind of scientific or technical judgments that Congress envisioned for the endangerment test. The legislative history indicates Congress was focused on issues of science and medicine, including issues at the frontiers of these fields. It referred to data, research resources, science and medicine, chemistry, biology, and statistics. There is no indication Congress envisioned exercising judgment on the very different types of issues involved in projecting the political actions likely to be taken by various local, State, and Federal governments, or judgments on the business or other decisions that are likely to be made by companies or other organizations, or the changes in personal behavior that may be occasioned by the adverse impacts of air pollution. The second approach would take EPA far away from the kind of judgments Congress envisioned for the endangerment test.

D. Geographic Scope of Impacts

It is the Administrator's view that the primary focus of the vulnerability, risk, and impact assessment is the United States. As described in Section IV of these Findings, the Administrator gives some consideration to climate change effects in world regions outside of the United States. Given the global nature of climate change, she has also examined potential impacts in other regions of the world. Greenhouse gases, once emitted, become well mixed in the atmosphere, meaning U.S. emissions can affect not only the U.S. population and environment, but other regions of the world as well. Likewise, emissions in other countries can affect the United States. Furthermore, impacts in other regions of the world may have consequences that in turn raise humanitarian, trade, and national security concerns for the United States.

Commenters argue that EPA does not have the authority to consider international effects. They contend that the burden is on EPA is to show endangerment based on impacts in the United States. They note that EPA proposed this approach, which is the only relevant issue for EPA. The purpose of CAA section 202(a), as the stated purpose of the CAA, commenters note, is to protect the quality of the nation's air resources and to protect the health and welfare of the U.S. population. Thus, they continue, international public health and welfare are not listed or stated, and are not encompassed by these provisions. Moreover, they argue that Congress addressed international impacts expressly in two other provisions of the CAA. They note that under CAA section 115, EPA considers emissions of pollutants that cause or contribute to air pollution that is reasonably anticipated to endanger public health or welfare in a foreign country, and that CAA section 179B addresses emissions of air pollutants in foreign countries that interfere with attainment of a National Ambient Air Quality Standards (NAAQS) in the United States. Because Congress intentionally addressed international impacts in those provision, commenters argue that the absence of this direction in CAA section 202(a) means that EPA is not to consider international effects when assessing endangerment under this provision.

Commenters fail to recognize that EPA's consideration of international effects is directed at evaluating their impact on the public health and welfare of the U.S. population. EPA is not considering international effects to determine whether the health and welfare of the public in a foreign country is endangered. Instead, EPA's consideration of international effects for purposes of determining endangerment is limited to how those international effects impact the health and welfare of the U.S. population.

The Administrator looked first at impacts in the United States itself, and determined that these impacts are reasonably anticipated to endanger the public health and the welfare of the U.S. population. That remains the Administrator's position, and by itself supports her determination of endangerment. The Administrator also considered the effects of global climate change outside the borders of the United States and evaluated them to determine whether these international effects impact the U.S. population, and if so whether it impacts the U.S. population in a manner that supports or does not support endangerment to the health and welfare of the U.S. public. She is not evaluating international effects to determine whether populations in a foreign country are endangered. The Administrator is looking at international effects solely for the purpose of evaluating their effects on the U.S. population.

For example, the U.S. population can be impacted by effects in other countries. These international effects can impact U.S. economic, trade, and humanitarian and national security interests. These would be potential effects on the U.S. population, brought about by the effects of climate change occurring outside the United States. It is fully reasonable and rational to expect that events occurring outside our borders can affect the U.S. population.

Thus, commenters misunderstand the role that international effects played in the proposal. The Administrator is not evaluating the impact of international effects on populations outside the United States; she is considering what impact these international effects could have on the U.S. population. That is fully consistent with the CAA's stated purpose of protecting the health and welfare of this nation's population.

E. Temporal Scope of Impacts

An additional parameter of the endangerment analysis is the timeframe. The Administrator's view is that the timeframe over which vulnerabilities, risks, and impacts are considered should be consistent with the timeframe over which greenhouse gases, once emitted, have an effect on climate. Thus the relevant time frame is decades to centuries for the primary greenhouse gases of concern. Therefore, in addition to reviewing recent observations, the underlying science upon which the Administrator is basing her findings generally considers the next several decades—the time period out to around 2100, and for certain impacts, the time period beyond 2100. How the accumulation of atmospheric greenhouse gases and resultant climate change may affect current and future generations is discussed in section IV in these Findings. By current generations we mean a near-term time frame of approximately the next 10 to 20 years; by future generations we mean a longer-term time frame extending beyond that. Some public comments were received that questioned making an endangerment finding based on current conditions, while others questioned EPA's ability to make an endangerment finding based on future projected conditions. Some of these comments are likewise addressed in Section IV in these Findings; and all comments on these temporal issues are addressed in the Response to Comments document.

F. Impacts of Potential Future Regulations and Processes That Generate Greenhouse Gas Emissions

This action is a stand-alone set of findings regarding endangerment and cause or contribute for greenhouse gases under CAA section 202(a), and does not contain any regulatory requirements. Therefore, this action does not attempt to assess the impacts of any future regulation. Although EPA would evaluate any future proposed regulation, many commenters argue that such a regulatory analysis should be part of the endangerment analysis.

Numerous commenters argue that EPA must fully consider the adverse and beneficial impacts of regulation together with the impacts of inaction, and describe this balancing as ''risk-risk analysis,'' ''health-health analysis,'' and most predominantly ''risk tradeoff analysis.'' Commenters argue that EPA's final endangerment finding would be arbitrary unless EPA undertakes this type of risk trade-off analysis.

Commenters specifically argue that EPA must consider the economic impact of regulation, including the Prevention of Significant Deterioration (PSD) permitting program for major stationary sources because it is triggered by a CAA section 202(a) standard, when assessing whether there is endangerment to public welfare. In other words, they argue that the Administrator should determine if finding endangerment and regulating greenhouse gases under the CAA would be worse for public health and welfare than not regulating. Commenters also argue that the reference to ''public'' health or welfare in CAA section 202, as well as the fact that impacts on the economy should be considered impacts to welfare, especially requires EPA to consider the full range of possible impacts of regulation. Commenters provide various predictions regarding how regulating greenhouse gases under the CAA more broadly will impact the public, industry, states the overall economy, and thus, they conclude, public health and welfare. Examples of commenters' predictions include potential adverse impacts on (1) the housing industry and the availability of affordable housing, (2) jobs and income due to industry moving overseas, (3) the agriculture industry and its ability to provide affordable food, and (4) the nation's energy supply. They also cite to the letter from the Office of Management and Budget provided with the ANPR, as well as interagency comments on the draft Proposed Findings, in support of their argument.

At least one commenter argues that EPA fails to discuss the public health or welfare benefits of the processes that *produce* the emissions. The commenter contends that for purposes of CAA section 202(a), this process would be the combustion of gasoline or other transportation fuel in new motor vehicles, and that for purposes of other CAA provisions with similar endangerment finding triggers, the processes would be the combustion of fossil fuel for electric generation and other activities. The commenter continues that EPA's decision to limit its analysis to the perceived detrimental aspects of emissions after they enter the atmosphere—as opposed to the possible positive aspects of emissions because of the processes that create the emissions—is based on EPA's overly narrow interpretation of both the meaning of the term ''emission'' in CAA section 202(a) (and therefore in other endangerment finding provisions) and the intent of these provisions. The commenter states that logically, it makes little sense to limit the definition of the term ''emission'' to only the ''air pollutants'' that are emitted. The commenter concludes that when EPA assesses whether the emission of greenhouse gases endanger public health and welfare, EPA must assess the dangers and benefits on both sides of the point where the emissions occur: in the atmosphere where the emissions lodge and, on the other side of the emitting stack or structure, in the processes that create the emissions. Otherwise, EPA will not be able to accurately assess whether the fact that society emits greenhouse gases is a benefit or a detriment. The commenter states that because greenhouse gas emissions, particularly carbon dioxide emissions, are so closely tied with all facets of modern life, a finding that greenhouse gas emissions endanger public health and welfare is akin to saying that modern life endangers public health or welfare. The commenter states that simply cannot be true because the lack of industrial activity that causes greenhouse gas emissions would pose other, almost certainly more serious health and welfare consequences.

Finally, some commenters argue that the impact of regulating under CAA section 202(a) supports making a final, negative endangerment finding. These commenters contend that the incredible costs associated with using the inflexible regulatory structure of the CAA will harm public health and welfare, and therefore EPA should exercise its discretion and find that greenhouse gases do not endanger public health and welfare because once EPA makes an endangerment finding under CAA section 202(a), it will be forced to regulate greenhouse gases under a number of other sections of the CAA, resulting in regulatory chaos.

At their core, these comments are not about whether commenters believe greenhouse gases may reasonably be anticipated to endanger public health or welfare, but rather about commenters' dissatisfaction with the decisions that Congress made regarding *the response* to any endangerment finding that EPA makes under CAA section 202(a). These comments do not discuss the science of greenhouse gases or climate change, or the impacts of climate change on public health or welfare. Instead they muddle the rather straightforward scientific judgment about whether there may be endangerment by throwing the potential impact of responding to the danger into the initial question. To use an analogy, the question of whether the cure is worse than the illness is different than the question of whether there is an illness in the first place. The question of whether there is endangerment is like the question of whether there is an illness. Once one knows there is an illness, then the next question is what to do, if anything, in response to that illness.

What these comments object to is that Congress has already made some decisions about next steps after a finding of endangerment, and commenters are displeased with the results. But if this is the case, commenters should take up their concerns with Congress, not EPA. EPA's charge is to issue new motor vehicle standards under CAA section 202(a) applicable to emissions of air pollutants that cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. It is not to find that there is no endangerment in order to avoid issuing those standards, and dealing with any additional regulatory impact.

Indeed, commenters' argument would insert policy considerations into the endangerment decision, an approach already rejected by the Supreme Court. First, as discussed in Section I.B of these Findings, in *Massachusetts* v. *EPA*, the court clearly indicated that the Administrator's decision must be a ''scientific judgment.'' 549 U.S. at 534. She must base her decision about endangerment on the science, and not on policy considerations about the repercussions or impact of such a finding.

Second, in considering whether the CAA allowed for economic considerations to play a role in the promulgation of the NAAQS, the

Supreme Court rejected arguments that because many more factors than air pollution might affect public health, EPA should consider compliance costs that produce health losses in setting the NAAQS. *Whitman* v. *ATA*, 531 U.S. at 457, 466 (2001). To be sure, the language in CAA section 109(b) applicable to the setting of a NAAQS is different than that in CAA section 202(a) regarding endangerment. But the concepts are similar—the NAAQS are about setting standards at a level requisite to protect public health (with an adequate margin of safety) and public welfare, and endangerment is about whether the current or projected future levels may reasonably be anticipated to endanger public health or welfare. In other words, both decisions essentially are based on assessing the harm associated with a certain level of air pollution.

Given this similarity in purpose, as well as the Court's instructions in *Massachusetts* v. *EPA* that the Administrator should base her decision on the science, EPA reasonably interprets the statutory endangerment language to be analogous to setting the NAAQS. Therefore, it is reasonable to interpret the endangerment test as not requiring the consideration of the impacts of implementing the statute in the event of an endangerment finding as part of the endangerment finding itself.[16]

Moreover, EPA does not believe that the impact of regulation under the CAA as a whole, let alone that which will result from this particular endangerment finding, will lead to the panoply of adverse consequences that commenters predict. EPA has the ability to fashion a reasonable and common-sense approach to address greenhouse gas emissions and climate change. The Administrator thinks that EPA has and will continue to take a measured approach to address greenhouse gas emissions. For example, the Agency's recent Mandatory Greenhouse Gas Reporting Rule focuses on only the largest sources of greenhouse gases in order to reduce the burden on smaller facilities.[17]

We also note that commenters' approach also is another version of the argument that EPA must consider adaptation and mitigation in the endangerment determination. Just as EPA should consider whether mitigation would *reduce* endangerment, commenters argue we should consider whether mitigation would *increase* endangerment. But as discussed previously, EPA disagrees and believes its approach better achieves the goals of the statute.

Finally, EPA simply disagrees with the commenter who argues that because we are better off now than before the industrial revolution, greenhouse gases cannot be found to endanger public health or welfare. As the DC Circuit noted in the *Ethyl* decision, ''[m]an's ability to alter his environment has developed far more rapidly than his ability to foresee with certainty the effects of his alterations.'' See *Ethyl Corp.,* 541 F.2d at 6. The fact that we as a society are better off now than 100 years ago, and that processes that produce greenhouse gases are a large part of this improvement, does not mean that those processes do not have unintended adverse impacts. It also was entirely reasonable for EPA to look at ''emissions'' as the pollution once it is emitted from the source into the air, and not also as the process that generates the pollution. Indeed, the definition of ''air pollutant'' talks in terms of substances ''emitted into or otherwise enter[ing] the ambient air'' (CAA section 302(g)). It is entirely appropriate for EPA to consider only the substance being emitted as the air pollution or air pollutant.

IV. The Administrator's Finding That Greenhouse Gases Endanger Public Health and Welfare

The Administrator finds that elevated concentrations of greenhouse gases in the atmosphere may reasonably be anticipated to endanger the public health and to endanger the public welfare of current and future generations. The Administrator is making this finding specifically with regard to six key directly-emitted, long-lived and well-mixed greenhouse gases: Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The Administrator is making this judgment based on both current observations and projected risks and impacts into the future. Furthermore, the Administrator is basing this finding on impacts of climate change within the United States. However, the Administrator finds that when she considers the impacts on the U.S. population of risks and impacts occurring in other world regions, the case for endangerment to public health and welfare is only strengthened.

A. The Air Pollution Consists of Six Key Greenhouse Gases

The Administrator must define the scope and nature of the relevant air pollution for the endangerment finding under CAA section 202(a). In this final action, the Administrator finds that the air pollution is the combined mix of six key directly-emitted, long-lived and well-mixed greenhouse gases (henceforth ''well-mixed greenhouse gases''), which together, constitute the root cause of human-induced climate change and the resulting impacts on public health and welfare. These six greenhouse gases are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

EPA received public comments on this definition of air pollution from the Proposed Findings, and summarizes responses to some of those key comments below; fuller responses to public comments can be found in EPA's Response to Comments document, Volume 9. The Administrator acknowledges that other anthropogenic climate forcers also play a role in climate change. Many public comments either supported or opposed inclusion of other substances in addition to the six greenhouse gases for the definition of air pollution. EPA's responses to those comments are also summarized below, and in volume 9 of the Response to Comments document.

The Administrator explained her rationale for defining air pollution under CAA section 202(a) as the combined mix of the six greenhouse gases in the Proposed Findings. After review of the public comments, the Administrator is using the same definition of the air pollution in the

[16] Indeed, some persons may argue that due to the similarities between setting a NAAQS and making an endangerment finding, EPA cannot consider the impacts of implementation of the statute.

[17] Note that it is EPA's current position that these Final Findings do not make well-mixed greenhouse gases ''subject to regulation'' for purposes of the CAA's Prevention of Significant Deterioration (PSD) and title V programs. *See, e.g.*, memorandum entitled ''EPA's Interpretation of Regulations that Determine Pollutants Covered By Federal Prevention of Significant Deterioration (PSD) Permit Program'' (Dec. 18, 2008). While EPA is reconsidering this memorandum and is seeking public comment on the issues raised in it generally, including whether a final endangerment finding should trigger PSD, the effectiveness of the positions provided in the memorandum was not stayed pending that reconsideration. Prevention of Significant Deterioration (PSD): Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by the Federal PSD Permit Program, 74 FR 515135, 51543–44 (Oct. 7, 2009). In addition, EPA has proposed new temporary thresholds for greenhouse gas emissions that define when PSD and title V permits are required for new or existing facilities. Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule (74 FR 55292, October 27, 2009). The proposed thresholds would ''tailor'' the permit programs to limit which facilities would be required to obtain PSD and title V permits. As noted in the preamble for the tailoring rule proposal, EPA also intends to evaluate ways to streamline the process for identifying GHG emissions control requirements and issuing permits. See the Response to Comments Document, Volume 11, and the Tailoring Rule, for more information.

final finding, for the following reasons: (1) These six greenhouse gas share common properties regarding their climate effects; (2) these six greenhouse gases have been estimated to be the primary cause of human-induced climate change, are the best understood drivers of climate change, and are expected to remain the key driver of future climate change; (3) these six greenhouse gases are the common focus of climate change science research and policy analyses and discussions; (4) using the combined mix of these gases as the definition (versus an individual gas-by-gas approach) is consistent with the science, because risks and impacts associated with greenhouse gas-induced climate change are not assessed on an individual gas approach; and (5) using the combined mix of these gases is consistent with past EPA practice, where separate substances from different sources, but with common properties, may be treated as a class (*e.g.,* oxides of nitrogen).

1. Common Physical Properties of the Six Greenhouse Gases

The common physical properties relevant to the climate change problem shared by the six greenhouse gases include the fact that they are long-lived in the atmosphere. ''Long-lived'' is used here to mean that the gas has a lifetime in the atmosphere sufficient to become globally well mixed throughout the entire atmosphere, which requires a minimum atmospheric lifetime of about one year.[18] Thus, this definition of air pollution is global in nature because the greenhouse gas emissions emitted from the United States (or from any other region of the world) become globally well mixed, such that it would not be meaningful to define the air pollution as the greenhouse gas concentrations over the United States as somehow being distinct from the greenhouse gas concentrations over other regions of the world.

It is also well established that each of these gases can exert a warming effect on the climate by trapping in heat that would otherwise escape to space. These six gases are directly emitted as greenhouse gases rather than forming as a greenhouse gas in the atmosphere after emission of a pre-cursor gas. Given these properties, the magnitude of the warming effect of each of these gases is generally better understood than other climate forcing agents that do not share these same properties (addressed in more detail below). The ozone-depleting substances that include chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HFCs) also share the same physical attributes discussed here, but for reasons discussed throughout the remainder of this section are not being included in the Administrator's definition of air pollution for this finding.

2. Evidence That the Six Greenhouse Gases Are the Primary Driver of Current and Projected Climate Change

a. Key Observations Driven Primarily by the Six Greenhouse Gases

The latest assessment of the USGCRP, as summarized in EPA's TSD, confirms the evidence presented in the Proposed Findings that current atmospheric greenhouse gas concentrations are now at elevated and essentially unprecedented levels as a result of both historic and current anthropogenic emissions. The global atmospheric carbon dioxide concentration has increased about 38 percent from pre-industrial levels to 2009, and almost all of the increase is due to anthropogenic emissions. The global atmospheric concentration of methane has increased by 149 percent since pre-industrial levels (through 2007); and the nitrous oxide concentration has increased 23 percent (through 2007). The observed concentration increase in these gases can also be attributed primarily to anthropogenic emissions. The industrial fluorinated gases have relatively low concentrations, but these concentrations have also been increasing and are almost entirely anthropogenic in origin.

Historic data show that current atmospheric concentrations of the two most important directly emitted, long-lived greenhouse gases (carbon dioxide and methane) are well above the natural range of atmospheric concentrations compared to at least the last 650,000 years. Atmospheric greenhouse gas concentrations have been increasing because anthropogenic emissions are outpacing the rate at which greenhouse gases are removed from the atmosphere by natural processes over timescales of decades to centuries. It also remains clear that these high atmospheric concentrations of greenhouse gases are the unambiguous result of human activities.

Together the six well-mixed greenhouse gases constitute the largest anthropogenic driver of climate change.[19] Of the total anthropogenic heating effect caused by the accumulation of the six well-mixed greenhouse gases plus other warming agents (that do not meet all of the Administrator's criteria that pertain to the six greenhouse gases) since pre-industrial times, the combined heating effect of the six well-mixed greenhouses is responsible for roughly 75 percent, and it is expected that this share may grow larger over time, as discussed below.

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Global mean surface temperatures have risen by 0.74 °C (1.3 °F) (±0.18 °C) over the last 100 years. Eight of the 10 warmest years on record have occurred since 2001. Global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries.

The global surface temperature record relies on three major global temperature datasets, developed by NOAA, NASA, and the United Kingdom's Hadley Center. All three show an unambiguous warming trend over the last 100 years, with the greatest warming occurring over the past 30 years.[20] Furthermore, all three datasets show that eight of the 10 warmest years on record have occurred since 2001; that the 10 warmest years have all occurred in the past 12 years; and that the 20 warmest years have all occurred since 1981. Though most of the warmest years on record have occurred in the last decade in all available datasets, the rate of warming has, for a short time in the

[18] The IPCC also refers to these six GHGs as long-lived. Methane has an atmospheric lifetime of roughly a decade. One of the most commonly used hydrofluorocarbons (HFC–134a) has a lifetime of 14 years. Nitrous oxide has a lifetime of 114 years; sulfur hexafluoride over 3,000 years; and some PFCs up to 10,000 to 50,000 years. Carbon dioxide in the atmosphere is sometimes approximated as having a lifetime of roughly 100 years, but for a given amount of carbon dioxide emitted a better description is that some fraction of the atmospheric increase in concentration is quickly absorbed by the oceans and terrestrial vegetation, some fraction of the atmospheric increase will only slowly decrease over a number of years, and a small portion of the increase will remain for many centuries or more.

[19] As summarized in EPA's TSD, the global average net effect of the increase in atmospheric greenhouse gas concentrations, plus other human activities (*e.g.,* land use change and aerosol emissions), on the global energy balance since 1750 has been one of warming. This total net heating effect, referred to as forcing, is estimated to be +1.6 (+0.6 to +2.4) Watts per square meter (W/m^2), with much of the range surrounding this estimate due to uncertainties about the cooling and warming effects of aerosols. The combined radiative forcing due to the cumulative (*i.e.,* 1750 to 2005) increase in atmospheric concentrations of CO_2, CH_4, and N_2O is estimated to be +2.30 (+2.07 to +2.53) W/m^2. The rate of increase in positive radiative forcing due to these three GHGs during the industrial era is very likely to have been unprecedented in more than 10,000 years.

[20] *See* section 4 of the TSD for more detailed information about the three global temperature datasets.

Hadley Center record, slowed. However, the NOAA and NASA trends do not show the same marked slowdown for the 1999–2008 period. Year-to-year fluctuations in natural weather and climate patterns can produce a period that does not follow the long-term trend. Thus, each year may not necessarily be warmer than every year before it, though the long-term warming trend continues.[21]

The scientific evidence is compelling that elevated concentrations of heat-trapping greenhouse gases are the root cause of recently observed climate change. The IPCC conclusion from 2007 has been re-confirmed by the June 2009 USGCRP assessment that most of the observed increase in global average temperatures since the mid-20th century is very likely [22] due to the observed increase in anthropogenic greenhouse gas concentrations. Climate model simulations suggest natural forcing alone (*e.g.,* changes in solar irradiance) cannot explain the observed warming.

The attribution of observed climate change to anthropogenic activities is based on multiple lines of evidence. The first line of evidence arises from our basic physical understanding of the effects of changing concentrations of greenhouse gases, natural factors, and other human impacts on the climate system. The second line of evidence arises from indirect, historical estimates of past climate changes that suggest that the changes in global surface temperature over the last several decades are unusual.[23] The third line of evidence arises from the use of computer-based climate models to simulate the likely patterns of response of the climate system to different forcing mechanisms (both natural and anthropogenic).

The claim that natural internal variability or known natural external forcings can explain most (more than half) of the observed global warming of the past 50 years is inconsistent with the vast majority of the scientific literature, which has been synthesized in several assessment reports. Based on analyses of widespread temperature increases throughout the climate system and changes in other climate variables, the IPCC has reached the following conclusions about external climate forcing: ''It is extremely unlikely (<5 percent) that the global pattern of warming during the past half century can be explained without external forcing, and very unlikely that it is due to known natural external causes alone'' (Hegerl *et al.,* 2007). With respect to internal variability, the IPCC reports the following: ''The simultaneous increase in energy content of all the major components of the climate system as well as the magnitude and pattern of warming within and across the different components supports the conclusion that the cause of the [20th century] warming is extremely unlikely (<5 percent) to be the result of internal processes'' (Hegerl *et al.,* 2007). As noted in the TSD, the observed warming can only be reproduced with models that contain both natural and anthropogenic forcings, and the warming of the past half century has taken place at a time when known natural forcing factors alone (solar activity and volcanoes) would likely have produced cooling, not warming.

United States temperatures also warmed during the 20th and into the 21st century; temperatures are now approximately 0.7 °C (1.3 °F) warmer than at the start of the 20th century, with an increased rate of warming over the past 30 years. Both the IPCC and CCSP reports attributed recent North American warming to elevated greenhouse gas concentrations. The CCSP (2008g) report finds that for North America, ''more than half of this warming [for the period 1951–2006] is likely the result of human-caused greenhouse gas forcing of climate change.''

Observations show that changes are occurring in the amount, intensity, frequency, and type of precipitation. Over the contiguous United States, total annual precipitation increased by 6.1 percent from 1901–2008. It is likely that there have been increases in the number of heavy precipitation events within many land regions, even in those where there has been a reduction in total precipitation amount, consistent with a warming climate.

There is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate. It is very likely that the response to anthropogenic forcing contributed to sea level rise during the latter half of the 20th century. It is not clear whether the increasing rate of sea level rise is a reflection of short-term variability or an increase in the longer-term trend. Nearly all of the Atlantic Ocean shows sea level rise during the last 50 years with the rate of rise reaching a maximum (over 2 mm per year) in a band along the U.S. east coast running east-northeast.

Satellite data since 1979 show that annual average Arctic sea ice extent has shrunk by 4.1 percent per decade. The size and speed of recent Arctic summer sea ice loss is highly anomalous relative to the previous few thousands of years.

Widespread changes in extreme temperatures have been observed in the last 50 years across all world regions including the United States. Cold days, cold nights, and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent.

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. However, directly attributing specific regional changes in climate to emissions of greenhouse gases from human activities is difficult, especially for precipitation.

Ocean carbon dioxide uptake has lowered the average ocean pH (increased the acidity) level by approximately 0.1 since 1750. Consequences for marine ecosystems may include reduced calcification by shell-forming organisms, and in the longer term, the dissolution of carbonate sediments.

Observations show that climate change is currently affecting U.S. physical and biological systems in significant ways. The consistency of these observed changes in physical and biological systems and the observed significant warming likely cannot be explained entirely due to natural variability or other confounding non-climate factors.

b. Key Projections Based Primarily on Future Scenarios of the Six Greenhouse Gases

There continues to be no reason to expect that, without substantial and near-term efforts to significantly reduce emissions, atmospheric levels of greenhouse gases will not continue to climb, and thus lead to ever greater rates of climate change. Given the long atmospheric lifetime of the six greenhouse gases, which range from roughly a decade to centuries, future atmospheric greenhouse gas

[21] Karl T. *et al.,* (2009).

[22] The IPCC Fourth Assessment Report uses specific terminology to convey likelihood and confidence. Likelihood refers to a probability that the statement is correct or that something will occur. ''Virtually certain'' conveys greater than 99 percent probability of occurrence; ''very likely'' 90 to 99 percent; ''likely'' 66 to 90 percent. IPCC assigns confidence levels as to the correctness of a statement. ''Very high confidence'' conveys at least 9 out of 10 chance of being correct; ''high confidence'' about 8 out of 10 chance; ''medium confidence'' about 5 out of 10 chance. The USGCRP uses the same or similar terminology in its reports. See also Box 1.2 of the TSD. Throughout this document, this terminology is used in conjunction with statements from the IPCC and USGCRP reports to convey the same meaning that those reports intended. In instances where a word such as ''likely'' may appear outside the context of a specific IPCC or USGCRP statement, it is not meant to necessarily convey the same quantitative meaning as the IPCC terminology.

[23] Karl T. *et al.* (2009).

concentrations for the remainder of this century and beyond will be influenced not only by future emissions but indeed by present-day and near-term emissions. Consideration of future plausible scenarios, and how our current greenhouse gas emissions essentially commit present and future generations to cope with an altered atmosphere and climate, reinforces the Administrator's judgment that it is appropriate to define the combination of the six key greenhouse gases as the air pollution.

Most future scenarios that assume no explicit greenhouse gas mitigation actions (beyond those already enacted) project increasing global greenhouse gas emissions over the century, which in turn result in climbing greenhouse gas concentrations. Under the range of future emission scenarios evaluated by the assessment literature, carbon dioxide is expected to remain the dominant anthropogenic greenhouse gas, and thus driver of climate change, over the course of the 21st century. In fact, carbon dioxide is projected to be the largest contributor to total radiative forcing in all periods and the radiative forcing associated with carbon dioxide is projected to be the fastest growing. For the year 2030, projections of the six greenhouse gases show an increase of 25 to 90 percent compared with 2000 emissions. Concentrations of carbon dioxide and the other well-mixed gases increase even for those scenarios where annual emissions toward the end of the century are assumed to be lower than current annual emissions. The radiative forcing associated with the non-carbon dioxide well-mixed greenhouse gases is still important and increasing over time. Emissions of the ozone-depleting substances are projected to continue decreasing due to the phase-out schedule under the Montreal Protocol on Substances that Deplete the Ozone Layer. Considerable uncertainties surround the estimates and future projections of anthropogenic aerosols; future atmospheric concentrations of aerosols, and thus their respective heating or cooling effects, will depend much more on assumptions about future emissions because of their short atmospheric lifetimes compared to the six well-mixed greenhouse gases.

Future warming over the course of the 21st century, even under scenarios of low emissions growth, is very likely to be greater than observed warming over the past century. According to climate model simulations summarized by the IPCC, through about 2030, the global warming rate is affected little by the choice of different future emission scenarios. By the end of the century, projected average global warming (compared to average temperature around 1990) varies significantly depending on emissions scenario and climate sensitivity assumptions, ranging from 1.8 to 4.0 °C (3.2 to 7.2 °F), with an uncertainty range of 1.1 to 6.4 °C (2.0 to 11.5 °F).

All of the United States is very likely to warm during this century, and most areas of the United States are expected to warm by more than the global average. The largest warming is projected to occur in winter over northern parts of Alaska. In western, central and eastern regions of North America, the projected warming has less seasonal variation and is not as large, especially near the coast, consistent with less warming over the oceans.

3. The Six Greenhouse Gases Are Currently the Common Focus of the Climate Change Science and Policy Communities

The well-mixed greenhouse gases are currently the common focus of climate science and policy analyses and discussions. For example, the United Nations Framework Convention on Climate Change (UNFCCC), signed and ratified by the United States in 1992, requires its signatories to ''develop, periodically update, publish and make available * * * national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies * * *'' [24] [25] To date, the focus of UNFCCC actions and discussions has been on the six greenhouse gases that are the same focus of these Findings.

Because of these common properties, it has also become common practice to compare these gases on a carbon dioxide equivalent basis, based on each gas's warming effect relative to carbon dioxide (the designated reference gas) over a specified timeframe. For example, both the annual *Inventory of U.S. Greenhouse Gases and Sinks* published by EPA and the recently finalized EPA Mandatory Greenhouse Gas Reporting Rule (74 FR 56260), use the carbon dioxide equivalent metric to sum and compare these gases, and thus accept the common climate-relevant properties of these gases for their treatment as a group. This is also common practice internationally as the UNFCCC reporting guidelines for developed countries, and the Clean Development Mechanism procedures for developing countries both require the use of global warming potentials published by the IPCC to convert the six greenhouse gases into their respective carbon dioxide equivalent units.

4. Defining Air Pollution as the Aggregate Group of Six Greenhouse Gases Is Consistent With Evaluation of Risks and Impacts Due to Human-Induced Climate Change

Because the well-mixed greenhouse gases are collectively the primary driver of current and projected human-induced climate change, all current and future risks due to human-induced climate change—whether these risks are associated with increases in temperature, changes in precipitation, a rise in sea levels, changes in the frequency and intensity of weather events, or more directly with the elevated greenhouse gas concentrations themselves—can be associated with this definition of air pollution.

5. Defining the Air Pollution as the Aggregate Group of Six Greenhouse Gases Is Consistent With Past EPA Practice

Treating the air pollution as the aggregate of the well-mixed greenhouse gases is consistent with other provisions of the CAA and previous EPA practice under the CAA, where separate emissions from different sources but with common properties may be treated as a class (*e.g.,* particulate matter (PM)). This approach addresses the total, cumulative effect that the elevated concentrations of the six well-mixed greenhouse gases have on climate, and thus on different elements of health, society and the environment.[24]

EPA treats, for example, PM as a common class of air pollution; PM is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

6. Other Climate Forcers Not Being Included in the Definition of Air Pollution for This Finding

Though the well-mixed greenhouse gases that make up the definition of air pollution for purposes of making the endangerment decision under CAA section 202(a) constitute the primary

[24] Due to the cumulative purpose of the statutory language, even if the Administrator were to look at the atmospheric concentration of each greenhouse gas individually, she would still consider the impact of the concentration of a single greenhouse gas in combination with that caused by the other greenhouse gases.

[25] The range of uncertainty in the current magnitude of black carbon's climate forcing effect is evidenced by the ranges presented by the IPCC Fourth Assessment Report (2007) and the more recent study by Ramanathan, V. and Carmichael, G. (2008) Global and regional climate changes due to black carbon. Nature Geoscience, 1(4): 221–227.

driver of human-induced climate change, there are other substances emitted from human activities that contribute to climate change and deserve careful attention, but are not being included in the air pollution definition for this particular action. These substances are discussed immediately below.

a. Black Carbon

Several commenters request that black carbon be included in the definition of air pollution because of its warming effect on the climate. Black carbon is not a greenhouse gas, rather, it is an aerosol particle that results from the incomplete combustion of carbon contained in fossil fuels and biomass, and remains in the atmosphere for only about a week. Unlike any of the greenhouse gases being addressed by this action, black carbon is a component of particulate matter (PM), where PM is a criteria air pollutant under section 108 of the CAA. The extent to which black carbon makes up total PM varies by emission source, where, for example, diesel vehicle PM emissions contain a higher fraction of black carbon compared to most other PM emission sources. Black carbon causes a warming effect primarily by absorbing incoming and reflected sunlight (whereas greenhouse gases cause warming by trapping outgoing, infrared heat), and by darkening bright surfaces such as snow and ice, which reduces reflectivity. This latter effect, in particular, has been raising concerns about the role black carbon may be playing in observed warming and ice melt in the Arctic.

As stated in the April 2009 Proposed Findings, there remain some significant scientific uncertainties about black carbon's total climate effect,[25] as well as concerns about how to treat the short-lived black carbon emissions alongside the long-lived, well-mixed greenhouse gases in a common framework (*e.g.,* what are the appropriate metrics to compare the warming and/or climate effects of the different substances, given that, unlike greenhouse gases, the magnitude of aerosol effects can vary immensely with location and season of emissions). Nevertheless, the Administrator recognizes that black carbon is an important climate forcing agent and takes very seriously the emerging science on black carbon's contribution to global climate change in general and the high rates of observed climate change in the Arctic in particular. As noted in the Proposed Findings, EPA has various pending petitions under the CAA calling on the Agency to make an endangerment finding and regulate black carbon emissions.

b. Other Climate Forcers

There are other climate forcers that play a role in human-induced climate change that were mentioned in the Proposed Findings, and were the subject of some public comments. These include the stratospheric ozone-depleting substances, nitrogen trifluoride (NF_3), water vapor, and tropospheric ozone.

As mentioned above, the ozone-depleting substances (CFCs and HCFCs) do share the same physical, climate-relevant attributes as the six well-mixed greenhouse gases; however, emissions of these substances are playing a diminishing role in human-induced climate change. They are being controlled and phased out under the Montreal Protocol on Substances that Deplete the Ozone Layer. Because of this, the major scientific assessment reports such as those from IPCC focus primarily on the same six well-mixed greenhouse gases included in the definition of air pollution in these Findings. It is also worth noting that the UNFCCC, to which the United States is a signatory, addresses ''all greenhouse gases not controlled by the Montreal Protocol.'' [26] One commenter noted that because the Montreal Protocol controls production and consumption of ozone-depleting substances, but not existing banks of the substances, that CFCs should be included in the definition of air pollution in this finding, which might, in turn, create some future action under the CAA to address the banks of ozone-depleting substances as a climate issue. However, the primary criteria for defining the air pollution in this finding is the focus on the core of the climate change problem, and concerns over future actions to control depletion of stratospheric ozone are separate from and not central to the air pollution causing climate change.

Nitrogen trifluoride also shares the same climate-relevant attributes as the six well-mixed greenhouse gases, and it is also included in EPA's Mandatory Greenhouse Gas Reporting Rule (FR 74 56260). However, the Administrator is maintaining the reasoning laid out in the Proposed Findings to not include NF_3 in the definition of air pollution for this finding because the overall magnitude of its forcing effect on climate is not yet well quantified. EPA will continue to track the science on NF_3.

A number of public comments question the exclusion of water vapor from the definition of air pollution because it is the most important greenhouse gas responsible for the natural, background greenhouse effect. The Administrator's reasoning for excluding water vapor, was described in the Proposed Findings and is summarized here with additional information in Volume 10 of the Response to Comments document. First, climate change is being driven by the buildup in the atmosphere of greenhouse gases. The direct emissions primarily responsible for this are the six well-mixed greenhouse gases. Direct anthropogenic emissions of water vapor, in general, have a negligible effect and are thus not considered a primary driver of human-induced climate change. EPA plans to further evaluate the issues of emissions of water that are implicated in the formation of contrails and also changes in water vapor due to local irrigation. At this time, however, the findings of the IPCC state that the total forcing from these sources is small and that the level of understanding is low.

Water produced as a byproduct of combustion at low altitudes has a negligible contribution to climate change. The residence time of water vapor is very short (days) and the water content of the air in the long term is a function of temperature and partial pressure, with emissions playing no role. Additionally, the radiative forcing of a given mass of water at low altitudes is much less than the same mass of carbon dioxide. Water produced at higher altitudes could potentially have a larger impact. The IPCC estimated the contribution of changes in stratospheric water vapor due to methane and other sources, as well as high altitude contributions from contrails, but concluded that both contributions were small, with a low level of understanding. The report also addressed anthropogenic contributions to water vapor arising from large scale irrigation, but assigned it a very low level of understanding, and suggested that the cooling from evaporation might outweigh the warming from its small radiative contribution.

Increases in tropospheric ozone concentrations have exerted a significant anthropogenic warming effect since pre-industrial times. However, as explained in the Proposed Findings, tropospheric ozone is not a long-lived, well-mixed greenhouse gas, and it is not directly emitted. Rather it forms in the atmosphere from emissions of pre-cursor gases. There is increasing attention in climate change research and the policy community about the extent to which further reductions in tropospheric ozone levels may help

[26] UNFCCC, Art. 4.1(b).

slow down climate change in the near term. The Administrator views this issue seriously but maintains that tropospheric ozone is sufficiently different such that it deserves an evaluation and treatment separate from this finding.

7. Summary of Key Comments on Definition of Air Pollution

a. It Is Reasonable for the Administrator To Define the Air Pollution as Global Concentrations of the Well-Mixed Greenhouse Gases

Many commenters argue that EPA does not have the authority to establish domestic rights and obligations based on environmental conditions that are largely attributed to foreign nations and entities that are outside the jurisdiction of EPA under the CAA. They contend that in this case, the bulk of emissions that would lead to mandatory emissions controls under the CAA would not and could not be regulated under the CAA. They state that CAA requirements cannot be enforced against foreign sources of air pollution, and likewise domestic obligations under the CAA cannot be caused by foreign emissions that are outside the United States. The commenters argue that EPA committed procedural error by not addressing this legal issue of authority in the proposal.

Commenters cite no statutory text or judicial authority for this argument, and instead rely entirely on an analogy to the issues concerning the exercise of extra-territorial jurisdiction. The text of CAA section 202(a), however, does not support this claim. Nothing in CAA section 202(a) limits the term air pollution to those air pollution matters that are caused solely or in large part by domestic emissions. The only issue under CAA section 202(a) is whether the air pollution is reasonably anticipated to endanger, and whether emissions from one domestic source category—new motor vehicles—cause or contribute to this air pollution. Commenters would read into this an additional cause or contribute test—whether foreign sources cause or contribute to the air pollution in such a way that the air pollution is largely attributable to the foreign emissions, or the bulk of emissions causing the air pollution are from foreign sources. There is no such provision in CAA section 202(a). Congress was explicit about the contribution test it imposed, and the only source that is relevant for purposes of contribution is new motor vehicles. Commenters suggest an ill-defined criterion that is not in the statute.

In addition, as discussed in Section II of these Findings, Congress intentionally meant the agency to judge the air pollution endangerment criteria based on the ''cumulative impact of all sources of a pollutant,'' and not an incremental look at just the endangerment from a subset of sources. Commenters' arguments appear to lead to this result. Under the commenters' approach, in those cases where the bulk of emissions which form the air pollution come from foreign sources, EPA apparently would have no authority to make an endangerment finding. Logically, EPA would be left with the option of identifying and evaluating the air pollution attributable to domestic sources alone, and determining whether that narrowly defined form of air pollution endangers public health or welfare. This is the kind of unworkable, incremental approach that was rejected by the court in *Ethyl* and by Congress in the 1977 amendments adopting this provision.

The analogy to extra-territorial jurisdiction is also not appropriate. The endangerment finding itself does not exercise jurisdiction over any source, domestic or foreign. It is a judgment that is a precondition for exercising regulatory authority. Under CAA section 202(a), any exercise of regulatory authority following from this endangerment finding would be for new motor vehicles either manufactured in the United States or imported into the United States. There would be no extra-territorial exercise of jurisdiction. The core issues for endangerment focus on impacts inside the United States, not outside the United States. In addition, the contribution finding is based solely on the contribution from new motor vehicles built in or imported to the United States. The core judgments that need to be made under CAA section 202(a) are all focused on actions and impacts inside the United States. This does not raise any concerns about an extra-territorial exercise of jurisdiction. The basis for the endangerment and contribution findings is fully consistent with the principles underlying the desire to avoid exercises of extra-territorial jurisdiction. Any limitations on the ability to exercise control over foreign sources of emissions does not, however, call into question the authority under CAA section 202 to exercise control over domestic sources of emissions based on their contribution to an air pollution problem that is judged to endanger public health or welfare based on impacts occurring in the United States or otherwise affecting the United States and its citizens.

In essence, commenters are concerned about the effectiveness of the domestic control strategies that can be adopted to address a global air pollution problem that is caused only in part by domestic sources of emissions. While that is a quite valid and important policy concern, it does not translate into a legal limitation on EPA's authority to make an endangerment finding. Neither the text nor the legislative history of CAA section 202(a) support such an interpretation and Congress explicitly separated the decision on endangerment from the decision on what controls are required or appropriate once an affirmative endangerment finding has been made. The effectiveness of the resulting regulatory controls is not a relevant factor to determining endangerment.

EPA also committed no procedural flaw as argued by commenters. The proposal fully explored the interpretation of endangerment and cause or contribution under CAA section 202(a), and was very clear that EPA was considering air pollution to mean the elevated global concentration of greenhouse gases in the atmosphere, recognizing that these atmospheric concentrations were the result of world wide emissions, not just or even largely U.S. emissions. The separation of the effectiveness of the control strategy from the endangerment criteria, and the need to consider the cumulative impact of all sources in evaluating endangerment was clearly discussed. Commenters received fair notice of EPA's proposal and the basis for it.

Similarly, some commenters argue that EPA's proposal defines air pollution as global air pollution, but EPA is limited to evaluating domestic air only; in other words that EPA may only regulate domestic emissions with localized effects. They argue this limitation derives from the purpose of the CAA—to enhance the quality of the Nation's air resources, recognizing that air pollution prevention and control focus on the sources of the emissions, and are the primary responsibility of States and local governments. Therefore, commenters continue, that ''air pollution'' has to be air pollution that originates domestically and is to be addressed only at the domestic source. Sections 115 and 179B of the CAA, as discussed below, reflect this intention as well. The result, they conclude, is that ''air pollution'' as used in CAA section 202(a), includes only pollution that originates domestically, where the effects occur locally. They argue EPA has improperly circumvented this by a ''local-global-local'' analysis that injects

global air pollution into the middle of the endangerment test.

The statutory arguments made by the commenters attempt to read an unrealistic limitation into the general provisions discussed. The issues are similar in nature to those raised by the commenters arguing that EPA has no authority to establish domestic rights and obligations based on environmental conditions that are largely attributable to emissions from foreign nations and entities that are outside the jurisdiction of EPA under the CAA. In both cases, the question is whether EPA has authority to make an endangerment finding when the air pollution of concern is a relatively homogenous atmospheric concentration of greenhouse gases. According to the commenters, although this global pool includes the air over the United States, and leads to impacts in the United States and on the U.S. population, Congress prohibited EPA from addressing this air pollution problem because of its global aspects.

The text of the CAA does not specifically address this, as the term air pollution is not defined. EPA interprets this term as including the air pollution problem involved in this case—elevated atmospheric concentration of greenhouse gases that occur in the air above the United States as well as across the globe, and where this pool of global gases leads to impacts in the United States and on the U.S. population. This is fully consistent with the statutory provisions discussed by commenters. This approach seeks to protect the Nation's air resources, as clearly the Nation's air resources are an integral part of this global pool. The Nation's air resources by definition are not an isolated atmosphere that only contains molecules emitted within the United States, or an atmosphere that bears no relationship to the rest of the globe's atmosphere. There is no such real world body of air. Protecting the Nation's resources of clean air means to protect the air in the real world, not an artificial construct of ''air'' that ignores the many situations where the air over our borders includes compounds and pollutants emitted outside our borders, and in this case to ignore the fact that the air over our borders will by definition have elevated concentrations of greenhouse gases only when the air around the globe also has such concentrations. The suggested narrow view of ''air pollution'' does not further the protection of the Nation's air resources, but instead attempts to limit such protection by defining these resources in a scientifically artificial way that does not comport with how the air in the atmosphere is formed or changes over time, how it relates to and interacts with air around the globe, and how the result of this can affect the U.S. population.

The approach suggested by commenters fails to provide an actual definition for EPA to follow—for example, would U.S. or domestic ''air pollution'' be limited to only those air concentrations composed of molecules that originated in the United States? Is there a degree of external gases or compounds that could be allowed? Would it ignore the interaction and relationship between the air over the U.S. borders and the air around the rest of the globe? The latter approach appears to be the one suggested by commenters. Commenters' approach presumably would call for EPA to only consider the effects that derive solely from the air over our borders, and to ignore any effects that occur within the United States that are caused by air around the globe. However the air over the United States will by definition affect climate change only in circumstances where the air around the world is also doing so. The impacts of the air over the United States cannot be assessed separately from the impacts from the global pool, as they occur together and work together to affect the climate. Ignoring the real world nature of the Nation's air resources, in the manner presumably suggested by the commenters, would involve the kind of unworkable, incremental, and artificially isolating approach that was rejected by the court in *Ethyl* and by Congress in 1977. Congress intended EPA to interpret this provision by looking at air pollutants and air pollution problems in a broad manner, not narrowly, to evaluate problems within their broader context and not to attempt to isolate matters in an artificial way that fails to account for the real world context that lead to health and welfare impacts on the public. Commenters' suggested interpretation fails to implement this intention of Congress.

Commenters in various places refer to the control of the pollution, and the need for it to be aimed at local sources. That is addressed in the standard setting portion of CAA section 202(a), as in other similar provisions. The endangerment provision does not address how the air pollution problem should be addressed—who should be regulated and how they should be regulated. The endangerment provision addresses a different issue—is there an air pollution problem that should be addressed? In that context, EPA rejects the artificially narrow interpretation suggested by the commenters, and believes its broader interpretation in this case is reasonable and consistent with the intention of Congress.

b. Consideration of Greenhouse Gases as Air Pollution Given Their Impact Is Through Climate Rather Than Direct Toxic Effects

A number of commenters argue that carbon dioxide and the other greenhouse gases should not be defined as the air pollution because these gases do not cause direct human health effects, such as through inhalation. Responses to such comments are summarized in Section IV.B.1 of these Findings in the discussion of the public health and welfare nature of the endangerment finding.

c. The Administrator's Reliance on the Global Temperature Data Is a Reasonable Indicator of Human-Induced Climate Change

We received many comments suggesting global temperatures have stopped warming. The commenters base this conclusion on temperature trends over only the last decade. While there have not been strong trends over the last seven to ten years in global surface temperature or lower troposphere temperatures measured by satellites, this pause in warming should not be interpreted as a sign that the Earth is cooling or that the science supporting continued warming is in error. Year-to-year variability in natural weather and climate patterns make it impossible to draw any conclusions about whether the climate system is warming or cooling from such a limited analysis. Historical data indicate short-term trends in long-term time series occasionally run counter to the overall trend. All three major global surface temperature records show a continuation of long-term warming. Over the last century, the global average temperature has warmed at the rate of about 0.13 °F (0.072 °C) per decade in all three records. Over the last 30 years, the global average surface temperature has warmed by about 0.30 °F (0.17 °C) per decade. Eight of the 10 warmest years on record have occurred since 2001 and the 20 warmest years have all occurred since 1981. Satellite measurements of the troposphere also indicate warming over the last 30 years at a rate of 0.20 to 0.27 °F (0.11 °C to 0.15 °C) per decade. Please see the relevant volume of the Response to Comments document for more detailed responses.

Some commenters indicate the global surface temperature records are biased by urbanization, poor siting of instruments, observation methods, and

other factors. Our review of the literature suggests that these biases have in many cases been corrected for, are largely random where they remain, and therefore cancel out over large regions. Furthermore, we note that though the three global surface temperature records use differing techniques to analyze much of the same data, they produce almost the same results, increasing our confidence in their legitimacy. The assessment literature has concluded that warming of the climate system is unequivocal. The warming trend that is evident in all of the temperature records is confirmed by other independent observations, such as the melting of Arctic sea ice, the retreat of mountain glaciers on every continent, reductions in the extent of snow cover, earlier blooming of plants in the spring, and increased melting of the Greenland and Antarctic ice sheets. Please see the relevant volume of the Response to Comments document for more detailed responses.

A number of commenters argue that the warmth of the late 20th century is not unusual relative to the past 1,000 years. They maintain temperatures were comparably warm during the Medieval Warm Period (MWP) centered around 1000 A.D. We agree there was a Medieval Warm Period in many regions but find the evidence is insufficient to assess whether it was globally coherent. Our review of the available evidence suggests that Northern Hemisphere temperatures in the MWP were probably between 0.1 °C and 0.2 °C below the 1961–1990 mean and significantly below the level shown by instrumental data after 1980. However, we note significant uncertainty in the temperature record prior to 1600 A.D. Please see the relevant volume of the Response to Comments document for more detailed responses.

d. Ability To Attribute Observed Climate Change to Anthropogenic, Well-Mixed Greenhouse Gases

Many commenters question the link between observed temperatures and anthropogenic greenhouse gas emissions. They suggest internal variability of the climate system and natural forcings explain observed temperature trends and that anthropogenic greenhouse gases play, at most, a minor role. However, the attribution of most of the recent warming to anthropogenic activities is based on multiple lines of evidence. The first line of evidence arises from our basic physical understanding of the effects of changing concentrations of greenhouse gases, natural factors, and other human impacts on the climate system. Greenhouse gas concentrations have indisputably increased and their radiative properties are well established. The second line of evidence arises from indirect, historical estimates of past climate changes that suggest that the changes in global surface temperature over the last several decades are unusual. The third line of evidence arises from the use of computer-based climate models to simulate the likely patterns of response of the climate system to different forcing mechanisms (both natural and anthropogenic). These models are unable to replicate the observed warming unless anthropogenic emissions of greenhouse gases are included in the simulations. Natural forcing alone cannot explain the observed warming. In fact, the assessment literature [27] indicates the sum of solar and volcanic forcing in the past half century would likely have produced cooling, not warming. Please see the relevant volume of the Response to Comments for more detailed responses.

B. The Air Pollution Is Reasonably Anticipated To Endanger Both Public Health and Welfare

The Administrator finds that the elevated atmospheric concentrations of the well-mixed greenhouse gases may reasonably be anticipated to endanger the public health and welfare of current and future generations. This section describes the major pieces of scientific evidence supporting the Administrator's endangerment finding, discusses both the public health and welfare nature of the endangerment finding, and addresses a number of key issues the Administrator considered when evaluating the state of the science as well as key public comments on the Proposed Findings. Additional detail can be found in the TSD and the Response to Comments document.

As described in Section II of these Findings, the endangerment test under CAA section 202(a) does not require the Administrator to identify a bright line, quantitative threshold above which a positive endangerment finding can be made. The statutory language explicitly calls upon the Administrator to use her judgment. This section describes the general approach used by the Administrator in reaching the judgment that a positive endangerment finding should be made, as well as the specific rationale for finding that the greenhouse gas air pollution may reasonably be anticipated to endanger both public health and welfare.

First, the Administrator finds the scientific evidence linking human emissions and resulting elevated atmospheric concentrations of the six well-mixed greenhouse gases to observed global and regional temperature increases and other climate changes to be sufficiently robust and compelling. This evidence is briefly explained in more detail in Section V of these Findings. The Administrator recognizes that the climate change associated with elevated atmospheric concentrations of carbon dioxide and the other well-mixed greenhouse gases have the potential to affect essentially every aspect of human health, society and the natural environment. The Administrator is therefore not limiting her consideration of potential risks and impacts associated with human emissions of greenhouse gases to any one particular element of human health, sector of the economy, region of the country, or to any one particular aspect of the natural environment. Rather, the Administrator is basing her finding on the total weight of scientific evidence, and what the science has to say regarding the nature and potential magnitude of the risks and impacts across all climate-sensitive elements of public health and welfare, now and projected out into the foreseeable future.

The Administrator has considered the state of the science on how human emissions and the resulting elevated atmospheric concentrations of well-mixed greenhouse gases may affect each of the major risk categories, *i.e.,* those that are described in the TSD, which include human health, air quality, food production and agriculture, forestry, water resources, sea level rise and coastal areas, the energy sector, infrastructure and settlements, and ecosystems and wildlife. The Administrator understands that the nature and potential severity of impacts can vary across these different elements of public health and welfare, and that they can vary by region, as well as over time.

The Administrator is therefore aware that, because human-induced climate change has the potential to be far-reaching and multi-dimensional, not all

[27] Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt (2007) Technical Summary. In: *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Karl, T. et al. (2009).

risks and potential impacts can be characterized with a uniform level of quantification or understanding, nor can they be characterized with uniform metrics. Given this variety in not only the nature and potential magnitude of risks and impacts, but also in our ability to characterize, quantify and project into the future such impacts, the Administrator must use her judgment to weigh the threat in each of the risk categories, weigh the potential benefits where relevant, and ultimately judge whether these risks and benefits, when viewed in total, are judged to be endangerment to public health and/or welfare.

This has a number of implications for the Administrator's approach in assessing the nature and magnitude of risk and impacts across each of the risk categories. First, the Administrator has not established a specific threshold metric for each category of risk and impacts. Also, the Administrator is not necessarily placing the greatest weight on those risks and impacts which have been the subject of the most study or quantification.

Part of the variation in risks and impacts is the fact that climbing atmospheric concentrations of greenhouse gases and associated temperature increases can bring about some potential benefits to public health and welfare in addition to adverse risks. The current understanding of any potential benefits associated with human-induced climate change is described in the TSD and is taken into consideration here. The potential for both adverse and beneficial effects are considered, as well as the relative magnitude of such effects, to the extent that the relative magnitudes can be quantified or characterized. Furthermore, given the multiple ways in which the buildup of atmospheric greenhouse gases can cause effects (*e.g.,* via elevated carbon dioxide concentrations, via temperature increases, via precipitation increases, via sea level rise, and via changes in extreme events), these multiple pathways are considered. For example, elevated carbon dioxide concentrations may be beneficial to crop yields, but changes in temperature and precipitation may be adverse and must also be considered. Likewise, modest temperature increases may have some public health benefits as well as harms, and other pathways such as changes in air quality and extreme events must also be considered.

The Administrator has balanced and weighed the varying risks and effects for each sector. She has judged whether there is a pattern across the sector that supports or does not support an endangerment finding, and if so whether the support is of more or less weight. In cases where there is both a potential for benefits and risks of harm, the Administrator has balanced these factors by determining whether there appears to be any directional trend in the overall evidence that would support placing more weight on one than the other, taking into consideration all that is known about the likelihood of the various risks and effects and their seriousness. In all of these cases, the judgment is largely qualitative in nature, and is not reducible to precise metrics or quantification.

Regarding the timeframe for the endangerment test, it is the Administrator's view that both current and future conditions must be considered. The Administrator is thus taking the view that the endangerment period of analysis extend from the current time to the next several decades, and in some cases to the end of this century. This consideration is also consistent with the timeframes used in the underlying scientific assessments. The future timeframe under consideration is consistent with the atmospheric lifetime and climate effects of the six well-mixed greenhouse gases, and also with our ability to make reasonable and plausible projections of future conditions.

The Administrator acknowledges that some aspects of climate change science and the projected impacts are more certain than others. Our state of knowledge is strongest for recently observed, large-scale changes. Uncertainty tends to increase in characterizing changes at smaller (regional) scales relative to large (global) scales. Uncertainty also increases as the temporal scales move away from present, either backward, but more importantly forward in time. Nonetheless, the current state of knowledge of observed and past climate changes and their causes enables projections of plausible future changes under different scenarios of anthropogenic forcing for a range of spatial and temporal scales.

In some cases, where the level of sensitivity to climate of a particular sector has been extensively studied, future impacts can be quantified whereas in other instances only a qualitative description of a directional change, if that, may be possible. The inherent uncertainty in the direction, magnitude, and/or rate of certain future climate change impacts opens up the possibility that some changes could be more or less severe than expected, and the possibility of unanticipated outcomes. In some cases, low probability, high impact outcomes (*i.e.,* known unknowns) are possibilities but cannot be explicitly assessed.

1. The Air Pollution Is Reasonably Anticipated To Endanger Public Health

The Administrator finds that the well-mixed greenhouse gas air pollution is reasonably anticipated to endanger public health, for both current and future generations. The Administrator finds that the public health of current generations is endangered and that the threat to public health for both current and future generations will likely mount over time as greenhouse gases continue to accumulate in the atmosphere and result in ever greater rates of climate change.

After review of public comments, the Administrator continues to believe that climate change can increase the risk of morbidity and mortality and that these public health impacts can and should be considered when determining endangerment to public health under CAA section 202(a). As described in Section IV.B.1 of these Findings, the Administrator is not limited to only considering whether there are any direct health effects such as respiratory or toxic effects associated with exposure to greenhouse gases.

In making this public health finding, the Administrator considered direct temperature effects, air quality effects, the potential for changes in vector-borne diseases, and the potential for changes in the severity and frequency of extreme weather events. In addition, the Administrator considered whether and how susceptible populations may be particularly at risk. The current state of science on these effects from the major assessment reports is described in greater detail in the TSD, and our responses to public comments are provided in the Response to Comments Documents.

a. Direct Temperature Effects

It has been estimated that unusually hot days and heat waves are becoming more frequent, and that unusually cold days are becoming less frequent, as noted above. Heat is already the leading cause of weather-related deaths in the United States. In the future, severe heat waves are projected to intensify in magnitude and duration over the portions of the United States where these events already occur. Heat waves are associated with marked short-term increases in mortality. Hot temperatures have also been associated with increased morbidity. The projected warming is therefore projected to increase heat related mortality and

morbidity, especially among the elderly, young and frail. The populations most sensitive to hot temperatures are older adults, the chronically sick, the very young, city-dwellers, those taking medications that disrupt thermoregulation, the mentally ill, those lacking access to air conditioning, those working or playing outdoors, and socially isolated persons. As warming increases over time, these adverse effects would be expected to increase as the serious heat events become more serious.

Increases in temperature are also expected to lead to some reduction in the risk of death related to extreme cold. Cold waves continue to pose health risks in northern latitudes in temperature regions where very low temperatures can be reached in a few hours and extend over long periods. Globally, the IPCC projects reduced human mortality from cold exposure through 2100. It is not clear whether reduced mortality in the United States from cold would be greater or less than increased heat-related mortality in the United States due to climate change. However, there is a risk that projections of cold-related deaths, and the potential for decreasing their numbers due to warmer winters, can be overestimated unless they take into account the effects of season and influenza, which is not strongly associated with monthly winter temperature. In addition, the latest USGCRP report refers to a study that analyzed daily mortality and weather data in 50 U.S. cities from 1989 to 2000 and found that, on average, cold snaps in the United States increased death rates by 1.6 percent, while heat waves triggered a 5.7 percent increase in death rates. The study concludes that increases in heat-related mortality due to global warming in the United States are unlikely to be compensated for by decreases in cold-related mortality.

b. Air Quality Effects

Increases in regional ozone pollution relative to ozone levels without climate change are expected due to higher temperatures and weaker circulation in the United States relative to air quality levels without climate change. Climate change is expected to increase regional ozone pollution, with associated risks in respiratory illnesses and premature death. In addition to human health effects, tropospheric ozone has significant adverse effects on crop yields, pasture and forest growth, and species composition. The directional effect of climate change on ambient particulate matter levels remains less certain.

Climate change can affect ozone by modifying emissions of precursors, atmospheric chemistry, and transport and removal. There is now consistent evidence from models and observations that 21st century climate change will worsen summertime surface ozone in polluted regions of North America compared to a future with no climate change.

Modeling studies discussed in EPA's Interim Assessment [28] show that simulated climate change causes increases in summertime ozone concentrations over substantial regions of the country, though this was not uniform, and some areas showed little change or decreases, though the decreases tend to be less pronounced than the increases. For those regions that showed climate-induced increases, the increase in maximum daily 8-hour average ozone concentration, a key metric for regulating U.S. air quality, was in the range of 2 to 8 ppb, averaged over the summer season. The increases were substantially greater than this during the peak pollution episodes that tend to occur over a number of days each summer. The overall effect of climate change was projected to increase ozone levels, compared to what would occur without this climate change, over broad areas of the country, especially on the highest ozone days and in the largest metropolitan areas with the worst ozone problems. Ozone decreases are projected to be less pronounced, and generally to be limited to some regions of the country with smaller population.

c. Effects on Extreme Weather Events

In addition to the direct effects of temperature on heat- and cold-related mortality, the Administrator considers the potential for increased deaths, injuries, infectious diseases, and stress-related disorders and other adverse effects associated with social disruption and migration from more frequent extreme weather. The Administrator notes that the vulnerability to weather disasters depends on the attributes of the people at risk (including where they live, age, income, education, and disability) and on broader social and environmental factors (level of disaster preparedness, health sector responses, and environmental degradation). The IPCC finds the following with regard to extreme events and human health:

Increases in the frequency of heavy precipitation events are associated with increased risk of deaths and injuries as well as infectious, respiratory, and skin diseases. Floods are low-probability, high-impact events that can overwhelm physical infrastructure, human resilience, and social organization. Flood health impacts include deaths, injuries, infectious diseases, intoxications, and mental health problems.

Increases in tropical cyclone intensity are linked to increases in the risk of deaths, injuries, waterborne and food borne diseases, as well as post-traumatic stress disorders. Drowning by storm surge, heightened by rising sea levels and more intense storms (as projected by IPCC), is the major killer in coastal storms where there are large numbers of deaths. Flooding can cause health impacts including direct injuries as well as increased incidence of waterborne diseases due to pathogens such as *Cryptosporidium and Giardia.*

d. Effects on Climate-Sensitive Diseases and Aeroallergens

According to the assessment literature, there will likely be an increase in the spread of several food and water-borne pathogens among susceptible populations depending on the pathogens' survival, persistence, habitat range and transmission under changing climate and environmental conditions. Food borne diseases show some relationship with temperature, and the range of some zoonotic disease carriers such as the Lyme disease carrying tick may increase with temperature.

Climate change, including changes in carbon dioxide concentrations, could impact the production, distribution, dispersion and allergenicity of aeroallergens and the growth and distribution of weeds, grasses, and trees that produce them. These changes in aeroallergens and subsequent human exposures could affect the prevalence and severity of allergy symptoms. However, the scientific literature does not provide definitive data or conclusions on how climate change might impact aeroallergens and subsequently the prevalence of allergenic illnesses in the United States.

It has generally been observed that the presence of elevated carbon dioxide concentrations and temperatures stimulate plants to increase photosynthesis, biomass, water use efficiency, and reproductive effort. The IPCC concluded that pollens are likely to increase with elevated temperature and carbon dioxide.

[28] U.S. EPA (2009) *Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone.* An Interim Report of the U.S. EPA Global Change Research Program. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–07/094.

e. Summary of the Administrator's Finding of Endangerment to Public Health

The Administrator has considered how elevated concentrations of the well-mixed greenhouse gases and associated climate change affect public health by evaluating the risks associated with changes in air quality, increases in temperatures, changes in extreme weather events, increases in food and water borne pathogens, and changes in aeroallergens. The evidence concerning adverse air quality impacts provides strong and clear support for an endangerment finding. Increases in ambient ozone are expected to occur over broad areas of the country, and they are expected to increase serious adverse health effects in large population areas that are and may continue to be in nonattainment. The evaluation of the potential risks associated with increases in ozone in attainment areas also supports such a finding.

The impact on mortality and morbidity associated with increases in average temperatures which increase the likelihood of heat waves also provides support for a public health endangerment finding. There are uncertainties over the net health impacts of a temperature increase due to decreases in cold-related mortality, but there is some recent evidence that suggests that the net impact on mortality is more likely to be adverse, in a context where heat is already the leading cause of weather-related deaths in the United States.

The evidence concerning how human-induced climate change may alter extreme weather events also clearly supports a finding of endangerment, given the serious adverse impacts that can result from such events and the increase in risk, even if small, of the occurrence and intensity of events such as hurricanes and floods. Additionally, public health is expected to be adversely affected by an increase in the severity of coastal storm events due to rising sea levels.

There is some evidence that elevated carbon dioxide concentrations and climate changes can lead to changes in aeroallergens that could increase the potential for allergenic illnesses. The evidence on pathogen borne disease vectors provides directional support for an endangerment finding. The Administrator acknowledges the many uncertainties in these areas. Although these adverse effects, provide some support for an endangerment finding, the Administrator is not placing primary weight on these factors.

Finally, the Administrator places weight on the fact that certain groups, including children, the elderly, and the poor, are most vulnerable to these climate-related health effects.

f. Key Comments on the Finding of Endangerment to Public Health

EPA received many comments on public health issues and the proposed finding of endangerment to public health.

i. EPA's Consideration of the Climate Impacts as Public Health Issues Is Reasonable

Several commenters argue that EPA may only consider the health effects from direct exposure to pollutants in determining whether a pollutant endangers public health. The commenters state that EPA's proposal acknowledges that there is no evidence that greenhouse gases directly cause health effects, citing 74 FR 18901. To support their claim that EPA can only consider health effects that result from direct exposure to a pollutant, commenters cite several sources, discussed below.

Clean Air Act and Legislative History. Several commenters argue that the text of the CAA and the legislative history of the 1977 amendments demonstrate that Congress intended public health effects to relate to risks from direct exposure to a pollutant. They also argue that by considering health effects that result from welfare effects, EPA was essentially combining the two categories into one, contrary to the statute and Congressional intent.

Commenters state that the CAA, including CAA section 202(a)(1), requires EPA to consider endangerment of public health separately from endangerment of public welfare. Commenters note that while the CAA does not provide a definition of public health, CAA section 302(h) addresses the meaning of ''welfare,'' which includes weather and climate. Thus, they argue, Congress has instructed that effects on weather and climate are to be considered as potentially endangering welfare—not human health. They continue that Congress surely knew that weather and climatic events such as flooding and heat waves could affect human health, but Congress nonetheless classified air pollutants' effects on weather and climate as effects on welfare.

Commenters also argue that the legislative history confirms that Congress intended for the definition of ''public health'' to only include the consequences of direct human exposure to ambient air pollutants. They note an early version of section 109(b) would have required only a single NAAQS standard to protect ''public health,'' with the protection of ''welfare'' being a co-benefit of the single standard. Commenters note that the proponents of this early bill explained, ''[i]n many cases, a level of protection of health would take care of the welfare situation'' Sen. Hearing, Subcommittee on Air and Water Pollution, Comm. On Public Works (Mar. 17, 1970) (statement of Dr. Middleton, Comm'r, Nat'l Air Pollution Control Admin., HEW), 1970 Leg. Hist. 1194. Commenters state that the Senate bill that ultimately passed rejected this combined standard, requiring separate national ambient air quality standards and national ambient air quality goals. Commenters contend that Congress intended that the national ambient air quality goals be set ''to protect the public health and welfare from any known or anticipated effects associated with'' air pollution, including the list of ''welfare'' effects currently found in CAA section 302(h), such as effects on water, vegetation, animals, wildlife, weather and climate. Commenters note the Senate Committee Report stated that the national ambient air quality *standards* were created to protect public health, while the national ambient air quality *goals* were intended to address broader issues because ''the Committee also recognizes that man's natural and man-made environment must be preserved and protected. Therefore, the bill provides for the setting of national ambient air quality goals at levels necessary to protect public health and welfare from any known or anticipated adverse effects of air pollution—including effects on soils, water, vegetation, man-made materials, animals, wildlife, visibility, climate, and economic values.'' Commenters argue this statement is clearly the source of the current definition of welfare effects in CAA section 302(h), which also includes ''personal comfort and well being.'' They argue the Senate bill contemplated the NAAQS would include only direct health effects, while the *goals* would encompass effects on both the public health and welfare. Commenters continue that considering both public health effects and welfare effects under a combined standard, as the Administrator attempts to do in the proposed endangerment finding, would resurrect the combined approach to NAAQS that the Senate emphatically rejected.

The commenters also cite language from the House Report in support of their view that Congress only intended that EPA consider direct health effects

when assessing endangerment to public health: ''By the words 'cause or contribute to air pollution,' the committee intends to require the Administrator to consider all sources of the contaminant which contributes to air pollution and to consider all sources of exposure to the contaminant—food, water, air, etc.—in determining health risks'' 7 H.R. Rep. No. 95–294, at 49–50 (1977). Commenters also cite language in the Senate Report: ''Knowledge of the relationship between the exposure to many air pollution agents and acute and chronic health effects is sufficient to develop air quality criteria related to such effects'' S. Rep. No. 91–1196, at 7 (1970).

The specific issue here is whether an effect on human health that results from a change in climate should be considered when EPA determines whether the air pollution of well-mixed greenhouse gases is reasonably anticipated to endanger public health. In this case, the air pollution has an effect on climate. For example the air pollution raises surface, air, and water temperatures. Among the many effects that flow from this is the expectation that there will be an increase in the risk of mortality and morbidity associated with increased intensity of heat waves. In addition, there is an expectation that there will be an increase in levels of ambient ozone, leading to increased risk of morbidity and mortality from exposure to ozone. All of these are effects on human health, and all of them are associated with the effect on climate from elevated atmospheric concentrations of greenhouse gases. None of these human health effects are associated with direct exposure to greenhouse gases.

In the past, EPA has not had to resolve the issue presented here, as it has been clear whether the effects relate to public health or relate to public welfare, with no confusion over what category was at issue. In those cases EPA has routinely looked at what effect the air pollution has on people. If the effect on people is to their health, we have considered it an issue of public health. If the effect on people is to their interest in matters other than health, we have considered it public welfare.

For example, there are serious health risks associated with inhalation of ozone, and they have logically been considered as public health issues. Ambient levels of ozone have also raised the question of indirect health benefits through screening of harmful UVB rays. EPA has also considered this indirect health effect of ozone to be a public health issue.[29] Ozone pollution also affects people by impacting their interests in various vegetation through foliar damage to trees, reduced crop yield, adverse impacts on horticultural plants, and the like. EPA has consistently considered these issues when evaluating the public welfare based NAAQS standards under CAA section 109.

In all of these situations the use of the term ''public'' has focused EPA on how people are affected by the air pollution. If the effect on people is to their health then we have considered it a public health issue. If the effect on people is to their interest in matters other than health, then we have treated it as a public welfare issue.

The situation presented here is somewhat unique. The focus again is on the effect the air pollution has on people. Here the effect on people is to their health. However this effect flows from the change in climate and effects on climate are included in the definition of effects on welfare. That raises the issue of how to categorize the health effects—should we consider them when evaluating endangerment to public health? When we evaluate endangerment to public welfare? Or both?

The text of the CAA does not resolve this question. While Congress defined ''effects on welfare,'' it did not define either ''public health'' or ''public welfare''. In addition, the definition of ''effects on welfare'' does not clearly address how to categorize health effects that flow from effects on soils, water, crops, vegetation, weather, climate, or any of the other factors listed in CAA section 302(h). It is clear that effects on climate are an effect on welfare, but the definition does not address whether health impacts that are caused by these changes in climate are also effects on welfare. The health effects at issue are not themselves effects on soils, water, crops, vegetation, weather, or climate. They are instead effects on health. They derive from the effects on climate, but they are not themselves effects on climate or on anything else listed in CAA section 302(h). So the definition of effects on welfare does not address whether an effect on health, which is not itself listed in CAA section 302(h), is also an effect on welfare if it results from an effect on welfare. The text of the CAA also does not address the issue of direct and indirect health effects. Contrary to commenters' assertions, the legislative history does not address or resolve this issue.

In this context, EPA is interpreting the endangerment provision in CAA section 202(a) as meaning that the effects on peoples' health from changes to climate can and should be included in EPA's evaluation of whether the air pollution at issue endangers public health. EPA is not deciding whether these health effects also could or should be considered in evaluating endangerment to public welfare.

The stating of the issue makes the answer seem straightforward. If air pollution causes sickness or death, then these health effects should be considered when evaluating whether the air pollution endangers public health. The term public health is undefined, and by itself this is an eminently reasonable way to interpret it. This focuses on the actual effect on people, as compared to ignoring that and focusing on the pathway from the air pollution to the effect. The question then becomes whether there is a valid basis in the CAA to take the different approach suggested by commenters, an approach contrary to the common sense meaning of public health.

Notably, the term ''public welfare'' is undefined. While it clearly means something other than public health, there is no obvious indication whether Congress intended there to be a clear boundary between the two terms or whether there might be some overlap where some impacts could be considered both a public health and a public welfare impact. Neither the text nor the legislative history resolves this issue. Under either approach, EPA believes the proper interpretation is that these effects on health should be considered when evaluating endangerment to public health.

If we assume Congress intended that effects on public welfare could not include effects on public health and vice versa, then the effects at issue here should most reasonably be considered in the public health category. Indisputably they are health effects, and the plain meaning of the term public health would call for their inclusion in that term. The term public welfare is

[29] As discussed later, in the past EPA took the position that this kind of potential indirect beneficial impact on public health should not be considered when setting the primary health based NAAQS for ozone. This was not based on the view that it was not a potential public health impact, or that it was a public welfare impact instead of a public health impact. Instead EPA was interpreting the NAAQS standard setting provisions of section 109, and argued that they were intended to address only certain public health impacts, those that were adverse, and were not intended to address indirect, beneficial public health impacts. This interpretation of section 109 was rejected in *ATA* v. *EPA*, 175 F.3d 1027 (1999) *reh'g granted in part and denied in part*, 195 F.3d 4 (DC Cir. 1999). The court made it clear that the potential indirect beneficial impact of ambient ozone on public health from screening UVB rays needed to be considered when setting the NAAQS to protect public health.

undefined. If Congress intended that public welfare not include matters included in the public health category, then a reasonable interpretation of this undefined term would include those effects on welfare that impact people in ways other than impacting their health.

The definition of ''effects on welfare'' does not clearly address how to categorize health effects that flow from effects on water, soil, land, climate, or weather. As noted above, the definition does not address whether health impacts that are caused by these changes in climate are also ''effects on welfare.'' Certainly effects on health are not included in the list in CAA section 302(h). The lack of clarity in the definition of effects on welfare, combined with the lack of definition of public welfare, do not warrant interpreting the term public health differently from its straightforward and common sense meaning.

The inclusion of the phrase ''effects on * * * personal comfort and well-being'' as an effect on welfare supports this view. The term would logically mean something other than the different term public health. The term ''well-being'' is not defined, and generally has a broader and different connotation of positive physical, emotional, and mental status. The most straightforward meaning of this term, in a context where Congress used the different term public health in a wide variety of other provisions, would be to include effects on people that do not rise to the level of health effects, but otherwise impact their physical, emotional, and mental status. This gives full meaning to both terms.

The term well-being is a general term, and in isolation arguably could include health effects. However there is no textual basis to say it would include some health effects but not others, as argued by commenters. If sickness impacts your well-being, then it impacts your well-being whether it results directly or indirectly from the pollution in the air. Nothing in CAA section 302(h) limits the term well-being to indirect impacts on people, or to health effects that occur because of other welfare effects, such as climate change. It is listed as its own effect on welfare. Instead of interpreting well-being as including all health effects, or some health effects, the much more logical way to interpret this provision in the context of all of the other provisions of the CAA is to interpret it as meaning effects on people other than health effects.

Thus, if Congress intended to draw a strict line between the two categories of public health and public welfare, for purposes of determining endangerment under CAA section 202(a), then EPA believes that its interpretation is a reasonable and straightforward way to categorize the health effects at issue here. This gives weight to the common sense meaning of the term public health, where the terms public health and public welfare are undefined and the definition of effects on welfare is at best ambiguous on this issue.

In the alternative, if Congress did not intend any such bright line between these two categories and there could be an overlap, then it is also reasonable for EPA to include these health effects in its consideration of whether the air pollution endangers public health. Neither approach condenses or conflates the two different terms. Under either approach EPA's interpretation, as demonstrated in this rulemaking, would still consider numerous and varied effects from climate change as indisputable impacts on public welfare and not impacts on public health. In addition, this interpretation will not change the fact that in almost all cases impacts on public health would not also be considered impacts on public welfare.

Prior EPA actions. Several commenters argue that EPA's decision to include health impacts that occur because of climate change is inconsistent with its past approach, which has been to treat indirect health effects as welfare effects. Commenters contend that in the latest Criteria Document for ozone EPA listed tropospheric ozone's effects on UVB-induced human diseases, as well as its effects on climate change, as welfare effects, even though the agency acknowledged significant health effects such as sunburn and skin cancer. Commenters also argue that EPA listed ''risks to human health'' from toxins released by algal blooms due to excess nitrogen as ''ecological and other welfare effects'' in the recent Criteria Document for oxides of nitrogen and sulfur. Finally, commenters argue that EPA's proposed action was contrary to the Agency decision to list new municipal solid waste landfills as a source category under CAA section 111. Commenters state that EPA listed climate change as a welfare effect in that action, (citing 56 FR 24469).

The Agency's recent approach regarding UVB-induced health effects is consistent with the endangerment findings, and demonstrates that the Agency considers indirect effects on human health as public health issues rather than public welfare issues. While the ozone Criteria Document may have placed the discussion of UV–B related health effects among chapters on welfare effects, in evaluating the evidence presented in the Criteria Document for purposes of preparing the policy assessment document, EPA staff clearly viewed UVB-induced effects as human health effects that were relevant in determining the public health based primary NAAQS for ozone, rather than welfare effects, regardless of which chapter in the Criteria Document described those effects. The evaluation of the UVB-related evidence is discussed with other human health effects evidence. The policy assessment document noted that Chapter 10 of the Criteria Document, ''provides a thorough analysis of the current understanding of the relationship between reducing tropospheric [ozone] concentrations and the potential impact these reductions might have on UV–B surface fluxes and *indirectly contributing to increased UV–B related health effects.*'' *See*, *Review of the National Ambient Air Quality Standards for Ozone: Policy Assessment of Scientific and Technical Information*, p 3–36 (January 2007) (emphasis added).

EPA repeated this view in the 2007 proposed ozone NAAQS rule. In presenting its evaluation of the human health evidence for purposes of setting the public health based primary NAAQS, EPA stated: ''This section also summarizes the uncertainty about the *potential indirect effects on public health* associated with changes due to increases in UV–B radiation exposure, such as UV–B radiation-related skin cancers, that may be associated with reductions in ambient levels of ground-level [ozone], as discussed in chapter 10 of the Criteria Document and chapter 3 of the Staff Paper.'' 72 FR 37818, 37827. *See* also, 72 FR 37837 (''* * * the Criteria Document also assesses the potential indirect effects related to the presence of [ozone] in the ambient air by considering the role of ground-level [ozone] in mediating human health effects that may be directly attributable to exposure to solar ultraviolet radiation (UV–B).'')

Thus, EPA's approach to UV–B related health effects clearly shows the Agency has treated indirect health effects not as welfare effects, as commenters suggest, but as human health effects that need to be evaluated when setting the public health based primary NAAQS. In this ozone NAAQS rulemaking, EPA did not draw a line between direct and indirect health effects for purposes of evaluating UV–B related health effects and the public health based primary NAAQS.

Similarly, the NO_X/SO_X criteria document does not establish a precedent that indirect human health effects are welfare effects. Toxic algal blooms themselves are a welfare effect, so it is not surprising a discussion of algal blooms appears in sections dealing with welfare effects. The more relevant question is how EPA evaluated information regarding human health risks resulting from algal blooms. In the case of the Criteria Document, the role of nitrogen in causing algal blooms was unclear. As a result, the Agency did not have occasion to evaluate any resulting human health effects and the Criteria Document does not support the view that EPA treats indirect health effects as anything other than a public health issue.

Finally, EPA disagrees that its action here is at odds with the listing of municipal solid waste landfills under CAA section 111. In the landfills New Source Performance Standard (NSPS) EPA did not consider health effects resulting from climate change much less draw any conclusions about health effects from climate change being health or welfare effects. If anything, the landfills NSPS is consistent with EPA's approach. In the proposed rule, EPA stated: ''The EPA has documented many cases of acute injury and death caused by explosions and fires related to municipal landfill gas emissions. In addition to these health effects, the associated property damage is a welfare effect'' (56 FR 24474). EPA considered injury and death from fires resulting from landfill gasses to be health effects. Yet the injury did not result from direct exposure to the pollutant (landfill gas). Instead, the injury resulted from the combustion of the pollutant—the injury is essentially an indirect effect of the pollutant. Yet, as with this action, EPA considered the injury as a human health effect.

Case law. Several commenters argue that EPA's proposed endangerment finding was inconsistent with *NRDC* v. *EPA*, 902 F.2d 962 (DC Cir 1990). Commenters argue that in rejecting the argument that EPA must consider the health effects of increased unemployment that could result from a more stringent primary NAAQS standard, the DC Circuit explained that, ''[i]t is only the health effects relating to pollutants in the air that EPA may consider.'' *Id.* at 973. Several commenters further argue that EPA later relied on that holding to defend its decision to set a primary NAAQS for ozone based solely on direct health effects of ozone. Citing, *EPA Pet'n for Rehearing, Am. Trucking Ass'n* v. *EPA*, No. 97–1440 (DC Cir. June 28, 1999) (''ATA I'') (arguing that the primary NAAQS should be set through consideration of only ''direct adverse effects on public health, and not indirect, allegedly beneficial effects.'')

The *NRDC* case is not contrary to EPA's endangerment finding. In *NRDC*, petitioner American Iron and Steel Institute argued that EPA had to consider the costs of health consequences that might arise from increased unemployment. The court ruled that, ''[c]onsideration of costs associated with alleged health risks from unemployment would be flatly inconsistent with the statute, legislative history and case law on this point.'' 902 F.2d at 973. The cases cited by the court in support of its decision all hold that EPA may not consider economic or technological feasibility in establishing a NAAQS. The *NRDC* decision does not establish a precedent that the CAA prohibits EPA from considering indirect health effects as a public health issue rather than a public welfare issue.

EPA also believes reliance on the Agency's petition for rehearing in noted above is misplaced. In that case, EPA did not argue that indirect beneficial health effects were not public health issues. Instead EPA argued that under the CAA, it did not have to consider such indirect beneficial health effects of an air pollutant when setting the health based primary NAAQS. EPA was interpreting the NAAQS standard setting provisions of CAA section 109, and argued that they were intended to address only certain public health impacts, those that were adverse, and were not intended to address indirect, beneficial public health impacts. The issue in the case was not whether indirect health effects are relevant for purposes of making an endangerment decision concerning public health, but rather whether EPA must consider such beneficial health effects in establishing a primary NAAQS under CAA section 109. EPA's interpretation of CAA section 109 was rejected in *ATA* v. *EPA*, 175 F.3d at 1027 (1999) *reh'g granted in part and denied in part*, 195 F.3d at 4 (DC Cir. 1999). The court made it clear that the potential indirect beneficial impact of ambient ozone on public health from screening UVB rays needed to be considered when setting the NAAQS to protect public health. As discussed above, EPA has done just that as noted above in the UV–B context. Moreover, as discussed in Section II of these Findings, EPA is doing that here as well (*e.g.*, considering any benefits from reduced cold weather related deaths).

ii. EPA's Treatment and Balancing of Heat- vs. Cold-Related Public Health Risks Was Reasonable

A number of public commenters maintain that the risk of heat waves in the future will be modulated by adaptive measures. The Administrator is aware of the potential benefits of adaptation in reducing heat-related morbidity and mortality and recognizes most heat-related deaths are preventable. Nonetheless, the Administrator notes the assessment literature [30] indicates heat is the leading weather-related killer in the United States even though countermeasures have been employed in many vulnerable areas. Given projections for heat waves of greater frequency, magnitude, and duration coupled with a growing population of older adults (among the most vulnerable groups to this hazard), the risk of adverse health outcomes from heat waves is expected to increase. Intervention and response measures could certainly reduce the risk, but as we have noted, the need to adapt supports an increase in risk or endangerment. For a general discussion about EPA's treatment of adaptation see Section III.C of these Findings.

Several commenters also suggest cold-related mortality will decrease more than heat-related mortality will increase, which indicates a net reduction in temperature-related mortality. Some commenters point to research suggesting migration to warmer climates has contributed to the increased longevity of some Americans, implying climate warming will have benefits for health. The Administrator is very clear that the exact balance of how heat- versus cold-related mortality will change in the future is uncertain; however, the assessment literature points to evidence suggesting that the increased risk from heat would exceed the decreased risk from cold in a warming climate. The Administrator does not dispute research indicating the benefits of migration to a warmer climate and nor that average climate warming may indeed provide health benefits in some areas. These points are reflected in the TSD's statement projecting less cold-related health effects. The Administrator considers these potential warming benefits independent of the potential negative effects of extreme heat events which are projected to increase under future climate change scenarios affecting vulnerable groups and communities.

[30] Karl *et al.* (2009).

iii. EPA Was Reasonable To Find That the Air Quality Impacts of Climate Change Contribute to the Endangerment of Public Health

Several commenters suggest that air quality effects of climate change will be addressed through the CAA's NAAQS process, as implemented by the State Implementation Plans (SIP) and national regulatory programs. According to these commenters, these programs will ensure no adverse impact on public health due to climate change. Though climate change may cause certain air pollutant ambient concentrations to increase, States will continue to be compelled to meet the standards. So, while additional measures may be necessary, and result in increased costs, these commenters assert that, ultimately, public health will be protected by the continued existence of the NAAQS and therefore no endangerment with respect to this particular climate change-related impact will occur. One commenter states that EPA inappropriately assigns air quality risk to climate change that will be addressed through other programs. The CAA provides a mechanism to meet the standards and additional control measures consistent with the CAA will be adopted in the future, keeping pollution below unhealthy levels. The commenters state that the fact that NAAQS are in place that require EPA to fulfill its legal obligation to prevent this particular form of endangerment to public health.

EPA does have in place NAAQS for ozone, which are premised on the harmfulness of ozone to public health and welfare. These standards and their accompanying regulatory regime have helped to reduce the dangers from ozone in the United States. However, substantial challenges remain with respect to achieving the air quality protection promised by the NAAQS for ozone. It is the Administrator's view that these challenges will be exacerbated by climate change.

In addition, the control measures to achieve attainment with a NAAQS are a mitigation measure aimed at reducing emissions of ozone precursors. As discussed in Section III.C of these Findings, EPA is not considering the impacts of mitigation with respect to future reductions in emissions of greenhouse gases. For the same reasons, EPA is reasonably not considering mitigation in the form of the control measures that will need to be adopted in the future to reduce emissions of ozone precursors and thereby address the increased ambient ozone levels that can occur because of climate change.

It is important to note that controls to meet the NAAQS are typically put in place only *after* air quality concentrations exceeding the standard are detected. Furthermore, implementation of controls to reduce ambient concentrations of pollutants occurs over an extended time period, ranging from three years to more than twenty years depending on the pollutant and the seriousness of the nonattainment problem. Thus, while the CAA provides mechanisms for addressing adverse health effects and the underlying air quality exacerbation over time, it will not prevent the adverse impacts in the interim. Given the serious nature of the health effects at issue—including respiratory and cardiovascular disease leading to hospital admissions, emergency department visits, and premature mortality—this increase in adverse impacts during the time before additional controls can be implemented is a serious public health concern. Historically, a large segment of the U.S. population has lived in areas exceeding the NAAQS, despite the CAA and its implementation efforts. Half of all Americans, 158 million people, live in counties where air pollution exceeds national health standards.[31] Where attainment of the NAAQS is especially difficult, leading to delays in meeting attainment deadlines, the health effects of increased ozone due to climate change may be substantial.

It is also important to note that it may not be possible for States and Tribes to plan accurately for the impacts of climate change in developing control strategies for nonattainment areas. As noted in the TSD and EPA's 2009 Interim Assessment report (IA), climate change is projected to lead to an increase in the variability of weather, and this may increase peak pollution events including increases in ozone exceedances. While the modeling studies in the IA all show significant future changes in meteorological quantities, there is also significant variability across the simulations in the spatial patterns of these future changes, making it difficult to select a set of future meteorological data for planning purposes. At this time, models used to develop plans to attain the NAAQS do not take potential changes in future meteorology into consideration. Inability to predict the frequency and magnitude of such events could lead to an underestimation of the controls needed to bring areas into attainment, and a prolonged period during which adverse health impacts continue to occur.

Even in areas that meet the NAAQS currently, air quality may deteriorate sufficiently to cause adverse health effects for some individuals. Some at-risk individuals, for example those with preexisting health conditions or other characteristics which increase their risk for adverse effects upon exposure to PM or ozone, may experience health effects at levels below the standard. Current evidence suggests that there is no threshold for PM or ozone concentrations below which no effects can be observed. Therefore, increases in ozone or PM in locations that currently meet the standards would likely result in additional adverse health effects for some individuals, even though the pollution increase might not be sufficient to cause the area to be designated nonattainment. While the NAAQS is set to protect public health with an adequate margin of safety, it is recognized that in attainment areas there may be individuals who remain at greater risk from an increase in ozone levels. The clear risk to the public from ozone increases in nonattainment areas, in combination with the risk to some individuals in attainment areas, supports the finding that overall the public health is endangered by increases in ozone resulting from climate change.

Finally, it is also important to note that not all air pollution events are subject to CAA controls under the NAAQS implementation provisions. ''Exceptional events'' are events for which the normal planning and regulatory process established by the CAA is not appropriate (72 FR 13561). Emissions from some events, including some wildfires, are not reasonably controllable or preventable. Such emissions, however, can adversely impact public health and welfare and are expected to increase due to climate change. As described in the TSD, PM emissions from wildfires can contribute to acute and chronic illnesses of the respiratory system, particularly in children, including pneumonia, upper respiratory diseases, asthma and chronic obstructive pulmonary disease. The IPCC (Field et al., 2007) reported with very high confidence that in North America, disturbances like wildfires are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons.

2. The Air Pollution Is Reasonably Anticipated to Endanger Public Welfare

The Administrator also finds that the well-mixed greenhouse gas air pollution may reasonably be anticipated to

[31] U.S. EPA (2008) National Air Quality: Status and Trends Through 2007. EPA–454/R–08–006, November 2008.

endanger public welfare, both for current and future generations.

As with public health, the Administrator considered the multiple pathways in which the greenhouse gas air pollution and resultant climate change affect climate-sensitive sectors, and the impact this may have on public welfare. These sectors include food production and agriculture; forestry; water resources; sea level rise and coastal areas; energy, infrastructure, and settlements; and ecosystems and wildlife. The Administrator also considered impacts on the U.S. population from climate change effects occurring outside of the United States, such as national security concerns for the United States that may arise as a result of climate change impacts in other regions of the world. The Administrator examined each climate-sensitive sector individually, informed by the summary of the scientific assessments contained in the TSD, and the full record before EPA, and weighed the extent to which the risks and impacts within each sector support or do not support a positive endangerment finding in her judgment. The Administer then viewed the full weight of evidence looking across all sectors to reach her decision regarding endangerment to public welfare.

a. Food Production and Agriculture

Food production and agriculture within the United States is a sector that will be affected by the combined effects of elevated carbon dioxide concentrations and associated climate change. The Administrator considered how these effects, both adverse and beneficial, are affecting the agricultural sector now and in the future, and over different regions of the United States, taking into account that different regions of the country specialize in different agricultural products with varying degrees of sensitivity and vulnerability to elevated carbon dioxide levels and associated climate change.

Elevated carbon dioxide concentrations can have a stimulatory effect on grain and oilseed crop yield, as may modest temperature increases and a longer growing season that results. A report under the USGCRP concluded that, with increased carbon dioxide and temperature, the life cycle of grain and oilseed crops will likely progress more rapidly. However, such beneficial influences need to be considered in light of various other effects. For example, the literature indicates that elevated carbon dioxide concentrations may also enhance pest and weed growth. Pests and weeds can reduce crop yields, cause economic losses to farmers, and require management control options. How climate change (elevated carbon dioxide, increased temperatures, altered precipitation patterns, and changes in the frequency and intensity of extreme events) may affect the prevalence of pests and weeds is an issue of concern for food production and the agricultural sector. Research on the combined effects of elevated carbon dioxide and climate change on pests, weeds, and disease is still limited. In addition, higher temperature increases, changing precipitation patterns and variability, and any increases in ground-level ozone induced by higher temperatures, can work to counteract any direct stimulatory carbon dioxide effect, as well as lead to their own adverse impacts. There may be large regional variability in the response of food production and agriculture to climate change.

For grain and oilseed crop yields, there is support for the view that in the near term climate change may have a beneficial effect, largely through increased temperature and increased carbon dioxide levels. However there are also factors noted above, some of which are less well studied and understood, which would tend to offset any near term benefit, leaving significant uncertainty about the actual magnitude of any overall benefit. The USGCRP report also concluded that as temperature rises, these crops will increasingly begin to experience failure, especially if climate variability increases and precipitation lessens or becomes more variable.

A key uncertainty is how human-induced climate change may affect the intensity and frequency of extreme weather events such as droughts and heavy storms. These events have the potential to have serious negative impact on U.S. food production and agriculture, but are not always taken into account in studies that examine how average conditions may change as a result of carbon dioxide and temperature increases. Changing precipitation patterns, in addition to increasing temperatures and longer growing seasons, can change the demand for irrigation requirements, potentially increasing irrigation demand.

Another key uncertainty concerns the many horticultural crops (*e.g.,* tomatoes, onions, fruits), which make up roughly 40 percent of total crop value in the United States. There is relatively little information on their response to carbon dioxide, and few crop simulation models, but according to the literature, they are very likely to be more sensitive to the various effects of climate change than grain and oilseed crops.

With respect to livestock, higher temperatures will very likely reduce livestock production during the summer season in some areas, but these losses will very likely be partially offset by warmer temperatures during the winter season. The impact on livestock productivity due to increased variability in weather patterns will likely be far greater than effects associated with the average change in climatic conditions. Cold-water fisheries will likely be negatively affected; warm-water fisheries will generally benefit; and the results for cool-water fisheries will be mixed, with gains in the northern and losses in the southern portions of ranges.

Finally, with respect to irrigation requirements, the adverse impacts of climate change on irrigation water requirements may be significant.

There is support for the view that there may be a benefit in the near term in the crop yield for certain crops. This potential benefit is subject to significant uncertainty, however, given the offsetting impact on the yield of these crops from a variety of other climate change impacts that are less well understood and more variable. Any potential net benefit is expected to change to a disbenefit in the longer term. In addition, there is clear risk that the sensitivity of a major segment of the total crop market, the horticultural sector, may lead to adverse affects from climate change. With respect to livestock production and irrigation requirements, climate change is likely to have adverse effects in both the near and long terms. The impact on fisheries varies, and would appear to be best viewed as neutral overall.

There is a potential for a net benefit in the near term for certain crops, but there is significant uncertainty about whether this benefit will be achieved given the various potential adverse impacts of climate change on crop yield, such as the increasing risk of extreme weather events. Other aspects of this sector are expected to be adversely affected by climate change, including livestock management and irrigation requirements, and there is a risk of adverse effect on a large segment of the total crop market. For the near term, the concern over the potential for adverse effects in certain parts of the agriculture sector appears generally comparable to the potential for benefits for certain crops.

However, considering the trend over near- and long-term future conditions, the Administrator finds that the body of evidence points towards increasing risk

of net adverse impacts on U.S. food production and agriculture, with the potential for significant disruptions and crop failure in the future.

b. Forestry

The factors that the Administrator considered for the U.S. forest sector are similar to those for food production and agriculture. There is the potential for beneficial effects due to elevated concentrations of carbon dioxide and increased temperature, as well as the potential for adverse effects from increasing temperatures, changing precipitation patterns, increased insects and disease, and the potential for more frequent and severe extreme weather events. The potential beneficial effects are better understood and studied, and are limited to certain areas of the country and types of forests. The adverse effects are less certain, more variable, and also include some of the most serious adverse effects such as increased wildfire, drought, and major losses from insects and disease. As with food production and agriculture, the judgment to be made is largely a qualitative one, balancing impacts that vary in certainty and magnitude, with the end result being a judgment as to the overall direction and general level of concern.

According to the underlying science assessment reports, climate change has very likely increased the size and number of wildfires, insect outbreaks, and tree mortality in the Interior West, the Southwest, and Alaska, and will continue to do so. Rising atmospheric carbon dioxide levels will very likely increase photosynthesis for forests, but the increased photosynthesis will likely only increase wood production in young forests on fertile soils. Nitrogen deposition and warmer temperatures have very likely increased forest growth where water is not limiting and will continue to do so in the near future.

An increased frequency of disturbance (such as drought, storms, insect-outbreaks, and wildfire) is at least as important to forest ecosystem function as incremental changes in temperature, precipitation, atmospheric carbon dioxide, nitrogen deposition, and ozone pollution. Disturbances partially or completely change forest ecosystem structure and species composition, cause short-term productivity and carbon storage loss, allow better opportunities for invasive alien species to become established, and command more public and management attention and resources. The combined effects of expected increased temperature, carbon dioxide, nitrogen deposition, ozone, and forest disturbance on soil processes and soil carbon storage remain unclear.

Precipitation and weather extremes are key to many forestry impacts, accounting for part of the regional variability in forest response. If existing trends in precipitation continue, it is expected that forest productivity will likely decrease in the Interior West, the Southwest, eastern portions of the Southeast, and Alaska, and that forest productivity will likely increase in the northeastern United States, the Lake States, and in western portions of the Southeast. An increase in drought events will very likely reduce forest productivity wherever such events occur.

Changes in disturbance patterns are expected to have a substantial impact on overall gains or losses. More prevalent wildfire disturbances have recently been observed in the United States. Wildfires and droughts, among other extreme events (*e.g.,* hurricanes) that can cause forest damage, pose the largest threats over time to forest ecosystems.

For the near term, the Administrator believes the beneficial impact on forest growth and productivity in certain parts of the country from climate change to be more than offset by the clear risk from the more significant and serious adverse effects from the observed increases in wildfires, combined with the adverse impacts on growth and productivity in other areas of the country and the serious risks from the spread of destructive pests and disease. Increased wildfires can also increase particulate matter and thus create public health concerns as well. For the longer term, the Administrator views the risk from adverse effects to increase over time, such that overall climate change presents serious adverse risks for forest productivity. The Administrator therefore finds there is compelling reason to find that the greenhouse gas air pollution endangers U.S. forestry in both the near and long term, with the support for a positive endangerment finding only increasing as one considers expected future conditions in which temperatures continue to rise.

c. Water Resources

The sensitivity of water resources to climate change is very important given the increasing demand for adequate water supplies and services for agricultural, municipal, and energy and industrial uses, and the current strains on this resource in many parts of the country.

According to the assessment literature, climate change has already altered, and will likely continue to alter, the water cycle, affecting where, when, and how much water is available for all uses. With higher temperatures, the water-holding capacity of the atmosphere and evaporation into the atmosphere increase, and this favors increased climate variability, with more intense precipitation and more droughts.

Climate change is causing and will increasingly cause shrinking snowpack induced by increasing temperature. In the western United States, there is already well-documented evidence of shrinking snowpack due to warming. Earlier meltings, with increased runoff in the winter and early spring, increase flood concerns and also result in substantially decreased summer flows. This pattern of reduced snowpack and changes to the flow regime pose very serious risks to major population regions, such as California, that rely on snowmelt-dominated watersheds for their water supply. While increased precipitation is expected to increase water flow levels in some eastern areas, this may be tempered by increased variability in the precipitation and the accompanying increased risk of floods and other concerns such as water pollution.

Warmer temperatures and decreasing precipitation in other parts of the country, such as the Southwest, can sustain and amplify drought impacts. Although drought has been more frequent and intense in the western part of the United States, the East is also vulnerable to droughts and attendant reductions in water supply, changes in water quality and ecosystem function, and challenges in allocation. The stress on water supplies on islands is expected to increase.

The impact of climate change on groundwater as a water supply is regionally variable; efforts to offset declining surface water availability due to increasing precipitation variability may be hampered by the fact that groundwater recharge will decrease considerably in some already water-stressed regions. In coastal areas, the increased salinization from intrusion of salt water is projected to have negative effects on the supply of fresh water.

Climate change is expected to have adverse effects on water quality. The IPCC concluded with high confidence that higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution and can impact ecosystems, human health, and water system reliability and operating costs. These changes will also exacerbate many forms of water pollution, potentially making attainment of water quality goals more

difficult. Water pollutants of concern that are particularly relevant to climate change effects include sediment, nutrients, organic matter, pathogens, pesticides, salt, and thermal pollution. As waters become warmer, the aquatic life they now support will be replaced by other species better adapted to warmer water. In the long term, warmer water, changing flows, and decreased water quality may result in deterioration of aquatic ecosystems.

Climate change will likely further constrain already over-allocated water resources in some regions of the United States, increasing competition among agricultural, municipal, industrial, and ecological uses. Although water management practices in the United States are generally advanced, particularly in the West, the reliance on past conditions as the basis for current and future planning may no longer be appropriate, as climate change increasingly creates conditions well outside of historical observations. Increased incidence of extreme weather and floods may also overwhelm or damage water treatment and management systems, resulting in water quality impairments. In the Great Lakes and major river systems, lower water levels are likely to exacerbate challenges relating to water quality, navigation, recreation, hydropower generation, water transfers, and bi-national relationships.

The Administrator finds that the total scientific literature provides compelling support for finding that greenhouse gas air pollution endangers the water resources important for public welfare in the United States, both for current and future generations. The adequacy of water supplies across large areas of the country is at serious risk from climate change. Even areas of the country where an increase in water flow is projected could face water resource problems from the variability of the supply and water quality problems associated with precipitation variability, and could face the serious adverse effects from risks from floods and drought. Climate change is expected to adversely affect water quality. There is an increased risk of serious adverse effects from extreme events of flooding and drought. The severity of risks and impacts may only increase over time with accumulating greenhouse gas concentrations and associated temperature increases and precipitation changes.

d. Sea Level Rise and Coastal Areas

A large percentage of the U.S. population lives in coastal areas, which are particularly vulnerable to the risks posed by climate change. The most vulnerable areas are the Atlantic and Gulf Coasts, the Pacific Islands, and parts of Alaska.

According to the assessment literature, sea level is rising along much of the U.S. coast, and the rate of change will very likely increase in the future, exacerbating the impacts of progressive inundation, storm-surge flooding, and shoreline erosion. Cities such as New Orleans, Miami, and New York are particularly at risk, and could have difficulty coping with the sea level rise projected by the end of the century under a higher emissions scenario. Population growth and the rising value of infrastructure increases the vulnerability to climate variability and future climate change in coastal areas. Adverse impacts on islands present concerns for Hawaii and the U.S. territories. Reductions in Arctic sea ice increases extreme coastal erosion in Alaska, due to the increased exposure of the coastline to strong wave action. In the Great Lakes, where sea level rise is not a concern, both extremely high and low water levels resulting from changes to the hydrological cycle have been damaging and disruptive to shoreline communities.

Coastal wetland loss is being observed in the United States where these ecosystems are squeezed between natural and artificial landward boundaries and rising sea levels. Up to 21 percent of the remaining coastal wetlands in the U.S. mid-Atlantic region are potentially at risk of inundation between 2000 and 2100. Coastal habitats will likely be increasingly stressed by climate change impacts interacting with development and pollution.

Although increases in mean sea level over the 21st century and beyond will inundate unprotected, low-lying areas, the most devastating impacts are likely to be associated with storm surge. Superimposed on expected rates of sea level rise, projected storm intensity, wave height, and storm surge suggest more severe coastal flooding and erosion hazards. Higher sea level provides an elevated base for storm surges to build upon and diminishes the rate at which low-lying areas drain, thereby increasing the risk of flooding from rainstorms. In New York City and Long Island, flooding from a combination of sea level rise and storm surge could be several meters deep. Projections suggest that the return period of a 100-year flood event in this area might be reduced to 19–68 years, on average, by the 2050s, and to 4–60 years by the 2080s. Additionally, some major urban centers in the United States, such as areas of New Orleans are situated in low-lying flood plains, presenting increased risk from storm surges.

The Administrator finds that the most serious risk of adverse effects is presented by the increased risk of storm surge and flooding in coastal areas from sea level rise. Current observations of sea level rise are now contributing to increased risk of storm surge and flooding in coastal areas, and there is reason to find that these areas are now endangered by human-induced climate change. The conclusion in the assessment literature that there is the potential for hurricanes to become more intense with increasing temperatures (and even some evidence that Atlantic hurricanes have already become more intense) reinforces the judgment that coastal communities are now endangered by human-induced climate change, and may face substantially greater risk in the future. The Administrator has concluded that even if there is a low probability of raising the destructive power of hurricanes, this threat is enough to support a finding that coastal communities are endangered by greenhouse gas air pollution.

In addition, coastal areas face other adverse impacts from sea level rise such as shoreline retreat, erosion, wetland loss and other effects. The increased risk associated with these adverse impacts also endangers the welfare of current and future generations, with an increasing risk of greater adverse impacts in the future.

Overall, the evidence on risk of adverse impacts for coastal areas from sea level rise provides clear support for finding that greenhouse gas air pollution endangers the welfare of current and future generations.

e. Energy, Infrastructure and Settlements

The Administrator also considered the impacts of climate change on energy consumption and production, and on key climate-sensitive aspects of the nation's infrastructure and settlements.

For the energy sector, the Administrator finds clear evidence that temperature increases will change heating and cooling demand, and to varying degrees across the country; however, under current conditions it is unclear whether or not net demand will increase or decrease. While the impacts on net energy demand may be viewed as generally neutral for purposes of making an endangerment determination, climate change is expected to call for an increase in electricity production, especially supply for peak demand. The U.S. energy sector, which relies heavily on water for cooling capacity and

hydropower, may be adversely impacted by changes to water supply in reservoirs and other water bodies.

With respect to infrastructure, climate change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change. The significance of gradual climate change, *e.g.*, increases in the mean temperature, lies mainly in changes in the intensity and frequency of extreme events. Extreme weather events could threaten U.S. energy infrastructure (transmission and distribution), transportation infrastructure (roads, bridges, airports and seaports), water infrastructure, and other built aspects of human settlements. Moreover, soil subsidence caused by the melting of permafrost in the Arctic region is a risk to gas and oil pipelines, electrical transmission towers, roads, and water systems. Vulnerabilities for industry, infrastructures, settlements, and society to climate change are generally greater in certain high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Additionally, infrastructures are often connected, meaning that an impact on one can also affect others.

A significant fraction of U.S. infrastructure is located in coastal areas. In these locations, rising sea levels are likely to lead to direct losses (*e.g.,* equipment damage from flooding) as well as indirect effects such as the costs associated with raising vulnerable assets to higher levels. Water infrastructure, including drinking water and wastewater treatment plants, and sewer and storm water management systems, may be at greater risk of flooding, sea level rise and storm surge, low flows, saltwater intrusion, and other factors that could impair performance and damage costly investments.

Within settlements experiencing climate change stressors, certain parts of the population may be especially vulnerable based on their circumstances. These include the poor, the elderly, the very young, those already in poor health, the disabled, those living alone, and/or indigenous populations dependent on one or a few resources. In Alaska, indigenous communities are likely to experience disruptive impacts, including shifts in the range or abundance of wild species crucial to their livelihoods and well-being.

Overall, the evidence strongly supports the view that climate change presents risks of serious adverse impacts on public welfare from the risk to energy production and distribution as well as risks to infrastructure and settlements.

f. Ecosystems and Wildlife

The Administrator considered the impacts of climate change on ecosystems and wildlife and the services they provide. The Administrator finds clear evidence that climate change is exerting major influences on natural environments and biodiversity, and these influences are generally expected to grow with increased warming. Observed changes in the life cycles of plants and animals include shifts in habitat ranges, timing of migration patterns, and changes in reproductive timing and behavior.

The underlying assessment literature finds with high confidence that substantial changes in the structure and functioning of terrestrial ecosystems are very likely to occur with a global warming greater than 2 to 3 °C above pre-industrial levels, with predominantly negative consequences for biodiversity and the provisioning of ecosystem goods and services. With global average temperature changes above 2 °C, many terrestrial, freshwater, and marine species (particularly endemic species) are at a far greater risk of extinction than in the geological past. Climate change and ocean acidification will likely impair a wide range of planktonic and other marine calcifiers such as corals. Even without ocean acidification effects, increases in sea surface temperature of about 1–3 °C are projected to result in more frequent coral bleaching events and widespread mortality. In the Arctic, wildlife faces great challenges from the effects of climatic warming, as projected reductions in sea ice will drastically shrink marine habitat for polar bears, ice-inhabiting seals, and other animals.

Some common forest types are projected to expand, such as oak-hickory, while others are projected to contract, such as maple-beech-birch. Still others, such as spruce-fir, are likely to disappear from the contiguous United States. Changes in plant species composition in response to climate change can increase ecosystem vulnerability to other disturbances, including wildfires and biological invasion. Disturbances such as wildfires and insect outbreaks are increasing in the United States and are likely to intensify in a warmer future with warmer winters, drier soils and longer growing seasons. The areal extent of drought-limited ecosystems is projected to increase 11 percent per °C warming in the United States. In California, temperature increases greater than 2 °C may lead to conversion of shrubland into desert and grassland ecosystems and evergreen conifer forests into mixed deciduous forests. Greater intensity of extreme events may alter disturbance regimes in coastal ecosystems leading to changes in diversity and ecosystem functioning. Species inhabiting salt marshes, mangroves, and coral reefs are likely to be particularly vulnerable to these effects.

The Administrator finds that the total scientific record provides compelling support for finding that the greenhouse gas air pollution leads to predominantly negative consequences for biodiversity and the provisioning of ecosystem goods and services for ecosystems and wildlife important for public welfare in the U.S., both for current and future generations. The severity of risks and impacts may only increase over time with accumulating greenhouse gas concentrations and associated temperature increases and precipitation changes.

g. Summary of the Administrator's Finding of Endangerment to Public Welfare

The Administrator has considered how elevated concentrations of the well-mixed greenhouse gases and associated climate change affect public welfare by evaluating numerous and far-ranging risks to food production and agriculture, forestry, water resources, sea level rise and coastal areas, energy, infrastructure, and settlements, and ecosystems and wildlife. For each of these sectors, the evidence provides support for a finding of endangerment to public welfare. The evidence concerning adverse impacts in the areas of water resources and sea level rise and coastal areas provide the clearest and strongest support for an endangerment finding, both for current and future generations. Strong support is also found in the evidence concerning infrastructure and settlements, as well ecosystems and wildlife. Across the sectors, the potential serious adverse impacts of extreme events, such as wildfires, flooding, drought, and extreme weather conditions provide strong support for such a finding.

Water resources across large areas of the country are at serious risk from climate change, with effects on water supplies, water quality, and adverse effects from extreme events such as floods and droughts. Even areas of the country where an increase in water flow is projected could face water resource problems from the supply and water quality problems associated with temperature increases and precipitation variability, and could face the increased risk of serious adverse effects from extreme events, such as floods and

drought. The severity of risks and impacts is likely to increase over time with accumulating greenhouse gas concentrations and associated temperature increases and precipitation changes.

Overall, the evidence on risk of adverse impacts for coastal areas provides clear support for a finding that greenhouse gas air pollution endangers the welfare of current and future generations. The most serious potential adverse effects are the increased risk of storm surge and flooding in coastal areas from sea level rise and more intense storms. Observed sea level rise is already increasing the risk of storm surge and flooding in some coastal areas. The conclusion in the assessment literature that there is the potential for hurricanes to become more intense (and even some evidence that Atlantic hurricanes have already become more intense) reinforces the judgment that coastal communities are now endangered by human-induced climate change, and may face substantially greater risk in the future. Even if there is a low probability of increasing the destructive power of hurricanes, this threat is enough to support a finding that coastal communities are endangered by greenhouse gas air pollution. In addition, coastal areas face other adverse impacts from sea level rise such as land loss due to inundation, erosion, wetland submergence, and habitat loss. The increased risk associated with these adverse impacts also endangers public welfare, with an increasing risk of greater adverse impacts in the future.

Strong support for an endangerment finding is also found in the evidence concerning energy, infrastructure, and settlements, as well ecosystems and wildlife. While the impacts on net energy demand may be viewed as generally neutral for purposes of making an endangerment determination, climate change is expected to result in an increase in electricity production, especially to meet peak demand. This increase may be exacerbated by the potential for adverse impacts from climate change on hydropower resources as well as the potential risk of serious adverse effects on energy infrastructure from extreme events. Changes in extreme weather events threaten energy, transportation, and water resource infrastructure. Vulnerabilities of industry, infrastructure, and settlements to climate change are generally greater in high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Climate change will likely interact with and possibly exacerbate ongoing environmental change and environmental pressures in settlements, particularly in Alaska where indigenous communities are facing major environmental and cultural impacts on their historic lifestyles. Over the 21st century, changes in climate will cause some species to shift north and to higher elevations and fundamentally rearrange U.S. ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will likely alter ecosystem structure, function, and services, leading to predominantly negative consequences for biodiversity and the provision of ecosystem goods and services.

With respect to food production and agriculture, there is a potential for a net benefit in the near term for certain crops, but there is significant uncertainty about whether this benefit will be achieved given the various potential adverse impacts of climate change on crop yield, such as the increasing risk of extreme weather events. Other aspects of this sector may be adversely affected by climate change, including livestock management and irrigation requirements, and there is a risk of adverse effect on a large segment of the total crop market. For the near term, the concern over the potential for adverse effects in certain parts of the agriculture sector appears generally comparable to the potential for benefits for certain crops. However, the body of evidence points towards increasing risk of net adverse impacts on U.S. food production and agriculture over time, with the potential for significant disruptions and crop failure in the future.

For the near term, the Administrator finds the beneficial impact on forest growth and productivity in certain parts of the country from elevated carbon dioxide concentrations and temperature increases to date is offset by the clear risk from the observed increases in wildfires, combined with risks from the spread of destructive pests and disease. For the longer term, the risk from adverse effects increases over time, such that overall climate change presents serious adverse risks for forest productivity. There is compelling reason to find that the support for a positive endangerment finding increases as one considers expected future conditions where temperatures continue to rise.

Looking across all of the sectors discussed above, the evidence provides compelling support for finding that greenhouse gas air pollution endangers the public welfare of both current and future generations. The risk and the severity of adverse impacts on public welfare are expected to increase over time.

h. Impacts in Other World Regions That Can Affect the U.S Population

While the finding of endangerment to public health and welfare discussed above is based on impacts in the United States, the Administrator also considered how human-induced climate change in other regions of the world may in turn affect public welfare in the United States. According to the USGCRP report of June 2009 and other sources, climate change impacts in certain regions of the world may exacerbate problems that raise humanitarian, trade, and national security issues for the United States.[32] The IPCC identifies the most vulnerable world regions as the Arctic, because of the effects of high rates of projected warming on natural systems; Africa, especially the sub-Saharan region, because of current low adaptive capacity as well as climate change; small islands, due to high exposure of population and infrastructure to risk of sea-level rise and increased storm surge; and Asian mega-deltas, such as the Ganges-Brahmaputra and the Zhujiang, due to large populations and high exposure to sea level rise, storm surge, and river flooding. Climate change has been described as a potential threat multiplier with regard to national security issues.

The Administrator acknowledges these kinds of risks do not readily lend themselves to precise analyses or future projections. However, given the unavoidable global nature of the climate change problem, it is appropriate and prudent to consider how impacts in other world regions may present risks to the U.S. population. Because human-induced climate change has the potential to aggravate natural resource, trade, and humanitarian issues in other world regions, which in turn may contribute to the endangerment of public welfare in the United States, this provides additional support for the Administrator's finding that the greenhouse gas air pollution is reasonably anticipated to endanger the public welfare of current and future

[32] ''In an increasingly interdependent world, U.S. vulnerability to climate change is linked to the fates of other nations. For example, conflicts or mass migrations of people resulting from food scarcity and other resource limits, health impacts or environmental stresses in other parts of the world could threaten U.S. national security.'' (Karl *et al.,* 2009).

generations of the United States population.

i. Summary of Key Public Comments on Endangerment to Public Welfare

Several public commenters point out the anticipated benefits that increasing carbon dioxide levels and temperatures will have on agricultural crops. In addition, commenters note how U.S. agricultural productivity, in particular, has been steadily rising over the last 100 years. Responses to major comments are found here and more detailed responses are found in the Response to Comments document.

The Administrator acknowledges that plants including agricultural crops respond to carbon dioxide positively based on numerous well-documented studies. However, previous assessments of food production and agriculture have been modified to highlight increasing vulnerability, stress, and adverse impacts from climate change over time, based on improvements in the understanding of plant physiology, concern over impacts on plant pests and pathogens, and the implications of changes in average temperatures for temperature extremes and for changes in the patterns of precipitation and evaporation. While it is still the case today and for the next few years that climate change benefits agriculture in some places and harms them in others, the Administrator considers that the far larger temperature increases expected over coming decades and beyond on the ''business as usual'' trajectory will put significant stresses on agriculture and land resources in all regions of the United States. The Administrator prudently considers increased climate variability associated with a warming climate, which may overwhelm the positive plant responses from elevated carbon dioxide over time. Further, the effects of climate change on weeds, insect pests, and pathogens are recognized as key factors in determining plant damage in future decades. The Administrator also notes that scientific literature clearly supports the finding that drought frequency and severity are projected to increase in the future over much of the United States, which will likely reduce crop yields because of excesses or deficits of water. Vulnerability to extended drought, according to IPCC, has been documented as already increasing across North America. Further, based on review of the assessment literature, the Administrator considers multiple stresses, such as limited availability of water resources, loss of biodiversity, and air pollution, which are likely to increase sensitivity and reduce resilience in the agricultural sector to climate change over time.

Similar to food production and agriculture, public commenters often noted that forest productivity is projected to increase in the coming years due to the direct stimulatory effect of carbon dioxide on plant growth combined with warmer temperatures and thus extended growing seasons. The Administrator notes this phenomenon has been well documented by numerous studies but recognizes that increased productivity will be associated with significant variation at local and regional scales. The Administrator considers that climate strongly influences forest productivity and composition, and the frequency and magnitude of disturbances that impact forests. Based on the most recent IPCC assessment of the scientific literature, several recent studies confirm previous findings that temperature and precipitation changes in future decades will modify, and often limit, direct carbon dioxide effects on plants. For example, increased temperatures may reduce carbon dioxide effects indirectly, by increasing water demand. The Administrator also considers that new research more firmly establishes the negative impacts of increased climate variability. Projected changes in the frequency and severity of extreme climate events have significant consequences for forestry production and amplify existing stresses to land resources in the future.

Several public commenters maintain that wildfires are primarily the result of natural climatic factors and not climate change and dispute that they are or will increase in the future. The Administrator notes the scientific literature and assessment reports provide several lines of evidence that suggest wildfires will likely increase in frequency over the next several decades because of climate warming. Wildfires and droughts, among other extreme events (*e.g.,* hurricanes) that cause forest damage, pose the largest threats over time to forest ecosystems. The assessment literature suggests that large, stand-replacing wildfires will likely increase in frequency over the next several decades because of climate warming and general climate warming encourages wildfires by extending the summer period that dries fuels, promoting easier ignition and faster spread. Furthermore, current climate modeling studies suggest that increased temperatures and longer growing seasons will elevate wildfire risk in connection with increased aridity.

V. The Administrator's Finding That Emissions of Greenhouse Gases From CAA Section 202(a) Sources Cause or Contribute to the Endangerment of Public Health and Welfare

As discussed in Section IV.A of these Findings, the Administrator is defining the air pollution for purposes of the endangerment finding to be the elevated concentration of well-mixed greenhouse gases in the atmosphere. The second step of the two-part endangerment test is for the Administrator to determine whether the emission of any air pollutant emitted from new motor vehicles cause or contribute to this air pollution. This is referred to as the cause or contribute finding, and is the second finding by the Administrator in this action.

Section V.A of these Findings describes the Administrator's definition and scope of the air pollutant ''well-mixed greenhouse gases.'' Section V.B of these Findings puts forth the Administrator's finding that emissions of well-mixed greenhouse gases from new motor vehicles contribute to the air pollution which is reasonably anticipated to endanger public health and welfare. Section V.C of these Findings provides responses to some of the key comments on these issues. See Response to Comments document Volume 10 for responses to other significant comments on the cause or contribute finding. More detailed emissions data summarized in the discussion below can be found in Appendix B of the TSD.

A. The Administrator's Definition of the ''Air Pollutant''

As discussed in the Proposed Findings, to help appreciate the distinction between air pollution and air pollutant, the *air pollution* can be thought of as the total, cumulative stock in the atmosphere, while the *air pollutant,* can be thought of as the flow that changes the size of the total stock. Given this relationship, it is not surprising that the Administrator is defining the air pollutant similar to the air pollution; while the air pollution is the concentration (*e.g.,* stock) of the well-mixed greenhouse gases in the atmosphere, the air pollutant is the same combined grouping of the well-mixed greenhouse gases, the emissions of which are analyzed for contribution (*e.g.,* the flow into the stock).

Thus, the Administrator is defining the air pollutant as the aggregate group of the same six long-lived and directly-emitted greenhouse gases: Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons,

and sulfur hexafluoride. As noted above, this definition of a single air pollutant made up of these well-mixed greenhouse gases is similar to definitions of other air pollutants that are comprised of substances that share common attributes with similar effects on public health or welfare (*e.g.,* particulate matter and volatile organic compounds).

The common attributes shared by these six greenhouse gases are discussed in detail in Section IV.A of these Findings, where the Administrator defined the ''air pollution'' for purposes of the endangerment finding. These same common attributes support the Administrator grouping these six greenhouse gases for purposes of defining a single air pollutant as well. These attributes include the fact that they are all greenhouse gases that are directly emitted (*i.e.,* they are not formed through secondary processes in the atmosphere from precursor emissions); they are sufficiently long-lived in the atmosphere such that, once emitted, concentrations of each gas become well mixed throughout the entire global atmosphere; and they exert a climate warming effect by trapping outgoing, infrared heat that would otherwise escape to space. Moreover, the radiative forcing effect of these six greenhouse gases is well understood.

Furthermore, these six greenhouse gases are currently the common focus of climate science and policy. For example, the UNFCCC, signed and ratified by the U.S. in 1992, requires its signatories to ''develop, periodically update, publish and make available * * * national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol [33], using comparable methodologies * * * '' [34] To date, the focus of UNFCCC actions and discussions has been on the six greenhouse gases that are the same focus of these findings. As a Party to the UNFCCC, EPA annually submits the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* to the Convention, which reports on national emissions of anthropogenic emissions of the well-mixed greenhouse gases. International discussions about a post-Kyoto agreement also focus on the well-mixed greenhouse gases.

As noted above, grouping of many substances with common attributes as a single pollutant is common practice under the CAA. Thus, doing so here is not novel. Indeed CAA section 302(g) defines air pollutant as ''any air pollutant agent or *combination of such agents,* * * * '' CAA § 302(g) (emphasis added). Thus, it is clear that the term ''air pollutant'' is not limited to individual chemical compounds. In determining that greenhouse gases are within the scope of this definition, the Supreme Court described section 302(g) as a ''sweeping'' and ''capacious'' definition that unambiguously included greenhouse gases, that are ''unquestionably 'agents' of air pollution.'' *Massachusetts* v. *EPA,* 549 U.S. at 528, 532, 529 n.26. Although the Court did not interpret the term ''combination of'' air pollution agents, there is no reason this phrase would be interpreted any less broadly. Congress used the term ''any'', and did not qualify the kind of combinations that the agency could define as a single air pollutant. Congress provided EPA broad discretion to determine appropriate combinations of compounds that should be treated as a singe air pollutant.[35]

For the same reasons discussed in Section IV.A above, at this time, only carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride share all of these common attributes and thus they are the only substances that the Administrator finds to meet the definition of ''well-mixed greenhouse gas'' at this time.[36] Also as noted above, if in the future other substances are shown to meet the same criteria they may be added to the definition of this single air pollutant.

The Administrator is aware that CAA section 202(a) source categories do not emit all of the substances meeting the definition of well-mixed greenhouse gases. But that does not change the fact that all of these greenhouse gases share the attributes that make grouping them as a single air pollutant reasonable. As discussed further below, the reasonableness of this grouping does not turn on the particular source category being evaluated in a contribution finding.

B. The Administrator's Finding Regarding Whether Emissions of the Air Pollutant From Section 202(a) Source Categories Cause or Contribute to the Air Pollution That May Be Reasonably Anticipated To Endanger Public Health and Welfare

The Administrator finds that emissions of the well-mixed greenhouse gases from new motor vehicles contribute to the air pollution that may reasonably be anticipated to endanger public health and welfare. This contribution finding is for all of the CAA section 202(a) source categories and the Administrator considered emissions from all of these source categories. The relevant mobile sources under CAA section 202 (a)(1) are ''any class or classes of new motor vehicles or new motor vehicle engines, * * *.'' CAA section 202(a)(1) (emphasis added). The new motor vehicles and new motor vehicle engines (hereinafter ''CAA section 202(a) source categories'') addressed are: Passenger cars, light-duty trucks, motorcycles, buses, and medium and heavy-duty trucks. Detailed combined greenhouse gas emissions data for CAA section 202(a) source categories are presented in Appendix B of the TSD.[37]

The Administrator reached her decision after reviewing emissions data on the contribution of CAA section 202(a) source categories relative to both global greenhouse gas emissions and U.S. greenhouse gas emissions. Given that CAA section 202(a) source categories are responsible for about 4 percent of total global greenhouse gas emissions, and for just over 23 percent of total U.S. greenhouse gas emissions, the Administrator finds that both of these comparisons, independently and together, support a finding that CAA section 202(a) source categories contribute to the air pollution that may be reasonably anticipated to endanger public health and welfare. The Administrator is not placing primary weight on either approach; rather she finds that both approaches clearly establish that emissions of the well-mixed greenhouse gases from section 202(a) source categories contribute to air pollution with may reasonably be anticipated to endanger public health and welfare. As the Supreme Court noted, ''[j]udged by any standard, U.S.

[33] The Montreal Protocol covers ozone-depleting substances which may also share physical attributes of the six key greenhouse gases in this action, but they do not share other attributes such as being the focus of climate science and policy. See section * * *.

[34] UNFCCC Art. 4.1(b).

[35] Indeed, the greenhouse gases hydrofluorocarbons and perfluorocarbons each are already a combination of multiple compounds.

[36] The term ''well-mixed greenhouse gases'' is based on one of the shared attributes discussed above—these greenhouse gases are sufficiently long-lived in the atmosphere such that, once emitted, concentrations of each gas become well mixed throughout the entire global atmosphere. Defining the air pollutant to be the combination of these six well-mixed greenhouse gases is based in part on this attribute—after the gases are emitted, they are sufficiently long-lived in the atmosphere to become well mixed as part of the air pollution.

[37] For section 202(a) source categories, only the hydrofluorocarbon emissions related to passenger compartment cooling are included. Emissions from refrigeration units that may be attached to trucks are considered emissions from nonroad engines under CAA section 213.

motor-vehicle emissions make a meaningful contribution to greenhouse gas concentrations and hence, * * * to global warming.'' *Massachusetts v. EPA,* 549 U.S. at 525.[38]

1. Administrator's Approach in Making This Finding

Section 202(a) of the CAA source categories consist of passenger cars, light-duty trucks, motorcycles, buses, and heavy- and medium-duty trucks. As noted in the Proposed Findings, in the past the requisite contribution findings have been proposed concurrently with proposing emission standards for the relevant mobile source category. Thus, prior contribution findings often focused on a subset of the CAA section 202(a) (or other section) source categories. This final cause or contribute finding, however, is for all of the CAA section 202(a) source categories. The Administrator is considering emissions from all of these source categories in the determination.

Section 202(a) source categories emit the following well-mixed greenhouse gases: carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. As the basis for the Administrator's determination, EPA analyzed historical data of emissions of the well-mixed greenhouse gases for motor vehicles and motor vehicle engines in the United States from 1990 to 2007.

The Proposed Findings discussed a number of possible ways of assessing cause or contribute and the point was made that no single approach is required by the statute or has been used exclusively in previous determinations under the CAA. The Administrator also discussed how, consistent with prior cause or contribute findings and the science, she is using emissions as a proxy for contributions to atmospheric concentrations. This approach is reasonable for the well-mixed greenhouse gases, because cumulative emissions are responsible for the cumulative change in the concentrations in the atmosphere. Similarly, annual emissions are a perfectly reasonable proxy for annual incremental changes in atmospheric concentrations.

In making a judgment about the contribution of emissions from CAA section 202(a) source categories, the Administrator focused on making a reasoned overall comparison of emissions from the CAA section 202(a) source categories to emissions from other sources of greenhouse gases. This allows a determination of how the CAA section 202(a) source categories compare to all of the other sources that together as a group make up the total emissions contributors to the air pollution problem. The relative importance of the CAA section 202(a) source categories is central to making the contribution determination. Both the magnitude of these emissions and the comparison of these emissions to other sources provide the basis to determine whether the CAA section 202(a) source categories may reasonably be judged as contributing to the air pollution problem.

In many cases EPA makes this kind of comparison of source categories by a simple percentage calculation that compares the emissions from the source category at issue to a larger total group of emissions. Depending on the circumstances, a larger percentage often means a greater relative impact from that source category compared to the other sources that make up the total of emissions, and vice versa. However, the actual numerical percentages may have little meaning when viewed in isolation. The context of the comparison is needed to ensure the information is useful in evaluating the relative impact of one source compared to others. For example, the number of sources involved and the distribution of emissions across all of the sources can make a significant difference when evaluating the results of a percentage calculation. In some cases a certain percentage might mean almost all other sources are larger or much larger than the source at issue, while in other circumstances the same percentage could mean that the source at issue is in fact one of the larger contributors to the total.

The Administrator therefore considered the totality of the circumstances in order to best understand the role played by CAA section 202(a) source categories. This is consistent with Congress' intention for EPA to consider the cumulative impact of all sources of pollution. In that context, the global nature of the air pollution problem and the breadth of countries and sources emitting greenhouse gases means that no single country and no single source category dominate or are even close to dominating on a global scale. For example, the United States as a country is the second largest emitter of greenhouse gases, and emits approximately 18 percent of the world's total greenhouse gases. The total emissions of greenhouse gases worldwide are from numerous sources and countries, with each country and each source category contributing a relatively small percentage of the total emissions. That means that the relative ranking of countries or sources is not at all obvious from the magnitude of the percentage by itself. A country or a source may be a large contributor, in comparison to other countries or sources, even though its percentage contribution may appear relatively small.

In this situation, addressing a global air pollution problem may call for many different sources and countries to address emissions even if none by itself dominates or comes close to dominating the global inventory. A somewhat analogous situation can be found in the ozone air pollution problem in the United States. Emissions of NOx and volatile organic compounds (VOCs) often come from numerous small sources, as well as certain large source categories. We have learned that successful ozone control strategies often need to take this into account, and address both the larger sources of NOx and VOCs as well as the many smaller sources, given the breadth of sources that as a group lead to the total inventory of VOCs and NOx.

The global aspects of the greenhouse gas air pollution problem amplify this kind of situation many times over, where no single country or source category dominates or comes close to dominating the global inventory of greenhouse gas emissions. These unique, global aspects of the climate change problem tend to support consideration of contribution at lower percentage levels of emissions than might otherwise be considered appropriate when addressing a more typical local or regional air pollution problem. In this situation it is quite reasonable to consider emissions from source categories that are more important in relation to other sources, even if their absolute contribution initially may appear to be small.

In addition, the Administrator is aware of the fact that the United States is the second largest emitter of well-mixed greenhouse gases in the world. As the United States evaluates how to address climate change, the Administrator will analyze the various sources of emissions and the source's share of U.S. emissions. Thus, when analyzing whether a source category that emits well-mixed greenhouse gases in the United States contributes to the global problem, it is appropriate for the Administrator to consider how that source category fits into the larger picture of U.S. emissions. This ranking process within the United States allows the importance of the source category to

[38] Because the Administrator is defining the air pollutant as the combination of well-mixed greenhouse gases, she is not issuing a final contribution finding based on the alternative definition discussed in the proposed findings (*e.g.,* each greenhouse gas as an individual air pollutant).

be seen compared to other U.S. sources, informing the judgment of the importance of emissions from this source category in any overall national strategy to address greenhouse gas emissions.

It is in this broader context that EPA considered the contribution of CAA section 202(a) sources. This provides useful information in determining the importance that should be attached to the emissions from the CAA section 202(a) sources.

In reaching her determination, the Administrator used two simple and straightforward comparisons to assess cause or contribute for CAA section 202(a) source categories: (1) As a share of total current global aggregate emissions of the well-mixed greenhouse gases; and (2) as a share of total current U.S. aggregate emissions of the well-mixed greenhouse gases.

Total well-mixed greenhouse gas emissions from CAA section 202(a) source categories were compared to total global emissions of the well-mixed greenhouse gases. The total air pollution problem, as already discussed, is the elevated and climbing levels of the six greenhouse gas concentrations in the atmosphere, which are global in nature because these concentrations are globally well mixed (whether they are emitted from CAA section 202(a) source categories or any other source within or outside the United States). In addition, comparisons were also made to U.S. total well-mixed greenhouse gases emissions to appreciate how CAA section 202(a) source categories fit into the larger U.S. contribution to the global problem. It is typical for the Administrator to consider these kinds of comparisons of emissions of a pollutant in evaluating contribution to air pollution, such as the concentrations of that same pollutant in the atmosphere (*e.g.,* the Administrator analyzes $PM_{2.5}$ emissions to determine if a source category contributes to $PM_{2.5}$ air pollution). When viewed in the circumstances discussed above, both of these comparisons provide useful information in determining whether these source categories should be judged as contributing to the total air pollution problem.

a. Section 202(a) of the CAA—Share of Global Aggregate Emissions of the Well-Mixed Greenhouse Gases

Global emissions of well-mixed greenhouse gases have been increasing, and are projected to continue increasing unless the major emitters take action to reduce emissions. Total global emissions of well-mixed greenhouse gases in 2005 (the most recent year for which data for all countries and all greenhouse gases are available) [39] were 38,726 teragrams of CO_2-equivlant ($TgCO_2eq$.) [40] This represents an increase in global greenhouse gas emissions of about 26 percent since 1990 (excluding land use, land use change and forestry). In 2005, total U.S. emissions of well-mixed greenhouse gases were responsible for 18 percent of global emissions, ranking only behind China, which was responsible for 19 percent of global emissions of well-mixed greenhouse gases.

In 2005 emissions of the well-mixed greenhouse gas pollutant from CAA section 202(a) source categories represented 4.3 percent of total global well-mixed greenhouse gas emissions and 28 percent of global transport well-mixed greenhouse gas emissions (Table 1 of these Findings). If CAA section 202(a) source categories' emissions of well-mixed greenhouse gas were ranked against total well-mixed greenhouse gas emissions for entire countries, CAA section 202(a) source category emissions would rank behind only China, the United States as a whole, Russia, and India, and would rank ahead of Japan, Brazil, Germany and every other country in the world. Indeed, countries with lower emissions than the CAA section 202(a) source categories are members of the 17 ''major economies'' ''that meet to advance the exploration of concrete initiatives and joint ventures that increase the supply of clean energy while cutting greenhouse gas emissions.'' *See http://www.state.gov/g/oes/climate/mem/.* It would be anomalous, to say the least, to consider Japan and these other countries as major players in the global climate change community and an integral part of the solution, but not find that CAA section 202(a) source category emissions contribute to the global problem. Thus, the Administrator finds that emission of well-mixed greenhouse gases from CAA section 202(a) source categories contribute to the air pollution of well-mixed greenhouse gases.

TABLE 1—COMPARISON TO GLOBAL GREENHOUSE GAS (GHG) EMISSIONS ($TG\ CO_2E$)

	2005	Sec 202(a) share (percent)
All U.S. GHG emissions	7,109	23.5
Global transport GHG emissions	5,968	28.0
All global GHG emissions	38,726	4.3

b. Section 202(a) of the CAA—Share of U.S. Aggregate Emissions of the Well-Mixed Greenhouse Gases

The Administrator considered compared total emissions of the well-mixed greenhouse gases from CAA section 202(a) source categories to total U.S. emissions of the well-mixed greenhouse gases as an indication of the role these sources play in the total U.S. contribution to the air pollution problem causing climate change.[41]

In 2007, U.S. well-mixed greenhouse gas emissions were 7,150 $TgCO_2eq$. The dominant gas emitted was carbon dioxide, mostly from fossil fuel combustion. Methane was the second largest well-mixed greenhouse gas, followed by N_2O, and the fluorinated gases (HFCs, PFCs, and SF_6). Electricity generation was the largest emitting sector (2,445 $TgCO_2eq$ or 34 percent of

[39] The source of global greenhouse gas emissions data, against which comparisons are made, is the Climate Analysis Indicators Tool of the World Resources Institute (WRI) (2007). Note that for global comparisons, all emissions are from the year 2005, the most recent year for which data for all greenhouse gas emissions and all countries are available. WRI (2007) Climate Analysis Indicators Tool (CAIT). Available at *http://cait.wri.org.* Accessed August 5, 2009.

[40] One teragram (Tg) = 1 million metric tons. 1 metric ton = 1,000 kg = 1.102 short tons = 2,205 lbs. Long-lived greenhouse gases are compared and summed together on a CO_2 equivalent basis by multiplying each gas by its Global Warming Potential (GWPs), as estimated by IPCC. In accordance with UNFCCC reporting procedures, the U.S. quantifies greenhouse gas emissions using the 100-year time frame values for GWPs established in the IPCC Second Assessment Report.

[41] Greenhouse gas emissions data for the United States in this section have been updated since the Proposed Findings to reflect EPA's most up-to-date information, which includes data for the year 2007. The source of the U.S. greenhouse gas emissions data is the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007,* published in 2009 (hereinafter ''U.S. Inventory'').

total U.S. greenhouse gas emissions), followed by transportation (1,995 $TgCO_2eq$ or 28 percent) and industry (1,386 $TgCO_2eq$ or 19 percent). Emissions from the CAA section 202(a) source categories constitute the major part of the transportation sector. Land use, land use change, and forestry offset almost 15 percent of total U.S. emissions through net sequestration. Total U.S. well-mixed greenhouse gas emissions have increased by over 17 percent between 1990 and 2007. The electricity generation and transportation sectors have contributed the most to this increase.

In 2007 emissions of well-mixed greenhouse gases from CAA section 202(a) source categories collectively were the second largest emitter of well-mixed greenhouse gases within the United States (behind the electricity generating sector), emitting 1,663 $TgCO_2eq$ and representing 23 percent of total U.S. emissions of well-mixed greenhouse gases (Table 2 of these Findings). The Administrator is keenly aware that the United States is the second largest emitter of well-mixed greenhouse gases. Part of analyzing whether a sector within the United States contributes to the global problem is to see how those emissions fit into the contribution from the United States as a whole. This informs her judgment as to the importance of emissions from this source category in any overall national strategy to address greenhouse gas emissions. Thus, it is relevant that CAA section 202(a) source categories are the second largest emitter of well-mixed greenhouse gases in the country. This is part of the Administrator looking at the totality of the circumstances. Based on this the Administrator finds that emission of well-mixed greenhouse gases from CAA section 202(a) source categories contribute to the air pollution of well-mixed greenhouse gases.

TABLE 2—SECTORAL COMPARISON TO TOTAL U.S. GREENHOUSE GAS (GHG) EMISSIONS ($TG\ CO_2E$)

U.S. emissions	1990	1995	2000	2005	2006	2007
Section 202(a) GHG emissions	1231.9	1364.4	1568.1	1670.5	1665.7	1663.1
Share of U.S. (%)	20.2%	21.1%	22.4%	23.5%	23.6%	23.3%
Electricity Sector emissions	1859.1	1989.0	2329.3	2429.4	2375.5	2445.1
Share of U.S. (%)	30.5%	30.8%	33.2%	34.2%	33.7%	34.2%
Industrial Sector emissions	1496.0	1524.5	1467.5	1364.9	1388.4	1386.3
Share of U.S. (%)	24.5%	23.6%	20.9%	19.2%	19.7%	19.4%
Total U.S. GHG emissions	6098.7	6463.3	7008.2	7108.6	7051.1	7150.1

C. Response to Key Comments on the Administrator's Cause or Contribute Finding

EPA received numerous public comments regarding the Administrator's proposed cause or contribute finding. Below is a brief discussion of some of the key comments. Responses to comments on this issue are also contained in the Response to Comments document, Volume 10.

1. The Administrator Reasonably Defined the ''Air Pollutant'' for the Cause or Contribute Analysis

a. The Supreme Court Held that Greenhouse Gases Fit Within the Definition of ''Air Pollutant'' in the CAA

Several commenters reiterate arguments already rejected by the Supreme Court, arguing that greenhouse gases do not fit into the definition of ''air pollutant'' under the CAA. In particular, at least one commenter contends that EPA must show how greenhouse gases impact or materially change ''ambient air'' when defining air pollutant and making the endangerment finding. This commenter argues that because carbon dioxide is a naturally occurring and necessary element in the atmosphere, it cannot be considered to materially change air.

These and similar arguments were already rejected by the Supreme Court in *Massachusetts* v. *EPA*, 549 U.S. 497 (2007). Briefs before the Supreme Court also argued that carbon dioxide is an essential role for life on earth and therefore cannot be considered an air pollutant, and that the concentrations of greenhouse gases that are a potential problem are not in the ''ambient air'' that people breathe.

The Court rejected all of these and other arguments, noting that the statutory text forecloses these arguments. ''The Clean Air Act's sweeping definition of 'air pollutant' includes '*any* air pollution agent or combination of such agents, including *any* physical, chemical * * * substance or matter which is emitted into or otherwise enters the ambient air . * * *' § 7602(g) (emphasis added). On its face, the definition embraces all airborne compounds of whatever stripe, and underscores that intent through the repeated use of the word 'any.' Carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons are without a doubt 'physical [and] chemical * * * substance[s] which [are] emitted into * * * the ambient air.' The statute is unambiguous.''

547 U.S. at 529–30 (footnotes omitted); see also *id.* at 530, n26 (the distinction regarding ambient air, however, finds no support in the text of the statute, which uses the phrase ''the ambient air'' without distinguishing between atmospheric layer.). Thus, the question of whether greenhouse gases fit within the definition of air pollutant under the CAA has been decided by the Supreme Court and is not being revisited here.

b. The Definition of Air Pollutant May Include Substances Not Emitted by CAA Section 202(a) Sources

Many commenters argue that the definition of ''air pollutant''—here well-mixed greenhouse gases—cannot include PFCs and SF6 because they are not emitted by CAA section 202(a) motor vehicles and hence, cannot be part of any ''air pollutant'' emitted by such sources. They argue that by improperly defining ''air pollutant'' to include substances that are not present in motor vehicle emissions, the Agency has exceeded its statutory authority under CAA section 202(a). Commenters contend that past endangerment findings under CAA section 202(a) demonstrate EPA's consistent approach of defining ''air pollutant(s)'' in accordance with the CAA's clear direction, to include only those pollutants emitted from the relevant source category (citing Notice of Proposed Rulemaking for Heavy-Duty Engine and Vehicle Standards finding that ''emissions of NO_X, VOCs, SO_X, and PM from heavy-duty trucks can reasonably be anticipated to endanger the public health or welfare.'' (65 FR 35436, June 2, 2000). Commenters argue that EPA itself is inconsistent in the Proposed Findings, sometimes referring

to ''air pollutant'' as the group of six greenhouse gases, and other times falling back on the four greenhouse gases emitted by motor vehicles.

EPA acknowledges that the Proposed Findings could have been clearer regarding the proposed definition of air pollutant, and how it was being applied to CAA section 202(a) sources, which emit only four of the six substances that meet the definition of well-mixed greenhouse gases. However, our interpretation does not exceed EPA's authority under CAA section 202(a). It is reasonable to define the air pollutant under CAA section 202(a) to include substances that have similar attributes (as discussed above), even if not all of the substances that meet that definition are emitted by motor vehicles. For example, as commenters note, EPA has heavy duty truck standards applicable to VOCs and PM, but it is highly unlikely that heavy duty trucks emit *every* substance that is included in the group defined as VOC or PM. *See* 40 CFR 51.100(s) (defining volatile organic compound (VOC) as ''any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions'', a list of exemptions are also included in the definition); 40 CFR 51.100(oo) (defining particulate matter (PM) as ''any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometers'').

In this circumstance the number of substances included in the definition of well-mixed greenhouse gases is much smaller than other ''group'' air pollutants (*e.g.,* six greenhouse gases versus hundreds of VOCs), and CAA section 202(a) sources emit an easily discernible number of these six substances. However, this does not mean that the definition of the well-mixed greenhouse gases as the air pollutant is unreasonable. By defining well-mixed greenhouse gases as a single air pollutant comprised of six substances with common attributes, the Administrator is giving effect to these shared attributes and how they are relevant to the air pollution to which they contribute. The fact that these six substances share these common, relevant attributes is true regardless of the source category being evaluated for contribution. Grouping these six substances as one air pollutant is reasonable regardless of whether a contribution analysis is undertaken for CAA section 202(a) sources that emit one subset of the six substances (*e.g.*, carbon dioxide, CH_4, N_20 and HFCs, but not PFCs and SF_6), or for another category of sources that may emit another subset. For example, electronics manufacturers that may emit N_2O, PFCs, HFCs, SF_6 and other fluorinated compounds, but not carbon dioxide or CH_4 unless there is on-site fuel combustion. In other words, it is not necessarily the source category being evaluated for contribution that determines the reasonableness of defining a group air pollutant based on the shared attributes of the group.

Even if EPA agreed with commenters, and defined the air pollutant as the group of four compounds emitted by CAA section 202(a) sources, it would not change the result. The Administrator would make the same contribution finding as it would have no material effect on the emissions comparisons discussed above.

c. It Was Reasonable for the Administrator To Define the Single Air Pollutant as the Group of Substances With Common Attributes

Several commenters disagree with EPA's proposed definition of a single air pollutant composed of the six well-mixed greenhouse gases as a class. Commenters argue that the analogy to VOCs is misplaced because VOCs are all part of a defined group of chemicals, for which there are established quantification procedures, and for which there were extensive data showing that the group of compounds had demonstrated and quantifiable effects on ambient air and human health and welfare, and for which verifiable dispersion models existed. They contend this is in stark contrast to the entirely diverse set of organic and inorganic compounds EPA has lumped together for purposes of the Proposed Findings, and for which no model can accurately predict or quantify the actual impact or improvement resulting from controlling the compounds. Moreover, they argue that the gases EPA is proposing to list together as one pollutant are all generated by different processes and, if regulated, would require different types of controls; the four gases emitted by mobile sources can generally be limited only by using controls that are specific to each.

At least one commenter argues that EPA cannot combine greenhouse gases into one pollutant because their common attribute is not a ''physical, chemical, biological or radioactive property'' (quoting from CAA section 302(g)), but rather their effect or impacts on the environment. They say this differs from VOCs, which share the common attribute of volatility, or PM which shares the physical property of being particles.

As discussed above, the well-mixed greenhouse gases share physical attributes, as well as attributes based on sound policy considerations. The definition of ''air pollutant'' in CAA section 302(g) does not limit consideration of common attributes to those that are ''physical, chemical, biological or radioactive property'' as one commenter claims. Rather, the definition's use of the adjectives ''physical, chemical, biological or radioactive'' refer to the different types of substance or matter that is emitted. It is not a limitation on what characteristics the Administrator may consider when deciding how to group similar substances when defining a single air pollutant.

The common attributes that the Administrator considered when defining the well-mixed greenhouse gases are reasonable. While these six substances may originate from different processes, and require different control strategies, that does not detract from the fact that they are all long-lived, well-mixed in the atmosphere, directly emitted, of well-known radiative forcing, and generally grouped and considered together in climate change scientific and policy forums. Indeed, other group pollutants also originate from a variety of processes and a result may require different control technologies. For example, both a power plant and a dirt road can result in PM emissions, and the method to control such emissions at each source would be different. But these differences in origin or control do not undermine the reasonableness of considering PM as a single air pollutant. The fact that there are differences, as well as similarities, among the well-mixed greenhouse gases does not render the decision to group them together as one air pollutant unreasonable.

2. The Administrator's Cause or Contribute Analysis Was Reasonable

a. The Administrator Does Not Need To Find Significant Contribution, or Establish a Bright Line

Many commenters essentially argue that EPA must establish a bright line below which it would never find contribution regardless of the air pollutant, air pollution, and other factors before the Agency. For example, some commenters argue that EPA must provide some basis for determining de minimis amounts that fall below the threshold of ''contributing'' to the endangerment of public health and welfare under CAA section 202(a).

Commenters take issue with EPA's statement that it ''need not determine at this time the circumstances in which emissions would be trivial or de minimis and would not warrant a finding of contribution.'' Commenters argue that EPA cannot act arbitrarily by determining that a constituent contributing a certain percent to endangerment in one instance is de minimis and in another is contributing to endangerment of public health and welfare. They request that EPA revise the preamble language to make clear that the regulated community can rely on its past determinations with respect to ''contribution'' determinations to predict future agency action and argue that EPA should promulgate guidance on how it determines whether a contribution exceeds a de minimis level for purposes of CAA section 202(a) before finalizing the proposal.

The commenters that argue that the air pollution EPA must analyze to determine endangerment is limited to the air pollution resulting from new motor vehicles also argue that as a result, the contribution of emissions from new motor vehicles must be significant. They essentially contend that the endangerment and cause or contribute tests are inter-related and the universe of both tests is the same. In support of their argument, commenters argue that because the clause ''cause, or contribute to, air pollution'' is in plural form, it must be referring back to ''any class or classes of new motor vehicles or new motor vehicle engines,'' demonstrating that EPA must consider only the emissions from new motor vehicles which emit the air pollution which endangers.

Since the Administrator issued the Proposed Findings, the DC Circuit issued another opinion discussing the concept of contribution. See *Catawba County* v. *EPA*, 571 F.3d 20 (DC Cir. 2009). This decision, along with others, supports the Administrator's interpretation that the level of contribution under CAA section 202(a) does not need to be significant. The Administrator is not required to establish a bright line below which she would never find contribution under any circumstances. Finally, it is reasonable for the Administrator to apply a ''totality-of-the-circumstances test to implement a statute that confers broad discretionary authority, even if the test lacks a definite 'threshold' or 'clear line of demarcation to define an open-ended term.'' *Id.* at 39 (citations omitted).

In upholding EPA's $PM_{2.5}$ attainment and nonattainment designation decisions, the DC Circuit analyzed CAA section 107(d), which requires EPA to designate an area as nonattainment if it ''contributes to ambient air quality in a nearby area'' not attaining the national ambient air quality standards. *Id.* at 35. The court noted that it had previously held that the term ''contributes'' is ambiguous in the context of CAA language. *See EDF* v. *EPA*, 82 F.3d 451, 459 (DC Cir. 1996). ''[A]mbiguities in statutes within an agency's jurisdiction to administer are delegations of authority to the agency to fill the statutory gap in reasonable fashion.'' 571 F.3d at 35 (citing *Nat's Cable & Telecomms. Ass'c* v. *Brand X Internet Servs,* 545 U.S. 967, 980 (2005)).

The court then proceeded to consider and reject petitioners' argument that the verb ''contributes'' in CAA section 107(d) necessarily connotes a significant causal relationship. Specifically, the DC Circuit again noted that the term is ambiguous, leaving it to EPA to interpret in a reasonable manner. In the context of this discussion, the court noted that ''a contribution may simply exacerbate a problem rather than cause it * * * '' 571 F.3d at 39. This is consistent with the DC Circuit's decision in *Bluewater Network* v. *EPA,* 370 F.3d 1 (DC Cir. 2004), in which the court noted that the term contribute in CAA section 213(a)(3) ''[s]tanding alone, * * * has no inherent connotation as to the magnitude or importance of the relevant 'share' in the effect; certainly it does not incorporate any 'significance' requirement.'' 370 F.3d at 13. The court found that the bare ''contribute'' language invests the Administrator with discretion to exercise judgment regarding what constitutes a sufficient contribution for the purpose of making an endangerment finding. *Id.* at 14.

Finally, in *Catawba County,* the DC Circuit also rejected ''petitioners' argument that EPA violated the statute by failing to articulate a quantified amount of contribution that would trigger'' the regulatory action. 571 F.3d at 39. Although petitioners preferred that EPA establish a bright-line test, the court recognized that the statute did not require that EPA ''quantify a uniform amount of contribution.'' *Id.*

Given this context, it is entirely reasonable for the Administrator to interpret CAA section 202(a) to require some level of contribution that, while more than de minimis or trivial, does not rise to the level of significance. Moreover, the approach suggested by at least one commenter collapses the two prongs of the test by requiring that contribution must be significant because any climate change impacts upon which an endangerment determination is made result solely from the greenhouse gas emissions of motor vehicles. It essentially eliminates the ''contribute'' part of the ''cause or contribute'' portion of the test. This approach was clearly rejected by the en banc court in *Ethyl.* 541 F.2d at 29 (rejecting the argument that the emissions of the fuel additive to be regulated must ''in and of itself, *i.e.* considered in isolation, endanger[ ] public health.''); see also *Catawba County,* 571 F.3d at 39 (noting that even if the test required significant contribution it would be reasonable for EPA to find a county's addition of $PM_{2.5}$ is significant even though the problem would persist in its absence). It is the commenter, not EPA that is ignoring the statutory language. Whether or not the clause ''cause, or contribute to, air pollution'' refers back to ''any class or classes of new motor vehicles or new motor vehicle engines,'' or to ''emission of any air pollutant,'' the language of CAA section 202(a) clearly contemplates that emission of an air pollutant from any class or classes may merely contribute to, versus cause, the air pollution which endangers.

It is also reasonable for EPA to decline to establish a ''bright-line 'objective' test of contribution.'' 571 F.3d at 39. As noted in the Proposed Findings, when exercising her judgment, the Administrator not only considers the cumulative impact, but also looks at the totality of the circumstances (*e.g.,* the air pollutant, the air pollution, the nature of the endangerment, the type of source category, the number of sources in the source category, and the number and type of other source categories that may emit the air pollutant) when determining whether the emissions justify regulation under the CAA. *Id.* (It is reasonable for an agency to adopt a totality-of-the-circumstances test).

Even if EPA agreed that a level of significance was required to find contribution, for the reasons discussed above, EPA would find that the contribution from CAA section 202(a) source categories is significant. Their emissions are larger than the great majority of emitting countries, larger than several major emitting countries, and they constitute one of the largest parts of the U.S. emissions inventory.

b. The Unique Global Aspects of Climate Change Are an Appropriate Consideration in the Contribution Analysis

Some commenters disagree with statements in the Proposed Findings that the ''unique, global aspects of the climate change problem tend to support a finding that lower levels of emissions should be considered to contribute to the air pollution than might otherwise

be appropriate when considering contribution to a local or regional air pollution problem.'' They argue there is no basis in the CAA or existing EPA policy for this position, and that it reveals an apparent effort to expand EPA's authority to the ''truly trivial or de minimis'' sources that are acknowledged to be outside the scope of regulation, in that it expands EPA's authority to regulate pollutants to address global effects.

Commenters also assert that contrary to EPA's position, lower contribution numbers are appropriate when looking at local pollution, like nonattainment concerns—in other words, in the context of a statutory provision like CAA section 213 specifically aimed at targeting small source categories to help nonattainment areas meet air quality standards. However, they conclude this policy is simply inapplicable in the context of global climate change.

As discussed above, the term ''contribute'' is ambiguous and subject to the Administrator's reasonable interpretation. It is entirely appropriate for the Administrator to look at the totality of the circumstances when making a finding of contribution. In this case, the Administrator believes that the global nature of the problem justifies looking at contribution in a way that takes account of these circumstances. More specifically, because climate change is a global problem that results from global greenhouse gas emissions, there are more sources emitting greenhouse gases (in terms both of absolute numbers of sources and types of sources) than EPA typically encounters when analyzing contribution towards a more localized air pollution problem. From a percentage perspective, there are no dominating sources and fewer sources that would even be considered to be close to dominating. The global problem is much more the result of numerous and varied sources each of which emit what might seem to be smaller percentage amounts when compared to the total. The Administrator's approach recognizes this reality, and focuses on evaluating the relative importance of the CAA section 202(a) source categories compared to other sources when viewed in this context.

This recognition of the unique totality of the circumstances before the Administrator now as compared to previous contribution decisions is entirely appropriate. It is not an attempt by the Administrator to regulate ''truly trivial or de minimis'' sources, or to regulate sources based on their global effects. The Administrator is determining whether greenhouse gas emissions from CAA section 202(a) sources contribute to an air pollution problem is endangering U.S. public health and welfare. As discussed in the Proposed Findings, no single greenhouse gas source category dominates on the global scale, and many (if not all) individual greenhouse gas source categories could appear small in comparison to the total, when, in fact, they could be very important contributors in terms of both absolute emissions or in comparison to other source categories, globally or within the United States. If the United States and the rest of the world are to combat the risks associated with global climate change, contributors must do their part even if their contributions to the global problem, measured in terms of percentage, are smaller than typically encountered when tackling solely regional or local environmental issues. The commenters' approach, if used globally, would effectively lead to a tragedy of the commons, whereby no country or source category would be accountable for contributing to the global problem of climate change, and nobody would take action as the problem persists and worsens. The Administrator's approach, on the contrary, avoids this kind of approach, and is a reasonable exercise of her discretion to determine contribution in the global context in which this issue arises.

Importantly, as discussed above, the contribution from CAA section 202(a) sources is anything but trivial or de minimis under any interpretation of contribution. See, *Massachusetts v. EPA,* 549 U.S. at 1457–58 (''Judged by any standard, U.S. motor-vehicle emissions make a meaningful contribution to greenhouse gas concentrations and hence, * * * to global warming'').

c. The Administrator Reasonably Relied on Comparisons of Emissions From Existing CAA Section 202(a) Source Categories

i. It Was Reasonable To Use Existing Emissions From Existing CAA Section 202(a) Source Categories Instead of Projecting Future Emissions From New CAA Section 202(a) Source Categories

Many commenters argue that EPA improperly evaluated the emissions from the entire motor vehicle fleet, and it is required to limit its calculation to just emissions from new motor vehicles. Thus the emissions that EPA should consider in the cause or contribute determination is far less than the 4.3 percent of U.S. greenhouse gas emissions attributed to motor vehicles in the Proposed Findings, because this number includes both new and existing motor vehicles. One commenter calculated the emissions from new motor vehicles as being 1.8 percent of global emissions, assuming approximately one year of new motor vehicle production in the United States (11 million vehicles) in a total global count currently of approximately 600 million motor vehicles.

In the Proposed Findings, EPA determined the emissions from the entire fleet of motor vehicles in the United States for a certain calendar year. EPA explained that, consistent with its traditional practice, it used the recent motor vehicle emissions inventory for the entire fleet as a surrogate for estimates of emissions for just new motor vehicles and engines. This was appropriate because future projected emissions are uncertain and current emissions data are a reasonable proxy for near-term emissions.

In effect, EPA is using the inventory for the current fleet of motor vehicles as a reasonable surrogate for a projection of the inventory from new motor vehicles over the upcoming years. New motor vehicles are produced year in and year out, and over time the fleet changes over to a fleet composed of such vehicles. This occurs in a relatively short time frame, compared to the time period at issue for endangerment. Because new motor vehicles are produced each year, and continue to emit over their entire life, over a relatively short period of time the emission from the entire fleet is from vehicles produced after a certain date. In addition, the emissions from new motor vehicles are not limited to the emissions that occur only during the one year when they are new, but are emissions over the entire life of the vehicle.

In such cases, EPA has traditionally used the recent emissions from the entire current fleet of motor vehicles as a reasonable surrogate for such a projection instead of trying to project and model those emissions. While this introduces some limited degree of uncertainty, the difference between recent actual emissions from the fleet and projected future emissions from the fleet is not expected to differ in any way that would substantively change the decision made concerning cause or contribution. There is not a specific numerical bright line that must be achieved, and the numerical percentages are not treated and do not need to be treated as precise values. This approach provides a reasonable and clear indication of the relative magnitudes involved, and EPA does not believe that attempting to make future

projections (for both vehicles and the emissions value they are compared to) would provide any greater degree of accuracy or precision in developing such a relative comparison.

ii. The Administrator Did Not Have To Use a Subset or Reduced Emissions Estimate From Existing CAA Section 202(a) Source Categories

Several commenters note that although EPA looks at emissions from all motor vehicles regulated under CAA section 202(a) in its contribution analysis, the Presidential announcement in May 2009 indicated that EPA was planning to regulate only a subset of 202(a) sources. Thus, they question whether the correct contribution analysis should look only at the emissions from that subset and not all CAA section 202(a) sources. Some commenters also argue that because emission standards will not eliminate all greenhouse gas emissions from motor vehicles, the comparison should compare the amount of greenhouse gas emissions ''reduced'' by those standards to the global greenhouse emissions. They also contend that the cost of the new standards will cause individual consumers, businesses, and other vehicle purchasers to hold on to their existing vehicles to a greater extent, thereby decreasing the amount of emissions reductions attributable to the standard and appropriately considered in the contribution analysis. Some commenters go further and contend that EPA also can only include that incremental reduction that the EPA regulations will achieve beyond any reductions resulting from CAFE standards that NHTSA will set.

Although the May announcement and September proposed rule involved only the light duty motor vehicle sector, the Administrator is making this finding for all classes of new motor vehicles under CAA section 202(a). Thus, although the announcement and proposed rule involve light duty vehicles, EPA is working to develop standards for the rest of the classes of new motor vehicles under CAA section 202(a). As the Supreme Court noted, EPA has ''significant latitude as to the manner, timing, content, and coordination of its regulations with those of other agencies. *Massachusetts* v. *EPA,* 549 U.S. at 533.

The argument that the Administrator can only look at that portion of emissions that will be reduced by any CAA section 202(a) standards, and even then only the reduction beyond those attributable to CAFE rules, finds no basis in the statutory language. The language in CAA section 202(a) requires that the Administrator set ''standards applicable to the emission of any air pollutant from [new motor vehicles], which in [her] judgment cause, or contribute to, air pollution which [endangers].'' It does not say set ''standards applicable to the emission of any air pollutant from [new motor vehicles], if in [her] judgment the emissions of that air pollutant as reduced by that standard cause, or contribute to, air pollution which [endangers].'' As discussed above, the decisions on cause or contribute and endangerment are separate and distinct from the decisions on what emissions standards to set under CAA section 202(a). The commenter's approach would improperly integrate these separate decisions. Indeed, because, as discussed above, the Administrator does not have to propose standards concurrent with the endangerment and cause or contribute findings, she would have to be prescient to know at the time of the contribution finding exactly the amount of the reduction that would be achieved by the standards to be set. As discussed above, for purposes of these findings we look at what would be the emissions from new motor vehicles if no action were taken. Current emissions from the existing CAA section 202(a) vehicle fleet are an appropriate estimate.

d. The Administrator Reasonably Compared CAA Section 202(a) Source Emissions to Both Global and Domestic Emissions of Well-Mixed Greenhouse Gases

EPA received many comments on the appropriate comparison(s) for the contribution analysis. Several commenters argue that in order to get around the ''problem'' of basing an endangerment finding upon a source category that contributes only 1.8 percent annually to global greenhouse gas emissions, EPA inappropriately also made comparisons to total U.S. greenhouse gas emissions. These commenters argue that a comparison of CAA section 202(a) source emissions to U.S. greenhouse gas emissions, versus global emissions, is arbitrary for purposes of the cause or contribute analysis, because it conflicts with the Administrator's definition of ''air pollution,'' as well as the nature of global warming. They note that throughout the Proposed Findings, the Administrator focuses on the global nature of greenhouse gas. Thus, they continue, while the percentage share of motor vehicle emissions at the U.S. level may be relevant for some purposes, it is irrelevant to a finding of whether these emissions contribute to the air pollution, which the Administrator has proposed to define on a global rather than a domestic basis. Commenters also accuse EPA of arbitrarily picking and choosing when it takes a global approach (*e.g.,* endangerment finding) and when it does not (*e.g.,* contribution findings).

The language of CAA section 202(a) is silent regarding how the Administrator is to make her contribution analysis. While it requires that the Administrator assess whether emission of an air pollutant contributes to air pollution which endangers, it does not limit *how* she may undertake that assessment. It surely is reasonable that the Administrator look at how CAA section 202(a) source category emissions compare to global emissions on an absolute basis, by themselves. But the United States as a nation is the second largest emitter of greenhouse gases. It is entirely appropriate for the Administrator to decide that part of understanding how a U.S. source category emitting greenhouse gases fits into the bigger picture of global climate change is to appreciate how that source category fits into the contribution from the United States as a whole, where the United States as a country is a major emitter of greenhouse gases. Knowing that CAA section 202(a) source categories are the second largest emitter of well-mixed greenhouse gases in the country is relevant to understanding what role they play in the global problem and hence whether they ''contribute'' to the global problem. Moreover, the Administrator is not ''picking and choosing'' when she applies a global or domestic approach in these Findings. Rather, she is looking at both of these emissions comparisons as appropriate under the applicable science, facts, and law.

e. The Amount of Well-Mixed Greenhouse Gas Emissions From CAA Section 202(a) Sources Reasonably Supports a Finding of Contribution

Many commenters argue that the ''cause or contribute'' prong of the Proposal's endangerment analysis fails to satisfy the applicable legal standard, which requires more than a minimal contribution to the ''air pollution reasonably anticipated to endanger public health or welfare.'' They contend that emissions representing approximately four percent of total global greenhouse gas emissions are a minimal contribution to global greenhouse gas concentrations.

EPA disagrees. As stated above, CAA section 202(a) source category total emissions of well-mixed greenhouse gases are higher than most countries in the world; countries that the U.S. and others believe play a major role in the

global climate change problem. Moreover, the percent of global well-mixed greenhouse gas emissions that CAA section 202(a) source categories represent is higher than percentages that the EPA has found contribute to air pollution problems. *See Bluewater Network,* 370 F.3d at 15 (''For Fairbanks, this contribution was equivalent to 1.2 percent of the total daily CO inventory for 2001.'') As noted above, there is no bright line for assessing contribution, but as discussed in the Proposed Findings and above, when looking at a global problem like climate change, with many sources of emissions and no dominating sources from a global perspective, it is reasonable to consider that lower percentages contribute than one may consider when looking at a local or regional problem involving fewer sources of emissions. The Administrator agrees that ''[j]udged by any standard, U.S. motor-vehicle emissions make a meaningful contribution to greenhouse gas concentrations and hence, * * * to global warming.'' *Massachusetts v. EPA,* 549 U.S. at 525.

VI. Statutory and Executive Order Reviews

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order (EO) 12866 (58 FR 51735, October 4, 1993), this action is a ''significant regulatory action'' because it raises novel policy issues. Accordingly, EPA submitted this action to the Office of Management and Budget (OMB) for review under EO 12866 and any changes made in response to Office of Management and Budget (OMB) recommendations have been documented in the docket for this action.

B. Paperwork Reduction Act

This action does not impose an information collection burden under the provisions of the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* Burden is defined at 5 CFR 1320.3(b). These Findings do not impose an information collection request on any person.

C. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of this action on small entities, small entity is defined as: (1) A small business as defined by the Small Business Administration's (SBA) regulations at 13 CFR 121.201; (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

Because these Findings do not impose any requirements, the Administrator certifies that this action will not have a significant economic impact on a substantial number of small entities. This action does not impose any requirements on small entities. The endangerment and cause or contribute findings do not in-and-of-themselves impose any new requirements but rather set forth the Administrator's determination on whether greenhouse gases in the atmosphere may reasonably be anticipated to endanger public health or welfare, and whether emissions of greenhouse gases from new motor vehicles and engines contribute to this air pollution. Accordingly, the action affords no opportunity for EPA to fashion for small entities less burdensome compliance or reporting requirements or timetables or exemptions from all or part of the Findings.

D. Unfunded Mandates Reform Act

This action contains no Federal mandates under the provisions of Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), 2 U.S.C. 1531–1538 for State, local, or tribal governments or the private sector. The action imposes no enforceable duty on any State, local or tribal governments or the private sector. Therefore, this action is not subject to the requirements of sections 202 or 205 of the UMRA.

This action is also not subject to the requirements of section 203 of UMRA because it contains no regulatory requirements that might significantly or uniquely affect small governments. This finding does not impose any requirements on industry or other entities.

E. Executive Order 13132: Federalism

This action does not have federalism implications. Because this action does not impose requirements on any entities, it will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. Thus, Executive Order 13132 does not apply to this action.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

This action does not have tribal implications, as specified in Executive Order 13175 (65 FR 67249, November 9, 2000). This action does not have substantial direct effects on one or more Indian tribes, on the relationship between the Federal Government and Indian tribes, or on the distribution of power and responsibilities between the Federal Government and Indian tribes, nor does it impose any enforceable duties on any Indian tribes. Thus, Executive Order 13175 does not apply to this action.

G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks

EPA interprets EO 13045 (62 FR 19885, April 23, 1997) as applying only to those regulatory actions that concern health or safety risks, such that the analysis required under section 5–501 of the EO has the potential to influence the regulation. This action is not subject to EO 13045 because it does not establish an environmental standard intended to mitigate health or safety risks. Although the Administrator considered health and safety risks as part of these Findings, the Findings themselves do not impose a standard intended to mitigate those risks.

H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use

This action is not a ''significant energy action'' as defined in Executive Order 13211 (66 FR 28355 (May 22, 2001)), because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy because it does not impose any requirements.

I. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (''NTTAA''), Public Law 104–113, 12(d) (15 U.S.C. at 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus

standards are technical standards (*e.g.,* materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This action does not involve technical standards. Therefore, EPA did not consider the use of any voluntary consensus standards.

J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order (EO) 12898 (59 FR 7629, Feb. 16, 1994) establishes federal executive policy on environmental justice. Its main provision directs federal agencies, to the greatest extent practicable and permitted by law, to make environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations in the United States.

EPA has determined that these Findings will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations because it does not affect the level of protection provided to human health or the environment. Although the Administrator considered climate change risks to minority or low-income populations as part of these Findings, this action does not impose a standard intended to mitigate those risks and does not impose requirements on any entities.

K. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.,* as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2). This rule will be effective January 14, 2010.

Dated: December 7, 2009.

Lisa P. Jackson,

Administrator.

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Recovery *Through* Retrofit

OCTOBER 2009

MIDDLE CLASS TASK FORCE

COUNCIL ON ENVIRONMENTAL QUALITY

CONTENTS

Executive Summary

Making American homes and buildings more energy efficient presents an unprecedented opportunity for communities throughout the country. The Recovery Through Retrofit Report builds on investments made in the American Recovery and Reinvestment Act of 2009 (Recovery Act) to expand the home energy efficiency and retrofit market. Home retrofits can potentially help people earn money, as home retrofit workers, while also helping them save money, by lowering their utility bills. By encouraging nationwide weatherization of homes, workers of all skill levels will be trained, engaged, and will participate in ramping up a national home retrofit market.

There are almost 130 million homes in this country. Combined, they generate more than 20 percent of our nation's carbon dioxide emissions, making them a significant contributor to global climate change. Existing techniques and technologies in energy efficiency retrofitting can reduce home energy use by up to 40 percent per home and lower associated greenhouse gas emissions by up to 160 million metric tons annually by the year 2020. Furthermore, home energy efficiency retrofits have the potential to reduce home energy bills by $21 billion annually, paying for themselves over time.

By implementing Recovery Through Retrofit's recommendations, the Federal Government will lay the groundwork for a self-sustaining home energy efficiency retrofit industry. This Report provides a roadmap of how the Federal Government can use existing authorities and funds to unlock private capital and mobilize our communities.

Barriers to a National Retrofit Market

Despite the economic and environmental benefits of improving home energy efficiency, a series of barriers have prevented a self-sustaining retrofit market from forming, including:

1. **Access to Information:** Consumers do not have access to straightforward and reliable information on home energy retrofits that they need to make informed decisions.

2. **Access to Financing:** Homeowners face high upfront costs and many are concerned that they will be prevented from recouping the value of their investment if they choose to sell their home. The upfront costs of home retrofit projects are often beyond the average homeowner's budget.

3. **Access to Skilled Workers:** There are currently not enough skilled workers and green entrepreneurs to expand weatherization and efficiency retrofit programs on a national scale.

Recommendations Summary

The Recovery Act provides a unique opportunity to address these barriers. The Recovery Act allocates about $80 billion to projects related to energy and the environment, and much of this money is targeted toward improving the energy efficiency in buildings, both Federal and non-Federal. Under the Recovery Act, state and local governments have an unprecedented opportunity to expand investments in energy retrofits and develop community-based programs on a large scale. These investments will put our country on a path to real reductions in greenhouse gases, and contribute to the economic recovery our country needs. The recommendations and actions in this Report have been carefully designed by eleven Departments and Agencies and six White House Offices to ensure that the energy efficiency market will thrive long after the Recovery Act money is fully spent.

By coordinating Recovery Act funds, Federal Departments and Agencies and resources; through building strong partnerships with states and local communities; and by targeting government policy changes, a foundation for self-sustaining energy efficiency retrofit market will be built. Through implementation of the Recovery Through Retrofit recommendations, the Federal Government will leverage private capital, streamline the retrofitting process, and reduce energy costs for homeowners.

Provide American Homeowners with Straightforward and Reliable Home Energy Retrofit Information

Develop Energy Performance Label for Homes

We propose to do for homes what ENERGY STAR® has done for appliances, helping consumers identify energy efficient products. New homes can already earn the ENERGY STAR® label – but no such label is available for existing homes. The Department of Energy and the Environmental Protection Agency are working together to develop an energy performance label for these homes. The end result will be an easily recognizable benchmark that energy auditors, retrofitters, lenders, realtors, and consumers can use to compare home energy performance and identify the most energy efficient homes.

Develop a National Home Energy Performance Measure

Before we can develop an energy performance label for existing homes, we must establish a standardized home energy performance measure applicable to every home in America. This measure will make it much easier for consumers to understand how much they can save by retrofitting their home. It will also give lenders the information they need to work with homeowners who are looking to invest in home energy improvements.

Reduce High Upfront Costs and Make it Easy for Homeowners to Borrow Money for Home Energy Retrofits

Support Municipal Energy Financing

Property tax or municipal energy financing allows the costs of retrofits to be added to a homeowner's property tax bill, with monthly payments generally lower than utility bill savings. This arrangement attaches the costs of the energy retrofit to the property, not the individual, eliminating uncertainty about

recovering the cost of the improvements if the property is sold. Federal Departments and Agencies will work in partnership with state and local governments to establish standardized underwriting criteria and safeguards to protect consumers and minimize financial risks to the homeowners and mortgage lenders. The Department of Energy will support model financing programs to provide much needed upfront capital utilizing Recovery Act funding provided for the Department's Energy Efficiency Conservation Block Grant and State Energy Programs.

Improve Energy Efficient Mortgages

Expanding the use of Energy Efficient Mortgages will simplify the process of obtaining and financing energy retrofits at a home's point of sale. This effort will also work to lower the cost of home energy audits as well as the monthly financing payments, and ensure that retrofits are accurately valued in the appraisal process. Federal Departments and Agencies will work collaboratively to: advance a standard home energy performance measure and more uniform underwriting procedures; develop procedures for more accurate home energy appraisals; and streamline the energy audit process.

Expand State Revolving Loan Funds

Expanding state revolving loan funds from 16 states to all 50 states will leverage private capital and achieve economies of scale necessary to produce consistent and affordable loan products. This will allow consumers to borrow money for home energy retrofits from private firms at lower interest rates. In addition to funding new programs through the Recovery Act, the Federal Government will work to provide examples of successful revolving loan programs and technical assistance to states without revolving loan programs in order to encourage their adoption.

Mobilize a Well-Trained National Energy Retrofit Workforce and Expand Good, Green Job Opportunities for All American Workers

Establish National Workforce Certifications and Training Standards

A uniform set of national standards to qualify energy efficiency and retrofit workers and industry training providers will establish the foundation of consumer confidence that work will be completed correctly and produce the expected energy savings and benefits. Consistent high-level national standards will spur the utilization of qualified training providers that offer career-track programs for people of all skill levels, promote and expand green jobs opportunities, and facilitate the mobilization of a national home retrofit workforce. Federal Departments and Agencies (including the Department of Labor, the Department of Energy, the Department of Housing and Urban Development, and the Environmental Protection Agency) will work in collaboration to assess existing standards and training programs and develop consistent models, guides, and best practices for training and certification. The Department of Education, the Department of Commerce, and the Small Business Administration will assist in implementing the best practices developed by the other Departments and Agencies.

These recommendations do not involve spending large new sums of Federal dollars in our fiscally-constrained environment. Rather, they focus on removing information barriers, transaction costs,

liquidity constraints, and other market failures that often prevent homeowners from making investments that have both private and social benefits.

Moving Forward

To ensure that the recommendations in this Report are implemented, CEQ will convene an interagency Energy Retrofit Working Group, which will be chaired by the Department of Energy, the Department of Housing and Urban Development, the Department of Agriculture, the Department of Labor, and the Environmental Protection Agency. In addition to implementing the recommendations and proposed actions of this Recovery Through Retrofit effort, the Working Group will track its progress and operate as the single point of contact for the successful implementation of this effort. Within thirty days, the Working Group will submit an implementation plan to the Vice President. Additional strategies will also be developed to expand the retrofit market to rental housing. Moreover, the Working Group will report to the Vice President regularly on its progress towards implementing each of the recommendations identified in this Report.

Introduction

On Tuesday, May 26, 2009, at a Middle Class Task Force meeting, Vice President Biden charged the White House Council on Environmental Quality (CEQ) with developing a proposal for Federal action that will grow green job opportunities and boost energy savings by retrofitting homes for energy efficiency. In response to this charge, CEQ has facilitated an interagency process with the Office of the Vice President to develop this Report—involving eleven Departments and Agencies and six White House Offices. This Report contains a set of recommendations for specific Federal actions, which address the market and non-market barriers that have prevented the home retrofit market from achieving national-scale. The following Departments and Agencies contributed to this Report and participated in drafting the recommendations:

- Office of the Vice President
- Department of Agriculture
- Department of Commerce
- Department of Education
- Department of Energy
- Department of Housing and Urban Development
- Department of Labor
- Department of Treasury
- Environmental Protection Agency
- Equal Employment Opportunity Commission
- General Services Administration
- Small Business Administration
- Executive Office of the President
  - Council of Economic Advisers
  - Domestic Policy Council
  - National Economic Council
  - Office of Management and Budget
  - Office of Public Engagement and Intergovernmental Affairs
  - Office of Science and Technology Policy

A Strategic Plan for Recovery Through Retrofit

Market Barrier 1: Consumers need reliable home retrofitting information to make informed decisions

Consistent, accessible, and trusted information is a critical element to building a robust, energy efficient home retrofit market in the United States. This information must provide consumers with a reliable benchmark for energy efficiency and sound estimates of the costs and benefits of home energy retrofits. Currently, there are a variety of energy performance rating tools in the home retrofit market, each one supplying different information and performance predictions. The lack of a standard rating causes great confusion for consumers. Without some level of standardization combined with an effort to increase recognition and awareness, energy efficiency retrofits will likely remain a niche product, keeping consumer demand low and investors out of the market.

Solution 1: We must provide straightforward and credible information to American homeowners on the costs and benefits of home energy retrofits

The Federal Government already promotes an energy efficiency measure that helps consumers save money by identifying appliances and other household products that use less energy. The ENERGY STAR® program is a proven solution that has helped to revolutionize the market for cost-effective, energy efficient products. With the help of ENERGY STAR® Americans saved $19 billion on their utility bills last year. We propose to do for homes what ENERGY STAR® has done for appliances so homeowners know that retrofits will bring their home to a recognized and trusted standard of energy efficiency and home buyers, lenders, and realtors have an easy way to understand the energy performance of homes. To get there, we must take two steps:

Develop Energy Performance Label for Homes

When consumers see the ENERGY STAR® label on a dishwasher or a refrigerator, they know they are getting an energy efficient product and they can take the savings into account as they decide what to purchase. New homes can qualify for an ENERGY STAR® label but there is no similar label for existing homes that have undergone retrofits. The Federal Government will develop a home performance label for existing homes. The label will be based on the national home energy performance measure described below, and it will be developed in partnership with industry leaders, realtors, and efficiency advocates to promote widespread adoption. The end result will be an easily recognizable benchmark that auditors, retrofitters, lenders, realtors, and consumers can use to compare home energy performance and identify the most efficient homes.

The new home performance label should be accompanied by a national marketing campaign to increase consumer awareness and expand the demand for home energy retrofits. This campaign should build on the marketing that Federal Government already does in conjunction with the ENERGY STAR® label on products and the Home Performance with ENERGY STAR® program for whole-home retrofits. The national marketing campaign will help homeowners find reliable sources of information on how to improve their homes and quality, skilled contractors to do the work.

Develop a Standardized Home Energy Performance Measure

We cannot develop an energy performance label for existing homes without first developing a standardized home energy performance measure that is applicable to every home in America. The measure will make it much easier for consumers to understand how much they can save by investing in retrofitting. A uniform and nationally-recognized measure could be incorporated in home appraisals at the point of sale and utilized in energy retrofit transactions, which would spur new interest in the retrofit industry from large-scale suppliers and institutional lenders.

The Department of Energy (DOE) is currently working with the Department of Housing and Urban Development (HUD), the Environmental Protection Agency (EPA) and other Agencies to design a standard energy performance measure and related tools to meet this need. The Federal Housing Administration (FHA) will work to link the new energy performance measure to its redesigned Energy

Efficient Mortgage products. DOE will promote adoption of a national energy performance measure through its advisory role to States and will encourage the use of a common national standard.

Market Barrier 2: The costs of home retrofit projects are beyond the average homeowner's budget

High upfront costs and a lack of credit and financing options dissuade many homeowners from completing or even considering energy efficiency home retrofits. Many homeowners are understandably concerned with how to fund these key improvements. The Recovery Act began to address these issues by extending and expanding a 30% tax credit for investment in residential energy efficiency property, up to a cap of $1,500 per primary residence over 2 years. Other existing financing tools, while successful in some local markets, have not succeeded in making significant inroads in the market at large. Because home buyers lack information about the payoffs associated with increasing a home's energy efficiency and because the industry does not properly incentivize retrofits that pay-off over long periods of time, homeowners often do not recoup the actual value of their energy efficiency investments when they sell. The solution is to make financing more transparent, more accessible, repayable over a longer time period, and overall, more consumer-friendly.

Solution 2: We must make it easy for homeowners to identify and access home energy retrofit financing tools and products

Today, the Recovery Act is already making it easier for homeowners to access home energy retrofit financing. A number of states are currently leveraging the Department of Energy's Recovery Act funds to support long lasting job creation and the deployment of renewable energy and energy efficiency technologies. For example, the State Energy Program (SEP) offers states the opportunity to encourage renewable energy and energy efficiency projects through their state's financing mechanisms, such as revolving loan funds. For example, Kansas plans on spending over $34 million to establish a low-interest revolving loan fund to finance cost-effective energy efficiency improvements in homes and small commercial and industrial buildings. In addition, Nebraska plans on spending $11 million to create a revolving loan fund to provide low-interest financing to deploy energy efficient building technologies to the residential, public, commercial and industrial building sectors. Lastly, Florida plans on spending $10 million to create a low-interest solar loan program that will provide capital to deploy commercially available solar water heaters to Florida residents. These are just a few examples of how Recovery Act funding is currently creating green jobs and reducing greenhouse gas emissions, at the state level.

Support Municipal Energy Financing

The high turnover rate of housing in the United States has proven to be a significant problem when it comes to financing home retrofits. The debt accrued by a retrofit is tied to the individual making the investment, rather than the home itself, even though the savings are passed on to the next owner of the home. This means that retrofits frequently don't pay for themselves before the homeowner who took the initiative moves. As a result, people are less inclined to invest in home retrofitting. In recent years, a number of innovative financing mechanisms have been implemented by municipalities that permit property owners to request financing for energy retrofits or renewable energy systems secured by a special tax assessment on the property. These mechanisms tie the retrofitting loan to the property instead of the individual, permitting the energy retrofit assessment to be paid off in annual installments as part of the property's usual property tax bill.

The Property Assessed Clean Energy (PACE) financing programs enable the costs for energy efficiency retrofits to be added to an owner's property tax bill as part of a municipal property tax assessment, which takes the same priority as traditional property tax liens and assessments.

PACE programs are designed to overcome several barriers that may otherwise impede property owners from making energy investments. These barriers include: (1) limited access to capital; (2) high transaction costs; (3) lack of information on the part of home buyers that leads them to undervalue efficiency investments; and (4) potential downstream home sale, all of which may dissuade property owners from taking on debt that might not be fully recovered by energy savings before the property is sold.

PACE programs address these barriers by providing access to capital that might be otherwise limited to homeowners. PACE provides beneficial financial terms, streamlines the application process with lower application and transaction fees relative to other lending options, and establishes a financing mechanism in which that debt obligation is tied to the property and the owners receiving the energy savings benefits.

Along with the exciting potential of PACE programs for energy retrofits, homeowners and mortgage lenders can encounter certain risks if the programs are not implemented correctly. Building on the expertise of the Federal Government, the Department of Energy, the Department of Housing and Urban Development, and the Department of the Treasury will announce new principles for PACE program design. Moving forward, Federal Agencies will work in partnership with state and local governments to establish standardized underwriting criteria and safeguards to protect consumers and minimize financial risks to homeowners and mortgage lenders.

A Federal role to encourage PACE pilot programs will also facilitate the collection of data, objectively measure and evaluate the performance of PACE programs, and speed the adoption of more detailed, uniform "Best Practices" that include robust and effective homeowner and lender protections. Further research can then assess the efficacy of PACE programs, including the cost-effectiveness of energy retrofits, reductions in greenhouse gases, and economic impacts on community spending and green job creation.

DOE will be funding model PACE projects, which will incorporate the new principles for PACE program design. Under the State Energy Program, DOE has received approximately $80 million of applications for PACE-type programs to provide upfront capital, out of nearly $3.1 billion in total funding available. Smaller PACE-like programs may also be funded through the Energy Efficiency Conservation Block Grant Programs. Funding at these levels will encourage pilots of PACE programs, with more developed homeowner and lender protections than have been provided to date.

Improve Energy Efficient Mortgages

Energy Efficient Mortgages (EEMs) enable home buyers and homeowners refinancing their properties to add energy efficiency upgrades and improvements to their properties as part of the underlying mortgage financing transaction. This permits the energy retrofits to be financed over a longer period of time, with lower monthly payments. Energy improvements are typically identified as part of a Home Energy Rating or energy audit and must be cost effective, generating energy savings that are equal to or greater than the costs of the improvements over the useful life of the improvement.

Historically, there have been significant barriers to widespread utilization of Energy Efficient Mortgages. A four-part solution is proposed to expand and increase the effectiveness of Energy Efficient Mortgages:

1. To lower transaction costs, EPA and DOE will advance a standard home energy performance measure that can be used to easily rate the energy performance of a home;

2. Federal Agencies will work with the home energy rating and home performance industries, as well as states, municipalities and utilities to streamline the energy audit and the home energy ratings process, and expand consumer education and lender awareness of the product;

3. To the extent feasible, HUD will work with Fannie Mae and Freddie Mac to establish uniform procedures for Energy Efficient Mortgage products; and

4. Federal Agencies will work with the home appraisal industry to develop procedures for appraisals to more accurately reflect energy efficiency.

These enhancements are aimed at boosting the volume of Energy Efficient Mortgages. States, cities, or counties can also use their Recovery Act funds to provide credit enhancements and implement other initiatives to boost EEMs.

Expand State Revolving Loan Funds

A Revolving Loan Fund is a funding mechanism that enables loans to be provided to pay for an energy retrofit project's upfront capital costs. Once the energy retrofit is completed, the principal and interest on the loan, along with any financed transaction costs, are paid from the energy savings generated from the project. As energy retrofit loans are paid off, the funds are constantly "revolving" – being used, earned back, and reinvested, thus sustaining the fund over time.

Revolving Loan Funds for energy efficiency retrofits in homes already exist in 16 states. However, they are presently too diverse for private sector suppliers, installers, retail lenders and secondary loan markets to realize economies of scale, which would lower transaction costs. Conforming efficiency loans will be required to bring down capital costs and create sustainable secondary loan funding. Such conforming measures should require: (1) similar loan lengths up to 15 years, so monthly payments are greatly reduced; (2) standard approved products linked to ENERGY STAR®; (3) common procedures with product tiers installed in logical order, linked via Home Performance with ENERGY STAR®; and (4) standardized home energy performance measures and data protocols, so that both loan performance and retrofit performance can be measured accurately over time.

The Federal Government will also work to encourage the development of revolving loan funds in all 50 states. State revolving loan funds produce consistent and affordable loan products, allowing consumers to borrow money for home energy retrofits at lower interest rates. These efforts will create reliable, easy to close, unsecured loan products in every jurisdiction and mobilize private sector funds and achieve economies of scale in installation costs, transaction costs, and persuasive marketing efforts. In order to encourage development of state revolving loan funds in all 50 states, the Department of Energy will also provide technical assistance to states without revolving loan programs in order to encourage their adoption. Finally, existing funding through the Recovery Act can be used to expand current and create new revolving loan fund programs throughout the country.

Market Barrier 3: Increase the number of skilled workers and green entrepreneurs to successfully expand efficiency retrofit programs on a national-scale

To achieve the desired scale of efficient and healthy home retrofits, a sizable increase in the number of well-trained green retrofit workers is needed. Many states and localities are looking for guidance and information on how to both streamline and rapidly expand quality training opportunities for those looking to enter the home energy retrofit industry. Furthermore, there is no clear guideline or standard to assure consumers of the quality of the work being done on their home. A consistent set of standards will increase consumer confidence in energy retrofit workers, promote good green job opportunities and training opportunities for people of all skill levels, and facilitate the mobilization of a national home retrofit workforce.

In addition, a lack of business skills training has been a barrier to the widespread success of efficiency retrofits programs. Business skills training and business development must therefore be a key component of any large-scale efficiency retrofit workforce capacity development initiative to ensure that a commercially viable effort can be maintained by small- and medium-sized businesses in the open market over the long-term. Developing a workforce equipped with both technical and business skills will improve the rate of success for small efficiency retrofit businesses and increase the ability to respond to rising retrofit demand. This will enable sustained economic and green job growth while achieving further energy savings and healthy homes.

Solution 3: Mobilize a skilled national energy retrofit workforce and expand good, green job opportunities for all American workers

Develop Consistent Workforce Certifications and Training Standards

To rapidly expand retrofit capacity, a national effort is needed to conclusively identify required job skills upon which certification standards will be based, and develop standard training goals or methods. The availability of model training programs based around best practices will lower the barriers to entry for programs needed to train workers, allowing an expanded offering of quality training opportunities. The widespread adoption of model training approaches will also facilitate the development of a well-trained workforce across the country, which will improve energy and environmental outcomes, enable worker mobility, and enhance career opportunities. In addition, as outlined in the *Surgeon General's Call to Action To Promote Healthy Homes*,[1] healthy and environmentally friendly housing education should be incorporated in weatherization training programs. Proper certification and training standards will ensure that retrofitted homes are healthy homes.

To facilitate consistent, high-quality training of a green retrofit workforce, the Federal Government will:

1. Advance a nationally recognized worker certification standard for comprehensive training that provides evidence that a worker is well qualified to properly complete efficiency and healthy home retrofits.
2. Promote a nationally recognized training accreditation standard to enable students to identify trainers with a demonstrated capacity to provide quality instruction.
3. Develop and deploy model training programs for workers, including pre-apprenticeship and other programs that serve as onramps for lower skilled workers, provide clear pathways to career track jobs, and assist training providers in ramping up training capacity efficiently and effectively.
4. Leverage existing workplace training, labor management partnerships, and other public-private partnerships and the local presence of Federal Agencies in communities to link workforce training to job opportunities.
5. Provide business development support and business skills training to improve the rate of success for small efficiency retrofit businesses and to engage both small businesses and larger contractors in entering the retrofit market to build an industry at scale. This support should also include a focus on making sure small businesses and minority and/or women owned businesses have a seat at the table.

To ensure that efficiency retrofit training programs translate into thriving efficiency retrofit businesses, the Federal Government will use its resources to make business skills a critical component of efficiency retrofit training. By combining industry-specific business skills training with industry-specific jobs skills training, the Federal Government can help provide a steady stream of skilled retrofit workers, and a steady stream of healthy small and medium-sized retrofit businesses ready to hire these workers.

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[1] For the full report, see: http://www.surgeongeneral.gov/topics/healthyhomes/index.html

Federal Departments and Agencies, including: the Department of Labor, the Department of Energy, the Department of Housing and Urban Development, and the Environmental Protection Agency will work in collaboration to assess existing standards and training programs and develop consistent models, guides, and best practices for training and certification. The Department of Education, the Department of Commerce, and the Small Business Administration will assist in implementing the best practices developed by the other Departments and Agencies.

Implementation

CEQ will convene an interagency Energy Retrofit Working Group chaired by the Department of Energy, Department of Housing and Urban Development, Department of Agriculture, the Department of Labor, and the Environmental Protection Agency, to implement the recommendations and proposed actions of this Recovery Through Retrofit effort and track its progress. The Working Group will operate as the single point of contact for the successful implementation of this effort. Within thirty days, the Working Group will submit an implementation plan to the Vice President. In addition, the Working Group will report to the Vice President regularly on the progress towards implementing each of the recommendations identified in this Report. Additional strategies will also be developed to expand the retrofit market to rental housing.

Further, Federal Agencies will collaborate with local communities to test business models and develop best practices for encouraging energy efficiency programs that address the three key market failures identified in this Report.

Conclusion

Coordinated and principled Federal actions, like those described in this Report, in partnership with states, cities, counties, and the existing home energy industry, may be able to tackle the challenges faced by the current retrofit market. These recommendations can pave the way for a self-sustaining retrofit market, a market that can reliably cut energy bills while also creating good green jobs and saving consumers money. We can build on the foundation of the Recovery Act to jumpstart a thriving, private market for energy efficient and healthy home retrofitting that will put thousands of people back to work while also reducing our impact on the environment.

Announcement SEL-2010-15 December 1, 2010

New Energy Improvement Feature and Other Related Updates

Fannie Mae supports energy efficiency in residential housing, and encourages the development of viable financing and securitization opportunities that do not place undue risk on lenders, investors, or homeowners. Fannie Mae's commitment to serving this sector of the housing finance market has continued since the 1970s when energy-related mortgage flexibilities were first offered on a negotiated basis.

In an effort to provide assistance to more borrowers seeking financing for energy improvements, Fannie Mae has re-evaluated its energy improvement guidelines in light of current market conditions. As a result, the *Selling Guide* is being updated to incorporate a new energy improvement feature as a standard offering available to all lenders. The energy improvement feature provides an option to fund energy-efficient home upgrades while aligning with the principles of borrower sustainability. Other updates related to home energy improvements are also covered in this *Selling Guide* update, including revisions to the HomeStyle® Renovation mortgage product and clarification of postponed improvement requirements for new or proposed construction.

The energy improvement feature has been added to the *Selling Guide* within the "Construction and Energy Financing" Chapter. (This Chapter was previously titled "Construction-Related Products"). The new feature and the other updates are described below. The affected topics (and specific paragraphs) are noted and are linked to the updated *Selling Guide* posted on eFannieMae.com. Lenders should review each topic within the *Selling Guide* to gain a full understanding of the changes. The topics are dated December 1, 2010.

Energy Improvement Feature on Existing Properties

The key requirements for mortgage loans with the energy improvement feature are summarized in this Announcement. In general, Fannie Mae is allowing loan proceeds to be used to finance energy improvements under certain conditions. Fannie Mae is also providing lenders with a loan-level pricing adjustment (LLPA) credit of $250 (to be passed on to the borrower) for loans with the energy improvement feature. The $250 credit is intended to provide a borrower incentive that will help to offset the costs associated with the required energy audit report. Lenders must refer to B5-3.3-01, Mortgage Loans with Energy Improvement Features on Existing Properties, and B4-1.2-04, Requirements for Postponed Improvements, for complete details.

Eligible transactions: All transactions and products are permitted with the exception of cash-out refinances, Refi Plus™, and DU® Refi Plus™. Loans with energy improvements are subject to the applicable LTV, CLTV, and HCLTV ratios found in the Eligibility Matrix.

- Purchases: The proceeds can be used to finance the acquisition of the property and the energy improvements. The LTV ratio is determined by dividing the loan amount (including the cost of the energy improvements) by the lesser of the "as completed" appraised value of the property or the sum of the purchase price of the property and the cost of the energy improvements.

- Limited cash-out refinances: The loan must meet all of the standard requirements for limited cash-out refinances except for the following:
  - The borrower can finance energy improvements in the loan amount.
  - The borrower may only receive $250 cash back to accommodate rounding of the loan amount at closing. (The 2%/$2,000 cash back policy is not applicable.) When the lender passes on the $250 LLPA credit from Fannie Mae to the borrower as is expected, the maximum cash back is $500.
  - The LTV ratio is determined by dividing the loan amount (including the cost of the energy improvements) by the "as completed" appraised value of the property.

Eligible properties and occupancy types: All one-unit existing properties are eligible for the energy improvement feature with the exception of manufactured homes and units in a co-op project. All occupancy types are permitted.

Energy improvements: The amount of the financed energy improvements is limited to 10% of the "as completed" appraised value of the property. There is no minimum dollar amount for the energy improvements.

- Borrowers must obtain an energy report prepared by a Home Energy Rating Systems (HERS) energy rater. The energy report must:
  - identify the recommended energy improvements and expected costs of the completed improvements,
  - specify the monthly energy savings to the borrower, and
  - verify that the recommended energy improvements are cost-effective.
- If the cost of the energy report is paid for by the borrower, the cost may be financed as part of the mortgage by including it in the cost of the energy improvements.
- Mortgages may be delivered before the energy improvements are completed if the lender represents and warrants that the postponed improvements will be completed within 180 days of the date of the mortgage note.
- Acceptable postponed items include items that will not require an occupancy permit.
- The value of sweat equity and do-it-yourself improvements cannot be financed.
- Lenders and borrowers must execute an escrow agreement that states how the escrow account will be managed and how funds from the escrow account will be disbursed.
- See B4-1.2-04 for additional requirements related to postponed improvements.

Appraisal and completion requirements:

- The lender is responsible for ensuring that the appraiser has been provided with a copy of the energy report.
- All mortgage loans with energy improvement features require an appraisal based on an interior and exterior property inspection.
- Appraisers must determine the "as completed" value of the property subject to the energy improvements being completed.
- Lenders are responsible for managing the escrow account in which improvement funds are held, and for monitoring the completion of the energy improvement work.
- A certification of completion is required to verify the work was completed and must:
  - be completed by the appraiser,
  - state that the improvements were completed in accordance with the requirements and conditions in the original appraisal report, and
  - be accompanied by photographs of the completed improvements.

Underwriting with Desktop Underwriter® (DU®): Mortgage loans with an energy improvement feature can be underwritten manually or through DU. However, DU is unable to identify the transaction as having an energy improvement feature and as such, will not issue any specific verification messages.

- The lender must confirm outside of DU that all requirements of the energy improvement feature are met.
- DU will apply the standard limited cash-out refinance cash back policy and, as a result, the loan casefile may receive an Ineligible recommendation if it appears that the borrower is receiving more than 2%/$2,000 cash back. The lender may deliver the loan with the Ineligible recommendation and retain the DU limited waiver of underwriting representations and warranties provided the mortgage loan meets certain requirements.
- See B5-3.3-01 for additional information about underwriting with DU.

Delivery and Pricing:

- Special Feature Code (SFC) 375 is required for all mortgage loans delivered with the energy improvement feature.
- Fannie Mae will credit the lender a $250 LLPA for mortgage loans with energy improvements on existing properties. Lenders are expected to pass the $250 credit on to the borrower. See the Loan-Level Price Adjustment (LLPA) Matrix and Adverse Market Delivery Charge (AMDC) Information.

New and Updated *Selling Guide* Topics

B5-3.3-01, Mortgage Loans with Energy Improvement Features on Existing Properties (new topic)
B4-1.2-04, Requirements for Postponed Improvements (revised topic title) (Overview, Postponed Improvements for New or Proposed Construction, Requirements for the Energy Improvement Feature on Existing Construction)
E-2-07, Post-Closing Mortgage Loan File Documentation (Post-Closing Review File Submission Documentation)

Effective Dates:

Lenders may begin delivering mortgage loans with an energy improvement feature effective immediately.

Updates to HomeStyle® Renovation Mortgages

Combining the Energy Improvement Feature with HomeStyle Renovation Mortgages

Borrowers have always been able to finance the cost of energy-related improvements with a HomeStyle Renovation Mortgage. If the HomeStyle Renovation loan is used to finance energy-related improvements and the loan meets the requirements of the energy improvement feature (with the exception of the 10% maximum limit requirement for costs financed under the energy improvement feature - which may be exceeded for HomeStyle Renovation loans), the lender will receive the $250 LLPA credit. In order to receive the credit, the lender must deliver the loan with SFC 375 along with all other special feature codes that may apply. Lenders are expected to pass the LLPA credit on to the borrower.

Changes to the LTV Ratio Calculation for HomeStyle Renovation Refinances

Currently, Fannie Mae requires the calculation of the LTV ratio for HomeStyle Renovation refinances to be based on the *lesser of* the "as completed" appraised value of the property, or the sum of the unpaid principal balances of all eligible liens and the total renovation costs.

Fannie Mae is simplifying this calculation. For refinance transactions, the LTV ratio is now determined by dividing the loan amount by the "as completed" appraised value of the property. The LTV ratio calculation for purchase transactions remains unchanged.

Updated *Selling Guide* Topics

B5-3.2-01, HomeStyle Renovation Mortgage: Lender Eligibility (Overview, Delivery and Recourse Requirements)
B5-3.2-02, HomeStyle Renovation Mortgages: Borrower Eligibility (Renovation-Related Costs, Eligibility)
B5-3.2-03, HomeStyle Renovation Mortgages: Underwriting and Collateral Considerations (LTV Ratios, Energy Report Requirements)

Updated HomeStyle Renovation Forms

The following Fannie Mae forms have been revised and can be found on eFannieMae.com:

HomeStyle® Approval Form (Form 1000A): The name of this form has been changed to *Special Lender Approval Form*. In addition, changes have been made to eliminate extraneous information and clarify the information required by the form.

HomeStyle® Renovation Maximum Mortgage Worksheet (Form 1035): Extraneous information was removed and changes were made to the names of several line items.

Effective Dates

Lenders may deliver HomeStyle Renovation loans with energy improvement features and SFC 375, and begin using the revised forms immediately. Lenders may also begin applying the updated LTV calculation immediately.

Note: The DU message that reminds lenders to enter the lesser of the "as completed" appraised value or the sum of the unpaid principal balances of all outstanding liens and the total renovation costs will be retired with DU Version 8.2. Lenders may apply the updated LTV calculation to their DU loan casefiles immediately, although the retirement of the message will only be reflected on those HomeStyle Renovation loan casefiles underwritten through DU Version 8.2.

Clarification of Postponed Improvement Requirements for New and Proposed Construction

The contents of the table titled "Requirements for New or Proposed Construction" have been re-arranged for clarity. In addition, the statement that required a certification of completion before

loan delivery has been corrected. (The very nature of postponed improvements allows completion after loan delivery to Fannie Mae).

Updated *Selling Guide* Topic

B4-1.2-04, Requirements for Postponed Improvements (revised topic title) (Overview, Postponed Improvements for New or Proposed Construction)

Effective Date

The clarification and correction are effective immediately.

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Lenders who have questions about this Announcement should contact their Customer Account Team.

John S. Forlines
Vice President
Single-Family Chief Risk Officer

LBNL-4476E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California

Ben Hoen, Ryan Wiser, Peter Cappers and Mark Thayer

Environmental Energy Technologies Division

April 2011

Download from http://eetd.lbl.gov/ea/emp/reports/lbnl-4476e.pdf

This work was supported by the Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231, by the National Renewable Energy Laboratory under Contract No. DEK-8883050, and by the Clean Energy States Alliance.

Disclaimer

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Abstract

An increasing number of homes with existing photovoltaic (PV) energy systems have sold in the U.S., yet relatively little research exists that estimates the marginal impacts of those PV systems on home sales prices. A clearer understanding of these effects might influence the decisions of homeowners considering installing PV on their home or selling their home with PV already installed, of home buyers considering purchasing a home with PV already installed, and of new home builders considering installing PV on their production homes. This research analyzes a large dataset of California homes that sold from 2000 through mid-2009 with PV installed. Across a large number of hedonic and repeat sales model specifications and robustness tests, the analysis finds strong evidence that California homes with PV systems have sold for a premium over comparable homes without PV systems. The effects range, on average, from approximately $3.9 to $6.4 per installed watt (DC) of PV, with most coalescing near $5.5/watt, which corresponds to a home sales price premium of approximately $17,000 for a relatively new 3,100 watt PV system (the average size of PV systems in the study). These average sales price premiums appear to be comparable to the investment that homeowners have made to install PV systems in California, which from 2001 through 2009 averaged approximately $5/watt (DC), and homeowners with PV also benefit from electricity cost savings after PV system installation and prior to home sale. When expressed as a ratio of the sales price premium to estimated annual electricity cost savings associated with PV, an average ratio of 14:1 to 22:1 can be calculated; these results are consistent with those of the more-extensive existing literature on the impact of energy efficiency (and energy cost savings more generally) on home sales prices. The analysis also finds - as expected - that sales price premiums decline as PV systems age. Additionally, when the data are split between *new* and *existing* homes, a large disparity in premiums is discovered: the research finds that *new* homes with PV in California have demonstrated average premiums of $2.3-2.6/watt, while the average premium for *existing* homes with PV has been more than $6/watt. One of several *possible* reasons for the lower premium for new homes is that new home builders may also gain value from PV as a market differentiator, and have therefore often tended to sell PV as a standard (as opposed to an optional) product on their homes and perhaps been willing to accept a lower premium in return for faster sales velocity. Further research is warranted in this area, as well as a number of other areas that are highlighted.

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1. Introduction

In calendar year 2010, approximately 880 megawatts (MW)[1] of grid-connected solar photovoltaic (PV) energy systems were installed in the U.S. (of which approximately 30% were residential), up from 435 MW installed in 2009, yielding a cumulative total of 2,100 MW (SEIA & GTM, 2011). California has been and continues to be the country's largest market for PV, with nearly 1000 MW of cumulative capacity. California is also approaching 100,000 individual PV systems installed, more than 90% of which are residential. An increasing number of these homes with PV have sold, yet to date, relatively little research has been conducted to estimate the existence and level of any premium to sales prices that the PV systems may have generated. One of the primary incentives for homeowners to install a PV system on their home, or for home buyers to purchase a home with a PV system already installed, is to reduce their electricity bills. However, homeowners cannot always predict if they will own their home for enough time to fully recoup their PV system investment through electricity bill savings. The decision to install a PV system or purchase a home with a PV system already installed may therefore be predicated, at least in part, on the assumption that a portion of any incremental investment in PV will be returned at the time of the home's subsequent sale through a higher sales price. Some in the solar industry have recognized this potential premium to home sales prices, and, in the absence of having solid research on PV premiums, have used related literature on the impact of energy efficiency investments and energy bill savings on home prices as a proxy for making the claim that residential PV systems can increase sales prices (e.g., Black, 2010).

The basis for making the claim that an installed PV system may produce higher residential selling prices is grounded in the theory that a reduction in the carrying cost of a home will translate, *ceteris paribus,* into the willingness of a buyer to pay more for that home. Underlying this notion is effectively a present value calculation of a stream of savings associated with the

[1] All references to the size of PV systems in this paper, unless otherwise noted, are reported in terms of direct current (DC) watts under standard test conditions (STC). This convention was used to conform to the most-common reporting conventions used outside of California. In California, PV systems sizes are often referred to using the California Energy Commission Alternating Current (CEC-AC) rating convention, which is approximately a multiple of 0.83 of the DC-STC convention, but depends on a variety of factors including inverter efficiency and realistic operating efficiencies for panels. A discussion of the differences between these two conventions and how conversions can be made between them is offered in Appendix A of Barbose et al., 2010.

reduced electricity bills of PV homes, which can be capitalized into the value of the home. Along these lines, a number of studies have shown that residential selling prices are positively correlated with lower energy bills, most often attributed to energy related home improvements, such as energy efficiency investments (Johnson and Kaserman, 1983; Longstreth et al., 1984; Laquatra, 1986; Dinan and Miranowski, 1989; Horowitz and Haeri, 1990; Nevin and Watson, 1998; Nevin et al., 1999). The increased residential sales prices associated with lower energy bills and energy efficiency measures might be expected to apply to PV as well. Some homeowners have stated as much in surveys (e.g., CEC, 2002; McCabe and Merry, 2010), though the empirical evidence supporting such claims is limited in scope. Farhar et al. (2004a; 2008) tracked repeat sales of 15 "high performance" energy efficient homes with PV installed from one subdivision in San Diego and found evidence of higher appreciation rates, using simple averages, for these homes over comparable homes (n=12). More recently, Dastrop et al. (2010) used a hedonic analysis to investigate the selling prices of 279 homes with PV installed in the San Diego, California metropolitan area, finding clear evidence of PV premiums that averaged approximately 3% of the total sales price of non-PV homes, which translates into $4.4 per installed PV watt (DC).

In addition to energy savings, higher selling prices might be correlated with a "cachet value" based on the "green" attributes that come bundled with energy-related improvements (e.g., helping combat global warming, impressing the neighbors, etc.). A number of recent papers have investigated this correlation. Eichholtz et al. (2009, 2011) analyzed commercial green properties in the U.S, and Brounen and Kok (2010) and Griffin et al. (2009) analyzed green labeled homes in the Netherlands and Portland, Oregon, respectively, each finding premiums, which, in some cases, exceeded the energy savings (Eichholtz et al., 2009, 2011; Brounen and Kok, 2010). Specifically related to PV, Dastrop et al. (2010) found higher premiums in communities with a greater share of Toyota Prius owners and college grads, indicating, potentially, the presence of a cachet value to the systems over and above energy savings. It is therefore reasonable to believe that buyers of PV homes might price both the energy savings and the green cachet into their purchase decisions.

Of course there is both a buyer and a seller in any transaction, and the sellers of PV homes might be driven by different motivations than the buyers. Specifically, recouping the *net* installed cost of the PV system (i.e., the cost of PV installation after deducting any available state and federal incentives) might be one driver for sellers. In California, the average net installed cost of residential PV hovered near $5/watt (DC) from 2001 through 2009 (Barbose et al., 2010). Adding slightly to the complexity, the average net installed cost of PV systems has varied to some degree by the type of home, with PV systems installed on *new* homes in California enjoying approximately a $1/watt lower average installed cost than PV systems installed on *existing* homes in retrofit applications (Barbose et al., 2010). Further, sellers of *new* homes with PV (i.e., new home developers) might be reluctant to aggressively increase home sale prices for installed PV systems because of the burgeoning state of the market for PV homes and concern that more aggressive pricing might slow home sales, especially if PV is offered as a standard (not optional) product feature (Farhar and Coburn, 2006). At the same time, the possible *positive* impact of PV on product differentiation and sales velocity may make new home developers willing to sell PV at below the net installed cost of the system. After all, some studies that have investigated whether homes with PV (often coupled with energy efficient features) sell faster than comparable homes without PV have found evidence of increased velocity due to product differentiation (Dakin et al., 2008; SunPower, 2008). Finally, as PV systems age, and sellers (i.e., homeowners) recoup a portion of their initial investment in the form of energy bill savings (and, related, the PV system's lifespan decreases), the need (and ability) to recoup the full initial investment at the time of home sale might decrease. On net, it stands to reason that premiums for PV on *new* homes might be lower than those for *existing* homes, and that older PV systems might garner lower premiums than newer PV systems of the same size.

Though a link between selling prices and some combination of energy cost savings, green cachet, recouping the net installed cost of PV, seller attributes, and PV system age likely exists, the existing empirical literature in this area, as discussed earlier, has largely focused on either energy efficiency in residential and commercial settings, or PV in residential settings but in a limited geographic area (San Diego), with relatively small sample sizes. Therefore, to date, establishing a reliable estimate for the PV premiums that may exist across a wide market of homes has not

been possible. Moreover, establishing premiums for *new* versus *existing* homes with PV has not yet been addressed.

Additionally, research has not investigated whether there are increasing or decreasing returns on larger PV systems, and/or larger homes with the same sized PV systems, nor has research been conducted that investigates whether older PV systems garner lower premiums. In the case of returns to scale on larger PV systems, it is not unreasonable to expect that any increase in value for PV homes may be non-linear as it relates to PV system size. For example, if larger PV systems push residents into lower electricity price tiers[2], energy bill savings could be diminished on the margin as PV system size increases. This, in turn, might translate into smaller percentage increases in residential selling prices as PV systems increase in size, and therefore a decreasing return to scale. Larger PV systems might also enjoy some economies of scale in installation costs, which, in turn, might translate into lower marginal premiums at the time of home sale as systems increase in size – a decreasing return to scale. Additionally, "cachet value", to the degree that it exists, is likely to be somewhat insensitive to system size, and therefore might act as an additional driver to decreasing returns to scale. Somewhat analogously, PV premiums may be related to the number of square feet of living area in the home. Potentially, as homes increase in size, energy use can also be expected to increase, leading homeowners to be subjected to higher priced electricity rate tiers and therefore greater energy bill savings for similarly sized PV systems. Finally, as discussed previously, as PV systems age, and both a portion of the initial investment is recouped and the expected life and operating efficiency of the systems decrease, home sales price premiums might be expected to decline.

To explore these possible relationships, we investigate the residential selling prices across the state of California of approximately 2,000 homes with existing PV systems against a comparable set of approximately 70,000 non-PV homes. The sample is drawn from 31 California counties, with PV home sales transaction dates of 2000 through mid-2009. We apply a variety of hedonic pricing (and repeat sales) models and sample sets to test and bound the possible effects of PV on residential sales prices and to increase the confidence of the findings. Using these tools, we also

[2] Many California electric utilities provide service under tiered residential rates that charge progressively higher prices for energy as more of it is used.

explore whether the effects of PV systems on home prices are impacted by whether the home is *new* or *existing*, by the size of either the PV system or the home itself, and finally by how old the PV system is when the home sells.[3] It should be stated that this research is not intended to disentangle the specific effects of energy savings, green cachet, recovery of the cost of installation, or seller motivations, but rather to establish credible estimates of aggregate PV residential sales price effects.

The paper begins with a discussion of the data used for the analyses (Section 2). This is followed by a discussion of the empirical basis for the study (Section 3), where the variety of models and sample sets are detailed. The paper then turns to a discussion of the results and their potential implications (Section 4), and finally offers some concluding remarks with recommendations for future research (Section 5).

[3] Due to the limited sample of PV home sales in many individual years, the results presented in this report reflect average impacts over the entire 2000-09 period (after controlling for housing market fluctuations).

2. Data Overview

To estimate the models described later, a dataset of California homes is used that joins the following five different sets of data: (1) PV home addresses and system information from three organizations that have offered financial incentives to PV system owners in the state; (2) real estate information that is matched to those addresses and that also includes the addresses of and information on non-PV homes nearby; (3) home price index data that allow inflation adjustments of sale prices to 2009 dollars; (4) locational data to map the homes with respect to nearby neighborhood/environmental influences; and (5) elevation data to be used as a proxy for "scenic vista." Each of these data sources is described below, as are the data processing steps employed, and the resulting sample dataset.

2.1. Data Sources

The California Energy Commission (CEC), the California Public Utilities Commission (CPUC), and the Sacramento Municipal Utility District (SMUD) each provide financial incentives under different programs to encourage the installation of PV systems in residential applications, and therefore have addresses for virtually all of those systems, as well as accompanying data on the PV systems.[4] Through these programs, Berkeley Laboratory was provided information on approximately 42,000 homes where PV was installed, only a fraction of which (approximately 9%) subsequently sold with the PV system in place. The data provided included: address (street, street number, city, state and zip); incentive application and PV system install and operational dates; PV system size; and delineations as to whether the home was *new* or *existing* at the time the PV system was installed (where available).

[4] The CEC and CPUC have both been collecting data on PV systems installed on homes in the utility service areas of investor owned utilities (e.g., PG&E, SCE, SDG&E) for which they have provided incentives, as have some of California's publicly owned utilities (e.g., SMUD) that offer similar incentives. The CEC began administering its incentive program in 1998, and provided rebates to systems of various sizes for both residential and commercial customers. The CPUC began its program in 2001, initially focusing on commercial systems over 30 kW in size. In January 2007, however, the CEC began concentrating its efforts on new residential construction through its New Solar Home Partnership program, and the CPUC took over the administration of residential retrofit systems through the California Solar Initiative program. Separately, SMUD has operated a long-standing residential solar rebate program, but of smaller size than the efforts of the CEC and CPUC.

These addresses were then matched to addresses as maintained by Core Logic (CL)[5], which they aggregate from both the California county assessment and deed recorder offices. Once matched, CL provided real estate information on each of the California PV homes, as well as similar information on approximately 150,000 non-PV homes that were located in the same (census) block group and/or subdivision as the matched PV homes. The data for both of these sets of homes included:

- address (e.g., street, street number, city, state and zip+4 code);
- most recent ("second") sale date and amount;
- previous ("first") sale date and amount (if applicable);
- home characteristics (where available) (e.g., acres, square feet of living area, bathrooms, and year built);
- assessed value;
- parcel land use (e.g., commercial, residential);
- structure type (e.g., single family residence, condominium, duplex);
- housing subdivision name (if applicable)[6]; and
- census tract and census block group.

These data, along with the PV incentive provider data, allowed us to determine if a home sold after a PV system was installed ("second" sale). 3,657 such homes were identified in total, and these homes, therefore, represent the possible sample of homes on which our analysis focused. A subset of these data for which "first" sale information was available and for which a PV system had not yet been installed as of this "first" sale, were culled out. These "repeat sales" were also used in the analysis, as will be discussed in Section 3.

In addition to the PV and real estate data, Berkeley Laboratory obtained from Fiserv a zip-code-level weighted repeat sales index of housing prices in California from 1970 through mid-2009, by quarter. These indices, where data were available, were differentiated between low, middle,

[5] More information about this product can be obtained from http://www.corelogic.com/. Note that Core Logic, Inc. was formerly known as First American Core Logic.

[6] In some cases the same subdivisions were referred to using slightly different names (e.g., "Maple Tree Estates" & "Maple Trees Estates"). Therefore, an iterative process of matching based on the names, the zip code, and the census tract were used to create "common" subdivision names, which were then used in the models, as discussed later.

and high home price tiers, to accommodate the different appreciation/depreciation rates of market segments. Using these indices, all sale prices were adjusted to Q1, 2009 prices.[7]

From Sammamish Data, Berkeley Laboratory purchased x/y coordinates for each zip+4 code, which allowed the mapping of addresses to street level accuracy.[8] Additionally, Berkeley Laboratory obtained from the California Natural Resources Agency (via the California Environmental Resources Evaluation System, CERES) a 30 meter level Digital Elevation Map (DEM) for the state of California.[9] Combining these latter two sets of data, a street level elevation could be obtained for each home in the dataset, which allowed the construction of a variable defined as the elevation of a home relative to its (census) block group. This relative elevation served as a proxy for "scenic vista", a variable used in the analysis.

2.2. Data Processing

Data cleaning and preparation for final analysis was a multifaceted process involving selecting transactions where all of the required data fields were fully populated, determining if sales of PV homes occurred after the PV system was installed, matching the homes to the appropriate index, ensuring the populated fields were appropriately coded, and finally, eliminating obviously suspicious observations (e.g., not arms length transactions, outliers, etc.). Initially provided were a total of 150,000 detached single family residential sale records without PV and a total of 3,657 with PV. These totals, however, were substantially reduced (by approximately 65,000 records, 1,400 of which were PV sales) because of missing/erroneous core characteristic data (e.g., sale date, sale price, year built, square feet).[10] Additionally, the final dataset was reduced (by approximately 14,000 records, 300 of which were PV sales) because some sales occurred outside the range of the index that was provided (January 1970 to June 2009). Moreover, to focus our analysis on more-typical California homes and minimize the impact of outliers or potential data-

[7] The inflation adjustment instrument used for this analysis is the Fiserv Case-Shiller Index. This index is a weighted repeat sales index, accumulated quarterly at, optimally, the zip code level over three home price tiers (e.g., low, middle and high prices). More information can be found at: http://www.caseshiller.fiserv.com/indexes.aspx

[8] More information about this product can be obtained from http://www.sammdata.com/

[9] More information about this product can be obtained from http://www.ceres.ca.gov/

[10] Examples of "erroneous" data might include a year built or sale date that is in the future (e.g., "2109" or "Jan 1, 2015", respectively), or large groups of homes that were listed at the same price in the same year in the same block group that were thought to be "bulk" sales and therefore not valid for our purposes.

entry errors on our results, observations not meeting the following criteria were screened out (see Table 1 for variable descriptions):

- the inflation adjusted most recent (second) sale price (*asp2*) is between $85,000 and $2,500,000;[11]
- the number of square feet (*sqft*) is greater than 750;
- *asp2* divided by *sqft* is between $40 and $1,000;
- the number of acres is less than 25 and greater than *sqft* divided by 43,560 (where one acre equals 43,560 *sqft*);[12]
- the year the home was built (*yrbuilt*) is greater than 1900;
- the age of the home (in years) at the time of the most recent sale (*ages2*) is greater than or equal to negative one;
- the number of bathrooms (*baths*) is greater than zero and less than ten;
- the size of the PV system (*size*) is greater than 0.5 and less than 10 kilowatts (kW);
- each block group contains at least one PV home sale and one non-PV home sale; and
- the total assessed value (*avtotal*), as reported by the county via Core Logic, is less than or equal to the predicted assessed value (*pav*), where *pav* = *sp2**1.02^(2010-year of sale).[13]

In addition, the repeat sales used in the analysis had to meet the following criteria:

- the difference in sale dates (*sddif*) between the most recent (second) sale date (*sd2*) and the previous (first) sale date (*sd1*) is less than 20 years;
- PV is not installed on the home as of *sd1*; and
- the adjusted annual appreciation rate (*adjaar*) is between -0.14 and 0.3 (where *adjaar* = ln(*asp2*/*asp1*)/(*sddif*/365), which corresponds to the 5th and 95th percentile for the distribution of *adjaar*.[14]

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[11] An alternative screen was tested that limited the data to homes under $1 million (leaving 90% of the data) and $600,000 (leaving 75%), with no significant change to the results.

[12] An alternative screen that incorporated the number of stories for the home along with the number of square feet in calculating the "footprint", and therefore allowed smaller parcels to be used, was also explored, with no significant change in results.

[13] This screen was intended to help ensure that homes that had significant improvements since the most recent sale, which would be reflected in a higher assessed value than would otherwise be the maximum allowable under California property tax law, were removed from the dataset. The screen was not applied to homes that sold in 2009, however, because, in those cases, assessed values often had not been updated to reflect the most recent sale.

[14] This final screen was intended to remove homes that had unusually large appreciation or deprecations between sales, after adjusting for inflation, which could indicate that the underlying home characteristics between the two sales changed (e.g., an addition was added, the condition of the home dramatically worsened, etc.), or the data were erroneous.

Table 1: Variable Descriptions

Variable	Description
acre	size of the parcel (in acres)
acregt1	number of acres more than one
acrelt1	number of acres less than one
adjaar	adjusted annual appreciation rate
ages2	age of home as of sd2
ages2sqr	ages2 squared
asp1	inflation adjusted sp1 (in 2009 dollars)
asp2	inflation adjusted sp2 (in 2009 dollars)
avtotal	total assessed value of the home
bath	number of bathrooms
bgre_100	relative elevation to other homes in block group (in 100s of feet)
elev	elevation of home (in feet)
lasp1	natural log of asp1
lasp2	natural log of asp2
pav	predicted assessed value
pvage	age of the PV system at the time of sale
sd1	first sale date
sd2	second sale date
sddif	number of days separating sd1 and sd2
size	size (in STC DC kW) of the PV system
sp1	first sale price (not adjusted for inflation)
sp2	second sale price (not adjusted for inflation)
sqft	size of living area
sqft_1000	size of living area (in 1000s of square feet)
yrbuilt	year the home was built

2.3. Data Summary

The final full dataset includes a total of 72,319 recent sales, 1,894 of which are PV homes and 70,425 of which are non-PV (see Table 2). The homes with PV systems are distributed evenly between *new* (51%) and *existing* (49%) home types, while the non-PV homes are weighted toward *existing* homes (62%) over *new* (38%) (see Table 5). The final repeat sales dataset of homes selling twice total 28,313 homes, of which 394 are PV and 27,919 are non-PV (see Table 3).

As indicated in Table 2, the average non-PV home in the full sample (not the repeat sales sample) sold for $584,740 (unadjusted) in late 2005, which corresponds to $480,862 (adjusted)

in 2009 dollars.[15] This "average" home is built in 1986, is 19 years old at the time of sale, has 2,200 square feet of living space, has 2.6 bathrooms, is situated on a parcel of 0.3 acres, and is located at the mean elevation of the other homes in the block group. On the other hand, the average PV home in the full sample sold for $660,222 in early 2007, which corresponds to $537,442 in 2009 dollars. Therefore, this "average" PV home, as compared to the "average" non-PV home, is higher in value. This difference might be explained, in part, by the fact that the average PV home is slightly younger at the time of sale (by two years), slightly bigger (by 200 square feet), has more bathrooms (by 0.3), is located on a parcel that is slightly larger (by 0.06 acres), and, of course, has a PV system (which is, on average, 3,100 watts and 1.5 years old).[16]

The repeat sale dataset, as summarized in Table 3, shows similar modest disparities between PV and non-PV homes, with the "average" PV homes selling for more (in 2009 $) in both the first and second sales. Potentially more telling, though, non-PV homes show a slight depreciation (of -1.4%) between sales after adjusting for inflation, while PV homes show a modest appreciation (of 3.2%). Average PV homes in the sample are found to be slightly bigger (by 100 square feet), occupy a slightly larger parcel (by 0.2 acres), older (by 10 years), and, of course, have a PV system (which is, on average, 4,030 watts and 2.5 years old).

Focusing on the full dataset geographically (see Table 4 and Figure 1), we find that it spans 31 counties with the total numbers of PV and non-PV sales ranging from as few as nine (Humboldt) to as many as 11,991 (Placer). The dataset spans 835 separate (census) block groups (not shown in the table), though only 162 (18.7%) of these block groups contain subdivisions with at least one PV sale. Within the block groups that contain subdivisions with PV sales there are 497 subdivision-specific delineations. As shown in Table 5, the data on home sales are fairly evenly split between *new* and *existing* home types, are located largely within four utility service areas,

[15] The adjusted values, which are based on a housing price index, demonstrate the large-scale price collapse in the California housing market post 2005; that is, there has been significant housing price depreciation.

[16] Age of PV system at the time of sale is determined by comparing the sale date and ideally an "installation date", which corresponds to the date the system was operational, but, in some cases, the only date obtained was the "incentive application date", which might precede the installation date by more than one year. For this reason the age of the system reported for this research is lower than the actual age.

with the largest concentration in PG&E's territory, and occurred over eleven years, with the largest concentration of PV sales occurring in 2007 and 2008.

In summary, the full dataset shows higher sales prices for the average PV home than the average non-PV home, while the repeat sales dataset shows positive appreciation between sales for PV homes, but not for non-PV homes. Though these observations seem to indicate that a PV sales price premium exists, these simple comparisons do not take into account the other underlying differences between PV and non-PV homes (e.g., square feet), their neighborhoods, and the market conditions surrounding the sales. The hedonic and difference-in-difference statistical models discussed in the following section are designed to do just that.

Table 2: Summary Statistics of Full Dataset

	Non-PV Homes				
Variable	***n***	**Mean**	**Std. Dev.**	**Min**	**Max**
acre	70425	0.3	0.8	0.0	24.8
acregt1	70425	0.1	0.7	0.0	23.8
acrelt1	70425	0.2	0.2	0.0	1.0
ages2	70425	19	23.3	-1	108
ages2sqr	70425	943	1681	0	11881
asp2	70425	$ 480,862	$ 348,530	$ 85,007	$ 2,498,106
avtotal	70425	$ 497,513	$ 359,567	$ 10,601	$ 3,876,000
bath	70425	2.6	0.9	1	9
bgre_100	70425	0.0	1.2	-18.0	19.0
elev	70425	424	598	0	5961
lasp2	70425	12.9	0.6	11.4	14.7
pvage	70425	0	0	0	0
sd2	70425	9/30/2005	793 days	1/7/1999	6/30/2009
size	70425	0	0	0	0
sp2	70425	$ 584,740	$ 369,116	$ 69,000	$ 4,600,000
sqft_1000	70425	2.2	0.9	0.8	9.3
yrbuilt	70425	1986	23	1901	2009

	PV Homes				
Variable	***n***	**Mean**	**Std. Dev.**	**Min**	**Max**
acre	1894	0.4	1.0	0.0	21.6
acregt1	1894	0.1	0.9	0.0	20.6
acrelt1	1894	0.2	0.2	0.0	1.0
ages2	1894	17.3	24.5	-1	104
ages2sqr	1894	937	1849	0	11025
asp2	1894	$ 537,442	$ 387,023	$ 85,973	$ 2,419,214
avtotal	1894	$ 552,052	$ 414,574	$ 23,460	$ 3,433,320
bath	1894	2.9	1	1	7
bgre_100	1894	0.2	1.3	-10.0	17.9
elev	1894	414	584	0	5183
lasp2	1894	13.0	0.6	11.4	14.7
pvage	1894	1.5	2.0	-1.0	9.0
sd2	1894	3/28/2007	622 days	8/1/2000	6/29/2009
size	1894	3.1	1.6	0.6	10.0
sp2	1894	$ 660,222	$ 435,217	$ 100,000	$ 3,300,000
sqft_1000	1894	2.4	0.9	0.8	11.0
yrbuilt	1894	1989	25	1904	2009

Table 3: Summary Statistics of Repeat Sale Dataset

	Non-PV Homes				
Variable	***n***	**Mean**	**Std. Dev.**	**Min**	**Max**
acre	27919	0.3	0.7	0.0	23.2
acregt1	27919	0.1	0.6	0.0	22.2
acrelt1	27919	0.2	0.2	0.0	1.0
ages2	27919	23.6	22.7	0	108
ages2sqr	27919	1122.0	1775.0	1.0	11881.0
asp1	27919	$ 488,127	$ 355,212	$ 85,398	$2,495,044
asp2	27919	$ 481,183	$ 347,762	$ 85,007	$2,472,668
avtotal	27919	$ 498,978	$ 360,673	$ 35,804	$3,788,511
bath	27919	2.5	0.8	1	9
bgre_100	27919	0.0	1.3	-17.7	19.0
elev	27919	426	588	0	5961
lasp1	27919	12.9	0.6	11.4	14.7
lasp2	27919	12.9	0.6	11.4	14.7
pvage	27919	0	0	0	0
sd1	27919	5/5/2001	1780 days	11/1/1984	12/11/2008
sd2	27919	5/14/2006	786 days	3/11/1999	6/30/2009
sddif	27919	1835	1509	181	7288
size	27919	0	0	0	0
sp1	27919	$ 444,431	$ 287,901	$ 26,500	$2,649,000
sp2	27919	$ 577,843	$ 371,157	$ 69,000	$3,500,000
sqft_1000	27919	2.1	0.8	0.8	7.7
yrbuilt	27919	1982	23	1901	2008

	PV Homes				
Variable	***n***	**Mean**	**Std. Dev.**	**Min**	**Max**
acre	394	0.5	1.4	0.0	21.6
acregt1	394	0.2	1.3	0.0	20.6
acrelt1	394	0.2	0.2	0.0	1.0
ages2	394	34.6	25.6	1	104
ages2sqr	394	1918.0	2336.0	4.0	11025.0
asp1	394	$ 645,873	$ 417,639	$ 110,106	$2,339,804
asp2	394	$ 666,416	$ 438,544	$ 91,446	$2,416,498
avtotal	394	$ 682,459	$ 478,768	$ 51,737	$3,433,320
bath	394	2.6	0.9	1	7
bgre_100	394	0.1	1.6	-5.5	17.9
elev	394	479	581	3	3687
lasp1	394	13.2	0.6	11.6	14.7
lasp2	394	13.2	0.6	11.4	14.7
pvage	394	2.5	1.6	-1.0	9.0
sd1	394	11/22/1999	1792 days	11/30/1984	1/7/2008
sd2	394	1/9/2007	672 days	8/1/2000	6/29/2009
sddif	394	2605	1686	387	7280
size	394	4.03	1.94	0.89	10
sp1	394	$ 492,368	$ 351,817	$ 81,500	$2,500,000
sp2	394	$ 800,359	$ 489,032	$ 121,000	$3,300,000
sqft_1000	394	2.2	0.8	0.8	5.3
yrbuilt	394	1972	26	1904	2008

Table 4: Frequency Summary by California County

CA County	Non-PV	PV	Total
Alameda	4,826	153	**4,979**
Butte	457	12	**469**
Contra Costa	5,882	138	**6,020**
El Dorado	938	85	**1,023**
Humboldt	7	2	**9**
Kern	2,498	53	**2,551**
Kings	134	5	**139**
Los Angeles	3,368	82	**3,450**
Marin	1,911	61	**1,972**
Merced	48	2	**50**
Monterey	10	2	**12**
Napa	36	1	**37**
Orange	1,581	44	**1,625**
Placer	11,832	159	**11,991**
Riverside	4,262	87	**4,349**
Sacramento	10,928	483	**11,411**
San Bernardino	2,138	50	**2,188**
San Diego	1,083	30	**1,113**
San Francisco	407	16	**423**
San Joaquin	1,807	20	**1,827**
San Luis Obispo	232	1	**233**
San Mateo	2,647	92	**2,739**
Santa Barbara	224	7	**231**
Santa Clara	6,127	157	**6,284**
Santa Cruz	90	1	**91**
Solano	2,413	39	**2,452**
Sonoma	1,246	32	**1,278**
Tulare	774	14	**788**
Ventura	1,643	42	**1,685**
Yolo	16	1	**17**
Yuba	860	23	**883**
Total	**70,425**	**1,894**	**72,319**

Figure 1: Map of Frequencies of PV Homes by California County

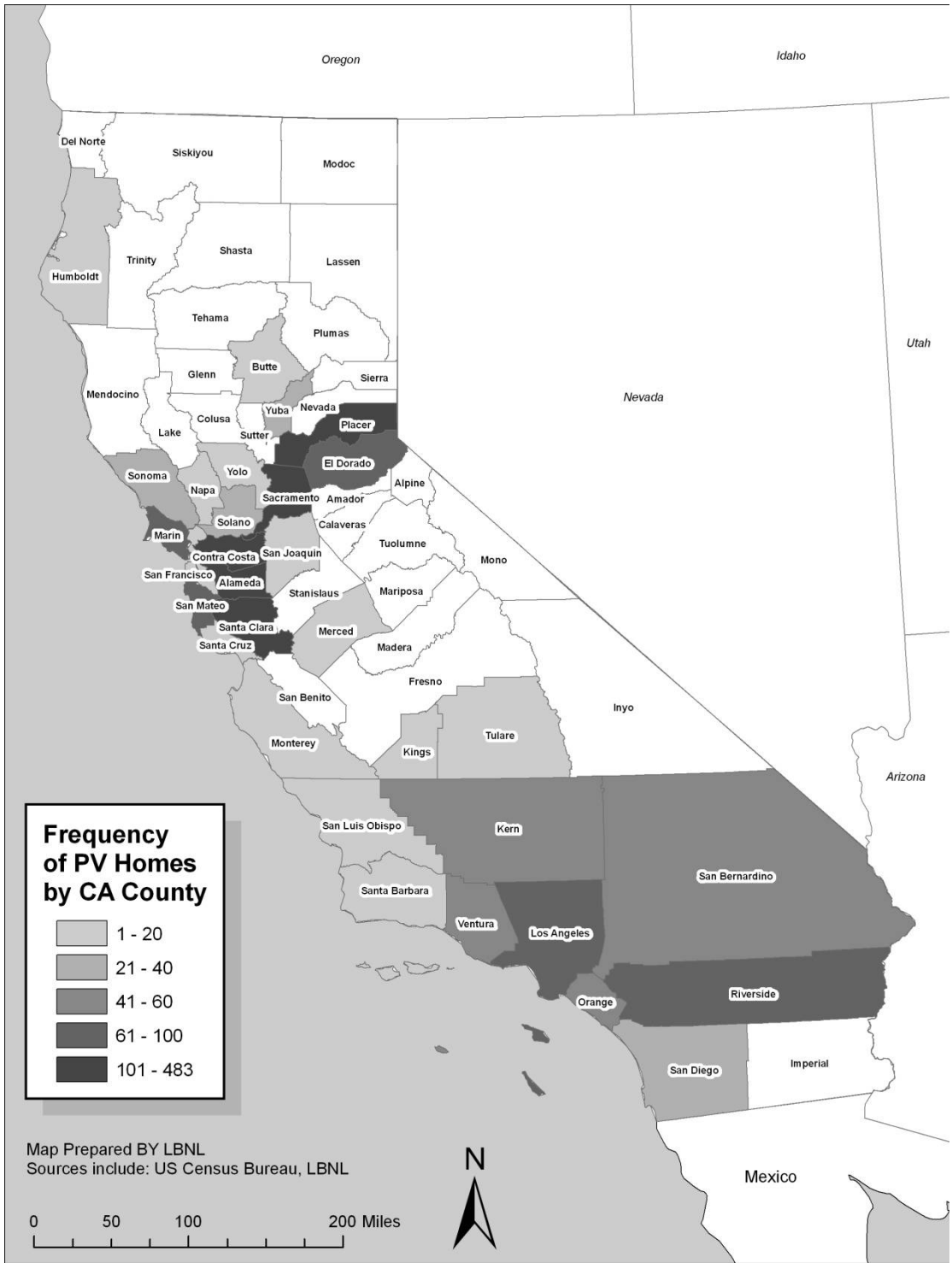

Table 5: Frequency Summary by Home Type, Utility and Sale Year

Home Type *	Non-PV	PV	Total
New Home	26,938	935	27,873
Existing Home	43,487	897	44,384
Utility **	**Non-PV**	**PV**	**Total**
Pacific Gas & Electric (PG&E)	36,137	1,019	37,156
Southern California Edison (SCE)	14,502	337	14,839
San Diego Gas & Electric (SDG&E)	8,191	35	8,226
Sacramento Municipal Utility District (SMUD)	11,393	498	11,891
Other	202	5	207
Sale Year	**Non-PV**	**PV**	**Total**
1999	110	0	110
2000	379	1	380
2001	1,335	10	1,345
2002	6,278	37	6,315
2003	8,783	63	8,846
2004	10,888	153	11,041
2005	10,678	168	10,846
2006	9,072	173	9,245
2007	8,794	472	9,266
2008	9,490	642	10,132
2009	4,618	175	4,793

** A portion of the PV homes could not be classified as either new or existing and therefore are not included in these totals*

*** Non-PV utility frequencies were estimated by mapping block groups to utility service areas, and then attributing the utility to all homes that were located in the block group*

3. Methods and Statistical Models

3.1. Methodological Overview

The data, as outlined above, not only show increased sales values and appreciation for PV homes (in 2009 $) over non-PV homes, but also important differences between PV and non-PV homes as regards other home, site, neighborhood and market characteristics that could, potentially, be driving these differences in value and appreciation. A total of 21 empirical model specifications, with a high reliance on the hedonic pricing model, are used in this paper to disentangle these potentially competing influences in order to determine whether and to what degree PV homes sell for a premium.

The basic theory behind the hedonic pricing model starts with the concept that a house can be thought of as a bundle of characteristics. When a price is agreed upon between a buyer and seller there is an implicit understanding that those characteristics have value. When data from a number of sales transactions are available, the average individual marginal contribution to the sales price of each characteristic can be estimated with a hedonic regression model (Rosen, 1974; Freeman, 1979). This relationship takes the basic form:

Sales price = *f* (home and site, neighborhood, and market characteristics)

"Home and site characteristics" might include, but are not limited to, the number of square feet of living area, the size of the parcel of land, and the presence of a PV system. "Neighborhood" characteristics might include such variables as the crime rate, the quality of the local school district, and the distance to the central business district. Finally, "market characteristics" might include, but are not limited to, temporal effects such as housing market inflation/deflation.

A variant of the hedonic model is a repeat sales model, which holds constant many of the characteristics discussed above, and compares inflation adjusted selling prices of homes that have sold twice, both before a condition exists (e.g., before a PV system is installed on the home) and after the condition exists (e.g., after a PV system is installed on the home), and across PV

and non-PV homes. This repeat sales model, in the form used in this paper, is referred to as a difference-in-difference (DD) model, and is discussed in more detail later.

To test for the impact of PV systems on residential selling prices, a series of "base" hedonic models, a "base" difference-in-difference model, a series of robustness models, and two "other" models are estimated for this research.[17] As discussed later, these models are used to test for fixed (whether the home has a PV system) and continuous (the size of the PV system) effects using the full dataset of PV homes. They are also used to test for any differences that exist between new and existing PV homes and between homes with PV systems of different ages, and to test for the possibility of non-linear returns to scale based on the size of the PV system or the home itself. Before describing these models in more detail, however, a summary of the variables to be included in the models is provided.

3.2. Variables Used in Models

In each base model, be it hedonic or difference-in-difference, four similar sets of parameters are estimated, namely coefficients on the variables of interest and coefficients for three sets of controls that include home and site characteristics, neighborhood (census block group) fixed effects, and temporal (year and quarter) fixed effects. The variables of interest are the focus of the research, and include such variables as whether the home has a PV system installed or not, the size of the PV system, and interactions between these two variables and others, such as the size of the home or the age of the PV system. To accurately measure these variables of interest (and their interactions) other potentially confounding variables need to be controlled for in the models. The base models differ in their specification and testing of the variables of interest, as discussed later, but use the same three sets of controls.

The first of these sets of control variables accounts for differences across the dataset in home and site-specific characteristics, including the age of the home (linear and squared), the total square feet of living area, and the relative elevation of the home (in feet) to other homes in the block group; the latter variable serves as a proxy for "scenic vista," a value-influencing characteristic

[17] As will be discussed later, each of the "base" models is coupled with a set of two or three robustness models. The "other" models are presented without "robustness" models.

(see e.g., Hoen et al., 2009).[18] Additionally, the size of the property in acres was entered into the model in spline form to account for different valuations of less than one acre and greater than one acre.

The second set of controls, the geographic fixed effects variables, includes dummy variables that control for aggregated "neighborhood" influences, which, in our case, are census block groups.[19] A census block group generally contains between 200 and 1,000 households,[20] and is delineated to never cross boundaries of states, counties, or census tracts, and therefore, in our analysis, serves as a proxy for "neighborhood." To be usable, each block group had to contain at least one PV home and one non-PV home. The estimated coefficients for this group of variables capture the combined effects of school districts, tax rates, crime, distance to central business district and other block group specific characteristics. This approach greatly simplifies the estimation of the model relative to determining these individual characteristics for each home, but interpreting the resulting coefficients can be difficult because of the myriad of influences captured by the variables. Because block groups are fairly small geographically, spatial autocorrelation[21] is also, to some degree, dealt with through the inclusion of these variables.

Finally, the third set of controls, the temporal fixed effect variables, includes dummy variables for each quarter of the study period to control for any inaccuracies in the housing inflation adjustment that was used. A housing inflation index is used to adjust the sales prices throughout the study period to 2009 prices at a zip code level across as many as three price tiers. Although

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[18] Other home and site characteristics were also tested, such as the condition of the home, the number of bathrooms, the number of fireplaces, and if the home had a garage and/or a pool. Because these home and site characteristics were not available for all home transactions (and thus reduced the sample of homes available), did not add substantial explanatory power to the model, and did not affect the results substantively, they were not included in the model results presented in this paper.

[19] For a portion of the dataset, a common subdivision name was identified, which, arguably, serves as a better proxy for neighborhood than block group. Unfortunately, not all homes fell within a subdivision. Nonetheless, a separate combined subdivision-block group fixed effect was tested and will be discussed later.

[20] Census block groups generally contain between 600 and 3,000 people, and the median household size in California is roughly 3.

[21] Spatial Autocorrelation - a correlation between neighbors' selling prices - can produce unstable coefficient estimates, yielding unreliable significance tests in hedonic models if not accounted for. One reason for this spatial autocorrelation is omitted variables, such as neighborhood characteristics (e.g., distance to the central business district), which affect all properties within the same area similarly. Having micro-spatial controls, such as block groups or subdivisions, helps control for such autocorrelation.

this adjustment is expected to greatly improve the model - relative to using *just* a temporal fixed effect with an unadjusted price - it is also assumed that because of the volatility of the housing market, the index may not capture price changes perfectly and therefore the model is enhanced with the additional inclusion of these quarterly controls.[22]

3.3. Fixed and Continuous Effect Hedonic Models

The analysis begins with the most basic model comparing prices of all of the PV homes in the sample (whether new or existing) to non-PV homes across the full dataset. As is common in the literature (Malpezzi, 2003; Sirmans et al., 2005b; Simons and Saginor, 2006), a semi-log functional form of the hedonic pricing model is used where the dependent variable, the (natural log of) sales price (P), is measured in zip code-specific inflation-adjusted (2009) dollars. To determine if an average-sized PV system has an effect on the sale price of PV homes (i.e., a fixed effect) we estimate the following base fixed effect model:

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(PV_i) + \varepsilon_{itk} \quad (1)$$

where

P_{itk} represents the inflation adjusted sale price for transaction *i*, in quarter *t*, in block group *k*,

α is the constant or intercept across the full sample,

T_t is the quarter in which transaction *i* occurred,

N_k is the census block group in which transaction *i* occurred,

X_i is a vector of *a* home characteristics for transaction *i* (e.g., acres, square feet, age, etc.),

PV_i is a fixed effect variable indicating a PV system is installed on the home in transaction *i*,

β_1 is a parameter estimate for the quarter in which transaction *i* occurred,

β_2 is a parameter estimate for the census block group in which transaction *i* occurred,

β_3 is a vector of parameter estimates for home characteristics *a*,

β_4 is a parameter estimate for the PV fixed effects variable, and

ε_{itk} is a random disturbance term for transaction *i*,in quarter *t*, in block group *k*.

[22] A number of models were tested both with and without these temporal controls and with a variety of different temporal controls (e.g., monthly) and temporal/spatial controls (e.g., quarter and tract interactions). The quarterly dummy variables were the most parsimonious, and none of the other approaches impacted the results substantively.

The parameter estimate of primary interest in this model is β_4, which represents the marginal percentage change in sale price with the addition of an average sized PV system. If differences in selling prices exist between PV and non-PV homes, we would expect the coefficient to be positive and statistically significant.

An alternative to equation (1) is to interact the PV fixed effect variable (PV_i) with the size (in kW) of the PV system as installed on the home at the time of sale ($SIZE_i$), thereby producing an estimate for the differences in sales prices as a function of size of the PV system. This base continuous effect model takes the form:

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(PV_i * SIZE_i) + \varepsilon_{itk} \quad (2)$$

where

$SIZE_i$ is a continuous variable for the size (in kW) of the PV system installed on the home prior to transaction *i*,

β_4 is a parameter estimate for the percentage change in sale price for each additional kW added to a PV system, and all other terms are as were defined for equation (1).

If differences in selling prices exist between PV and non-PV homes, we would expect the coefficient to be positive and statistically significant, indicating that for each additional kilowatt added to the PV system the sale price increases by β_4 (in % terms).

This continuous effect specification may be preferable to the PV fixed effect model because one would expect that the impact of PV systems on residential selling prices would be based, at least partially, on the size of the system, as size is related to energy bill savings.[23] Moreover, this specification allows for a direct estimate of any PV home sales premium in dollars per watt ($/watt), which is the form in which other estimates – namely average net installed costs – are reported. With the previous fixed effects specification, a $/watt estimate can still be derived, but

[23] Ideally, the energy bill savings associated with individual PV systems could be entered into the model directly, but these data were not available. Moreover, estimating the savings accurately on a system-by-system basis was not possible because of the myriad of different rate structures in California, the idiosyncratic nature of energy use at the household level, and variations in PV system designs and orientations.

not directly. Therefore, where possible in this paper, greater emphasis is placed on the continuous effect specification than on the fixed effect estimation.

As mentioned earlier, for each base model we explore a number of different robustness models to better understand if and to what degree the results are unbiased. In the present research, two areas of bias are of particular concern: omitted variable bias and sample selection bias.

The omitted variables that are of specific concern are any that might be correlated with the presence of PV, and that might affect sales prices. An example is energy efficiency (EE) improvements, which might be installed contemporaneously with a PV energy system. If many homes with PV have EE improvements, whereas the comparable non-PV homes do not, then estimates for the effects of PV on selling prices might be inclusive of EE effects and, therefore, may be inappropriately high. Any other value-influencing home improvements (e.g., kitchen remodels, new roofs, etc.), if correlated with the presence of PV, could similarly bias the results if not carefully addressed.

With respect to selection bias, the concern is that the distribution of homes that have installed PV may be different from the broad sample of homes on which PV is not installed. If both sets of homes are assumed to have similar distributions but are, in point of fact, dissimilar due to selection, then the estimates for the effects of PV on the selling price could be inclusive of these underlying differences but attributed to the existence of PV, thereby also potentially biasing the results.

To mitigate the issue of omitted variable bias, one robustness model uses the same data sample as the base model but a different model specification. Specifically, a combined subdivision-block group fixed effect variable can be substituted, where available, in place of the block group fixed effect variable as an alternative proxy for "neighborhood." Potentially omitted variables are likely to be more similar between PV and non-PV homes at the subdivision level than at the

block group level, and therefore this model may more-effectively control for such omitted variables.[24]

To mitigate the issue of selection bias, one robustness model uses the same model specification as the base model but with an alternative (subset) of the data sample. Specifically, instead of using the full dataset with equations (1) and (2), a "coarsened exact matched" dataset is used (King et al., 2010).[25] This matching procedure results in a reduced sample of homes to analyze, but the PV and non-PV homes that remain in the matched sample are statistically equal on their covariates after the matching process (e.g., PV homes within a block group are matched with non-PV homes such that both groups are similar in the number of bathrooms, date of sale, etc.). As a result, biases related to selection are minimized.

Finally, specific to equation (2), a robustness model to mitigate both omitted variable and selection bias is constructed in which the sample is restricted to include *only* PV homes (in place of the full sample of PV *and* non-PV homes). Because this model does not include non-PV "comparable" homes, sales prices of PV homes are "compared" against each other based on the size of the PV systems, while controlling for the differences in the home via the controlling characteristics (e.g., square feet of living space). PV system size effects are therefore estimated without the use of non-PV homes, providing an important comparison to the base models, while also directly addressing any concerns about the inherent differences between PV and non-PV homes (e.g., whether energy efficient upgrades were made contemporaneously with the PV) and therefore omitted variable and sample selection bias.

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[24] Subdivisions are often geographically smaller than block groups, and therefore more accurately control for geographical influences such as distance to central business district. Moreover, homes in the same subdivision are often built at similar times using similar materials and therefore serve as a control for a variety of house specific characteristics that are not controlled for elsewhere in the model. For example, all homes in a subdivision will often be built using the same building code with similar appliances being installed, both of which might control for the underlying energy efficiency (EE) characteristics of the home. For homes not situated in a subdivision, the block group delineation was used, and therefore these fixed effects are referred to as "combined subdivision-block group" delineations.

[25] The procedure used, as described in the referenced paper, is coarsened exact matching (cem) in Stata, available at: http://ideas.repec.org/c/boc/bocode/s457127.html. The matching procedure creates statistically matched sets of PV and non-PV homes in each block group, based on a set of covariates, which, for this research, include the number of square feet, acres, and baths, as well as the age of the home, its elevation, and the date at which it sold. Because this matching process excludes non-PV homes that are without a statistically similar PV match (and vice versa), a large percentage of homes (approximately 80% non-PV and 20% PV) are *not* included in the resulting dataset.

3.4. New and Existing Home Models

Although equations (1) and (2) are used to estimate whether a PV system, on average, effects selling prices across the entire data sample, they do not allow one to distinguish any such effects as a function of house type, specifically whether the home is *new* or *existing*. As discussed earlier, *new* homes with PV might have different premiums than *existing* homes. To try to tease out these possible differences, two base hedonic models are estimated using equation (2), one with only *new* homes and the other with only *existing* homes.[26] Comparing the coefficient of the variable of interest (β_4) between these two models allows for an assessment of the relative size of the impact of PV systems across the two home types.

Additionally, two sets of robustness models that were discussed earlier are also applied to the *new* and *existing* home models, one using the coarsened exact matched datasets and the other using the combined subdivision-block group delineations. These models test the robustness of the results for selection and omitted variable bias, respectively. Although it is discussed separately as a base model in the following subsection, the difference-in-difference model, using repeat sales of *existing* homes, also doubly serves as a robustness test to the *existing* homes base model.

3.4.1. Difference-in-Difference Models

One classic alternative to estimating a hedonic model, as briefly discussed earlier, is to estimate a difference-in-difference (DD) model (Wooldridge, 2009). This model (see Table 1) uses a set of homes that have sold twice, both with and without PV, and provides estimates of the effect of adding PV to a subset of those homes as of the second sale ("DD" as noted in Table 1), while simultaneously accounting for both the inherent differences in the PV and non-PV groups and the trend in housing prices between the first and second sales of non-PV homes. Repeat sales models of this type are particularly effective in controlling for selection and certain types of

[26] *New* and *existing* homes were determined in an iterative process. For PV homes, the type of home was often specified by the data provider. It was also discovered that virtually all of the *new* PV homes (as specified by the PV data providers) had ages, at the time of sale, between negative one and two years, inclusive, whereas the *existing* PV homes (as specified by the PV data providers) had ages greater than two years in virtually every case. The small percentage (3%) of PV homes that did not fit these criteria were excluded from the models. For non-PV homes, no data specifying the home type were available, therefore, groupings were created following the age at sale criteria used for PV homes (e.g., ages between negative one and two years apply to *new* non-PV homes).

omitted variable bias. In the former case, any underlying difference in home prices between PV and non-PV homes prior to the addition of PV is controlled for. In the latter case, PV and non-PV homes are assumed to have undergone mostly similar changes (e.g., home improvements) between sales. Any changes to the home that are coincident with the installation of a PV system (or the PV system household), on the other hand, are not directly controlled for in this model, though there is reason to believe that any such remaining influences are not imposing substantial bias in the present study.[27]

The set of PV homes that are used in the DD model are, by default, *existing* homes (i.e., the home was not new when the PV system was installed). Estimates derived from this model, therefore, apply to - while also serving as a robustness tests for - the *existing* home models as specified above.

Table 6: Difference-in-Difference Description

	Pre PV	Post PV	Difference
PV Homes	PV_1	PV_2	$\Delta PV = PV_2 - PV_1$
Non-PV Homes	NPV_1	NPV_2	$\Delta NPV = NPV_2 - NPV_1$
			$DD = \Delta PV - \Delta NPV$
1 and 2 denote time periods			

The base DD model is estimated as follows:

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(PVH_i) + \beta_5(SALE2_i) + \beta_6(PVS_i) + \varepsilon_{itk} \qquad (3)$$

where

PVH_i is a fixed effect variable indicating if a PV system is or <u>will be</u> installed on the home in transaction *i*,

[27] Support for this assumption comes from two sources. Although surveys (e.g., CPUC, 2010) indicate that PV homeowners install energy efficient "measures" with greater frequency than non-PV homeowners, the differences are relatively small and largely focus on lighting and appliances. The former is not expected to substantially impact sales prices, while the latter could. The surveys also indicate that PV homeowners tend to install other larger EE measures, such as building shell, water heating and cooling improvements, with greater frequency than non-PV homes. Additionally, it might also be hypothesized that PV homeowners may be more-likely to have newer roofs (perhaps installed at the time of PV installation). Dastrop et al. (2010), however, investigated whether home improvements that might require a permit affect PV home sales premium estimates, and found they did not. It should be noted that the PV Only model, discussed previously, directly addresses the concern of omitted variable bias for this analysis.

$SALE2_i$ is a fixed effect variable indicating if transaction *i* is the second of the two sales,

PVS_i is a fixed effect variable (an interaction between PVH_i and $SALE2_i$) indicating if transaction *i* is both the second of the two sales and contained a PV system at the time of sale,

α is the constant or intercept across the full sample,

β_4 is a parameter estimate for homes that have or will have PV installed (i.e., from Table 6 "$PV_1 - NPV_1$"),

β_5 is a parameter estimate if transaction *i* occurred as of the second sale (i.e., "ΔNPV"),

β_6 is a parameter estimate if transaction *i* occurred as of the second sale and the home contained PV (i.e., "$\Delta PV - \Delta NPV$" or "DD"), and all other terms are as were defined for equation (1).

The coefficient of interest is β_6, which represents the percentage change in sale price, as expressed in 2009 dollars, when PV is added to the home, after accounting for the differences between PV and non-PV homes (β_4) and the differences between the initial sale and the second sale of non-PV homes (β_5). If differences in selling prices exist between PV and non-PV homes, we would expect the coefficient to be positive and statistically significant.[28]

To further attempt to mitigate the potential for omitted variable bias, two robustness models are estimated for the base DD model: one with the combined subdivision-block group delineations and a second with a limitation applied on the number of days between the first and second sale.[29] The first robustness model is similar to the one discussed earlier. The second robustness model accounts for the fact that the home characteristics used (in all models) reflect the most recent home assessment, and therefore do not necessarily reflect the characteristics at the time of the sale. Especially worrisome are the first sales in the DD model, which can be as much as 20 years before the second sale. To test if our results are biased because of these older sales - and the

[28] This is the classic model form derived from a quasi-experiment, where the installation of PV is the treatment. An alternative specification would look at the incremental effect of PV system size holding the starting differences between PV and non-PV homes as well as the time-trend in non-PV homes constant. This model form was not evaluated in the current analysis effort, but could be considered grounds for future research in this area.

[29] Ideally a matched dataset could be utilized, for reasons described earlier, but because the matching procedure severely limited the size of the dataset, the resulting dataset was too small to be useful.

large periods between sales - an additional data screen is applied in which the difference between the two sale dates is limited to five years.[30]

3.5. Age of the PV System for Existing Homes Hedonic Models

The age of the PV system at the time of home sale could affect the sales price premium for *existing* homes (PV systems on new homes are, by definition, also new). This might occur because older PV systems have a shorter expected remaining life and may become somewhat less efficient with age (and therefore deliver a lower net present value of bill savings), but also because older PV systems will have generated more energy bill savings for the home seller and the seller may therefore more-willingly accept a lower price. Together, these factors suggest that premiums for older PV systems on *existing homes* would be expected to be lower than for newer systems. In order to test this directly the following base model is estimated:

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(PV_i \times SIZE_i \times AGE_i) + \varepsilon_{itk} \quad (4)$$

where

AGE_i is a categorical variable for three groups of PV system age as of the time of sale of the home: 1) less than or equal to one year old; 2) between 2 and 4 years old; and, 3) five or more years old.

Therefore, β_4 is a vector of parameter estimates for the percentage change in sales price for each additional kW added to a PV system for each of the three PV system age groups, and all other terms are as are defined for equation (2). The assumption is that the coefficients for β_4 will be decreasing - indicating they are valued less - as the age of the PV systems decrease. The sample used for this model is the same as for the *existing* home model defined previously.

Additionally, two sets of robustness models are explored, one using the coarsened exact matched dataset and the other using the combined subdivision-block group delineations, to test the robustness of the results for selection and omitted variable bias, respectively.

[30] As was discussed earlier, a screen for this eventuality (using *adjaar*) is incorporated in our data cleaning. This test therefore serves as an additional check of robustness of the results.

3.6. Returns to Scale Hedonic Models

As discussed earlier, it is not unreasonable to expect that any increases in the selling prices of PV homes may be non-linear with PV system size. In equation (2), it was assumed that estimated price differences were based on a continuous linear relationship with the size of the system. To explore the possibility of a non-linear relationship among the full sample of homes in the dataset, the following model is estimated:[31]

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(PV_i \cdot SIZE_i) + \beta_5(PV_i \cdot SIZE_i \cdot SIZE_i) + \varepsilon_{itk} \quad (5)$$

where

β_5 is a parameter estimate for the percentage change in sales price for each additional kW added to a PV system squared, and all other terms are as are defined for equation (2).

A negative statistically significant coefficient (β_5) would indicate decreasing returns to scale for larger PV systems, while a positive coefficient would indicate the opposite.

Somewhat analogously, as was discussed previously, premiums for PV systems may be related to the size of the home.[32] To test this directly using the full dataset, the following model is estimated:

$$\ln(P_{itk}) = \alpha + \beta_1(T_t) + \beta_2(N_k) + \sum_a \beta_3(X_i) + \beta_4(SQFT_i) + \beta_5(PV_i \cdot SIZE_i) + \beta_6(PV_i \cdot SIZE_i \cdot SQFT_i) + \varepsilon_{itk} \quad (6)$$

where

$SQFT_i$ is a continuous variable for the number of square feet for the home in transaction *i*,[33]

β_4 is a parameter estimate for the percentage change in sale price for each additional 1000 square feet added to the home,

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[31] Neither this nor the following model is coupled with robustness models in this paper.

[32] PV system size is also somewhat correlated with house size as a result of the tendency for increasing energy use and larger roof areas on larger homes. If this correlation was particularly strong then coefficient estimates could be imprecise. The correlation between PV house size and PV system size in the full sample of our data, however, is rather weak, at only 0.14. Clearly, many factors other than house size impact the sizing of PV systems.

[33] In all of the previous models the number of square feet is contained in the vector of characteristics represented by X_i, but in this model it is separated out for clarity.

β_5 is a parameter estimate for the percentage change in sale price for each additional kW added to a PV system,

β_6 is a parameter estimate for the percentage change in sale price for each additional 1000 square feet added to PV homes, assuming the size of the PV system does not change, and all other terms are as were defined for equation (2).

A negative statistically significant coefficient for β_6 would indicate decreasing returns to scale for PV systems as homes increase in size. Alternatively, a positive and statistically significant coefficient would indicate increasing returns to scale for PV systems installed on larger homes.

3.7. Model Summary

To summarize, the entire set of 21 estimated models discussed herein is shown in Table 7. The following definitions of terms, all of which were discussed earlier, are relevant for interpreting the models listed in the table, and therefore are briefly reviewed again. All "base" models are coupled with a set of "robustness" models (as noted by a capital "R" in the model number). The "Other" (returns to scale) models are presented alone. Models 1 - 4 and 6 - 8 use the hedonic pricing model, whereas Model 5 is based on the difference-in-difference (DD) model. "Fixed" (versus "continuous") means that the PV variable is entered into the regression as a zero-one dichotomous variable (for Models 1-1Rb and 5-5Rb), whereas "continuous" (for all other models) means that the model estimates the impact of an increase in PV system size on residential selling prices. Base Models 1, 2, 7 and 8 use the full dataset, while Models 4 and 6 are restricted to *existing* homes, Model 3 to *new* homes, and Model 5 to the repeat sales dataset. The "matched" models use the smaller dataset of coarsened exact matched (PV and non-PV) homes. "Base" models estimate neighborhood fixed effects at the census block group level, whereas the "subdivision" models estimate neighborhood fixed effects at the combined subdivision-block group level.

Table 7: Summary of Models

Model Number	Model Name	Base Model	Robustness Model	Other Models	Dataset	Neighborhood Fixed Effects
1	Fixed - Base	**X**			Full	Block Group
1Ra	Fixed - Matched		**X**		Full Matched	Block Group
1Rb	Fixed - Subdivision		**X**		Full	Subdivision/Block Group
2	Continuous - Base	**X**			Full	Block Group
2Ra	Continuous - Matched		**X**		Full Matched	Block Group
2Rb	Continuous - Subdivision		**X**		Full	Subdivision/Block Group
2Rc	Continuous - PV Only		**X**		PV Only	Block Group
3	New Homes - Base	**X**			New	Block Group
3Ra	New - Matched		**X**		New - Matched	Block Group
3Rb	New - Subdivision		**X**		New	Subdivision/Block Group
4	Existing Homes - Base	**X**			Existing	Block Group
4Ra	Existing - Matched		**X**		Existing - Matched	Block Group
4Rb	Existing - Subdivision		**X**		Existing	Subdivision/Block Group
5	Difference-in-Difference (DD) - Base	**X**			Repeat Sales	Block Group
5Ra	Difference-in-Difference (DD) - Subdivision		**X**		Repeat Sales	Subdivision/Block Group
5Rb	Difference-in-Difference (DD) - Sddif < 5 Years		**X**		Repeat Sales w/ sddif < 5	Block Group
6	Age of System - Base	**X**			Existing	Block Group
6Ra	Age of System - Matched		**X**		Existing - Matched	Block Group
6Rb	Age of System - Subdivision		**X**		Existing	Subdivision/Block Group
7	Returns to Scale - Size			**X**	Full	Block Group
8	Returns to Scale - Square Feet			**X**	Full	Block Group

4. Estimation Results

Estimation results for all 21 models (as defined in Table 7) are presented in Tables 8-11, with the salient results on the impacts of PV on homes sales prices summarized in Figures 2-4.[34, 35] The adjusted R^2 for all models is high, ranging from 0.93 to 0.95, which is notable because the dataset spanned a period of unusual volatility in the housing market. The model performance reflects, in part, the ability of the inflation index and temporal fixed effects variables to adequately control for market conditions.[36]

Moreover, the sign and magnitude of the home and site control variables are consistent with *a priori* expectations, are largely stable across all models, and are statistically significant at the 1% level in most models.[37] Each additional 1000 square feet of living area added to a home is estimated to add between 19% and 26% to its value, while the first acre adds approximately 40% to its value with each additional acre adding approximately 1.5%. For each year a home ages, it is estimated that approximately 0.2% of its value is lost, yet at 60 years, age becomes an asset with homes older than that estimated to garner premiums for each additional year in age. Finally, for each additional 100 feet above the median elevation of the other homes in the block group, a home's value is estimated to increase by approximately 0.3%. These results can be benchmarked to other research. Specifically, Sirmans et al. (2005a; 2005b) conducted a meta-analysis of 64 hedonic pricing studies carried out in multiple locations in the U.S. during multiple time periods, and investigated similar characteristics as included in the models presented here, except for relative elevation. As a group, each of the home and site characteristic estimates in the present

[34] For simplicity, this paper does not present the results for the quarter and block group (nor combined subdivision-block group) fixed effects, which consist of more than 900 coefficients. These are available upon request from the authors.

[35] All models were estimated with Stata SE Version 11.1 using the "areg" procedure with White's correction for standard errors (White, 1980). It should also be noted that all Durbin-Watson (Durbin and Watson, 1951) test statistics were within the acceptable range (Gujarati, 2003), there was little multicollinearity associated with the variables of interest, and all results were robust to the removal of any cases with a Cook's Distance greater than $4/n$ (Cook, 1977) and/or standardized residuals greater than four.

[36] As mentioned in footnote 22, a variety of approaches were tested to control for market conditions, such as spatial temporal fixed effects (e.g., census block / year quarter) both with and without adjusted sale prices. The models presented here were the most parsimonious. As importantly, the results were robust to the various specifications, which, in turn, provides additional confidence that the effects presented are not biased by the fluctuating market conditions that have impacted the housing market for some years.

[37] In some models, where there is little variation between the cases on the covariate (e.g., acres), the results are non-significant at the 10% level.

study differ from the mean Sirmans et al. estimates by no more than one half of one standard deviation.

In summary, these results suggest that the hedonic and repeat sales models estimated here are effectively capturing many of the drivers to home sales prices in California, and therefore increasing confidence that those same models can be used to accurately capture any PV effects that may exist.

4.1. Fixed and Continuous Effect Hedonic Model Results

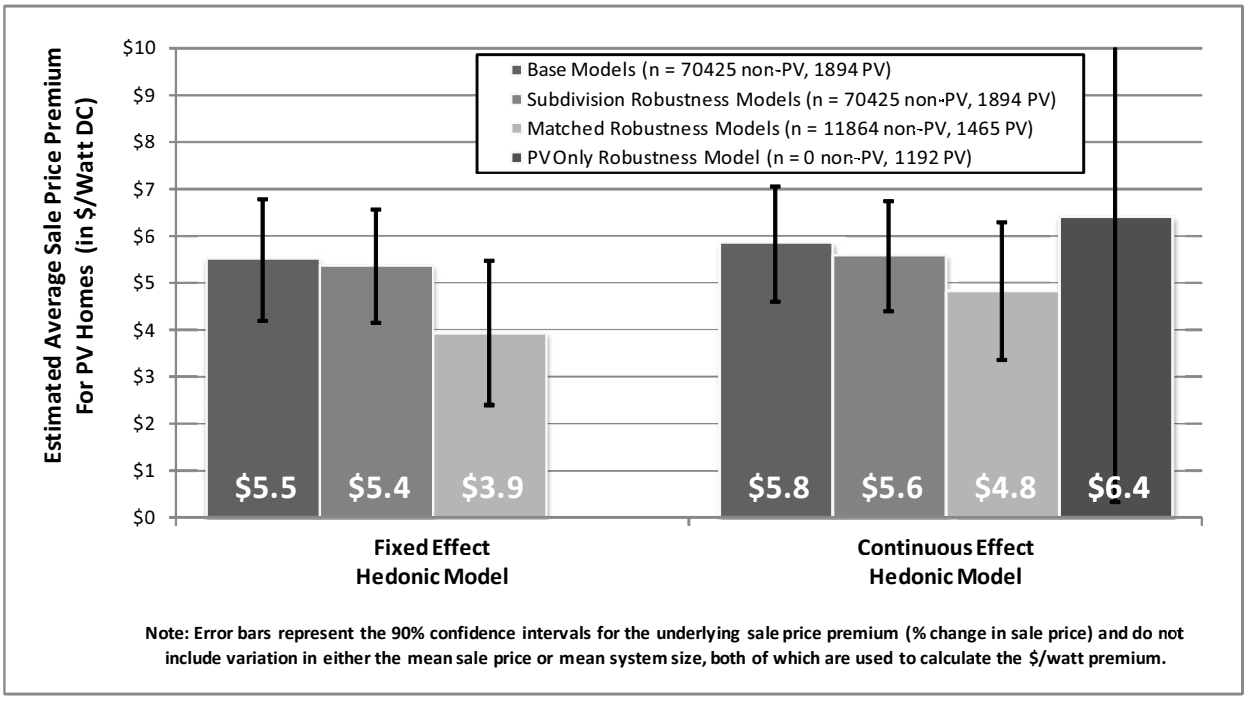
The results from the base hedonic models (equations 1 and 2) are shown in Table 8 as Models 1 and 2, respectively. These models estimate the differences across the full dataset between PV and non-PV homes, with Model 1 estimating this difference as a fixed effect, and Model 2 estimating the difference as a continuous effect for each additional kilowatt (kW) of PV added. Also shown in the table are the results from the robustness tests using the coarsened exact matching procedure and the combined subdivision-block group delineations, as shown as Models 1Ra and 1Rb for PV fixed effect models and Models 2Ra and 2Rb for continuous effect variables. Finally, the model that derives marginal impact estimates from ***only*** PV homes is shown in the table as Model 2Rc.

Across all seven of these models (Models 1 – 2Rc), regardless of the specification, the variables of interest of PV and SIZE are positive and significant at the 10% level, with six out of seven estimates being significant at the 1% level. Where a PV fixed effect is estimated, the coefficient can be interpreted as the percentage increase in the sales price of a PV home over the mean non-PV home sales price in 2009 dollars based on an average sized PV system. By dividing the monetary value of this increase by the number of watts for the average sized system, this premium can be converted to 2009 dollars per watt ($/watt). For example, for base Model 1, multiplying the mean non-PV house value of $480,862 by 0.036 and dividing by 3120 watts, yields a premium of $5.5/watt (see bottom of Table 8). Where SIZE, a continuous PV effect, is used, the coefficients reflect the percentage increase in selling prices in 2009 dollars for each additional kW added to the PV system. Therefore, to convert the SIZE coefficient to $/watt, the mean house value for non-PV homes is multiplied by the coefficient and divided by 1000. For

example, for base Model 2, $480,862 is multiplied by 0.012 and divided by 1000, resulting in an estimate of $5.8/watt.[38]

As summarized in Figure 2, these base model results for the impact of PV on residential selling prices are consistent with those estimated after controlling for subdivision fixed effects ($5.4/watt and $5.6/watt for fixed and continuous effects, respectively), differing by no more than $0.2/watt. On the other hand, the estimated PV premiums derived from the coarsened exact matched dataset are noticeably smaller, decreasing by 20 to 30%, and ranging from $3.9/watt to $4.8/watt for fixed and continuous effects, respectively. Alternatively, the PV only Model 2Rc estimates a higher $/watt continuous effect of $6.4/watt, although that estimate is statistically significant at a lower 10% level. This estimate, because it is derived from PV homes only, corroborates that any changes to the home that are coincident with the installation of the PV (e.g., energy efficient upgrades) are not influencing results dramatically.

Figure 2: Fixed and Continuous Effect Base Model Results with Robustness Tests



[38] To be exact, the conversion is a bit more complicated. For example, for the fixed effect model the conversion is actually (EXP(LN(480,862)+0.036)-480,862)/3.12/1000, but the differences are *de minimis*, and therefore are not used herein.

Though results among these seven models differ to some degree, the results are consistent in finding a premium for PV homes over non-PV homes in California, which varies from $3.9 to $6.4/watt on average, depending on the model specification. These sale price premiums are very much in line with, if not slightly above, the historical mean net installed costs (i.e., the average installed cost of a system, after deducting available state and federal incentives) of residential PV systems in California of approximately $5/watt from 2001 through 2009 (Barbose et al., 2010), which, as discussed earlier, may be reasonable given that both buyers and sellers might use this cost as a partial basis to value a home.[39]

Additionally, the one other hedonic analysis of PV selling price premiums (which used reasonably similar models as those employed here but a different dataset, concentrating only on homes in the San Diego metropolitan area) found a similar result (Dastrop et al., 2010). In their analysis of 279 homes that sold with PV systems installed in San Diego (our model only contained 35 homes from this area[40] – See Table 5), Dastrop et al. estimated an average increase in selling price of $14,069, which, when divided by their mean PV system size of 3.2 kW, implies an effect of $4.4/watt.[41]

[39] Although not investigated here, one possible reason for sales price premiums that are above net installed costs is that buyers of PV homes may in some cases price in the opportunity cost of avoiding having to do the PV installation themselves, which might be perceived as complex. Moreover, a PV system installation that occurs after the purchase of the home would likely be financed outside the first mortgage and would therefore loose valuable finance and tax benefits, thereby making the purchase of a PV home potentially more attractive that installing a PV system later, even if at the same cost.

[40] Though we identified a higher number of PV homes that sold in the San Diego metropolitan area in our dataset, the home and site characteristics provided to us from the real estate data provider did not contain information on the year of the sale and therefore were not usable for the purpose of our analysis.

[41] In a different model, Dastrop et al. (2010) estimated an effect size of $2.4/watt but, for reasons not addressed here, this estimate is not believed to be as robust.

Table 8: Fixed and Continuous Base Hedonic Model Results with Robustness Tests

	Fixed			Continuous			
	Base	Robustness Matched	Robustness Subdivision	Base	Robustness Matched	Robustness Subdivision	Robustness PV Only
	Model 1	Model 1Ra	Model 1Rb	Model 2	Model 2Ra	Model 2Rb	Model 2Rc
pv	0.036***	0.024***	0.035***				
	(0.005)	(0.006)	(0.005)				
size				0.012***	0.010***	0.012***	0.013*
				(0.002)	(0.002)	(0.001)	(0.008)
sqft_1000	0.253***	0.205***	0.250***	0.253***	0.205***	0.250***	0.224***
	(0.001)	(0.006)	(0.001)	(0.001)	(0.006)	(0.001)	(0.010)
lt1acre	0.417***	0.514***	0.414***	0.416***	0.510***	0.413***	0.441***
	(0.009)	(0.040)	(0.010)	(0.009)	(0.040)	(0.010)	(0.066)
acre	0.016***	0.013	0.015***	0.016***	0.013	0.015***	-0.002
	(0.002)	(0.011)	(0.003)	(0.002)	(0.010)	(0.003)	(0.012)
ages2	-0.004***	-0.006***	-0.004***	-0.004***	-0.006***	-0.004***	-0.008***
	(0.0002)	(0.0012)	(0.0002)	(0.0002)	(0.0012)	(0.0002)	(0.0030)
ages2sqr	0.00003***	0.00004***	0.00003***	0.00003***	0.00004***	0.00003***	0.00004***
	(0.000003)	(0.000012)	(0.000003)	(0.000003)	(0.000012)	(0.000003)	(0.000033)
bgre_100	0.003***	0.015***	0.003***	0.003***	0.015***	0.003***	0.013***
	(0.001)	(0.004)	(0.001)	(0.001)	(0.004)	(0.001)	(0.005)
intercept	12.703***	12.961***	12.710***	12.702***	12.957***	12.710***	12.842***
	(0.010)	(0.044)	(0.012)	(0.010)	(0.043)	(0.012)	(0.073)
*Numbers in parenthesis are standard errors, *** p<0.01, ** p<0.05, * p<0.1*							
Results for subdivision, block group, and quarterly fixed effect variables are not reported here, but are available upon request from the authors							
Total n	72,319	13,329	72,319	72,319	13,329	72,319	1,192
Adjusted R^2	0.93	0.95	0.94	0.93	0.95	0.94	0.93
n (pv homes)	1,894	1,465	1,894	1,894	1,465	1,894	1,192
Mean non-pv asp2	$ 480,862	$ 480,533	$ 480,862	$ 480,862	$ 480,533	$ 480,862	$ 475,811
Mean size (kW)	3.1	3.0	3.1	3.1	3.0	3.1	2.7
Estimated $/Watt	$ 5.5	$ 3.9	$ 5.4	$ 5.8	$ 4.8	$ 5.6	$ 6.4
PV Only Model Notes: Mean non-pv asp2 amount shown is actually the mean PV asp2. Sample is limited to blockgroups with more than one PV home							

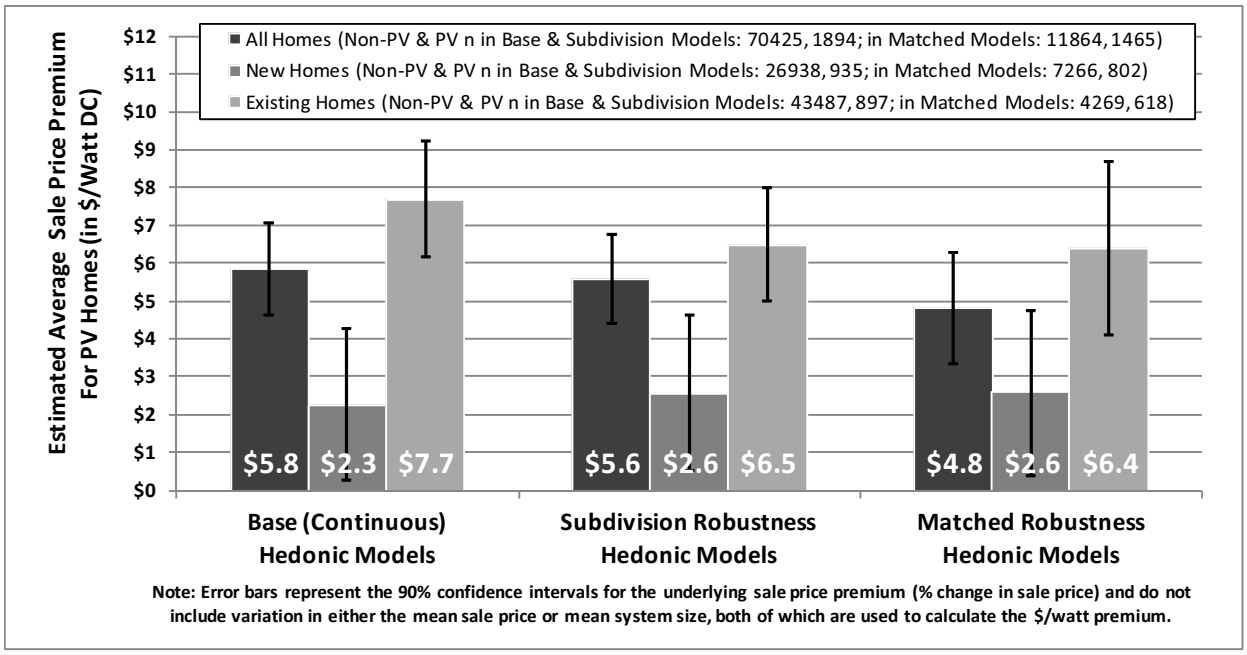
4.2. New and Existing Home Model Results

Turning from the full dataset to one specific to the home type, we estimate continuous effects models for *new* and *existing* homes (see equation (2)). These results are shown in Table 9, with Model 3 the base model for *new* homes and Model 4 the base model for *existing* homes. Also

shown are the results from the robustness tests using the coarsened exact matching procedure and the combined subdivision-block group delineations, as Models 3Ra and 3Rb, respectively, for *new* homes, and as Models 4Ra and 4Rb, respectively, for *existing* homes.

The coefficient of interest, SIZE, is statistically significant at or below the 10% level in all of the *new* home models and at the 1% level in all of the *existing* home models. Estimates for the average $/watt increase in selling prices as a result of PV systems (as summarized in Figure 3, which also includes the results presented earlier for all homes, Models 2, 2Ra, and 2Rb) for *new* homes are quite stable, ranging from $2.3 to $2.6/watt. In comparison, for PV sold with *existing* homes, not only are the selling price impacts found to be higher, but their range across the three models is somewhat greater, ranging from $ 6.4 to $7.7/watt.

Figure 3: New and Existing Home Base Model Results with Robustness Tests



Though the reasons for the apparent discrepancy in selling price impacts between *new* and *existing* homes are unclear, and warrant future research, they might be explained, in part, by the difference in average *net* installed costs, which, from 2007 to 2009, were approximately $5.2/watt for *existing* homes and $4.2/watt for *new* homes in California (derived from the dataset used for Barbose et al., 2010). The gap in net installed costs between new and existing homes is

not wide enough to fully account for these findings, however, with the model estimates for PV selling price premiums below the average net installed costs for *new* homes and above the average net installed costs for *existing* homes.[42]

Several alternative explanations for the disparity between *new* and *existing* home premiums exist. As discussed previously, there is evidence that builders of *new* homes might discount premiums for PV if, in exchange, PV systems provide other benefits for new home developers, such as greater product differentiation and increased the sales velocity, thus decreasing overall carrying costs (Dakin et al., 2008; SunPower, 2008). Further, sellers of *new* homes with PV might be reluctant to aggressively increase home sale prices for installed PV systems because of the burgeoning state of the market for PV homes and concern that more aggressive pricing could even slow home sales. Additionally, because many builders of *new* homes found that offering PV as an option, rather than a standard feature, posed a set of difficulties (Farhar et al., 2004b; Dakin et al., 2008), it has been relatively common in past years for PV to be sold as a standard feature on homes (Dakin et al., 2008). This potentially affects the valuation of PV systems for two reasons. First, because sales agents for the *new* PV homes have sometimes been found to either not be well versed in the specifics of PV and felt that selling a PV system was a new sales pitch (Farhar et al., 2004b) or to have combined the discussion of PV with a set of other energy features (Dakin et al., 2008), up-selling the full value of the PV system as a standard product feature might not have been possible. Secondly, the average sales price of new homes in our dataset is lower than the average sales price of existing homes: to the extent that PV is considered a luxury good, it may be somewhat less-highly valued for the buyers of these homes.

These downward influences for *new* homes are potentially contrasted with analogous upward influences for *existing* homes. Related, buyers of *existing* homes with PV may - to a greater degree than buyers of the less expensive *new* homes in our sample - be self selected towards those who place particular value on a PV home, and therefore value the addition more. Finally, in contrast to *new* home sellers, who might not be familiar with the intricacies and benefits of the

[42] A small number of "affordable homes" (n = 7) are included in the *new* PV homes subset, which, as a group, appear to have a slight downward yet inconsequential effect on the overall sales premium results, and therefore were not investigated further herein. If the number of affordable homes with PV was significant in future research, those effects would best be controlled for directly.

PV system, *existing* home sellers are likely to be very familiar with the particulars of the system and its benefits, and therefore might be able to "up-sell" it more effectively.

These possible influences, in combination, may explain the difference in average PV premium between *new* and *existing* homes. The present analysis did not seek to disentangle or evaluate these specific drivers, however, leaving that important effort for future research.

Table 9: New and Existing Home Base Hedonic Model Results with Robustness Tests

	New Homes			Existing Homes		
	Base	**Robustness Matched**	**Robustness Subdivision**	**Base**	**Robustnes Matched**	**Robustness Subdivision**
	Model 3	**Model 3Ra**	**Model 3Rb**	**Model 4**	**Model 4Ra**	**Model 4Rb**
size	0.006*	0.006*	0.006**	0.014***	0.011***	0.012***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
sqft_1000	0.247***	0.190***	0.250***	0.256***	0.238***	0.251***
	(0.002)	(0.006)	(0.002)	(0.002)	(0.015)	(0.002)
lt1acre	0.536***	0.279***	0.517***	0.373***	0.426***	0.376***
	(0.019)	(0.073)	(0.024)	(0.010)	(0.046)	(0.012)
acre	-0.007	0.338***	-0.009*	0.019***	0.011	0.017***
	(0.005)	(0.027)	(0.005)	(0.002)	(0.011)	(0.003)
ages2	-0.010	0.081***	-0.010*	-0.005***	-0.006***	-0.005***
	(0.006)	(0.017)	(0.006)	(0.000)	(0.002)	(0.000)
ages2sqr	0.00768***	-0.02443***	0.00715***	0.00004***	0.00004***	0.00004***
	(0.001676)	(0.004407)	(0.001604)	(0.000003)	(0.000014)	(0.000004)
bgre_100	0.008***	0.027***	0.007***	0.002	-0.002	0.002
	(0.001)	(0.003)	(0.001)	(0.001)	(0.009)	(0.001)
intercept	12.651***	12.585***	12.627***	12.820***	13.023***	12.833***
	(0.022)	(0.066)	(0.025)	(0.013)	(0.077)	(0.014)
*Numbers in parenthesis are standard errors, *** p<0.01, ** p<0.05, * p<0.1*						
Results for subdivision, block group, and quarterly fixed effect variables are not reported here, but are available upon request from the authors						
Total n	27,873	8,068	27,873	44,384	4,887	44,384
Adjusted R^2	0.94	0.94	0.94	0.93	0.95	0.94
n (pv homes)	935	802	935	897	618	897
Mean non-pv asp2	$ 397,265	$ 399,162	$ 397,265	$ 532,645	$ 590,428	$ 532,645
Mean size (kW)	2.5	2.4	2.5	3.8	3.7	3.8
Estimated $/Watt	$ 2.3	$ 2.6	$ 2.6	$ 7.7	$ 6.4	$ 6.5

4.2.1. Difference-in-Difference Model Results

Delving deeper into PV system impacts on *existing* homes, Table 10 (and Figure 4) shows the results of the base Difference-in-Difference Model 5 as well as results from the two robustness tests (all of which can be compared to Models 4, 4Ra, and 4rb above, as is done in Figure 4). As a reminder, one robustness model limited the differences in sales dates between the first and second sales to five years (Model 5Rb), and the other robustness model used the combined subdivision-block group delineations as fixed effects variables (Model 5Rc). The variables of interest are PVH, SALE2 and especially PVS.

PVH estimates the difference in the first sale prices of homes that will have PV installed (as of the second sale date) relative to non-PV homes. The three models are consistent in their estimates, showing approximately a 2% premium for "future" PV homes, though only two of these estimates are statistically significant, and then only at the 10% level. Regardless, this finding suggests that PV homes tend to sell for somewhat more even before the installation of PV, presumably as a result of other amenities that are correlated with the (ultimate) installation of PV (such as, potentially, energy efficiency features). SALE2 estimates the price appreciation trend between the first and second sales for all homes. The coefficient for this variable is significant at the 1% level, and is fairly stable across the models, indicating a clear general trend of price increases, over and above inflation adjustments, of approximately 2% to 2.5% between the first and second sales.

Finally, and most importantly, homes with PV systems installed on them as of the second sale - after controlling for any inherent differences in first sale prices (PVH) and any trend between the first and second sales (SALE2) - show statistically significant sale price premiums of approximately 5 to 6%. These premiums equate to an increase in selling prices of approximately $6/watt for *existing* homes, closely reflecting the results presented earlier for the hedonic models in Table 9 and Figure 3. For comparison purposes, both sets of results are presented in Figure 4.

The premium for *existing* PV homes as estimated in the DD Models 5, 5Ra, and 5Rb and both robustness tests for the hedonic model (using the "matched" and "subdivision" datasets, Models 4Ra and 4Rb respectively) are consistently between $6 and $6.5/watt and are in line with –

though slightly higher than - the mean net installed costs of PV on existing homes in California of approximately $5.2/watt from 2007 through 2009. The base hedonic *existing* home model, on the other hand, estimates a higher premium of $7.7/watt. One possible explanation for this inconsistency is that the two robustness tests for the hedonic model and the various difference-in-difference models are less likely to be influenced by either selection or omitted variable bias than the base hedonic model. Regardless of the absolute magnitude, a sizable premium for *existing* PV homes over that garnered by *new* PV homes is clearly evident in these and the earlier results.

Figure 4: Existing Home Hedonic and Difference-in-Difference Model Results with Robustness Tests

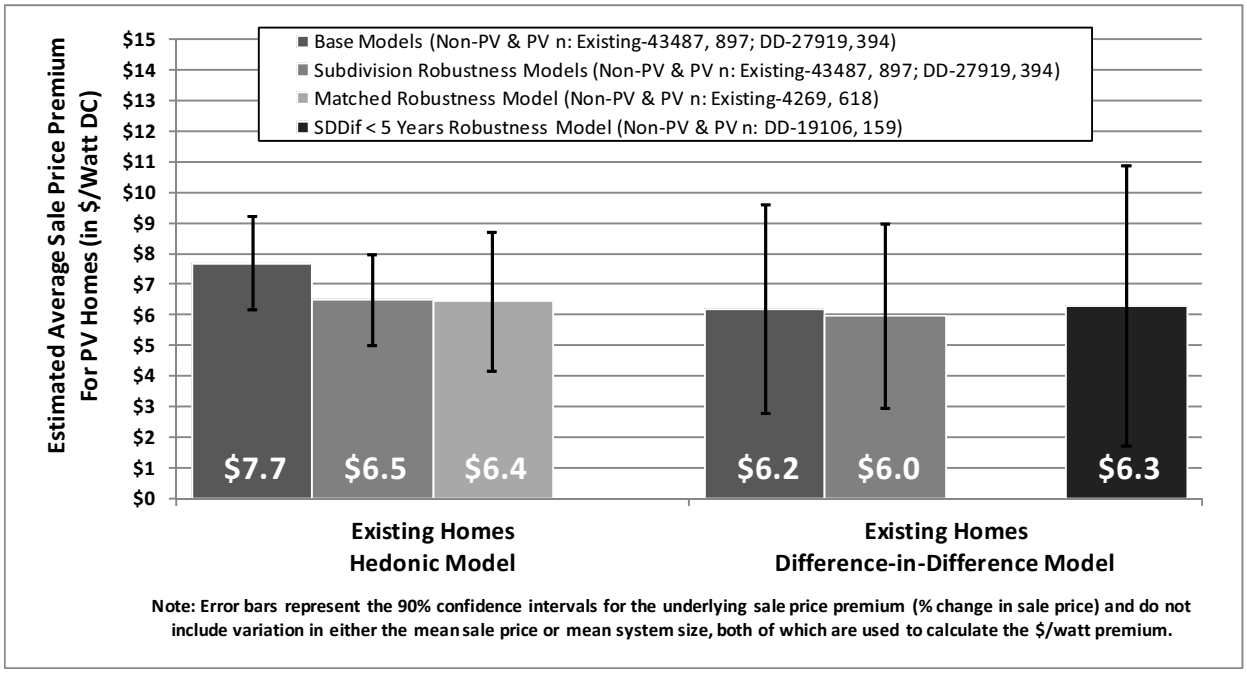


Table 10: Difference-in-Difference Model Results

	Difference-in-Difference		
	Base	Robustness	Robustness
		Subdivision	Sddif < 5
	Model 5	Model 5Ra	Model 5Rb
pvh	0.022*	0.024	0.022*
	(0.013)	(0.021)	(0.012)
sale2	0.023***	0.026***	0.019***
	(0.002)	(0.002)	(0.002)
pvs	0.051***	0.061**	0.049***
	(0.017)	(0.027)	(0.015)
sqft_1000	0.255***	0.256***	0.251***
	(0.002)	(0.002)	(0.002)
lt1acre	0.374***	0.385***	0.377***
	(0.011)	(0.013)	(0.012)
acre	0.012***	0.009**	0.011***
	(0.003)	(0.004)	(0.003)
age	-0.005***	-0.005***	-0.005***
	(0.0002)	(0.0003)	(0.0003)
agesqr	0.00004***	0.00004***	0.00004***
	(0.000003)	(0.000003)	(0.000003)
bgre_100	0.002*	0.000	0.001
	(0.001)	(0.001)	(0.001)
intercept	12.677***	12.594***	12.694***
	(0.013)	(0.015)	(0.014)
*Numbers in parenthesis are standard errors. *** p<0.01, ** p<0.05, * p<0.1. Results for subdivision, block group, and quarterly fixed effect variables are not reported here, but are available upon request from the authors*			
Total n	28,313	19,265	28,313
Adjusted R^2	0.93	0.94	0.94
n (pv homes)	394	159	394
Mean non-pv asp2	$ 488,127	$ 450,223	$ 488,127
Mean size (kW)	4.0	4.3	4.0
Estimated $/Watt	$ 6.2	$ 6.3	$ 6.0

4.3. Age of PV System for Existing Home Hedonic Model Results

To this point, the marginal impacts to selling prices of each additional kW of PV added to *existing* homes have been estimated using the full dataset of *existing* homes, which has produced an average effect, regardless of the age of the PV system. As discussed previously, it is

conceivable that older PV systems would garner lower premiums than newer, similarly sized systems. To test this directly, a base model is constructed - see equation (4) - that estimates the marginal impacts for three age groups of PV systems: no more than one year old at the time of sale; between two and four years old; and five or more years old. Results from this model as well as two robustness tests, using the coarsened exact matching procedure and the combined subdivision-block group delineations, are shown in Table 11 as Models 6, 6Ra, and 6Rb, respectively.

Each model finds statistically significant differences between PV and non-PV homes for each age group, and more importantly, premium estimates for newer PV systems are - as expected - larger than those for older PV systems and are monotonically ordered between groups, providing some evidence that older systems are being discounted by the buyers and sellers of PV homes. Specifically, the three models estimate an average premium for PV systems that are one year or less in age of $8.3-9.3/watt, whereas those same models estimate an average premium of $4.1-6.1/W for systems that are five or more years old.

4.4. Returns to Scale Hedonic Model Results

In the previous modeling, the marginal impacts to selling prices of each additional kW of PV in the continuous models have been estimated using a linear relationship. To test whether a non-linear relationship may be a better fit, a SIZE squared term is added to the model as shown in equation (5). Similarly, decreasing or increasing returns to scale might be related to other house characteristics, such as the size of the home (i.e., square feet). This hypothesis is explored using equation (6). Both model results are shown in Table 11 as Model 7 and 8, respectively.

Both models find small and non-statistically significant relationships between their interacted variables, indicating a lack of compelling evidence of a non-linear relationship between PV system size and selling price in the dataset, and a lack of compelling evidence that the linear relationship is affected by the size of the home. As such, the impact of PV systems on residential selling prices appears to be well approximated by a simple linear relationship, while the size of the home is not found to impact the PV sales price premium. In combination, these results seem to suggest that while California's tiered rate structures may lead to energy bill savings from PV

investments that vary non-linearly with PV system size and also vary by home size, those same rate structures have not – to this point – led to any clear impact on the PV premium garnered at the time of home sale. Similarly, though larger PV systems may be installed at a discount to smaller ones on a $/watt basis, and though any marginal green cachet that exists may diminish with system size, those possible influences are not apparent in the results presented here.

Table 11: Age of PV System and Return to Scale Hedonic Model Results

	Age of PV Systems for Existing Homes			Returns to Scale	
	Base	Robustness Matched	Robustness Subdivision	Size	Square Feet
	Model 6	Model 6Ra	Model 6Rb	Model 7	Model 8
size*1 year old	0.016***	0.016***	0.013***		
	(-0.004)	(-0.005)	(-0.004)		
size*2-4 years old	0.015***	0.010***	0.013***		
	(-0.002)	(-0.003)	(-0.002)		
size*5+ years old	0.012***	0.008**	0.008**		
	(-0.003)	(-0.004)	(-0.003)		
size				0.008**	0.021***
				(0.003)	(0.006)
sizesqr				0.001	
				(0.001)	
size*sqft_1000					-0.003
					(0.002)
sqft_1000	0.256***	0.238***	0.251***	0.253***	0.253***
	(0.002)	(0.015)	(0.002)	(0.001)	(0.001)
lt1acre	0.373***	0.426***	0.376***	0.416***	0.416***
	(0.010)	(0.046)	(0.012)	(0.009)	(0.009)
acre	0.019***	0.010***	0.017***	0.016***	0.016***
	(0.002)	(0.011)	(0.003)	(0.002)	(0.002)
ages2	-0.005***	-0.006***	-0.005***	-0.004***	-0.004***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)
ages2sqr	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
bgre_100	0.002***	-0.002***	0.002***	0.003***	0.003***
	(0.001)	(0.009)	(0.001)	(0.001)	(0.001)
intercept	12.820***	13.024***	12.834***	12.702***	12.701***
	(0.013)	(0.078)	(0.014)	(0.010)	(0.011)
*Numbers in parenthesis are standard errors. *** p<0.01, ** p<0.05, * p<0.1*					
Results for subdivision, block group, and quarterly fixed effect variables are not reported here, but are available upon request from the authors					
Total n	44,384	4,887	44,384	72,319	72,319
Adjusted R^2	0.93	0.95	0.94	0.93	0.93
n (pv homes)	897	618	897	1,894	1,894
Mean non-pv asp2	$ 532,645	$ 590,428	$ 532,645	$ 480,862	$ 480,862
Mean size (kW)	3.8	3.7	3.8	3.1	3.1
Estimated $/Watt	$8.3 - $6.1	$9.3 - $4.9	$7.0 - $4.1	$ 6.3	$ 6.4
Note: $/watt estimates for Returns to Scale models include the non-statistically significant interaction coefficients and therefore should be interpreted with caution					

5. Conclusions

The market for solar PV is expanding rapidly in the U.S. Almost 100,000 PV systems have been installed in California alone, more than 90% of which are residential. Some of those "PV homes" have sold, yet little research exists estimating if those homes sold for significantly more than similar non-PV homes. Therefore, one of the claimed incentives for solar homes - namely that a portion of the initial investment into a PV system will be recouped if the home is sold – has, to this point, been based on limited evidence. Practitioners have sometimes transferred the results from past research focused on energy efficiency and energy bills more generally and, while recent research has turned to PV that research has so far focused largely on smaller sets of PV homes concentrated in certain geographic areas. Moreover, the home sales price effect of PV on a *new* versus an *existing* home has not previously been the subject of research. Similarly unexplored has been whether the relationship of PV system size to home sales prices is linear, and/or is affected by either the size of the home or the age of the PV system.

This research has used a dataset of approximately 72,000 California homes, approximately 2,000 of which had PV systems installed at the time of sale, and has estimated a variety of different hedonic and repeat sales models to directly address the questions outlined above. Moreover, an extensive set of robustness tests were incorporated into the analysis to test and bound the possible effects and increase the confidence of the findings by mitigating potential biases. The research was not intended to disentangle the various individual underlying influences that might dictate the level of the home sales price premium caused by PV, such as, energy costs savings, the net (i.e., after applicable state and federal incentives) installed cost of the PV system, the possible presence of a green cachet, or seller attributes. Instead, the goal was to establish credible estimates for the aggregate PV residential sale price effect across a range of different circumstances (e.g., new vs. existing homes, PV system age).

The research finds strong evidence that homes with PV systems in California have sold for a premium over comparable homes without PV systems. More specifically, estimates for average PV premiums range from approximately $3.9 to $6.4 per installed watt (DC) among a large number of different model specifications, with most models coalescing near $5.5/watt. That

value corresponds to a premium of approximately $17,000 for a relatively new 3,100 watt PV system (the average size of PV systems in the study). These results are similar to the average increase for PV homes found by Dastrop et al. (2010), which used similar methods but a different dataset, one that focused on homes in the San Diego metropolitan area. Moreover, these average sales price premiums appear to be comparable to the average *net* (i.e., after applicable state and federal incentives) installed cost of California residential PV systems from 2001-2009 (Barbose et al., 2010) of approximately $5/watt, and homeowners with PV also benefit from electricity cost savings after PV system installation and prior to home sale.

Although the results for the full dataset from the variety of models are quite similar, when the dataset is split among *new* and *existing* homes, PV system premiums are found to be markedly affected, with *new* homes demonstrating average premiums of $2.3-2.6/watt, while *existing* homes are found to have average premiums of $6-7.7/watt. Possible reasons for this disparity between *new* and *existing* PV homes include: differences in underlying net installation costs for PV systems; a willingness among builders of new homes to accept a lower PV premium because PV systems provide other benefits to the builders in the form of product differentiation, leading to increased sales velocity and decreased carrying costs; and, lower familiarity and/or interest in marketing PV systems separately from the other features of *new* homes contrasted with a likely strong familiarity with the PV systems among *existing* home sellers.

The research also investigated the impact of PV system age on the sales price premium for existing homes, finding - as would be expected - evidence that older PV systems are discounted in the marketplace as compared to newer PV systems. Finally, evidence of returns to scale for either larger PV systems or larger homes was investigated but not found.

In addition to benchmarking the results of this research to the limited previous literature investigating the sales price premiums associated with PV, our results can also be compared to previous literature investigating premiums associated with energy efficiency (EE) or, more generally, energy cost savings. A number of those studies have converted this relationship into a ratio representing the relative size of the home sales price premium to the annual savings expected due to energy bill reductions. These ratios have ranged from approximately 7:1

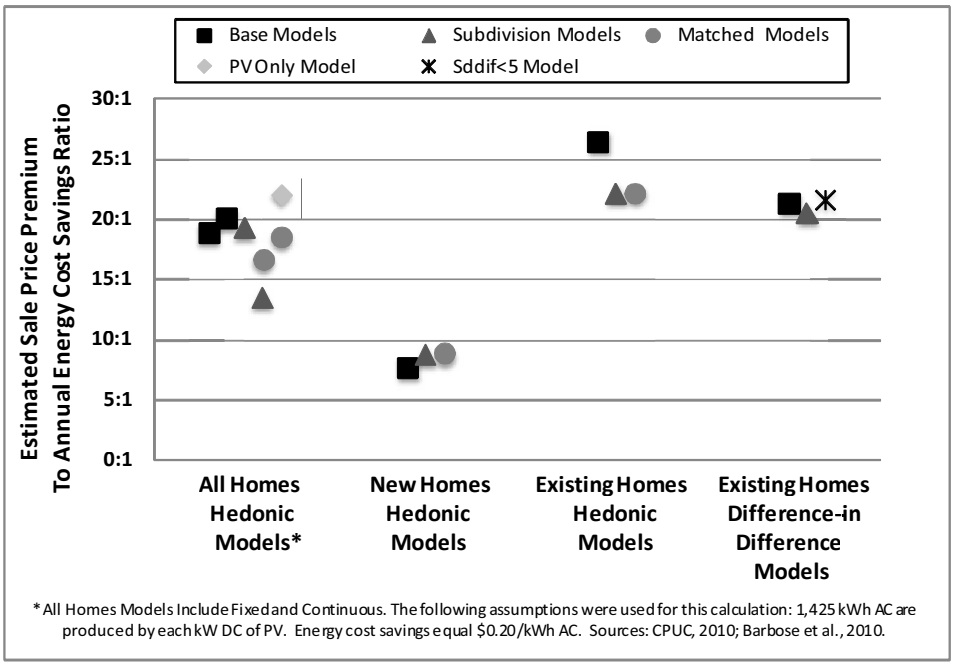
(Longstreth et al., 1984; Horowitz and Haeri, 1990), to 12:1 (Dinan and Miranowski, 1989), to approximately 20:1 (Johnson and Kaserman, 1983; Nevin et al., 1999; Eichholtz et al., 2009), and even as high as 31:1 (Nevin and Watson, 1998).

Although actual energy bill savings from PV for the sample of homes used for this research were not available, a rough estimate is possible, allowing for a comparison to the previous results for energy-related homes improvements and energy efficiency. Specifically, assuming that 1,425 kWh (AC) are produced per year per kW (DC) of installed PV on a home (Barbose et al., 2010; CPUC, 2010)[43] and that this production offsets marginal retail electricity rates that average $0.20/kWh (AC) (Darghouth et al., 2010), each watt (DC) of installed PV can be estimated to save $0.29 in annual energy costs. Using these assumptions, the $/watt PV premium estimates reported earlier can be converted to sale price to annual energy savings ratios (see Figure 5).

A $3.9 to $6.4/watt premium in selling price for an average California home with PV installed equates to a 14:1 to 22:1 sale price to energy savings ratio, respectively. For *new* homes, with a $2.3-2.6/watt sale price premium, this ratio is estimated to be 8:1 or 9:1, and for *existing* homes, with an overall sale price premium range of $6-7.6/watt, the ratio is estimated to range from 21:1 to 26:1. Without <u>actual</u> energy bill savings, these estimates are somewhat speculative, but nonetheless are broadly consistent with the previous research that has focused on EE-based home energy improvements.

[43] The 1,425 kWh (AC) estimate is based on a combination of a 19% capacity factor (based on AC kWh and CEC-AC kW) from CPUC (2010), and an 0.86 conversion factor between CEC-AC kW and DC kW (Barbose et al., 2010).

Figure 5: Estimated Ratios of Sale Price Premium to Annual Energy Cost Savings



Although this research finds strong evidence that homes with PV systems in California have sold for a premium over comparable homes without PV systems, the extrapolation of these results to different locations or market conditions (e.g., different retail rates or net installed costs) should be done with care.

Finally, additional questions remain that warrant further study. Perhaps most importantly, although the dataset used for this analysis consists of almost 2,000 PV homes, the study period was limited to sales occurring prior to mid-2009 and the dataset was limited to California. Future research would therefore ideally include more-recent sales from a broader geographic area to better understand any regional/national differences that may exist as well as any changes to PV premiums that occur over time as the market for PV homes and/or the net installed cost of PV changes. More research is also warranted on *new* versus *existing* homes to better understand the nature and underlying drivers for the differential premium discovered in this research; in addition to further hedonic analysis, that research could include interviewing/surveying home builders and buyers and exploring the impact of demographic, socio-economic, and others factors on the PV premium.

Additionally, future research might compare sales price premiums to actual annual home energy cost savings, to not only to explore the sale price to annual energy cost savings ratio directly, but also to explore if a green cachet exists over and above any sale price premiums that would be expected from energy cost savings alone. Further, house-by-house PV system and other information not included in the present study might be included in future studies, such as the actual net installed costs of PV for individual households, rack-mounted or roof-integrated distinctions as well as other elements of PV system design, the level of energy efficiency of the home, whether the home has a solar hot water heater, whether the PV system is customer or 3rd party owned at the time of sale, and if the homeowner can sell the green attributes the system generates.[44] Such research could elucidate important differences in PV premiums among households, PV system designs and state and federal programmatic designs, as well as bolster confidence in the magnitude of the PV premium estimated here. Finally, and more generally, additional research could investigate the impact of PV systems on the time homes remain on the market before sale, a factor that may be especially important for large developers and sellers of *new* homes.

[44] 3rd party owned PV systems would not be expected to command the same sort of premium as was discovered here. Although the level of penetration of 3rd party owners in our data was not significant (below 10%), and therefore would likely have not influenced our results in a substantive way, any future research, using more recent data, must account for their inclusion specifically.

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Valuing Green Home Designs: A Study of ENERGY STAR® Homes

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Abstract A number of researchers have attempted to isolate the incremental effect of energy efficiency on home value; however, few studies have benefited from the availability of a comprehensive and continuous indicator of home energy efficiency such as the ENERGY STAR® program. This case study builds on past research by comparing original sale prices between ENERGY STAR qualified homes and non-ENERGY STAR qualified homes in Fort Collins, Colorado. Sale prices were analyzed using hedonic regression analysis. Results indicate that ENERGY STAR homes originally sold for $8.66 more per square foot than non-ENERGY STAR homes.

Homebuyers in the United States play a significant role in reducing fuel consumption and the resulting carbon emissions. ‘‘The housing sector provides a number of opportunities to address two urgent national goals—reducing greenhouse gases and U.S. foreign oil dependence,’’ (Fernald, 2009). Total energy consumption, including both primary energy and renewable energy, in the U.S. residential sector has averaged 18.093 quadrillion Btu between 1980 and 2005 according to the U.S. Energy Information Administration (EIA, 2010). Residential energy consumption was 15.759 quadrillion Btu in 1980; by 2005, it had increased 37% to 21.659 quadrillion Btu (EIA, 2010). In comparison, the commercial sector averaged 14.105 quadrillion Btu and the transportation sector averaged 23.249 quadrillion Btu per year between 1980 and 2005 (EIA, 2010). In 2005, the majority of residential energy consumption was for space and water heating (Elliot, Langer, and Nadel, 2006).

Beyond the impact of residential energy consumption on total U.S. energy consumption, the level of energy efficiency designed into a home also has a direct bearing on homeownership costs. According to the Consumer Expenditure Survey, 34% of homeowners’ average annual expenditures were on housing in 2009 (Bureau of Labor Statistics, 2010). Of the amount spent by homeowners on their housing, 21.5% went to pay for utilities. In comparison, 13% of household annual expenditures were on food and 16% were for transportation costs in 2009. Since housing expenditures comprise such a significant portion of the average household budget, any reduction in operating and maintaining of homes will have direct benefits to homeowners in terms of reducing the overall cost of housing. By choosing to place more value on unseen amenities such as added insulation, infiltration reduction, duct sealing, or high efficiency furnaces versus other more visible amenities (i.e., marble flooring and granite counters), homeowners can realize significant reductions in utility requirements necessary to heat and cool

their homes (NAPEE, 2011). For example, homes designed and built to ENERGY STAR® standards are at least 15% more energy efficient than homes built to the 2004 International Residential Code, while many are 20%–30% more efficient than standard homes (''Features and Benefits'', n.d.; NAPEE, 2008). The result is both reduced homeownership costs and reductions in U.S. residential energy consumption and carbon emissions (Elliott, Langer, and Nadel, 2006; Fernald, 2009).

Although it is evident that energy-efficient homes can play a significant role in reducing U.S. energy consumption, greenhouse gas emissions, and home ownership expenses, widespread adoption and incorporation of energy-efficient designs and construction practices have been slow. Currently, energy-efficient homes only account for 21% of U.S. new home construction (2009 ENERGY STAR Qualified New Homes, 2010). Researchers have identified numerous reasons for this lack of implementation, including transaction costs, lack of information, uncertainty of energy savings, split incentives, and initial capital investment (Elliott, Langer, and Nadel, 2006; Fuller, 2009). Significant to this study are homebuilders' perceptions that initial capital investments for increased energy efficiency will not be recaptured through energy savings or capitalization of these investments when the home is sold (Galuppo and Tu, 2010). As long as these perceptions persist among homebuilders, they will remain reluctant to invest in these systems and the residential market will continue to be a significant contributor to U.S. greenhouse gas emissions (Lande, 2008). Ultimately, the value consumers place on energy-efficient residential design either encourages or hinders further incorporation of energy-efficient features into homes (Galuppo and Tu, 2010).

Compounding this issue is the relatively short periods for which U.S. homeowners own their homes. On average, U.S. homeowners tend to sell their home every eight years (Dacquisto, Emrath, Laquatra, and Laitner, 2001; Lande, 2008). Generally, for homeowners to justify additional design and construction costs related to increasing energy efficiency from an economic stand point, they must believe that they will recoup the added capital investments either through (1) reduced utility bills during the time they own their home, (2) an increased sales price, or (3) some combination thereof (Lande, 2008). Because payback periods for many energy efficient upgrades can easily exceed the duration homeowners typically own their homes, and little evidence exists to give them confidence that these costs will be capitalized into the sales price, many homeowners rationally conclude that added construction costs for increased energy efficiency are not economically justifiable.

Ultimately, homebuyers play a significant role in determining what role the residential sector will play in addressing U.S. energy consumption, greenhouse gas emissions, dependence on foreign oil, and home ownership costs. Through their purchasing behaviors, homebuyers either support or hinder progress within the residential sector in meeting the aforementioned objectives. If homebuyers are not willing to realize the capitalization of increased energy efficiency in the purchase of a home, builders will remain reluctant to include energy-efficient design and strategies in their projects. For energy-efficient building practices to

become more prevalent, it must be established that homebuyers are willing to pay more for energy-efficient homes, which is consistent with basic economic theory (Laquatra, Dacquisto, Emrath, and Laitner, 2002; Lande, 2008).

Incorporation of energy-efficient designs and construction techniques offer have the potential to offer immediate cash-flow benefits on monthly or yearly returns. As a result, buyers should be willing to pay more for homes with lower utility bills in anticipation of savings on future costs of operation, and consequently, sellers should attempt to charge more for homes with energy efficient features Laquatra, Dacquisto, Emrath, and Laitner, 2002). Mandell and Wilhelmsson (2011) found that homeowners are willing to pay for increased energy efficiency. Other studies, however, that have sought to provide empirical evidence that homebuyers are in fact paying more for energy-efficient homes have suffered from the challenges inherent in quantifying energy efficiency in a manner that is recognized in the marketplace (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Homes are complex commodities; finding historical and observable data to support the hypothesis that energy efficiency positively impacts housing values is difficult, especially when numerous other aesthetically-pleasing features exist that presumably take precedence over utility bills. Previous research studies attempting to capture and report the incremental value of energy efficiency have not had the benefit of utilizing a comprehensive measure of home energy efficiency. Not until recently has an assessment tool existed that allows researchers to easily identify which homes are more energy efficient. When the Environmental Protection Agency (EPA) extended its ENERGY STAR rating to homes, it created an easily identifiable metric of residential energy efficiency based on a Home Energy Rating System (HERS) index. The purpose of this study is to extend previous research to approach a more accurate answer to the question of whether or not and to what extent housing markets capitalize the value of energy efficiency using ENERGY STAR labeling.

The research question guiding this study is: Do homes constructed with more energy-efficient building systems, as qualified by the ENERGY STAR labeling program, have higher market values than non-ENERGY STAR qualified homes? If so, how much more are they worth?

Based on this question, the following hypothesis was developed:

H_1: ENERGY STAR rated homes will have higher sales prices than comparable non-ENERGY STAR rated homes in the study area.

Review of Literature

The literature review focuses on prior studies of capitalization of energy efficiency within the residential markets. Although this topic has received considerable attention in the commercial real estate sector (both in the U.S. and internationally), there has been considerably less research relevant to this study conducted in the residential section. In 2001, the EPA sponsored a comprehensive analysis of published research literature titled *The Value of Energy Efficiency in Housing:*

Review and Analysis of the Literature (Dacquisto, Emrath, Laquatra, and Laitner, 2001). The report presents a review of published research on the capitalization of energy efficiency in housing over a 20-year history. Their report focused primarily on using past applications of hedonic regression analysis and, to a lesser extent, willingness-to-pay surveys to determine if energy efficiency is reflected in home values.

Sopranzetti (2010) explains hedonic regression as an analytical process that allows for the deconstruction of home prices into their component parts to determine how individual components contribute to the overall value. Similarly, Meese and Wallace (1997) define hedonic regression as a way of estimating the value of a complex commodity with a bundle of attributes, such as a house, by modeling the price of that commodity as a function of the particular set of attributes it possesses. Each attribute is valued independently and contributes its individual value to the overall value of the commodity, making it easier to observe the market value of each attribute by itself. For example, appraisers can use hedonic regression to determine the value of house attributes such as structural characteristics (e.g., square footage, number of rooms, number of bathrooms, and known defects), neighborhood characteristics (e.g., quality of the school system and/or neighborhood), or location within a given market (Sopranzetti, 2010). Energy efficiency, the attribute of most interest to this study, can also be identified and included as an analysis component in hedonic regression to determine its contribution to overall home value.

Hedonic Regression Studies

The literature on hedonic house price models reviewed for this study dates back two and a half decades and includes many different methodologies. A summary of studies reviewed is provided in Appendix A. The collective results of these studies (Exhibit 1) indicate varying levels of capitalization of energy efficiency when homes are sold (Nevin and Watson, 1998; Dacquisto, Emrath, Laquatra, and Laitner, 2001); yet, the body of research as a whole suffers from challenges associated with identifying levels of residential energy efficiency. This shortcoming hinders integration of these findings into property appraisals; as a result, homebuilders are reluctant to trust that additional cost for increased energy efficiency design/construction will be capitalized in the future.

Some consistency is evident in the studies among the attributes identified for inclusion in the hedonic regression analysis (see Appendix A for a summary table), although considerable variations are also apparent and worthy of review. While all studies reviewed attempted to control for the various factors contributing to home value, all did so to a different degree. Furthermore, the studies reviewed included a wide range of sample sizes and variables in an effort to best identify the incremental market value of energy efficiency (Laquatra, 2002). An overview of the methodologies utilized in the studies is provided in Appendix B. In total, eight studies were reviewed. All but one were limited to small geographic markets and short periods of time. Sample sizes for these studies ranged from 67 to more than 15,000; the majority of studies had sample sizes between 81 and 505.

Exhibit 1 | Key Results From Hedonic Studies

Reference	Key Findings	R^2
Halvorsen (1981)	The 1974 spike in relative cost of fuel oil raised price differential between gas- and oil-heated houses to $761 in 1974, and up to $4,597 in the first half of 1975.	0.75
Corgel (1982)	Value of energy-efficient homes (with lower structural heat loss) was $3,248 higher than inefficient homes.	0.73
Johnson (1983)	Home value increased by about $20.73 for every $1 in annual fuel bills.	0.80
Longstreth (1986)	A one inch increase in wall insulation increased home value by $1.90 per square foot; a one inch increase in ceiling insulation increased home value by $3.37 per square foot; high quality (energy efficient) windows increased home value by $1.63 per square foot.	0.43
Laquatra (1989)	Home value increased by $2,510 for each one-point decrease in thermal integrity factor.	0.67
Dinan (1989)	Home value increased by $11.63 per $1 decrease in fuel expenditures needed to maintain a home at 65 degrees F in average heating season.	n/a
Horowitz (1990)	Home value increased by about $12.52 per $1 decrease in electric bills, consistent with home buyers discounting savings at after-tax mortgage interest rate.	0.86
Nevin (1998)	Home value increased by about $20 for every $1 reduction in annual fuel bills.	0.41

Note: The sources are Nevin and Watson (1996) and Dacquisto, Emrath, Laquatra, and Laitner (2001).

Additionally, some of the samples looked strictly at new or nearly-new homes, some looked only at resale values, and others looked at all sales data within a given marketplace (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Following is an overview of the variables used in each study reviewed.

Structural Variables. Structural variables account for the physical characteristics that contribute to home value (Sopranzetti, 2010). All of the studies reviewed included square footage as a structural variable while also controlling for property age to some degree. Additional structural variables most often included in the models were number of bathrooms, lot size, fireplaces, and garages. Only two of the eight studies reviewed account for all of the aforementioned variables. In some cases, the absence of certain variables may be the result of data limitations. Nevertheless, these variables have been found to have significant effects in the other regression analyses; failure to include these variables would compromise internal validity.

Neighborhood and Locational Variables. Neighborhood and locational variables represent the locational quality of a property within a community (Sopranzetti, 2010). The handling of neighborhood and locational variables differed significantly across the reviewed studies. These factors are not binary variables; they are not *have* or *have-not* items. As a result, it is not easy to quantify them

on a numerical scale, unlike *size* and *age*, making it difficult to measure the impact of their exclusion or mistreatment in a regression study. All but two of the reviewed studies included some degree of locational effects. For example, one study used distance to the central business district, while another used distance to the nearest interstate ramp. In smaller sample sizes with relatively few subdivisions, it may be easier to control for locational effects and more simplified criteria may suffice.

Energy Efficiency Variables. Energy efficiency variables represent different measures of energy conservation resulting from home design/construction. In the studies reviewed, significant differences existed on the approach used to identify energy efficiency. Some treated energy efficiency as a binary variable while others used utility bills as proxies for energy efficiency. For example, in one study energy efficiency was based solely on the type of fuel (natural gas or oil) that was used to heat the house. Another study based energy efficiency on roof temperatures as measured using infrared aerial photographs. All of these studies ignored other contributing factors to home energy efficiency, which is reflective of the difficulty inherent in identifying a single measure of energy efficiency. Because energy efficiency is clearly not a simple either-or phenomenon, it will be difficult to generalize results from studies employing this sort of methodology.

Other studies reviewed by Dacquisto, Emrath, Laquatra, and Laitner (2001) identify energy efficiency as the sum of four attributes: inches of wall insulation, inches of ceiling insulation, presence of storm windows and/or thermopane glass, and presence of wood/vinyl window frames. In these studies, separate coefficients are assigned to represent the implicit price of each of these features. A major limitation of this approach is that information on specific physical features contributing some level of energy efficiency may not be available in many data sets.

One particularly relevant study reviewed by Dacquisto, Emrath, Laquatra, and Laitner (2001) is the Laquatra (1986) study (Appendix B). Laquatra constructed a continuous variable called the ''Thermal Integrity Factor'' (TIF) to represent varying levels of energy efficiency. TIF assesses the annual heating load as measured in Btu per square foot of heated floor space per heating degree day, although it does not adjust for equipment efficiency, duct and distribution system losses, differences in fuel type, and energy usage for water heating, cooling, and other purposes. All of these deficiencies could result in differences in utility bills for houses with the same TIF and floor area (Dacquisto, Emrath, Laquatra, and Laitner, 2001). Application of this approach is also limited by the ability to obtain the data needed to calculate the TIF variable.

Based on the review of these studies, a minimal level of consistency can be identified with respect to which structural, neighborhood, and locational variables should be included in hedonic regression analysis of home values. Prior measures of energy efficiency, however, vary considerably. It is clear from the studies reviewed that identifying a usable measure of energy efficiency has been problematic. As a result, replication and application of study results have been limited, as evidenced by a general lack of application within the appraisal industry.

The measures of efficiency utilized in these studies were based on information that is simply not easily accessible to appraisers.

Improving Methodology

Despite the limitations of research investigating how housing markets capitalize the value of home energy improvements, it still remains consistent with economic theory that such a phenomenon occurs to some degree. Improved methodologies are needed to enable more reliable and implicit conclusions; hedonic regression models seem to be the most effective way of achieving these conclusions (Dacquisto, Emrath, Laquatra, and Laitner, 2001; Sopranzetti, 2010). While each regression study possesses its own set of weaknesses, the ones reviewed here do take significant steps toward employing a reliable analysis. Taken together, all of the models provide a seemingly comprehensive list of explanatory variables that should encourage future studies to include as many of them as possible. The challenge remaining is to incorporate better identifiers of energy efficiency that are also accessible to appraisers.

Since these studies were conducted, better measurements of energy efficiency have become available, such as ENERGY STAR labeling for homes, LEED for Homes, and the National Green Building Standard. Third-party ratings of homes as either green or energy efficient provides a paper trail for appraisers to incorporate into appraisals. This paper trail provides the documentation necessary to support the analysis of a high performance home and measurements of contributory value (Admoatis, 2010).

Green Home Assessment Tools

The green building industry has grown substantially in the last few decades. At the same time, several green home assessment tools have entered the residential market, providing consistent assessments of varying levels of energy efficiency and essentially creating a branding for energy-efficient homes that is readily identifiable. Current assessment tools for the residential market include the Environmental Protection Agency's (EPA) ENERGY STAR rating, the U.S. Green Building Council's LEED for Homes, and the National Association of Home Builders' National Green Building Standard. Each of these assessment tools sets forth various criteria to ensure that the homes certified met a minimum level of increased energy efficiency compared with more common building designs and construction practices. While each assessment tool has its strengths and weaknesses, it is not the purpose of this paper to provide an in-depth review of these assessment tools and the comparable levels of energy efficiency between assessments. Rather, the purpose is to access the impact of energy efficiency branding on the ability to isolate increases in home value as a result of increased energy efficiency. Since consumers are likely to be more familiar with the ENERGY STAR rating system, which has been in existence longer than the other two rating systems, this system was chosen for use in this study.

ENERGY STAR. In an attempt to reduce the emission of greenhouse gases, the EPA introduced the ENERGY STAR program in 1992. The purpose of this voluntary program was to identify and promote energy-efficient products designed

to reduce greenhouse gas emissions. The ENERGY STAR label was initially listed only on items such as major appliances, office equipment, lighting, and home electronics. It has since expanded to include the construction of new homes, taking on a whole-house approach to measure energy efficiency. To qualify as ENERGY STAR labeled, a home must (a) meet the appropriate Home Energy Rating System (HERS) Index, (b) be verified and field-tested in accordance with the Residential Energy Services Network (RESNET) Standards by a RESNET-accredited provider, and (c) meet all applicable codes (''The Performance Path,'' n.d.).

Methodology

A sample of 300 homes in Fort Collins, Colorado were selected to test the research question and related hypothesis guiding this study. The sample consisted of 150 ENERGY STAR qualified homes and 150 non-ENERGY STAR qualified homes. While this sample selection limits the application of the results to a broader population, it is within the range of sample size commonly utilized for similar studies. Sample homes were identified using energy rating data available through E-Star Colorado and the county assessor's records. For each ENERGY STAR home included in the data set, a comparable home in the surrounding area was identified. To control for the considerable effect of location on home price, comparable homes were identified as close to the ENERGY STAR homes as possible based on address information. Generally comparable homes were at most 2–3 miles from the ENERGY STAR homes. It should be noted that although Fort Collins is a college town, all of the homes included in the study were in newer subdivisions that were located away from the campus community. Further, the study is delimited to single-family detached homes constructed during or after 1999 since newer homes have presumably higher levels of energy efficiency. Delimiting the study to nearly new homes also avoids the challenges of evaluating efficiency across homes of vastly different ages (Adomatis, 2010). Sales for all homes occurred between 1999 and 2005. When selecting comparable properties, it was also important to ensure that these properties were not infarct ENERGY STAR homes. To control for this, the builder name listed in the county assessor's records was cross-checked with the list of participating ENERGY STAR builders as listed on the ENERGY STAR website.

Data and Analysis

Consistent with related literature on hedonic regression, the regression used in this study contains several independent variables (Exhibit 2). Original sale price per square foot is the dependent variable. The expected relationship between each independent variable and the dependent variable is indicated under the heading *Expected Relationship* (Exhibit 2). All of the model variables, with the exception of *BaseFin*, *Quality*, *CovProch*, and *ENERGYSTAR*, are scale variables. Variables appearing with a subscript ''d'' are considered dummy variables. These variables were measured in binary terms, whether or not a feature is present. For dummy variables, a value of 1 was given if the feature was present and 0 if the feature

Exhibit 2 | Independent Variables and Expected Sign of Coefficient

Variable	Description	Expected Relationship
Age	Age of home in years	−
TotalSF	Total finished square feet of home	+
LotSF	Size of lot in square feet	+
BaseSF	Total basement square feet	+
$BaseFin_{(d)}$	Whether or not home has finished basement	+
Stories	Number of stories	+ / −
Bedrooms	Number of bedrooms	+
Bathrooms	Number of bathrooms	+
$Quality_{(d)}$	Superior quality of construction	+
$CovPorch_{(d)}$	Whether or not home has covered porch	+
GarageSF	Total garage square feet	+
$ENERGYSTAR_{(d)}$	Whether or not home is ENERGY STAR® qualified	+

Note: A subscript *d* represents a dummy variable.

Exhibit 3 | Regression Coefficients and *P*-Values

Variable	Coeff.	*p*-Value
Age	−3.981***	<.001
LotSF	0.002***	.001
TotalSF	−0.038***	<.001
BaseSF	0.018***	<.001
$BaseFin_{(d)}$	0.395	.912
Stories	−6.594	.069
Bedrooms	−0.065	.969
Bathrooms	4.765	.057
Quality	5.830**	.013
$CovPorch_{(d)}$	−3.141	.362
GarageSF	0.043***	<.001
$ENERGYSTAR_{(d)}$	8.664**	.005
R^2	73.5%	

Notes: A subscript *d* represents a dummy variable.
* $p < .05$
** $p < .01$
*** $p < .001$

was absent. The variable *Quality* is based on the quality indicator included in the county assessor's records.

Independent variables with a positive *Expected Relationship* are expected to increase house value as buyers are expected to pay more for houses with these amenities. *Age*, the only variable with a negative coefficient, is expected to have a negative effect on house value as buyers are expected to pay less for older homes (Exhibit 3). *Number of stories* does not have a predictable coefficient as the decision to buy a ranch or two-story house is presumably a decision of preference, not superiority. The *quality* variable is a seemingly subjective judgment of home construction, yet it is expected to be a strong indicator of home value. Quality ratings were provided within the county assessor's data. Homes could be rated as poor, average, or good. All of the homes in the data set were rated as being either of average or good quality.

Results

The result of the regression analysis for the independent variables identified in Exhibit 2 and the dependent variable *sales price* was statistically significant at $p < .01$. The R^2 value was .735, indicating that 74% of the market valuation variation could be explained by the model. The effect size for the model was large ($r = .857$) and it had good internal reliability as evidenced by a Cronbach's alpha of .317. The absolute coefficient (β) values for the independent variables included in the model ranged from a low of 0.018 to a high of 8.664. Independent variables with beta approaching zero essentially have minimal effect on the *sales price*, while variables with larger beta have a greater impact on *sales price*.

Almost all of the non-energy coefficients have the expected signs with the exception of *TotalSF* and *Bedrooms*; the latter of which is not statistically significant ($p = .969$). The coefficient of the *ENERGYSTAR* variable was statistically significant at $p < .01$. The beta of the *ENERGY STAR* variable is 8.664, higher than any other predictor variable.

TotalSF, one variable that would seem to be a strong predictor of home value, had a surprisingly negative coefficient, as well as a significant *p*-value. This may be because *TotalSF* is strongly correlated with other variables (e.g., *LotSF* and *Quality*) and that there might be a diminishing point of return for additional square footage (Nevin and Watson, 1998). Another possible reason for this result is that homebuyers that are more aware of the environmental impact of buildings may place more value on a smaller home that uses less materials and is more energy efficient. *Bedrooms* did not have a significant effect on sale price, even though this is typically a significant factor in residential pricing. Again, this may be due to inefficiency in recognizing collinearity. Future studies might benefit from considering and testing for collinearity and providing an approach to account for such correlation.

Two important limitations of these results were the exclusion of a location variable and the use of only ENERGY STAR rated homes. The model used in this study

did not address locational effects on home price. The data set used did not include quantifiable information on the market effect of locational variation. Instead, the researchers controlled for locational impacts by identifying comparables homes based proximity to ENERGY STAR certified homes. Had a locational variable been included in the data set, it is expected that the beta for *ENERGYSTAR* would be lessened but would not change from a positive to a negative relationship. Additionally, it would be expected that a significant amount of collinearity would exist between a locational variable and the *ENERGYSTAR* variable (and possibility *AGE*) since all of the homes were located in fairly new neighborhoods. It is recommended that future studies include a locational variable.

Further, employing the ENERGY STAR label and accompanying home energy rating as the determinant and measure of home energy efficiency does not take into account that homes without the ENERGY STAR label may have an equal or greater degree of energy efficiency. The purpose of focusing on ENERGY STAR homes was simplify the identification of energy efficient homes as this was identified as a significant challenge in previous studies. Additionally, identification of energy-efficient homes without third-party certification by either homebuyers or appraisers would require thorough understanding of design and construction strategies by homebuyers (or appraisers) as homes may be marketed as energy efficient when in fact they are not (Adomatis, 2010). Therefore, this study focused only on ENERGY STAR labeled homes. The purpose of this study, however, was to test the impact of third-party certification of home energy efficiency on market prices paid by consumers. In the area where this study was conducted, the results provide further support for added contributory value in the assessment of a certified energy-efficient home.

Conclusion

Although significant awareness exists on the impact of energy consumption by the U.S. residential sector, adoption of energy-efficient residential designs has been slow. Of most concern to homebuilders is the perception that the added costs related to increased energy-efficient design and construction will not be recognized when the home is sold (Galuppo and Tu, 2010). This concern has persisted even though prior studies have provided empirical evidence of consumers who recognize the contributory value of increased energy efficiency. These past studies, however, used measures of energy efficiency that were not easily replicable or recognizable by homebuyers, appraisers, or homebuilders. In recent years, several third-party certifications have become available that can be used to address this shortcoming of prior studies. Third-party certification can be used to document the incorporation of design and construction techniques (Adomatis, 2010). One well-established certification is the EPA's ENERGY STAR labeling for homes. By incorporating ENERGY STAR certification into a hedonic regression analysis of sales prices for homes in Fort Collins, Colorado, this study provides a much needed update on homebuyers' willingness to pay for increased energy efficiency.

The model tested in this study and which incorporated ENERGY STAR certification had an R^2 of 74%, consistent with the range of R^2 values for similar

models (see Exhibit 1), which ranged from a low of 0.41 to a high of 0.86. These results support the hypothesis that ENERGY STAR rated homes will have higher sales prices than comparable non-ENERGY STAR homes in the study area. Results indicate that ENERGY STAR homes originally sold for $8.66 more per square foot than non-ENERGY STAR homes in the study area.

This study provides additional empirical evidence that homebuyers recognize the contributory value of increased energy efficiency. There is also evidence that the use of a third-party certification such as the ENERGY STAR rating system is valued by residential consumers. As similar assessment tools of residential energy efficiency (e.g., USGBC's LEED for Homes or the NAHB's National Green Building Standard) become more prevalent, similar cost premiums will be found for those homes as well. Further analysis, however will be needed to verify these predictions across other residential energy assessment tools. As additional studies are conducted, their combined results should strengthen the market for energy-efficient homes that are third-party certified. This, in turn should result in an increased percentage of new homes that are designed and constructed to be more energy efficient and an overall reduction in the energy consumption of the U.S. residential sector.

Appendix A

Review of Hedonic Studies

Study	Market Area, Time Period, and Types of Homes Included	Sample Size	Age of Homes in Sample
Halvorsen, R. and H.O. Pollakowski. The Effects of Fuel Prices on House Prices. *Urban Studies*, 1981, 18, 2, 205–11.	Oil and gas heated homes in Greenwood neighborhood in Seattle, Washington sold from 1970 to 1975.	269	Mean age not given
Corgel, J.B., P.R. Goebel, and C.E. Wade. Measuring Energy Efficiency for Selection and Adjustment of Comparable Sales. *The Appraisal Journal*, 1982, January, 71–8.	Single-family homes in Lubbock, Texas sold from 1978 to 1979.	100	Mean age not given
Johnson, R.C. and D.L. Kaserman. Housing Market Capitalization of Energy-saving Durable Good Investments. *Economic Inquiry*, 1983, 21, 374–86.	Electricity or natural gas-heated, single-family detached homes in Knox County, Tennessee sold in 1978.	1,317	Mean = 14 years Standard Deviation = 13 years
Longstreth, M. (1986). Impact of Consumers' Personal Characteristics on Hedonic Prices of Energy-conserving Durables. *Energy,* 1986, 11:9, 893–905.	Gas-heated, single-family detached homes in Columbus, Ohio SMSA sold from 1971 to 1978.	505	Mean = 22 years Std. Dev. = 15 years
Laquatra, J. Housing Market Capitalization of Thermal Integrity. *Energy Economics*, 1986, 8, 3, 134–38.	Newly built "Energy Efficient Housing Demonstration Program" homes in Minneapolis, Minnesota from 1980 to 1981.	81	New homes only

Appendix A (continued)

Review of Hedonic Studies

Study	Market Area, Time Period, and Types of Homes Included	Sample Size	Age of Homes in Sample
Dinan, T.M. and J.A. Miranowski. Estimating the Implicit Price of Energy Efficiency Improvements in the Residential Housing Market: A Hedonic Approach. *Journal of Urban Economics*, 1989, 25, 52–67.	Single-family detached homes in Des Moines, Iowa sold from January 1982 to June 1982.	234	Mean = 30 years Std. Dev. = 22 years
Horowitz, M.J. and H. Haeri. Economic Efficiency v. Energy Efficiency—Do Model Conservation Standards Make Good Sense? *Energy Economics*, 1990, 122–31.	42 nearly-new, electrically-heated homes in Tacoma City Light service district in Seattle, Washington built to the Model Conservation Standards (MCS) resold from 1983–1985, and 25 nearly new, electrically-heated control homes in the same area resold from 1983 to 1985.	67 (45 MCS and 25 control)	Nearly new homes
Nevin, R. and G. Watson. Evidence of Rational Market Values for Home Energy Efficiency. *The Appraisal Journal*, 1998, 401–09.	Electrically, piped gas or fuel oil-heated, single-family homes in American Housing Survey (AHS) national data from 1991, 1993, and 1995, and AHS metropolitan data from 1992 to 1996.	15,000+	Mean age not given

Note: The source is Dacquisto, Emrath, Laquatra, and Laitner (2001).

Appendix B

Variables Used in Hedonic Studies

Reference	Halvorsen & Pollakowski (1981)	Corgel, Goebel, & Wade (1982)	Johnson & Kaserman (1983)	Longstreth (1986)	Laquatra (1986)	Dinan & Miranowski (1989)	Horowitz & Haeri (1990)	Nevin & Watson (1998)
Dependent Variable	*Sale Price*	*Sale Price*	*Sale Price*	*Sale Price/Sf*	*Sale Price*	*Sale Price*	*Sale Price*	Occupant-Estimated Market Value
Independent Variables	—	*Area* (sf) *Age* (yrs) *# of bathrooms* *2-car garage* (D) *Central air conditioning* (D) *Date* (month of sale = 100–112) *Fireplace* (D) *Brick veneer* (D) *Cedar roof* (D) *Infra* (D)	*Util* ($/yr, ending) *Size* (sf) *Age* (yrs) *# of bathrooms* *Ranch* (D) *Split foyer* (D) *2-Story* (D) *Brick* (D) *Carport* (D) *Garage–1car* (D) *Garage–2car+* (D) *Patio* (D) *Deck* (D) *Paved drive* (D) *Fireplace* (D) *Unit air* (D) *Central air* (D) *A index* (D) *Census increase from 78% black within census tract* *Population density* *City lot* (sf)	*House size* (sf) *# of bathrooms* *# of stories* *House age* (yrs) *Distance to central business district* *Pupils per teacher* *Sale year* *Ceiling insulation* *Wall insulation* *Wood or vinyl window frames*	*Area* (sf) *Lot size* (sf) *Duplex* (D) *Attached* (D) *Thermal integrity factor* *Median house value for census tract* *Per pupil expenditure* *Mean commute for census tract* *Distance to interstate ramp*	*Floor area* (sf) *# of bedrooms* *# of bathrooms* *Family room* (D) *Dining room* *Lot* (100 sf) *Dishwasher* (D) *Central air conditioning* (D) *Window air conditioning* (D) *Garage–1 car* *Garage–2 car* *Garage* (D) *Fireplace* (D) *Age* (yrs) *Census income* *Basement* (D) *Miles from central business district*	*Floor area* (sf) *Heat pump* (D) *# of bathrooms* *Fireplace* (D) *Wood/tile roof* (D) *Note: A second regression with different sample used to estimate electricity use:* *Model Conservation Standards* (D) *Floor area* (sf) *Household size* *Household income* *Wood stove* (D) *Electric blanket or bed heaters* (D) *Central thermostat* (D) *Dishwasher* (D) *Electric dryer* (D) *# TVs/computers* *Electric water for tub/sauna* (D)	*Unit* (sf) *Lot size* (sf) *Age* (years) *# of rooms* *Total utilities* (all fuels) *Lot size* *Unit size times total utility* *# of rooms times total utility* *Garage* (D) *Porch* (D) *Central air conditioning* (D) *South* (D) *West* (D) *Midwest* (D) *Urban* (D) *Rural* (D)

Appendix B (continued)

Variables Used in Hedonic Studies

Reference	Halvorsen & Pollakowski (1981)	Corgel, Goebel, & Wade (1982)	Johnson & Kaserman (1983)	Longstreth (1986)	Laquatra (1986)	Dinan & Miranowski (1989)	Horowitz & Haeri (1990)	Nevin & Watson (1998)
Dependent Variable	*Sale Price*	*Sale Price*	*Sale Price*	*Sale Price/Sf*	*Sale Price*	*Sale Price*	*Sale Price*	Occupant-Estimated Market Value
Method of Measuring Energy Efficiency	Fuel type used to heat home (natural gas or oil)	Existence of either a cold roof (energy efficient) or a warm roof (not energy efficient)	Utility bills	Inches of insulation, presence of storm windows and/or thermopane glass, presence of wood/vinyl window frames	Thermal Integrity Factor = annual heating load for the house, measured in Btu/sf of heated floorspace/heating degree day	Utility bills/sf	Construction to meet Model Conservation Standards	Utility bills

Notes: The source is Dacquisto, Emrath, Laquatra, and Laitner (2001).
sf = square feet
yrs = years
D = Dummy, or indicator variable

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State Energy Price and Expenditure Estimates

1970 Through 2009

Independent Statistics & Analysis
U.S. Energy Information Administration

Table ET1. Primary Energy, Electricity, and Total Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy																		
	Coal			Coal Coke			Petroleum								Biomass				
	Coking Coal	Steam Coal	Total	Exports	Imports	Natural Gas [a]	Distillate Fuel Oil	Jet Fuel [b]	LPG [c]	Motor Gasoline [d]	Residual Fuel Oil	Other [e]	Total	Nuclear Fuel	Wood and Waste [f,g]	Total [g,h,i,j]	Electric Power Sector [h,j]	Retail Electricity	Total Energy [g,h,j]
	Prices in Dollars per Million Btu																		
1970	0.45	0.36	0.38	1.27	0.93	0.59	1.16	0.73	1.43	2.85	0.42	1.38	1.71	0.18	1.29	1.08	0.32	4.98	1.65
1975	1.65	0.90	1.03	2.37	3.47	1.18	2.60	2.05	2.93	4.65	1.93	2.94	3.34	0.24	1.50	2.19	0.97	8.61	3.33
1980	2.10	1.38	1.46	2.54	3.19	2.86	6.70	6.36	5.59	9.84	3.88	7.04	7.40	0.43	2.26	4.57	1.77	13.95	6.89
1985	2.03	1.67	1.69	2.76	2.99	4.61	7.22	5.91	6.55	9.01	4.30	7.55	7.63	0.71	2.47	4.92	1.91	19.05	8.37
1990	1.79	1.48	1.49	3.53	3.80	3.82	7.68	5.68	6.72	9.12	3.17	5.82	7.47	0.67	1.32	4.45	1.48	19.32	8.24
1995	1.76	1.35	1.37	2.71	3.43	3.73	6.98	4.00	6.51	9.22	2.46	5.74	7.28	0.54	1.40	4.23	1.29	20.29	8.28
1996	1.77	1.32	1.33	2.20	3.87	4.25	7.87	4.82	7.98	9.85	2.80	6.20	8.01	0.51	1.25	4.63	1.35	20.16	8.75
1997	1.79	1.30	1.32	2.64	3.25	4.53	7.66	4.53	7.39	9.81	2.93	5.89	7.86	0.51	1.15	4.66	1.38	20.13	8.80
1998	1.69	1.28	1.29	3.73	3.07	4.13	6.57	3.35	5.95	8.45	2.15	5.02	6.63	0.50	1.27	4.08	1.32	19.80	8.20
1999	1.69	1.25	1.27	3.88	2.83	4.16	7.19	4.01	6.60	9.31	2.51	5.30	7.33	0.48	1.34	4.37	1.33	19.52	8.53
2000	1.67	1.23	1.24	3.64	2.66	5.62	9.86	6.64	9.55	11.89	4.32	7.04	9.82	0.46	1.58	5.70	1.71	20.03	10.28
2001	1.74	1.27	1.29	3.27	3.04	6.87	9.18	5.72	9.54	11.34	3.99	6.41	9.32	0.44	2.08	5.83	1.85	21.41	10.73
2002	1.94	1.28	1.30	3.25	3.04	5.31	8.64	5.33	8.09	10.69	3.91	6.59	8.83	0.43	2.19	5.25	1.54	21.15	10.06
2003	1.93	1.30	1.32	3.88	3.49	7.08	10.05	6.46	10.32	12.34	4.75	7.62	10.31	0.42	1.98	6.28	1.84	21.85	11.42
2004	2.31	1.39	1.41	3.28	7.23	7.91	12.23	8.93	12.24	14.67	4.92	8.56	12.27	0.42	2.17	7.37	2.00	22.38	12.87
2005	3.19	1.58	1.62	3.39	8.92	9.92	16.41	12.86	14.58	17.89	6.65	10.98	15.53	0.43	3.10	9.24	2.61	23.92	15.55
2006	3.54	1.73	1.78	3.19	6.31	9.62	18.55	14.80	16.85	20.27	7.93	13.37	17.92	0.44	3.15	10.21	2.48	26.15	17.36
2007	3.64	1.83	1.88	3.66	7.84	9.31	R 19.87	16.01	18.76	22.01	8.57	R 14.94	R 19.47	0.46	3.36	R 10.75	2.68	26.84	18.24
2008	4.49	2.15	2.21	4.33	18.76	R 10.83	R 26.33	22.56	23.35	25.53	12.64	R 18.83	R 24.18	0.47	3.71	R 12.93	3.21	28.64	R 21.37
2009	5.43	2.26	2.33	4.17	10.82	7.66	16.98	12.61	16.38	18.51	9.69	14.29	16.86	0.55	3.30	9.37	2.44	28.90	17.03
	Expenditures in Million Dollars																		
1970	1,175	3,455	4,630	78	4	10,891	6,253	1,441	2,395	31,596	2,046	4,172	47,904	44	438	63,872	-4,357	23,345	82,860
1975	3,692	9,329	13,021	75	156	20,061	15,680	4,193	5,157	59,446	10,374	8,493	103,343	448	534	137,638	-16,545	50,680	171,773
1980	3,753	18,853	22,607	130	52	51,061	40,797	13,923	10,823	124,408	21,573	26,049	237,573	1,189	1,232	314,176	-38,027	98,095	374,244
1985	2,228	27,450	29,678	77	43	72,938	43,972	14,747	13,580	118,048	11,493	22,088	223,929	2,878	1,597	R 332,913	-43,970	149,233	R 438,176
1990	1,862	26,740	28,602	50	72	65,278	49,335	17,784	13,631	126,558	8,721	19,255	235,284	4,104	1,997	R 336,379	-40,626	176,691	R 472,444
1995	1,558	25,874	27,431	91	325	75,020	47,533	12,526	16,197	136,647	4,676	19,225	236,803	3,810	2,938	347,144	-39,073	205,876	513,947
1996	1,507	26,521	28,028	88	244	86,904	56,455	15,770	21,086	148,344	5,313	21,144	268,112	3,624	2,668	390,437	-41,652	211,105	559,890
1997	1,453	26,825	28,277	83	253	93,382	55,922	15,000	19,781	149,668	5,206	21,631	267,208	3,369	2,425	395,817	-42,947	213,843	566,714
1998	1,304	26,585	27,888	104	292	83,620	48,350	11,239	15,241	132,730	4,280	19,835	231,675	3,555	2,477	350,464	-43,311	218,361	525,515
1999	1,306	26,003	27,310	86	226	84,960	54,565	13,878	19,038	149,260	4,686	21,250	262,676	3,643	2,659	382,668	-44,689	218,413	556,392
2000	1,327	26,752	28,080	103	249	119,094	78,209	23,777	27,970	192,153	8,870	26,496	357,475	3,628	3,194	514,398	-60,054	231,577	685,922
2001	1,247	26,956	28,202	109	191	139,388	75,035	19,602	25,543	185,752	7,266	23,097	336,294	3,524	3,494	513,673	-64,672	245,483	694,484
2002	1,258	27,254	28,511	64	244	111,368	69,285	17,802	22,980	179,796	6,156	24,167	320,185	3,504	4,005	468,877	-54,230	247,598	662,246
2003	1,283	28,119	29,402	70	239	144,489	83,873	21,096	28,161	209,493	8,325	28,061	379,010	3,362	3,599	561,401	-64,685	R 257,992	R 754,708
2004	1,499	30,265	31,764	107	1,232	162,702	105,772	30,219	34,408	254,873	9,717	35,212	470,200	3,445	3,692	674,543	-71,720	R 268,133	R 870,956
2005	1,964	34,969	36,932	147	780	200,303	143,598	44,679	38,874	312,047	13,951	44,136	597,285	3,469	5,896	847,031	-95,975	R 295,787	R 1,046,843
2006	2,132	37,873	40,005	128	636	190,382	164,399	50,007	45,355	357,286	12,432	52,986	682,465	3,637	6,108	925,627	-90,104	R 323,962	R 1,159,485
2007	2,175	40,541	42,717	131	478	196,868	R 177,172	53,754	51,081	389,282	14,129	R 55,211	R 740,628	3,871	6,404	R 994,035	-100,719	R 340,925	R 1,234,240
2008	2,606	46,832	49,438	210	1,676	R 230,305	R 221,435	72,046	R 59,875	438,237	R 17,984	R 61,417	R 870,993	3,976	6,926	R 1,166,660	-118,545	R 360,570	R 1,408,685
2009	2,192	43,632	45,824	135	93	159,235	131,050	36,353	43,466	317,088	11,310	39,228	578,496	4,560	5,083	795,310	-84,496	350,438	1,061,252

[a] Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.
[b] Through 2004, includes kerosene-type and naphtha-type jet fuel. Beginning in 2005, includes kerosene-type jet fuel only; naphtha-type jet fuel is included in "Other Petroleum."
[c] Liquefied petroleum gases.
[d] Beginning in 1993, includes fuel ethanol blended into motor gasoline.
[e] Includes asphalt and road oil, aviation gasoline, kerosene, lubricants, and the other petroleum products as described in the Technical Notes, Section 4, "Other Petroleum Products."
[f] Wood, wood-derived fuels, and biomass waste. Prior to 2001, includes non-biomass waste.
[g] There is a discontinuity in this time series between 1988 and 1989 due to the expanded coverage of the use of wood and biomass waste beginning in 1989.
[h] There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.
[i] From 1981 through 1992, includes fuel ethanol blended into motor gasoline that is not included in the motor gasoline column.
[j] Electricity imports are included in total primary energy and electric power sector but are not shown separately.
Where shown, R = Revised data.
Note: Expenditure totals may not equal sum of components due to independent rounding.
Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.
Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET2. Total End-Use Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy													Retail Electricity	Total Energy [g,h,i]
	Coal	Coal Coke		Natural Gas [a]	Petroleum							Biomass	Total [g,h,i]		
		Exports	Imports		Distillate Fuel Oil	Jet Fuel [b]	LPG [c]	Motor Gasoline [d]	Residual Fuel Oil	Other [e]	Total	Wood and Waste [f,g]			
	Prices in Dollars per Million Btu														
1970	0.48	1.27	0.93	0.68	1.18	0.73	1.43	2.85	0.44	1.39	1.82	1.30	1.31	4.98	1.65
1975	1.51	2.37	3.47	1.28	2.62	2.05	2.93	4.65	1.86	2.94	3.50	1.51	2.65	8.61	3.33
1980	1.87	2.54	3.19	3.05	6.72	6.36	5.59	9.84	3.60	7.04	7.67	2.26	5.84	13.95	6.89
1985	1.91	2.76	2.99	4.91	7.24	5.91	6.55	9.01	4.33	7.57	7.75	2.51	6.49	19.05	8.37
1990	1.70	3.53	3.80	4.17	7.72	5.68	6.72	9.12	3.07	5.87	7.64	1.58	6.14	19.32	8.24
1995	1.63	2.71	3.43	4.20	7.02	4.00	6.51	9.22	2.41	5.86	7.40	1.47	5.93	20.29	8.28
1996	1.62	2.20	3.87	4.62	7.92	4.82	7.98	9.85	2.69	6.33	8.14	1.38	6.52	20.16	8.75
1997	1.62	2.64	3.25	4.96	7.71	4.53	7.39	9.81	3.00	6.03	8.00	1.31	6.56	20.13	8.80
1998	1.58	3.73	3.07	4.64	6.63	3.35	5.95	8.45	2.21	5.16	6.81	1.44	5.79	19.80	8.20
1999	1.58	3.88	2.83	4.65	7.25	4.01	6.60	9.31	2.62	5.44	7.50	1.57	6.25	19.52	8.53
2000	1.55	3.64	2.66	5.98	9.93	6.64	9.55	11.89	4.48	7.22	10.00	1.84	8.24	20.03	10.28
2001	1.63	3.27	3.04	7.49	9.25	5.72	9.54	11.34	4.24	6.57	9.52	2.27	8.43	21.41	10.73
2002	1.75	3.25	3.04	5.96	8.68	5.33	8.09	10.69	3.99	6.89	8.98	2.33	7.66	21.15	10.06
2003	1.74	3.88	3.49	7.65	10.12	6.46	10.32	12.34	5.04	7.97	10.52	2.06	9.15	21.85	11.42
2004	1.99	3.28	7.23	8.64	12.28	8.93	12.24	14.67	5.19	9.00	12.54	2.34	10.83	22.38	12.87
2005	2.55	3.39	8.92	10.64	16.47	12.86	14.58	17.89	6.51	11.62	15.84	3.31	13.66	23.92	15.55
2006	2.81	3.19	6.31	10.91	18.59	14.80	16.85	20.27	7.87	14.06	18.12	3.31	15.36	26.15	17.36
2007	2.90	3.66	7.84	10.40	19.91	16.01	18.76	22.01	8.44	15.59	19.68	3.40	16.26	26.84	18.24
2008	3.49	4.33	18.76	11.68	26.38	22.56	23.35	25.53	12.47	19.67	24.36	4.07	19.66	28.64	21.37
2009	3.84	4.17	10.82	9.13	17.01	12.61	16.38	18.51	9.82	14.97	16.98	3.65	14.16	28.90	17.03
	Expenditures in Million Dollars														
1970	2,393	78	4	9,741	6,173	1,441	2,395	31,596	1,249	4,166	47,021	435	59,516	23,345	82,860
1975	5,843	75	156	17,639	15,222	4,150	5,157	59,446	4,532	8,491	96,998	532	121,093	50,680	171,773
1980	6,157	130	52	42,705	39,893	13,856	10,823	124,408	11,127	26,035	226,142	1,224	276,149	98,095	374,244
1985	5,622	77	43	62,119	43,470	14,747	13,580	118,048	7,262	22,080	219,187	1,585	288,943	149,233	438,176
1990	4,932	50	72	57,469	48,794	17,784	13,631	126,558	4,879	19,230	230,876	1,889	295,753	176,691	472,444
1995	4,293	91	325	66,251	47,083	12,526	16,197	136,647	3,211	19,169	234,832	2,461	308,071	205,876	513,947
1996	4,166	88	244	76,517	55,905	15,770	21,086	148,344	3,414	21,087	265,606	2,340	348,785	211,105	559,890
1997	4,122	83	253	81,793	55,421	15,000	19,781	149,668	3,192	21,533	264,595	2,190	352,870	213,843	566,714
1998	3,748	104	292	72,096	47,880	11,239	15,241	132,730	2,097	19,752	228,939	2,183	307,153	218,361	525,515
1999	3,643	86	226	72,057	53,988	13,878	19,038	149,260	2,382	21,181	259,727	2,412	337,979	218,413	556,392
2000	3,656	103	249	94,990	77,009	23,777	27,970	192,153	5,308	26,449	352,666	2,887	454,344	231,577	685,922
2001	3,742	109	191	110,770	73,984	19,602	25,543	185,752	3,475	22,997	331,352	3,055	449,001	245,483	694,484
2002	3,700	64	244	90,529	68,559	17,802	22,980	179,796	3,657	24,067	316,861	3,376	414,648	247,598	662,246
2003	3,715	70	239	115,983	82,773	21,096	28,161	209,493	4,441	27,955	373,920	2,930	496,716	257,992	754,708
2004	4,288	107	1,232	129,269	104,845	30,219	34,408	254,873	5,693	35,037	465,074	3,067	602,823	268,133	870,956
2005	5,248	147	780	150,496	142,282	44,679	38,874	312,047	7,942	43,897	589,721	4,957	751,056	295,787	1,046,843
2006	5,580	128	636	146,166	163,345	50,007	45,355	357,286	9,504	52,717	678,214	5,054	835,523	323,962	1,159,485
2007	5,640	131	478	146,872	175,783	53,754	51,081	389,282	10,566	54,948	735,413	5,042	893,315	340,925	1,234,240
2008	6,533	210	1,676	168,396	219,868	72,046	59,875	438,237	14,744	61,127	865,896	5,825	1,048,115	360,570	1,408,685
2009	5,625	135	93	125,498	130,112	36,353	43,466	317,088	9,685	39,004	575,708	4,025	710,814	350,438	1,061,252

[a] Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.

[b] Through 2004, includes kerosene-type and naphtha-type jet fuel. Beginning in 2005, includes kerosene-type jet fuel only; naphtha-type jet fuel is included in "Other Petroleum."

[c] Liquefied petroleum gases.

[d] Beginning in 1993, includes fuel ethanol blended into motor gasoline.

[e] Includes asphalt and road oil, aviation gasoline, kerosene, lubricants, and the other petroleum products as described in the Technical Notes, Section 4, "Other Petroleum Products."

[f] Wood, wood-derived fuels, and biomass waste. Prior to 2001, includes non-biomass waste.

[g] There is a discontinuity in this time series between 1988 and 1989 due to the expanded coverage of the use of wood and biomass waste beginning in 1989.

[h] There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.

[i] For 1981 through 1992 expenditures, total includes fuel ethanol blended into gasoline that is not shown in the motor gasoline column.

Where shown, R = Revised data.

Notes: Price estimates are weighted averages of price estimates and expenditure estimates are the sum of expenditure estimates for the residential, commercial, industrial, and transportation sectors. • Expenditure totals may not equal sum of components due to independent rounding.

Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.

Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET3. Residential Sector Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy								Retail Electricity	Total Energy [d]
			Petroleum				Biomass			
	Coal	Natural Gas [a]	Distillate Fuel Oil	Kerosene	LPG [b]	Total	Wood [c]	Total [d]		
	Prices in Dollars per Million Btu									
1970	1.14	1.06	1.39	1.54	2.08	1.54	0.66	1.22	6.51	2.10
1975	2.45	1.67	2.74	3.14	3.96	3.01	1.31	2.11	10.29	3.80
1980	2.90	3.60	7.02	8.32	7.82	7.24	3.10	4.50	15.71	7.46
1985	3.26	5.94	7.93	7.90	8.98	8.13	3.71	6.37	21.66	10.91
1990	3.01	5.63	8.01	7.46	10.79	8.66	3.59	6.21	22.96	11.87
1995	2.58	5.89	6.52	5.74	10.62	7.61	2.88	6.13	24.63	12.62
1996	2.53	6.16	7.47	6.33	12.04	8.79	3.30	6.60	24.50	12.72
1997	2.48	6.75	7.45	6.29	11.99	8.77	3.24	7.06	24.71	13.29
1998	2.46	6.61	6.44	5.25	10.79	7.70	2.80	6.72	24.21	13.47
1999	2.37	6.50	6.61	5.73	10.67	7.94	2.87	6.71	23.93	13.18
2000	2.24	7.64	9.92	9.13	14.26	11.36	4.32	8.37	24.14	14.26
2001	2.93	9.42	9.48	8.81	15.59	11.46	4.22	9.75	25.16	15.67
2002	2.59	7.69	8.60	8.26	13.17	10.20	3.83	8.12	24.75	14.69
2003	2.46	9.24	10.32	9.83	15.50	12.09	4.60	9.73	25.56	15.85
2004	3.03	10.47	11.72	11.33	17.56	13.59	5.22	11.01	26.22	17.06
2005	3.46	12.34	15.53	14.76	20.29	17.10	6.96	13.22	27.68	19.20
2006	3.51	13.35	17.89	18.59	22.83	19.66	8.02	14.48	30.49	21.54
2007	3.50	12.72	19.62	21.27	24.93	21.65	8.80	14.34	31.22	21.62
2008	4.62	R 13.52	24.36	25.55	29.36	26.53	10.93	R 15.88	33.01	R 23.13
2009	4.57	11.81	18.14	22.00	25.43	21.49	8.14	13.46	33.72	22.13
	Expenditures in Million Dollars									
1970	236	5,272	2,603	459	1,124	4,186	68	9,761	10,352	20,112
1975	153	8,410	4,954	504	1,964	7,422	143	16,128	20,644	36,771
1980	90	17,497	9,234	887	2,331	12,451	678	30,716	38,458	69,174
1985	127	27,136	8,667	1,252	2,650	12,570	944	40,776	58,672	99,448
1990	93	25,439	7,839	477	3,591	11,907	878	38,317	72,378	110,696
1995	45	29,362	5,903	426	3,960	10,289	657	40,352	87,610	127,961
1996	41	33,219	6,920	562	5,314	12,796	781	46,837	90,503	137,340
1997	39	34,590	6,516	584	5,139	12,239	630	47,497	90,704	138,201
1998	31	30,875	4,975	569	4,309	9,852	484	41,242	93,360	134,602
1999	33	31,577	5,471	637	5,289	11,397	522	43,529	93,482	137,012
2000	24	38,959	8,980	864	7,440	17,283	843	57,109	98,209	155,319
2001	32	46,189	8,610	837	7,721	17,169	694	64,083	103,158	167,241
2002	31	38,490	7,393	495	6,661	14,549	639	53,709	106,834	160,542
2003	30	48,278	9,334	691	7,984	18,010	807	67,125	111,249	178,374
2004	35	52,265	10,830	961	8,474	20,264	940	73,503	115,577	189,080
2005	29	61,196	13,261	1,237	9,822	24,320	1,248	86,793	128,393	215,186
2006	22	59,834	12,738	1,233	9,559	23,531	1,309	84,695	140,582	225,277
2007	27	61,598	14,247	934	11,287	26,468	1,582	89,675	148,295	237,970
2008	37	R 67,851	R 16,297	544	15,231	R 32,071	2,056	R 102,015	155,433	R 257,448
2009	33	57,839	10,912	609	12,904	24,425	1,463	83,760	157,008	240,768

[a] Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.
[b] Liquefied petroleum gases.
[c] Wood and wood-derived fuels.
[d] There are no direct fuel costs for geothermal, photovoltaic, or solar thermal energy.

Where shown, R = Revised data.
Note: Expenditure totals may not equal sum of components due to independent rounding.
Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.
Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET4. Commercial Sector Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy										Retail Electricity	Total Energy [f,g,h]
			Petroleum						Biomass			
	Coal	Natural Gas [a]	Distillate Fuel Oil	Kerosene	LPG [b]	Motor Gasoline [c]	Residual Fuel Oil	Total [d]	Wood and Waste [e,f]	Total [f,g,h]		
	Prices in Dollars per Million Btu											
1970	0.44	0.75	1.10	0.77	1.26	2.86	0.45	0.91	0.66	0.80	6.09	1.97
1975	1.31	1.32	2.42	2.32	2.62	4.66	1.91	2.40	1.31	1.68	10.11	4.07
1980	1.53	3.32	6.45	6.46	5.19	9.77	4.12	5.64	3.10	4.01	16.06	7.83
1985	1.77	5.34	6.33	8.18	9.43	9.01	4.50	6.50	3.71	5.54	21.30	11.64
1990	1.64	4.70	5.97	7.31	9.29	9.15	3.41	6.07	3.02	4.94	21.20	11.88
1995	1.55	4.94	4.70	5.55	9.42	9.40	3.14	5.18	2.25	4.85	22.29	12.63
1996	1.51	5.26	5.63	6.40	10.75	10.28	3.75	6.23	2.47	5.30	22.17	12.77
1997	1.51	5.67	5.28	6.18	10.97	10.01	3.27	6.16	2.43	5.59	22.03	13.04
1998	1.51	5.38	4.15	4.88	9.95	8.73	2.38	5.14	2.09	5.20	21.48	13.06
1999	1.51	5.22	4.65	5.33	9.71	9.45	2.69	5.62	1.89	5.15	21.01	12.86
2000	1.45	6.56	7.48	8.87	12.70	11.94	4.49	8.36	2.99	6.75	21.52	13.92
2001	1.57	8.32	6.70	8.38	13.72	11.50	4.06	7.96	3.22	8.05	22.99	15.56
2002	1.63	6.49	6.21	8.14	11.20	10.81	4.08	7.23	2.81	6.47	22.81	14.67
2003	1.59	8.07	7.62	9.80	13.23	12.26	5.30	8.71	3.48	8.01	23.54	15.64
2004	1.84	9.19	9.58	11.41	15.37	14.44	5.26	10.27	3.54	9.14	23.95	16.57
2005	2.25	10.98	13.63	14.96	17.95	17.86	7.48	13.68	4.67	11.19	25.40	18.61
2006	2.37	11.60	15.74	18.73	20.11	20.20	8.69	16.09	4.72	12.14	27.72	20.65
2007	2.47	10.98	17.24	21.13	22.19	21.94	9.71	17.73	5.54	11.87	28.27	20.75
2008	2.84	11.89	R 23.86	25.57	26.26	25.46	13.19	23.31	6.58	13.48	30.38	R 22.47
2009	3.10	9.69	14.66	21.91	21.04	18.41	9.88	15.68	4.73	10.52	29.81	20.69
	Expenditures in Million Dollars											
1970	72	1,844	646	47	177	247	323	1,440	1	3,358	7,319	10,678
1975	191	3,385	1,423	114	329	415	939	3,219	3	6,799	16,157	22,956
1980	179	8,858	3,337	262	438	1,046	2,325	7,409	17	16,463	30,611	47,074
1985	243	13,368	3,995	268	842	866	1,025	6,996	22	20,633	50,092	70,725
1990	203	12,681	3,199	87	898	1,018	785	5,986	104	18,979	60,627	79,605
1995	181	15,383	2,250	123	967	170	445	3,956	106	19,625	72,481	92,106
1996	181	17,106	2,717	135	1,239	273	515	4,879	127	22,293	74,121	96,414
1997	195	18,755	2,344	152	1,244	428	363	4,531	125	23,606	77,153	100,758
1998	151	16,667	1,778	152	1,102	340	203	3,575	99	20,492	78,999	99,492
1999	154	16,351	2,038	143	1,283	269	197	3,931	104	20,539	79,141	99,681
2000	125	21,339	3,672	263	1,796	532	411	6,674	155	28,294	85,129	113,423
2001	139	25,879	3,404	263	1,844	430	284	6,225	145	32,388	93,402	125,790
2002	143	20,926	2,758	130	1,485	488	326	5,187	146	26,402	93,763	120,164
2003	132	26,411	3,668	183	1,964	735	589	7,137	188	33,868	96,263	130,132
2004	189	29,518	4,506	234	2,203	645	644	8,233	209	38,148	100,546	138,694
2005	215	33,838	6,098	323	2,226	817	866	10,331	258	44,642	110,522	155,164
2006	153	33,736	6,314	284	2,327	984	654	10,563	262	44,714	122,914	167,628
2007	174	34,005	6,620	194	2,522	1,342	732	11,410	305	45,894	128,903	174,797
2008	206	R 38,476	R 8,865	109	3,893	1,164	965	R 14,996	394	R 54,072	138,469	R 192,541
2009	204	31,012	6,056	93	2,709	981	747	10,587	285	42,088	132,940	175,027

[a] Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.
[b] Liquefied petroleum gases.
[c] Beginning in 1993, includes fuel ethanol blended into motor gasoline.
[d] Includes small amounts of petroleum coke not shown separately.
[e] Wood, wood-derived fuels, and biomass waste. Prior to 2001, includes non-biomass waste.
[f] There is a discontinuity in this time series between 1988 and 1989 due to the expanded coverage of the use of wood and biomass waste beginning in 1989.
[g] There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.
[h] From 1981 through 1992, includes fuel ethanol blended into motor gasoline that is not included in the motor gasoline column.

Where shown, R = Revised data.

Notes: Expenditure totals may not equal sum of components due to independent rounding. • The commercial sector includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.

Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.

Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET5. Industrial Sector Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy														Retail Electricity	Total Energy f,g,h
	Coal			Coal Coke		Natural Gas a	Petroleum						Biomass	Total f,g,h		
	Coking Coal	Steam Coal	Total	Exports	Imports		Distillate Fuel Oil	LPG b	Motor Gasoline c	Residual Fuel Oil	Other d	Total	Wood and Waste e,f			
	Prices in Dollars per Million Btu															
1970	0.45	0.44	0.45	1.27	0.93	0.38	0.72	1.10	2.86	0.46	1.13	0.98	1.59	0.61	2.99	0.84
1975	1.65	1.28	1.50	2.37	3.47	0.95	2.23	2.51	4.65	1.91	2.64	2.46	1.60	1.67	6.07	2.20
1980	2.10	1.56	1.87	2.54	3.19	2.52	5.54	5.18	9.82	3.69	6.59	5.75	1.67	3.77	10.81	4.71
1985	2.03	1.81	1.90	2.76	2.99	3.87	6.26	5.91	9.07	4.24	6.87	6.29	1.67	4.45	14.57	6.03
1990	1.79	1.62	1.69	3.53	3.80	2.95	5.90	5.66	9.15	3.10	5.26	5.48	0.99	3.59	13.92	5.23
1995	1.76	1.56	1.63	2.71	3.43	2.80	4.86	5.55	9.17	2.75	5.07	5.20	1.21	3.39	13.68	4.97
1996	1.77	1.54	1.62	2.20	3.87	3.30	5.80	6.93	9.83	3.25	5.56	6.05	1.01	3.91	13.49	5.40
1997	1.79	1.54	1.62	2.64	3.25	3.53	5.43	6.24	9.80	3.03	5.35	5.69	1.01	3.90	13.29	5.34
1998	1.69	1.53	1.58	3.73	3.07	3.16	4.21	4.74	8.43	2.25	4.41	4.53	1.24	3.36	13.13	4.91
1999	1.69	1.52	1.58	3.88	2.83	3.21	4.92	5.48	9.23	2.62	4.81	5.08	1.38	3.62	12.98	5.12
2000	1.67	1.49	1.55	3.64	2.66	4.61	7.66	8.23	11.88	4.22	6.53	7.30	1.43	5.04	13.60	6.42
2001	1.74	1.57	1.63	3.27	3.04	5.71	7.00	7.74	11.33	3.85	5.79	6.77	1.95	5.37	14.78	6.88
2002	1.94	1.66	1.75	3.25	3.04	4.47	6.32	6.69	10.69	3.87	6.07	6.46	2.11	4.79	14.30	6.30
2003	1.93	1.65	1.74	3.88	3.49	6.20	7.62	8.76	12.28	4.83	7.02	7.81	1.62	5.99	14.97	7.48
2004	2.31	1.84	1.99	3.28	7.23	7.02	10.06	10.79	14.59	4.95	8.02	9.36	1.79	7.14	15.38	8.45
2005	3.19	2.27	2.56	3.39	8.92	9.08	14.25	12.92	17.84	6.98	10.29	11.93	2.73	9.11	16.77	10.39
2006	3.54	2.50	2.83	3.19	6.31	8.76	16.38	15.42	20.21	8.16	12.52	14.25	2.66	10.06	18.02	11.37
2007	3.64	2.58	2.92	3.66	7.84	8.28	17.88	17.20	22.01	9.26	R 13.92	R 15.82	2.53	R 10.53	18.71	R 11.92
2008	4.49	3.04	3.51	4.33	18.76	10.06	24.48	21.30	25.47	12.98	R 17.97	R 20.35	2.85	R 13.10	19.96	R 14.29
2009	5.43	3.23	3.87	4.17	10.82	6.48	14.66	13.67	18.43	9.40	13.11	13.75	2.64	9.09	20.00	11.04
	Expenditures in Million Dollars															
1970	1,175	907	2,082	78	4	2,625	866	1,046	824	635	2,698	6,069	366	11,067	5,624	16,691
1975	3,692	1,806	5,498	75	156	5,844	2,907	2,760	1,039	2,367	6,470	15,544	386	27,353	13,760	41,113
1980	3,753	2,135	5,888	130	52	16,350	7,232	7,967	1,553	4,175	21,837	42,765	529	65,453	28,863	94,316
1985	2,228	3,024	5,252	77	43	21,615	6,977	9,804	1,978	2,815	17,302	38,876	619	66,338	40,190	106,528
1990	1,862	2,774	4,636	50	72	19,348	6,773	8,916	1,695	1,070	15,678	34,132	906	59,053	43,358	102,411
1995	1,558	2,510	4,068	91	325	21,487	5,473	11,061	1,836	778	15,029	34,177	1,699	61,665	45,402	107,067
1996	1,507	2,436	3,943	88	244	26,167	6,857	14,348	1,965	913	16,771	40,853	1,432	72,551	46,102	118,654
1997	1,453	2,434	3,887	83	253	28,411	6,512	13,235	2,077	732	17,329	39,886	1,435	73,790	45,610	119,400
1998	1,304	2,263	3,566	104	292	24,515	5,084	9,646	1,681	425	15,307	32,143	1,600	62,012	45,634	107,647
1999	1,306	2,150	3,457	86	226	24,079	5,823	12,290	1,400	447	17,006	36,966	1,786	66,427	45,429	111,857
2000	1,327	2,180	3,507	103	249	34,624	9,158	18,555	1,785	867	21,701	52,066	1,888	92,232	47,859	140,090
2001	1,247	2,325	3,572	109	191	38,597	9,055	15,757	3,343	629	18,389	47,173	2,216	91,639	48,519	140,158
2002	1,258	2,268	3,526	64	244	31,031	7,586	14,627	3,302	619	19,551	45,685	2,592	83,015	46,606	129,620
2003	1,283	2,269	3,552	70	239	41,168	8,616	17,944	3,978	966	22,725	54,228	1,935	101,053	49,962	151,015
2004	1,499	2,565	4,064	107	1,232	47,322	12,168	23,385	5,431	1,163	28,905	71,052	1,919	125,482	51,491	176,973
2005	1,964	3,040	5,004	147	780	55,247	17,945	26,248	6,354	1,867	35,870	88,285	3,451	152,620	56,229	208,849
2006	2,132	3,273	5,405	128	636	52,363	20,647	32,858	7,608	1,849	43,659	106,621	3,483	168,380	59,764	228,144
2007	2,175	3,264	5,439	131	478	51,037	22,573	36,734	6,739	1,700	R 45,744	R 113,491	3,155	R 173,469	62,934	R 236,403
2008	2,606	3,684	6,290	210	1,676	R 61,743	R 31,203	R 39,598	6,367	R 2,463	R 52,327	R 131,958	3,375	R 204,832	65,840	R 270,673
2009	2,192	3,196	5,388	135	93	36,381	16,195	27,215	4,503	942	31,727	80,583	2,277	124,586	59,662	184,248

a Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.
b Liquefied petroleum gases.
c Beginning in 1993, includes fuel ethanol blended into motor gasoline.
d Includes asphalt and road oil, kerosene, lubricants, and the other petroleum products as described in the Technical Notes, Section 4, "Other Petroleum Products."
e Wood, wood-derived fuels, and biomass waste. Prior to 2001, includes non-biomass waste.
f There is a discontinuity in this time series between 1988 and 1989 due to the expanded coverage of the use of wood and biomass waste beginning in 1989.
g There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.
h From 1981 through 1992, includes fuel ethanol blended into motor gasoline that is not included in the motor gasoline column.

Where shown, R = Revised data.

Notes: Expenditure totals may not equal sum of components due to independent rounding. • The industrial sector includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.

Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.

Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET6. Transportation Sector Energy Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Primary Energy											Retail Electricity	Total Energy [d]
	Coal	Natural Gas	Petroleum								Total [d]		
			Aviation Gasoline	Distillate Fuel Oil	Jet Fuel [a]	LPG [b]	Lubricants	Motor Gasoline [c]	Residual Fuel Oil	Total			
	Prices in Dollars per Million Btu												
1970	0.41	—	2.17	1.31	0.73	1.11	5.08	2.85	0.38	2.31	2.31	4.65	2.31
1975	1.26	—	3.45	2.80	2.05	2.51	7.48	4.64	1.72	4.02	4.02	11.72	4.02
1980	—	—	9.02	7.19	6.36	5.20	14.36	9.84	3.31	8.60	8.60	14.71	8.61
1985	—	—	9.99	7.52	5.91	10.24	17.61	9.01	4.36	8.26	8.26	19.74	8.27
1990	—	3.29	9.32	8.46	5.68	10.48	14.60	9.12	2.98	8.27	8.27	20.26	8.28
1995	—	3.91	8.36	7.98	4.00	12.49	19.41	9.22	2.18	8.08	8.08	22.63	8.09
1996	—	3.97	9.29	8.82	4.82	12.62	20.08	9.85	2.33	8.76	8.76	22.59	8.77
1997	—	4.34	9.39	8.57	4.53	12.16	17.98	9.81	2.95	8.69	8.69	22.47	8.70
1998	—	4.00	8.11	7.49	3.35	11.08	19.07	8.45	2.18	7.47	7.47	21.72	7.48
1999	—	4.19	8.81	8.13	4.01	13.05	16.75	9.31	2.61	8.23	8.22	20.57	8.23
2000	—	5.21	10.87	10.69	6.64	16.04	17.99	11.89	4.54	10.71	10.71	20.71	10.72
2001	—	7.09	11.01	10.00	5.72	17.06	19.00	11.34	4.38	10.20	10.20	21.59	10.21
2002	—	5.34	10.72	9.42	5.33	15.37	21.74	10.69	4.01	9.64	9.64	21.02	9.65
2003	—	6.68	12.42	10.79	6.46	17.24	26.51	12.34	5.06	11.20	11.20	R 22.05	11.21
2004	—	7.78	15.13	13.04	8.93	19.21	29.35	14.67	5.26	13.43	13.43	R 21.05	13.43
2005	—	9.16	18.56	17.28	12.86	21.75	38.40	17.89	6.22	16.89	16.88	R 25.12	16.89
2006	—	9.61	22.31	19.28	14.80	23.67	46.08	20.28	7.73	19.13	19.12	R 27.96	19.13
2007	—	9.25	23.70	R 20.50	16.01	26.17	R 48.12	22.01	8.19	20.61	20.60	R 28.42	R 20.61
2008	—	R 12.20	27.23	R 27.16	22.56	30.62	R 52.19	25.53	12.31	R 25.24	R 25.23	R 31.48	R 25.23
2009	—	8.91	20.32	17.54	12.61	24.51	47.50	18.51	9.87	17.54	17.53	31.20	17.54
	Expenditures in Million Dollars												
1970	3	—	218	2,058	1,441	49	745	30,525	291	35,327	35,330	49	35,379
1975	1	—	245	5,938	4,150	105	1,158	57,992	1,226	70,813	70,814	119	70,933
1980	—	—	580	20,090	13,856	88	2,468	121,809	4,626	163,517	163,517	163	163,680
1985	—	—	503	23,830	14,747	284	2,754	115,205	3,422	160,745	R 161,196	279	R 161,475
1990	—	1	419	30,982	17,784	227	2,569	123,845	3,025	178,852	R 179,404	328	R 179,732
1995	—	18	331	33,457	12,526	209	3,260	134,641	1,988	186,411	186,429	384	186,813
1996	—	25	347	39,410	15,770	186	3,272	146,106	1,987	207,078	207,103	379	207,483
1997	—	37	373	40,050	15,000	163	3,095	147,164	2,096	207,940	207,977	376	208,353
1998	—	39	288	36,043	11,239	184	3,436	130,709	1,469	183,368	183,407	368	183,775
1999	—	50	345	40,656	13,878	176	3,049	147,592	1,737	207,433	207,483	360	207,843
2000	—	68	394	55,199	23,777	179	3,227	189,836	4,029	276,642	276,710	380	277,090
2001	—	106	385	52,914	19,602	221	3,122	181,979	2,562	260,785	260,891	404	261,295
2002	—	82	361	50,822	17,802	207	3,530	176,006	2,712	251,441	251,523	397	251,919
2003	—	126	375	61,155	21,096	270	3,981	204,781	2,887	294,544	294,670	R 518	R 295,188
2004	—	164	473	77,341	30,219	346	4,464	248,796	3,886	365,526	365,690	R 519	R 366,208
2005	—	215	656	104,978	44,679	579	5,810	304,875	5,208	466,785	467,001	R 643	R 467,644
2006	—	234	746	123,646	50,007	611	6,793	348,695	7,002	537,500	537,734	R 702	R 538,436
2007	—	233	749	R 132,343	53,754	538	R 7,326	381,201	8,135	R 584,045	R 584,278	R 792	R 585,070
2008	—	R 326	770	R 163,504	72,046	R 1,154	R 7,375	430,705	11,317	R 686,871	R 687,197	R 827	R 688,024
2009	—	266	540	96,949	36,353	637	6,035	311,605	7,995	460,114	460,380	828	461,209

[a] Through 2004, includes kerosene-type and naphtha-type jet fuel. Beginning in 2005, includes kerosene-type jet fuel only; naphtha-type jet fuel is included in "Industrial Sector, Other Petroleum."
[b] Liquefied petroleum gases.
[c] Beginning in 1993, includes fuel ethanol blended into motor gasoline.
[d] From 1981 through 1992, includes fuel ethanol blended into motor gasoline that is not included in the motor gasoline column.

Where shown, R = Revised data.
— = No consumption, including cases where adjustments were made. See explanation of adjustments in Section 7 of the Technical Notes.
Note: Expenditure totals may not equal sum of components due to independent rounding.
Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.
Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

Table ET7. Electric Power Sector Price and Expenditure Estimates, Selected Years, 1970-2009, United States

Year	Coal	Natural Gas [a]	Petroleum				Nuclear Fuel	Biomass	Electricity Imports [c]	Total Energy [d]
			Residual Fuel Oil	Distillate Fuel Oil	Petroleum Coke	Total		Wood and Waste [b]		
	Prices in Dollars per Million Btu									
1970	0.31	0.28	0.41	0.57	0.29	0.42	0.18	0.65	1.92	0.32
1975	0.82	0.75	1.99	2.22	0.53	2.00	0.24	0.92	3.89	0.97
1980	1.35	2.20	4.25	5.75	2.61	4.34	0.43	1.74	6.94	1.77
1985	1.65	3.43	4.24	5.89	1.27	4.35	0.71	0.79	9.34	1.91
1990	1.46	2.34	3.30	5.61	0.82	3.42	0.67	0.34	8.37	1.48
1995	1.32	2.03	2.59	4.16	0.70	2.61	0.54	1.13	6.21	1.29
1996	1.29	2.68	3.02	5.03	0.72	3.07	0.51	0.75	6.37	1.35
1997	1.28	2.79	2.82	4.53	0.96	2.82	0.51	0.53	6.71	1.38
1998	1.26	2.45	2.09	3.46	0.67	2.09	0.50	0.66	7.87	1.32
1999	1.23	2.62	2.40	4.11	0.61	2.43	0.48	0.54	8.69	1.33
2000	1.21	4.53	4.09	6.87	0.48	4.20	0.46	0.68	16.78	1.71
2001	1.25	5.21	3.78	6.16	0.97	3.87	0.44	1.30	20.47	1.85
2002	1.25	3.60	3.79	5.69	0.57	3.46	0.43	1.66	8.94	1.54
2003	1.27	5.42	4.47	6.84	0.61	4.22	0.42	1.68	13.21	1.84
2004	1.35	5.96	4.58	8.33	0.79	4.23	0.42	1.61	13.84	2.00
2005	1.53	8.25	6.86	11.48	0.98	6.13	0.43	2.31	16.53	2.61
2006	1.68	6.92	8.12	14.31	1.26	6.56	0.44	2.55	17.32	2.48
2007	1.78	7.11	8.98	15.56	1.54	7.94	0.46	3.22	18.25	2.68
2008	2.09	9.04	13.48	21.44	1.88	10.90	0.47	2.53	18.28	3.21
2009	2.21	4.79	8.98	13.37	1.62	7.15	0.55	2.40	12.10	2.44
	Expenditures in Million Dollars									
1970	2,237	1,151	797	80	6	882	44	2	40	4,357
1975	7,178	2,422	5,842	502	1	6,345	448	2	150	16,545
1980	16,450	8,357	10,446	972	14	11,432	1,189	8	592	38,027
1985	24,056	10,819	4,232	502	9	4,742	2,878	11	1,463	43,970
1990	23,671	7,809	3,841	541	25	4,408	4,104	108	527	40,626
1995	23,138	8,769	1,465	449	57	1,971	3,810	476	908	39,073
1996	23,862	10,387	1,899	550	57	2,506	3,624	328	945	41,652
1997	24,156	11,588	2,014	501	98	2,613	3,369	235	985	42,947
1998	24,140	11,525	2,184	470	83	2,736	3,555	294	1,061	43,311
1999	23,666	12,903	2,304	576	69	2,949	3,643	247	1,281	44,689
2000	24,424	24,104	3,562	1,201	47	4,809	3,628	307	2,783	60,054
2001	24,460	28,618	3,792	1,050	100	4,942	3,524	439	2,689	64,672
2002	24,811	20,839	2,499	725	99	3,324	3,504	629	1,122	54,230
2003	25,687	28,506	3,884	1,100	106	5,090	3,362	669	1,370	64,685
2004	27,476	33,433	4,023	927	176	5,126	3,445	625	1,615	71,720
2005	31,684	49,807	6,010	1,316	239	7,564	3,469	938	2,512	95,975
2006	34,425	44,216	2,927	1,054	269	4,251	3,637	1,054	2,523	90,104
2007	37,076	49,995	3,562	1,389	263	5,215	3,871	1,362	3,200	100,719
2008	42,905	61,909	3,240	1,567	290	5,097	3,976	1,101	3,556	118,545
2009	40,199	33,737	1,626	938	224	2,788	4,560	1,058	2,155	84,496

[a] Natural gas as it is consumed; includes supplemental gaseous fuels that are commingled with natural gas.
[b] Wood, wood-derived fuels, and biomass waste. Prior to 2001, includes non-biomass waste.
[c] Electricity imported from Canada and Mexico.
[d] There are no direct fuel costs for hydroelectric, geothermal, wind, photovoltaic, or solar thermal energy.
Where shown, R = Revised data.

Notes: Expenditure totals may not equal sum of components due to independent rounding. • The electric power sector comprises electricity-only and combined-heat-and-power (CHP) plants within the NAICS 22 category whose primary business is to sell electricity, or electricity and heat, to the public. • Through 1988, data are for electric utilities only. Beginning in 1989, data include independent power producers.
Web Page: All data are available at http://www.eia.gov/state/seds/seds-data-complete.cfm.
Sources: Data sources, estimation procedures, and assumptions are described in the Technical Notes.

State Energy Data System 2009: Prices and Expenditures

Introduction to the Technical Notes

Purpose

The State Energy Data System (SEDS) was developed and is maintained and operated by the U.S. Energy Information Adminstration (EIA). The goal in maintaining SEDS is to create historical time series of energy production, consumption, prices and expenditures by State that are defined as consistently as possible over time and across sectors. SEDS exists for two principal reasons: (1) to provide State energy production, consumption, price and expenditure estimates to Members of Congress, Federal and State agencies, and the general public, and (2) to provide the historical series necessary for EIA's energy models.

The Report

SEDS provides annual energy price and expenditure estimates for all energy sources by major economic sectors for the 50 States and the District of Columbia and in aggregate for the United States. These data are available on the EIA website at http://www.eia.gov/state/seds/seds-data-complete.cfm. Companion tables containing State-level consumption data can also be found at the same website. In addition, tables showing State-level consumption, price, and expenditure estimates by energy source as they are updated for the most current year can be found at http://www.eia.gov/state/seds/seds-data-fuel.cfm.

Note: Throughout this report, the term "State" includes the District of Columbia.

Due to page-size constraints, most of the time series tables displayed as Portable Document Format (PDF) files show estimates for only selected years from 1970 through 1995; thereafter, estimates are shown consecutively through 2009. However, estimates for all years from 1970 forward are maintained in SEDS and are included in the HTML versions of the tables and in the CSV data files available via EIA's website. All years are covered by the documentation in this report.

All estimates with revisions since the last edition of SEDS that are large enough to be seen in the published tables' level of rounding are preceded with an "R" in the PDF data tables on the website.

Expenditures are calculated by multiplying the price estimates by the consumption estimates found in SEDS. In some cases, consumption is adjusted to remove process fuel; intermediate petroleum products; other consumption that has no direct fuel costs, i.e., hydroelectric, geothermal, wind, solar, and photovoltaic energy sources; and wood and waste obtained at no cost. (See the discussion in Section 7, "Consumption Adjustments for Calculating Expenditures," at http://www.eia.gov/state/seds/seds-technical-notes-complete.cfm.)

All prices and expenditures are in current dollars that have not been adjusted to reflect changes in the purchasing power of the dollar. All expenditures are consumer expenditures; that is, they represent estimates of money spent directly by consumers to purchase energy, generally including taxes. (See box below.)

Taxes in the Price and Expenditure Data

The objective in developing State energy prices is to provide estimates that include all taxes, but data sources often do not treat taxes uniformly. Where taxes are included in the source data, they are included in the price and expenditure tables. Where taxes are not included but can be separately estimated, they are added, with some exceptions listed below. In many cases, States and some localities provide tax exemptions for various kinds of activities or classes of end users. These complex exemptions are not incorporated into the State energy prices. The Energy Information Administration (EIA) is continuing to analyze these cases to see if a better representation can be made. A comprehensive and detailed study of taxes in EIA data is available in the report *End-Use Taxes: Current EIA Practices,* DOE/EIA-0583 (Washington, DC, August 1994). The report is available from EIA's Internet site at http://www.eia.gov/FTPROOT/financial/0583.pdf.

The status of tax data in this year's price and expenditure tables is summarized below and described more fully in the sections for each energy source and sector.

End-Use Sectors

Coal. All steam coal and coking coal prices include taxes in all years. Appropriately, coal imports and exports in the industrial sector do not include end-user taxes.

Natural Gas. Natural gas prices are intended to include all Federal, State, and local taxes, surcharges, and adjustments billed to consumers. Although the EIA data collection form states that taxes are to be included in the reported gross revenues, it is most likely that respondents would not consider sales taxes as part of their companies' gross revenues, and some may not be reporting them. As a result, consumer sales taxes may not be covered in full. For more information see *End-Use Taxes: Current EIA Practices*, page 23 of 134 in the PDF file, http://www.eia.gov/FTPROOT/financial/0583.pdf.

Petroleum. Prices of motor gasoline, diesel fuel, and liquefied petroleum gases used for transportation include excise and other per-gallon taxes but do not include general sales taxes due to wide variation at the local level. Other liquefied petroleum gases, distillate fuel oil, kerosene, and residual fuel oil prices include sales taxes in all years. Jet fuel, aviation gasoline, asphalt and road oil, lubricants, and other petroleum products do not include taxes. Other petroleum products are miscellaneous products, petrochemical feedstocks (naphtha, other oils, and still gas), industrial petroleum coke, special naphthas, and waxes.

Wood and Waste. Wood and waste prices for the residential, commercial, and industrial sectors include taxes.

Electricity. Taxes paid directly by the electric power sector (rather than end users) are considered operating costs and are passed on to the end users as part of the price. Sales and other use taxes are included in the prices.

Electric Power Sector

Coal, natural gas, petroleum coke, nuclear, and wood and waste prices include all taxes, transportation, and handling costs. There are no direct fuel costs (or taxes) for hydroelectric, geothermal, centralized solar, or wind energy. Capital, operation, and maintenance costs and related taxes associated with these energy sources are included indirectly because electricity prices reflect their presence in the rate base.

The following Technical Notes describe how the price estimates are developed, including sources of data, methods of estimation, and conversion factors applied.

Reliable data for State-level prices rarely exist, especially as series that are consistent over a long period. Estimates and assumptions are applied to fill data gaps and to maintain consistent definitions in the data

series over time. SEDS incorporates the most consistent series and procedures possible. Users should recognize the limitations imposed on the system due to changing and inadequate data sources. Estimates often are based on a variety of surrogate measures that are selected on the basis of availability, applicability as indicators, continuity over time, and consistency among the various energy commodities. Original source documents for data used in SEDS (cited in this documentation) include descriptions of collection methodologies, universes, imputation or adjustment techniques (if any), and errors associated with the individual processes. Due to the numerous collection forms and procedures associated with these reports, it is not possible to develop a meaningful numerical estimate of the overall statistical errors of the material published in the SEDS price and expenditure tables.

It is also important to note that, even within a State, a single average price may have limited meaning in that it represents a consumption-weighted average over a whole State. For example, urban and rural electricity prices can vary significantly from a State's weighted average, and prices in one region of a State may differ from those in another because of access to less expensive hydroelectricity. Differences within a State may also be greater than differences among adjacent States. Thus, the principal value of the estimates in these tables lies in general comparisons among the States, interstate comparisons for a given year, and the analysis of trends over several years.

The five energy-consuming sectors used in the SEDS price and expenditure tables correspond to those used in the consumption tables as follows:

- **Residential Sector:** An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters.

- **Commercial Sector:** An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. *Note*: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.

- **Industrial Sector:** An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31–33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. *Note:* This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.

- **Transportation Sector:** An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use. In this report, natural gas used in the operation of natural gas pipelines is included in the transportation sector.

- **Electric Power Sector:** An energy-consuming sector that consists of electricity-only and combined-heat-and-power plants within the NAICS (North American Industry Classification System) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. *Note*: This sector includes electric utilities and independent power producers.

The first four energy-consuming sectors - residential, commercial, industrial, and transportation sectors - are also called end-use sectors.

Although end-use allocations of energy consumption and expenditures follow those guidelines as closely as possible, some data are collected by using different classifications. For example, electric utilities often classify commercial and industrial users by the quantity of electricity purchases rather than by the business activity of the purchaser. Agricultural use of natural gas is collected and reported in the commercial sector through 1995 and in the industrial sector for 1996 forward. Since agricultural use of natural gas cannot be identified separately, the discrepancy cannot be reconciled. Another example is master-metered condominiums, apartments, and buildings with a combination of residential and commercial units. In many cases, billing and metering practices cause residential energy usage of electricity, natural gas, or fuel oil to be included in the commercial sector. In those cases, there is no basis for separating residential from commercial use. Readers are advised to consult the consumption Technical Notes for specific assumptions regarding the consumption estimates.

Where prices for an energy source and sector are not available, comparable prices are substituted. For example, the transportation sector motor gasoline prices are applied to the commercial and industrial sectors. In some cases, the average of adjacent States' prices or the regional price is assigned to a missing State price. The documentation elaborates on these price assumptions.

Except where specified, it is generally not possible to describe the prices in these tables as entirely "wholesale" or "retail." The prices paid in each consuming sector are usually a combination of both sets of prices, depending on a number of closely interrelated factors. Almost all residential sector prices are close to retail prices, reflecting the relatively small quantities of individual purchases and the increased costs of extensive, multilayered distribution systems. Similarly, in the transportation sector almost everyone pays the same retail-like price for motor gasoline, regardless of volume purchased or location of purchase. Conversely, residual fuel oil prices in the transportation sector are certainly more wholesale-like as a result of large deliveries to bulk facilities in major ports. In the same manner, most large industrial and many large commercial expenditures can be thought of as near wholesale, frequently involving direct access to a producer or bulk distribution facility for very large quantities. Many smaller industrial and commercial facilities pay something much closer to retail prices as a result of the small quantities involved and their institutional distance from primary suppliers. Notable exceptions to these relationships include natural gas and electricity suppliers, which typically establish fixed rates for each of several classes of service, depending on representative quantities, service factors, and distribution expenses.

Section 1. Overview

The Technical Notes document data sources and procedures used to develop the price and expenditure estimates in the State Energy Data System (SEDS). Information is provided for each of the major energy sources: coal, natural gas, petroleum, wood and waste, and electricity. Section 7 describes adjustments for consumption of industrial process fuel and intermediate products and other uncosted energy sources.

Appendix A provides metric and other physical conversion factors for measures used in energy analyses. Appendix B presents the current-dollar gross domestic product (GDP) by State used to calculate energy expenditures as share of GDP. Appendix C summarizes the changes in SEDS content made since the last complete release of data.

Price Estimation Methodologies

Price data in the SEDS price and expenditure tables are expressed in dollars per million Btu. If the source data are in physical units, they are divided by the appropriate conversion factors to create the Btu prices. Estimated prices are used only when specific State-level prices are not available for a given energy source and sector. In some cases, prices for energy consumed in one sector in a State are assigned to another sector in the same State. Specific examples are: industrial steam coal prices are assigned to the commercial and transportation sectors' steam coal use; industrial lubricants prices are assigned to transportation lubricants uses; and transportation motor gasoline prices are assigned to commercial and industrial use of motor gasoline.

In addition, there are a few cases where State-level prices could not be identified for any economic sector for a given energy source for some or all years. In these instances, a national-level price is used for all States for a given year. The procedures for estimating these national-level prices are presented in the body of the Technical Notes under each energy source as appropriate. The cases where a national-level price is assigned to all States in all years are: transportation use of aviation gasoline; industrial and transportation use of lubricants; and some components of other petroleum products used in the industrial sector.

Finally, within a given energy source and sector where price data are usually available, there are some cases of missing prices. Two general approaches are used to assign or estimate prices in cases where consumption occurs but no price is directly available from the data sources. The first approach is to assign an adjacent State price or the simple average of adjacent States' prices. When this approach is not feasible, the consumption-weighted price from the Census division or region or the Petroleum Administration for Defense district or subdistrict in which the State is located is assigned.

Three State groupings used in the report—U.S. Census regions and divisions, Federal regions, and Petroleum Administration for Defense districts—are shown in Figures TN1, TN2, and TN3, respectively, on the following pages. States are often designated by their two-letter postal code abbreviations shown in the map legends. Throughout the Technical Notes, the term "State" includes the District of Columbia.

Expenditures

Full documentation of the data sources and the methods used to estimate energy consumption are described in the SEDS consumption Technical Notes, located on EIA's website at http://www.eia.gov/state/seds/seds-data-complete.cfm.

To calculate energy expenditures, SEDS consumption is adjusted to remove quantities of process fuel and intermediate products used in the industrial and transportation sectors that are not purchased directly by

end users. Electricity exported to Canada and Mexico are excluded from expenditure calculations. Use of hydroelectric, geothermal, wind, and solar energy sources are also removed from SEDS expenditure calculations since there are no direct fuel costs for those energy sources. SEDS consumption of wood in the residential sector and wood and waste consumption in the industrial and commercial sectors are adjusted to remove estimated quantities that were obtained at no cost. Adjusted energy consumption estimates used to calculate expenditures are explained in detail at EIA's website: http://www.eia.gov/state/seds/sep_prices/notes/pr_consum_adjust.pdf.

Energy expenditures, in million dollars, are calculated by multiplying SEDS prices for each fuel in dollars per million Btu by the SEDS adjusted consumption in billion Btu.

Labor Force Statistics from the Current Population Surve

HOUSEHOLD DATA
ANNUAL AVERAGES
1. Employment status of the civilian noninstitutional population, 1941 to date

[Numbers in thousands]

Year	Civilian noninstitutional population	Civilian labor force								Not in labor force
		Total	Percent of population	Employed				Unemployed		
				Total	Percent of population	Agri-culture	Nonagri-cultural industries	Number	Percent of labor force	
Persons 14 years of age and over										
1941	99,900	55,910	56.0	50,350	50.4	9,100	41,250	5,560	9.9	43,990
1942	98,640	56,410	57.2	53,750	54.5	9,250	44,500	2,660	4.7	42,230
1943	94,640	55,540	58.7	54,470	57.6	9,080	45,390	1,070	1.9	39,100
1944	93,220	54,630	58.6	53,960	57.9	8,950	45,010	670	1.2	38,590
1945	94,090	53,860	57.2	52,820	56.1	8,580	44,240	1,040	1.9	40,230
1946	103,070	57,520	55.8	55,250	53.6	8,320	46,930	2,270	3.9	45,550
1947	106,018	60,168	56.8	57,812	54.5	8,256	49,557	2,356	3.9	45,850
Persons 16 years of age and over										
1947	101,827	59,350	58.3	57,038	56.0	7,890	49,148	2,311	3.9	42,477
1948	103,068	60,621	58.8	58,343	56.6	7,629	50,714	2,276	3.8	42,447
1949	103,994	61,286	58.9	57,651	55.4	7,658	49,993	3,637	5.9	42,708
1950	104,995	62,208	59.2	58,918	56.1	7,160	51,758	3,288	5.3	42,787
1951	104,621	62,017	59.2	59,961	57.3	6,726	53,235	2,055	3.3	42,604
1952	105,231	62,138	59.0	60,250	57.3	6,500	53,749	1,883	3.0	43,093
1953	107,056	63,015	58.9	61,179	57.1	6,260	54,919	1,834	2.9	44,041
1954	108,321	63,643	58.8	60,109	55.5	6,205	53,904	3,532	5.5	44,678
1955	109,683	65,023	59.3	62,170	56.7	6,450	55,722	2,852	4.4	44,660
1956	110,954	66,552	60.0	63,799	57.5	6,283	57,514	2,750	4.1	44,402
1957	112,265	66,929	59.6	64,071	57.1	5,947	58,123	2,859	4.3	45,336
1958	113,727	67,639	59.5	63,036	55.4	5,586	57,450	4,602	6.8	46,088
1959	115,329	68,369	59.3	64,630	56.0	5,565	59,065	3,740	5.5	46,960
1960	117,245	69,628	59.4	65,778	56.1	5,458	60,318	3,852	5.5	47,617
1961	118,771	70,459	59.3	65,746	55.4	5,200	60,546	4,714	6.7	48,312
1962	120,153	70,614	58.8	66,702	55.5	4,944	61,759	3,911	5.5	49,539
1963	122,416	71,833	58.7	67,762	55.4	4,687	63,076	4,070	5.7	50,583
1964	124,485	73,091	58.7	69,305	55.7	4,523	64,782	3,786	5.2	51,394
1965	126,513	74,455	58.9	71,088	56.2	4,361	66,726	3,366	4.5	52,058

1966	128,058	75,770	59.2	72,895	56.9	3,979	68,915	2,875	3.8	52,288
1967	129,874	77,347	59.6	74,372	57.3	3,844	70,527	2,975	3.8	52,527
1968	132,028	78,737	59.6	75,920	57.5	3,817	72,103	2,817	3.6	53,291
1969	134,335	80,734	60.1	77,902	58.0	3,606	74,296	2,832	3.5	53,602
1970	137,085	82,771	60.4	78,678	57.4	3,463	75,215	4,093	4.9	54,315
1971	140,216	84,382	60.2	79,367	56.6	3,394	75,972	5,016	5.9	55,834
1972	144,126	87,034	60.4	82,153	57.0	3,484	78,669	4,882	5.6	57,091
1973	147,096	89,429	60.8	85,064	57.8	3,470	81,594	4,365	4.9	57,667
1974	150,120	91,949	61.3	86,794	57.8	3,515	83,279	5,156	5.6	58,171
1975	153,153	93,775	61.2	85,846	56.1	3,408	82,438	7,929	8.5	59,377
1976	156,150	96,158	61.6	88,752	56.8	3,331	85,421	7,406	7.7	59,991
1977	159,033	99,009	62.3	92,017	57.9	3,283	88,734	6,991	7.1	60,025
1978	161,910	102,251	63.2	96,048	59.3	3,387	92,661	6,202	6.1	59,659
1979	164,863	104,962	63.7	98,824	59.9	3,347	95,477	6,137	5.8	59,900
1980	167,745	106,940	63.8	99,303	59.2	3,364	95,938	7,637	7.1	60,806
1981	170,130	108,670	63.9	100,397	59.0	3,368	97,030	8,273	7.6	61,460
1982	172,271	110,204	64.0	99,526	57.8	3,401	96,125	10,678	9.7	62,067
1983	174,215	111,550	64.0	100,834	57.9	3,383	97,450	10,717	9.6	62,665
1984	176,383	113,544	64.4	105,005	59.5	3,321	101,685	8,539	7.5	62,839
1985	178,206	115,461	64.8	107,150	60.1	3,179	103,971	8,312	7.2	62,744
1986	180,587	117,834	65.3	109,597	60.7	3,163	106,434	8,237	7.0	62,752
1987	182,753	119,865	65.6	112,440	61.5	3,208	109,232	7,425	6.2	62,888
1988	184,613	121,669	65.9	114,968	62.3	3,169	111,800	6,701	5.5	62,944
1989	186,393	123,869	66.5	117,342	63.0	3,199	114,142	6,528	5.3	62,523
1990	189,164	125,840	66.5	118,793	62.8	3,223	115,570	7,047	5.6	63,324
1991	190,925	126,346	66.2	117,718	61.7	3,269	114,449	8,628	6.8	64,578
1992	192,805	128,105	66.4	118,492	61.5	3,247	115,245	9,613	7.5	64,700
1993	194,838	129,200	66.3	120,259	61.7	3,115	117,144	8,940	6.9	65,638
1994	196,814	131,056	66.6	123,060	62.5	3,409	119,651	7,996	6.1	65,758
1995	198,584	132,304	66.6	124,900	62.9	3,440	121,460	7,404	5.6	66,280
1996	200,591	133,943	66.8	126,708	63.2	3,443	123,264	7,236	5.4	66,647
1997	203,133	136,297	67.1	129,558	63.8	3,399	126,159	6,739	4.9	66,837
1998	205,220	137,673	67.1	131,463	64.1	3,378	128,085	6,210	4.5	67,547
1999	207,753	139,368	67.1	133,488	64.3	3,281	130,207	5,880	4.2	68,385
2000	212,577	142,583	67.1	136,891	64.4	2,464	134,427	5,692	4.0	69,994
2001	215,092	143,734	66.8	136,933	63.7	2,299	134,635	6,801	4.7	71,359
2002	217,570	144,863	66.6	136,485	62.7	2,311	134,174	8,378	5.8	72,707
2003	221,168	146,510	66.2	137,736	62.3	2,275	135,461	8,774	6.0	74,658
2004	223,357	147,401	66.0	139,252	62.3	2,232	137,020	8,149	5.5	75,956
2005	226,082	149,320	66.0	141,730	62.7	2,197	139,532	7,591	5.1	76,762
2006	228,815	151,428	66.2	144,427	63.1	2,206	142,221	7,001	4.6	77,387
2007	231,867	153,124	66.0	146,047	63.0	2,095	143,952	7,078	4.6	78,743
2008	233,788	154,287	66.0	145,362	62.2	2,168	143,194	8,924	5.8	79,501
2009	235,801	154,142	65.4	139,877	59.3	2,103	137,775	14,265	9.3	81,659
2010	237,830	153,889	64.7	139,064	58.5	2,206	136,858	14,825	9.6	83,941
2011	239,618	153,617	64.1	139,869	58.4	2,254	137,615	13,747	8.9	86,001

NOTE: Revisions to population controls and other changes can affect the comparability of labor force levels over time. In recent years, for example, updated population controls have been introduced annually with the release of January data. Information about historical comparability is online at www.bls.gov/cps/documentation.htm#comp.

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