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Impacts of the Property Assessed Clean Energy (PACE) Program on the Economies of California and Florida

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Executive Summary

Introduction

Property Assessed Clean Energy (PACE) is a way to finance a wide range of energy and water efficiency, renewable energy, and hazard mitigation improvements permanently attached to residential and commercial properties. Established by state statutes and enabled by local governments, PACE financing, unlike traditional alternatives, is structured as an assessment to the property and not the property owner. PACE provides one hundred percent of the cost of qualified structural improvements, which the property owner repays annually or semi-annually through a special assessment added to the property tax bill.

The direct benefits of PACE financing are rather straightforward—reduction in energy and water use, reduction in pollutants associated with this use, and reduction in hazard vulnerability. However, the financing also generates economic *co-benefits* directly and indirectly. These include direct impacts of PACE financing expenditures on site and economic ripple effects throughout the rest of the economy. They also include energy and water cost savings that stimulate spending on consumer goods and enhance business profits. At the same time, the efficiency improvements reduce the production of conventional energy and water services and affect their prices. Hazard mitigation improvements help prevent the need to dip into savings to repair damaged structures, prevent business interruption and temporary relocation costs, and also result in insurance premium reductions that stimulate further spending on regional goods and services. The stimulus effects are also enhanced by solar investment tax credits and are counterbalanced somewhat by the reduction in the production of centralized electricity and water services and the need of those receiving PACE financing to repay it over time.

Purpose

This study performs a regional economic impact analysis of PACE financing by one of the leading firms in the market—Ygrene Energy Fund, Inc. Since 2013, and through the end of July 2018, Ygrene has provided more than $1.16 billion to finance over 54,500 property improvement projects in over 500 cities and counties, primarily in the residential sector of California and Florida. We estimate the net impact of these financing projects on the economies of these two states, focusing on major macroeconomic indicators of gross output (sales revenue), gross domestic product (GDP), personal income, and employment. We also estimate the impacts on tax revenues for various levels of government. The estimation methodology includes both direct and various types of indirect effects rippling through the supply chains of the economy. Much of our analysis is based on the use of the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI^+) Model, a widely used macroeconometric model at the state and local levels in the United States.

Results

The results for California indicate that, during the up-front investment period (2013-2018) of the Ygrene PACE financed property improvements, an average annual increase of gross state product (GSP) of $134.7 million and employment of 1,305 full-time equivalent (FTE) jobs result from the aggregate stimulus effects from the expenditure of the PACE financing. In Florida, the average annual stimulus impacts are a $51 million increase in GSP and 603 FTE jobs during the investment period.

The economic increases for California over the entire period in which the improvements are operative (2013 to 2067) is estimated to be (in 2015 dollars):

- Net present value (NPV) of GDP of $661.4 million
- Total cumulative person-year jobs of 9,774
- NPV of gross output (sales revenue) of $1,279.2 million
- NPV of personal income of $490.5 million
- NPV of total tax impacts of $120.9 million

The economic increases for Florida over the entire study period are estimated to be:

- NPV of GDP of $608.2 million
- Total cumulative person-year jobs of 11,716
- NPV of gross output (sales revenue) of $1,130.5 million
- NPV of personal income of $513.0 million
- NPV of total tax impacts of $136.6 million

The aforementioned co-benefits in California are over and above the direct benefits, which include:

- Water consumption reduction of 2.36 billion gallons
- Electricity consumption reduction of 3.63 million MWh
- Natural gas consumption reduction of 2.86 bcf
- Greenhouse gas reduction of 1.15 million metric tCO2e
- Avoided property damage from earthquakes of $2.36 million

The aforementioned co-benefits in Florida are over and above the direct benefits, which include:

- Electricity consumption reduction of 0.46 million MWh
- Natural gas consumption reduction of 0.28 bcf
- Greenhouse gas reduction of 0.26 million metric tCO2e
- Avoided property damage from hurricanes of $507.76 million

Total Augmented GDP (AGDP) impacts, which include the non-market value of solar electricity production, social cost of carbon, and avoided disaster relocation cost, are nearly $850 million for California, and $760 million for Florida. Employment impacts are the same as the regular employment impacts noted above, since new jobs are not directly associated with any of these direct environmental and hazard reduction benefits.

Conclusions

The NPV of total GDP impacts are $661.4 million for California, and $608.2 million for Florida. The employment impacts are 9,774 person-year jobs for California, and 11,716 person-year jobs for Florida over the entire study period. These positive market-based impacts are even higher if we add the non-market value of solar electricity production, social cost of carbon, and avoided disaster relocation cost, as well as avoided property damage from disasters.

Impacts of the Property Assessed Clean Energy (PACE) Program on the Economies of California and Florida[*]

I. Introduction

Property Assessed Clean Energy (PACE) is a way to finance a wide range of energy and water efficiency, renewable energy, and hazard reduction improvements permanently attached to residential and commercial properties. Established by state statutes and enabled by local governments, PACE financing, unlike traditional alternatives, is structured as an assessment to the property and not the property owner. Only certain types of improvements are eligible to be financed through PACE, and all PACE programs are required to provide public benefits in the host state. PACE provides one hundred percent of the cost of qualified structural improvements, which the property owner repays annually or semi-annually through a special assessment added to the property tax bill.

The direct benefits of PACE financing are rather straightforward—reduction in energy and water use, reduction in pollutants associated with this use, and reduction in hazard vulnerability. However, the financing also generates economic *co-benefits* directly and indirectly. These benefits are more complex than those measured in ordinary economic impact analysis associated with, say, the opening of a new factory or mine, typical economic stimuli. Such stimuli, as well as PACE financing, all generate direct impacts on site and multiplier or broader general equilibrium impacts throughout the rest of the economy. However, many conventional stimuli provide products primarily for export and do not interact much with the host economy beyond a limited number of supply chain and wage/salary income increases and spending. PACE improvements, on the other hand, provide energy and water cost savings that stimulate spending on consumer goods and enhance business profits. At the same time, the efficiency improvements reduce the production of conventional energy and water services and affect their prices. Hazard mitigation improvements help prevent the need to dip into savings to repair damaged structures, prevent business interruption, and also result in insurance premium reductions that stimulate further spending on regional goods and services.

This study performs a regional economic impact analysis of PACE financing by one of the leading firms in the market—Ygrene Energy Fund, Inc. Since 2013, and through the end of July 2018, Ygrene has provided more than $1.16 billion to finance over 54,500 property improvement projects in over 500 cities and counties in California, Florida, and Missouri (Ygrene, 2018). We estimate the net impact of these financing projects on the economies of the two major states in which Ygrene does business – California and Florida. We focus on major macroeconomic indicators of gross output (sales revenue), gross domestic product (GDP), personal income, and employment. We also estimate the impacts on tax revenues for various levels of government. The estimation methodology includes both direct and various types of indirect effects rippling through the supply chains of the economy. The approach is that of Economic Consequence Analysis (ECA), which utilizes most of the principles of Benefit-Cost Analysis (BCA) at the multi-market level, but focuses on macroeconomic indicators rather than the traditional

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"welfare (personal "well-being") measures" (see, e.g., Rose et al., 2011; Rose et al., 2017; Farrow and Rose, 2018). Much of our analysis is based on the use of the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI^+) Model, which is a widely used macroeconometric model at the state and local levels in the United States.

II. Contributions of PACE Financing

The overall purpose of PACE financing is to provide funds for home and business building improvements that directly produce environmental or hazard risk reduction benefits. Additionally, PACE can provide financing to those that might otherwise have difficulty securing other forms of financing. In particular, PACE financing is not a credit score-dependent product, in part because the funds are collateralized by a first lien on the property, as well as a variety of underwriting requirements set forth by state and local governments. Another direct benefit to consumers and small businesses is that there is no down payment or upfront cost to the borrower.[1] Also, terms of the assessment are directly tied to the useful life of the improvements and thus can extend beyond typical terms of traditional financing, although earlier repayment options are available.

The direct benefits of PACE financing analyzed in this study include:

- Reduction in electricity and natural gas use
- Increase in renewable electricity generation
- Reduction in the emission of greenhouse gases
- Reduction in water use
- Reduction in vulnerability to earthquakes and hurricanes

These benefits are measured in terms of physical units, as well as dollar values where possible. Overall, they result in improvements in the efficiency of the economy by eliminating wasteful practices relating to water and energy use and also to the cost to society of "externalities", such as pollution. In addition to the "efficiency-improvement" contributions of PACE financing, there is also an improvement in equity, or fairness, in society because the PACE Program is available equally across all property-owner income groups and small businesses.

In addition, the "co-benefits" of PACE financing analyzed in the study are:

- Increase in business sales revenue, GDP, personal income, and employment
- Increase in tax revenues for various levels of government
- Reduction in property damage
- Reduction in disaster relocation cost
- Reduction in hazard insurance premiums

These co-benefits, together with other types of co-benefits (such as decreases in ordinary air pollutants and improvement in public health) that are not quantified in this study, add to the "business case", "household benefits" and "overall societal well-being" of PACE financing. Note that these various direct and co-benefits are measured not only at the site of the improvement but also in terms of the ripple effects of various forms that they generate throughout the economy.

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[1] For a discussion of various other pros and cons of PACE financing, we refer the reader to Pozdena and Josephson (2011); Sichtermann (2011); Goodman and Zhu (2016); RMI (2017); DBRS (2018); Deason and Murphy (2018).

Basic information on PACE-financed improvement projects is presented in Tables 1 and 2. Table 1 presents the total number of Ygrene PACE projects in residential buildings and commercial buildings in California and Florida between 2013 and July 2018.[2] Table 2 presents the distribution of the total of $1.16 billion contract dollars among the various improvement categories in the two states.

Table 1. Number of Ygrene Projects from 2013 to July 2018

CA	**32,513**
Residential	31,867
Commercial	646
FL	**21,855**
Residential	21,766
Commercial	89

Table 2. Distribution of Contract Dollars of Ygrene PACE Financing among Improvement Categories
(in thousands of 2015$)

	2013	2014	2015	2016	2017	2018	Total
CA							
Hurricane Mitigation	$0	$0	$0	$0	$0	$0	$0
Building Envelope Energy Efficiency	$259	$2,782	$18,718	$57,171	$68,486	$22,405	$169,821
Solar	$802	$7,904	$40,024	$151,942	$77,342	$25,537	$303,552
Energy-Efficient Windows and Doors	$104	$1,322	$10,357	$32,767	$35,132	$9,420	$89,102
HVAC Efficiency	$180	$2,437	$26,083	$55,680	$32,828	$9,919	$127,126
Water Conservation	$36	$533	$4,393	$17,170	$25,276	$9,505	$56,913
Lighting Efficiency	$5	$75	$631	$2,263	$4,576	$1,208	$8,758
High-Efficiency Water Heating	$0	$0	$0	$171	$1,934	$709	$2,814
Earthquake Mitigation	$0	$0	$0	$0	$387	$975	$1,362
High-Efficiency Pool Equipment	$0	$0	$0	$30	$338	$132	$500
CA Total	***$1,386***	***$15,051***	***$100,207***	***$317,193***	***$246,300***	***$79,810***	***$759,947***
FL							
Hurricane Mitigation	$67	$2,369	$10,794	$42,086	$141,849	$78,621	$275,786
Building Envelope Energy Efficiency	$72	$2,569	$9,141	$27,566	$12,074	$6,912	$58,334
Solar	$6	$223	$970	$3,317	$7,500	$7,469	$19,485
Energy Efficient Windows and Doors	$6	$207	$757	$2,979	$3,405	$2,707	$10,061
HVAC Efficiency	$21	$765	$2,826	$5,644	$17,013	$8,407	$34,676
Other	$0	$4	$14	$74	$64	$88	$244
Lighting Efficiency	$7	$243	$193	$637	$421	$260	$1,760
High-Efficiency Water Heating	$0	$0	$0	$32	$165	$140	$337
Earthquake Mitigation	$0	$0	$0	$0	$0	$0	$0
High-Efficiency Pool Equipment	$0	$0	$0	$20	$216	$32	$268
FL Total	***$179***	***$6,379***	***$24,695***	***$82,355***	***$182,707***	***$104,637***	***$400,951***

[2] Ygrene also has recently begun offering financing in Missouri, but, given the low number of projects (162 during the period of analysis) in that state, we have omitted it from our analysis.

III. Economic Analysis of PACE Impacts

A. Direct Economic Impacts

Estimating the economic impacts of the PACE Program involves a number of considerations. It includes several positive stimulus factors, as well as some partially offsetting ones. Some of these impacts relate to the buildings in which improvements are made, while others relate to direct and indirect impacts off-site. Many of the benefits of the PACE Program pertain to improving the environment and are complex to assess because of the absence of market prices associated with them. These various factors and their influence on the bottom-line impacts are summarized in Table 3.

A set of positive stimulus factors that directly affect the economy stems from the purchase of materials and equipment, as well as the labor involved in their installation, for PACE improvements. Examples include energy-efficient water heaters, solar panels, windows, caulking material, and wages paid to workers with various skill levels. The demand for the various inputs into the PACE improvements increase the production of several sectors of the economy directly, as well as putting money in the pockets of workers and business owners that they subsequently spend. Additional positive stimuli emanate from the operation and maintenance of PACE improvements throughout their useful life.

Another set of positive stimuli is associated with the savings from improved efficiency in the use of energy and water. Homeowners then use the major portion of these savings to purchase more of the typical basket of consumer goods, thereby generating additional economic activity. Business owners could use the savings for several purposes, including expanding production, lowering prices, or increasing wages and profits.

Similar savings stem from mitigation efforts that reduce vulnerability to disasters, often referred to more broadly as resilience.[3] Here, however, the assessment of spending is more complicated, because, in the absence of these improvements, property owners would spend money anyway to repair and reconstruct damaged facilities. On the surface this could be an equivalent amount to spending on the

[3] The terms "resilience" or "resiliency" are now often used to characterize various strategies and tactics aimed at reducing economic costs of disasters, ranging from pre-event mitigation and preparedness to post-disaster actions to accelerate the speed and reduce the duration of recovery (see, e.g., Cutter, 2016). Note that the PACE improvements analyzed here are all forms of hazard mitigation, i.e., actions taken prior to the disaster primarily to reduce property damage but also to reduce interruption of business and household activities, so we choose to use this more specific term. Note also that, in the hazards literature, "resilience" is increasingly being used only to refer to actions taken after the event to promote recovery, which is more consistent with its Latin root, *resilio*, meaning to bounce back. To the extent that PACE financing conserves electricity and water and also provides electricity through solar installations that make homes and businesses less dependent on the central grid, this does render those who make these improvements more able to bounce back after disaster, hence enhancing resilience as we have defined it. Moreover, we are likely to see an increased demand for solar installations, for example, in states like California, where prevention of wildfires is likely to cause electricity utility providers to shut down parts of the grid, thereby leaving customers without power unless they have their own sources such as solar panels or portable electricity generators. For a discussion of the various types of hazard risk reduction strategies and appropriate terminology, the reader is referred to NRC (2011) and Rose (2017).

Table 3. Overview of Economic Impacts of PACE Assessments

Impact Type	Stimulus	Complications	Assumptions	Estimation Bias
<u>Direct Impacts</u>				
1. Spending on Materials & Equipment	positive	offset by assessment repayment[a] offset by investment displacement[a]	-- minimal displacement	none overestimation
2. Spending on Installation Labor (subsequent consumer expenditures)	positive	offset by assessment repayment[a] offset by investment displacement[a] difficult to separate in available data	-- --	none unknown
3. Spending on Operation & Maintenance (throughout useful life of improvement)	positive or negative (depends on comparison to O&M of existing building/equipment/fixture)	data difficult to obtain, so not calculated in this report.	likely to be <3% annually[b]	underestimation
4. Solar Energy Generation and Energy Efficiency Savings (subsequent consumer & business expenditures throughout useful life)	positive	--	same avg annual price increase as in last 6 yrs	none
5. Water Savings (subsequent consumer & business expenditures throughout useful life)	positive	--	same avg annual price increase as in last 6 yrs	none
6. Decreased Demand for Energy	negative	--	economic impacts not attributed to PACE	--
7. Decreased Demand for Water	negative	--	--	--
8. Program Fees (increased expenditure on Gov't service)	positive	offset by assessment repayment[a]	--	none
9. Interest Payments	positive	offset by assessment repayment[a]	--	none
10. Reduced Disaster Losses	positive	difficult to measure welfare impacts	use dollar losses; use MS2 BCR's	underestimation
11. Property Insurance Savings	positive	--	--	none
<u>Energy and Environmental Impacts</u>				
12. Reduced Air Pollution	positive	difficult to measure welfare impacts	value of GHG reduction[c]	underestimation

13. Reduced Water Use	positive	difficult to measure welfare impacts	value of water	underestimation
Higher-Order Impacts				
14. Indirect Effects	same direction as direct	--	--[d]	--
15. Induced Effects	same direction as direct	--	--[d]	--

[a] Offset in all cases is less than 100%.
[b] Not estimated in this study.
[c] Value of ordinary air pollution reduction is not estimated.
[d] Calculated with use of the REMI Model (see Appendix A).

improvement and would appear to be a wash in terms of direct economic impacts as measured by standard economic indicators such as gross output or employment. However, implementing disaster mitigation improves the level of well-being of the property owners by reducing their risk of loss of property or income, while repair and reconstruction simply returns well-being to the original level. The well-being of homeowners and businesses are measured in this report in terms of their expenditures on hazard mitigation/resilience.[4]

Another set of savings stems from reduced insurance premiums that typically result from insurance companies offering reduced annual premiums for the installation of earthquake and hurricane mitigation improvements. This has long been the practice in the area of fire insurance and is on the increase for other hazards because it reduces the potential payouts by the insurers. It is mandated by FL statute, for example, that insurance companies offer discounts to properties that have undertaken hazard mitigation.

A set of direct substitution effects also needs to be taken into account, which offsets the aforementioned positive stimuli to a lesser, equal, or greater extent. Reduced spending on energy and water results in a decrease in the economic activity that produces them. The net effect is likely to be positive, however, within most states since the majority of the positive stimulus spending will increase the activity of in-state producers, while the inputs to displaced production are top-heavy with goods imported from other states (e.g., both California and Florida import nearly all of the natural gas used in their electric power plants). See also the discussion of Indirect Impacts below, especially with respect to differences in the multiplier effects of the positive and negative stimuli.

Additional positive stimuli stem from interest and fees paid to Ygrene and from fees paid to state and local governments for operating costs, including permitting and inspection. Fees paid to governments at various levels increase their revenues and are likely to be spent on government provision of goods and services within a state, thus generating an additional direct stimulus. Payments to Ygrene increase its business activity, and hence wages and profits, with the former subsequently spent primarily within the state.

Yet another stimulus associated with PACE financing stems from the 30% solar energy federal investment tax credit (ITC). This payment essentially increases the disposable income of households and increases consumer expenditures on goods and services, on the one hand, and increases business profits, or possibly lowers prices, on the other. The credit is usually received by the property owners between 4 and 16 months after the installation of the solar energy system. We assume that the

[4] The ideal measure of well-being (typically referred to as "economic welfare", or simply "welfare", in economic research) for homeowners would relate to the "utility" (subjective value) they receive from the spending on PACE improvements, and this measure is likely to exceed the expenditure because the willingness to pay for the benefit exceeds the typical amount expended (consider the typical downward sloping demand curve, which measures the marginal willingness to pay, and which is higher than the expenditure, or price, at all points except for the last, or marginal, dollar spent (this differential is typically referred to as "consumer surplus," which is the net welfare measure on the consumer side). However, in the absence of knowing the demand curve for energy savings, water savings, and reduced vulnerability to disasters, we cannot measure consumer surplus; hence, our estimates here are a lower bound for this stimulus. Similarly, the well-being of businesses would be measured by increased "producer surplus" (roughly equivalent to economic profits), but, in the absence of cost or profit function information, we are forced to use expenditures (equal to business revenues), which again results in a lower-bound estimate.

households will spend 50% of the credit dollars in the year of the installation, and 50% in the following year. Moreover, since the solar ITC is a federal tax incentive, we assume there will be no reduction in federal government spending in California or increase in other taxes in the state as an offset effect.

There are also tax impacts of PACE financing, though these need to be evaluated with caution. These tax payments are part of the macroeconomic stimuli estimated by our methodology described above, so they cannot be added to those estimates because that would amount to double-counting. We do, however, calculate the direct tax revenues that are collected as a result of PACE financing, as well as the net additional tax revenues generated by any expansion in economic activity that the PACE financing generates, because these are of interest to policy-makers.

Finally, we summarize some additional benefits and downsides of PACE financing, the estimation of which are beyond the scope of this study. There is evidence that the financed improvements increase the value of the home or business, in part because of the lower energy and water costs, as well as reduced vulnerability to hazards. Goodman and Zhu (2016) estimated that, on average, homeowners that utilize PACE financing could recoup its value at the point-of-sale. Another type of benefit is the reduction in uncertainty in home operating costs, which could be estimated in several ways, though with some difficulty. One way is to consider the reduced amount of reserve funds that homeowners need to be set aside for the contingency of spikes in energy costs, for example. However, the reduced cost is not the reduced dollar value of the funds, but rather the carrying cost on them, which is only a few percentage points at most. Also, there is the likelihood that lower operating costs of a home due to energy and water savings and reduced hazard losses facilitate not only repayment of PACE financing but mortgage financing in general, thereby decreasing defaults. Some analysts have also pointed out that PACE improvements enhance the performance of a home, thereby yielding additional non-market benefits to its residents (Rocky Mountain Institute, 2017). On the other hand, in 2010, the Federal Housing and Finance Agency (FHFA), as conservator of the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) instituted a policy that neither of these government entities would purchase a mortgage with a PACE assessment attached to the property. In 2017 FHA issued a similar policy, a reversal from its previous one, that it would not insure new mortgages with PACE assessments attached to the property. The effect is that some property owners that utilize PACE may be required to pay off the PACE assessment when they sell or refinance their home, rather than at the end of the original contract date.

A complex issue of the analysis is that the PACE Program provides assessments rather than outright grants. Since these assessments need to be repaid, this results in a diversion of expenditures from other goods and services by consumers or from production activities by businesses. Thus, with respect to the spending from and repayment of the assessments, there is a significant stimulus in the year(s) that the improvement is implemented, but a negative stimulus to the economy spread over the period during which the assessments are repaid. This repayment can come equivalently from prior savings or assets of the borrowers or from savings on the utility bills and insurance premiums that the improvement provides, or some combination of both.

Even the initial use of the assessments may involve some offsetting factors depending on the origin of the capital base of a PACE Program lender. The assessment of the PACE Program is being done at the local level within a state, so, if the capitalization of the lender comes from funds from out-of-state, then there is an equivalent positive stimulus from all the assessments. However, if the capital comes from within the state, we must evaluate whether it displaces the use of these investment funds for other purposes. If so, this displacement effect would have to be taken into account, and the ensuing direct and indirect impacts would have to be subtracted from the bottom-line impacts. The difficulty in addressing this component is that firms that invest in PACE securitizations are active in global markets. While many firms have headquarters in the US, some in states where PACE programs operate, we do not have access to their geographical investment portfolio. Thus, estimating where funds originated would be extremely difficult if not impossible. Given the relatively small amount of PACE financing as a proportion of total global capital market funds available, we believe that an assumption of zero in-state investment displacement is reasonable.

Another complexity when evaluating the economic impacts of PACE assessments by an individual lending company is the assessment of the "incremental" effort. This refers to whether other sources of PACE assessments would have been available to property owners and the extent to which they would have accessed them. This consideration is difficult to assess and estimates for solar energy improvements, for example, vary from 100% additionality (Kirkpatrick and Bennear, 2014) to a range of 25% to 100% (Eyer, 2019). In our Base Case, we simply estimate the economic impacts of Ygrene-funded local assessments, acknowledging that with respect to this consideration we are generating an upper-bound approximation of the company's economic impact on the states in which it operates.

B. Direct Energy and Environmental Impacts

A major set of direct impacts stems from reduced water use, reduced energy use, and reduced greenhouse gas emissions. Unfortunately, directly observable market prices do not exist for pollutants, so we will apply some measures in the literature of the damages they cause, where the benefits of PACE assessments represent these avoided losses. For example, we use the findings of a recent National Academies of Science report on the social cost of carbon (NRC, 2017);[5] however, we are not able to estimate the value of reduced amounts of ordinary air pollution, though we posit that this is likely to be a small amount in comparison to carbon dioxide emissions. Similarly, we are not able to measure the value of any reduced amount of water pollution.

In the case of the benefits of decreased energy use and water use, we encounter two complexities. First, we could apply the value of these resources, but this would overstate the benefits because we have already counted them in the consumer savings. At the same time, simply using the values of these resources at market prices omits the consumer and producer surplus components and causes some underestimation. Hence, we simply present the amounts of energy and water savings in physical units.

Another complexity here is that these benefits do not stop at state boundaries, but result in geographic spillover benefits. Many ordinary air pollutants are readily dispersed for hundreds of miles, and greenhouse gases are globally mixed. Water use affects contiguous and down-stream states, where applicable. We are not able to estimate these additional benefits.

C. Indirect Economic Impacts

As noted above, the spending on property improvements that are made possible by Ygrene financed local government assessments apply to the site of their application, or what is termed direct economic

[5] We are not able to estimate the amount of methane emissions from the extraction, storage or transportation of natural gas.

impacts. However, the estimation of the total, or macroeconomic, impacts includes the ripple, or multiplier, effects of the various increased or decreased spending streams, as well as the interaction of demand and supply in numerous markets. For example, the increased demand for high-efficiency water heaters directly stimulates the demand for inputs into their production, such as fabricated metals, insulation material, and labor. The process continues through a chain-reaction of indirect impacts, as more fabricated metal and insulation production stimulates demand for more of their inputs, and as the producers of these inputs demand more inputs, and so on. The total of all of these supply-chain effects is some multiple of the direct effects (usually on the order of 1.25 to 2.25, depending on the size and economic interdependence of the region) at the state level, hence the term "multiplier effect." Moreover, the increased employment in all of these sectors provides additional income, the vast majority of which is spent on consumer goods, causing an "induced" effect on economic activity, including additional employment and income growth from all the indirect demands, and further increasing the multipliers (typically to about 1.5 to 3.0).

The process just described applies to both positive and negative stimuli to economic activity. It works through interdependence of quantities of goods and services between sectors. The process is further affected by changes in prices resulting from changes in supply and demand; prices increase in cases of positive stimuli and decrease from negative stimuli. The price changes dampen the size of the multipliers even after various substitutions between inputs are taken into account (typically reducing them to levels of about 1.25 to 2.25).

The many types of linkages in the economy and macroeconomic impacts are extensive and cannot be traced by a simple set of calculations. They require the use of a sophisticated model that reflects the major structural features of an economy, the workings of its markets, and the interactions between them. In this study, we used the Regional Economic Models, Inc. (REMI), Policy Insight Plus (PI+) Model (REMI, 2018). This is the most widely used state and regional level macroeconometric modeling software package in the U.S. and has been extensively peer-reviewed. The reader is referred to Rose and Wei (2019) for a presentation of the structure and workings of the REMI Model.

IV. Data

A summary of the data used in this study is presented in Appendix Table 1. Below we summarize each of the data sets and associated estimates of key parameters used in our modeling simulations.

A. Basic Data

Ygrene Energy Fund, Inc. provided us with extensive data on its financing from 2013 through July 2018. The data covered major characteristics of the individual assessments, including major assessment characteristics (e.g., type of improvement, useful life of the improvement, total contract amount, type of property, location, settlement date), financing characteristics (e.g., interest rates, amortization period, annual coupon, program fees, initial face amount), and characteristics of the property (e.g., building area, property value, mortgage amount, owner type).

The research team then mapped improvement expenditures to the 160 economic sectors in the REMI Model to calculate the indirect effects. This began by dividing these expenditures between sectors that produced/supplied the property improvement materials/equipment and installation of the equipment or retrofit of the structure.[6]

Data on energy and water savings were obtained from the "Ygrene Proprietary Impact Metrics Model" developed by Ygrene.[7] This impact model is used to estimate the energy savings, water savings, natural gas savings, renewable energy generation, utility bill savings, and the associated greenhouse gas emissions reductions. The impact model was based on a 12-month data-set of Ygrene funded projects between July 2017 and June 2018. For each residential and commercial property in the data set, Baseline Energy Consumption by end-use (e.g., space heating, water heating, lighting, pool pumps) and Baseline Water Consumption by end-use (e.g., outdoor usage, toilet, faucet, shower) were determined to form the foundation upon which improvement level savings are estimated.[8]

Once baseline usages were determined, savings potential was identified for 24 distinct improvement types[9], which roll into the 10 improvement categories listed in Table 2. Savings potential for each improvement type was determined using a combination of two methodologies:

1. A percentage-savings-over-baseline approach. For example, if a property owner replaces an HVAC system that had a Seasonal Energy Efficiency Ratio (SEER) rating of 12 with an HVAC system of a 15 SEER rating, the more efficient HVAC system reduces the air conditioning load by 20%. That percentage of savings is then applied to the air conditioning baseline load to determine kilowatt-hours of energy saved.
2. An individual unit savings approach. For example, if a property owner replaced a 45 watt incandescent lightbulb with a 9 watt LED bulb, and it is assumed that lightbulb is on for three hours a day, the estimated energy savings from that improvement would be the difference in energy use between the two light bulbs over three hours (45w – 9w X 3 hours/day X 365 days = 39,420 watt-hours/year in energy savings).

Once the energy (electricity and natural gas) and water savings quantities were estimated at the improvement level, state-level energy and water rates for residential and commercial sectors and emissions factors were applied to these savings quantities to generate associated utility bill savings and greenhouse gas reductions. Appendix Figure 1 summarizes the methodological approach utilized in the impact model to estimate the energy and environmental savings.

All energy, water, utility bill, and greenhouse gas saving estimates were then divided by the total contract amount (cash equivalent of installed measures) within each of the improvement categories to derive the energy, water, utility bill, and greenhouse gas savings factors per thousand contract dollars by

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[6] Labor services are embedded in the production of materials and equipment but are separately calculated for the installation activities.

[7] The authors provided some input in the development of the impact model with regard to the distribution of contract dollars among the different improvement categories, as that distribution was utilized both in the impact model and in applying the contract amounts to the relevant REMI NAICS sectors.

[8] Residential Baseline Energy Consumption was obtained from the Energy Information Administration's Residential Energy Consumption Survey (EIA, 2018a; EIA, 2018b), and varies by state, household income bracket, and number of household members; Commercial Baseline Energy Consumption was obtained from the Energy Star Portfolio Manager, U.S. Energy Use Intensity by Property Type (EPA and DOE, 2018), and varies by building type, and square footage.

[9] For Example: Lighting, HVAC, Building Envelope – Insulation, Building Envelope – Cool Roof, Solar PV, Water Efficiency – Toilets/Showers/Faucets, Water Efficiency – Hardscape and Artificial Turf, etc.

improvement type, state, and property type. These factors are then applied to the entire Ygrene portfolio based on the contract amounts for each improvement types, state, and property type to estimate annual savings.

To estimate lifetime savings, annual factors are applied for the useful life of each improvement type. When calculating lifetime utility bill savings, it is assumed that the prices of electricity, natural gas, and water will increase or decrease at the average annual historical growth rates over the past 6 years in each state (EIA, 2018a; EIA, 2018b; Circle of Blue, 2018). Additionally, it is assumed that Solar PV output degrades at a constant annual rate over the lifetime of the panels, which affects lifetime energy, utility bill, and carbon emission savings.

Data relating to hazard mitigation improvements -- reduction in risk from earthquakes and hurricanes – were obtained from various sources. Ygrene provided information on expenditures for these improvements under item 1 above. Hazard loss savings by borrowers from the installation of mitigation improvements were calculated by multiplying the expenditure data by the benefit-cost ratios (BCRs) for the earthquake and hurricane threats for each improvement type. The BCRs for earthquakes were obtained from results calculated as part of the Mitigation Saves 2 Study (MMC, 2017; Porter, 2018). Note that these BCRs were not provided at the same detail as the improvement types, so it was necessary to aggregate the latter to a smaller number of categories. BCRs for hurricanes were based on an adaptation of Insurance Institute for Building and Home Safety (IBHS) BCRs for Gold, Silver and Bronze categories of building envelope improvements. The reader is referred to the following sub-section, as well as to Section V and Appendix C of Rose and Wei (2019) for more details on the data sources, major assumptions, calculation steps, and results of the analysis.

In this study, we only quantified the insurance premium savings for PACE hurricane improvement projects in Florida. Similar savings can potentially accrue to property owners implementing seismic retrofits in California; however, we did not quantify this because of lack of data and the small number of seismic projects compared to hurricane projects. Estimation of hurricane improvement insurance savings was primarily based on Florida Office of Insurance Regulation (FLOIR, 2018) data on the homeowners insurance rates offered by 27 major insurance companies for properties with and without wind mitigation (see Section V and Appendix D of Rose and Wei, 2019, for details).

Note also that due to the uncertainty surrounding some of the data, below we perform sensitivity tests around best estimates of data inputs into the analysis.

B. Benefit-Cost Ratios for Earthquake and Hurricane Improvements

Data on the ability of a broad set of individual hazard mitigation improvement types to reduce losses from earthquakes and hurricanes do not exist. Therefore, it was necessary to adapt data from credible studies on this topic. Essentially, we adapted benefit-cost ratios (BCRs) for various improvement types and then applied them to expenditures on improvements financed by Ygrene to determine the hazard loss reduction they bring about.

For earthquakes, we began with the Mitigation Saves 2 Study (MMC, 2017), which estimated benefit-cost ratios for hundreds of building improvements.[10] The research team received internal data on BCRs for major earthquake improvement types, since only a single aggregate figure was actually published (a 2.6:1 ratio).[11] The disaggregated BCR data for individual MS2 projects served as the starting point for our numerical estimation. They were first mapped into PACE categories. Note that most of the buildings for which BCRs are calculated in the MS2 study are for public sector structures such as fire stations and city halls. Although the function of these buildings differs from those of commercial operations, their structural performance is similar in relation to earthquakes. None of the BCRs in the MMC data base apply to residences, however, so these had to be further inferred from the data.

Adaptations of the earthquake improvement BCR just discussed were necessitated for all building types. All property and casualty losses are relevant to commercial and residential structures, but business interruption losses and public service interruptions are not for residential structures, so we removed this aspect of the benefits from our BCRs for residential structure improvements based on data in MMC (2017). This yields an average BCR for residential earthquake mitigation improvements of 1.166. BCRs for individual seismic improvement types ranged from 0.39 to 2.92. Additional unpublished data from MS2 were used to estimate the benefits of savings of relocation costs for homeowners during loss of services for their residences while they were being repaired or rebuilt. Further adjustments are explained in Rose and Wei (2019). The final BCRs for various earthquake improvement types are presented in Appendix Table 2 for the two categories of buildings for which PACE financing has been provided in California – Commercial and Residential.

For hurricanes, we improved upon the single aggregate BCR of 5:1 from MMC (2017) by using IBHS data on the benefits of various home improvement types, which are basically linked to various layers of protection of building envelopes. IBHS established a program in 2010 to reduce residential property losses in hurricane program areas by offering guidance in retrofitting existing residential structures.

A key aspect to this program is the promotion of risk reduction home improvements in incremental steps. Homeowners improve the most vulnerable failure points in their home first and then perform improvements from high to low vulnerability points, each building off of the previous enhancement. A major requirement of this program is an initial inspection, which is used to determine the improvements needed to occur in order for the home to achieve a "Bronze," "Silver," or "Gold" level of the program. The mapping of PACE resiliency improvement categories into IBHS categories is presented in Appendix C of Rose and Wei (2019).

Benefit-cost ratios for Hurricane mitigation by IBHS category were estimated as an underlying calculation step for the overall single Hurricane BCR in the Mitigation Saves 2 study and provided to the research team. They are based on assumptions of improvements during the construction of a single-story house and averaging of locations in relation to distance from coastlines, for example. These basic

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[10] The original Mitigation Saves Study evaluated 10 years of FEMA Hazard Mitigation Grant Program (HMGP) projects. It was thoroughly peer-reviewed and has been widely cited in congressional testimony to support the case for more government funding in this area (see MMC, 2005, and the summary of the study in Rose et al., 2007). The initial modules of the updated and expanded study have also gone through a rigorous peer-review process.

[11] The widely reported BCR, which appears in the Summary and major tables and figures of the MMC report, is 3:1; however, we calculated this BCR on the basis of the reported benefits and costs individually and took the calculation out to one decimal place.

BCRs are adjusted for the higher cost associated with retrofits, which we assume to be an additional 25%. The BCRs for individual hurricane improvement types range from 1.38 to 3.84. Additional unpublished data from MS2 were used to estimate the benefits of savings of relocation costs for homeowners during loss of services for their residences while they were being repaired or rebuilt. The reader is referred to Rose and Wei (2019) for additional refinements necessary to calculate the Hurricane BCRs. The results for various improvement types are presented in Appendix Table 3 below.

V. Direct Benefits

A. Energy and Environmental Improvements

The implementation of Ygrene PACE improvements is estimated to result in substantial direct benefits from energy consumption reductions and water conservation. In California, the energy/water efficiency and renewable energy PACE projects are estimated to lead to electricity consumption reductions of 3.63 million megawatt hours (MWh), natural gas consumption reductions of 2.86 billion cubic feet (bcf), and water savings of 2.36 billion gallons over the entire useful life of the improvements. In Florida, these direct benefits are estimated to be 0.46 million MWh electricity consumption reductions and 0.28 bcf natural gas use reductions.

B. Greenhouse Gas Emission Savings

State-specific emissions factors were applied to the energy saving quantities to calculate the associated greenhouse gas reductions.[12] In California, the Ygrene PACE improvements are estimated to result in GHG emission reductions of 1.15 million metric tons of CO2e, while, in Florida, Ygrene PACE improvements are estimated to result in GHG emission reductions of 0.263 million metric tons of CO2e.

C. Avoided Disaster Losses

We apply the hazard reduction BCRs to the total contract dollar amounts of the projects to obtain estimates of the avoided disaster losses from the implementation of these disaster mitigation improvements. The results are that the $1.45 million investment in seismic retrofits and new home seismic improvements in California is estimated to result in $2.36 million of avoided property damage and $0.38 million avoided temporary relocation costs of homeowners. In Florida, the $275 million investment in hurricane mitigation improvements is estimated to result in $507.8 million avoided property damage and $134.94 million in avoided temporary homeowner relocation costs. The large disparity in hazard reduction impacts between the two states is primarily due to the fact that PACE financing has significantly greater roles in the hurricane mitigation than in earthquake mitigation.

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[12] GHG emission factor for electricity is 0.2726 MtCO2e/MWh in CA and 0.5345 MtCO2e/MWh in FL (EPA, 2017). The GHG emission factor for natural gas combustion is 54.5 kgCO2e per mcf (EPA, 2014). These GHG emission factors include CO_2, CH_4 and N_2O, and are converted to a CO_2 equivalent based on the 100-year global warming potential of CH_4 and N_2O.

D. Insurance Premium Savings

With regard to analyzing the savings property owners can receive from insurance premium reductions because of the implementation of PACE disaster risk reduction (resiliency) improvements, we focus on the PACE hurricane protection and structural reinforcement projects in Florida, since it is mandated by state statute that insurance companies offer premium discounts to policy holders. We perform our analysis for 14,350 residential projects and 23 commercial projects in Florida that implemented hurricane-related improvements.

We use the Homeowners Rate Comparison Tool provided by the Florida Office of Insurance Regulation (FLOIR, 2018) as the primary source to obtain insurance premium saving estimates. Based on a sample of homeowners insurance rates offered by 27 major insurance companies that do business in Florida, the OIR Tool provides estimates of the premiums for a pre-2001 (thus pre-FL building code updates) home worth $150,000, both with and without wind mitigation improvements, in each county. The premium savings are calculated as the differences between the rates with and without Wind Mitigation by county and by insurance company (see Rose and Wei, 2019, for additional refinements in the calculations).

We also perform sensitivity analyses for both the lower-bound and upper-bound estimates, in which we assume the insurance savings are 50% lower or higher than in the Base Case level, respectively.

After property owners implemented the hurricane protection improvements, they would be able to receive insurance premium savings over the useful life of the projects. To be conservative, we use the shortest useful life of all PACE hurricane improvements, which is 20 years, to calculate the cumulative insurance savings over the entire analysis period. The cumulative savings on insurance premiums are estimated to be $708 million. Given the uncertainties in the insurance savings calculation (including, e.g., variations in the insurance premium credits offered across insurance companies based on the specific characteristics of the properties and the number and quality of wind mitigation improvements implemented by property owners), we also perform sensitivity analyses in which we assume the insurance savings are 50% lower or higher than in the Base Case.

In the REMI simulations, for residential PACE hurricane projects, we simulate the savings as increased consumption of the mix of consumer goods and services. For commercial projects, the insurance premium savings are simulated as production cost reductions in the relevant REMI commercial sectors.

VI. REMI Model Simulation of Indirect Economic Impacts

The REMI PI+ Model was selected to evaluate the macroeconomic impacts (such as gross state output, employment, and personal income) of the PACE Program. The version of the model used includes three geographical regions: California, Florida, and rest of U.S. The model is established based on U.S., California, and Florida historical data through 2016.

Before undertaking any economic simulations, the estimates of the direct costs and savings of the PACE projects are translated to REMI model inputs. This step involves the selection of appropriate economic activity and policy levers in the REMI PI+ Model. In Table 4, the first two columns show the various direct costs incurred by and savings accruing to the business (commercial) sectors and the household (residential) sector. The third column presents the corresponding economic variables in the REMI PI+ Model and their position within the Model (i.e., in which one of the five major blocks the policy variables can be found). The last column indicates whether the impact represents a positive or negative stimulus to the economy.[13]

Table 4. Linkages between Direct Costs/Savings of the PACE Projects and REMI Inputs

Linkage	Direct Costs/Savings of the PACE Program		Policy Variable Selection in REMI	Positive or Negative Stimulus to the Economy
1	Upfront Spending on Property Upgrades/Retrofit – Construction/Installation		Output and Demand Block →Exogenous Final Demand (amount) for Construction sector → Increase	Positive
2	Upfront Spending on Property Upgrades/Retrofit -- Building Materials/Components		Output and Demand Block →Exogenous Final Demand (amount) for Construction, Architectural and Structural Metals Mfg, Veneer, Plywood, and Engineered Wood Product Mft, Paint, Coating, and Adhesive Mfg, Clay Product and Refractory Mfg, Petroleum and Coal Products Mfg, Ventilation, Heating, Air-conditioning, and Commercial Refrigeration Equipment Mfg, Electric Lighting Equipment Mfg, Electrical Equipment Mfg, Glass and Glass Product Mfg, Petroleum and Coal Products Mfg, Steel Product Mfg, Cement and Concrete Product Mfg, Alumina and Aluminum Production and Processing, Other Fabricated Metal Product Mfg, Semiconductor and Other Electronic Component Mfg, Household Appliance Mfg, etc. sectors → Increase	Positive
3	Expenditure on Ygrene Fees		Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector →Increase	Positive
4	Expenditure on Program Fees		Output and Demand Block →State and Local Government Spending →Increase	Positive
5	Interest Payment of PACE Assessments		Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase	Positive
6	Annual Amortized Payment by PACE Assessment Borrowers	Businesses (Commercial Sectors)	Compensation, Prices, and Costs Block →Capital Cost (amount) of Individual Commercial and Industrial Sectors →Increase	Negative
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount) →All Consumption →Decrease	
7	Energy (Electricity and	Businesses (Commercial	Compensation, Prices, and Costs Block→ Production Cost of Individual Industrial and Commercial	Positive

[13] Note that the linkage #10 is not part of the Base Case discussed below, but rather part of sensitivity tests performed.

Linkage	Direct Costs/Savings of the PACE Program		Policy Variable Selection in REMI	Positive or Negative Stimulus to the Economy
	NG) and Water Savings	Sectors)	Sectors→Decrease	
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount) →All Consumption Sectors →Increase	
8	Solar Investment Tax Credit	Businesses (Commercial Sectors)	Compensation, Prices, and Costs Block →Production Cost of Individual Industrial and Commercial Sectors →Decrease	Positive
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount) →All Consumption Sectors →Increase	
9	Insurance Premium Savings	Businesses (Commercial Sectors)	Compensation, Prices, and Costs Block→ Production Cost of Individual Industrial and Commercial Sectors→Decrease	Positive
		Households (Residential Sector)	Output and Demand Block →Consumption Reallocation (amount) →All Consumption Sectors →Increase	
10	Energy Demand Decrease from the Energy Supply Sectors		Output and Demand Block →Exogenous Final Demand (amount) for Electric Power Generation, Transmission, and Distribution sector and Natural Gas Distribution sector→Decrease	Negative
11	Water Demand Decrease from the Water Supply Sector		Output and Demand Block →Exogenous Final Demand (amount) for Water, Sewage and Other Systems sector→Decrease	Negative

VII. REMI Simulation Results

In this section, we first present the REMI simulation results for the Base Case analysis for California and Florida. We then present sensitivity analyses, in which we test how the changes in the assumptions of key factors would affect the bottom-line REMI simulation results.

In the Base Case, we utilize our best estimates of key input variables. For example, these include the average BCRs for hurricane improvements and average insurance savings. They also include our assumption that property owners will repay their financing by displacing their other spending by an equivalent amount. Also, we do not include offset effects of reduced electricity and natural gas demand for the investment displacement in the Base Case analyses. Various adjustments of all of these inputs and assumptions are made in the sensitivity tests below.

A. Impacts of California Ygrene PACE Financing

Table 5 presents the macroeconomic impacts of the PACE financed improvements on the California economy for both residential and commercial properties for key years over the analysis period (see Rose and Wei, 2019, Appendix E for detailed results for each year from 2013, the year that Ygrene started providing PACE financing, to 2067, the end year of the improvements implemented in 2018 that have a useful life of 50 years). The impacts include employment, gross state product (GSP), gross output (sales revenue), personal income, and non-market value of electricity generated from solar energy. The results are presented in terms of both dollar impacts and percentage changes from baseline. For GSP, gross output, personal income, and non-market value of electricity generated from solar energy, the Net Present Values (NPVs, at a 5% rate of discount) over the entire analysis period are also presented.

The results indicate that, during the up-front investment period (2013-2018) of the Ygrene PACE financed property improvements, an average annual increase of GSP of $134.7 million and employment of 1,305 jobs[14] result from the aggregate stimulus effects from the expenditure of the PACE financing. The aggregate GSP and employment impacts become negative from 2019 to 2027, primarily because the negative impacts from the repayment of the PACE financing by the property owners exceed the positive impacts from utility bill savings. From 2028 to 2067, the GSP and employment impacts become positive again, as the period of many PACE financing repayment phase out (the repayment period is usually between 10 to 30 years), and the lasting positive impacts from utility bill savings lead to positive aggregate GSP impacts. The NPV of GSP impacts over the entire period (2013 to 2067) is estimated to be $661.4 million, despite the negative impacts during the years of 2019 to 2027. The total cumulative person-year jobs generated are 9,774. The NPVs of the gross output impacts, personal income impacts, and non-market value of electricity generation are estimated to be $1,279.15 million, $490.5 million, and $257.53 million respectively.

We also performed decomposition analyses for the GSP and employment impacts to evaluate how the various economic factors affect the aggregate macroeconomic results.

Figure 1 depicts the decomposed effects in terms of GSP impacts for all the impact components. The bars in different colors represent impacts of individual stimuli and individual dampening effects. The black solid line indicates the total net impact. The results indicate that the investment expenditures in Construction and Materials/Components Manufacturing sectors result in the highest positive impacts on the state economy in the investment period (2013 to 2018), and the energy bill (electricity and natural gas) savings result in the highest positive impacts on the economy over the entire analysis period. The PACE financing repayment results in the highest negative impacts, which is only partially offset by the stimulus effects to the Finance sector.

Note that the positive impacts of the non-market production of electricity can be added to REMI Model results for Gross Output (Sales Revenue) to obtain an "Augmented Gross Output" result. Analogous "Augmented GDP" and "Augmented Personal Income" can be estimated by applying value-added or personal income coefficient of the electric utility sector to the "Augmented Gross Output" result. Note, however, that the non-market electricity production does not generate any employment.

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[14] A job is defined as a person-year of employment full-time equivalent. Results presented for a given year represent the jobs in place that year whether they are new jobs or carryovers from past years.

B. Impacts of Florida Ygrene PACE Financing

Table 6 presents the macroeconomic impacts of the PACE financed improvements on the Florida economy for both residential and commercial properties for key years over the analysis period. More detailed results for each year of the entire analysis period and separate results for residential and commercial PACE financing are presented in Appendix E of Rose and Wei (2019).

The results indicate that during the up-front investment period (2013-2018), the expenditure of Ygrene's financing is estimated to result in an average annual increase of GSP of $51 million and employment of 603 jobs. The NPV of GSP impacts over the entire period (2013 to 2067) is estimated to be $608.22 million. The total cumulative person-year jobs generated are 11,716. The NPVs of the gross output impacts, personal income impacts, and non-market value of electricity generation are estimated to be $1,130.49 million, $512.96 million, and $7.85 million respectively.

Figure 2 depicts the decomposed effects in terms of the GSP impacts for all the impact components. The results indicate that the investment expenditures in Construction and Materials/Components manufacturing sectors have the highest positive impacts on the state economy in the investment period (2013 to 2018). Insurance premium savings result in the highest positive impacts on the economy in the next 20 years, followed by the stimulus impacts from interest payments to Finance sector. The PACE financing repayment by the property owners results in the highest negative impacts. However, it is more than offset by the positive impacts from the insurance savings, energy bill savings, and the stimulus effects to the Finance sector.

Table 5. REMI Simulation Results for Base Case: Macroeconomic Impacts of Ygrene PACE Financing on California for Key Years

Differences from Baseline Level

Variable	Units	2013	2014	2015	2016	2017	2018	2028	2038	2048	2058	2067	NPV (or Total Person-Year Jobs)
Total Employment	Individual (Jobs)	17	179	1,102	3,326	2,483	723	-5	170	50	76	24	9,774*
Gross Domestic Product	Mil of Fixed (2015) $	1.62	17.31	109.25	337.03	259.60	83.32	0.69	18.18	3.57	9.19	2.86	661.44
Output (Sales Revenue)	Mil of Fixed (2015) $	3.17	33.97	214.96	661.42	512.69	160.97	-0.56	34.57	6.79	18.58	5.79	1,279.15
Personal Income	Mil of Fixed (2015) $	1.09	11.46	70.34	212.71	142.62	41.76	5.34	14.98	8.77	16.56	5.16	490.50
Non-Market Electricity Production	Mil of Fixed (2015) $	0.07	0.64	3.21	12.76	17.58	19.50	19.59	19.77	0.00	0.00	0.00	257.53

Percent Change from Baseline Level

Variable	Units	2013	2014	2015	2016	2017	2018	2028	2038	2048	2058	2067
Total Employment	Individual (Jobs)	0.0001%	0.0008%	0.0044%	0.0135%	0.0102%	0.0030%	0.0000%	0.0006%	0.0002%	0.0003%	0.0001%
Gross Domestic Product	Mil of Fixed (2015) $	0.0001%	0.0006%	0.0041%	0.0125%	0.0095%	0.0031%	0.0000%	0.0004%	0.0000%	0.0001%	0.0000%
Output (Sales Revenue)	Mil of Fixed (2015) $	0.0001%	0.0008%	0.0043%	0.0132%	0.0100%	0.0031%	0.0000%	0.0004%	0.0000%	0.0001%	0.0000%
Personal Income	Mil of Fixed (2015) $	0.0000%	0.0006%	0.0030%	0.0089%	0.0060%	0.0018%	0.0002%	0.0004%	0.0002%	0.0003%	0.0001%

* Represents the total cumulative person-year of jobs over the entire analysis period, rather than sustained jobs over the years.

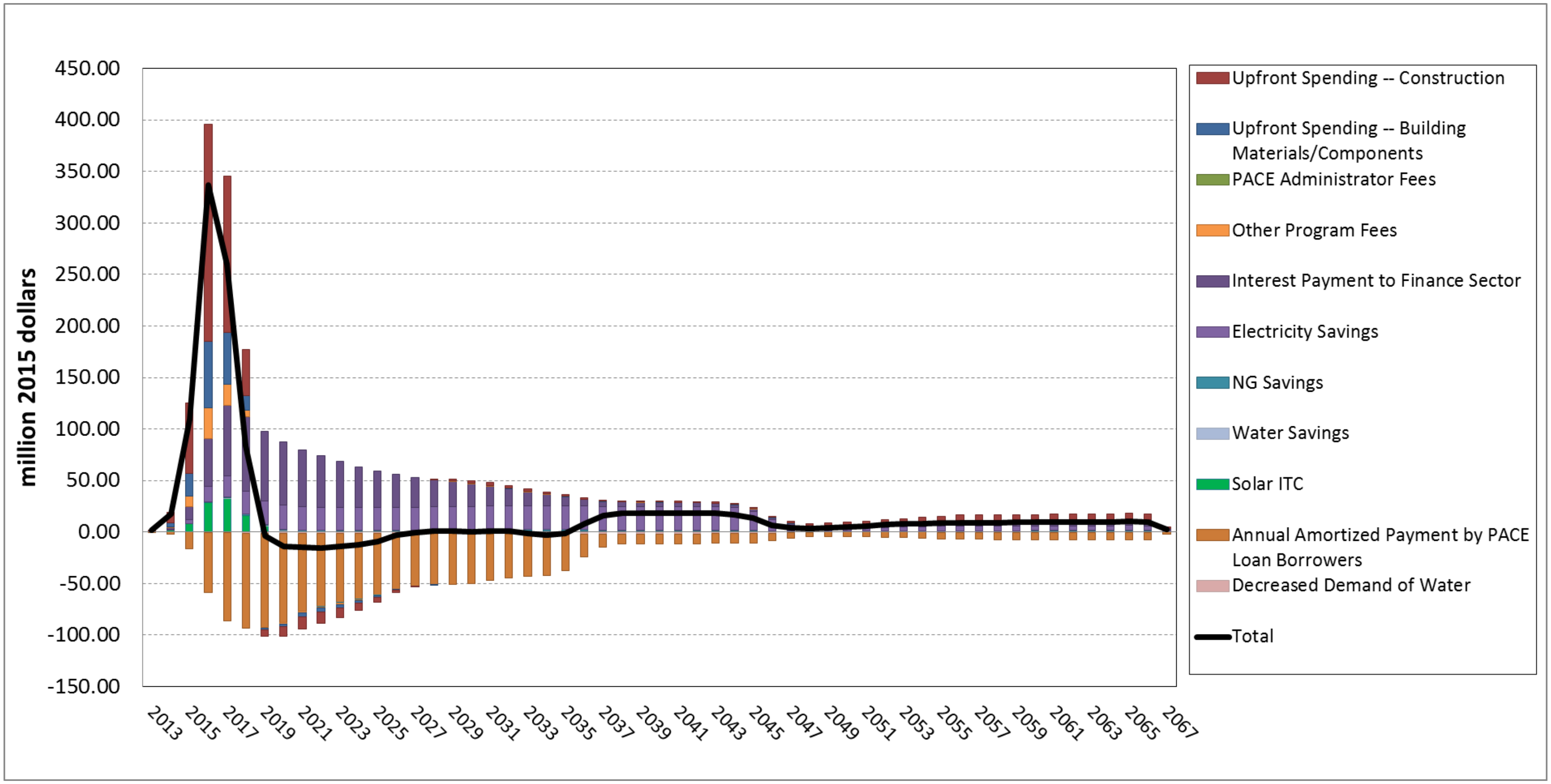

Figure 1. GSP Impacts of California Ygrene PACE Financing
(million 2015$)

Table 6. REMI Simulation Results for Base Case: Macroeconomic Impacts of Ygrene PACE Financing on Florida for Key Years

Differences from Baseline Level

Variable	Units	2013	2014	2015	2016	2017	2018	2028	2038	2048	2058	2067	NPV (or Total Person-Year Jobs)
Total Employment	Individual (Jobs)	2	79	211	975	2,247	1,500	275	51	50	41	20	11,716*
Gross Domestic Product	Mil of Fixed (2015) $	0.19	6.17	17.14	79.66	186.98	127.47	27.10	4.73	5.44	5.40	2.57	608.22
Output (Sales Revenue)	Mil of Fixed (2015) $	0.37	11.94	33.09	153.03	362.01	243.70	47.73	8.38	10.46	10.78	5.14	1,130.49
Personal Income	Mil of Fixed (2015) $	0.12	3.76	10.23	50.90	119.49	78.26	27.34	11.58	11.75	11.30	5.39	512.96
Non-Market Electricity Production	Mil of Fixed (2015) $	0.00	0.01	0.06	0.21	0.45	0.85	0.61	0.43	0.00	0.00	0.00	7.85

Percent Change from Baseline Level

Variable	Units	2013	2014	2015	2016	2017	2018	2028	2038	2048	2058	2067
Total Employment	Individual (Jobs)	0.0000%	0.0006%	0.0017%	0.0078%	0.0179%	0.0119%	0.0022%	0.0004%	0.0003%	0.0003%	0.0001%
Gross Domestic Product	Mil of Fixed (2015) $	0.0000%	0.0006%	0.0016%	0.0074%	0.0170%	0.0114%	0.0021%	0.0003%	0.0003%	0.0003%	0.0001%
Output (Sales Revenue)	Mil of Fixed (2015) $	0.0000%	0.0006%	0.0017%	0.0078%	0.0179%	0.0118%	0.0020%	0.0003%	0.0003%	0.0003%	0.0001%
Personal Income	Mil of Fixed (2015) $	0.0000%	0.0004%	0.0010%	0.0046%	0.0104%	0.0066%	0.0019%	0.0007%	0.0006%	0.0004%	0.0002%

* Represents the total cumulative person-year of jobs over the entire analysis period, rather than sustained jobs over the years.

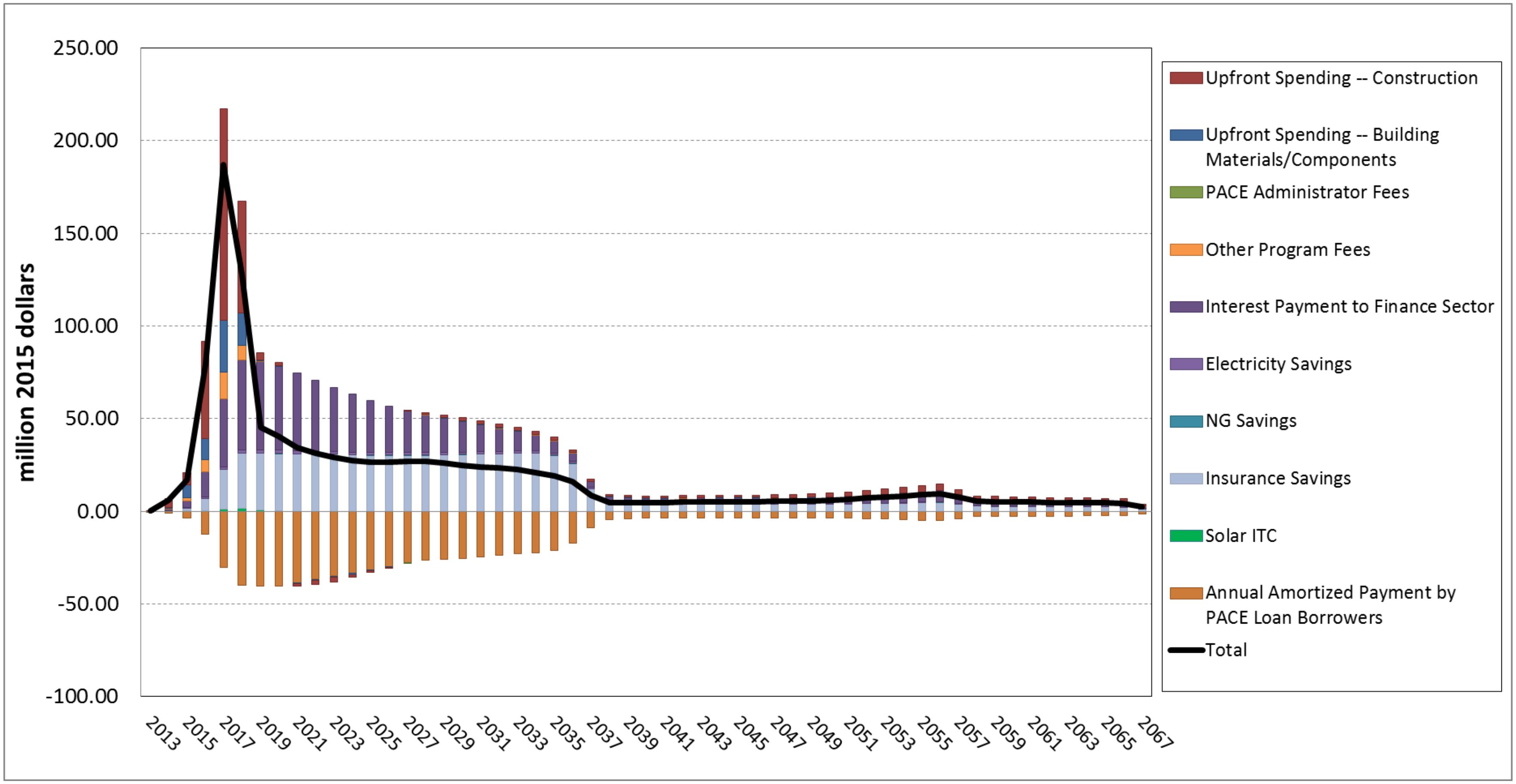

Figure 2. GSP Impacts of Florida Ygrene PACE Financing
(million 2015$)

C. Tax Impacts

Economic activities stimulated by the PACE financing also generate tax revenues to various levels of government. The impacts on tax revenues are estimated primarily based on the REMI macroeconomic impact results, supplemented by tax data obtained from social accounting matrices (SAMs) for California and Florida (IMPLAN, 2018). The REMI PI+ Model provides estimates of personal income tax revenues stemming from various PACE-related activities for each year in the analysis period. For Year 2018 and beyond, we adjusted the total federal personal income impacts by income bracket downwards taking into consideration the potential impacts of the 2017 Federal Tax Reform Bill (Kurtzleben, 2017).[15] For indirect business taxes (IBT)[16] and corporate income taxes, we first calculated the corresponding tax coefficients by sector using the IMPLAN SAM data.[17] We then applied these tax coefficients to the REMI sectoral macroeconomic impacts on sectoral gross output to estimate the changes in government revenues from these two types of taxes. For corporate income taxes, we took into account the tax rate cut from 35% to 21% to reflect the changes after the recent tax legislation.

Tables 7 and 8 present the net present value of tax impacts in California and Florida, respectively. The impacts are presented for the three major categories of taxes, with the distinction of state/local taxes vs. federal taxes. For California, the net present value (NPV) of total tax impacts is estimated to be $120.9 million, with personal income taxes accounting for about 65% of the total. About 45% of the increased tax revenues go to state/local governments, and 55% go to the federal government. For Florida, the NPV of total tax impacts is estimated to be $136.61 million, of which 47% are personal taxes, 28% are indirect business taxes, and 25% are corporate income taxes. The increase in federal tax revenues accounts for about two thirds of the total tax revenue increase. The relatively lower overall impact is primarily because Florida does not have a state income tax.

Table 7. Tax Impacts of California Ygrene PACE Financing
(NPV in million 2015$)

	State/Local	Federal	Total
Personal Income Taxes	32.34	46.56	78.90
Indirect Business Taxes	18.85	2.37	21.21
Corporate Income Taxes	3.52	17.27	20.79
Total	**54.70**	**66.20**	**120.90**

[15] The REMI Model only provides estimates on total personal tax revenue impacts across all income brackets. Based on the Kurtzleben (2017) estimates of the percentage increase of after tax income across income brackets from the Federal Tax Reform Bill and IRS data on Adjusted Gross Income and Income Tax across income brackets, we calculated the weighted average percentage reduction in federal personal income tax. This percentage is 12.9% for California and 12.3% for Florida. The California percentage is lowered by 1.0 percentage point because the limit on the amount that can be deducted for state/local income taxes may cause California taxpayers to gain less than the national average from the recent federal tax reform.

[16] Indirect Business Taxes include excise, sales and property taxes, as well as, nontax liabilities that are chargeable to businesses like fees, fines, licenses and permits (IMPLAN, 2018).

[17] Corporate income taxes are provided as two aggregated amounts for state/local government and federal government, respectively, in the IMPLAN SAM table. These total amounts are distributed across sectors based on the weights computed as the sum of capital-related income and proprietor income of each sector.

Table 8. Tax Impacts of Florida Ygrene PACE Financing
(NPV in million 2015$)

	State/Local	Federal	Total
Personal Income Taxes	$5.69	$58.58	$64.27
Indirect Business Taxes	$33.85	$4.25	$38.11
Corporate Income Taxes	$6.66	$27.57	$34.23
Total	**$46.20**	**$90.41**	**$136.61**

D. Summary of Base Case Regional Macroeconomic Impact Results

Tables 9 and 10 present a summary of the various impacts of Ygrene residential and commercial PACE financing for California and Florida, respectively. In the first partition of each table, "Direct Benefits" of PACE financing are presented. In the second partition, the Regional (State) Macroeconomic Benefits ("co-benefits") stemming from various positive and negative stimuli associated with PACE financing are presented. The decomposed economic impacts are presented in the first and second numerical columns in terms of GDP and employment impacts. Water and energy savings and GHG reduction impacts (all in physical quantities) are presented in the last column of the tables. GHG emission reductions are also translated into GDP impacts by applying the social cost of carbon. Note, however, that not all of these direct benefits can be included in the bottom line GDP impacts. Strictly speaking GDP includes only the value of all final goods and services bought and sold in the marketplace. Hence, the "Non-Market Electricity Production" cannot be included, nor can the dollar value of "Greenhouse Gas Reductions". However, both of these can be included in a measure of "Augmented GDP" (AGDP), an increasingly used measure of aggregate well-being in the vein of "green accounting". In addition, GDP only includes the "flow" of goods and services, and "Avoided Disaster Losses (in terms of property damage)" refers to a change in the "stock" of assets, which are not part of GDP; hence, they are not included even in AGDP. The reader is encouraged, however, to keep the avoided property damage in mind as another co-benefit of PACE financing. Finally, we do include the "Avoided Disaster Losses (in terms of relocation costs)" in the AGDP total.

As our focus is on estimating the macroeconomic co-benefits of PACE financing, we only provide a brief summary of the direct benefits: reductions in water and energy consumption, in GHG emissions, and in losses from natural disasters. It is important to note that these reductions are brought about by financing that basically pays for itself in terms of cost savings on utility bills and avoided costs from the need to repair homes and commercial buildings. The reader is referred to the first partition of Tables 9 and 10, which refers to these "Direct Benefits". Non-market benefits again are not counted in the Total GDP but are counted in Total AGDP. One exception is the Avoided Property Damages (the dollar value of which is presented in brackets), which is not included in AGDP either for the reason stated above. Note also that those direct benefit numbers presented in parentheses in the first partition are not added to Total GDP or AGDP at the bottom of the tables to avoid "double-counting" because not only their direct, but also their indirect, impacts are factored in the second partition, as calculated by the REMI Model (e.g., "Energy Cost Savings"). The direct impacts in California are sizeable, amounting to slightly less than $400 million (not including a few million dollars in benefits relating to avoided property damage). In Florida, the direct impacts in terms of GDP flows are over $163 million, but the avoided property damage is more than $507 million.

Table 9. Summary of Ygrene PACE Financing Impacts in California (Base Case)

Type of Impacts	GDP Impacts[a] (million 2015$)	Employment Impacts[b] (person-year jobs)	Energy, Water, and Environmental Impacts
Direct Benefits Stemming from:			
Water Consumption Reduction (billions of gallons)	(9.16)[c]	87[d]	2.36
Electricity Consumption Reductions (million MWh)	(196.37)[c]	836[d]	3.63
Natural Gas Consumption Reductions (bcf)	(9.25)[c]	83[d]	2.86
Non-Market Electricity Production (million 2015$)	131.66[e]	n/a[f]	n/a
Greenhouse Gas Reductions (metric MtCO2e)	54.53[g]	n/a	1.15
Avoided Disaster Losses (property damage)[h]	[2.36][i]	n/a[j]	n/a
Avoided Disaster Losses (relocation costs)	0.38[k]	n/a[j]	n/a
Regional Macroeconomic Benefits Stemming from:			
Ygrene Financing for Improvements	491.29	7,010	n/a
Ygrene and Other Program Fees	54.08	772	n/a
Interest Payments for Financing	486.98	7,019	n/a
Water Cost Savings	7.86	174	n/a
Energy (Electricity and Natural Gas) Cost Savings	320.74	6,841	n/a
Solar investment Tax Credit	76.41	1,103	n/a
Annual Repayment of PACE Financing	-754.85	-12,744	n/a
Decreased Demand from Water Supply Sector	-21.09	-402	n/a
Earthquake Insurance Savings	n/a[l]	n/a	n/a
Tax Impact	[120.90][m]	n/a[j]	n/a
Total GDP	661.42	9,774	n/a[n]
Total AGDP	847.99	9,774	n/a[n]

[a] Net present value (NPV) at a 5% discount rate over the period 2013-67.
[b] Total new jobs created over the period 2013-67.
[c] Calculated by first applying projected state average price to energy/water savings in physical terms to obtain estimates in gross output changes and then by applying value-added to gross output ratios to obtain changes in GDP; not included in Total Impacts to avoid double-counting, because its direct and indirect effects are included in the Regional Macroeconomic Benefits partition.
[d] Calculated by applying employment coefficients to gross output estimates; not included in Total Impacts to avoid double-counting.
[e] The non-market value of electricity production from solar energy is $257.53 million. This is converted to GDP by using the value-added to gross output ratio in the electricity sector (the average of the ratios in the private and government electricity sectors). This dollar amount is not included in Total GDP, but is included in Total AGDP.
[f] There are no direct employment impacts of non-market electricity production over and above the cost of installation of solar generation capability, which is captured in the Ygrene Financing row below.
[g] Based on NRC (2017) estimate of $42 per ton of CO_2 (in 2007$ and converted to $47.57 in 2015$). This dollar amount is not included in Total GDP, but is included in Total AGDP.
[h] Also includes a very small amount of prevented business interruption in commercial facilities.
[i] Pertains to the prevention of property damage primarily for residences; hence, not included in GDP or AGDP Total.
[j] We did not have sufficient data to estimate this impact.
[k] This dollar amount is not included in Total GDP, but is included in Total AGDP.
[l] Data not available to estimate earthquake insurance savings.
[m] Not included in Total Impacts to avoid double-counting.
[n] The total cannot be computed for this column because entries are in different units of measure.

Table 10. Summary of Ygrene PACE Financing Impacts in Florida (Base Case)

Type of Impacts	GDP Impacts[a] (million 2015$)	Employment Impacts[b] (person-year jobs)	Energy, Water, and Environmental Impacts
Direct Benefits Stemming from:			
Electricity Consumption Reductions (million MWh)	(10.83)[c]	34[d]	0.463
Natural Gas Consumption Reductions (million cf)	(1.21)[c]	15[d]	0.28
Non-Market Electricity Production (million 2015$)	4.01[e]	n/a[f]	n/a
Greenhouse Gas Reductions (metric MtCO2e)	12.51[g]	n/a	0.263
Avoided Disaster Losses (property damage)[h]	[507.76][i]	n/a[j]	n/a
Avoided Disaster Losses (relocation costs)	134.94[k]	n/a[j]	n/a
Regional Macroeconomic Benefits Stemming from:			
Ygrene Financing for Improvements	252.80	4,309	n/a
Ygrene and Other Program Fees	25.91	444	n/a
Interest Payments for Financing	329.11	6,423	n/a
Energy (Electricity and Natural Gas) Cost Savings	19.13	427	n/a
Solar investment Tax Credit	3.96	69	n/a
Annual Repayment of PACE Financing	-354.13	-7,191	n/a
Hurricane Insurance Savings	331.47	7,235	n/a
Tax Impact	[140.35][l]	n/a[j]	n/a
Total GDP	608.22	11,716	n/a[m]
Total AGDP	759.71	11,716	n/a[m]

[a] Net present value (NPV) at a 5% discount rate over the period 2013-67.

[b] Total new jobs created over the period 2013-67.

[c] Calculated by first applying projected state average price to energy/water savings in physical terms to obtain estimates in gross output changes and then by applying value-added to gross output ratios to obtain changes in GDP; not included in Total Impacts to avoid double-counting, because its direct and indirect effects are included in the Regional Macroeconomic Benefits partition.

[d] Calculated by applying employment coefficients to gross output estimates; not included in Total Impacts to avoid double-counting.

[e] The non-market value of electricity production from solar energy is $7.85 million. This is converted to GDP by using the value-added to gross output ratio in the electricity sector (the average of the ratios in the private and government electricity sectors). This dollar amount is not included in Total GDP, but is included in Total AGDP.

[f] There are no direct employment impacts of non-market electricity production over and above the cost of installation of solar generation capability, which is captured in the Ygrene Financing row below.

[g] Based on NRC (2017) estimate of $42 per ton of CO2 (in 2007$ and converted to $47.57 in 2015$). This dollar amount is not included in Total GDP, but is included in Total AGDP.

[h] Also includes a very small amount of prevented business interruption in commercial facilities.

[i] Pertains to the prevention of property damage primarily for residences; hence, not included in GDP or AGDP Total.

[j] We did not have sufficient data to estimate this impact.

[k] This dollar amount is not included in Total GDP, but is included in Total AGDP.

[l] Not included in Total Impacts to avoid double-counting.

[m] The total cannot be computed for this column because entries are in different units of measure.

Total GDP impacts (in net present values) are $661.4 million for California, and $608.2 million for Florida. The employment impacts are 9,773 person-year jobs for California, and 11,716 person-year jobs for Florida. In California, the largest contributor to these impacts emanate from Energy Cost Savings, followed by the net impacts of Ygrene Financing, Interest Payments and Other Program Fees minus Annual Repayment of this Financing. In Florida, the largest impact stems from Hurricane Insurance Savings, followed closely by interest payments for financing. Total GDP Impacts (in terms of market production of goods and services) are slightly higher in California than in Florida. However, the employment impacts are higher in Florida than in California, primarily because of the cost-savings from insurance payments, which allow consumers to increase their purchases of goods and services, the mix of which is much more labor-intensive than the average production in the economy. Note that, although Ygrene-Financed local government assessments, various Program Fees, and related Interest Payments are more than $400 million higher in California than in Florida, nearly all of this is offset by the negative stimulus of Annual Repayment of PACE Financing in California. Energy Cost Savings are more than $300 million higher in California than in Florida, but this is offset nearly entirely by the higher Insurance Savings in Florida.

Total AGDP impacts (including non-market value of solar electricity production, social cost of carbon, and avoided disaster relocation cost) are nearly $850 million for California, and $760 million for Florida. In California, the value of Non-Market Electricity Production becomes the third largest contributor to these impacts. In Florida, the two types of Avoided Disaster Losses, become the largest source of AGDP impacts. Although Total AGDP impacts are at similar levels for the two states, the composition of these impacts differs significantly. The value of non-market electricity generation in California is more than $125 million higher than in Florida. However, this differential is counterbalanced by the fact that Avoided Disaster Relocation Costs are nearly $135 million higher in Florida, due to much greater market penetration of disaster mitigation financing in that state.

VIII. Sensitivity Analyses

We perform several sensitivity tests to analyze how the changes in some key assumptions would affect the macroeconomic impact analysis results of the PACE financing. Note that we confine ourselves to the major assumptions and do not explicitly analyze the effects of others, because they are so minor or the modeling is not capable of performing such estimation. We should also note the several places in the report above where we have indicated a slight overestimation or underestimation due to a simplifying assumption, as well as the sensitivity analyses below, all of which cancel each other out to a great extent, so that our overall estimates come closer to the Base Case.

A. Displacement Effects of Repaying PACE Financing

We first perform a sensitivity test on our assumption that people need to reduce other purchases to repay PACE financing on a dollar-for-dollar basis. It is possible that they will dip into savings, so as not to fully displace other spending. We therefore performed a sensitivity test that reduces the direct offset by 10% and present the results in the row 2 of Table 11. They indicate that the Base Case results are not very sensitive to this assumption in either state.

B. Offsetting Effects of Energy Demand Reduction

We also include the dampening impacts from the decreased demand for electricity and natural gas from the energy supply sectors. These impacts are simulated as decreases in exogenous final demand from the Electricity Generation sector and Oil and Gas Extraction sector in the REMI simulations.

The primary reason for excluding this offset in the Base Case is that, in California, for example, the state law (under Senate Bill 350), requires the state to increase the share of electricity derived from renewable sources from 33% to 50% and to double the efficiency of existing buildings. Additionally, the California Energy Commission (CEC) established the Existing Buildings Energy Efficiency Action Plan to increase energy efficiency in residential, commercial, and government buildings. Utilities also established various types of incentives to procure energy efficiency. Florida also has similar specific energy efficiency goals. All of these policies and regulations are entirely independent of PACE, and most of them pre-dated the establishment of PACE programs in these states. Thus, PACE only serves to assist in achieving efficiency and renewable targets that are already mandated by state law and Public Utility Commission regulations. However, it is possible renewable energy and efficiency targets will more than be met by responses to market conditions, in which case PACE displacements of electricity and natural gas would represent an overage and justify including their value in the reduction of electricity and natural gas production. In our sensitivity test, we have thus assumed a 50% offset.

The results of this sensitivity analysis, presented in row 3 of Table 11, indicate that the estimated economic impacts for California are more sensitive to the inclusion of the offsetting effects of energy demand reduction than those for Florida. This is because over 99% of the Ygrene PACE improvement investment in California is energy efficiency upgrades and renewable energy installations. In Florida, hurricane prevention and mitigation projects account for about 69% of the total Ygrene PACE financing portfolio. The results for California are most sensitive to this assumption resulting in a reduction of Base Case GDP Impacts by 27 percent.

C. Insurance Savings

The decomposition analysis presented in a previous sub-section indicates that the factor resulting in the highest positive impacts in Florida is insurance premium saving. We now present the REMI results for the Lower-Bound and Upper-Bound saving cases, which assumes a 50% divergence of direct insurance savings below and above the Base Case. The results represent a decrease of Base Case GDP Impacts of 27 percent in the Lower-Bound Case and an increase of 29 percent in the Insurance Upper-Bound Case. The results are not perfectly symmetric because of the non-linearity of the REMI Model.

D. Additivity of Ygrene Financing

A question arises as to the extent to which the various improvements simulated here would have taken place in the absence of Ygrene financing, i.e., whether the impacts are truly additive. Estimates by Kirkpatrick indicate 100% additivity for PACE financing in general on solar energy improvements, and more recent estimates by Eyer (2019) indicate 25% to 100% additivity for solar energy. If we consider the Eyer estimate to represent a lower-bound not just for solar energy improvements but all improvements, we would simply reduce the Base Case estimates by 75%. This will reduce the Base Case GDP impacts from $661.4 million to $165.36 million for California, and from $608.22 million to $152.06 million for Florida.

Table 11. Summary Results of Base Case and Sensitivity Cases

	California		Florida	
	GDP Impacts (million 2015$)	**Employment (Person-year jobs)**	**GDP Impacts (million 2015$)**	**Employment (Person-year jobs)**
Base Case	$661.44	9,774	$608.22	11,716
Reduced Displacement Effect of PACE Repayment	$736.92	11,048	$643.67	12,438
Inclusion of Energy Demand Reduction Offsetting Effects	$482.74	7,356	$594.72	11,539
Insurance Savings Lower-Bound Case	n.a.	n.a.	$442.48	8,099
Insurance Savings Upper-Bound Case	n.a.	n.a.	$787.96	15,223

IX. Conclusion

The Property Assessed Clean Energy (PACE) Program has broadened significantly in recent years and now also includes financing for saving water and for reducing vulnerability to disasters for both residential and commercial properties. It is able to achieve its direct societal objectives while providing financial gains to those receiving financing and implementing the building improvements. It does so by providing financing that is beneficial to the financing recipients by saving money on utility bills and avoiding having to pay for building repairs or reconstruction following an earthquake or hurricane. Moreover, it represents an equitable alternative collateralization of the financing, in part because the property value is not a criterion for qualifying nor is a credit score, thereby making it available to some who could not otherwise secure financing through more conventional lending-related instruments.

We have estimated the direct benefits of PACE financing by one of its major administrators, Ygrene Energy Fund, Inc. More uniquely, we have also estimated the broader macroeconomic co-benefits of this financing in terms of impacts on market-based GDP and augmented GDP that takes into account the non-market effects. The analysis was performed in the context of an Economic Consequence Analysis that took into consideration the numerous positive and negative stimuli associated with PACE financing. The macro impacts were estimated with the use of the REMI Policy Insight Plus Model, the most widely used macroeconometric model at the state and local levels in the US.

The economic increases for California over the entire period in which the improvements are operative (2013 to 2067) is estimated to be (in 2015 dollars):

- Net present value (NPV) of GDP of $661.4 million
- Total cumulative person-year jobs of 9,774
- NPV of gross output (sales revenue) of $1,279.2 million
- NPV of personal income of $490.5 million
- NPV of total tax impacts of $120.9 million

The economic increases for Florida over the entire study period are estimated to be:

- NPV of GDP of $608.2 million
- Total cumulative person-year jobs of 11,716
- NPV of gross output (sales revenue) of $1,130.5 million
- NPV of personal income of $513.0 million
- NPV of total tax impacts of $136.6 million

The aforementioned co-benefits in California are over and above the direct benefits, which include:

- Water consumption reduction of 2.36 billion gallons
- Electricity consumption reduction of 3.63 million MWh
- Natural gas consumption reduction of 2.86 bcf
- Greenhouse gas reduction of 1.15 million metric tCO_2e
- Avoided property damage from earthquakes of $2.36 million

The aforementioned co-benefits in Florida are over and above the direct benefits, which include:

- Electricity consumption reduction of 0.46 million MWh
- Natural gas consumption reduction of 0.28 bcf
- Greenhouse gas reduction of 0.26 million metric tCO_2e
- Avoided property damage from hurricanes of $507.76 million

Total Augmented GDP (AGDP) impacts, which include the non-market value of solar electricity production, social cost of carbon, and avoided disaster relocation cost, are nearly $850 million for California, and $760 million for Florida. Employment impacts are the same as the regular employment impacts noted above, since new jobs are not directly associated with any of these direct environmental and hazard reduction benefits. The composition of the impacts differs significantly between the two states, primarily because of differences in the types of improvement financed. In California, the major stimuli of positive impacts are the expenditures on improvements for energy and the associated cost-saving and non-market values of electricity generation from solar installations. For Florida, the results are dominated by, hurricane insurance savings and expenditures on improvements, followed by the avoidance of relocation costs following disasters. In addition to the impacts on GDP and employment, Ygrene-financed projects are estimated to also result in more than $500 million worth of avoided property damage in Florida.

Sensitivity tests indicate our results are robust to changes in major assumptions relating to displacement effects of repaying PACE financing, offsetting effects of energy demand reduction, alternative estimates of insurance savings, and the relative additivity of Ygrene financing. Overall, the PACE financing provided by Ygrene, and even more so if we included all PACE financing, generates sizable net positive impacts on the economies of the major states of operation.

PACE financing has faced some criticism because it is not traditional in terms of collateral and because of some marketing and quality control issues of the independent contracting community, albeit a very small percentage, in implementing the various improvements. The industry addresses this through compliance guidelines that are implemented for each PACE program. In addition to the more straightforward direct benefits of PACE financing, this paper is intended to provide estimates of the several *co-benefits*, which are very positive on net. These economic benefits are thus likely to also be of considerable interest to policy-makers evaluating future decisions about accommodating and even facilitating PACE financing in addition to the broader public policy goals of achieving federal, state, and local energy, environmental, and disaster mitigation goals. PACE is a public policy tool designed to leverage private capital to provide public benefits and help homeowners and business owners overcome barriers to implementing building improvements.

PACE is a financing mechanism by which broader and more equitable access to property improvements in energy efficiency, water conservation, renewable energy, and hazard mitigation is made possible. This research shows that PACE has had a positive net impact on the environment and the economy in the states in which it is enabled.

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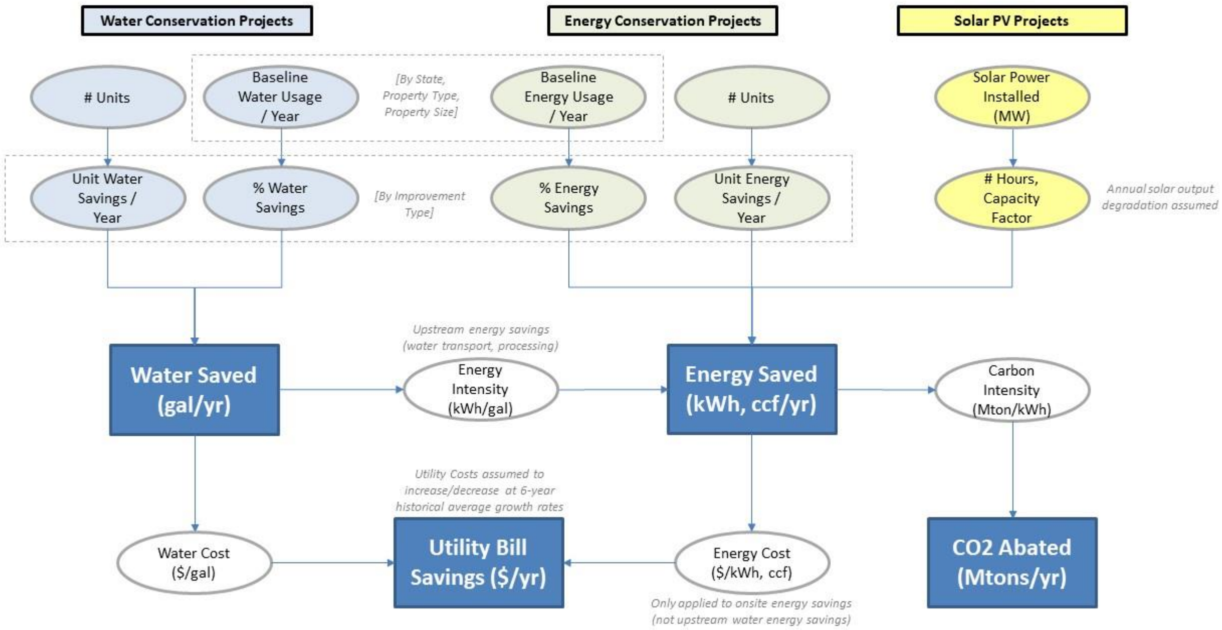
Appendix Table 1. Data, Refinement and Sources

Data Type	Description	Coverage	Source	Assumptions/ Modifications	Comments
1a. PACE Financing	major assessment characteristics	# of PACE improvements: CA: 32,513 FL: 21,855 MO: 162	Ygrene	--[a]	--
1b. Useful Life of Improvement	period generating benefits	all assessments	Ygrene	varies by improvement type	--
1c. Interest Rate	interest rate on assessments	all assessments	Ygrene	varies by state & year & project	--
1d. Fees	paid to Ygrene & governments	all assessments	Ygrene	varies by state & year & project	--
2. Production of Improvements	mapping improvement expenditures to REMI sectors	160 REMI sectors	NAICS website; specific expenditure references	--	--
3. Material/Labor Share of Improvements	disaggregation of expenditures	all assessments	various improvement type websites	labor part of Construction & Repair sector[b]	--
4a. Energy Savings (expenditures)	fossil energy reduction; overall energy reduction	all assessments (annual)	Ygrene	--	--
4b. Energy Savings (quantity)	fossil energy reduction; overall energy reduction	all assessments (annual)	Ygrene	--	--
4c. Energy Savings (value)	value of energy saved	all assessments (annual)	Ygrene	valued at market price[c]	--
4d. Energy Produced (solar electricity quantity)	quantity used + quantity sold to the grid	all assessments (annual)	Ygrene	valued at market price	--
4e. Energy Production Displaced (quantity)	fossil fuel demand reduction; same as Energy Savings quantity	quantity offset by solar & energy efficiency	Ygrene	--	calculated from Ygrene data
5a. Water Savings (quantity)	decrease water utilization	all assessments (annual)	Ygrene	--	--
5b. Water Savings (value)	decrease water utilization	all assessments (annual)	Ygrene	valued at market price[c]	--
5c. Water Production Displaced (quantity)	same as Water Savings quantity	all assessments (annual)	Ygrene	--	calculated from Ygrene data
5d. GHG Damage Avoided	social cost of carbon	carbon but not methane	NRC (2017)	--	--
6a. Hazard Mitigation Improvements (expenditures)	expenditure on hazard risk reduction	all assessments (annual)	Ygrene	--	--
6b. Hazard Mitigation Savings (value)	Dollar value of losses avoided	all assessments (annual)	*Mitigation Saves 2* benefit-cost ratios	apply BCRs to expenditures;[c] adapt MMC & IBHS data	--
6c. Insurance Savings	premium reduction	all assessments (annual)	FOIR (2017)	--	

[a] See Appendix B for minor adjustments.
[b] Minor exceptions, such as Landscaping Services sector for drought-resistant landscaping improvements.
[c] Value saved assumed to be spent entirely on consumer goods by home owners and to reduce production costs for owners of commercial property.



Appendix Figure 1. Ygrene Impact Metrics Model Methodological Flow Chart

Appendix Table 2. BCRs by PACE Seismic Improvement Category

PACE Seismic Retrofit Categories	Commercial BCR	Residential BCR
Seismic Foundation Strengthening	0.57[a]	0.39
Foundation Connection System	1.77[b]	1.21
Structural Connection System	3.66	2.49
Seismic Other/Custom	2.18	1.49
Lateral Systems, Moment Frames	0.47[c]	0.27
Lateral Systems, New Steel Columns	0.71[d]	0.48
Lateral Systems, Shear Walls	1.77[b]	1.21
Lateral Systems, Column Strengthening	0.57[a]	0.39
Masonry Reinforcement	5.04[c]	2.92

[a] Estimated as one-half of the BCR for "Structural strengthening of a university science building: jacket concrete columns and beams; strengthen footings" because it includes two PACE improvement categories.
[b] Estimated as one-half of the BCR for "Structural and nonstructural retrofit of a hospital building: install new concrete shearwalls, enlarge foundations, nonstructural bracing" because it includes two PACE improvement categories.
[c] Based on public building estimates.
[d] Based on an adjustment of "Lateral Systems, Column Strengthening", which was assumed to be a retrofit and assumed to have a 25% higher cost than New Steel Columns.

Appendix Table 3. BCRs for PACE Hurricane Improvement Types

PACE Improvements	Residential BCRs	Commercial BCRs
High-Impact Windows	1.38	1.43
High-Impact Doors - Standard	1.38	1.43
Wind Resistant Roofing	2.51	2.61
Wind Resistant Shingles	2.51	2.61
Storm Shutters	1.38	1.43
Roof Deck Attachment Strengthening	2.93	3.05
Opening Protections/Garage Doors	1.38	1.43
Roof to Wall Reinforcement	1.96	2.04
Secondary Water Barrier	2.51	2.61
Waterproofing - Basement Membrane	3.30	3.43
High-Impact Doors	1.38	1.43
Gable-end Bracing	3.84	3.99
Hurricane Protection-Impact Windows & Doors	1.48	1.54
Hurricane Protection-Other	1.93	2.00