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California 2030 Low Carbon Grid Study (LCGS)

Guidance on interpreting the forecast and production cost model for energy efficiency

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Abstract

This work paper was produced by Tierra Resource Consultants[1] to assist readers of the California 2030 Low Carbon Grid Study (LCGS) interpret the forecast and production cost model for energy efficiency. The discussion also outlines three areas of initiative that support the LCGS target case, and that might help industry participants and policy makers as they develop innovative strategies and tactics to increase the amount of energy efficiency achieved in California in the coming decades. These three areas of initiative include:

1. ***Voluntary participation regulated programs***. These are energy efficiency programs operated by various administrators, such as utilities, that promote energy efficiency through voluntary participation programs that are subject to regulatory oversight. Opportunities for voluntary programs to contribute additional savings include:
    - Expanded and accelerated adoption of new technologies.
    - Expanded use of data analytics.
2. ***Mandatory policy initiatives***. Mandatory policy initiatives are legislative and regulatory activities occurring at the state or local level that require some minimum level of energy efficiency. Opportunities for mandatory policy initiatives to contribute additional savings towards the target case include:
    - The acceleration of codes and standards and improved compliance on updates to existing buildings.
    - Mandatory upgrades to existing buildings.
3. ***Evolving market mechanisms***. For the purposes of the LCGS, evolving market mechanisms represent initiatives that will either expand participation in existing energy efficiency activities beyond what has historically been captured, or offer new pathways to achieve energy savings that have not been recognized in past market initiatives, including:
    - Opportunities from financing through Contract Assessment Districts, such as Property Assessed Clean Energy (PACE) programs.
    - Opportunities from California's Cap-and-Trade Program.

[1] With input from the California Energy Efficiency Industry Council

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Summary

The Low Carbon Grid Study (LCGS) includes a forecast for the amount of energy efficiency that would need to be implemented in California in order to achieve a low carbon grid. This forecast is referred to as the 'target case' for energy efficiency, and assumes that approximately 51% more energy efficiency can be achieved by 2030 than is forecast in the LCGS base case scenario. Both the LCGS base and target cases were developed from the same EE potential forecast that informed the California Energy Demand Updated Forecast 2015 – 2025 (the 'CED'). More specifically, the LCGS base case uses the same CED EE potential forecast[2] that was adopted as the basis for long term procurement planning (LTPP) and IOU goal setting for the 2015 and beyond IOU portfolio of EE programs. CASIO adopted a lower CED forecast of EE potential[3] for the purposes of local adequacy planning. As such, the LCGS target case represents an EE forecast that is about 51% higher than the forecast currently being used to form CEC and CPUC policy regarding 2015 IOU program activity, and about 132% higher than the forecast used most recently planning by CASIO.

This paper discusses the assumptions underlying the target case forecast used in the LCGS, and outlines three areas of initiative that provide additional potential for EE savings that are incremental to the LCGS base case. These areas of initiative represent some of the important strategies and tactics that industry participants and policy makers may consider when developing approaches to bridge the efficiency gap between the LCGS base and target cases. These areas of initiative include;

1. ***Voluntary participation regulated programs.*** These are energy efficiency programs operated by various administrators, such as utilities, that promote energy efficiency through voluntary participation programs that are subject to regulatory oversight. Opportunities for voluntary programs to contribute additional savings include:
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    - Opportunities from financing through Contract Assessment Districts, such as Property Assessed Clean Energy (PACE) programs.
    - Opportunities from California's Cap-and-Trade Program.

[2] The managed forecast that was adopted and used to inform LTPP and IOU goals setting is referred to as the Additional Achievable Energy Efficiency (AAEE) mid-case.

[3] CAISO adopted the AAEE mid-low for the purposes of local planning.

As context for the following discussion, Figure 1 shows the additional achievable energy efficiency (AAEE) scenarios developed in the 2013 CPUC energy efficiency potential study[4] (the '2013 study') that underlie both the 2015-2024 CED and the LCGS base and target cases[5]. The CED forecast extends to 2024 and shows that the cumulative difference between the AAEE mid and mid-high scenarios is about 12,000 GWh at the end of the forecast horizon.

Figure 1. 2015-2024 CED Additional Achievable Energy Efficiency scenarios

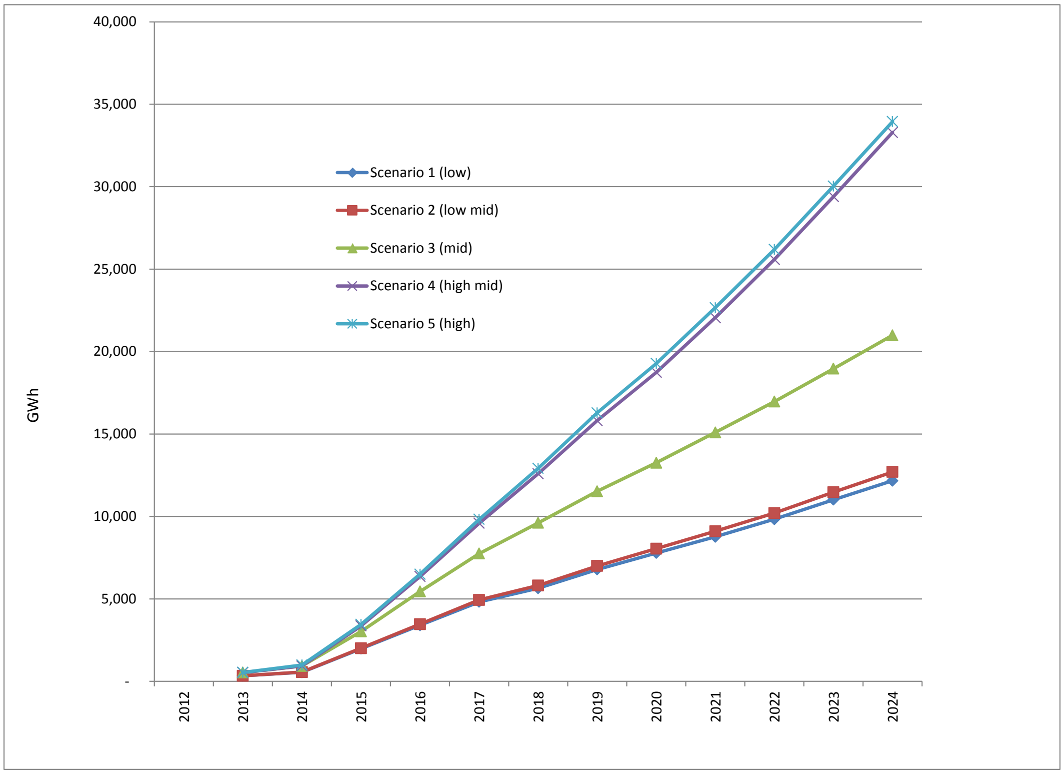

Figure 2 illustrates the impact of the base and target case EE projections on the load forecast used in the LCGS.[6] By the end of the LCGS forecast horizon in 2030, the base case[7] will reduce consumption forecast by 10%, while the target case will contribute an addition reduction of 5%, yielding a total cumulative forecast reduction in electric energy usage of 15% due to energy efficiency.

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[4] 2013 California Energy Efficiency Potential and Goals Study Final Report. Prepared for: California Public Utilities Commission. Navigant Consulting, Inc. February 14, 2014 at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

[5] It is important for readers to understand that there are numerous forecasts and targets for energy efficiency in California, and these may sometimes appear to be different or not aligned. This is generally because 'energy efficiency' can be defined on many ways and care must be taken to align forecasts and targets to ensure that proper comparisons can be made and interpreted correctly.

[6] Note that the LCGS final load forecast is based in the 2014 IEPR mid case scenario but varies from that forecast because the LCGS modelling methodology requires different accounting rules for electric vehicles, self-generation, and loses

[7] The LCGS base case for energy efficiency represents the 2014 IEPR mid AAEE scenario.

Figure 2. Impact of Energy Efficiency on LCGS Final Consumption Forecast

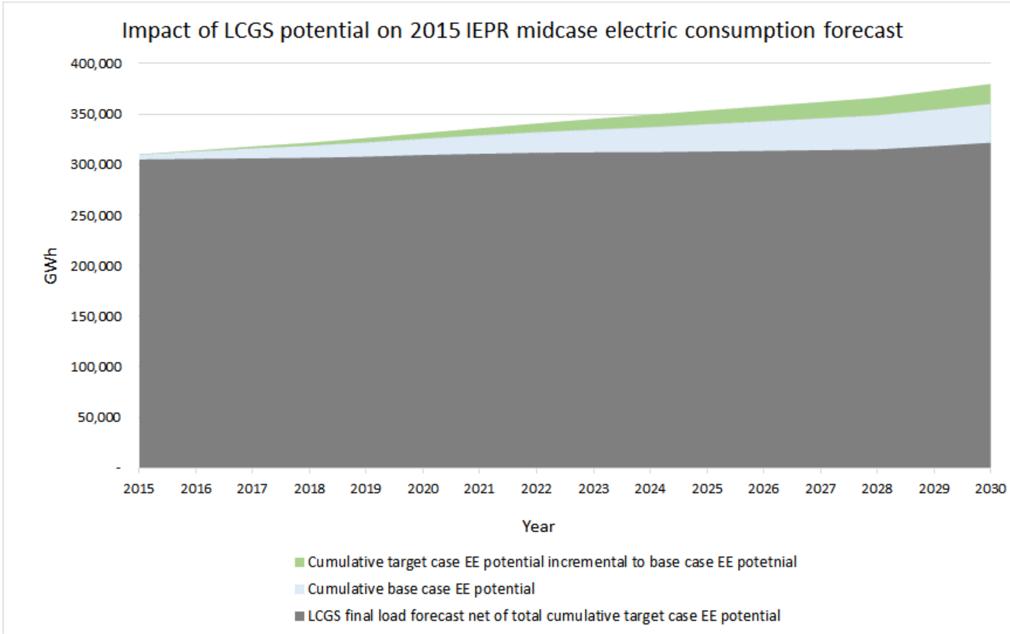

Figure 3 disaggregates the target case savings by area of initiative. The allocation of potential between these three initiatives begins with an assumption that by 2030, approximately 60% of incremental annual target case savings will be derived from mandatory policy initiatives such as codes and standards or mandatory upgrades to existing buildings. This is consistent with the AAEE forecasts that about 55% of mid scenario savings will originate from codes and standards by 2024. The remaining 40% of the 2030 savings forecast will derive equally from voluntary participation, regulated programs, and evolving market mechanisms.

Figure 3. Annual Incremental Energy Savings for the LCGS Target Case by Area of Initiative

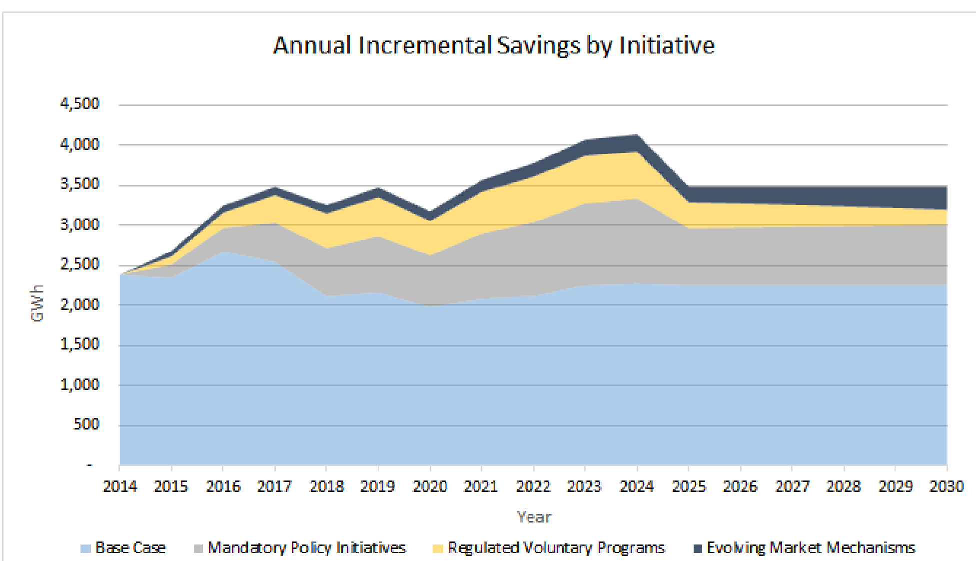

Figure 4 disaggregates the projected cost of target case savings by area of initiatives. These costs are further detailed in the discussion on 'Cost Assumptions' and were developed using recent kWh costs sources including:

1. Costs for voluntary participation in regulated programs are based on 2015 portfolio average net kWh cost. This includes the cost of all portfolio activities, including resource and non-resource activities.
2. Costs for mandatory policy initiatives are based on 2015 IOU portfolio Codes and Standards (C&S) advocacy costs per gross kWh.
3. Costs for evolving market mechanisms start with the E3 utility avoided cost forecast for 2015[8].

Figure 4. Annual Incremental Costs for the LCGS Base and Target Case by Area of Initiative

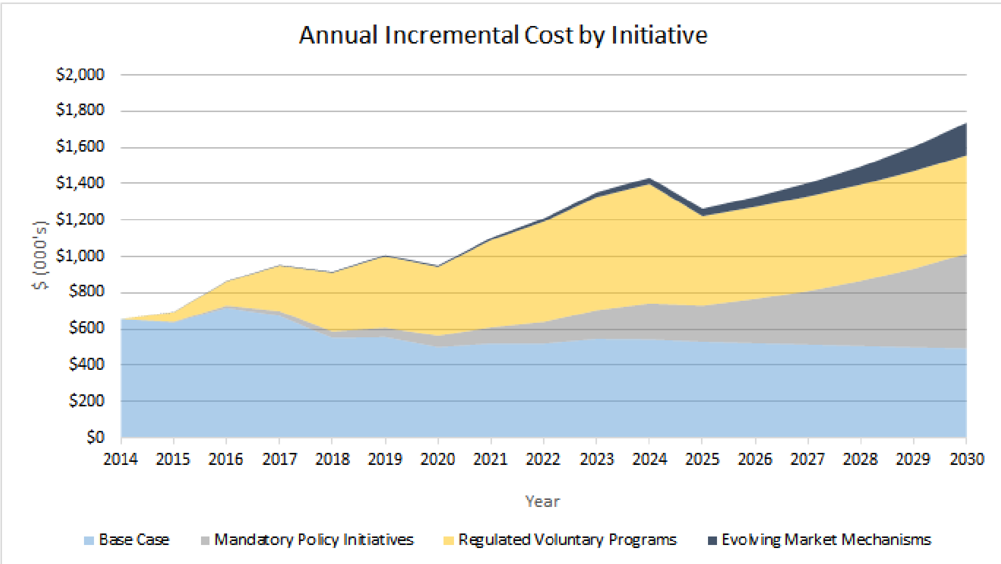

Table 1 provides the costs of electricity energy efficiency savings for the LCGS base and target cases. Note that these portfolio costs do not include the cost of energy efficiency programs targeting natural gas savings.

Table 1. Costs of Electricity Energy Efficiency Savings for the LCGS Base and Target Cases

Year	*Total annual cost for Baseline Case savings*	*Total annual cost for Target Case savings*	*Incremental costs for Target Case*
2015	$598,808,575	$626,923,789	$28,115,215
2030	$773,212,371	$1,390,687,644	$617,475,273

The next section discusses important modelling assumptions used to develop the LCGS target case. The paper then provides a discussion about the assumptions, risks, and opportunities for each of the three areas of energy efficiency initiatives. The paper concludes with a review of the assumptions associated with the LCGS production cost modelling of energy efficiency.

[8] Energy Efficiency Avoided Costs 2011 Update. Energy and Environmental Economics, Inc. December 19, 2011. Interpreted from Figure 6: Annual Average Energy Avoided Costs.

Important modelling assumptions

The AAEE scenarios that represent the EE forecasts underling the LCGS base and target cases are estimates of the energy efficiency savings that could be realized through utility programs that are incremental to the savings already incorporated in the California Energy Commission's CED and IEPR forecasts.

The 2013 potential study[9] used to develop the AAEE scenarios was intended primarily to set IOU energy efficiency goals for the 2015 program year, provide an estimate of AAEE potential to be used in 2015 IEPR demand forecast update, and for utility procurement planning. There are several characteristics of 2013 potential study and associated AAEE scenarios that should be considered when interpreting the use of that study for the LCGS, including:

1. The 2013 potential study does not include a forecast of savings from new market delivery mechanisms, such as PACE financing. PACE financing, will likely to continue to grow and will result in EE adoption rates that are higher than forecast in the 2013 potential study mid scenario (i.e., the LCGS base case). The potential contributions of PACE towards the LCGS target case is discussed in the section titled: Assumptions about Evolving Market Delivery Mechanisms.
2. The 2013 study does not forecast any energy efficiency that might result from other market initiatives, such as the cap-and-trade program initiated in 2013. Therefore, a portion of energy efficiency savings procured through large industrial and agricultural facilities participating in the cap-and-trade market, and savings associated with programs funded through auction proceeds, such as the Water-Energy Grant Program or the State Water Efficiency and Enhancement Program (SWEEP), are not included in any of the AAEE scenarios or the LCGS base case, however this activity will likely contribute to the target case.
3. All AAEE forecasts (and therefore the LCGS base and target cases) are net of free riders. Accordingly, the savings forecast for regulated voluntary participation programs are approximately 30% lower than the gross market potential used to set IOU energy efficiency goals.[10] The AAEE forecast also assumes that savings from free riders and market effects, such as spillover, are included in the IEPR forecast as part of naturally occurring market adoption estimates (NOMAD). It should be noted that assumptions about NOMAD have never been thoroughly reviewed and it is uncertain whether all market effects are being captured and presented in demand forecasts. For example, Figure 5 provides an overview of all of the sources of energy efficiency changes that can occur in the market.[11] The green shaded area of the diagram labelled "IOU/POU Resource Acquisition Programs" represents the EE savings that are most accurately represented in the mid AAEE scenario (and therefore the LCGS base case). The areas identified as non-program induced energy savings (including free-riders), program-induced market spillover energy savings, and savings originating from education, marketing, and outreach efforts are either undefined or absent from the AAEE and IEPR forecasts. The absence of some of these sources of savings in the AAEE mid scenario (and in some cases, the IEPR NOMAD component) imply the LCGS base case is a conservative forecast.

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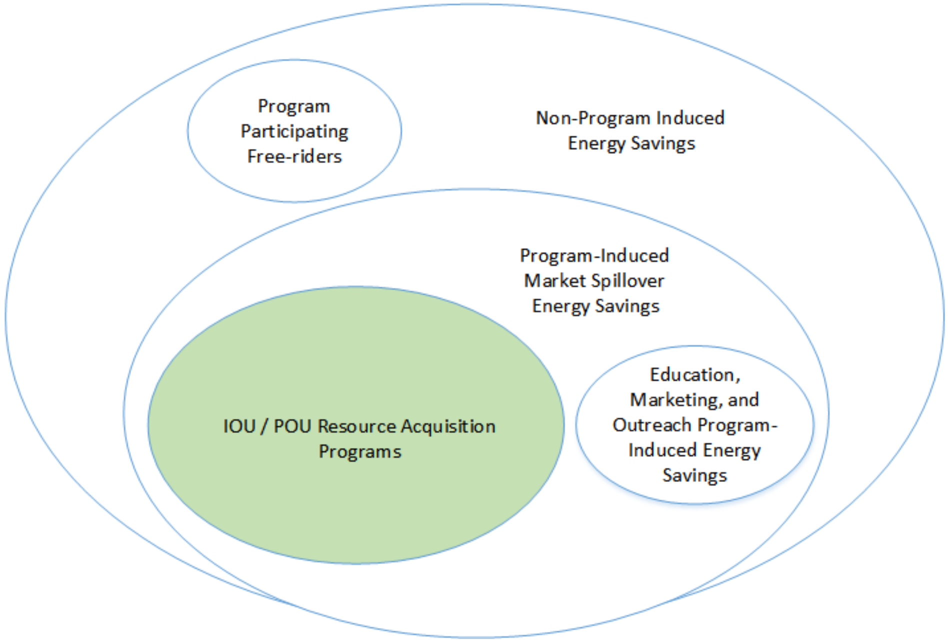
[9] 2013 California Energy Efficiency Potential and Goals Study Final Report. Prepared for: California Public Utilities Commission. Navigant Consulting, Inc. February 14, 2014 at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

[10] The forecasts for codes and standards (C&S) activity in AAEE are gross, and so reflect all market impacts for C&S activity, not just what is attributable to IOU C&S advocacy activity.

[11] Modified from Figure 11, California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, April 2006. Prepared for the California Public Utilities Commission by The TecMarket Works Team

Figure 5. Sources of Energy Efficiency Changes in the Market[12]



4. The EE potential forecast for POUs used in the LGCS was developed from the forecast completed for the CMUA in compliance with AB 2021.[13] This forecast included only a Business as Usual (BAU) forecast and did not include a high case scenario. As such, there is no increase in potential for POUs in the LCGS target case even though these utilities will benefit from the emerging technologies, evolving market mechanisms, and policy mandates that will help IOUs achieve the LGCS target case. Note that POUs account for approximately 25% of statewide consumption, and a similar amount of EE potential; the absence of a POU target case forecast implies the overall LCGS target case is conservative.
5. Finally, the 2013 potential model used to develop the LCGS base case did not model EE potential that would results from various mandated EE activities beyond a BAU forecast of codes and standards. As such, savings resulting from the ability of AB758 to mandate improvements in building energy efficiency under various conditions were not taken into account. Similarly, the 2013 potential study did not include any aggressive C&S activities beyond a BAU forecast, such as accelerating the rate of code adoption, or any significant improvements in code compliance. The potential contribution from policy mandates is discussed in the section titled: Assumptions about Mandatory Participation Policy Initiatives.

Collectively, these five assumptions imply that the LCGS base case represents a modest forecast and that the target case can be achieved if all EE resources are accounted for and if various technology, program, policy, and market initiatives can be developed and adopted.

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[12] Modified from Figure 11, California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, April 2006. Prepared for the California Public Utilities Commission by The TecMarket Works Team

[13] The 2013 potential study completed for the CPUC modelled only IOU territories and does not include a forecast of POU energy efficiency potential

Assumptions about voluntary participation regulated programs

Regulated voluntary participation programs ('voluntary programs') include energy efficiency programs operated by various program administrators, such as utilities, that promote energy efficiency and are subject to regulatory oversight.[14] These types of programs must comply with numerous statutory requirements, such as cost effectiveness requirements designed to protect ratepayers, and are usually based on marketing, education, and outreach efforts that are combined with financial incentives designed to offset the additional costs usually associated with energy efficiency. The LCGS target case represents several opportunities for voluntary programs not fully addressed in the base case, including:

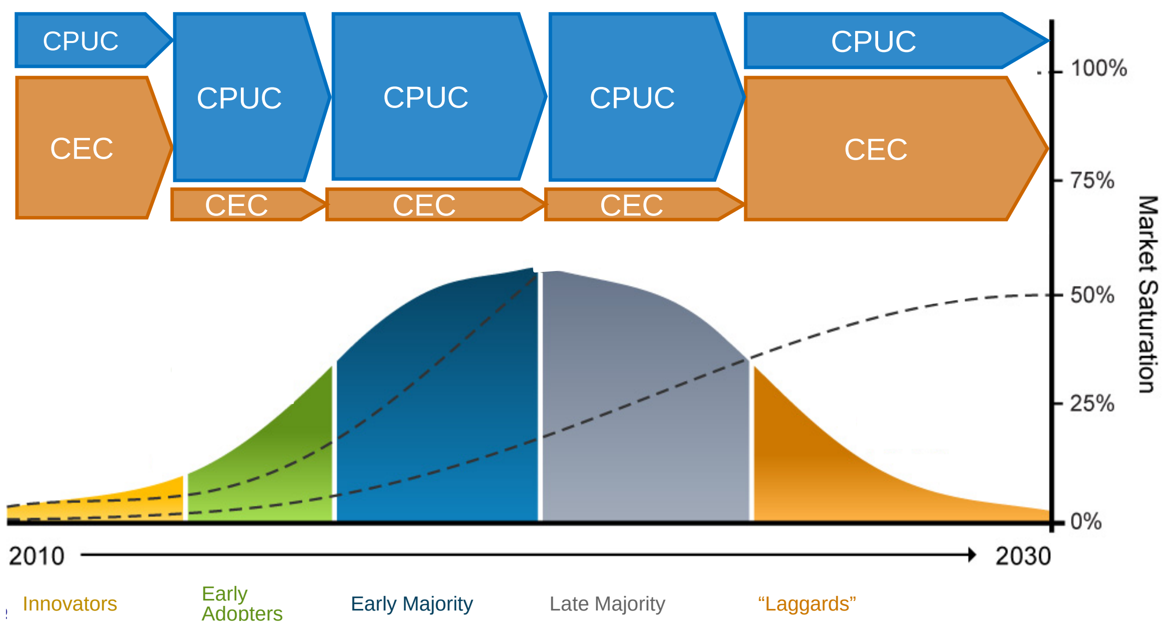
1. Additional opportunities to drive the market adoption of new technologies.
2. Expanded use of data analytics to drive higher levels of savings.

The following section provides a brief discussion of these opportunities.

Opportunities to expand the adoption of new technologies

It is likely that many of the measures currently included through regulated voluntary programs (e.g., IOU and POU DSM programs) will be subsumed by codes and standards during the LCGS study horizon, and program administrators will need to seek out new technologies and drive the market adoption. The acquisition of new technologies and promotion throughout the products adoption cycle has been a collaborative effort between the CPUC, and to some degree the CEC, as illustrated in Figure 6.[15]

Figure 6. CPUC and CEC policy relationship on voluntary market



[14] For programs operating in investor owned utility territories these programs are regulated by the CPUC while programs operating in public utility territories are regulated by the CEC.
[15] CPUC Energy Efficiency Primer. Energy Division, California Public Utilities Commission (CPUC). May 23, 2014

The LCGS target case includes partial representation of emerging technologies, but over 80 % of this potential comes from LED lighting. While the forecast of savings potential from LED lighting is well-founded, the LCGS base case has likely overlooked additional potential from Emerging Technologies (ET) in other end-use categories such as Heating, Ventilation, and Air Conditioning (HVAC), Domestic Hot Water (DHW), and building shell measures opportunities defined by the US. Department of Energy's (DOE) Building Technologies Office.

The DOE Building Technologies Office (BTO) exists within the Office of Energy Efficiency and Renewable Energy (EERE) and works with researchers and industry representatives to develop and deploy technologies that can substantially reduce energy consumption in residential and commercial buildings. The BTO aims to reduce building-related primary energy consumption by 50% by the year 2030, relative to 2010 consumption. Below are examples of the savings potential for emerging technology roadmaps currently under development at the BTO that were not considered in the LCGS base case.[16]

- HVAC Roadmap[17] - For HVAC, BTO targets 12% and 24% primary energy savings by 2020 and 2030, respectively. BTO identified near-term efficiency and cost targets for six different HVAC technology areas.
- Water Heating Roadmap[18] - For water heating, BTO targets 19% and 37% primary energy savings by 2020 and 2030, respectively.
- Appliances Roadmap[19] - The Research and Development (R&D) Roadmap for Next-Generation Appliances provides recommendations to the Building Technologies Office (BTO) on R&D activities to pursue that will aid in achieving BTO's energy savings goals. For appliances, BTO targets 14% and 29% primary energy savings by 2020 and 2030, respectively.
- Windows and Building Envelope Roadmap[20] - BTO analysis projects that if the overall BTO goal is met in 2030, buildings will consume over 20% less energy from HVAC and refrigeration due to improvements in the opaque portions of the building envelope (e.g., walls, roofs, foundation, and infiltration).
- Sensors, Controls, & Transactional Network Roadmaps[21] - The sensors, controls, & transactional network effort focuses on control technologies such as small to medium sized commercial building monitoring and energy savings for occupancy based control (OBC) of variable air volume (VAV) systems. Target savings include 0.06% savings from Occupancy-Based Lighting Control, 5.3% savings for OBC using common occupancy sensors,[22] and 17.8% savings from Occupancy-Based Control Using Advanced Occupancy Sensors.[23]

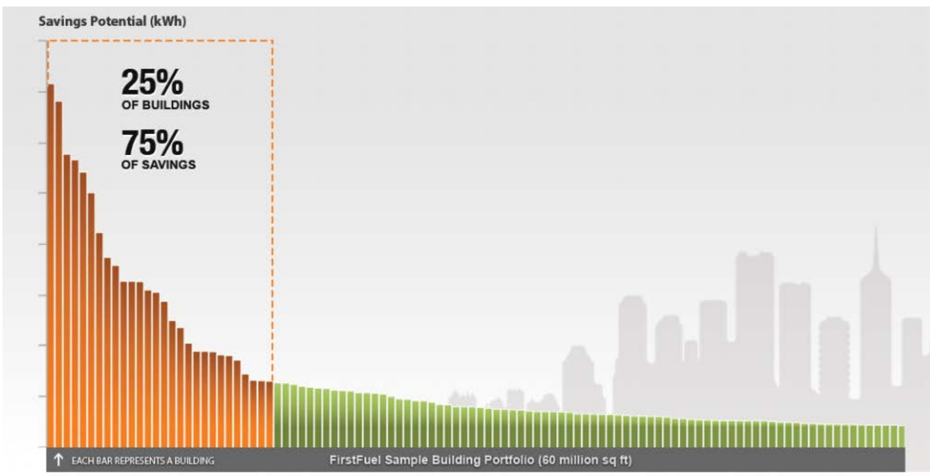
[16] Appendix 1 provides a more detailed list of these technologies.
[17] http://energy.gov/eere/buildings/downloads/research-development-roadmap-emerging-hvac-technologies
[18] http://energy.gov/eere/buildings/downloads/research-development-roadmap-emerging-water-heating-technologies
[19] http://energy.gov/eere/buildings/downloads/research-development-roadmap-next-generation-appliances
[20] http://energy.gov/eere/buildings/downloads/research-and-development-roadmap-windows-and-building-envelope
[21] http://energy.gov/eere/buildings/sensors-controls-transactional-network-reports
[22]Table 12. Energy Savings for Occupancy-Based Control (OBC) of Variable-Air-Volume (VAV) Systems. PNNL- 22072, January 2013. Energy savings for OBC using common occupancy sensors. Retrofit of large office building having common occupancy sensor for OBC of lighting with OBC for terminal boxes that also uses common occupancy sensors, improved case. Table 12. Energy savings for OBC using common occupancy sensors
[23] Table 13. Energy Savings for Occupancy-Based Control (OBC) of Variable-Air-Volume (VAV) Systems. PNNL- 22072, January 2013. National-average site EUIs for the Base Case and Improved Case III by major end use and for the whole building and energy savings in kBtu/ft2-y and as a percentage of the base case total building energy use for retrofit of the Base Case building with OBC for lighting and terminal boxes using common advanced sensors.

Opportunities from the expanded use of data analytics

In addition to savings that will result from new and emerging technologies, the expanded use of data analytics will drive higher levels of savings by increasing the cost effectiveness of regulated program spending, and by allowing greater savings from changes in building / process operations. The following section reviews several aspects of data analytics that were not explicitly accounted for in the LCGS base case, and that could contribute to the viability of the LCGS target case:

- Analytics software platforms are helping utilities deliver more cost-effective programs. Data analytics can be used to remotely screen through tens of thousands of data sets within hours and identify the customers with the highest savings potential, by segment, demand, geography, etc. The ability to screen interval meter data for savings potential is helping utilities and implementers target their programs to specific customer needs and drive down the cost of marketing and customer acquisition. Directing the right programs to the right customer at the right time is helping to increase customer engagement for many utility energy efficiency programs.[24] These tools which can cost-effectively identify the biggest opportunities will alleviate the need for blanket marketing solicitations that result in low utility program lift.[25] Figure 7 provides an example of one study's findings indicating that 75% of total building portfolio efficiency opportunity was found in 25% of buildings.

Figure 7. Illustration of the distribution of building portfolio energy savings potential.



- Data systems such as LA County's Enterprise Energy Management Information System (EEMIS) will provide local governments with the benefits of an online, real-time energy management accounting and information system. EEMIS will be used for benchmarking local government buildings across the region and has the capability of leveraging real-time data, sub-meter data, and building automation system data. For the cities that utilize EEMIS, a much more accurate and robust set of benchmarking information and data will be available.

- Much of the energy efficiency gains in the industrial and agricultural sectors will come from 'intelligent efficiency'; that is, "the additional energy efficiency made possible through the use of Information and Communication Technologies (ICT). This use is often referred to as smart manufacturing. Smart manufacturing is a broad, complex, and often confusing subject with many parts and connections with other technologies. Simply put, smart manufacturing is the integration of all facets of manufacturing

[24] CEEIC white paper
[25] Courtesy of FirstFuel

through the use of ICT. It seeks to integrate all aspects of manufacturing, regardless of level of automation, and all the individual units of an organization in order to achieve superior control and productivity.[26]"

Improvements in data availability and data analytics will likely increase the savings associated with changes in the way equipment or processes operate. These operational changes will sometimes be in the form of modified operator behavior, or the expanded use of automation and controls allowing equipment to operate more efficiently.

Energy efficiency potential studies, including the 2013 potential study, have not historically shown large potential for operational savings, and instead forecast the majority of savings from purchasing and installing more efficient equipment. For example, Table 2 illustrates the distribution of savings potential between equipment and operational changes from various potential studies and IOU portfolios, indicating that about 80% of savings originate from the installation of efficient equipment, while only 20% originates from operational savings. The growing availability of energy use data and evolving analytic capacity will facilitate a better understanding of the potential for operational savings, thereby increasing recognition and realization of the potential for savings energy through improved operations. Of particular note is that data analytics has allowed the 2013/2014 PG&E portfolio to significantly increase its operational and behavioral related savings initiatives to account for 36% of total portfolio savings. This represents the highest penetration of operational savings for any portfolio reviewed, and may indicate a general shift towards a more balanced statewide portfolio as data analytic products and services become increasingly available. An additional discussion comparing equipment and operational savings can be found in Appendix 2. These operational savings are incremental and supportive of the LCGS target case and do not diminish the savings associated with purchasing and installing more efficient equipment.

Table 2. Examples of the distribution of savings between equipment selection and operational savings.

Example	Savings from Efficient Equipment Purchase	Savings from Efficient Equipment Operation
2013 Navigant Potential Study	80%	20%
2008 Itron Potential Study	82%	17%
2013/14 PG&E portfolio filing	64%	36%
2013/14 SCE portfolio filing	77%	23%
2013/14 SDG&E portfolio filing	82%	18%

Key risks inherent in the assumptions about voluntary participation regulated programs include:

- The rate at which emerging technologies are identified and brought to market will need to be aggressive. A review of the emerging technology programs historically operating in California would likely conclude that these are primarily case study activities which are intended to establish the savings associated with a device or process, but generally lack an aggressive capacity to drive rapid market adoption once proven.
- Many of the emerging technologies to be deployed may never pass current costs effectiveness tests where benefits are largely determined by the value of avoided utility costs.

[26] The American Council for an Energy-Efficient Economy (ACEEE). The Energy Savings of Smart Manufacturing. Research Report IE1403. Ethan A. Rogers, JULY 30, 2014

- The expansion of data analytics will require that new market entrants have access to large amounts of energy usage data which will always reside with utilities as a product of their revenue metering. However, it is uncertain whether market participants will have access to the data necessary to drive innovation and subsequently increased levels of efficiency.

Assumptions about mandatory participation policy initiatives

In the context of this discussion, mandatory policy initiatives are legislative and regulatory activities occurring at the state or local level that require compliance with energy performance metrics for a building or process. Unlike regulated voluntary participation programs, these initiatives are mandatory and may require an energy efficiency upgrade if a building or process falls below a benchmark metric, such as a the Home Energy Rating Score (HERS) performance rating. The following section provides context on various types of mandatory initiatives that focus on energy efficiency upgrades to existing buildings. Initiatives intended to expand the potential for energy efficiency in new construction beyond the underlying LCGS base case exist but are not considered in this discussion.

Opportunities from performance mandates on existing buildings

The majority of the EE potential forecast in the 2013 potential model and included in the LCGS base case originated from two types of activities:

1. A stock turnover model that assumed certain levels of voluntary activity when equipment was replaced at burnout or at the end of its useful life.
2. An equipment update that involved either Title 20, Title24, or Federal Appliance Standards.

The model did not, however, explore the potential associated with mandatory updates that could be initiated ("triggered") when a real estate transaction occurs, such as a building changing hands from one owner or occupant to another. The potential for energy savings resulting from a mandated update at the time of transfer can be significant considering that in any given year, approximately 15 percent of U.S. households change their primary residence at least once,[27] including these various forms of occupant transition;

- Annually, approximately three percent of owner-occupants move to new owner-occupied homes. These owner-occupied to owner-occupied moves account for nearly 20 percent of all annual moves.
- Annually, approximately two percent of renters move to owner-occupied homes.
- Annually, approximately 10 percent of renters move to new rental units. These renter-occupied to renter-occupied moves account for nearly 50 percent of all annual moves.

While California's statistics may vary slightly from these national averages, the implication is that five percent of owner-occupied residences change hands each year and would be subject to some form of energy efficiency upgrade at time of sale while 10 percent of rental units may be required to update when occupants change. Examples of how mandates have been, or may be, used to achieve energy efficiency objectives include the city of Berkeley, California's Residential Energy Conservation Ordinance and California's Existing Buildings Energy Efficiency Action Plan, discussed below.

[27] The Ins and Arounds in the U.S. Housing Market*. Federal Reserve Bank of Boston. Rüdiger Bachmann and Daniel Cooper. July 21, 2014

Berkeley, California's Residential Energy Conservation Ordinance (RECO). The Residential Energy Conservation Ordinance (RECO) requires energy audits at (1) the time of sale (if the home has not already been audited), and (2) when extensive remodeling occurs. If the audit identifies energy efficiency measures required to meet the ordinance's standards, the homeowner must bring the home into compliance within one year after the audit.[28] RECO applies to all homes, residential areas of mixed-use buildings, tenants-in-common, condominiums, multi-family properties, live-work spaces and boarding houses (including the common areas/common systems) and requires compliance upon the following triggers:

- Sale or Transfer of Property
- Substantial Renovation

In 1994, the City of Berkeley also adopted CECO which requires commercial property owners to complete certain energy conservation measures in their buildings upon transfer of property ownership or when additions or renovations are made. CECO's triggers are similar to those of RECO. Effective December 1, 2015, Berkeley's Energy Saving Ordinance (BESO) replaces both the Residential and Commercial Energy Conservation Ordinances.

California's Existing Buildings Energy Efficiency Action Plan. Assembly Bill (AB) 758 requires the Energy Commission to develop a comprehensive energy efficiency program for existing residential and non-residential buildings. The program is required to improve the energy efficiency of existing residential and non-residential structures which fall significantly below the efficiency required by the current standards, and includes provisions for mandatory approaches to achieve specific performance levels. The draft action plan for the program discusses two possible mandatory approaches: [29]

> "Two possible approaches could be mandatory disclosure of energy performance ratings and mandatory completion of basic level energy efficiency upgrades, with both approaches having specific completion dates to allow enough lead-time for building owners to determine the best timing for them to act.
>
> These approaches could create a "glide path" for voluntary compliance in advance of the specified completion date, during which outreach, information, and technical assistance could be provided to the marketplace along with information on financing and incentive opportunities. Financial incentives could be made available to building owners who voluntarily comply and to market actors who encourage and facilitate voluntary compliance."

Neither local ordinances nor statewide initiatives that mandate energy performance levels on existing buildings were included in the LCGS base case. Both initiatives are examples of mandated policy initiatives that could contribute towards the LCGS target case.

Opportunities for codes and standards applied to existing buildings

The LCGS target case does not recognize the potential for energy efficiency gains resulting from an improvement in code compliance for existing buildings. This is because the LCGS base and target cases use the same code compliance rates that range from 50 to 95 percent, depending on the measure, and are based on the CPUC 2006-2008 C&S program evaluation report.[30] A 2013 report from the Bay Area Regional Energy

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[28] http://www.epa.gov/statelocalclimate/local/topics/residential.html
[29] Draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings, California Energy Commission
Efficiency and Renewable Energy Division. June 2013
[30] Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned

Networks (BayREN) indicates that compliance rates remain low and provides some insight into why this is occurring: [31]

1. Full conformance with all aspects of energy code documentation requirements is rare for all types of buildings and at all stages of construction.
2. Many buildings were compliant with code minimums once code errors and omissions (discrepancies) were corrected. However, the presence of the errors, and subsequent building energy savings represented by the correction of those errors, are a lost opportunity for energy savings.
3. Local governments, building departments, and their staff are very influential not only in enforcing minimum compliance rates, but also in encouraging best practice building design and construction.
4. Departmental pressures such as limited staffing and competing health and safety priorities constrain the ability of building departments to thoroughly review energy code requirements on every project executed.

Achieving higher compliance rates would contribute towards achieving the LCGS target case forecast, and the aforementioned BayREN report lists various activities that would help address these performance issues, including:

- Use of electronic permit system enhancements.
- Narrowing the tolerance band for inadequate energy compliance documentation.
- Developing energy code expertise internal to each compliance office.
- Developing internal consistency in energy code plan reviews.

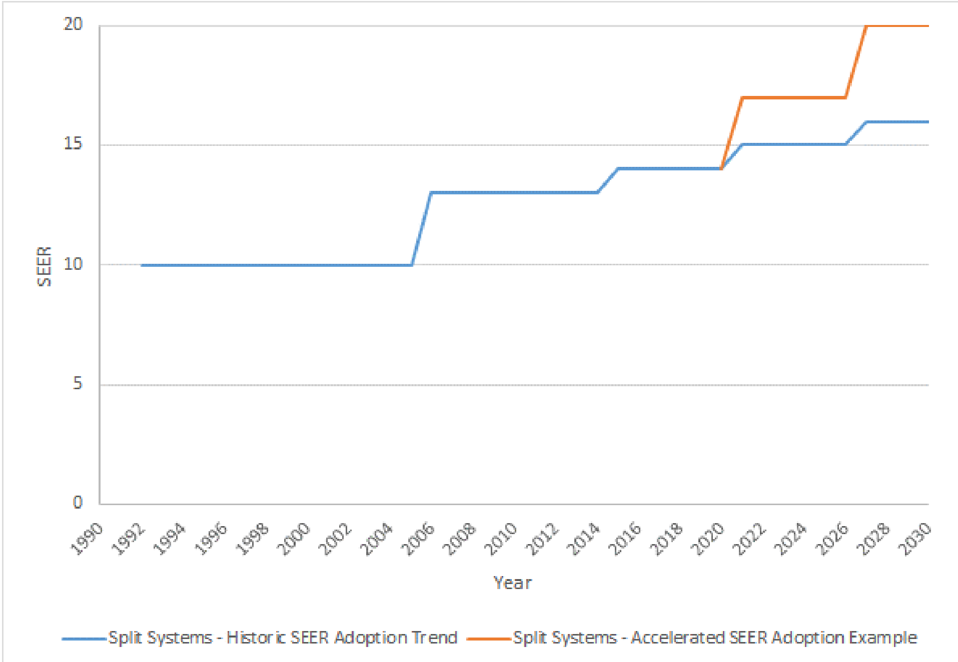
In addition to the potential savings from higher compliance rates, the 2013 potential model did not consider the potential to increase energy efficiency by accelerating the rate at which codes increase performance requirements for equipment. For example, in 14 years, from 1992 through 2005, the minimum required efficiency for residential AC systems in both new construction and replacement projects remained at 10 SEER. Beginning in 2006, Title 24 (T24) code increased to 13 SEER and remained in effect for nine years until January of 2015, when it changed to 14 SEER. This implies that on average, code requirements increase by a nominal value of about 1 SEER every 5 years.

As illustrated in Figure 8, this rate of increase indicates that the code minimum efficiency for residential AC systems will peak at 16 SEER within the LCSGS study horizon. However, it is possible for residential AC equipment efficiency standards to increase at a much faster rate because the market currently offers AC equipment based on the same fundamental technology (and therefore reasonable incremental costs) with efficiency ratings that exceed SEER 20.

Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008. Prepared by KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc. Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008. Prepared by KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc.

[31] BayREN Codes & Standards Permit Resource Opportunity Program (PROP) Final Report and Energy Code Resource Guide. April 1, 2015. Prepared by the Benningfield Group, Inc., BKi, and Association of Bay Area Governments

Figure 8. History of Residential Central AC T24 SEER Standards



Key risks inherent in the assumptions regarding mandatory participation policy initiatives include:

- While AB758 allows for mandatory upgrades to existing buildings and the Comprehensive Energy Efficiency Program for Existing Buildings defines several 'no-regrets' strategies that require various levels of energy efficiency performance; the capacity to actually complete energy efficiency upgrades remains uncertain. One less encouraging indication occurred on March 10, 2015 when the City of Berkeley rescinded RECO and CECO ordinances, dropping the mandatory performance upgrades in favor of a voluntary approach referred to as the Building Energy Saving Ordinance (BESO). BESO requires building owners to develop "a building-specific energy assessment and action plan, as well as public reporting on energy and water efficiency."
- Codes and standards represent an increasing component of the energy efficiency portfolio. And while code compliance issues are both known and well documented, addressing these compliance issues will require additional funding for parties engaged in codes enforcement. Currently, codes enforcement is mostly funded through city-specific permit fees. Anecdotal evidence indicates that permit fees have not increased at a rate necessary to cover the increased prevalence and complexity of energy code; as a result, compliance remains an issue at large. History indicates that cities are unlikely to raise permit fees adequately or find other internal resources to address this funding discrepancy.
- Rapidly increasing the rate at which codes and standards increase equipment efficiency levels may require that financial incentives remain in place after code mandates a higher efficiency machine. Business as usual does not typically provide incentives for installing equipment that performs to code.
- It is likely that without a significant increase in the value of benefits from energy efficiency, many of the policy support initiatives will not pass current cost effectiveness tests where benefits are largely determined by the value of avoided utility costs, or the time-dependent valuation of energy used for developing building efficiency standards.

Assumptions about evolving market delivery mechanisms

For the purposes of the LCGS, evolving market delivery mechanisms are those initiatives that will either expand participation in 'traditional' energy efficiency activities beyond what has historically been captured in past program designs, or offer a pathway to achieve energy savings that have not been recognized in past market initiatives, including:

1. Opportunities from financing through Contract Assessment Districts and associated PACE programs
2. Opportunities from California's Cap-and-Trade Program

The following discussion is not inclusive of all evolving market mechanisms, but outlines the potential contribution to the LCGS target case from market innovations that have been deployed within the past five years and that are continuing to expand and gain market traction.

Opportunities from financing through Contract Assessment Districts

Property Assessed Clean Energy (PACE) financing programs are quickly being implemented across California and are driving higher levels of adoption of energy efficient technologies by eliminating the 'first cost' barrier that has traditionally hampered participation. From a study published by the California Financial Opportunities Roundtable,[32] PACE is a form of financing enabled by Contract Assessment Districts[33] that allow a jurisdiction's property tax authority to be used as a mechanism to pay back third party loans used to fund the installation of energy efficiency, water conservation, distributed generation, and storage technologies, as well as technologies that support the electrification of transportation.

The first PACE program was implemented in 2010 by Berkeley, California, led by Cisco DeVries, the Chief of Staff to Berkeley's Mayor. Berkeley's PACE program "was recommended as an alternative to the [solar bonds] authority approved by neighboring San Francisco voters in 2001 in conjunction with the City's Community Choice Aggregation program, which is being implemented in both San Francisco and Sonoma counties. DeVries saw PACE to provide a viable means to help achieve the Bay Area's climate goals. California passed the first legislation for PACE financing and started the BerkeleyFIRST climate program in 2008. Since then, PACE-enabling legislation has been passed in 30 states and the District of Columbia, allowing localities to establish PACE financing programs."[34]

At the time this paper was produced 26 California counties that have either adopted PACE, or have cities that operate PACE. As of late 2014, over 140 cities in California offer PACE financing including programs from one or more of the following providers;

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[32] Access to Capital, Developed by the California Financial Opportunities Roundtable Representing finance, impact investing, philanthropy, business, economic development, government and more. California Financial Opportunities Roundtable (CalFOR). August 2012.

[33] Any California county, city, special district, school district or joint powers authority can establish a Contract Assessment District (CAD) which allows for financing of public improvements and services. CADs can be known by several names (e.g., Energy Financing Districts, Clean Energy Assessment Districts (CEAD), Special Tax Districts, etc.) and were first proposed by the City of Berkeley in 2007. CADs have received increasing attention as a mechanism for financing residential or commercial projects for energy efficiency, solar photovoltaic, or solar thermal systems. Recently, they have expanded into water conservation and have the potential to facilitate individual homeowners and/or businesses financing a wide array of improvements and/or services such as e-commerce, information technology, rainwater harvesting, etc.

[34] PACE financing, from Wikipedia at http://en.wikipedia.org/wiki/PACE_financing

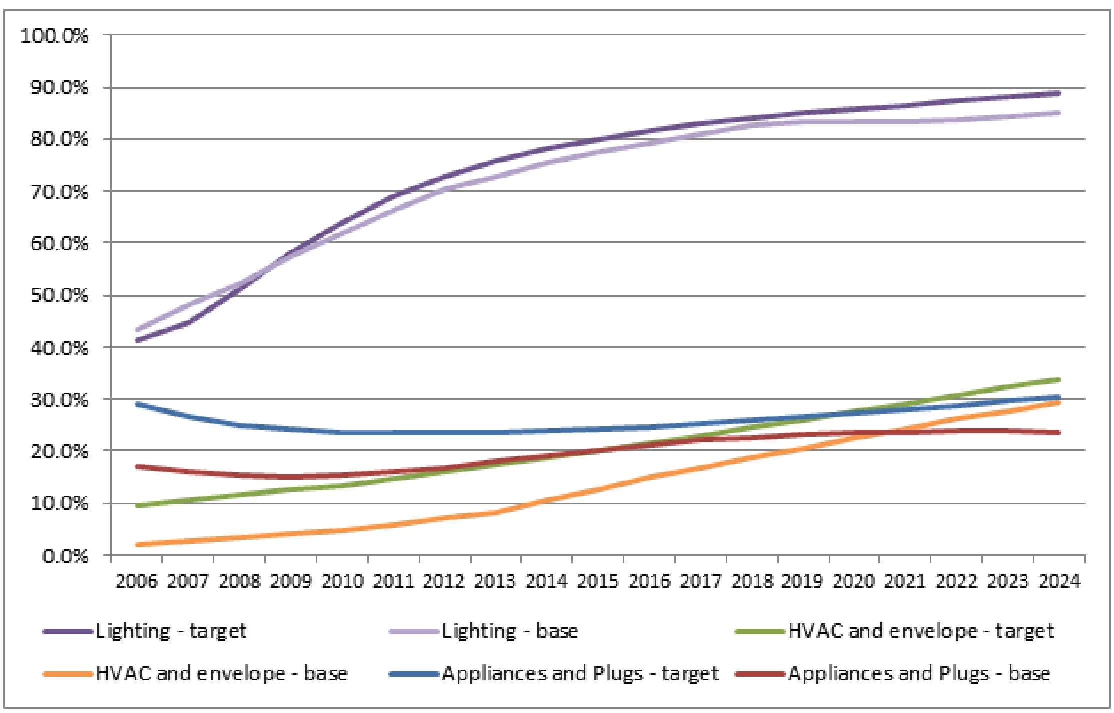
- CaliforniaFIRST
- Clean Energy Sacramento
- Figtree PACE
- Green Finance San Francisco
- HERO Program - Renovate America
- Los Angeles County PACE program
- mPower Placer
- Palm Desert Energy Independence Program
- Sonoma County Energy Independence Program
- Ygrene

PACE will have profound impacts on the market for energy efficiency products and services by increasing rates of adoption, expanding the types and breadth of efficient equipment being installed, and providing a platform that will allow consumers to engage in energy efficiency activities that is more stable than the voluntary regulated programs (e.g. IOU energy efficiency programs) that have historically served as the primary market delivery mechanism. The following section provides a brief discussion of each of these facets of PACE.

Increasing rates of market adoption

Numerous studies in California and Nationwide have cited high initial costs as one of the most significant barriers to customers for the adoption of energy efficient equipment. PACE financing largely addresses this barrier by allowing building owners who have adequate equity to "finance energy efficiency, water efficiency, and renewable energy projects on existing residential and commercial structures through a special tax assessment on the property. This provides financing for these types of improvements without requiring a down payment or payment of the full or partial upfront capital cost of the improvement."[35] Figure 9 provides examples of the changes in the rates of energy efficient technology adoption over time between the LCGS base and target case, and demonstrates that the target case savings may be achieved with relatively small changes in EE technology adoptions. The capacity of PACE to address the first cost barrier for a significant portion of the residential and commercial markets may drive adoption rates to levels consistent with the LCGS target case forecast.

Figure 9. Examples of the Changes in Energy Efficient Technology Adoption



[35] Residential and Commercial Property Assessed Clean Energy (PACE) Financing in California March 2013. Prepared by University of San Diego Energy Policy Initiatives Center Joe Kaatz, Consulting Attorney Scott J. Anders, Director

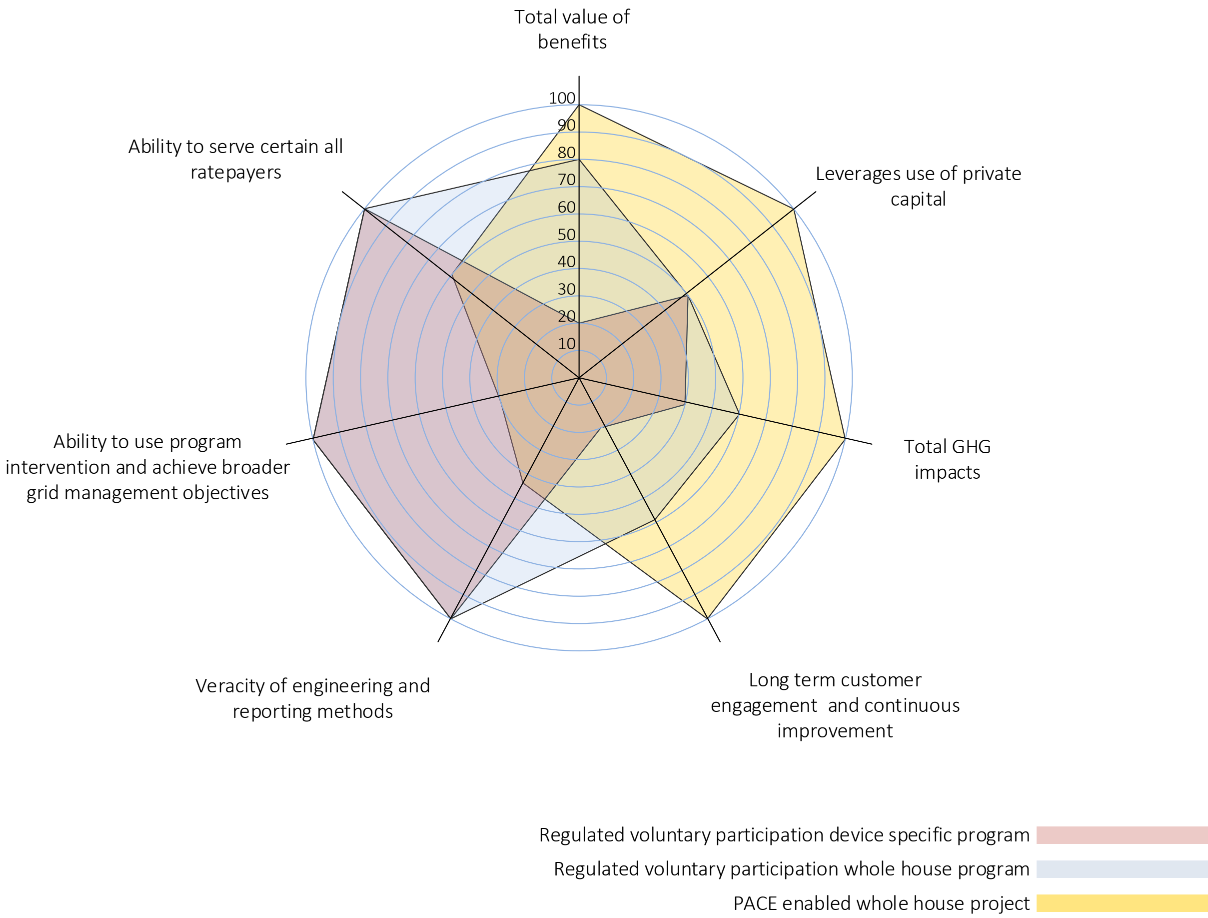
Expanding the value of energy efficiency

In addition to increasing the adoption rates for historically important energy efficiency measures, PACE financing will also increase the value of energy efficiency when compared to regulated voluntary participation programs. This increase value will manifest in several ways, including:

- The total value of benefits will increase compared to regulated voluntary programs because measures installed through PACE programs are not constrained by utility cost benefit tests. The program allows customers to install the efficiency and conservation measures they desire, such as efficient windows that do not pass utility cost effectiveness tests or grey water recovery systems that are not offered through electric utility programs.
- PACE leverages the use of private capital and thus has access to a larger and more diverse funding pool than regulated programs that rely solely on public goods charges. This increased access to capital will lead to additional innovations in financing instruments and the types of measures installed.
- The expanded list of measures available through PACE will increase the total Greenhouse Gas (GHG) reductions that result from energy efficiency and conservation activities beyond what can feasibly be achieved through regulated voluntary programs.
- PACE programs represent a catch-all for the majority of efficiency and conservation products. And because PACE is not dependent on a single source of capital or funding, it offers a more viable platform for continuous improvements than do regulated voluntary participation programs.

While PACE offers certain advantages, regulated voluntary participation programs also offer benefits not typically afforded by PACE programs. Some of these benefits include the ability to serve certain ratepayer groups including hard to reach, disadvantaged groups, or customers without the equity necessary to qualify for PACE programs. Additionally, regulated programs can be used to achieve broader grid management goals and have excellent engineering and reporting capacity. Figure 10 provides an illustrative comparison of the various attributes of PACE and regulated voluntary participation programs. In this diagram a score of 100 represents the greatest value in any category.

Figure 10. Illustrative Comparison of PACE and Regulated Voluntary Participation Programs



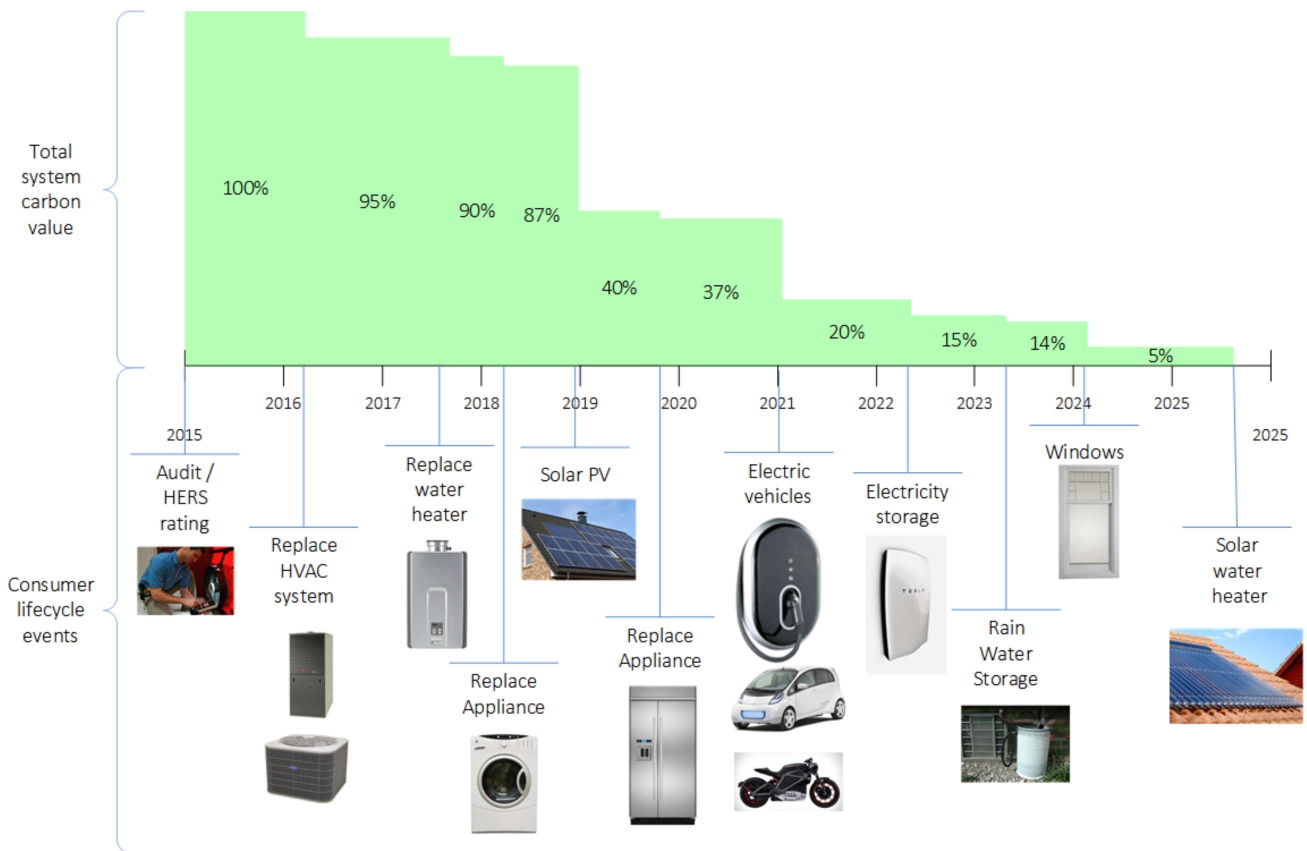
Providing a more stable funding platform

PACE provides a stable funding platform that allows for multiple transactions over time, thus promoting an ongoing customer relationship that is available when needed. Having the capacity to maintain a long term relationship is important because customers make multiple purchase choices over the course of many years, including decisions about energy efficiency, water conservation, distributed generation, choices impacting the electrification of transportation, and possible decisions on distributed storage. In contrast, there is usually less certainty regarding the duration of regulated programs. For example, since 2006, the average duration of IOU programs regulated by the CPUC has been two years, and there is no certainty that any program will be available at the time a consumer makes a purchasing decision. [36]

Figure 11 provides an illustration of various purchasing decisions that customers make over time that involve products supported by PACE, and the potential for the cumulative impact of these decisions to drive a resident's carbon footprint to zero over a 10 year period. The breadth of systems involved in this hypothetical example include all market aspects addressed in the LCGS, including energy efficiency, distributed generation, distributed storage, and the electrification of transportation.

[36] The 2006 –2008 portfolio had a three-year duration and the 2009 portfolio had a one-year duration. The 2010–2012 portfolio had a three-year duration, the 2013–2014 portfolio had a two-year duration, while the 2015 portfolio is a one-year bridge fund.

Figure 11. Illustration of Customer Purchasing Decision and Resulting Carbon Impacts over Time



Opportunities from emerging carbon markets

California's Cap-and-Trade Program launched in 2012 and provides roughly $832 million of proceeds to support existing and pilot programs defined in the 2014-2015 California state budget.[37] This expenditure plan permanently allocates 60 percent of future auction proceeds to a diverse set of predefined initiatives, and reserves 40 percent for future allocations that are to be determined. For the 2014-2015 period, the budget includes $240 million allocated for energy efficiency related activities such as sustainable communities, weatherization, and energy efficiency in public buildings in addition to the industrial and agricultural sectors. The impact of this funding, and rules about how it is to be applied, indicate that it will generate energy efficiency that is incremental to the LCGS base case for several reasons, including:

- The 2013 potential model on which the LCGS base case relies did not consider the amount of funding or the types of energy efficiency programs being implemented through funding related to the Cap-and-Trade market. The potential model was calibrated to assume market adoption rates more consistent with total EE funding levels which have historically been lower than what is now contributed from the cap and trade market.

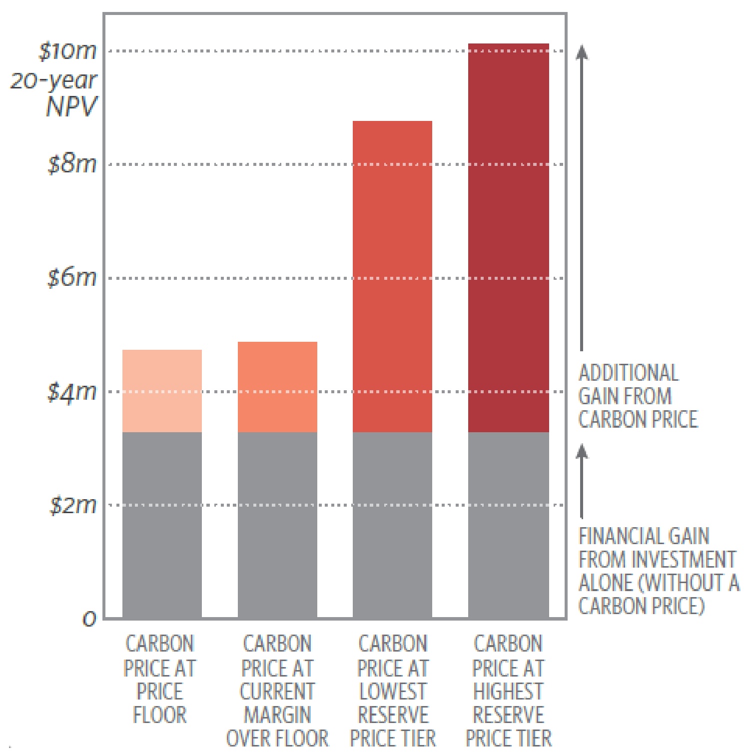
[37] California State Budget for 2014 – 2015, Cap and Trade Expenditure Plan.

- Energy efficiency activities accrued through Cap-and-Trade markets might be focused on operational efficiencies that have not been captured through voluntary participation regulated programs. For example, energy efficiency achieved through changes in operations or maintenance are expressly excluded from consideration in the CPUC custom retrofit programs,[38] or allowed only in non-resource programs such as continuous improvement offerings. For example, as discussed in a recent report on Cap-and-Trade barriers and opportunities:[39]

  "By introducing a carbon price, the Cap-and-Trade Program makes already-profitable investments in energy efficiency more financially attractive. However, firms' internal priorities and short required payback periods for investment will continue to limit investment in efficiency if carbon prices remain low. Higher carbon prices might be able to overcome some of these barriers."

Figure 12 shows the 20-year net present value of the modeled energy efficiency investment. The gray bars show the financial gain from energy cost savings, while the orange and red bars show the financial gain from the plant's ability to purchase fewer allowances, or profit from selling excess allowances. The additional value of energy efficiency resulting from Cap-and-Trade policies were not included in the LCGS base case and are supportive of the target case forecast.

Figure 12. Lifetime Value of Energy Efficiency Investment for Cement Plants



Key risks inherent in the assumptions about evolving market delivery mechanisms include;

[38] 2013-14 Statewide Customized Offering Procedure Manual for Businesses, page 13.

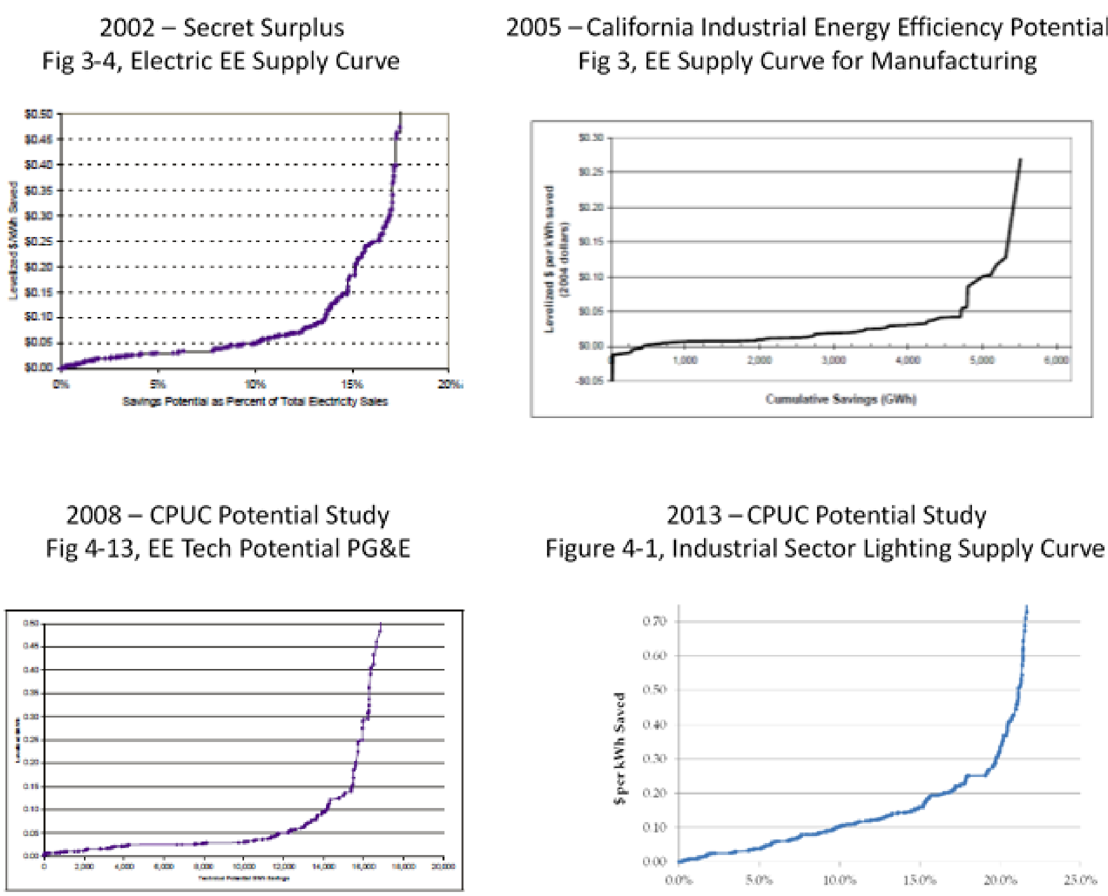
[39] Cap and Trade in Practice: Barriers and Opportunities for Industrial Emissions Reductions in California. Climate Policy Initiative working paper, July 2014.

- Forecasted savings for both the PACE and Cap-and-Trade markets are at risk of double counting savings that originate from voluntary participation regulated programs. As both programs are new, neither has been evaluated from the perspective of where savings are originating and whether these are incremental to savings that originate from more established program delivery modes.

Assumptions about the cost of energy efficiency

Underlying the cost assumptions for any forecast of energy efficiency potential is the recognition that efficiency is a finite resource where the relationship between costs and savings is determined by technology, market, and regulatory conditions and limitations. Figure 13 provides examples of costs curves from various California energy efficiency potential studies dating back to 2002 showing that higher levels of cumulative savings cost more. While no cost of supply analysis was conducted for the LCGS study, the level of energy efficiency forecast in the LCGS target case implies that there may be supply constraints on the types of energy efficiency activities that have defined utility portfolios for the past several decades, resulting in increasingly higher costs per unit savings. However, some of the new mechanisms for acquiring energy efficiency, such as savings from PACE financing, might be acquired at a lower cost per unit than in past DSM program portfolios. The following discussion provides a summary of the cost assumptions for each of the three areas of energy efficiency initiatives that comprise the LCGS target case EE forecast.

Figure 13. Example of EE Supply Cost Curves



The production costs for energy efficiency used in the LCGS model were calculated by multiplying total energy savings (kWh) by an estimated unit cost ($/kWh) for each year. Separate unit costs were used for each of the three areas of energy efficiency initiatives. Table 3 provides a summary of the beginning and ending unit costs for each initiative, followed by a brief discussion on how unit costs are derived, along with the most relevant cost drivers.

Table 3. First Year Cost per Net kWh Saved

Year	Voluntary regulated program costs	Evolving market mechanism costs	Mandatory policy initiative costs	Average cost
2015	$0.49	$0.05	$0.02	$0.23
2030	$1.02	$0.14	$0.27	$0.40

- The 2015 estimate of $0.49 / net kWh for voluntary participation regulated programs (i.e., IOU and POU energy efficiency programs) are based on the average cost per net kWh saved in the 2015 IOU portfolio filing, excluding costs associated with natural gas savings goals.[40] Net unit costs are used to be consistent with the AAEE net savings forecast. This value represents full portfolio costs, including resource and non-resource activity.

  The LCGS EE cost model assumes that the cost of introducing and sustaining emerging technologies, and expanding the infrastructure needed to fully realize the benefits of data analytics, will be an important cost driver for voluntary participation regulated programs. Additionally, the annual rate of inflation for the unit costs associated with voluntary participation regulated programs reaches six percent per year by 2030, as shown in Table 4. The annual rate of cost inflation for all three EE areas of initiative, shown in Table 4, includes two time periods where the rate of inflation in the second part of the LCGS study horizon (2021 to 2030) is higher to reflect the increasing cost of EE resource as the markets for less expensive EE options saturate.

Table 4. Annual Growth Rate in the Cost per Unit Saved, by EE Area of Initiative

Annual growth rate of savings costs, by EE area of initiative	Baseline	Target	
		2015-2020	2021 - 2030
Voluntary regulated program costs	1.5%	3.00%	6.00%
Evolving market mechanism costs	0.0%	4.0%	8.0%
Mandatory policy initiative costs	10.0%	15.0%	20.0%

- The 2015 estimate of $0.02/kWh for mandatory program costs (e.g., Codes and Standards, AB758 mandates) is based on 2015 IOU portfolio C&S advocacy costs. The model assumes that these costs will increase rapidly, reaching an annual 20 percent per year in later years, as shown in Table 4. This aggressive inflator reflects the low costs currently associated with mandates, and the perceived need for increased funding support as discussed below:
  - The cost model assumes that it will be necessary to provide funding for code compliance activities. At the local jurisdiction level, code compliance activities are funded through a combination of

[40] 2015 portfolio savings were normalized as MMBtu savings and program costs were allocated proportionately to electric and natural gas savings goals.

permit fees and local government budgets. As energy efficiency codes become more pervasive and aggressive, it is unlikely that permit fees will be adequate cover staffing levels required, and California cities are facing difficult economic trends that may impede their ability to increase funding for code compliance. Examples of the adverse economic trends are discussed at the California Local Government Finance Almanac[41] and include:

- State and federal aid to California cities is declining, down from 21 percent of a city's budget in 1974–75 to 10 percent today.
- The sales tax base is declining, due to a shift towards a service-oriented economy and increasing Internet and catalog retail sales.
- Limitations on taxes and fees that cities can impose are driven by Prop. 13, Prop. 218, and other state laws.
- State population growth is higher in cities.
- Cities must respond to citizens' demand for a greater array of services that bring with them additional costs and new challenges (high tech, cable, transit, etc.).
- Public safety spending is up.
- Infrastructure improvements and maintenance are lagging.

- The capacity exists to increase the level of efficiency required by codes on most building systems and many processes, and the rate at which codes can advance may also be accelerated. The cost model assumes that accelerating codes on select items, such as higher SEER residential HVAC units, will require continued incentive funding after codes have been adopted. These post-code incentives may be in the form of continued up-stream and mid-stream buy downs, or ongoing incentives for hard to reach populations.
- AB758 provides for the ability to mandate updates to buildings at the time of sale, which will be an important contributor to realizing aggressive energy efficiency goals. The cost model assumes that many of these mandated upgrades will require some subsidy, such as exchanges involving occupants that qualify for low income assistance.

- The 2015 estimate of $0.05 / kWh for evolving market mechanism costs were derived from the utility avoided cost 2011 update forecast.[42] The model assumes that the costs of resources acquired through evolving market mechanisms will increase each year, reaching an annual inflation rate of eight percent by 2030, as shown in Table 4. The type of market mechanisms for which this funding would apply, for example, include the third party pilot program proposed by NRDC as part of Rulemaking 13-11-005,[43] included in Appendix 4. This type of program could potentially set up a market where savings achieved through unregulated or innovative programs, such as PACE financing, are sold to utilities or regulators.

  Regulators and utilities will be have an interest interacting with evolving market mechanisms because these savings will play an increasing role in achieving aggressive green-house-gas goals, assisting in procurement planning, or help in addressing increasingly complex grid management issues. For example

[41] http://www.californiacityfinance.com/
[42] Energy Efficiency Avoided Costs 2011 Update. Energy and Environmental Economics, Inc. December 19, 2011
[43] Response Administrative Law Judge's Ruling re Comments on Phase II Workshop 3 (Statewide and Third Party Energy Efficiency Programs). Natural Resources Defense Council (NRDC). April 13, 2015

Figure 14 shows the variation in the value of avoided distribution costs for California's three electricity utility[44]. A mechanisms that funds the acquisition of energy efficiency savings through market mechanisms such as PACE may also be able to incorporate the value of avoided distribution costs, and pay a premium to drive installations in locations where there are transmission or distribution constraints.

Figure 14. Variation in the Value of Avoided Distribution Costs

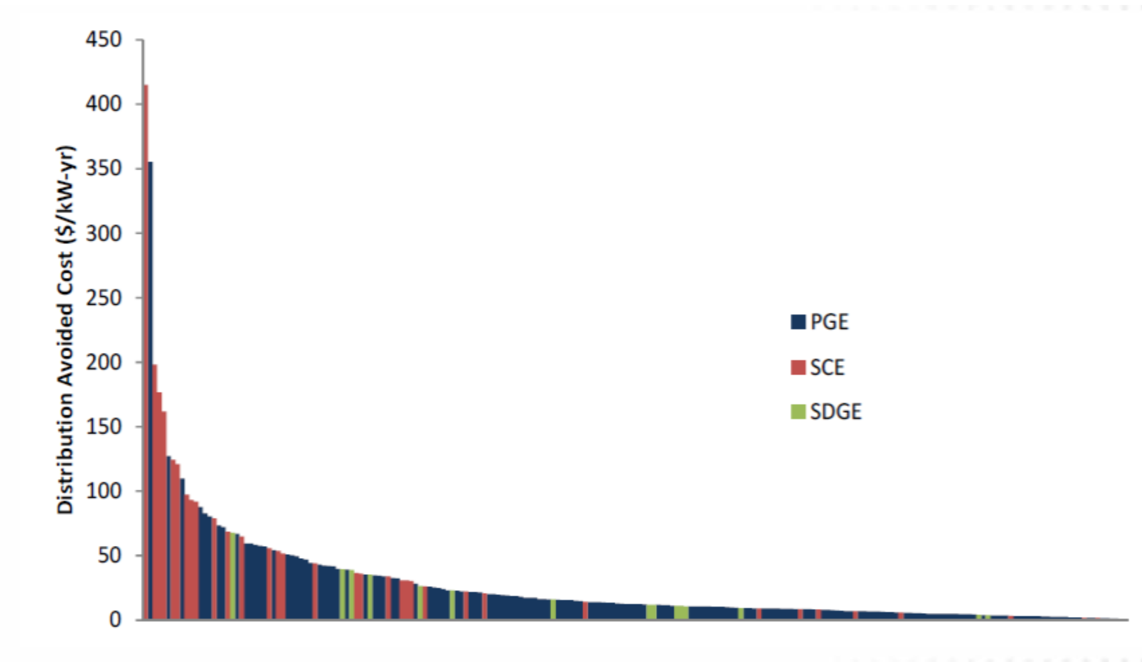


Table 5 provides the estimated cost for each of the three areas of EE initiatives at various points in the LCGS study horizon. These values represent expenditures on EE activities associated with electricity only, and do not include an estimate of funding necessary to support natural gas efficiency. In this model, voluntary regulated programs (i.e. IOU programs) continue to receive the majority of throughout the LCGS forecast horizon. Funding for mandatory policy initiatives grow each year until they account for approximately 47% of all EE funding derived through, and supporting, Public Utility Codes.

Table 5. Total Annual Cost by EE Area of Initiative

	Total Annual Cost by EE Area of Initiative ($M)			
Year	Voluntary regulated program costs	Evolving market mechanism costs	Mandatory policy initiative costs	**Total Annual Investment (Electric EE only)**
2015	$591	$7	$29	$627
2020	$708	$16	$74	$797
2025	$835	$41	$212	$1,089
2030	$733	$99	$558	$1,391

44 Energy and Environmental Economics, Inc. Workshop Discussion: Using Avoided Costs to Set SB32 Feed-in Tariffs SB32 Workshop. September 26th, 2011.

Appendices

Appendix 1. Emerging Technologies not Fully Represented in the LCGS Base Case

Technologies with limited or no representation in the LCGS base case

Space Cooling Technologies	**Appliance Technology**
Next generation rooftop unit	Refrigerator/Freezer: Advanced compressor tech
Efficient window A/C	Refrigerator/Freezer: Vacuum insulation panels
Rooftop unit w/ integrated active desiccant wheel	Refrigerator/Freezer: Magnetic refrigeration
Low-GWP A/C	Clothes Dryer: Heat pump (electric only)
Non-vapor-compression cooling	Clothes Dryer: Mechanical steam compression
Fan/diffuser w/an evap condenser pre-cooler	Refrigerator/Freezer: Thermo-elastic refrigeration
Heating Technologies	Clothes Washer: Polymer bead cleaning
Commercial CCHP	Refrigerator/Freezer: Thermoelectric refrigeration
Variable speed CCHP	Clothes Dryer: Inlet air preheat
International HVAC&R R&D collaboration	Refrigerator/Freezer: Sterling cycle refrigeration
Natural refrigerant high efficiency commercial HP	Clothes Washer: Sanitizing agents
Building Envelope Technologies	Clothes Dryer: Indirect heating
R-12/in building envelope thermal insulation material	Cooking Equipment: Specialized cookware
Air-Sealing Technologies (systems-level approach)	Clothes Dryer: Microwave (electric only)
Air-sealing systems, reduce air leakage to <1 ACH50	**Window Technologies**
Roofs for Commercial Buildings	R-10 windows
Highly insulating roof, doubles ASHRAE standards	R-7 windows
Water Heating Technologies	Dynamic Window Technologies
Thermoelectric HPWH	Dynamic window films
Smart Controls	Dynamic windows buildings
Improve HPWH Compressor	Visible Light Redirection Technologies
Grey-Water-Source HPWH	**Integrated Water Heat/Space Conditioning Systems**
Advanced Storage Tanks	Two stage AS-IHP
Commercial HPWH	Variable speed AS-IHP
Cross-Cutting and Related Activities	Variable speed ground source-IHP (GS-IHP
Rotating heat exchanger for residential HVAC	AS-IHP and GS-IHP field tests
Miniaturized air-to-refrigerant heat exchangers	Advanced GHP tech for very-low-energy buildings
Building integrated heat and moisture exchange	Multi-function fuel-fired HP
	Natural refrigerant high-efficiency HVAC
	High performance CCHP
	Supercharger for CCHP

Appendix 2. Comparison of Characteristics of Equipment and Operational Savings

Definitions	Equipment Savings	Operational Savings
Definitions	Most commonly defined as 'efficiency'	Most commonly defined with 'conservation'
Relationship to work	Saves energy by doing the same work for less energy	Saves energy by doing less work
Nature of fuel savings	Savings based on a delta watt	Savings based on changing device operation
Demand savings certainty	Demand savings a certain	Demand savings are uncertain
Load shape impacts	Keeps load shape, but shifts it 'down'	Changes load shape
Organizational decision process	Organizational decisions are generally purchasing decisions	Organizational decisions center on ability to influence behavior, and developing information and management infrastructure needed to maintain savings
Key assumptions in forecasting EE potential	Potential is estimated primarily by modelling stock turnover and assuming consistent equipment operation	Potential is calculated primarily by estimating how information, controls, and modifying operator/occupant behavior can save energy by changing equipment operation.
Nature of measure costs	High percentage of projects require capital budget	Most projects are expense items or do not require any money for purchase. Controls (e.g. EMCS or EIS) can be capital

Appendix 3. List of Products Approved for Installation through PACE Financing

Renewable & Alternative Energy Products

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
Solar Photovoltaic	Solar Panel	Product must be listed as California Solar Initiative incentive-eligible photovoltaic module in compliance with CA-SB1 guidelines. 2. Installation Contractor must be registered with the California Solar Initiative Program and have the correct CSLB licensure to install solar systems. 3. System must be grid connected unless the property is not currently connected to the grid. 4. Installed per manufacturer specifications.	20
	Solar Inverter	Product must be listed as California Solar Initiative eligible inverter in compliance with CA-SB1 guidelines. Installation contractor must be registered with the California Solar Initiative Program and have the correct CSLB licensure to install solar systems. System must be grid connected unless the property is not currently connected to the grid. 4. Installed per manufacturer specifications.	20
Solar Thermal	Solar Water Heating	System must have the OG-300 System Certification by the Solar Rating and Certification Corporation (SRCC). 2. System Solar Fraction (SF) must be ≥ 0.5. 3. Auxiliary tank must be residential class. 4. Installed per manufacturer specifications.	15
	Solar Pool Heating	Product must have the OG-100 Collector Certification by the Solar Rating and Certification Corporation (SRCC). 2. Installed per manufacturer specs.	15

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)

Alternative Energy	Small Wind Turbine	Product must be certified by the Small Wind Certification Council as meeting the requirements of the AWEA *Small Wind Turbine Performance and Safety Standard* (9.1-2009). 2. Product must be grid connected unless the property is not currently connected to the grid. 3. Installed per manufacturer specs.	20
	Advanced Energy Storage System	System must meet the eligibility requirements outlined in the current California Self-Generation Incentive Program (SGIP) Handbook. System must be tied to a program eligible Solar PV system. 3. System must be grid connected unless the property is not currently connected to the grid. 4. Installed per manufacturer specs.	10
	Electric Vehicle Charging Station	Product must certified as meeting the UL Subject 2594 Standard Testing for Charging Stations. 2. Product must be a Level 2 charger with SAE J1772 standard charging plug. 3. Installed per manufacturer specs.	10
	Stationary Fuel Cell Power System	1. System must be certified as meeting the ANSI/CSA America FC1 standard. 2. Installed per manufacturer specs. Installed in accordance with local code and/or the Standard for the Installation of Stationary Fuel Cell Power Plants, NFPA 853, the National Fuel Gas Code, ANSI Z223.1/NFPA 54, National Electrical Code, NFPA 70, as applicable.	15

Energy Efficiency Products

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
High-Efficiency Heating, Ventilation, and Air Conditioning (HVAC)	Air-Source Heat Pump	1. Product must be AHRI Certified and AHRI number must be provided. 2. Product must be ENERGY STAR Certified: a. Split: SEER ≥ 14.5 and EER ≥ 12 and HSPF ≥ 8.2. b. Package: SEER ≥ 14 and EER ≥ 11 and HSPF ≥ 8.0. 3. Must replace an existing product.	15
	Central Air Conditioner	1. Product must be AHRI Certified and AHRI number must be provided. 2. Product must be ENERGY STAR Certified: a. Split: SEER ≥ 14.5 and EER ≥ 12. b. Package: SEER ≥ 14 and ≥ EER 11. 3. Must replace an existing product. 4. Installed per manufacturer specs.	15
	Furnace	1. Product must be AHRI Certified and AHRI number must be provided. 2. ENERGY STAR Certified: AFUE ≥ 90%. 3. Must replace an existing product. 4. Installed per manufacturer specs.	20
	Evaporative Cooler	Product must be listed in California Energy Commission Appliance Efficiency Database. Must have separate ducting system—independent of the air conditioning and heating duct system. Must be permanently installed through wall or on the roof; window installed product is not eligible. 4. Installed per manufacturer specs.	10
	Boiler	1. Product must be AHRI Certified and AHRI number must be provided. Product must be ENERGY STAR Certified: AFUE ≥ 85%. 3. Must replace an existing product.	20

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
High-Efficiency Heating, Ventilation, and Air Conditioning (HVAC)	Geothermal Heat Pump	1. Product must be ENERGY STAR Certified: a. Closed Loop Water-to-Air: ≥ 14.1 EER and ≥ 3.3 COP b. Open Loop Water-to-Air: ≥ 16.2 EER and ≥ 3.6 COP c. Closed Loop Water-to-Water: ≥ 15.1 EER and ≥ 3.0 COP d. Open Loop Water-to-Water: ≥ 19.1 EER and ≥ 3.4 COP e. DGX: ≥ 15.0 EER and ≥ 3.5 COP 2. Product must replace an existing product. 3. Installed per manufacturer specs.	15
	Hydronic Radiant Heating System	System must be powered by a high-efficiency HERO-qualified heating source. 2. Installed per manufacturer specs.	15
	Mini-Split Air Conditioner	1. Product must be AHRI certified and AHRI number must be provided. 2. Efficiency: ≥ 15 SEER. 3. Product must replace an existing product. 5. Installed per manufacturer specs.	15
	Mini-Split Heat Pump	1. Product must be AHRI certified and AHRI number must be provided. 2. Efficiency: ≥ 15 SEER and HSPF ≥ 8.2. 3. Product must replace an existing product. 4. Installed per manufacturer specs.	15
	Biomass / Wood Stove	Product must be certified and listed on the EPA Certified Wood Stoves list. 2. Installed per manufacturer specs.	15
	Duct Replacement	1. Duct system leakage: a. Partial Replacement: ≤ 15% total system nominal flow b. Full Replacement: ≤ 6% total system nominal flow 2. Duct Insulation R-Value ≥ R-6. 3. Installed per Title 24, Part 6.	20

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
High-Efficiency Heating, Ventilation, and Air Conditioning (HVAC)	Heat/Energy Recovery Ventilator	1. Product must be certified by the Home Ventilation Institute (HVI). 2. Installed per manufacturer specs.	10
	Exhaust Ventilation Fixture	1. Product must be ENERGY STAR Certified. 2. Installed per manufacturer specs.	10
	Whole House Fan	1. Product must be listed in California Energy Commission Appliance Efficiency Database. 2. Installed per manufacturer	20
	Attic Ventilation Fixture	1. Product must have thermostat control. 2. Installed per manufacturer specs.	15
	Ceiling Fan	1. Product must be ENERGY STAR Certified. 2. Installed per manufacturer specs.	10
Vindows, Doors, and Skylights	Window	1. Product must be ENERGY STAR and NFRC Certified: a. U-Factor ≤ 0.32 and SHGC ≤ 0.30. 2. Product must replace existing product. 3. Product NFRC label to be submitted with Completion Certificate. 4. Installed per manufacturer specs. 5. Product must meet Title 24 requirements.	20
	Door	1. Product must be ENERGY STAR and NFRC Certified: a. Opaque: U-Factor ≤ 0.21 and SHGC = Any b. ≤ 1/2-Lite: U ≤ 0.27 and SHGC ≤ 0.30 c. > 1/2-Lite: U ≤ 0.32 and SHGC ≤ 0.30 2. Product must replace existing product. 3. Product NFRC label to be submitted with Completion Certificate. 4. Installed per manufacturer specs.	20
	Skylights and Tubular Daylighting Device	Product must be ENERGY STAR and NFRC Certified: U-Factor ≤ 0.55 and SHGC ≤ 0.30 2. NFRC label for each different product to be submitted with Completion Certificate. 3. Installed per manufacturer specs.	20
	Applied Window Film	1. Product must be NFRC Certified. 2. NFRC label for each different product to be submitted with Completion Certificate. 3. Installed per manufacturer specs.	10

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
Windows, Doors, and Skylights	Exterior Window Shading Device	Product must be permanently secured to the exterior of the property with attachments or fasteners that are not intended for removal. Each device must be installed to provide shading to at least one window or door. 3. Product must be one of the following styles: a. Fixed Awning b. Operable Awning c. Louvered Shutter d. Roll-down Shutter e. Roll-down Solar Screen Product is only eligible to be installed on properties located within California Building Climate Zones 2, and 6-16. Exterior structural elements including, but not limited to sunroom enclosures, exterior decks, balconies, roof overhangs, trellises, pergolas, arbors, and/or carports are <u>NOT</u> eligible. 6. Interior window shading products including, but not limited to, blinds, shutters, shades, or curtains are <u>NOT</u> eligible. Product is <u>NOT</u> eligible to be installed on properties located with CA Building Climate Zones 1, and 3-5. 8. Installed per manufacturer specs	10
Building Envelope	Cool Wall Coating	1. Product must be included on HERO Cool Wall Eligible Product List. 2. Product must have solar reflectance ≥ 0.5 as tested by recognized third-party laboratory to ASTM C1549-09 standard. Product is <u>only</u> eligible to be installed on properties located within CA Building Climate Zones 4-10 and 12-15. 4. Installed per manufacturer specs.	20
	Cool Roof - Prescriptive	1. Product must be ENERGY STAR Qualified: a. Low-Slope Roofs: ≥ 0.5 Aged (3 yrs.) Solar Reflectance b. Steep-Slope Roof: ≥ 0.15 Aged Solar Reflectance 2. Product must meet Title 24, Part 6. 3. Installed per manufacturer specs.	20

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
Building Envelope	Cool Roof - Performance	If ENERGY STAR Qualified roofing product is not specified, one of the following cool roof performance measures must also be implemented: Install ≥ 1" Air-space between the top of the roof deck to the bottom of the roofing product. b. Insulate attic floor to R-value ≥ 38. Seal & Insulate attic HVAC duct work to R-8 and ≤ 6% leakage. d. Install an eligible radiant barrier. e. Insulate roof deck to R-value ≥ 4. f. Install roof construction with thermal mass over a membrane with a weight of at least 25 lb/ft^2. 2. Project must comply with CA Title 24 Part 6. Project stakeholder is fully and solely responsible to meet any such additional requirements.	20
	Attic Insulation	1. R-value ≥ 38. 2. Installed per CEC QII Standards.	20
	Wall Insulation	1. R-value ≥ 13 to full framing cavity depth. 2. Installed per CEC QII Standards.	20
	Under-Floor Insulation	1. R-value ≥ 19 to full joist depth. 2. Installed per CEC QII Standards.	20
	Radiant Barrier	1. Emissivity ≤ 0.1. 2. Reflectivity ≥ 0.9. 3. Installed per manufacturer specs.	20
	Air Sealing	Performed to BPI, ENERGY STAR, and ASHRAE 62.2 guidelines.	10
High-Efficiency Water Heating	Gas Storage Water Heater	1. Product must be ENERGY STAR Certified. 2. EF ≥ 0.67. 3. Installed per manufacturer specs.	10
	Electric Heat Pump Storage Water Heater	1. Product must be ENERGY STAR Certified. 2. EF ≥ 2.0. 3. Installed per manufacturer specs.	10
	Gas Tankless Water Heater	1. Product must be ENERGY STAR Certified. 2. EF ≥ 0.82. 3. Installed per manufacturer specs.	10

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
High-Efficiency Pool Equipment	Pool Pump and Motor	1. Product must be ENERGY STAR Certified: a. Single Speed Pump: EF ≥ 3.8 for single speed b. Multi/Variable Speed/Flow: EF ≥ 3.8 for most efficient speed. 2. Product must replace existing product. 3. Installed per manufacturer specs.	10
	Electric Heat Pump Pool Heater	1. Product must be listed in California Energy Commission Appliance Efficiency Database. 2. COP ≥ 4.5. 3. Installed per manufacturer specs.	10
	Gas Pool Heater	1. Product must be listed in California Energy Commission Appliance Efficiency Database. 2. Thermal Efficiency ≥ 83%. 3. Installed per manufacturer specs.	10
	Automatic Pool Cover	1. Product must be an automatic pool cover UL certified as meeting ASTM F1346 Standard Performance Specification. Product must be permanently installed on an existing swimming pool. 3. Installed per manufacturer specs. Manual swimming pool covers are not eligible	10
High-Efficiency Lighting	Indoor Lighting Fixture	Product must be ENERGY STAR Certified and meet Title 24, Part 6 requirements. 2. Product must be permanently installed. 3. Installed per manufacturer specs.	20
	Outdoor Lighting Fixture	Product must be ENERGY STAR Certified and meet Title 24, Part 6 requirements. 2. Product must be permanently installed. 3. Installed per manufacturer specs.	20
	Lighting Control	1. Product must be listed in the California Energy Commission Appliance Efficiency Database. 2. Eligible control types include: a. Automatic Time-Switch b. Daylight/Photo- Sensor c. Dimmer d. Occupant/Motion/Vacancy Sensor 3. Install per manufacturer specs.	20

Water Efficiency Products

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
Indoor Water Efficiency	High-Efficiency Toilet Fixture	1. Product must be listed in the CEC Appliance Efficiency Database. 2. Toilet and urinals fixtures are eligible. 3. Flow rate ≤ 1.28 GPF. 4. Installed per manufacturer specs.	20
	High-Efficiency Faucet Fitting	1. Product must be listed in the CEC Appliance Efficiency Database. 2. Flow rate ≤ 1.5 GPM. 3. Must be permanently installed. 4. Installed per manufacturer specs.	15
	High-Efficiency Showerhead	1. Product must be listed in the CEC Appliance Efficiency Database. 2. Flow ≤ 2.0 GPM. 3. Installed per manufacturer specs.	15
	Hot Water Delivery System	System meets the definition of one of the following water delivery options: a. Dedicated Recirculation Line b. Whole House Manifold System c. Demand-initiated Recirculating System d. Core Plumbing System 2. Installed per manufacturer	15
Outdoor Water Efficiency	High-Efficiency Sprinkler Nozzle	1. Product must be on SoCal Water Smart Qualified Sprinkler Nozzle product list. 2. Installed per manufacturer specs.	10
	Weather-Based Irrigation	1. Product must be WaterSense Qualified. 2. Installed per manufacturer specs.	10
	Drip Irrigation	Product installed be installed in turf, garden, planter, or flower bed area. 2. Installed per manufacturer specs.	10
	Rainwater Catchment System	1. Sized to hold ≥ 50 gallons at one time. 2. Must be permanently installed. 3. Installed per manufacturer specs.	20
	Gray Water System	1. System must meet California Plumbing Code, Chapter 16A. Product must comply with local code and permitting requirements. 3. Eligible system types include: a. Single-Fixture b. Multi-Fixture Simple (≤ 250 GPD) c. Multi-Fixture Complex (> 250 GPD) 4. Installed per manufacturer specs.	20

PRODUCT CATEGORY	PRODUCT TYPE	ELIGIBILITY SPECIFICATIONS	MAXIMUM TERM (YEARS)
Outdoor Water Efficiency	Artificial Turf	1. Product must be water and air permeable. 2. Product must be non-toxic and lead free. 3. Product must be recyclable. 4. Product installation must carry ≥ 10 year warranty. 5. Installed per manufacturer specs. Product infill material must be one of the following: a. Acrylic Covered Sand b. Crumb Rubber c. Zeolite	10

Appendix 4. Natural Resources Defense Council Propose New Mechanisms for the 2016 third Party Programs

The following is an excerpt from NRDC's response to the Administrative Law Judge's Ruling re Comments on Phase II Workshop 3 (Statewide and Third Party Energy Efficiency Programs)," April 1, 2015[45].

> *4. What framework or process offers promise for obtaining higher levels of efficiency outcomes and/or with lower costs, so as to obtain improved portfolio metrics?*
>
> NRDC and TURN, via separate comments, provide framework and process improvement suggestions in the above respective portions of their comments and urge the Commission to also explore new *approaches* that offer promise for "obtaining higher levels of efficiency," potentially at lower cost. **Specifically, NRDC and TURN recommend that the Commission direct the Program Administrators (PAs) to propose new mechanisms for the 2016 third party programs that rely on meter-measured performance to yield greater savings in both the residential and commercial sectors.** Exploring ways to pay for savings based on performance and leveraging Advanced Metering Infrastructure (AMI) data is supported by many interested stakeholders -- as expressed at the Workshop 3 of this proceeding, in the comments of other parties such as SoCalREN[46] and others such as PG&E and CEEIC[47], as well as by the California Energy Commission's recently-released draft AB 758 Action Plan.
>
> NRDC and TURN understand that trillions in investment capital are needed to transition to an efficient, renewable, reliable, and affordable energy economy. Energy efficiency, a key distributed resource, is a critical component of this transition. However, energy efficiency currently falls significantly short of its economic potential[48].[49]The recent implementation of AMI in many locations is an important step toward driving investment in EE; however, while AMI data is available throughout most of California, PAs and implementers have not yet been able to leverage the data from this technology to scale energy savings through innovative efficiency program design. This smart meter investment is therefore not being used to its full potential and creative ways of scaling efficiency savings to save customers money are not being explored.
>
> New transaction structures that value "efficiency as energy" are needed to further displace the procurement of other energy resources and the associated costs of integration, and to enable investment by capital markets in energy efficiency resources. We recommend that PAs launch a set of residential and commercial third party pilots in 2016 that are based on AMI data and use innovative meter-measured performance strategies to capture greater savings by paying for savings as the difference between metered energy usage and adjusted baselines.
>
> This approach is intended to spur private sector innovation and investment by building a market for efficiency, creating transparent and real time accounting for savings using smart meter data, increasing quality installations by making contractors accountable to measured performance, and ultimately reducing program administration and evaluation costs by making the industry (and not just the program) responsible for performance risk. In addition, we support expanding current demonstration efforts to better understand the value of operations and maintenance in buildings where owners and facility managers are not pursuing such activities on their own.

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[45] NATURAL RESOURCES DEFENSE COUNCIL (NRDC) RESPONSE TO THE ADMINISTRATIVE LAW JUDGE'S RULING REGARDING COMMENTS ON PHASE II WORKSHOP 3. April 13, 2015. Lara Ettenson. Natural Resources Defense Council

[46] SoCalREN has consistently supported measured performance program design; see their Phase II Workshop 1 comments (April 6, 2015) as well as their comments on the 2015 potential and goals study draft result (April 10, 2015)

[47] PG&E, CEEIC and others will be expressing their support for these concepts in their comments on Phase II Workshop 3; others may be supportive as well be these comments have not been widely circulated with enough time for review.

[48] McKinsey & Company, Unlocking Energy Efficiency in the U.S. Economy, July 2009.

[49] The international investment banking firm Lazard recently published an analysis of the comparative costs of a wide range of resources, "Lazard's Levelized Cost of Energy Analysis - Version 8.0" Energy efficiency exceeded all others by a wide margin.

NRDC and TURN recommend that the Commission provide guidance in the forthcoming decision to pursue such activities and that the structure of these pilots and qualifications for third party implementers be developed by the PAs in close consultation with stakeholders through the engagement process (which includes CPUC staff) as described at Workshop 1 on March 9, 2015. The three pilots we envision include:

● A residential sector pilot based on the existing Home Upgrade program, but with savings paid to an aggregator of projects only when savings show up at the meter using the open-source CalTRACK / Open EE Meter system - described in section I below;[50]8

● A commercial sector pilot based on the Metered Energy Efficiency Transaction Structure ("MEETS"), or other similar methodology, that pays for performance - described by TURN in their comments; and

● A commercial sector pilot based on PG&E's existing Commercial Whole Building Demonstration project, which captures and measures operational and behavioral savings - brief description of this demonstration project described in section II below.

All of these pilots should be structured such that a performance standard is set by the PAs, and multiple third parties can qualify to provide savings from residential and commercial projects.

I. Residential Pay-for-Performance Pilot

While programs such as the Energy Upgrade California (EUC) Home Upgrade and Advanced Home Upgrade have shown that they can deliver substantial measured energy savings on a per-building basis[51], to date these programs have failed to reach the scale and broad penetration that is needed to meet ambitious policy goals going forward. While there have been many efforts to improve current programs and reduce barriers, including the adoption of the CalTRACK[52] process to allow additional software tools into the market, a more fundamental change is required to change the trajectory of residential efficiency in order to achieve California's climate and energy goals.

This proposed *Pay-for-Performance Residential Pilot* will test a model in which smart meter data is used to measure energy savings that can be aligned with incentives and paid for on delivery, making it possible to create accountability to results. Incentives will be paid to "aggregators," who are entities able to take responsibility for the performance of a portfolio of projects -- these could be finance providers (such as Property Assessed Clean Energy (PACE) providers), a large contractor, a coalition of contractors, or other entity. It is important that the payments are made on a portfolio of projects to ensure the statistical significance of the savings and to manage the performance risk, because while individual project performance can vary greatly depending on the idiosyncrasies of different homes, efficiency performance is more reliable on a portfolio basis.

By allowing the market players (contractors and aggregators of projects) to carry performance risk rather than relying on utility customer funds that are paid as rebates (often "up front," irrespective of performance), programs will likely be able to substantially reduce the percentage of program funds devoted to program specific administrative costs by increasing the overall yield of energy savings, and allowing industry to innovate the best way to package and deliver efficiency to the consumer. Aligning incentives with actual savings will reward business models that are profitable for industry, drive consumer demand, and achieve reliable energy savings.

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[50] NRDC would like to acknowledge that Matt Golden of Efficiency.com contributed substantially to this proposal.

[51] EUC Software Initiative analysis of PG&E Advanced Path EUC jobs, based on weather normalized pre vs. post usage data showed an average of 21% gas reductions on homes with heating loads and measures.

[52] The CalTRACK (http://www.caltrack.org/)/ Open EE Meter (http://www.openeemeter.org/) methodology was originally developed through the Advanced Energy Upgrade Software Initiative working group of the IOUs, CEC, and CPUC (http://www.caltrack.org/team.html) is now being developed as a BPI / ACCA joint ANSI Standard "Protocolfor Quantifying Energy Efficiency Savings in Residential Buildings."

In a Pay-for-Performance market model, the PA and regulators will be able a focus on protecting consumers, establishing the "weights and measures"[53] for integrated demand-side resources through the CalTRACK / Open EE Meter, and creating sound market structures that send the right price signals. **Rather than attempting to directly design the delivery of energy efficiency services through programs, PAs and regulators can influence outcomes but leave execution up to market players.** Higher energy savings yields become valuable and drive innovation and investment in projects that deliver such measurable savings. Energy efficiency can be transformed from a rebate incentive into a financial asset with long-term cash flow that can be funded through project finance -- the same mechanism we use to finance other energy infrastructure include power plants and the highly successful PPA agreements for solar.

Key elements of the residential pay-for-performance pilot

The purpose of this pilot is to test a pay-for-performance approach to energy efficiency procurement, leveraging the open-source CalTRACK / Open EE Meter system that was developed by order of the CPUC by all four IOUs and in cooperation with the CEC.

● PAs that elect to offer this pilot[54] would procure savings measured as the difference between metered usage and adjusted baselines from third parties who manage portfolios of residential projects, completed within two years of the pilot launch.

● Similar to the existing EUC Home Upgrade program rules, this third party pilot would pay for savings above the actual historical usage baseline. The difference is, rather than paying on prediction and discrete measures and sometimes on an individual building basis, this pilot would test a model that pays based on measured savings as they are delivered for a portfolio of projects that achieve a confidence interval better than 95%.

● The third party aggregators (e.g., finance providers, contractors, etc.) would then sell this proposition to homeowners (or use contractors or other implementers to sell the proposal on their behalf).

● Homeowners would agree to the upgrade, and the contractors would be responsible for quality installations that ensure the predicted savings are achieved.

● The aggregator then bundles the portfolio of residential projects and the PA then pays for performance based weather-normalized savings over a period of three years post upgrade.

● The CalTRACK Open EE Meter would use currently available interval meter data to quantify the savings achieved by the installation of energy efficiency projects. Changes in energy usage will be documented for a pre-post period to be detailed in the pilot design.

● Savings would be calculated and purchased by the PA on a portfolio basis upon delivery, as opposed to an individual project basis. This allows aggregators and contractors to manage their performance risk and the unavoidable building-level variability of efficiency measures, while enabling the procurement of measured and verified energy efficiency resources.

● This savings value would be the basis for the incentive payments. PAs would pay for savings documented by the CalTRACK Open EE Meter on a bi-annual basis to the aggregator of savings. The first two performance payments would be paid based on estimated expected performance, using metrics from the existing Home Upgrade program to provide a comparable data set for similar measures, with a true-up to actual measured savings done by adjusting payments in the subsequent four years. Projects would not utilize any other consumer utility rebates.

[53] Link: http://www.nist.gov/pml/wmd/

[54] One or more PAs could choose to participate in this pilot, but ideally a single application template would be used for statewide consistency when feasible.

● The price paid for savings, to be determined during the pilot planning process, should be based on the IOU's avoided marginal cost of energy procurement and the current program cost of savings (including program administration and incentives) being delivered through the Home Upgrade program.

● The price per kWh and therm should be lower than current total program costs per savings unit, including administration costs and incentives, since the aggregators will be taking on the bulk of current program overhead costs and a value per unit of energy will be established less than the current total cost structure.

While design details should be determined by the PAs and experts through the stakeholder engagement process, we recommend that any pilot be sufficiently funded to yield reliable data from which a decision could be made to expand the program after pilot completion (e.g., $20 to $30 million for all PAs).[55] The budget would cover necessary implementation costs of the pilot over two years and for the payments on performance for three years after the upgrade is completed.

The PAs should select multiple third parties with which to contract to test this model in the market, and should aim to strike a balance between fostering the engagement of multiple third parties in this program, while also providing enough certainty of deal flow to attract aggregators with the potential to scale. Eventually this market should be open to all parties that can aggregate portfolios of sufficient size to achieve an allowable confidence interval on savings, but this first pilot should be kept as simple as possible while systems are established. Evaluation of this pilot should be timely and geared toward informing the next iteration of the program, leveraging the "evaluation team" concept put forth by NRDC in comments on Workshop 1.[56]

If successful, subsequent versions of this program may include allowing aggregators to bid savings into a competitive markets, differentiation in procurement so that higher levels of incentive can be given to reward deeper total savings or innovation and learning that contribute to market transformation, integration of demand and location variables into how savings are valued, and the implementation of a transparent, forward-looking pre-post market assessments to establish a baseline that includes societal trends in energy use.[57]

Benefits of the residential pay-for-performance pilot

1. **Allowing PAs to pay for actual savings at lower total cost.** By purchasing savings measured as the difference between metered usage and adjusted baselines, the PAs can overcome potential performance risk by only paying for what actually occurs. This should also lower the cost of delivered energy savings.

2. **Aligning incentives with results to encourage savings.** By aligning revenue and profitability with actual performance at the meter, market players that deliver solutions that customers want, while also delivering enough real savings to make a profit, will be rewarded. Delivering real energy efficiency becomes a source of profit, driving the market toward improving efficiency outcomes.

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[55] Currently, the EUC Home Upgrade program pays roughly $2,000 on average in incentives to the customer, not including program overhead and marketing costs. Payments would vary based on actual savings over the three-year period post retrofit, but if you assume a rough average total cost of $2,000 per home, the pilot could serve approximately 10,000 to 15,000 customers statewide during the pilot for the amount suggested. This would not include the program administration and EM&V costs.

[56] April 6, 2015 "Natural Resources Defense Council (NRDC) Response to Administrative Law Judge's Ruling Regarding Comments on Phase II Workshop I," p.45

[57] See Regional Technical Forum "Guidelines for RTF Savings Estimation Methods (8-15-2012) Discussion Mark-up," August 21, 2012. Accessed on October 24, 2012 at: http://www.nwcouncil.org/energy/rtf/subcommittees/Guidelines/ p.2 and "Reply Comments of the NRDC on Administrative Law Judge's Ruling Seeking Post-workshop Comments on Demand-side Cost-effectiveness Issues." October 25, 2012 (p.4-6)

3. **Accelerating already growing business models such as residential PACE while encouraging deeper savings.** While this third party procurement should be open to all qualified third parties, the prospect of collaboration between PAs and the rapidly scaling residential PACE providers could yield substantially more participants and savings. In 2014, residential PACE in California drove approximately $250 million in energy efficiency projects, mostly independent of program incentives. However, the current PACE providers lack an incentive to focus on energy efficiency. Allowing PAs to procure the savings from PACE-financed projects would align the interests of PACE providers with the delivery of substantial energy savings. This in turn would support the acceleration of PACE and enable system planners to incorporate these projects into load forecasting and grid management activities.

4. **Reducing program administration costs.** By paying for performance and moving performance risk from utility bill payers to private market actors, this program may also be able to reduce program marketing and administration costs, as many functions currently provided by the program will become a responsibility of market players.

5. **Lowering M&V costs.** By providing a verified and transparent system to track savings, the cost of M&V for PAs and the Commission may be decreased by relying on an automated system leveraging smart meter data.

6. **Building a dataset on performance.** This pilot will develop a rich dataset including location and demand reductions that can be used in future procurements to align the value of savings with a more integrated demand-side management strategy. The CalTRACK Open EE Meter is 100% open-source and built on a standard data platform that includes Green Button integration, HP-XML, and the DOE Standard Energy Efficiency Data Platform. This data platform aligns with recommendations put forward in the California Energy Commission's AB 758 Action Plan.

Table 6. Comparison of EM&V methods with pay-for-performance

Activity	Traditional Program EM&V	EE Meter Enabled Measurement
Field Investigations	1. Typically based on sample designed to provide random selection of participants.	1. Based on meter data providing real time performance metrics.
	2. Field investigations focus on collecting uniform datasets for subsequent analysis.	2. Market assessments can identify the dynamic or "naturally occurring" savings and apply results to future procurements (this should be done in future pay-for-performance programs).
Analysis	1. As data collection is nearing completion, analysis begins to compare actual performance to deemed ex-ante performance estimates.	1. Ongoing data stream continuously analyzed to identify anomalies in site and project portfolio level performance.
Reporting	1. Reporting generally occurs at the end of program cycles.	1. Reporting is frequent and intended to define various performance characteristics throughout the program cycle.

2. Compare calculated ex-post performance to ex-ante estimates. 3. Present historic perspective on program performance. 4. Provide comparison of performance from code to measure. 5. System planners estimate full grid impact using deemed savings estimates using to code baseline conditions.	a. Compared to EE meter calculated performance to ex-ante estimate. b. Assess individual contractor performance in near real time. c. Provide data on field-based savings, including delta from existing baseline consumption to installed measure. d. System planners provided actual data showing with full grid impact based on customer meter data. e. Inform corrective actions during the program cycle. f. Long term calibration of incentives based on yield trends.

History of Energy Upgrade California Software Initiative / CalTRACK

CalTRACK was created by a CPUC decision 12-05-015[58]16, Ordering Paragraph 61 of Decision 12-05-015 and was headed by PG&E as a representative of all four investor-owned utilities: "We direct Commission Staff and the IOUs to work collaboratively with the California Energy Commission and other Energy Upgrade California stakeholders to identify approaches to adequately broaden allowable software under Energy Upgrade California while containing costs required for needed Commission Staff Reviews."

The solution developed consisted of two stages, complete information at www.CalTRACK.org:

Stage 1: CalTEST – California Test for Energy Software Tools (COMPLETE)

● Software Test against set of typical EUC Home Upgrade Homes

● HPXML 2.0 (output and program intake)

● 5 Tools now in market

Stage 2: CalTRACK (Open EE Meter) – Data-Driven Tracking and Feedback System

● Jobs tracked by software version

● Savings predictions compared to weather normalized post retrofit billing data

● Adjustment factor to calibrate predictions on an ongoing basis

● Program / Regulator / Contractor transparency

The Software Initiative was led by PG&E with the participation and co-funding of all four Investor Owned Utilities and active participation from the CEC and CPUC.

[58] 16 http://www.calmac.org/events/Decision_12-05-15.pdf

II. Commercial Whole Building Pay-for-Performance Pilot

NRDC also recommends expanding PG&E's Commercial Whole Building Performance Demonstration to further test the opportunities to ramp up efficiency from operations and maintenance activities that are not currently being achieved. This demonstration entails the determination of predictive energy use baseline models for participating buildings using new, innovative software tools. These models establish whole building level energy use baselines against which realized energy savings from retrofit and retro-commissioning (RCx) measure impacts are estimated. Final savings estimates are based on actual performance as determined through modeled billing analysis and calibrated simulation. The energy savings estimates would be normalized with respect to weather effects with estimates supplemented with data collected on the operating conditions of the participating buildings.

The demonstration was designed to provide a testing ground for best practice "Whole Building Approach" program delivery methods that could be scaled further within the next program cycle. While we understand some modifications are in play for this program, NRDC strongly supports testing this approach on a wider scale to determine whether or not programs such as these could scale up low-cost operations and maintenance savings at greater scale and on a quicker timeframe than currently is occurring.