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Residential Property Assessed Clean Energy in California

Feasibility of Studying Impacts on Mortgage Performance and Energy Savings

Emily Martin Fadrhonc, Jeff Deason, Liesel Hans, Ben Hoen, Steven R. Schiller, and Lisa Schwartz, Lawrence Berkeley National Laboratory

Property assessed clean energy financing (PACE) is a highly secure form of financing that can be used to fund clean energy and other improvements on private property. PACE assessments are repaid through property tax bills, transfer from one property owner to the next, and can accommodate long-payback projects. Over 47,000 residential PACE assessments worth nearly $960 million have been placed across California.

Several important but unanswered research questions surround PACE financing. Because PACE assessments in California are senior to mortgages, a PACE assessment might reduce the funds available to repay a mortgage holder in the event of default and foreclosure. PACE payments also introduce a new expense that may impact homeowners' overall ability to pay. Many stakeholders question how PACE may impact mortgage performance. Understanding actual (versus projected) energy savings attributable to PACE-funded projects, for comparison to other financing- and non-financing focused energy-saving interventions, is also of interest.

While PACE administrators are collecting the relevant data, the performance history (in years) available for PACE-encumbered mortgages limits our ability to study PACE's impact on mortgage performance over time, which is important to stakeholders. Over 75 percent of PACE assessments in California were placed in 2014 or more recently; according to surveyed stakeholders, three to five years of performance history would be ideal. To examine energy savings from PACE-funded projects, we prefer a large-scale data analysis using utility bill data to a deemed savings approach. However, only 4 percent of all PACE projects have access to utility bill data, thus a study of energy savings is not feasible with currently available data.

Stakeholders wishing to support future studies of these two questions should consider (1) continuing to collect high-quality information on PACE assessments and recipients, including FICO score and (2) obtaining permission to access utility bill information before and after the PACE-funded upgrade as well as other participant information that would be relevant to the selection of comparison groups. Other stakeholders can encourage sharing of non-PACE assessed properties' (the comparison group's) utility data with researchers.

Purpose of This Report

In January 2015, the White House, the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Energy (DOE), and Governor Brown of California announced a number of actions to expand financing for energy efficiency and solar energy in multifamily housing.[1] As part of

[1] Original announcement is available at https://www.whitehouse.gov/the-press-office/2015/01/29/fact-sheet-administration-and-california-partner-drive-renewable-energy-

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the announcement, DOE stated that it would "work with the state of California to design and undertake a study assessing the performance of California's Property Assessed Clean Energy (PACE) programs as data becomes available." While the announcement focused on multifamily housing, stakeholders' strong interest in residential-sector PACE activity led us to focus on single-family PACE projects. This scoping study is a first step towards fulfilling DOE's objective of completing a large-scale assessment of PACE in California.[2]

This report's objectives are to (1) categorize residential PACE activity in California to date ("Background"), (2) establish research questions relevant to PACE activity in California ("Definition of Research Questions" and "Research Approach"), (3) identify data sources required to address these research questions ("Data Required"), (4) identify the existence or non-existence of required data ("Data Availability"), and (5) make recommendations on potential future studies of PACE in California ("Summary").

Background

Land-secured financing districts, also called special assessment districts, have been used in the United States for more than 100 years to pay for infrastructure improvements deemed to be in the public interest. PACE financing in California allows state and local governments to extend the use of land-secured financing districts to fund energy efficiency, water efficiency, and renewable energy improvements on private property.[3] PACE assessments are repaid on the property tax bill and are intended to survive foreclosure in a position senior to the first mortgage. This strong form of security may allow for loan terms that enable larger projects with longer paybacks. PACE assessments attach to the property, not the original borrower,

Multifamily PACE Data
LBNL research discovered only about 25 multifamily PACE projects in California. Until at least several thousand multifamily projects are completed, an analysis of PACE mortgage performance and energy savings impacts in the multifamily sector is unfeasible. Thus, this report focuses on the single family residential PACE market.

[2] In August 2015, additional announcements from the White House and others introduced the possibility of "contractually subordinated" PACE assessments as a key to unlocking the residential PACE market. The specifics of contractual subordination and its impacts on the ability of the Federal Housing Administration (FHA) and possibly the GSEs (FannieMae and FreddieMac) to process PACE-encumbered mortgages is still under discussion. Nearly all existing PACE assessments in California are not contractually subordinated. Even if, in the future, the major of PACE assessments include contractual subordination, the research questions introduced in this brief will remain relevant. Understanding non-subordinated PACE assessments' impact on mortgage performance and energy savings will still provide key policy insights regarding the impact and value of a long-term, low-cost, highly-secure, land-tied form of financing. Practically, due to the large sample size required to conduct a large-scale analysis, it is unlikely that contractually subordinated PACE assessments would be available for study in the next few years. However, if a sufficient volume of subordinated PACE assessments were available, a comparison of subordinated and non-subordinated PACE assessments could provide important information on the value of first-priority status of PACE. See the White House's announcement (https://www.whitehouse.gov/the-press-office/2015/08/24/fact-sheet-president-obama-announces-new-actions-bring-renewable-energy), the FHA's (http://portal.hud.gov/hudportal/documents/huddoc?id=FTDO.pdf), and PACE programs' (http://www.prnewswire.com/news-releases/statement-of-renovate-america-ceo-jp-mcneill-on-fha-action-on-pace-300132320.html).

[3] In California, PACE may also be used for water efficiency and conservation, electric vehicle charging infrastructure, and seismic strengthening. Others states allow non-energy measures as well; for example, in Florida PACE may be used for wind mitigation.

allowing occupants to pay for improvements only so long as they benefit from those improvements.[4] PACE may also make attractive, long-term financing for energy improvements available to a wider range of consumers, because PACE financing is not contingent solely on an individual's credit history.[5]

PACE programs serving single-family residential (3 units or less) and multifamily (4 units or more)[6] properties have been active in California since 2008 with the large majority of activity occurring in the single-family residential sector (see sidebar "Multifamily PACE"). Early programs were administered by local government or county entities. More recently, multi-county PACE programs administered by local agencies in partnership with private firms have gained traction. Two of these programs, CaliforniaFIRST and California HERO, are available statewide (see Table 1).[7]

In 2013, the California legislature and the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) established a $10 million residential loss reserve fund that will compensate first mortgage holders for direct losses experienced in a foreclosure that are attributable to a PACE lien covered under the program.[8] Participating programs must conform to CAEATFA's program requirements (e.g., PACE assessment may not exceed 15 percent of property value for properties valued at $700,000 or less). To date, no claims against the loss reserve have been received.

Table 1: Overview of Residential PACE Programs in California

Program	Available In	Launch Date	Available To
Sonoma County Energy Independence Program	Sonoma County	2009	Residential and Commercial
mPOWER Placer County*	Placer County	2010	Residential
Western Riverside Council of Governments (WRCOG) HERO**	Members of WRCOG	2011	Residential
San Bernardino Associated Governments (SANBAG) HERO**	Members of SANBAG	2013	Residential
California HERO**	State-wide	2014	Residential
CaliforniaFIRST†	State-wide	2014	Residential and Commercial
Ygrene Works††	Multiple counties	Varies by county (2013-2015)	Residential and Commercial

** Placer County also administers the mPOWER Folsom program.*

*** These programs are administered by Renovate America.*

† Administered by Renew Financial; BerkeleyFIRST has been rolled into this program.

†† The City of Palm Desert's Energy Independence Program, an early residential PACE program, has been rolled into this program; Ygrene does not, as of this writing, participate in the CAEATFA Loss Reserve program and data from this program is not available.

[4] In practice, PACE assessments in California are often paid off during a transfer of ownership, although many have transferred to subsequent homeowners. PACE assessments are more likely to carry through a refinancing, and at least two have carried through foreclosure proceedings.

[5] No programs use FICO score as an eligibility criterion; some use history of past defaults or history of delinquency on property taxes.

[6] Other programs define multifamily properties with four or fewer units as residential; the enabling legislation for CAEATFA's loss reserve specifies residential as 3 units or fewer.

[7] CaliforniaFIRST is offered through the California Statewide Communities Development Authority Joints Powers Authority and CaliforniaHERO is offered through the Western Riverside Council of Governments Joint Powers Authority.

[8] For details, see http://www.treasurer.ca.gov/CAEATFA/pace/index.asp

Over 47,000 residential PACE assessments worth nearly $960 million have been placed across California, with concentration in Riverside, San Bernardino, San Diego, Los Angeles, Sonoma, and Placer counties (Elias, 2015) (McNeill, 2015) (Fruscha, 2015) (Windeshausen, 2015). Over 75 percent of these assessments, by count and by dollar volume, have been originated since 2014 (see Figure 1). Approximately one-third of PACE assessments have been used to fund solar photovoltaic (PV) systems. Other common PACE-funded measures include heating, ventilation and air conditioning (HVAC); roofing; and windows/doors. Statewide, PACE assessments average over $20,000, and the typical FICO score of individuals receiving PACE assessments is between 700 and 720. Interest rates range from 6 percent to 9 percent, depending on program and length of the assessment (years).

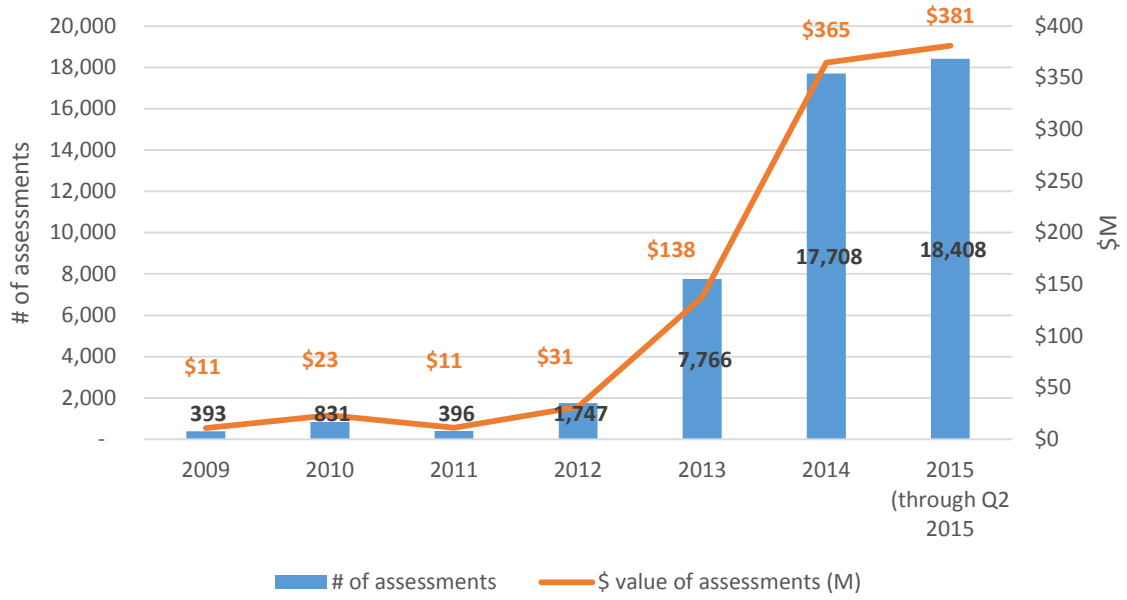

Figure 1: California Residential PACE Assessments, 2009-2015

Definition of Research Questions

To ensure that a DOE-supported study on PACE in California will be useful to a broad range of stakeholders, we interviewed relevant personnel from HUD, the White House, the California Energy Commission, CAEATFA, and several PACE programs.[9] Some interviewees expressed interest in understanding PACE's impact on property values, property tax revenues, job creation, and energy cost savings. The majority of interviewees emphasized the importance of understanding PACE's impact on mortgage performance and the energy savings created as a result of the PACE mechanism:

- **Mortgage Performance.** Interviewees highlighted concerns from mortgage lenders and regulators regarding risks that PACE assessments introduce in the event of a default.[10] If a property with a PACE lien were sold in foreclosure or forced sale proceedings, the total funds available to repay the mortgage holder *might* be reduced by part or all of the PACE

[9] Appendix 1 lists interviewees and interview questions.

[10] See for example http://www.fhfa.gov/Media/PublicAffairs/Pages/FHFA-Statement-on-Certain-Energy-Retrofit-Loan-Programs.aspx and http://www.fhfa.gov/mobile/Pages/public-affairs-detail.aspx?PageName=Statement-of-the-Federal-Housing-Finance-Agency-on-Certain-Super-Priority-Liens.aspx

assessment.[11] PACE assessments also add expense to a homeowner's total financial burden, raising concerns that PACE could negatively affect homeowners' ability to meet their mortgage obligations and thereby cause mortgage defaults. Others argue that since PACE-funded improvements may generate energy and cost savings that could partially or wholly offset the PACE payment, ability to pay should be unaffected or even improved. Interviewees noted that an empirical study of PACE's impact on mortgage performance could provide new information and possibly address these concerns. The audience of such a study—mortgage lenders and regulators—would expect to see multi-year information to understand PACE's impact over time.

- **Energy Savings.** Interviewees noted that understanding energy savings generated as a result of the PACE mechanisms would allow policy makers to (a) compare PACE financing to other energy-saving interventions (e.g., on-bill financing, education, rebates and incentives) and (b) assess whether realized energy cost savings typically offset the PACE payment. Interviewees were more interested in actual savings than predicted savings, reflecting a desire to understand the impact of PACE-financed projects over time. Since PACE programs do not make use of utility customer funds, they are not subject to reporting requirements typical of ratepayer-funded programs. As a result, PACE programs take a range of approaches to reporting energy saving impacts created by PACE-funded improvements. Understanding (1) the magnitude of these savings and (2) if these savings are "incremental" to what would have otherwise occurred and been financed using other options (e.g., a homeowner completes the same improvement but pays for it using a home equity line of credit) has important policy implications. The question of energy savings realized as a result of PACE is especially relevant as California focuses on financing programs as possible routes to achieve greater energy savings.

Priority Research Areas

Considering interviewee input, discussions with DOE, and the need to inform policy-making and program administration, we selected two priority research areas:

1. **Mortgage Performance**[12]
   - Research Question: Controlling for other variables (e.g., FICO score, home value), do properties with PACE assessments and properties without PACE assessments exhibit different mortgage performance?
   - Metrics: Mortgage performance defined as rates of default and rates of prepayment[13]
2. **Energy Savings**
   - Research Question: Do projects funded with PACE financing generate energy savings?
     - Sub-question: Does PACE financing generate additional savings by enabling projects that would not have otherwise occurred, would have been smaller in scope, or would have occurred later in time if PACE financing had not been available?

[11] Exact treatment of a PACE assessment in foreclosure and bankruptcy is an open question. See Zimring & Fuller 2010 for discussion.
[12] The questions here are about PACE's impact on default, not on its impact on recovery in the event of default. Very few PACE-encumbered mortgages have defaulted, so there is little evidence base to study recovery; we therefore set it aside for now.
[13] Prepayment reduces interest income to the mortgage lender and is a less extreme outcome than default.

- Metrics: Gross energy savings, energy generated, ideally energy savings attributable to PACE financing

Research Approach

Mortgage Performance

Mortgage performance over time is typically studied using survival analysis techniques.[14,15] These statistical methods explore the relationship between the length of time that a mortgage survives—does not default and is not prepaid—and other explanatory variables such as borrower characteristics, economic indicators, and a "treatment variable"—in this case, participation or non-participation in a PACE program. A range of survival analysis techniques can be applied, on their own or in combination with matching methods (e.g., matching PACE-assessed properties as closely as possible with non-PACE accessed properties or controls).

If applied in the absence of matching, survival analysis of mortgage default involves estimation of a hazard function. Hazard analysis models estimate survival time as a function of one or more explanatory variables. The resulting hazard function relates the proportion of mortgages that default or are prepaid in a certain time period, given their survival up to that point:

$$h(t) = \frac{number\ of\ mortgages\ experiencing\ an\ event\ in\ interval\ beginning\ at\ time\ t}{(number\ of\ mortgages\ surviving\ at\ time\ t)\ x\ (interval\ width)}$$

Multivariable regression techniques that set the hazard function as the dependent variable allow us to understand the impact of explanatory variables on the hazard function and by extension on the risk of prepayment or default. Several explanatory variables of interest (e.g., location of property, FICO score of borrower, participation or non-participation in a PACE program) can be related to the hazard of default and prepayment as follows:

$$h(t) = h_0(t)\ x\ \exp(b_{FICO}\ FICO + b_{home\ value} home\ value + \ b_{PACE} PACE \ldots)$$

The coefficients (b) indicate the change to the hazard that can be expected as a function of changes in the explanatory variables. The model relates the hazard of prepayment and default to the explanatory variables (including participation or non-participation in a PACE program).[16] The coefficient on the PACE variable is of primary interest, as it shows the change in the hazard function associated with participation in PACE.

Matching methods can enhance the survival analysis technique. Matching methods employ a treatment/control group design to determine the impact of one variable of interest (e.g., participation in PACE programs) on an outcome (e.g., mortgage performance).[17] Matching methods create a synthetic

[14] Other approaches are possible. See discussion in http://urbanpolicy.berkeley.edu/pdf/Marquez_modeling_mortgage.pdf.
[15] See Ibrahim 2005 for more information on survival analysis.
[16] Prepayment and default can be modeled together, as in Quercia, Sahadi, & Stellberg 2013, or separately.
[17] Employing a treatment/control group experimental design to determine the impact of one variable of interest (e.g., participation in PACE programs) on an outcome (e.g., mortgage performance) is best-practice. The ideal treatment/control design would randomly assign a household to a treatment group (participation in PACE) or a control group (non-participation in PACE); this is known as a randomized

control group that is as similar to the treatment group as practical along other observable characteristics that are potentially related to the studied outcome. If treatment and synthetic control groups are alike in all other respects that could influence the outcome, any difference in mortgage performance between the two groups can be attributed to PACE participation.

A variety of matching methods exist, and we could specify the method further depending on ultimate data availability. After matching is conducted, we could directly compare mortgage outcomes across the treatment and synthetic control groups in several ways. We could compare simple default rates between the two groups; however, we could learn more about the impact of PACE over time by employing survival analysis techniques to the matched data. Because matching yields estimates that can more readily be interpreted as causal, we would emphasize results obtained using these methods over results from a regression analysis that does not employ matching.

Energy Savings

Energy savings impacts are typically reported as either gross or net savings:

- **Gross savings**. Changes in energy consumption that result directly from program-related actions taken by participants of an efficiency program, regardless of why they participated.
- **Net savings**. Changes in energy use that are attributable to a particular EE program. These changes may implicitly or explicitly include the effects of free ridership, spillover, and induced market effects.[18]

Both net and gross savings could be appropriate metrics for assessing PACE programs. Gross savings are typically the metric of interest for consumers, contractors, and financing providers, while net savings are the metric of interest to policy makers when evaluating efficiency inducement options. Understanding savings attributable specifically to the existence of the PACE financing mechanisms is challenging. Methods to evaluate savings attributable to financing are under development, with few examples available to date.[19] Due to data and methodological constraints, we focus this study on gross savings methods. However, understanding the question of what savings are attributable specifically to PACE is a key policy question. As methods to assess savings attributable to financing develop, they should be used to understand savings attributable to PACE.

Gross Savings Methods

Gross savings, if that is the metric of interest, are calculated as the savings associated with the efficiency measures (e.g., lights, HVAC, insulation) installed by the PACE participants. Gross savings are estimated by comparing energy use before and after implementation of a program and adjusting for factors that are beyond the control of the PACE program or participant. Common adjustments include corrections for weather and occupancy levels and hours. The industry-standard gross savings determination methods are:[20]

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control trial (RCT). However, RCTs are often infeasible to implement for a variety of reasons, and PACE has not been evaluated using RCTs.

[18] See NREL 2014 for more information.

[19] See SEE Action 2015 for more information on the state of evaluation for financing programs.

[20] For a detailed discussion on savings estimation and impact evaluation, see National Action Plan for Energy Efficiency 2007.

- **Deemed savings**. Savings are estimated based on stipulated values of typical or average performance; these values come from historical savings values for well-understood measures. With the use of deemed savings there are no or very limited measurement activities and only the installation and operation of measures is verified. This approach involves multiplying the number of installed measures by the deemed savings per measure.
- **Large-scale data analysis**. Statistical analyses are conducted on the energy usage data (typically collected from meter data reported on utility bills) for all or most of the participants and possibly non-participants in the program. A variety of statistical methods are applied to measured facility energy consumption meter data and independent variable data to estimate gross energy impacts.

  Two options within this category include (see Table 2):
  - A time series comparison of participants only, without a comparison group
  - A comparison group time series analysis

Participants-only data analyses are quite common. The challenge in using this method is that other factors (e.g., weather, energy prices, number of occupants in a household, effects of other policies) may influence energy use before, during, and after the program. Some of these factors can be measured and accounted for to obtain reasonable gross savings estimates. Others are less easily observed or accounted for; for example, the economy could worsen, leading households and businesses to decrease energy use (even if there were no program); participants may take advantage of other financing and non-financing programs (e.g., rebates, behavior programs).

A comparison group of non-participants can help account for these confounding factors. As in the mortgage performance methodology, non-participants would be identified using matching so that the non-participant group is as similar as possible to the treatment group. The change in energy usage before and after project completion for the treatment group can be compared to the change in energy usage over the same time period in the comparison group. As such, this is our preferred method—data permitting. This approach requires data from non-participants to form the comparison group, and these data could be difficult to access.

Large-scale data analysis is the current best practice for residential programs with relatively homogenous participants and measures, and we recommend large-scale data analysis with a comparison group for assessing gross energy savings from PACE.[21] However, we explore data requirements for both a deemed savings and a large-scale data analysis approach in the remainder of this report. It is important to note again that these methods indicate gross savings and cannot determine if savings are attributable to the PACE financing mechanisms or to some other influence.

[21] As discussed below, many PACE programs currently focus on a deemed savings approach.

Table 2: Equation for times series and comparison group combined analysis

Time Series Comparison	Comparison Group Time Series
Savings = $Q_{pre\text{-}installation} - Q_{post\text{-}installation}$	Savings = $(Q_{pre\text{-}installation} - Q_{post\text{-}installation})_{participants} - (Q_{pre\text{-}installation} - Q_{post\text{-}installation})_{non\text{-}participants}$
Where $Q_{pre\text{-}installation}$ = quantity of energy used before projects were implemented, corrected for adjustments such as weather or occupancy to match reporting period conditions $Q_{post\text{-}installation}$ = quantity of energy used after the projects were implemented	Where $Q_{pre\text{-}installation}$ = quantity of energy used before projects were implemented $Q_{post\text{-}installation}$ = quantity of energy used after projects were implemented **Preferred approach**

Data Required

Mortgage Performance

To complete an analysis of mortgage performance for properties with and without PACE assessments, three types of data are necessary:

1. Basic project data, such as date of PACE assessment, property identifying information, zip code, and measures installed;[22]
2. Explanatory variables, such as FICO score, debt-to-income ratio, demographic variables, and presence or absence of a PACE assessment; many of these variables can also be used to construct a control group that is as similar as possible to the treatment group; and
3. Outcomes of interest, including prepayment and default.[23]

Mortgage lenders and regulators we spoke with stated that at least three to five years of performance history, and ideally seven or more years, are needed to address stakeholders' desire to understand PACE's impact on mortgage performance over time and over multiple economic cycles. Some would argue for even longer performance history (e.g., ten to fifteen years). However, the benefit of amassing additional years of performance data must be weighed against the importance of providing insights and answers that can inform policy makers today. A statistically significant finding may be possible with as little as one year of performance data but may not address stakeholders' desire to understand PACE's impact over time.[24]

Data needs are summarized in Table 3 (drawn from Quercia, Sahadi, & Stellberg 2013).

[22] Because PACE assessments are placed on property tax rolls, they are items of public record. Nonetheless, when information on mortgage performance or borrower information is associated with publically available information, personally identifiable information sensitivities may arise and should be taken into account.

[23] Mortgage delinquency is also of interest; however, it is significantly more difficult to characterize without detailed and labor-intensive data collection. Because delinquency and default are related, mortgage delinquency is not discussed in this report.

[24] Deason 2015 found a statistically significant difference in default rates for on-bill loans in New York using loans with an average age of just over one year.

Table 3: Data Required for Mortgage Performance Analysis

Data Point	Purpose
Property Information	
Property identifier	Match PACE data to mortgage records
Home value	Control group creation, possible explanatory variables
Home area	
Mortgage amount	
Year built	
Mortgage origination loan to value	
Home value / area median sale price	
Mortgage type	
Project Information	
Date of assessment	Policy data
Size of assessment	Explanatory variable
Project type	Explanatory variable
PACE term	Explanatory variable
PACE interest rate	Explanatory variable
Hazard Information	
Date of foreclosure	Outcome of interest
Date of prepayment	Outcome of interest
Borrower Information	
FICO	Control group creation and/or explanatory variables
Age	
Income	
Employment status	
Education level	
# of dependents	
Other Indicators[28]	
Unemployment	Control group creation and/or explanatory variables
Average neighborhood home value	
Property tax rates	
Neighborhood foreclosure rate	
Zip code or neighborhood average income	
Zip code or neighborhood unemployment	
Electricity price	
Heating degree days	
Cooling degree days	

[28] Additional common economic adjustments can also be incorporated—for example, consumer price index or federal funds interest rate. This may not be necessary given the relatively short performance history of PACE financing.

Energy Savings

In California, methods to determine gross savings determination methods, using M&V or deemed savings, are well established, particularly for the type of measures typically implemented in residential projects. M&V is defined by long-standing California utility practices and are being further enhanced with EM&V 2.0 type approaches.

Also in California, inputs and assumptions required for deemed savings approaches have been well documented, especially in the context of programs that the California Public Utilities Commission (CPUC) oversees. These approaches are documented in the Database for Energy Efficient Resources (DEER), which provides energy savings estimates for typical energy efficient technologies and measures, including effective useful lifetime values and per unit energy savings estimates.[29] Measures not captured in DEER are handled through a work paper process, which is reviewed by the CPUC as needed. Large-scale data analysis approaches are also relatively well defined through common industry practice and documents such as the California Energy Efficiency Evaluation Protocols. [30,31]

Table 4 summarizes data needs for a deemed savings analysis and Table 5 summarizes data needed for a large-scale bill analysis (the preferred approach).

Table 4: Data Requirements for Deemed Savings Analysis

Data Point	Purpose
Property Information	
Property identifier	Basic data
Year built	Input
Home area and other home-specific information	Input
Project and Measure Information	
Date of project completion	Basic data
Measure category (e.g., appliance, envelope, refrigeration, HVAC, lighting, hot water)	Input
Measure type (e.g., high-efficiency windows, air conditioner, or water heater; additional insulation; solar PV)	Input
Measure details (e.g., SEER rating, R value, number of linear feet installed, capacity)	Input
Manufacturer	Input
Other measure- and property-specific assumptions	Input
Deemed savings values (from DEER or other sources)	Calculations

[29] DEER in managed by the CPUC Energy Division and can be accessed at www.deeresources.com.
[30] See SEE Action 2012 for more information.
[31] See CPUC 2006 for more information.

Table 5: Data Requirements for Large-Scale Data Analysis

Data Point	Purpose
Property Information	
Property identifier	Match PACE data to energy bills
Home value	Control group creation and/or explanatory variables
Home area	
Mortgage amount	
Year built	
Mortgage origination loan to value	
Home value / area median sale price	
Mortgage type	
Project and Measure Information	
Date of project completion	Match PACE data to energy bills
Project type	Control group creation and/or explanatory variables
Utility Bill Information	
Utility bill data before project completion	Outcome of interest
Utility bill data after project completion	Outcome of interest
Other Indicators	
Heating degree days	Explanatory variables
Cooling degree days	
Energy prices	

Data Availability

Mortgage Performance

A sufficient number of PACE assessments are available to complete a large-scale analysis of PACE's impacts on mortgage performance; over 90 percent of PACE assessments in California (over 40,000 assessments) have the associated data required to be useful in a large-scale study. However, over 75 percent of PACE assessments have been issued since 2014, which limits their usefulness for studying how PACE assessments impact mortgage performance over time.

Assuming that stakeholders prefer at least five years of loan history, we calculate (1) the number of PACE assessments with sufficient performance history available and (2) the detectable effect possible with that number of assessments (see Table 6 below). Detectable effect is the percentage difference between the PACE and non-PACE group that a statistical test would be likely to detect. For example, a detectable effect of 100% means that if the PACE group's mortgage default rate were double or half of the non-PACE group, the statistical test would be likely to detect that difference. The test would be less likely to detect smaller differences. The number of available PACE assessments drives the size of the detectable effect: the larger the number of available PACE assessments, and the longer each has been in place, the smaller the detectable effect.

Table 6: PACE assessments available if five years of performance data is needed and expected detectable effect[32]

Year study is conducted	PACE assessments available (treatment group)[33]	Detectable effect
End of Year (EOY) 2015	1,224	115%
EOY 2016	1,620	88%
EOY 2017	3,367	55%
EOY 2018	11,133	28%
EOY 2019	28,841	17%

If stakeholders were satisfied with three years of loan performance history, detectable effects are smaller at any given time because more PACE assessments are available (see Table 7). If stakeholders are open to using all PACE assessments available regardless of their performance history, detectable effects are smaller still: we estimate that we could detect a 28% effect today using all PACE assessments that existed as of July/August 2015.

Table 7: PACE assessments available if three years of performance data is needed and expected detectable effect

Year study is conducted	PACE assessments available (treatment group)	Detectable effect
EOY 2015	3,367	70%
EOY 2016	11,133	35%
EOY 2017	28,841	21%
EOY 2018	47,249	15%

The tables above show effect sizes that are likely attainable using different data sets at different times, assuming three control properties for each PACE-assessed property. More specifically, we would be 80% likely to detect the effect sizes shown (if they exist) at a statistical significance level of 95% or higher. These are standard assumptions in power calculations and mean that the values in the table are somewhat conservative. We are also assuming mortgage default rates remain at today's low values; if default rates were to rise again, we could expect to detect smaller effects.

Larger samples would be required to explore questions such as, Do solar-only PACE projects perform differently than energy efficiency-only PACE projects? Do assessments granted to high-FICO households perform differently than lower FICO households?

[32] The calculations in these tables relate to statistical power only. There is value in studying more seasoned PACE-encumbered mortgages above and beyond statistical concerns, as these mortgages allow comparisons between PACE and non-PACE mortgages under a wider diversity of macroeconomic environments. On the other hand, there is also value in studying PACE assessments across multiple jurisdictions, which also introduces a wider diversity of macroeconomic environments. These two values are in conflict, as more than 99% of residential PACE assessments through 2011 were in Sonoma County. Starting in 2012, the geographic dispersion of PACE increases notably. There is no ready way to quantify the tradeoff between more seasoned mortgages and greater geographic diversity in mortgages, and we would defer to mortgage market experts and regulators on this issue. However, this tension does mean that choosing a more restrictive (older) set of mortgages does not necessarily make the results more robust.

[33] This table assumes a control group three times the size of the treatment group. Smaller or larger control groups would raise or lower, respectively, the detectable effect.

Data required to study PACE's impact on mortgage performance is available from PACE program administrators; CoreLogic, a provider of property, financial, and consumer datasets; and other public data sources (see Table 8).[34] The exception is borrower-level characteristics, such as education level, number of dependents, and income, which are not readily available. These data could help to create a more well-matched comparison group, but have not been used in other studies. Some proponents of energy efficiency lending have hypothesized that "unobservable traits" (e.g., environmental awareness) of individuals who take advantage of specialized energy-related loans can lead to above average performance even when compared to a well-matched peer group. These variables have not yet been quantified and are not articulated or included in this report.

Energy Savings

We recommend a large-scale data analysis approach with a comparison group to determine energy savings from PACE programs. This analysis will yield gross savings estimates, not energy savings attributable to PACE specifically, thus, ultimately, stakeholders must consider the relative value of this information for policy and program administration decisions. Table 9 summarizes data availability for energy savings analysis using a deemed savings approach and Table 10 does the same for a large-scale bill analysis approach.[35]

However, PACE programs have permission to access utility bill data for only 4 percent of California PACE projects (approximately 2,000 projects), making large-scale utility bill analysis unfeasible. Without analyzing assessment-level data, it is difficult to predict what sample size would be required to draw a statistically valid conclusion from this analysis. Using our best judgment, we estimate that at a minimum 4,000 PACE projects with at least one year of associated pre- and post-installation performance data would be required.[36,37] Larger samples would be required to explore savings from different types of PACE-funded projects (e.g., solar versus efficiency only). Some administrators indicate that obtaining permission to access utility bill data after project completion is possible, if a larger study were to be conducted.[38] Accessing utility bill history for non-participants may present data acquisition challenges, but this data does exist. This issue should be examined when scoping out a study of PACE energy savings; in the worst case, the non-participant group could be eliminated and a pre-post participant only analysis could be completed.

[34] Non-disclosure agreements, data security protocols, and other considerations would likely be necessary if PACE programs were to share assessment-level data. CoreLogic data must be purchased. Information from public records is significantly less expensive than information on mortgage performance (e.g., default status, prepayment).
[35] Note that pursuing an analysis of savings attributable to PACE would also require access to utility bill data.
[36] In addition, at least an equal number of non-PACE households similar to the treatment group would be required if employing the difference-in-differences comparison group method; a control group two to three times as large as the treatment group is not uncommon.
[37] Access to smart meter data in more frequent increments (e.g., 15-minutes) might reduce the length of pre- and post-data required. At a minimum, monthly data is needed.
[38] Homeowner follow-up to gather permission to access data would have an associated cost.

Table 8: Data Required for Mortgage Performance Analysis Compared to Data Availability

	Source	Notes
Property Information		
Property identifier	PACE administrators	100% collection rate
Home value	CoreLogic	
Home area	CoreLogic	Many other home-specific indicators available (e.g., number of bathrooms, number of bedrooms, number of fireplaces)
Mortgage amount	CoreLogic	
Year built	CoreLogic	
Mortgage origination loan to value	CoreLogic	
Home value / area median sale price	CoreLogic and Census American Community Survey	May require calculation by researchers given two inputs from CoreLogic
Mortgage type	CoreLogic	Would require categorization by researchers, as CoreLogic provides mortgage lender name only
Project Information		
Date of assessment	PACE administrators	100% collection rate
Size of assessment	PACE administrators	100% collection rate
Project type	PACE administrators	100% collection rate; some data cleaning and re-categorization would be necessary
PACE term	PACE administrators	100% collection rate
PACE interest rate	PACE administrators	100% collection rate
Hazard Information		
Date of foreclosure	CoreLogic	This data returned in anonymized format only; requires additional effort by CoreLogic and has associated increased cost
Date of prepayment	CoreLogic	This data returned in anonymized format only; requires additional effort by CoreLogic and has associated increased cost

	Source	Notes
Borrower Information		
FICO	PACE administrators	Over 90% collection rate, can also be estimated or retroactively collected by researchers
Age	Not collected	Could potentially be compiled starting with CoreLogic information on mortgage holder but at high effort and cost
Income	Not collected	
Employment status	Not collected	
Education level	Not collected	
# of dependents	Not collected	
Other Indicators		
Local unemployment rate	Census American Community Survey (district level)	
Average neighborhood home value	Census American Community Survey (district level)	
Property tax rates	County Auditors	
Neighborhood foreclosure rate	CoreLogic	
Zip code or neighborhood average income	Census American Community Survey (district level)	
Zip code or neighborhood unemployment	Census American Community Survey (district level)	
Energy prices	Open Energy Info or similar	
Heating degree days	National Climactic Data Center	
Cooling degree days	National Climactic Data Center	

Table 9: Data Required for Deemed Savings Analysis Compared to Data Available

	Source	Notes
Property Information		
Property identifier	PACE administrators	100% collection rate, allows identification of climate zone, an input to deemed savings calculations
Year built	CoreLogic	
Home area and other home-specific information	CoreLogic	Many other home-specific indicators available (e.g., number of bathrooms, number of bedrooms, number of fireplaces)
Project and Measure Information		
Date of project completion	PACE administrators	100% collection rate
Measure category (e.g., appliances, envelope, refrigeration, HVAC, lighting, water heater, renewables)	PACE administrators	100% collection rate
Measure type (e.g, high efficiency windows, air conditioner, water heater; solar PV)	PACE administrators	100% collection rate
Measure details (e.g., SEER rating, R value, number of linear feet installed, capacity)	PACE administrators	100% collection rate
Manufacturer	PACE administrators	Over 90% collection rate
Other measure- and property-specific assumptions	DEER	Including load shapes, hours of operation, effective useful lifetimes

Table 10: Data Required for Large-Scale Data Analysis Compared to Data Available

	Source	Notes
Property Information		
Property identifier	PACE administrators	100% collection rate
Home value	CoreLogic	
Home area	CoreLogic	Many other home-specific indicators available (e.g., number of bathrooms, number of bedrooms, number of fireplaces)
Mortgage amount	CoreLogic	
Year built	CoreLogic	
Mortgage origination loan to value	CoreLogic	
Home value / area median sale price	CoreLogic and Census American Community Survey	May require calculation by researchers given two inputs from CoreLogic
Mortgage type	CoreLogic	Would require categorization by researchers, as CoreLogic provides mortgage lender name only
Project and Measure Information		
Date of project completion	PACE administrators	100% collection rate
Project type	PACE administrators	100% collection rate, may require some manual sorting or reassignment
Utility Bill Information		
Utility bill data before project completion	PACE administrators, utilities	4% collection rate, as permission to access customer utility bills. Accessing non-participant utility bills may present additional challenges.
Utility bill data after project completion	PACE administrators, utilities	
Other Indicators		
Heating degree days	National Climactic Data Center	
Cooling degree days	National Climactic Data Center	
Energy prices	Open Energy Info or similar	

Summary

While the joint White House-HUD-California announcement focused on PACE for the multifamily sector, the lack of multifamily PACE projects in California makes analysis of this sector impractical. Single-family residential PACE programs, however, have generated significant volume—over 47,000 projects and nearly $1 billion in capital deployed. The majority of these assessments were originated in 2014 or later.

Stakeholders interviewed for our scoping study expressed interest in two research areas that DOE could consider supporting in the future: (1) impact of PACE on mortgage performance and (2) impact of PACE on energy savings. LBNL's review of data collected by PACE administrators or available through other channels indicates that, while a sufficient number of PACE assessments exist, insufficient performance

history is available to meet stakeholders' expressed requirements due to the recent origination dates of most PACE assessments (2014 or later). Large-scale, public bill analysis studies of energy savings are also not feasible at this moment, due to a lack of access to utility bill records for PACE participants; if researches could gain access to billing data (and ideally data from non-participants as well), this challenge could be corrected.

The first issue will be cured over time. Once a sufficient number of PACE assessments have amassed three years of performance data, stakeholders should reconsider the idea of a large-scale mortgage performance study. Stakeholders should continue conversations with mortgage lenders and regulators regarding how much performance history is needed before an analysis of PACE's impact on mortgage performance is seen as credible.

PACE programs that wish to support a large-scale study should:

1. Continue to or consider collecting FICO score information and other information on participant and neighborhood characteristics that will be important in establishing control groups; and
2. Consider obtaining permission to access PACE participants' utility bill information, either retroactively or for projects originated in the future. Assuming this permission is obtained, stakeholders should work with utilities to ensure that both data from PACE-assessed properties (e.g., energy usage, production from solar PV systems) and non-PACE assessed properties that are included in a control group will be available in a useable format.

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Disclaimer

Appendix 1: Interviewees and Interview Questions

Interviewees included:

- Deana Carillo, Ashley Bonnett, and Alejandro Ruiz (CAEATFA)
- Cisco DeVries and Mimi Fruscha (Renew Financial)
- Jane Elias (Sonoma County Energy Independence Program)
- David Hochschild, Andrew McAllister, and Emilio Camacho (California Energy Commission)
- Blair McNeill (Renovate America)
- Tricia Miller and Josh Geyer (HUD)
- Chrissa Pagitas (Fannie Mae)
- Barbara Spoonhour (WRCOG)
- Candace Vahl and Ali Zaidi (Whitehouse Commission on Environmental Quality)
- Jenine Windeshausen (mPOWER)

Interview questions focused on the following:

- **Interviewee's experience**
  - Open-ended: What is your experience with PACE to date, both in single family and in multifamily settings?
  - Possible threads:
    - Barriers you've encountered with PACE (especially data-related ones).
    - Trends you see with the PACE mechanism.
    - Sense of the benefit PACE financing offers – Larger projects? Easier to sell?
    - Why do you pursue PACE? (e.g., for energy savings, for business, for economic development)
    - For PACE programs: Do you have PACE for multifamily experience and if yes was it financed via a commercial PACE program or a residential PACE program?
- **Interviewee's priorities**
  - Open-ended: Tell us what your priorities for this study are.
  - If completed, what would the study you described help you to do?
  - Can you rank these four questions, in order of priority for you?
    - PACE impact on mortgage performance
    - Savings from PACE projects
    - PACE improvements' impact on property value
    - PACE impact on property tax rolls
  - For lenders: What concerns, if any, do you have regarding PACE? What kind of information or study could address those concerns?
  - For regulators: What are your policy priorities regarding PACE and how could this study support them?
- **Data**
  - Are you currently collecting PACE-related data that might be helpful?
  - Would you be willing to share it?
  - Can you put us in touch with the right person when we're ready for a more data-focused conversation?