2013 California Energy Efficiency Potential and Goals Study

Revised Draft Report

Prepared for:
California Public Utilities Commission

Navigant Consulting, Inc.
1990 North California Blvd.
Suite 700
Walnut Creek CA, 94596

925 930 2700
www.navigant.com

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In collaboration with:

Heschong Mahone Group

sound data management

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List of Acronyms

The following is a list of acronyms used in this report and their meanings.

Acronym or Abbreviation	Meaning
ARB	Air Resources Board
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
C&S	Codes and Standards
CALMAC	California Measurement Advisory Council
CARB	California Air Resources Board
CEC	California Energy Commission
CFL	Compact Fluorescent Lamp
CO_2e	Carbon Dioxide Equivalent
CPUC	California Public Utilities Commission
D.	Decision
DAWG	Demand Analysis Working Group
DEER	Database for Energy Efficient Resources
DMQC	Data Management and Quality Control
DSM	Demand Side Management
EE	Energy Efficiency
ET	Emerging Technology
EUC	Energy Upgrade California
EUL	Effective Useful Life
FEA	Frozen Ex Ante
GHG	Greenhouse Gas
GWh	Gigawatt-hour
HVAC	Heating, Ventilation, and Air-Conditioning
iDR	Implied Discount Rates
iDR_F	Implied Discount Rates with Financing
iDR_{NF}	Implied Discount Rates with No Financing
IEPR	Integrated Energy Policy Report
IOU	Investor-Owned Utility
kW	Kilowatt

Acronym or Abbreviation	Meaning
kWh	Kilowatt-hour
LTPP	Long-Term Procurement Plan
ME&O	Marketing, Education, and Outreach
MF	Multi-family
MMT	Million Metric Tons
MW	Megawatt
MWh	Megawatt-hour
NTG	Net to Gross
NOMAD	Naturally Occurring Market Adoption
NR	Non-Residential
OBF	On-Bill Financing
PG&E	Pacific Gas and Electric
PG	Potential and Goals
R.	Rulemaking
RRIM	Risk Reward Incentive Mechanism
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SF	Single Family
SoCalGas	Southern California Gas
SPTdb	Standard Program Tracking Database
TRC	Total Resource Cost
UEC	Unit Energy Consumption
ZNE	Zero Net Energy

Executive Summary

The Navigant Consulting, Inc. team (the Navigant team) developed the 2013 Potential and Goals Study to analyze energy and demand savings potential in the service territories of four of California's investor-owned utilities (IOUs) during the post-2014 energy efficiency (EE) portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SoCalGas). The primary product of the 2013 Potential and Goals Study is the Potential and Goals (PG) Model, which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and Policy Drivers.

ES.1 The Purpose of this Study

The *Analysis to Update Energy Efficiency Potential and Goals for 2013 and Beyond* is a statewide assessment of energy efficiency potential,[1] which considers key policy mechanisms that the State is employing to drive the energy efficiency market. It serves several important roles in the state regulatory framework:

1. To provide guidance for the utilities' 2015 energy efficiency portfolios[2]
2. To update the forecast for energy procurement planning[3]
3. To inform strategic contributions to California's greenhouse gas reduction targets[4]
4. To inform the development of benchmarks for Efficiency Savings and Performance Incentive[5]

The 2013 Potential and Goals Study updates and expands upon Track 1 of the Analysis (referred to as the "2011 Potential Study") by addressing the following research questions:

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[1] Navigant. May 8, 2012. Analysis to Update Energy Efficiency Potential and Targets for 2013 and Beyond, Track 1 Statewide Investor Owned Utility Energy Efficiency Potential Study. Prepared for California Public Utilities Commission (CPUC).

[2] The energy efficiency goals were first adopted in Decision D.04-06-090 to set the benchmark that the IOU energy efficiency programs were expected to achieve. The goal-setting process set a framework for the program planning cycle, determining the targets for utility energy efficiency program portfolio performance.

[3] As the Energy Action Plan established energy efficiency as first in the loading order, the state must adopt a long-term benchmark that can be used in utility energy procurement planning. The IOUs' energy efficiency goals adopted from this study will be incorporated into the California Energy Commission's (CEC) *Integrated Energy Policy Report* (IEPR), which establishes the demand forecast for long-term procurement planning. This forecast is an input into the CPUC's Long Term Procurement Planning proceeding, which determines the generation resources that energy efficiency is expected to offset in order to minimize costs to ratepayers.

[4] The California Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32) relies on intensified energy efficiency efforts across California. The California Air Resources Board's Scoping Plan for AB 32 establishes a statewide energy efficiency target for the year 2020.

[5] The Efficiency Savings and Performance Incentive is considered in R.12-01-005.and can be found at http://delaps1.cpuc.ca.gov/CPUCProceedingLookup/f?p=401:56:809728160393201::NO:RP,57,RIR:P5_PROCEEDING_SELECT:R1201005.

- What additional incremental potential can be quantified from the policy initiatives implemented from the California Energy Efficiency Strategic Plan, and by other statewide policies such as Assembly Bill (AB) 758?
- What additional quantifiable potential may be available from emerging technologies that has not been included in past portfolios or in the 2011 Potential Study?
- How can the methodology to quantify EE potential for the agricultural, industrial, mining, and street-lighting (AIMS) sectors be refined to use existing market data?

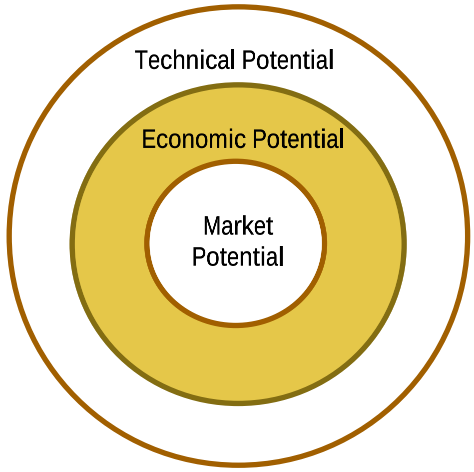
The Navigant team calculated potential energy efficiency savings for the 2013 Potential Study using a similar modeling methodology as the previous potential studies used to establish goals starting in 2004, and updated in 2008 and 2011. This methodology uses a bottom-up approach to identify and quantify the savings of all energy efficiency "measures", which are any possible change that can be made to a building, equipment or process that could save energy. The PG Model calculates the possible energy savings available above a baseline that is determined by a regulatory (i.e., code or standard) or market driver.

Consistent with the 2011 Potential Study, the 2013 Potential and Goals Study forecasts energy efficiency potential on three levels, as illustrated in Figure ES-1.

1. **Technical Potential Analysis:** Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency were taken, including retrofit measures, replace-on-burnout measures, and new construction measures.
2. **Economic Potential Analysis:** Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential available when limited to only cost-effective measures.[6] All components of economic potential are a subset of technical potential. The technical and economic potential represent the total energy savings available each year that are above the baseline of the Title 20/24 codes and federal appliance standards.
3. **Market Potential Analysis:** The final output of the potential study is a market potential analysis, which calculates the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as "maximum achievable potential." Market potential is used to establish the utilities' energy efficiency goals, as determined by the California Public Utilities Commission (CPUC).

[6] The default scenario for this study includes all non-emerging technologies with a total resource cost (TRC) test of 0.85 or greater; emerging technologies are included if they meet a TRC of 0.75 in a given year and achieve the TRC for non-emerging technologies (0.85) within ten years of market introduction.

Figure ES-1. Diagram of Types of Energy Efficiency Potential



Source: Navigant team, 2011 Potential Study

Market potential can be quantified by three different approaches, which each serve separate needs and provide necessary perspectives.

1. **Incremental savings** represent the annual energy and demand savings achieved by the set of programs and measures **in the first year** that the measure is implemented. It does not consider the additional savings that the measure will produce over the life of the equipment. A view of incremental savings is necessary in order to understand what additional savings an individual year of EE programs will produce. This has been the basis for IOU program goals.
2. **Cumulative savings** represent the total savings from energy efficiency program efforts from measures installed since 2006[7] and including the current program year, and are still active in the current year. It includes the decay of savings as measures reach the end of their useful lives. Cumulative savings also account for the timing effects of codes and standards that become effective after measure installation. This view is necessary for demand forecast, but creates challenges in accounting for IOU program goals.
3. **Life-cycle savings** refer to the expected trajectory of savings from an energy efficiency measure (or portfolio of measures) over the estimated useful life of the measure(s), taking account of any natural decay or persistence in performance over time. Whereas cumulative savings are a backward look at all measures installed in the past that are producing current savings, life-cycle savings accounts for all future savings from measures installed in the current year. Life-cycle

[7] Part of the calibration process for any potential model involves reviewing historic program data to assess various market characteristics such as measure saturation, incentive levels, and adoption patterns. This model is calibrated on program reported data from 2006 through 2011, and savings estimates for the 2013-2014 program cycle. As such, 2006 is the beginning of the calibration period.

savings is used in the cost-effectiveness evaluations and may be an appropriate basis for IOU program goals.

A large number of variables drive the calculation of market potential. These include assumptions about the manner in which efficient products and services are marketed and delivered, the level of customer awareness of energy efficiency, and customer willingness to install efficient equipment or operate equipment in ways that are more efficient. The Navigant team used the best available current market knowledge and followed these guidelines in developing the recommended market potential:

1. Provide a view of market potential where data sources and calculation methods are transparent and clearly documented.
2. Avoid assumptions and model design decision that would establish goals and targets that are aspirational, but for which the technologies or market mechanisms to attain these goals may not yet be clearly defined.

With these precepts in mind, the Navigant team considers that the market potential presented in this study is a viable target for energy efficiency to which load forecasters, system planners, and resource procurement specialists could agree. However, this study may not capture the upper bound on the total amount of energy efficiency that can be achieved. There may be additional energy savings to capture, particularly from systems efficiency and behavior change, which could not be reliably quantified based on past evaluation results available at the time of this study.

ES.2 Findings

This section discusses two high-level findings of the results of the analysis. Section 4 includes a more detailed set of overarching findings.

ES.2.1 Technical and economic potential increased from the 2011 Potential Study as a result of the new measures and methodologies included in the 2013 Potential and Goals Study

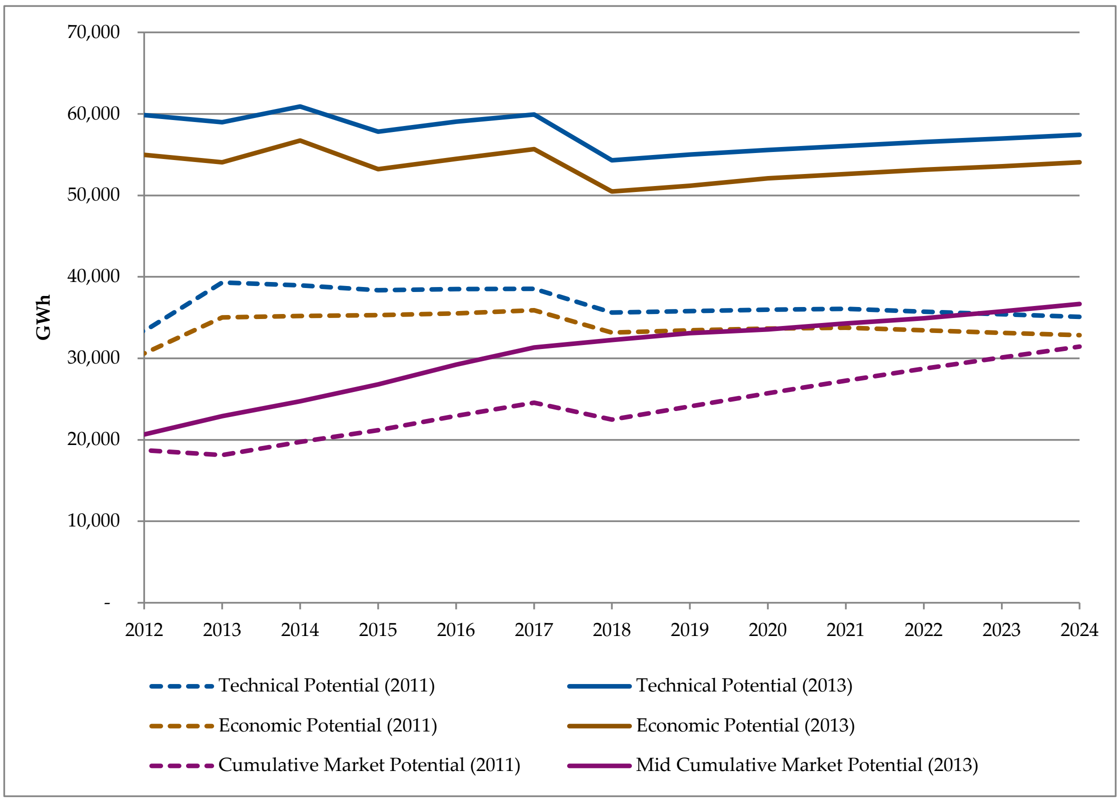
Technical and economic potential are about 50 percent higher than reported in the 2011 Potential Study, as seen in Figure ES-2. This increase is primarily driven by a change in the approach to modeling technical and economic potential. The approach to modeling technical potential used in the 2013 Potential and Goals Study demonstrates a best-case scenario for technical potential given what is known about the market today. Due to barriers such as payback considerations or split incentives, it is unlikely that all customers would replace baseline equipment with the most efficient technology in a competition group, but technical potential is intended to represent the savings possible if all technically available changes were made. This change was made to expand our view of potential from emerging technologies.

The 2013 Potential and Goals Study defines technical potential by the most efficient equipment option within a competition group. The technical and economic potential in the 2011 Potential Study was calculated based on the efficiency level of the measure that was most commonly adopted in IOU programs. For example, the 2011 model would assess technical potential for residential heating, ventilation, and air-conditioning (HVAC) based on the average efficiency being installed through IOU programs, such as a Seasonal Energy Efficiency Ratio (SEER) 15 HVAC unit. In comparison, the 2013

Study calculates the potential for all residential HVAC units to be replaced by SEER 22 machines, the most efficient equipment currently visible on the market.

The addition of the mining and street-lighting sectors to the 2013 Potential and Goals Study also added approximately 1,800 gigawatt-hours (GWh) to the technical and economic potential. These sectors were not included in the 2011 report.

Figure ES-2. Comparison of Technical, Economic, and Cumulative Market Potential in the 2011 and 2013 Studies



Source: PG model release August 2013

Note: 2013 Cumulative Potential includes behavioral savings and C&S savings to make a consistent comparison with the 2011 results.

ES.2.2 Gap between economic and cumulative market potential indicates that there are additional savings opportunities not being captured by current adoption patterns.

The trajectory of cumulative market potential toward economic potential in Figure ES-2 indicates the degree to which the market, using IOU program incentives and financing, is expected to capture the available potential of cost-effective energy efficiency.

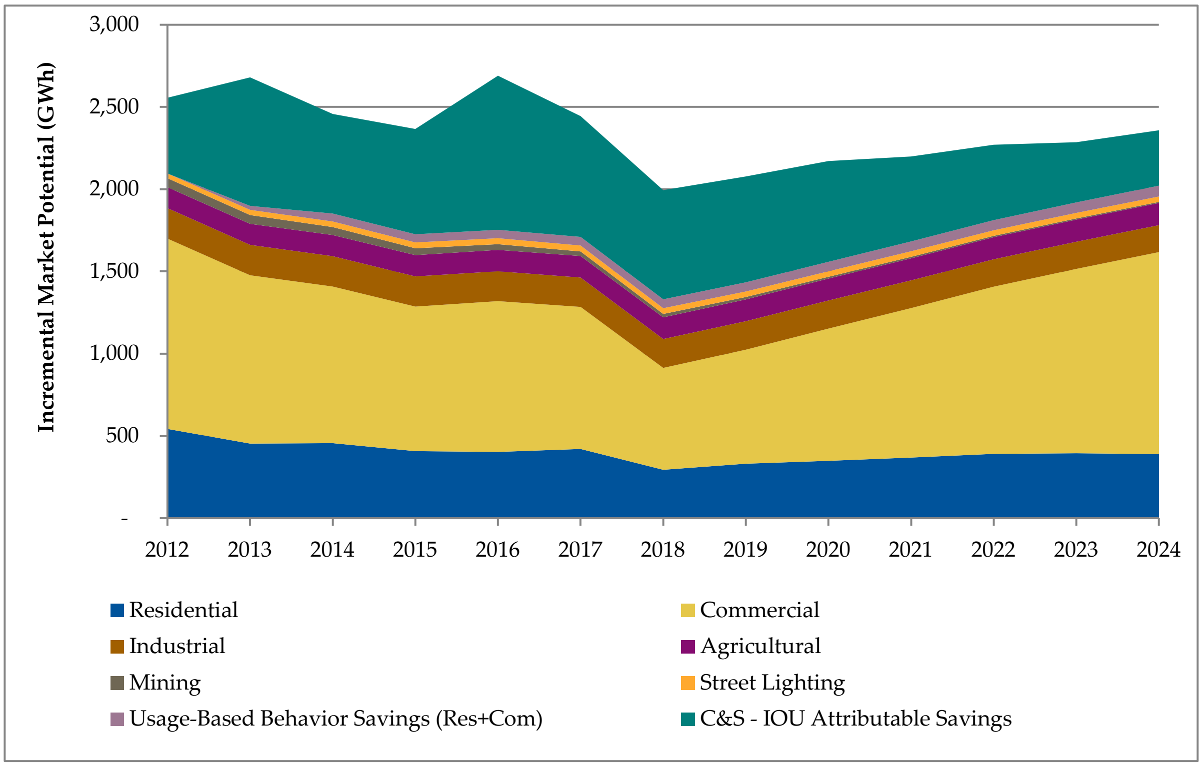
The cumulative market potential shown in Figure ES-2 includes voluntary adoption of energy efficient measures due to rebates and behavior-based initiatives from the 2011 and 2013 models. This definition of cumulative market potential does not include savings from codes and standards (C&S) that are attributable to IOUs. In addition, cumulative market potential excludes savings from energy efficiency financing programs because those programs are still in the pilot phase. Estimates of savings from financing programs will be better informed by more evaluation data and by more information about the structure of the programs in future program cycles. Considering savings due to financing separately from the cumulative market potential shown in Figure ES-2 enables policy makers and stakeholders to explicitly consider the effects of these factors on the estimated savings; Section 4.3 includes a discussion about the additional potential that could be realized by financing programs.

As shown in Figure ES-2, cumulative market potential in the base forecast achieves approximately 64 percent of the revised technical potential by 2024. This market potential estimate in 2024 is roughly 16 percent higher than the 2011 model estimate due to two initiatives that expanded adoption rates:

1. An expanded set of emerging technologies for which market adoption is expected to be moderately aggressive
2. An incremental gain in the adoption of energy efficiency through whole-building project delivery, including both retrofit and zero net energy new construction initiatives

At the sector level, the commercial sector will continue to drive savings for IOU programs as shown in Figure ES-3. The anticipation of continued higher market barriers for residential sector adoption of energy efficiency limits the adoption of emerging technologies in the residential sector, limiting its contribution as codes and standards increase baselines. The industrial sector incremental market potential is about the same as reported in the 2011 Potential Study, whereas agricultural incremental market potential increased by nearly 40 percent based on refinements in the forecasting methodology and improved data. Mining and street lighting represent significant cumulative market potential as a fraction of their sector demand forecasted by the California Energy Commission (CEC) (20 percent and 45 percent, respectively, in 2024).

Figure ES-3. Incremental Annual Market Potential by Sector



Source: PG model release August 2013

ES.3 Goals and Targets Scenarios

As discussed in greater detail in section 1, Methodology for the Residential and Commercial Sectors, the PG model can run numerous scenarios; however, the default scenario presented in this report is based on population, consumption, and economic inputs defined in the mid-case of the California Energy Commission's 2012 Integrated Energy Policy Report (IEPR). For the purposes of setting IOU goals, Navigant team developed two alternate scenarios to estimate potential in the PG Model: The High Energy Efficiency Penetration and the Low Energy Efficiency Penetration scenarios. These scenarios present a range of possible results based on the population, consumption, and economic inputs defined in the high and low energy demand forecasts in the 2012 IEPR, and also different assumptions for a set of variables that either have uncertainty associated with them or that the CPUC can influence through policy making. Table ES-1 includes a description of the variables for which the assumed values change during scenario analysis.

The PG model is also used to forecast energy efficiency savings in the 2013 IEPR demand forecast. The Additional Achievable Energy Efficiency scenarios are further discussed on page 76.

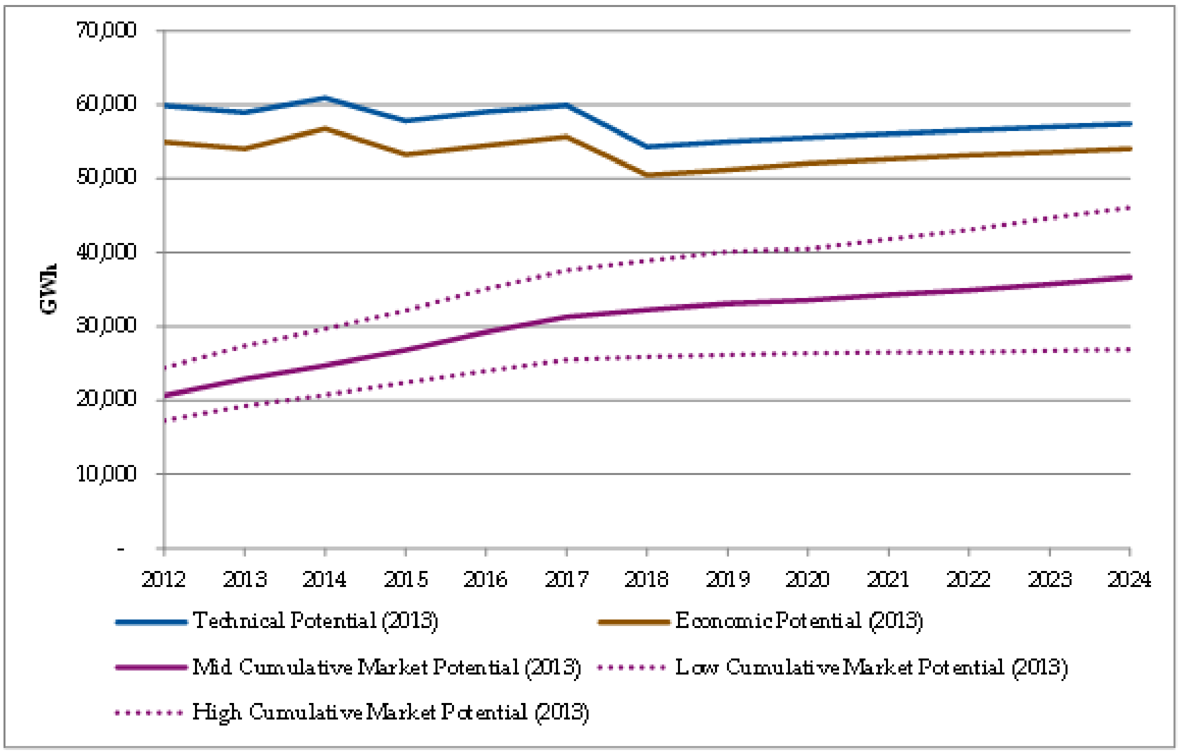
Table ES-1. Definition of Variables Used in Scenario Analysis

Scenario Element	Definition
Incentive Level	The incentive level refers to the percent of incremental cost that is covered by IOU program rebates.
Measures Cost Adjustment	The incremental costs for efficient technologies are from DEER 2008. Due to their vintage, the multiplier varies incremental costs across all technologies to account for changes over time.
Implied Discount Rate	The implied discount rate is the effective discount rate that consumers apply when making a purchase decision; it is the amount the customer is willing to pay for an EE investment, given all factors in the consumer's decision.
Marketing, Education and Outreach Effect	The marketing, education, and outreach (ME&O) effect moves customers from the unaware group to the aware group.
TRC Threshold	The TRC Threshold element varies the cost-benefit threshold that general measures must meet.
Avoided Costs	The avoided costs are the monetary benefit of energy and demand savings for a specific EE measure.
Measure Density Adjustment	Measure densities refer to the baseline and efficient measure densities. By modifying one of these for a given measure, the other is automatically updated in order to ensure that the sum of baseline and efficient measure densities is one.
Measure UES Adjustment	UES are less certain for ETs. The multiplier allows the user to examine the effects of varying the calculated UES for ETs.
Retail Price Forecast	The retail rates are the projected energy rates to the ratepayer.
Word-of-Mouth Effect	The word-of-mouth effect represents the influence of adopters (or other aware end users) on the unaware population by informing them of efficient technologies and their attributes.
Building Stock Forecast	The building stocks forecast is based on the expected development of each sector.
ET TRC Threshold	The ET TRC Threshold varies the cost-benefit threshold that emerging technology measures must meet.
C&S Scenario Name	The C&S Scenario Name refers to the types of C&S included in each scenario.
Note: The PG model allows the user to adjust the value of any one or all of these user inputs. The values used for each of these scenario elements in each scenario can be found in Section 3.	

Source: Navigant team analysis, 2013.

The Mid-Energy Efficiency Penetration scenario is intended to reflect the potential under business-as-usual circumstances. The incentive level, Total Resource Cost (TRC) threshold, avoided costs, measure-level data, and other variables use data that are consistent with current policies and program designs and widely accepted data sources. The Low and High Energy Efficiency Penetration scenarios adjust the inputs to reflect potential in the event that those underlying assumptions change. Figure ES-4 captures the results of these three scenario analyses for all sectors and all IOUs.

Figure ES-4. Results of Scenario Analysis



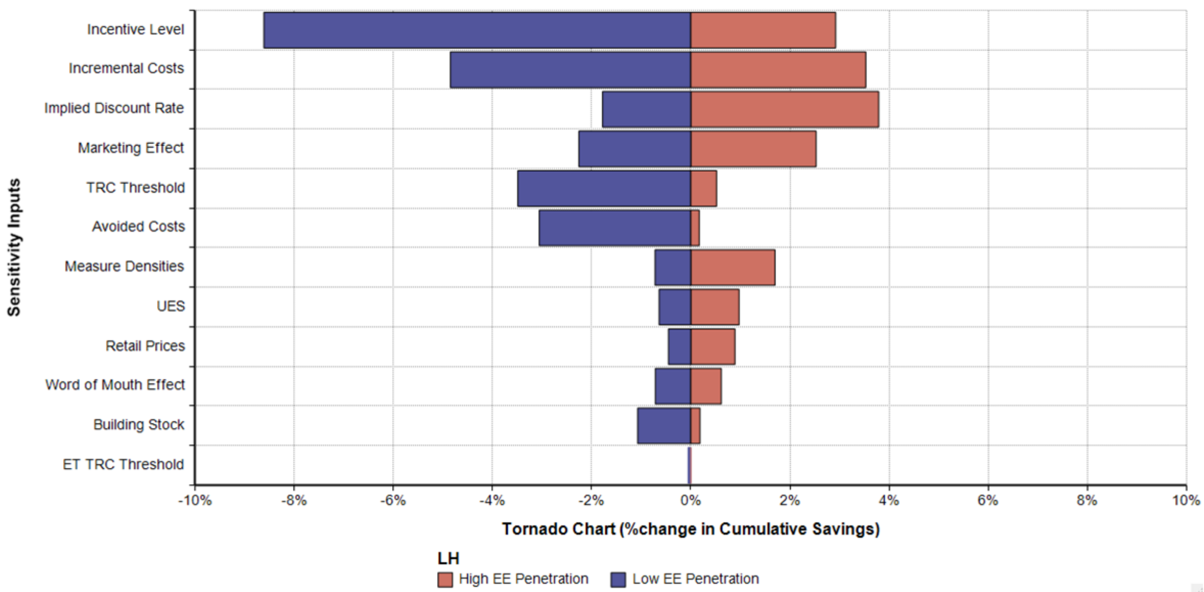
Source: PG model release August 2013

Note: This chart shows the High, Mid, and Low scenarios for the cumulative market potential; technical and economic potential are also adjusted in the High and Low scenarios, but those adjustments are omitted from this graph for simplicity.

In the case of the High Energy Efficiency Penetration scenario, the values for the variables are adjusted to consider a more optimistic future, one in which incentive levels and avoided costs are higher and the financial attractiveness of measures is better (in addition to other changes). The Low Energy Efficiency Penetration scenario includes assumptions that make investment in energy efficiency less favorable. The High Energy Efficiency Penetration scenario represents approximately a 25 percent increase while the Low Energy Efficiency Penetration scenario represents roughly a 25 percent decrease in cumulative market potential by 2024 relative to the Mid-Energy Efficiency Penetration scenario.

Figure ES-5 shows the relative importance of several model inputs on the range of market potential from the scenarios presented in Figure ES-4. This "tornado chart" was developed by varying one input assumption at a time, leaving the values of all other variables consistent with those in the Mid-Energy Efficiency Penetration scenario. The x-axis in the tornado chart shows the percent change in cumulative market potential in a specific year caused by changing the value of that single variable from the Mid to the High scenario (in red) or the Mid to the Low scenario (in purple). The variables with the bigger bars have a more significant impact on the results of the analysis.

Figure ES-5. Tornado Chart Showing Model Sensitivities to Changes in Key Variables



Note: This chart shows results for the Commercial sector; results in the Residential sector are similar.
Source: PG model release August 2013

The model shows that two types of variables have significant effects on the potential for energy efficiency:

1. **Technical inputs.** The accuracy of technical inputs is out of the control of policy makers, except to the extent that policy makers dedicate additional resources to studies that improve the accuracy of these values. Examples of technical inputs include incremental cost, avoided costs, and measure density.[8] The Navigant team used well-vetted sources (e.g., Database for Energy Efficiency Resources [DEER] 2008 and 2011, Commercial End Use Study, and Residential Appliance Saturation Study) to determine appropriate values for these, but future values may not align with these historical values.

[8] Historically, DEER updates have focused more resources on energy savings calculations than on incremental costs; consequently, the incremental cost data may be outdated. Avoided costs may change as the key inputs change. The studies that provide measure density data are dated; for example, the Commercial End-Use Survey was released more than seven years ago.

2. **Policy variables.** Policy makers can affect the value of other variables (e.g., TRC threshold, incentive level). The two policy variables that have the most impact on results are as follows:
    a. **Incentive level.** The Low Energy Efficiency Penetration scenario includes an incentive for 25 percent of incremental cost for all measures. The High Energy Efficiency Penetration scenario considers an incentive structure in which the incentives vary by stage of market adoption. Rebates for measures with up to 5 percent saturation are at 100 percent of incremental cost; for measures with 5 to 25 percent saturation are at 90 percent of incremental cost; for measures with 25 to 75 percent saturation are at 75 percent of incremental cost; for measures with more than 75 percent saturation are at 50 percent.
    b. **TRC threshold.** The Low Energy Efficiency Penetration scenario assumes a TRC threshold of 0.75, compared to 0.85 in the Mid-Energy Efficiency Penetration scenario and 1.0 in the High Energy Efficiency Penetration scenario. All non-emerging technology measures must pass this threshold in order to be eligible for adoption.

The values provided in the high and low scenarios provide a reasonable range of cumulative energy efficiency potential; however, the likelihood that the inputs that define the high and low scenario would align over the ten-year forecast horizon is doubtful. As such, the Navigant team recommends that the values from the mid scenario be considered as the basis for the IOU service territory goals for the portfolio beginning in 2015. Table ES-3, Table ES-4, and Table ES-5 provide the mid-case model outputs for annual incremental market potential for energy and demand for California's24 IOUs. The Navigant team considers these estimates a viable baseline target for energy efficiency to which program planners, load forecasters, system planners, and resource procurement specialists could agree. This is not, however, intended to define the upper bound on the total amount of energy efficiency that can be achieved during upcoming portfolio cycles. As noted in the discussion on the objectives for this study, that will be determined as the market for innovative products and services continues to evolve.

As discussed earlier, the potential model informs many different types of objectives, each with a different technical or temporal requirement. For example, the study serves to inform annual goals for near-term IOU portfolio goals, but also to provide support for system planners considering out-year planning decisions. The IEPR demand forecast depends on net estimates, while IOU goals setting is based on gross impacts. In addition to the IOU goals, Table ES-2 provides a summary of what types of potential model outputs are most appropriate for the various planning activities supported by this study. The scenario definitions for the IEPR demand forecast are discussed in section 2.3.5; while some output definitions remain to be determined at the time this report is being published.

Table ES-2. Recommended Potential Model Usage

Electric Goals	IOU Goals	LTPP	CAISO	CEC/IEPR
Annual energy and demand savings				
Model Scenario	Mid Case	TBD	TBD	High / Mid / Low
IOU Rebate/Finance Programs	Gross	TBD	Net	Net
Codes and Standards	Net IOU Attributable	TBD	Total Net IOU Service Territory	Total Net IOU Service Territory
Behavioral Initiatives	Gross	NA	NA	NA

Source: Navigant team analysis, 2013.

Table ES-3. Recommended IOU Baseline Program Energy (GWh) Target Inputs

IOU	PG&E		SCE		SDG&E		Total		
Source & Year	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	Total
2013	876	345	811	356	212	81	1,899	781	2,680
2014	872	267	779	276	201	63	1,852	606	2,458
2015	773	283	755	292	198	66	1,726	640	2,366
2016	778	414	780	427	195	97	1,753	937	2,690
2017	772	324	752	334	186	76	1,710	734	2,445
2018	610	293	583	302	138	69	1,331	664	1,994
2019	645	284	632	293	158	66	1,434	644	2,078
2020	696	270	693	279	169	63	1,559	613	2,171
2021	747	228	751	235	184	53	1,683	517	2,199
2022	811	202	793	209	208	47	1,812	458	2,271
2023	853	162	853	167	214	38	1,920	366	2,286
2024	897	149	902	153	223	35	2,022	337	2,359

Source: PG model release August 2013

Table ES-4. Recommended IOU Baseline Program Demand (MW) Target Inputs

IOU	PG&E		SCE		SDG&E		Total		
Source & Year	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	Total
2013	170	40	132	41	39	9	341	91	432
2014	177	37	133	38	38	9	348	84	432
2015	119	44	121	46	33	10	273	100	373
2016	121	85	127	87	33	20	281	192	473
2017	126	56	125	58	32	13	283	127	410
2018	104	54	103	56	26	13	233	123	356
2019	111	54	113	55	29	13	254	122	375
2020	122	53	125	54	31	12	278	119	397
2021	132	48	137	50	34	11	302	109	412
2022	145	46	147	47	38	11	329	103	433
2023	154	41	159	43	40	10	353	94	447
2024	164	40	170	41	42	9	376	90	466

Source: PG model release August 2013

Table ES-5. Recommended IOU Baseline Program Energy (MMTherms) Target Inputs

IOU	PG&E		SCG		SDG&E		Total		
Source & Year	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	IOU Programs	Net C&S	Total
2013	19	0	27	0	3	0	48	0	47
2014	20	0	27	1	3	0	49	1	51
2015	18	1	27	2	3	0	47	3	50
2016	18	3	27	4	3	0	48	7	55
2017	18	3	27	5	3	0	48	9	57
2018	21	4	27	6	3	0	52	10	63
2019	22	4	28	7	4	0	54	11	65
2020	23	4	28	7	4	0	55	11	67
2021	24	4	29	6	4	0	57	10	67
2022	24	4	30	6	5	0	59	10	69
2023	25	4	31	6	5	0	60	10	70
2024	26	4	31	6	5	0	62	10	72

Source: PG model release August 2013

1 Introduction

The Navigant Consulting, Inc. team (the Navigant team) developed this study ("2013 Potential and Goals Study") to analyze energy and demand savings potential in the service territories of four of California's investor-owned utilities (IOUs) during the post-2014 energy efficiency (EE) portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas. A key component of the 2013 Potential and Goals Study is the Potential and Goals (PG) Model, which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and Policy Drivers.

The 2013 Potential and Goals Study supports several parallel and related efforts:

- The primary purpose of the 2013 Potential and Goals Study is to support the California Public Utilities Commission's (CPUC's) determination of policy goals and energy savings targets for the IOUs' post-2014 energy efficiency programs. The 2013 Potential and Goals Study will support analytical efforts that lead to the establishment of those goals, including scenario and sensitivity analysis on key variables. Other users include the IOUs and stakeholders involved in the proceeding.
- The 2013 Potential and Goals Study will develop outputs to inform one component of the California Energy Commission's (CEC's) demand forecast for the post-2014 time period. The relevant output will be the energy efficiency and demand forecasts by IOU service territory by sector.
- As an added feature, the 2013 Potential and Goals Study will serve as one of several inputs to the IOUs' post-2014 program design. Neither the 2013 Potential and Goals Study nor the PG Model is intended to serve as a stand-alone tool for IOUs to use in program design.

CPUC policy making informed and directed this study, as outlined in Rulemaking (R.) 09-11-014 and most recently by Decision (D.) 12-05-015, which provide guidance on the 2012-2013 energy efficiency portfolios. The study period spans from 2013-2024 based on the direction provided by CPUC[9] and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of energy efficiency savings in publicly owned utility service territories was excluded as beyond the scope of this effort.

The Navigant team and the CPUC have conducted frequent and regular outreach to stakeholders in the development of this model. The Demand Analysis Working Group (DAWG) formed a subgroup (also known as a "pup") for energy savings to facilitate this engagement. The Navigant team and CPUC have met with the energy savings pup twice per month since September 2012. The comments and questions raised during these meetings have informed the development of the model.

[9] Direction provided in amendment to Energy Division (ED) Work Order KEMA006 as part of CPUC Contract Number 09PS5863B.

1.1 Overview of General Approach

The primary purpose of the 2013 Potential and Goals Study is to provide the CPUC with information and analytical tools to enable policy makers to engage in goal setting for the next investor-owned utility energy efficiency portfolio. In addition, this study informs forecasts used for procurement planning, can provide estimates of progress towards the state's greenhouse gas (GHG) savings goals,[10] and enables the establishment of benchmarks for the Efficiency Savings and Performance Incentive.[11] The model itself does not establish any regulatory requirements.

Consistent with the 2008 Itron Study[12] and 2011 Potential Study, the 2013 Potential and Goals Study forecasts three levels of energy efficiency potential:

1. **Technical Potential:** Technical potential is the amount of energy savings that would be possible if all technically applicable and feasible opportunities to improve energy efficiency were taken, including retrofit measures, replace-on-burnout (ROB) measures, and new construction measures.[13] Technical potential calculates energy savings that could be captured if all energy efficiency measures were installed in all feasible applications, regardless of cost or customer acceptability.
2. **Economic Potential:** Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential that passes a minimum level of cost-effectiveness.[14] All components of economic potential are a subset of technical potential.[15]
3. **Market Potential:** The final output of the potential study is a market potential analysis, which is defined as the energy efficiency savings that could be expected to occur based on specific economic conditions and market influences (e.g., past IOU program accomplishments and future IOU incentives). Market potential is generally considered a subset of economic potential.[16]

Figure 1-1 illustrates the relationship among these three types of potential.

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[10] As outlined in AB32. California Global Warming Solutions Act of 2006. Assembly Bill No 32. California Air Resources Board.

[11] The Efficiency Savings and Performance Incentive is considered in R.12-01-005.and can be found at http://delaps1.cpuc.ca.gov/CPUCProceedingLookup/f?p=401:56:809728160393201::NO:RP,57,RIR:P5_PROCEEDING_SELECT:R1201005.

[12] ITRON. *California Energy Efficiency Potential Study.* 2008. (www.calmac.org, CALMAC ID: PGE0264.01).

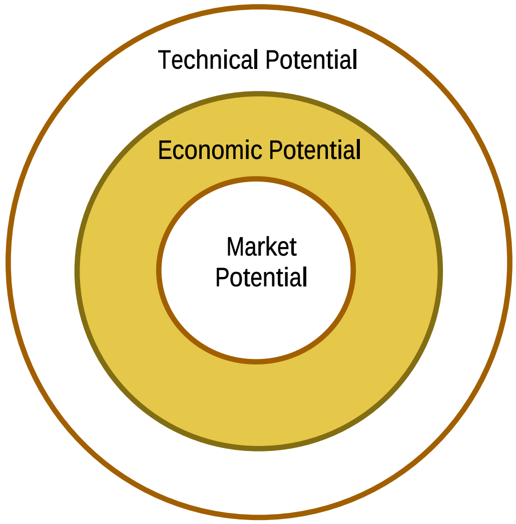
[13] For reference, technical potential typically ranges between 15 and 30 percent of annual electricity sales, depending on the market sector and market baseline conditions.

[14] As discussed in Section 2.3.4, the default cost-effectiveness threshold for economic potential is that a measure must have a total resource cost test value of 0.85 or greater in the Mid-Efficiency scenario.

[15] For reference, economic potential typically ranges from 13 to 23 percent of annual market sector sales, depending on several factors: the amount of technical potential available, the cost test used to screen for economic feasibility, the value of avoided energy costs to an energy provider, and the cost of energy to consumers.

[16] For reference, incremental annual market potential typically ranges between 0.5 and 2.5 percent of annual market sector sales, depending on the amount of economic potential and customer acceptance and barriers to implementing EE measures and initiatives.

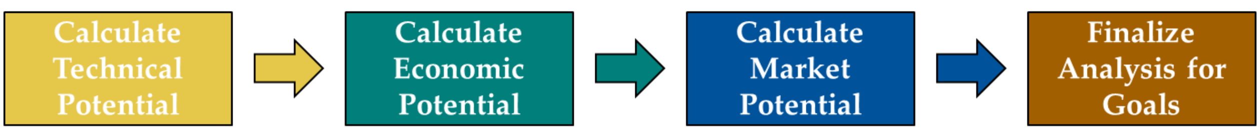
Figure 1-1. Diagram of Types of Energy Efficiency Potential



Source: Navigant team, 2011 Potential Study

The PG Model calculates these three types of potential and then conducts additional analysis to support decision making. The basic framework for this analysis is outlined in Figure 1-2; this graphic is used later in this report when providing additional detail on the analytical approaches used in this model.

Figure 1-2. PG Model Approach to Analysis for This Report



Source: Navigant team analysis, 2013.

1.1.1 Scope and Limitations of Energy Efficiency Activities Covered in the Potential Study

The 2013 Potential and Goals Study includes estimates of potential for the residential, commercial, mining, street-lighting, industrial, and agricultural sectors. Except for the industrial and agricultural, the Navigant team used a bottom-up approach to calculate market potential.[17] This "bottom-up" approach used measure-level data (e.g., unit energy savings [UES], incremental and full measure cost, and densities) and data about California building stocks to determine the timing and savings that result from decisions about whether to select energy efficient equipment or practices. This methodology results in a model and view of potential that is detailed and accurately reflects current industry research on how the

[17] The industrial and agricultural sectors required a top-down approach because of the diversity of end uses and custom nature of projects in the sector; the Navigant team used a supply curve approach to estimate potential in the Industrial sector. Additional detail on these methods is available in Section 3.

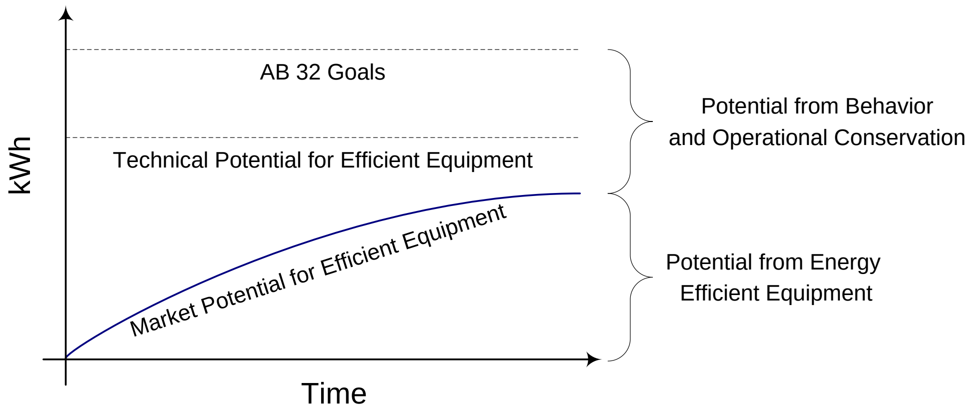
installation of more efficient equipment could decrease energy usage, but also has limitations in the ability to assess conservation activity such as behavioral initiatives or activities and programs designed to adjust how equipment is operated.

This limitation exists because the potential model is based largely on energy efficiency measures defined in the Database for Energy Efficient Resources (DEER) and Frozen Ex Ante (FEA) database. These sources include the majority of energy efficiency measures currently on the market, most of which involve replacing a piece of standard efficiency equipment with a more energy efficient alternative. It is generally assumed that the replacement equipment runs the same number of hours but requires less energy to perform the same work. There are extensive and current data sources available to forecast this type of measure-based potential. Therefore, the resulting forecast can be viewed as a reasonable estimate of energy efficiency potential that will result as the stock of standard efficiency equipment reaches the end of its useful life and is replaced by more efficient alternatives with the support of both voluntary and mandatory (i.e., codes and standards [C&S]) programs.

The potential for savings that result from changes in behavior, or how equipment is operated, has only limited representation in this model. Examples of these types of conservation-oriented savings include a resident adjusting the thermostat in their home to reduce the number of hours a heating, ventilating, and air-conditioning (HVAC) system might run, or a re-commissioning activity designed to establish an efficient operating schedule for the HVAC and lighting systems in an office building. These types of conservation and operational actions are often difficult to assess at the individual end use, and more difficult to scale across market sectors. This difficulty further compounds when attempts are made to forecast this activity over a long period of time because the persistence of these activities is not well documented.

While there is an increasing body of evidence that there is a significant amount of savings potential for behavior and operational changes, the Navigant team chose to present a conservative representation of this activity in the model. This conservative view is not intended to exclude or limit operational and behavioral initiatives that might be considered in setting goals and targets, but simply recognizes the uncertainty of these efforts based on the nascent state of market research. It would be helpful to keep these limitations in sight where the output of this study may be used to assess opportunities or gaps in related planning or forecasting activities. For example, it is likely that Assembly Bill (AB) 32 goals will need to be addressed through a combination of efficiency and conservation, as illustrated in Figure 1-3.

Figure 1-3. Example of Achieving AB32 Goals Through Efficiency and Conservation



Source: Navigant team analysis, 2013.

1.1.2 Relationship of the Potential Study to AB32 Targets for GHG Reductions

The 2013 Potential and Goals Study uses the AB32 target for GHG reductions from energy efficiency as a benchmark for assessing IOU energy savings. The California Air Resources Board (CARB) established a target for CPUC to achieve GHG emissions reductions from energy efficiency as part of its *Climate Change Scoping Plan* (Scoping Plan): 15.2 million metric tons (MMT) of carbon dioxide equivalent (CO_{2e}) from reduced electricity consumption and 4.3 MMT CO_2e from reduced consumption of natural gas in 2020.[18] In 2011, CARB updated these targets to reflect the new economic realities facing the state; CARB established a combined reduction target of 11.9 MMT CO_2e.[19] This latter target is used as a benchmark in the 2013 Potential and Goals Study.

1.2 Key Issues and Updates Since 2011 Potential Study

This study provides an update to the 2011 Potential Study.[20] The 2011 Potential Study developed estimates of technical, economic, and market potential from the four IOUs' energy efficiency programs and C&S under a single set of assumptions (i.e., one scenario). The 2013 Potential and Goals Study sharpens the focus on market potential and includes a broader range of CPUC's policy objectives (e.g., whole buildings, financing) than the 2011 Potential Study. The 2013 Potential and Goals Study provides updates in several key areas:

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[18] California Air Resources Board. December 2008. *Climate Change Scoping Plan: A Framework for Change.* http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf
[19] California Air Resources Board. July 2011. Status of Scoping Plan Recommended Measures. http://www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf
[20] Navigant Consulting, Inc. *Analysis to Update Energy Efficiency Potential, Goals and Targets for 2013 and Beyond: Track 1 Statewide Investor Owned Utility Energy Efficiency Potential Study*. May 2012. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

- » Measure-Related Changes that Affect Technical, Economic, and Market Potential (discussed in more detail in Sections 2.1.1 and 2.1.2.)
  - o Residential and Commercial Measures:
    - ▪ Align the measure list more completely with the DEER and the FEA database
    - ▪ Include measure characteristics by building type and climate zone
  - o Agriculture, Industrial, Mining, and Street-Lighting (AIMS) Measures:
    - ▪ Refine previous estimates of potential for the agricultural and industrial sectors
    - ▪ Add detail at the mining and street-lighting sector level
    - ▪ Expand estimates for industrial sectors to more closely align with CEC demand forecast sector definitions
  - o Emerging Technologies (ET) Measures:
    - ▪ Refine the approach to selecting emerging technologies
    - ▪ Expand the number of measures included in modeling
- » Analytical Issues that Affect Market Potential (discussed in more detail in Section 2.3.)
  - o Model Engine: Standardize approach for estimating market potential to Bass Diffusion theory[21] for residential, commercial, mining, and street-lighting sectors; update the calculation of willingness to consider levelized measure cost instead of simple payback; use a supply curve approach to calculate potential in the industrial and agriculture sectors that reflects the heterogeneity of the sectors' consumption
  - o C&S: Refine inputs to existing C&S; add new and future C&S to the model
  - o Strategic Plan: Finalize approach to modeling the California Strategic Plan[22]
  - o Financing: Estimate additional market potential from financing
  - o Decay: Update approach to calculating decay and reparticipation
  - o Savings Accounting: Calculating life-cycle savings
  - o Scenario and Sensitivity Analysis: Analyze savings potential using different input values

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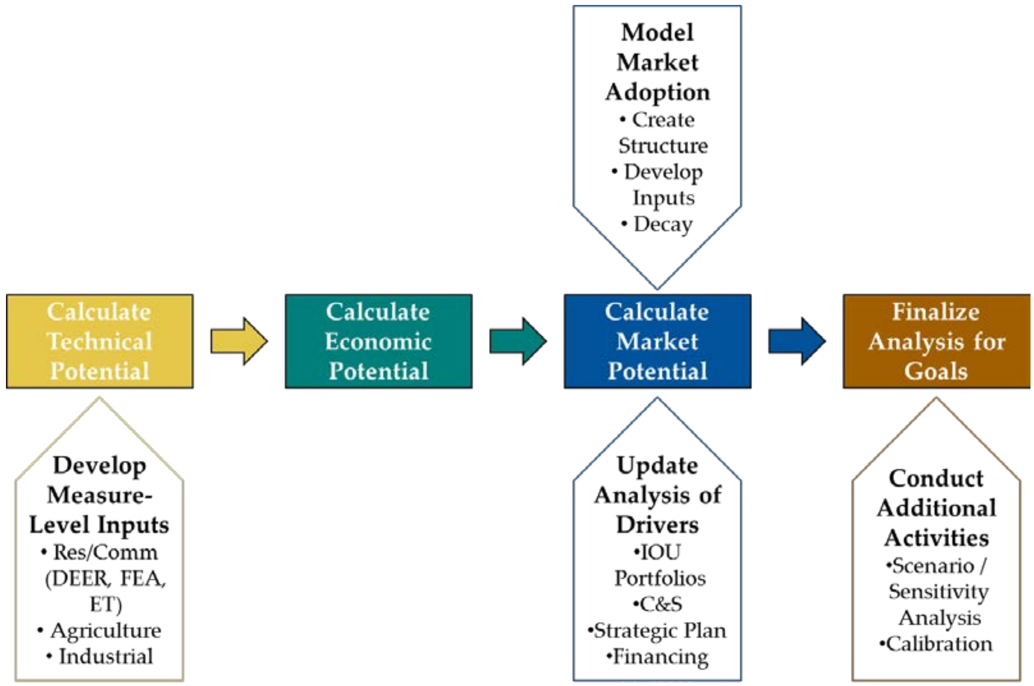
[21] Frank Bass. "A new product growth model for consumer durables." 1969. *Management Science* 15 (5): 215–227.

[22] Engage 360. *California Energy Efficiency Strategic Plan*. January 2011 Update.

Figure 1-4 indicates where each of these changes is integrated in the model framework.

Figure 1-4. Overview of Updates to the 2011 Potential Study



Source: Navigant team analysis, 2013.

2 Methodology for the Residential and Commercial Sectors

This section provides an overview of the Navigant team's approach to the key components of the 2013 Potential and Goals Study analysis:

» Section 2.1 describes the sources of the key inputs to the analysis, including the framework used for the measure-level data and the sources of other inputs.

» Section 2.2 describes the approach used to calculate technical and economic potential.

» Section 2.3 discusses the market potential analysis, including the model structure and underlying theory (Section 2.3.1), high-level overviews of the approaches used to analyze the Energy Policy Drivers (Section 2.3.2), an overview of four issues that cut across all of the calculations conducted as part of the market potential analysis (Section 2.3.3), and a discussion on the scenario and sensitivity analytical frameworks (Section 2.3.4).

Forthcoming appendices to this report will include additional information on many of these topics.

2.1 *Structure and Sources of Key Inputs*

The bottom-up approach used to calculate energy savings potential required detailed measure characterization data as well as other high-level inputs. The detailed measure characterization data provided the information needed to simulate market adoption; these inputs include information about the baseline consumption, energy savings, estimated useful life, costs, and others. The scale and scope of the data used for the 2013 Potential and Goals Study is substantially expanded from the 2011 Potential Study. This section describes the framework used to develop and manage the input data, including the list of the measures analyzed in the 2013 PG Model.

2.1.1 Measure-Level Data for the Residential and Commercial Sectors

The Navigant team compiled an extensive set of measure-level data for the residential and commercial sectors into an online database. The measure-level data is comprised of approximately 60,000 unique rows of measure characteristics that allow the calculation of technical, economic, and market potential for each measure by climate zone, building type, and service territory (see Section 2.1.3 for the description of measures analyzed). To develop the measure-level data, the Navigant team combined information from multiple versions of the DEER,[23] the FEA database,[24] various IOU work papers, and

[23] The Database for Energy Efficient Resources (DEER) contains information on energy efficient technologies and measures. This information includes energy consumption and savings, costs, and other supporting data required to calculate cost-effectiveness and willingness. DEER has been developed for the CPUC through funding from California ratepayers. Interested parties can access DEER at www.deeresources.org.
[24] The FEA is a database developed for the CPUC to house all approved measure-level ex ante data. This includes data on DEER and non-DEER measures. The FEA is housed by the CPUC's Energy Division (ED) on an internal server; access to the FEA data can be requested from ED.

saturation studies. The Navigant team applied common measure names across these various sources based on the Standard Program Tracking Database (SPTdb) 0.98 specification.[25]

All of the measure-level data is available online. The Measure Input Characterization System (MICS) Online provides a platform for stakeholders to access, review, and provide feedback on measure characterization data. MICS Online is available at https://navfact.com/pgt/index.php.

This section provides additional detail on the types of measure-level data developed and the sources of each type of input. Details regarding the key input variables in the MICS are explained herein.

Measure Nomenclature: The PG Model uses a measure nomenclature system that is consistent with DEER. The DEER team's four-level nomenclature system uniquely identifies measures for the purposes of planning and tracking energy efficiency program savings. The four levels of nomenclature are as follows:

- UseCategory: This is the broad end-use category (e.g., lighting, HVAC).
- UseSubCategory: This is a more specific end-use subcategory (e.g., the Lighting UseCategory contains Indoor General, Exit Signs).
- TechGroup: The SPTdb 0.98 document defines this field as follows: "All Technology Types are associated with a high-level Technology Group." For example, all split and packaged air conditioners are a part of the TechGroup "dxAC"; all screw-in lighting technologies, including compact fluorescent lamps (CFLs), light-emitting diodes (LEDs), and incandescent bulbs are a part of the TechGroup "Ltg_ScrewIn."
- TechType: This is a more specific measure category. For example, a Ltg_ScrewIn TechGroup can be further classified into, for example, CFL_Lamp, LED_Lamp, and Incan_Lamp (Incandescent Lamp).

A "measure" in the PG Model refers to a TechType. The PG Model aggregates all DEER and non-DEER measures at the TechType level for calculation purposes. For the sake of clarity, the Navigant team assigns a unique descriptive measure name to each TechType that is used in reporting savings. Throughout the rest of this section, "TechType" and "Measure" can be considered synonymous.

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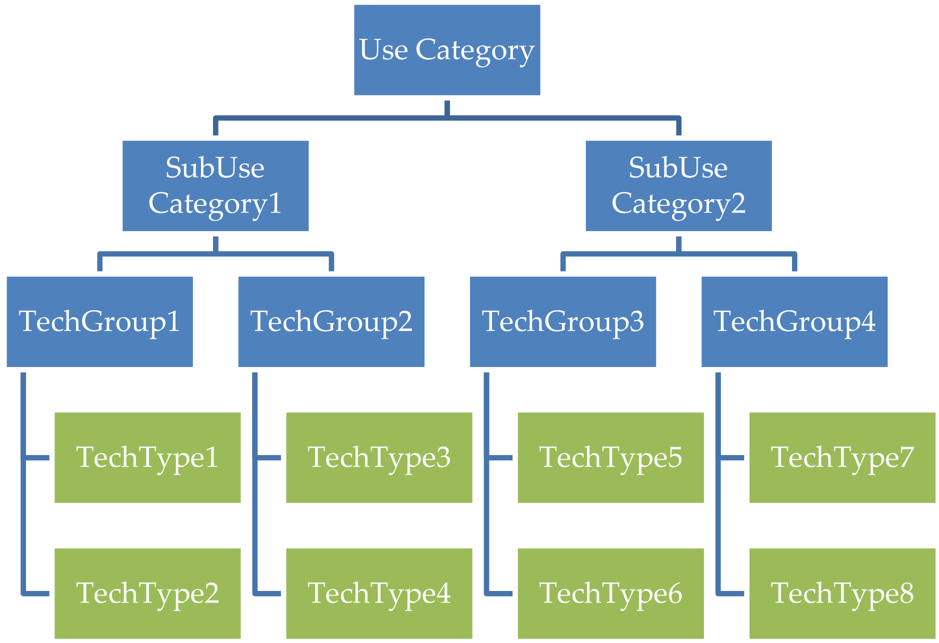
[25] The SPTdb contains all IOU-claimed and evaluated savings starting in 2006 in a unified, ED-approved format.

Figure 2-1. Illustration of the Measure Nomenclature



Note: The PG Model refers to TechType when referring to a "measure."
Source: Navigant team analysis of DEER 2011.

Unit Energy Savings and Consumption: The 2013 PG Study requires three types of data about measures energy use:

- *Measure consumption* is the amount of energy consumed annually by an energy efficient measure that is installed in a specific building type, building vintage (i.e., existing or new construction), and climate zone.
- *Baseline consumption* is the amount of energy consumed annually by the average existing installed equipment. Energy savings for retrofit measures are defined as the difference between *Baseline Consumption* and *Measure Consumption* if the relevant code or standard remains consistent throughout the remaining useful life of the equipment; in cases in which the code changes during the equipment's remaining useful life, the energy savings is calculated as the difference between Measure Consumption and Code Consumption.
- *Code consumption* is the amount of energy consumed annually by the equipment that meets the minimum federal/California state standard or code. Energy savings for ROB measures are defined as the difference between *Code Consumption* and *Measure Consumption.*

The Navigant team leveraged data in DEER 2008, DEER 2011, and saturation surveys to compile these data points for each measure. The most current measure-level data (available in DEER 2011) included only data on incremental measure energy savings. Incremental measure energy savings are not sufficient for the PG Model, which requires all three types of consumption data listed above. As such, the Navigant team derived consumption data for the TechTypes included in DEER 2011 from the 2011 savings data, DEER 2008 consumption data, and the saturation surveys. Additional explanation of this approach is included in Section 2.1.2.

Estimated Useful Life (EUL) and Net-to-Gross (NTG)[26] Ratio: EUL is an estimate of the median number of years that the measures installed under a program are still in place and operable. The values for EUL and the NTG ratios were derived from the FEA (except for the case of measures developed through work papers, in which case the work paper provided the EUL data). The Navigant team queried FEA to obtain a unique list of FEA-defined NTG and EUL descriptions. An FEA description contains the measure name and customer segment to which a particular NTG and EUL value applies. The Navigant team used this list of NTG and EUL to manually assign NTG and EUL values to TechTypes. The NTG ratio is included in the MICS database, but it has very limited application in the PG Model since the PG Model reports gross results. CEC, however, uses net savings to inform its demand forecast.

Measure Cost: Measure cost is defined as the total dollar amount that a customer pays to purchase and install a measure. Measure cost is calculated at the measure level and is the sum of two cost components:

- Material cost is the cost of buying the measure.
- Labor cost is the cost for installing that measure.

All assumptions made regarding measure cost are contained in the MICS Online. In general, for measures included in DEER, material cost and labor cost data were sourced from DEER 2008, which provided the most current vetted material and labor cost data for these measures. For measures not included in DEER, material and labor cost data were sourced from IOU-submitted work papers and secondary research.

Measure Density: Measure density is defined as the number of units of a technology per unit area. Specifically, measure density is categorized as follows:

- *Baseline measure density:* This is the number of units of a baseline technology per unit home for the residential sector, or per unit area for the commercial sector.
- *Energy efficient measure density*: This is the number of energy efficient units existing per unit home for the residential sector, or per unit area for the commercial sector.
- *Total measure density:* This is usually the sum of the baseline and efficient measure density. When two or more efficient measures compete to replace the same baseline measure, then the total density is equal to the sum of the baseline density and all applicable energy efficient technology densities.

These three measure densities were determined for each measure analyzed in the PG Model. The Navigant team applied measure densities consistent with those used in the 2011 study, but modified based on CEC consumption forecast data. CEC forecast data were used to estimate the change in unit energy consumption (UEC) (per home for the residential sector and per square foot for the commercial

[26] The NTG ratio is a factor representing net program load impacts divided by gross program load impacts that is applied to gross program load impacts to convert them into net program load impacts. This factor is also sometimes used to convert gross measure costs to net measure costs.

sector). These trends were used to modify the ratio of 2011 baseline and energy efficient measure density while keeping the total measure density constant.

The input sources detailed in Step 1, their definitions, and the data contained in these sources are presented in Table 2-1.

Table 2-1. Data Sources for the 2013 Potential and Goals Study

Input	Input Source		Data Availability	Source Notes
Measure Nomenclature	SPTdb* 0.98 Document		High	The SPTdb 0.98 document is created by the DEER team to standardize program-tracking nomenclature.
UES	DEER 2011		High	DEER 2011 contains ED-approved UES data.
UEC	DEER 2008		High	DEER 2008 contains ED-approved base and code consumption data. This was merged to DEER 2011 to get required data.
EUL	FEA Database, Workpapers		High	The FEA contains ED-approved measure information that IOUs use as ex ante claims. For measures developed through work papers, the work paper was the source.
NTG#	FEA		High	The FEA contains ED-approved measure information that IOUs use as ex ante claims.
Measure Costs	DEER 2008		Low	Measure cost data is available for a subset of DEER 2008 measures. Costs for other measures were sourced from IOU work papers and secondary research.
Density	RASS/ CEUS/ Research		Low	RASS contains density data for residential appliances. Density values were calculated using available data and secondary research.
* SPTdb contains all IOU claimed and evaluated savings starting in 2006 in a unified, ED-approved format.				
# The NTG ratio has limited application in the PG Model since results are reported at the gross level. CEC, however, applies the NTG ratio to determine net savings to inform its demand forecast.				

Source: Navigant team analysis, 2013.

These measure characteristics include energy consumption, measure cost, measure density,[27] EUL, and ex ante NTG ratio estimates. The sources for these data include DEER 2011, DEER 2008, FEA, IOU work papers, and secondary research conducted by the Navigant team.

[27] Measure density is the population density per unit area of energy efficient and baseline measures.

2.1.1.1 *Inclusion of Emerging Technologies*

The Navigant team expanded the scope of ETs and refined the modeling methodology for ETs beyond the scope and methodology of the 2011 Potential Study. ETs are defined as meeting one or more of the following criteria:

- » Not commercially available in today's market, but expected to be available in the next three to five years
- » Commercially available but representing less than 5 percent of the existing market share
- » Costs and/or performance are expected to substantially improve in the future.

Emerging technologies were only examined for the residential, commercial, and street-lighting sectors.[28] These sectors are modeled using individual measures for specific applications. This section describes the approach to ET analysis in the residential and commercial sectors.

Whereas the 2011 Potential Study only assessed the potential of 23 ETs that were most likely expected to be adopted in the market, the Navigant team took a systematic approach to redirect the ET analysis toward the end uses within the residential and commercial sectors that account for the largest energy use. ETs were examined for the largest end uses to better estimate their total impact on future potential. The Navigant team examined data from the CEC energy demand forecast models that are typically used for Integrated Energy Policy Report (IEPR) analysis. The CEC demand forecast models contain a total of 28 residential and commercial electric end uses and 16 residential and commercial gas end uses as summarized in Table 2-2.

Table 2-2. End Uses Included in the CEC Energy Demand Forecast Model

Sector	Electric End Uses	Gas End Uses
Residential	18	10
Commercial	10	6
Total	28	16

Source: Navigant team analysis, 2013.

[28] The Industrial and Agricultural sectors are modeled using the supply curve approach (see Section 3). The Mining sector was excluded from ET analysis given its small overall energy consumption relative to other sectors and its considerable reliance on motors and boilers for which there are few ET opportunities. Although small in overall energy use, the street lighting sector was included for ET analysis specifically to examine LED technologies (see Section 3.4).

The Navigant team analyzed the energy consumed by each end use and determined that 12 electric end uses account for 83 percent of residential and commercial electric consumption; 7 gas end uses account for 87 percent of residential and commercial gas consumption. These end uses, listed below in Table 2-3, were those that the Navigant team examined for possible ETs.

Table 2-3. Largest Residential and Commercial End Uses

Electric Sector and End Use	Percent of Total Electricity Use
Com Indoor Lighting	17%
Com Miscellaneous	13%
Res Miscellaneous	10 %
Com Space Cooling	8%
Res Refrigerator	8 %
Res Lighting	7%
Com Ventilation	6%
Com Refrigeration	4%
Res Space Cooling	4%
Com Outdoor Lighting	3%
Res Dryer	2%
Res Water Heater	1%
Total	84 %

Gas Sector and End Use	Percent of Total Gas Use
Res Space Heat	32%
Res Water Heater	16%
Com Heating	11%
Com Water Heating	10%
Res Clothes Washer	7%
Com Cooking	7%
Res Dishwasher	5%
Total	87%

Source: Navigant team analysis of CEC 2011 IEPR demand forecasts (Mid-case).

The Navigant team then investigated the range of possible emerging technologies for each of the 19 end uses listed in Table 2-3. The Navigant team consulted its own internal databases as well as third-party reports and U.S. Department of Energy (DOE) analyses to identify the highest efficiency technologies within each of these end uses. In some cases, the most efficient technology had already been characterized in the DEER database or through CPUC -approved utility work papers (e.g., electric heat pump water heaters). For such cases, no additional research was necessary.

Remaining ETs were characterized based mainly on their efficiency levels. Most ETs are simply higher efficiency levels of conventional technologies. For example, where Seasonal Energy Efficiency Ratio (SEER) 15 and SEER 18 residential ACs are modeled as conventional measures (data available from DEER), a new SEER 22 AC measure is modeled as an ET. The Navigant team relied on data from various sources to characterize each ET:

» U.S. Department of Energy standards rulemaking analysis provided the insight on the maximum technically feasible energy efficiency level for many measures and end uses.[29]

» The Navigant team extrapolated cost data from DEER where possible to ensure appropriate cost increments beyond baseline and non-ET measures.

[29] U.S. Department of Energy. *Standards and Test Procedures*. (online resource), http://www1.eere.energy.gov/buildings/appliance_standards/standards_test_procedures.html.

» IOU work papers and other case studies provided additional savings and cost estimates.

The Navigant team was agnostic about what technology components or strategies an equipment manufacturer used to produce a high-efficiency ET product. Rather, the team focused on what the maximum efficiency level was, how much energy it could save, and how much it would cost. This method allowed the Navigant team to avoid picking a "winning" technology or manufacturer, to avoid competing similar ET products against each other that effectively accomplish the same savings at the same costs, and to examine a broader range of ETs as they apply to specific building types and end uses.

The Navigant team assigned a risk factor to each ET to account for the inherent uncertainty in the ability for ETs to produce reliable future savings. The risk factor was determined based on qualitative metrics of market risk, technical risk, and data source risk. The framework for assigning the risk factor is shown in Table 2-4. Each ET has each risk category qualitatively assessed; a total weighted score is then calculated. Well-established and well-studied technologies (such as LEDs) have lower risk factors while nascent, unevaluated technologies (e.g., heat pump electric clothes dryers) have higher risk factors.

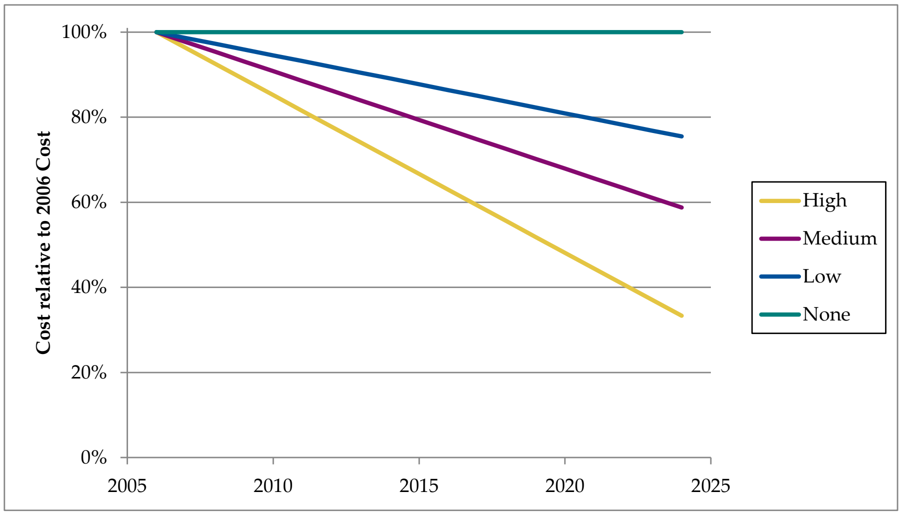
Table 2-4. Emerging Technology Risk Factor Scorecard

<table>
<tr><th></th><th colspan="5">ET Risk Factor</th></tr>
<tr><th>Risk Category</th><th>90%</th><th>70%</th><th>50%</th><th>30%</th><th>10%</th></tr>
<tr><td>Market Risk (25% weighting)</td><td colspan="2">High Risk:
• Requires new/changed business model
• Start-up, or small manufacturer
• Significant changes to infrastructure
• Requires training of contractors
Consumer acceptance barriers exist.</td><td></td><td colspan="2">Low Risk:
• Trained contractors
• Established business models
• Already in U.S. market
• Manufacturer committed to commercialization</td></tr>
<tr><td>Technical Risk (25% weighting)</td><td>High Risk: Prototype in first field tests</td><td>Low volume manufacturer. Limited experience</td><td>New product with broad commercial appeal</td><td>Proven technology in different application or different region</td><td>Low Risk: Proven technology in target application</td></tr>
<tr><td>Data Source Risk (50% weighting)</td><td>High Risk: Based only on manufacturer claims</td><td>Manufacturer case studies</td><td>Engineering assessment or lab test</td><td>Third-party case study (real-world installation)</td><td>Low Risk: Evaluation results or multiple third-party case studies</td></tr>
</table>

Source: Navigant team analysis, 2013.

Some ETs (along with some conventional technologies) are expected to decrease in cost over time. Historic data has shown the price of many common appliances to have decreased significantly over the past several decades.[30] Using this data, the Navigant team developed four cost reduction profiles that could apply to various ETs (and non-ETs when appropriate) in the model (Figure 2-2).

Figure 2-2. Cost Reduction Profiles

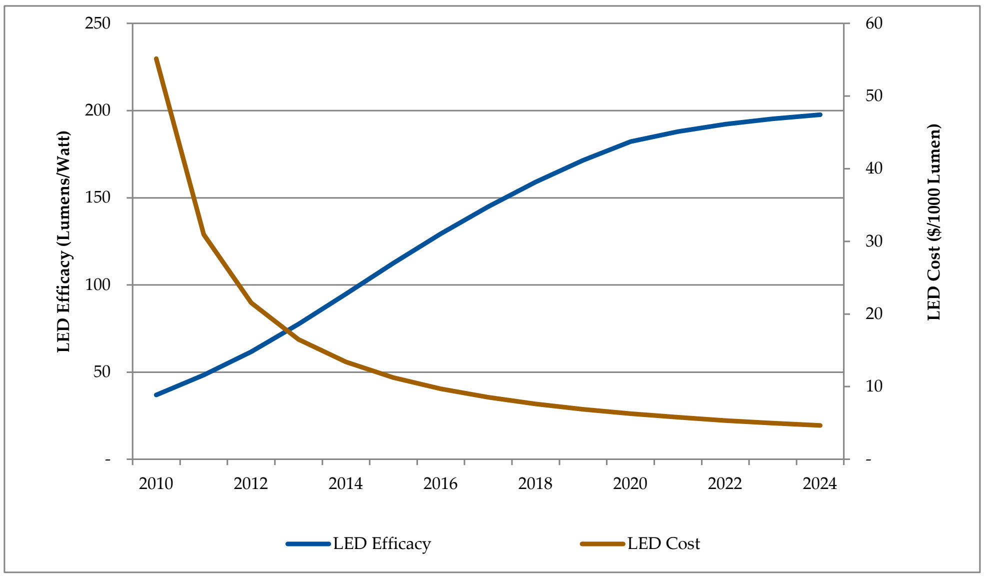


Source: Navigant team analysis, 2013.

[30] U.S. Department of Energy. February 2011. *Using the Experience Curve Approach for Appliance Price Forecasting.*

The Navigant team also collected data on the cost reduction and performance improvement profiles specifically for LED technologies (Figure 2-3). LED costs have come down rapidly in recent years (i.e., a 70 percent reduction from 2010 to 2013) and are expected to continue to decrease in the foreseeable future. Meanwhile, LED efficacy has been increasing and is expected to nearly double from 2014 to 2024. This efficacy change will decrease the wattage requirements of LEDs in the future. The PG Model incorporates both of these trends.

Figure 2-3. LED Technology Improvements



Source: Navigant. Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Prepared for the U.S. Department of Energy. January 2012.

The market potential of ETs is calculated using the same methodology as used to model conventional measures. Many ETs compete with lower efficiency conventional technologies (e.g., CFLs vs. LED) for market share. The addition of risk factor acts to decrease market potential of ETs by derating the savings values used to estimate customer willingness. This risk adjustment approach allows the model to appropriately estimate total potential from ETs given that some may fail in the market without having to predict which specific technologies fail or succeed.

A full list of the ETs included in this study along with their assigned risk factors and cost reduction profiles can be found in Appendix A.

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2.1.2 Development of Measure-Level Data for the Residential and Commercial Sectors

The PG model inputs are defined for each measure by building type, climate zone, and IOU service territory. These measure inputs were derived from existing ED-approved data sources and are housed in the MICS. Figure 2-4 presents the data architecture for measure data in the MICS.

Figure 2-4. Data Architecture Structure for the 2013 Potential and Goals Study

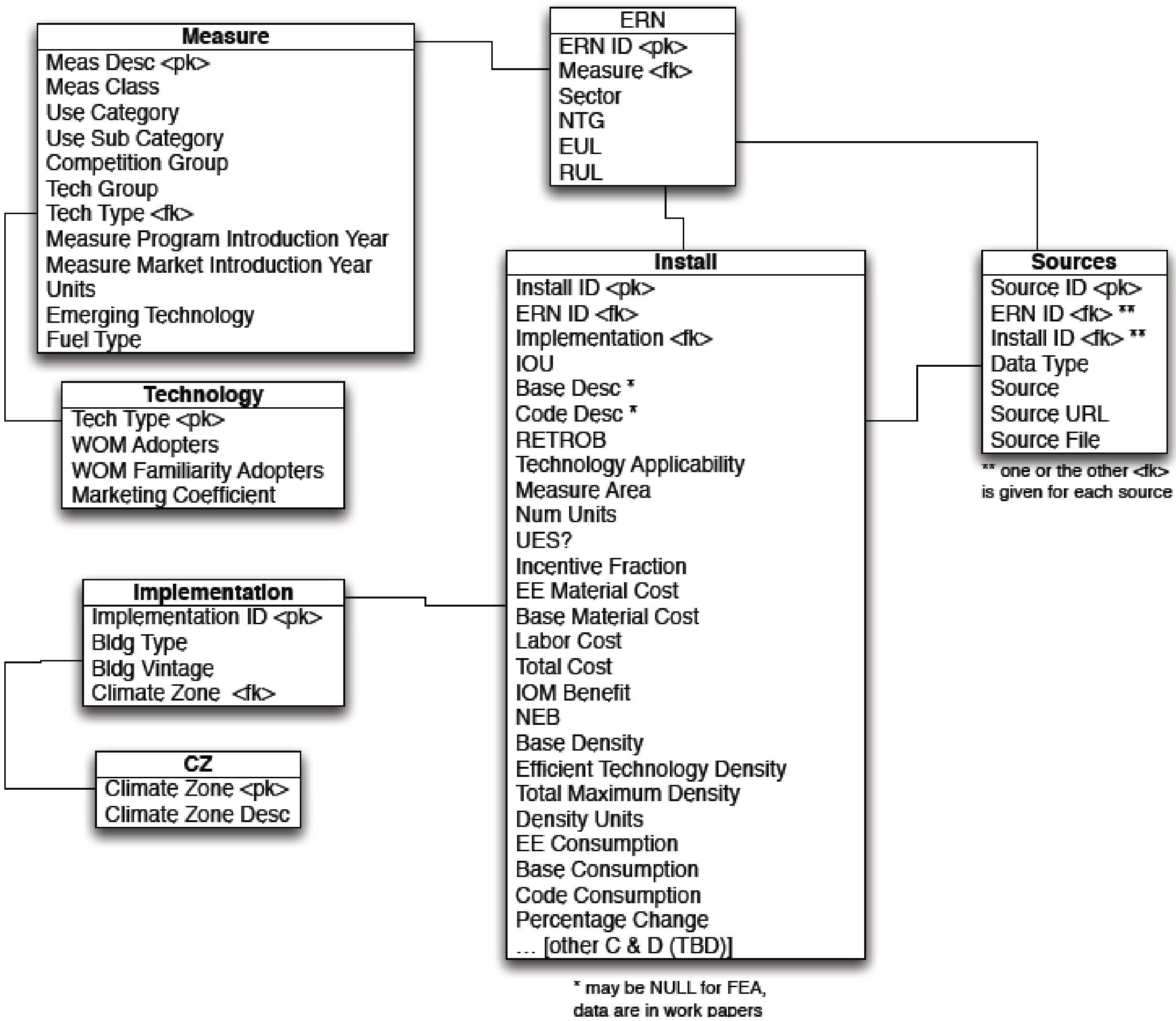


Figure 2-5 presents the process that the Navigant team used to create the measure list for conventional measures in the 2013 PG Study. The development of the measure list included the following steps:

» **Step 1: Define Measure Data Sources and Measure Lists:** The Navigant team researched available data sources for measure characteristics development. The data sources chosen for compiling measure input characteristic data are as follows:

  o DEER 2008 – Source for consumption data

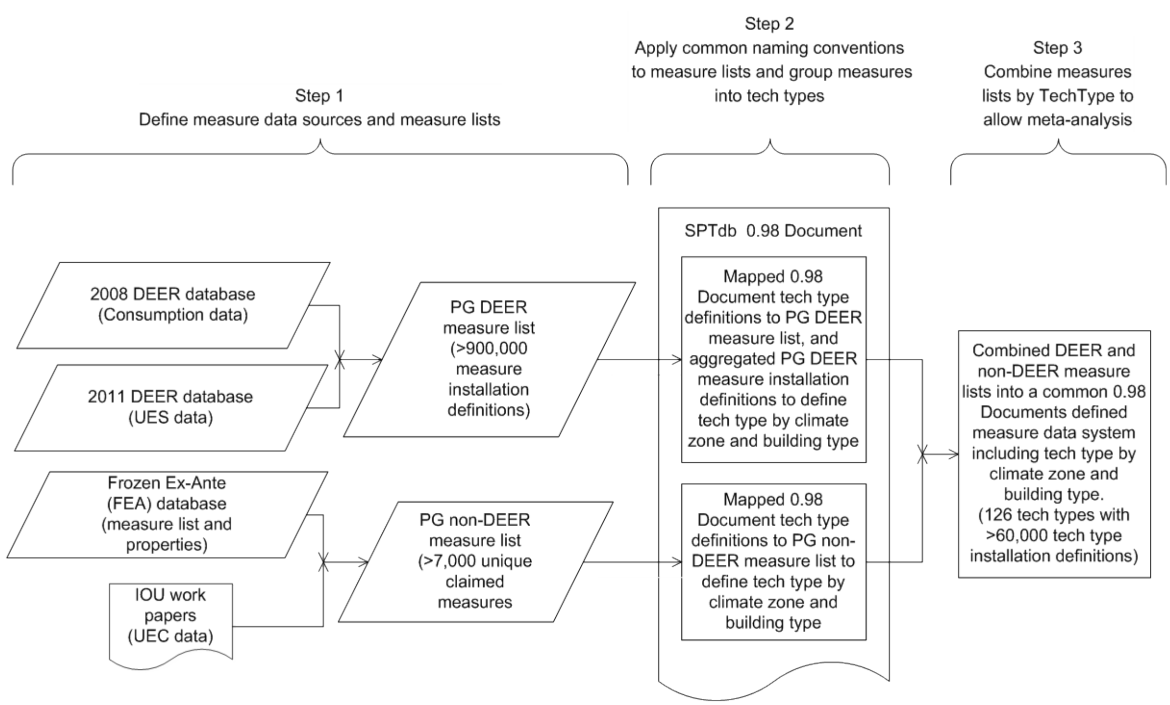
  o DEER 2011 – Source for energy savings data

  FEA – Source for non-energy measure properties for DEER measures, including EUL and incremental cost. For non-DEER measures, FEA provided ED-approved IOU work papers that contain energy and non-energy measure characteristics required for potential modeling.

» **Step 2: Data Source Consolidation:** All the different data sources were normalized by applying a consistent naming convention to all measures in these different data sources. This naming convention is defined by the SPTdb 0.98 naming convention.

» **Step 3: Develop Combined Measure List:** The Navigant team compiled a measure list that includes all measures represented by DEER and a subset of non-DEER measures for which ED-approved work papers exist. The MICS was created to house all this data in a relational online database.

Figure 2-5. Overview of the Process to Create the PG Measure List



Source: Navigant team analysis 2013.

The following discussion provides additional details on the development of the energy consumption data for the DEER and non-DEER measures included in the PG Model. The Navigant team took these steps to conduct the meta-analysis outlined in Step 3 of Figure 2-5 to complete the development of the measure list:

1. For DEER measures, the Navigant team used the merged DEER 2008-2011 data set to calculate measure, baseline, and code UEC. The Navigant team aggregated all DEER and non-DEER measures to an SPTdb 0.98 defined TechType level. For each TechType, the following level of detail was considered:
    a. IOU: Measure savings vary by IOU.
    b. Building type: Measure savings vary by building type. The Navigant team used the standard building type nomenclature used by DEER 2008, which was developed for the SPTdb and FEA.
    c. Climate zone: Measure savings vary by DEER climate zone.
2. For non-DEER measures, the Navigant team sourced the consumption data from ED-approved work papers submitted by the IOUs. Data from the work papers was used to populate measure UEC for building type and climate zone where provided. All Navigant team analysis sheets for non-DEER measures are sourced to an IOU work paper where applicable.

2.1.3 Residential and Commercial Sector Measure Lists

The residential and commercial measure list includes 169 unique measures. The Navigant team worked to make sure that all major Use Categories are covered by the measure list. Table 2-5 presents a count of measures included in the residential and commercial sectors by End-Use Category, End-Use Subcategory, and Fuel Type. These counts include both conventional and emerging technologies. Instructions for accessing a complete list of the measures and their descriptions are located in Appendix B.

Table 2-5. Count of Residential and Commercial Measures Included in the PG Model, Including Emerging Technologies

Sector	Fuel Type	Use Category	Use Category Definition	Use Category Examples	Measure Count
Com	Electric	AppPlug	Plug-in Appliances/Electronics	Computers, Power Strips, Vending Machine Controllers	4
Com	Electric	BldgEnv	Building Envelope (Insulation)	Window Films, Insulation	3
Com	Electric	ComRefrig	Commercial Refrigeration	Refrigerator Door Gaskets, Display Case Night Covers	6
Com	Electric	FoodServ	Food Service	Efficient Ovens and Griddles	5
Com	Electric	HVAC	HVAC	A/C and Heating Units, Thermostats	20
Com	Electric	Lighting	Lighting	LEDs, T8s, High-Bay T5s	27
Com	Electric	ProcHeat	Process Heating	Boiler Controls	1
Com	Electric	Service	Service/Non-Equipment	Re-commissioning, HVAC Fault Detection Services	3
Com	Electric	SHW	Service Hot Water	Water Heaters	2
Com	Electric	WholeBlg	Whole-building	Whole Building Retrofits and Efficient New Construction	6
Com	Gas	FoodServ	Food Service	Efficient Kitchen Equipment such as Ovens and Griddles	2
Com	Gas	HVAC	HVAC	A/C and Heating Units, Thermostats	5
Com	Gas	Service	Equipment Service	Re-commissioning	1
Com	Gas	SHW	Service Hot Water	Water Heaters	7
Res	Electric	AppPlug	Plug-in Appliances/Electronics	Computers, TVs, Clothes Washers	14
Res	Electric	BldgEnv	Building Envelope	Window Films, Insulation	3
Res	Electric	HVAC	HVAC	A/C and Heating Units, Thermostats	10
Res	Electric	Lighting	Lighting	LEDs, CFLs, Holiday Lights, Outdoor Lighting	29
Res	Electric	SHW	Service Hot Water	Water Heaters	3
Res	Electric	WholeBlg	Whole-building	Whole-Building Retrofits and Efficient New Construction	8
Res	Gas	AppPlug	Plug-in Appliances/Electronics	Clothes Washers, Dishwashers	4
Res	Gas	HVAC	HVAC	A/C and Heating Units	2
Res	Gas	SHW	Service Hot Water	Water Heaters	4

Source: Navigant team analysis, 2013.

2.1.4 Other Macro-Level Inputs

Apart from measure characteristics, other key inputs also inform this potential model. These key inputs fall into three categories:

» **Population and Consumption Inputs:** The model includes data from the CEC regarding building stock and energy and demand forecasts.

» **Economic Inputs:** The model includes data from the CEC regarding retail energy prices, and Energy + Environmental Economics' (E3) avoided cost assumptions and other inputs for inflation and discount rates.

» **Program Inputs:** The PG Model uses assumptions about key programmatic factors, including the administrative cost ratio and past program accomplishments (2006-2008 energy efficiency program cycle).

Table 2-6 summarizes the sources of the inputs that comprise each of these three categories.

Table 2-6. Sources of Macro-Level Inputs

Input	Source	Additional Notes
Population and Consumption Inputs:		
Building Stock	California Energy Commission's 2012 Integrated Energy Policy Report	Residential building stocks are based on number of households. Commercial building stocks are represented by 1,000 sq. ft. Industrial and agricultural building stocks are represented by energy consumption. Projections past 2022 were calculated using the annual growth rate that CEC used for 2010-2022.
Energy and Demand Forecasts	California Energy Commission's 2012 Integrated Energy Policy Report	Projections past 2022 were calculated using the annual growth rate that CEC used for 2010-2022. Assumed mid-demand case data.
Economic Inputs:		
Retail Rate Forecast	California Energy Commission's 2012 IEPR	Projections past 2022 were linearly extrapolated based on the growth rate in the last two years of the IEPR forecast.
Avoided Costs	TBD	TBD
Avoided Cost Discount Rates	CPUC Decision 12-05-015; Discussion with IOUs	Societal discount was assumed to be 3% based on insight from PG&E and the Navigant team's judgment.
Program Inputs:		
Administrative Costs	2013-2014 IOU Final Compliance Filings	Costs and savings were mapped to their corresponding sector and aggregated to calculate a cost ratio for each sector and IOU.
Past Program Accomplishments	SPTdB 2006-Present	Used the measure mapping to understand energy savings claimed by use category and year for each IOU.
Planned 2013–2014 Program Savings	IOU 2013-14 Compliance Filings	Used the measure mapping to understand energy savings claimed by use category and year for each IOU.

Source: Navigant team analysis, 2013

2.2 *Technical and Economic Potential Analysis*

Estimates of technical and economic potential establish theoretical bounds for the analysis of market potential for energy savings. Technical potential is the amount of energy savings that would be possible if all technically applicable and feasible opportunities to improve energy efficiency were taken, including retrofit measures, ROB measures, and new construction measures.[31] The economic potential is defined as the sum of the technical potential of all measures that pass a minimum level of cost-effectiveness. This section describes the approach to calculating technical potential (Section 2.2.1) and economic potential (Section 2.2.2) and how these approaches compare to those presented in the 2011 Potential Study (Section 2.2.3).

2.2.1 Calculation of Technical Potential

The PG Model uses a similar approach to calculating technical potential as described in the 2011 Potential Study. This section includes a restatement of that approach. Technical potential is calculated on a per-measure basis, as the product of the savings per unit, the quantity of applicable units in each building stock unit (i.e., residences, commercial floor space, and industrial energy consumption), and the total building stock in each IOU service territory.

The full populations of baseline units are considered instantaneously available for both replace-on-burnout and retrofit measures. The technical potential is calculated each forecast year. It accounts for stock turnover assumptions, as described above, and changes to measure impacts over time. Building stocks are treated differently for new construction, where the technical potential is a running cumulative total for each year of the forecast. No net-to-gross adjustments occur with technical potential.

The main difference in methodology between the 2013 Potential and Goals Study and the 2011 Potential Study is the treatment of competing measures when calculating technical potential.[32] In the 2013 PG Model technical potential is defined by the most efficient technology within a group of competing measures; in the 2011 Potential Study, technical potential was distributed amongst multiple competing measures (with varying levels of efficiency). This is one contributing factor to the higher technical potential in the 2013 Potential and Goals Study than the 2011 Potential Study.

2.2.2 Calculation of Economic Potential

The PG Model uses a similar approach to calculating economic potential as the 2011 Potential Study. The remainder of this section includes a restatement of that approach.

Economic potential is an estimate of the technical energy efficiency potential that is "cost-effective" as defined by the results of the Total Resource Cost (TRC) test. The TRC test is a cost-benefit analysis with a societal perspective of relevant energy efficiency measures. It does not include market barriers such as lack of consumer knowledge. The TRC is calculated using the following equation:

$$TRC = \frac{Benefits\ of\ Avoided\ Cost}{Technology\ Cost + Program\ Administrative\ Cost}$$

[31] The core measure list for this study is based on the DEER database, which is largely focused on cost-effective measures. As such, the study may not have assessed some energy-saving measures that are not cost effective if they were not included in DEER or in the list of emerging technologies included in the study.

[32] For additional information on competing measures, see Section 2.3.2.1.

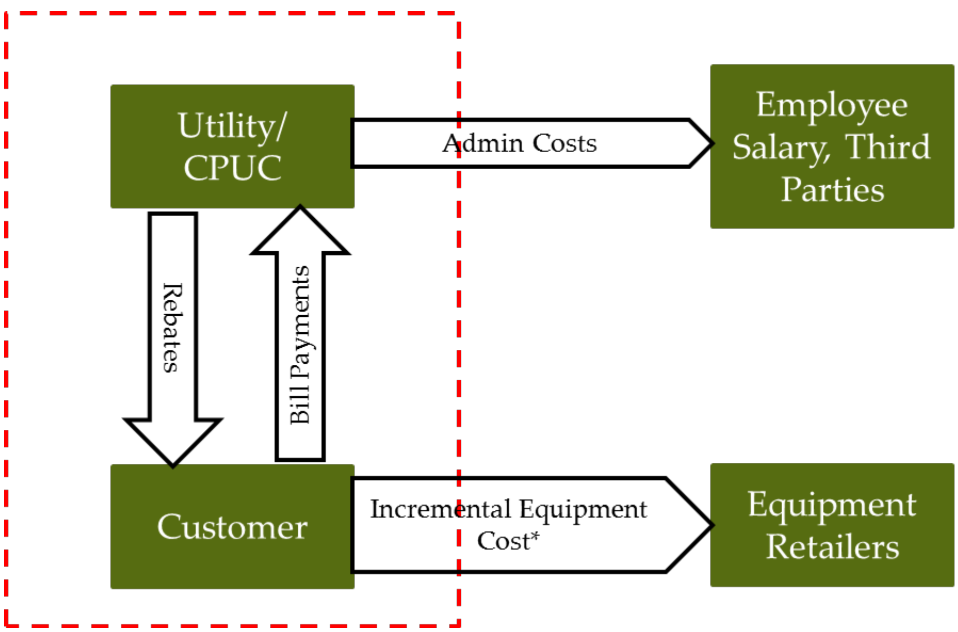
where

- *Benefits of Avoided Cost* is the monetary benefit of energy and demand savings (e.g., avoided costs of generation, and transmission and distribution investments, as well as avoided fuel costs due to energy conserved by energy efficiency programs).
- *Technology Cost* is the incremental equipment cost to the customer; in the case of an early retirement measure, the incremental equipment cost is equal to the full equipment cost.
- *Program Administrative Cost* is the money spent by IOUs to fully administer energy efficiency programs.[33]

Figure 2-6 includes a graphic representation of the costs included in the TRC test, which includes all costs that flow outside of the utility/CPUC-customer system. Rebates and bill payments stay within the utility/CPUC-customer system and are therefore not counted in the TRC calculation (i.e., they are considered “transfer" payments).

Economic potential uses the same approach as for technical potential for the treatment of new construction, ROB measures, and NTG issues.

Figure 2-6. Costs Included in the TRC Test



Note: * For retrofit measures, the PG Model uses full equipment cost.

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[33] The Navigant team worked with the IOUs and CPUC to properly assess Program Administrative Cost using data from the 2010-12 IOU programs. The IOUs report program costs in four different categories (Administrative, Marketing, Direct Implementation, and Evaluation, Measurement, and Verification [EM&V]) and two different program types (Resource and Non-Resource). The Navigant team worked with the IOUs to develop a common framework for properly categorizing the costs for inclusion in the Program Administrative Cost.

The TRC for each measure is calculated each year and compared against the measure-level TRC screen threshold. If a measure's TRC exceeds the threshold, that measure is included in the economic and market potential. Otherwise, the measure is excluded from economic potential. Through this approach, it is possible for a measure to initially be excluded from programs yet eventually be included in future years as measures costs decrease over time. The TRC threshold varies by technology type as illustrated in Table 2-7.

Table 2-7. TRC Screen Threshold (Mid-Energy Efficiency Scenario)

Measure Type	TRC Threshold
Low Income	0
Emerging Technology	0.5
All Other Measures	0.85

Source: Navigant team analysis, 2013.

A reduced TRC threshold is applied to ETs to allow inclusion of those measures that are ultimately expected to be cost-effective. The reduced ET threshold is applied only to measures that are estimated to surpass the standard threshold at a period of ten years after the ET's market introduction year. This ensures that the portfolio is not including measures that are not expected to be cost effective after they have passed the initial stages of market adoption.

The PG Model allows the user to independently set the TRC screen for emerging technologies or all other non-low-income measures (e.g., from DEER, FEA, or work papers). The values of the TRC Screen and the ET TRC Screen are variables on the user interface. The pre-set values for the TRC Screen and the ET TRC Screen vary across the model scenarios and are defined in Section 2.3.4 and 2.3.5.

2.2.3 Comparison to 2011 Potential Study

As mentioned in the previous two subsections, the approach in the current PG Model is largely consistent with that used for the 2011 Potential Study. The PG Model includes the following updates:

- The PG Model has a revised approach that estimates the maximum technical potential for competing measures.
- The PG Model calculates technical and economic potential at the building type and climate zone level, whereas the 2011 Potential Study performed these calculations at the IOU service territory and sector level. The current PG Model can aggregate results to the levels reported by the 2011 Potential Study.
- The PG Model assesses cost-effectiveness of ETs based on a reduced threshold and the expectation that the ET would ultimately pass the standard TRC threshold. The 2011 Potential Study did not include these dual criteria.

2.3 *Market Potential Analysis*

The market potential analysis estimates the amount of IOU program savings that there is a reasonable expectation that the market will achieve based on historic program participation, financial characteristics of measures, saturation rates, and other factors. It includes IOU program savings and savings from codes and standards over the forecast period. This calculation varies with program parameters, such as the magnitude of incentive or rebates for customer installations and program design.

This section provides an overview of the key aspects of the market potential analysis:

- » Section 2.3.1 presents the theory underlying the market adoption model, key model inputs, and user assumptions.
- » Section 2.3.2 discusses the approaches to modeling each of the key Policy Drivers, including codes and standards, IOU rebates for individual measures, the Strategic Plan, and financing.
- » Section 2.3.3 presents the approach to addressing two key crosscutting issues: (1) accounting for savings from IOU rebate programs, codes and standards, and whole-building approaches and (2) the application of a variable incentive structure.
- » Section 2.3.4 outlines the approach used to conduct sensitivity and scenario analysis in the PG model.

2.3.1 Key Frameworks for Market Potential Analysis

This section presents frameworks that are important for understanding the market potential analysis:

- » Section 2.3.1.1 describes the key model outputs.
- » Section 2.3.1.2 describes structure and theory that frame the analysis.
- » Section 2.3.1.3 describes the rationale for and approach to calibrating the model to historic IOU program accomplishments.
- » Finally, Section 2.3.1.4 defines decay and outlines the approach used in the PG model.

2.3.1.1 Market Potential Output

The primary output of the PG model is the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers. The 2013 Potential and Goals Study reports three different types of market potential:

- » *Incremental savings* represent the annual energy and demand savings achieved by the set of programs and measures in the first year that the measure is implemented.[34] It does not consider the additional savings that the measure will produce for the life of the equipment. A view of incremental saving is necessary in order to understand what additional savings an individual year of EE programs will produce. This has been the basis for IOU program goals.

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[34] CPUC. September 2004. Interim Opinion: Energy Savings Goals for Program Year 2006 and Beyond. Original Goals Decision. D.04-09-060. http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/40212.pdf. (p. 10).

- *Cumulative savings* represent the savings from previously installed energy efficiency measures that are still active in the current program year as well as savings from measures installed during the current program year.[35] This approach ensures that when an IOU-rebated measure reaches the end of its useful life, it no longer provides savings. In other words, cumulative savings include the cumulative effects of new measure installations, retirements, and the timing effects of codes and standards that become effective after measure installation. Cumulative savings do not assume automatic reparticipation at the end of a measure life and provide an accurate view of the savings that are "active" in each year.[36] Cumulative savings are necessary to forecast energy savings for demand resource planning.
- *Life-cycle savings* refer to the expected trajectory of savings from an energy efficiency measure (or portfolio of measures) over the estimated useful life of the measure(s), taking account of any natural decay or persistence in performance over time. [37] Whereas cumulative savings are a backward look at all measures installed in the past producing current savings in a given year, life-cycle savings accounts for all future savings from measures installed in a given year and counts those future savings in the year of installation. Life-cycle savings is used in the cost-effectiveness evaluations and may be an appropriate basis for IOU program goals.

2.3.1.2 Model Structure and Underlying Theory

The Navigant team developed the PG Model to analyze savings from all primary Policy Drivers using a single platform.[38] This integrated modeling approach enables analysis of the complex interactions among various inputs and Policy Drivers. This approach also streamlines scenario analysis by controlling all model assumptions and inputs from a single user interface.

The model simulates technology adoption through two mechanisms: compliance and voluntary adoption. Compliance adoption refers to adoption resulting from codes and standards (as discussed in Section 2.3.2.2). Voluntary adoption refers to adoption resulting from customer decisions to adopt efficient technologies over base technologies in the market based on their financial costs and benefits.

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[35] Ibid.

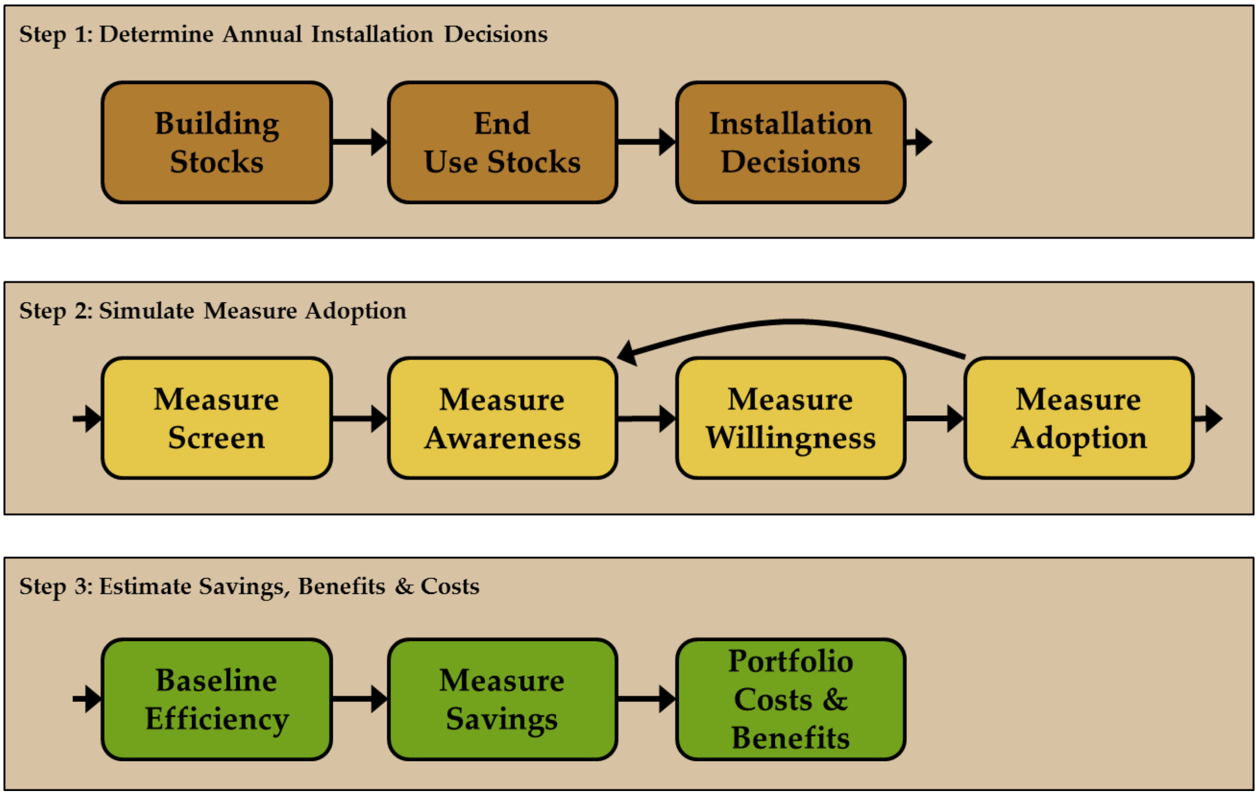
[36] The approach taken to estimate cumulative savings in the 2013 Potential and Goals Study does not simply accumulate first-year incremental savings and therefore does not require an explicit decay assumption. (See section 2.3.1.4 for a definition of decay.) Rather, market conditions drive adoption upon retirement and decay is implicit in the calculation.

[37] Ibid.

[38] Policy Drivers include IOU rebates for individual measures; C&S; the Strategic Plan, AB 758, and whole-building initiatives; financing; and IOU behavior programs.

Figure 2-7 shows the three-step process that the PG Model uses to calculate market potential from voluntary adoption.

Figure 2-7. Three-Step Approach to Calculating Market Potential from Voluntary Adoption



Source: Navigant team analysis, 2013.

In the first step, the PG Model calculates the number of installation decisions expected to occur for each measure in a given year. There are two types of installation decisions: replace-on-burnout decisions, which a customer makes at the end of a measure's life,[39] and early replacement decisions, which a customer may make to replace a measure before it is burned out due to, for instance, a building retrofit. The model can apply either decision type (i.e., replace on burnout or retrofit) for each measure depending on the treatment of the measure in its source files (e.g., DEER, work papers, and FEA).[40] Technology stocks are simulated for base and efficient technologies separately to account for EUL differences, and all early replacement measures are eligible for replacement by a more efficient measure one year after installation. The number of adoption decisions that may occur in a given year is considered the "eligible population." This calculation depends on the total building stock population,

[39] Each measure's life is defined as the effective useful life; this measure characteristic is based on DEER, FEA, or work papers as appropriate.

[40] Replace on burnout was the default assumption when source files did not specify a decision type. MICS Online includes full documentation of this assumption for each measure.

technology saturation (i.e., density) data, type of installation decision, and technology burnout rates (i.e., based on EUL).

In the second step, the PG Model simulates the adoption of each measure that passes a basic TRC screen in a given year.[41,42] The *measure screen* requires that measures meet or surpass a minimum TRC threshold ratio; this ratio differs for existing technologies and emerging technologies.[43] Measures that pass the TRC screen are then included in the economic potential (as described earlier in Section 2.1). The PG Model considers the number of installation decisions that may occur in that year, the estimated level of *awareness* of the measure in the eligible population, and the average *willingness* to adopt each measure that passes the TRC screen. Awareness is a comprehensive term that indicates that the customers are aware of the efficient technology, understand its financial attributes, and would consider adopting it. Willingness indicates the likelihood that an aware customer will adopt the efficient measure based on its financial attributes.

The model employs a dynamic Bass Diffusion approach to simulate market adoption, as illustrated in Figure 2-8.

- » ***Marketing, education, and outreach*** (ME&O) moves customers from the *unaware* group to the *aware* group at a consistent rate annually. Unaware customers, as the name implies, have no knowledge of the energy efficient technology option. Aware customers are those that have knowledge of the product and understand its attributes. ME&O may be conducted by IOUs or by other groups, including manufacturers and distributors of the product. An increase in the amount of effective ME&O can result in an increase in the rate of customer movement from the unaware to aware groups resulting in linear growth. ME&O is often referred to as the "Advertising Effect" in Bass Diffusion modeling.
- » ***Word of mouth*** represents the influence of adopters (or other aware consumers) on the unaware population by informing them of efficient technologies and their attributes. This influence increases the rate at which customers move from the unaware to the aware group; the word-of-mouth influence occurs in addition to the ongoing ME&O. When a product is new to the market with few installations, often ME&O is the main source driving unaware customers to the aware group. As more customers become aware and adopt, however, word of mouth can have a greater influence on awareness than ME&O, and leads to exponential growth. The exponential growth is ultimately damped by the saturation of the market, leading to an S-shaped adoption curve, which has frequently been observed for efficient technologies.
- » ***Willingness*** is the key factor affecting the move from an aware customer to an adopter. Once customers are aware of the measure, they consider adopting the technology based on the financial attractiveness of the measure. The PG Model applies a levelized measure cost to assess willingness; the levelized measure cost considers upfront cash outflows as well as cash outflows

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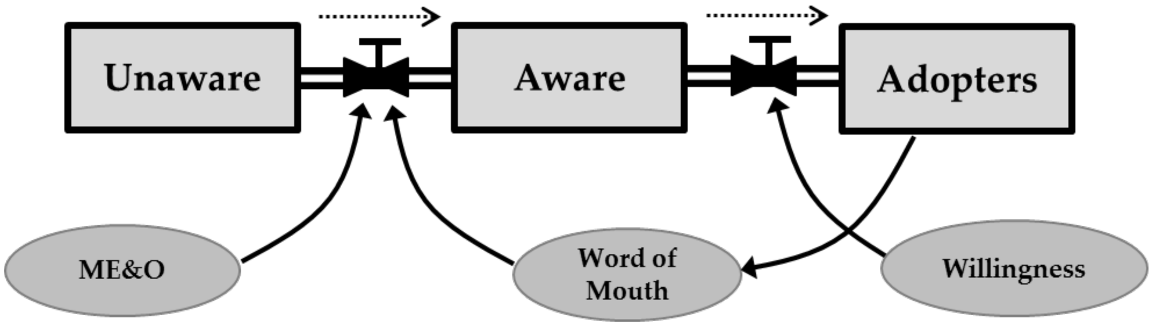
[41]Frank Bass. 1969. "A new product growth model for consumer durables." *Management Science* 15 (5): 215–227.
[42] John Sterman. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill.
[43] Section 2.3.4 includes additional information about the values used for these screens in the different scenarios.

that occur over time (e.g., energy costs).[44] IOU rebates and financing are factored in at this step; both increase the financial attractiveness of measures, thus improving customer willingness to purchase efficient technologies.

Figure 2-8. The PG Model Uses a Dynamic Approach to Calculating Measure Adoption



Source: Adapted from Sterman, 2000.

The PG Model applies a levelized measure cost approach rather than simple payback analysis to more appropriately capture the impacts of EE financing on market adoption. Simple payback is based on the time required for the investment to pay for itself (without discounting). The levelized measure cost approach is based on the present value of the cost of purchasing and operating the equipment throughout its EUL. The advantages of using the levelized measure cost approach are that it is more effective in capturing the effects of EE financing and it more easily allows competition of multiple measures with different EULs for each end use. This approach also applies best practices in predicting consumer behavior using a logit decision-maker approach.[45] [46]

In Step 3 (from Figure 2-7), the PG Model calculates the energy savings and corresponding costs and benefits resulting from measure adoption decisions in Step 2. The PG Model calculates ***measure savings*** relative to the appropriate ***baseline efficiency;*** in some cases (such as replace on burnout), the baseline is set by a code or standard, and in other cases (retrofit applications or any measure that is not regulated by an efficiency standard) it is set by the average product attributes of the currently installed baseline. For early replacement technologies, the baseline may shift multiple times due to both future changes in codes and standards as well as the assumed installations that would have otherwise occurred at the end of the remaining useful life; this is sometimes referred to as a dual baseline approach.

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[44] The levelized measure cost approach uses a discounted cash flow analysis to determine the present value of cash flows over the life of the measure; this present value of cash flows is levelized by the consumer-implied discount rate over the EUL to determine levelized measure cost.

[45] D. McFadden and K. Train 2000. "Mixed MNL Models for Discrete Response," *Journal of Applied Econometrics* 15, no. 5: 447-470.

[46] K. Train. 2003. *Discrete Choice Methods with Simulation*, Massachusetts: Cambridge University Press.

2.3.1.3 Model Calibration

Like any model that forecasts the future, the PG model faces challenges with validating results, as there is no future basis against which one can compare simulated versus actual results. Calibration, however, provides both the developer and recipient of model results with a level of comfort that simulated results are reasonable. Calibration is intended to achieve three main purposes:

» Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions

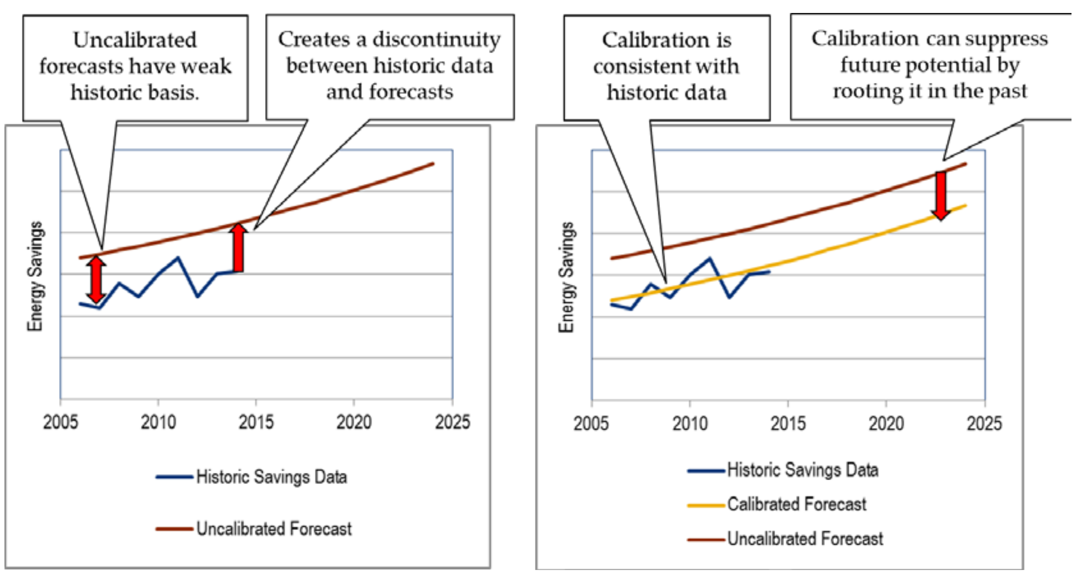
» Ensures a realistic starting point from which future projects are made

» Accounts for varying levels of market barriers across different types of technologies

The PG Model is calibrated by reviewing portfolio data from 2006 up through the 2013–2014 IOU compliance filings to assess how the market has reacted to program offerings in the past. The Navigant team reviewed ex-post EM&V data from 2006-2009 and ex ante data from 2010-2012 in addition to the compliance filing data. The Navigant team used the calibration data to adjust willingness and awareness parameters that drive measure adoption over the modeling period. This calibration method (a) tracks what measures have been installed or planned for installation over an historic eight-year period and (b) forecasts how remaining stocks of equipment will be upgraded, including the influence of various factors such as new codes and standards, emerging technologies, or new delivery mechanisms (e.g., financing or whole-building initiatives). This calibration approach is not applied to emerging technologies, as there is no historical basis to adjust future adoption for these technologies.

Figure 2-9 provides a conceptual illustration of how the calibration process affects market potential.

Figure 2-9. Conceptual Illustration of Calibration Effects on Market Potential



Source: Navigant team analysis 2013.

Calibration can limit market potential for measures when aligning model results with past IOU energy efficiency portfolio accomplishments. Although calibration provides a reasonable historic basis for estimating future market potential, past program achievements may not perfectly indicate the full potential of future programs. Calibration can be viewed as holding constant certain factors that might otherwise change future program potential, such as:

- Consumer values and attitudes toward energy efficient measures
- Program efficacy in delivering measures
- Program budgets and priorities

Changing values and shifting program characteristics would likely cause deviations from market potential estimates that are calibrated to past program achievements.

2.3.1.4 Treatment of "Decay"

"Decay" is an adjustment to cumulative market potential when cumulative potential is calculated by accumulating first-year incremental savings over past program years. When an IOU-rebated measure reaches the end of its effective useful life, it no longer saves energy. "Decay" describes the customer choice point to replace a high-efficiency measure that reached the end of its useful life with the original baseline measure as opposed to installing the exact same high-efficiency measure as before. In this case, savings from the originally installed efficiency measure are discontinued.

The CPUC assumes that IOU energy efficiency program efforts result in some degree of market transformation, changing consumption habits and preferences. Specifically, the CPUC has stated, "until EM&V results inform better metrics, utilities may apply a conservative deemed assumption that 50% of savings persist following the expiration of a given measure's life." This assumption means 50 percent of energy efficient measures that reach the end of their useful are actually replaced with the same energy efficient measure (i.e., consumers "reinstall" the measure and continue the savings), while the other 50 percent of previously installed program measures "regresses" to the existing baseline (and is therefore available to IOU programs as new potential). [47]

The PG Model advances existing assumptions about reinstallation rates by using the dynamic Bass Diffusion model to estimate reinstallation rates in each future year as opposed to applying a constant reinstallation rate of 50 percent across all measures in all future years. The PG Model assumes consumers reinstall measures at a rate consistent with uptake among new installers who are upgrading from baseline equipment. This maintains a conservative treatment of decay since previous adopters would typically be more likely to reinstall the efficient measure than a new adopter would be to switch to the new efficient measure.

2.3.2 Analysis of Policy Drivers

The 2013 Potential and Goals Study uses five primary Policy Drivers as the foundation of its analytical approach. These Policy Drivers provide a structure for considering the forces that drive the adoption of

[47] CPUC Decision 09-09-047 http://docs.cpuc.ca.gov/PUBLISHED/GRAPHICS/107829.PDF.

energy efficient measures. Understanding the extent to which these forces influence market adoption of energy efficiency can inform decisions about how to allocate resources to support deeper adoption of energy efficiency in California. The remainder of this section provides high-level descriptions of the approaches used to develop savings estimates for each of these Policy Drivers:

- IOU Portfolio Interventions (Section 2.3.2.1)
- C&S (Section 2.3.2.2)
- Whole-building Initiatives (Section 2.3.2.3)
- Financing (Section 2.3.2.4)
- IOU Behavior Programs (Section 2.3.2.5)

2.3.2.1 IOU Portfolio Intervention: IOU Rebates for Individual Measures

IOU portfolio interventions include the rebates that IOUs offer on individual measures through their existing portfolio of energy efficiency programs.[48] This section of the report and module in the model relate to voluntary market adoption in the presence of these rebates for individual, unbundled measures.

CALCULATING SAVINGS FROM IOU PORTFOLIO INTERVENTIONS

The PG Model calculates savings from IOU rebates using the underlying theory discussed in Section 2.3.1.2. Using a bottom-up approach, the PG Model builds on market saturation estimates, forecasts of new construction, energy efficiency technology data, past program savings, and market decision-making variables.[49] Separate simulations take place within each IOU service territory, which means that adoption of a given measure may proceed more quickly in one service territory than another in some cases.

Type of Measure Adoption. Measure adoption is considered at three points in the life of a base technology:

- *Replacement on Burnout:* An energy efficiency measure is implemented after the existing equipment fails.
- *Retrofit:* An energy efficiency measure that can be implemented immediately. The lifetime of the base technology is not a factor, as retrofit measures generally do not replace existing technologies but rather improve the efficiency of existing technologies. The energy impact is therefore the amount of that improvement.
- *New Construction:* A measure is installed at the time that a new building is constructed.

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[48] Analysis of IOU rebates for bundled measures (e.g., through Energy Upgrade California) and financing of energy efficiency measures will be addressed separately in the discussions about the Strategic Plan (Section 2.3.2.3) and about financing (Section 2.3.2.4).

[49] A few selected measures use modified approaches to calculating measure adoption. The approaches used for these measures in the 2013 Potential and Goals Study are consistent with those used in the 2011 Potential Study.[49] These measures are residential appliance recycling (i.e., refrigerators), residential and commercial behavior-based energy savings potential, and residential low-income measures.

Competition Groups. The market adoption methodology considers that some efficient technologies will compete against each other for the same installation.[50] For example, a consumer may adopt a SEER 13, SEER 15, SEER 18, or SEER 21 HVAC unit. The sum of all of these adoptions in a given year cannot exceed 100 percent of the market in that year; thus, the model considers that they are competing with one another for adoption in a given year. The model uses the levelized measure cost as a basis for assessing consumer decisions regarding which technology to adopt; this approach also accounts for differing lifetimes of the competing technologies.

General characteristics of competing technologies used to define competition groups include the following:

» Competing technologies share the same or similar base technology.

» Installation of competing technologies is mutually exclusive—installing one precludes installation of the others for that application.

» The base technology densities of competing efficient technologies are the same.

» The total maximum densities of competing efficient technologies are the same.

» Competing measures are "generally interchangeable." For example, it may be possible that split and package AC units would both be considered upon any AC unit burnout, but they are not easily interchangeable and therefore do not compete for most installations. Their competition is not as direct as for differing SEER values for each AC configuration, especially since switching costs of installation would vary substantially.

2.3.2.2 Codes and Standards

Codes and standards are implemented and enforced either by federal or state governmental agencies. Codes regulate building design, requiring builders to incorporate high-efficiency measures. Standards set minimum efficiency levels for newly manufactured appliances. The Navigant team assessed energy savings potentials for three types of C&S:

» Federal appliance standards

» Title 20 appliance standards

» Title 24 building energy efficiency code

C&S can be counted on to deliver energy savings, as they are required by law. Implementation of other voluntary standards (e.g., standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE] and various green building standards) cannot be easily predicted and, therefore, are not included in this study.[51] This treatment is consistent with the current CPUC

[50] The 2013 PG Study defines "competition" narrowly as competing for the same installation (e.g., SEER 15 vs. SEER 18) rather than broadly such as competing for the same savings (e.g., thermostat vs. SEER 18) or competing for the same budget (e.g., lighting vs. space conditioning).

[51] Much of the savings from voluntary standards will be achieved through voluntary IOU programs; these savings are inherently included in the IOU potential portion of the PG Model.

policies on IOU C&S programs.[52] This section includes an overview of the analysis completed as part of the 2013 Potential and Goals Study. Forthcoming appendices will include additional detail on the analytical and modeling approaches.

C&S program energy savings are generated from both currently adopted standards as well as future standards that will be adopted. Depending on adoption status of standards, they are classified into three different categories for scenario analysis: On-the-Books, Expected, and Possible standards. Different levels of information are available for these three types of standards and the corresponding energy savings have different levels of uncertainties.

» ***On-the-Books C&S*** include all codes and standards that have been passed into state or federal law. Relevant agencies already enforce many of these C&S and will enforce others as they come into effect in the near future. These C&S have high certainty to generate savings.

» ***Expected C&S*** are those currently undergoing regulatory rulemaking processes and are expected to be adopted in the near future. The adoption of these standards has a lower level of certainty than On-the-Books C&S, as the exact standard requirements have not been finalized. Therefore, the amount of potential energy savings is still uncertain.

» ***Possible C&S*** are in the process of being considered by government agencies. The Navigant team made several assumptions in the analysis as these C&S have little documentation from state or federal agencies. As such, these C&S have the lowest certainty of all the C&S modeled.

Table 2-8 summarizes the categories of C&S modeled as part of this study.

Table 2-8. Summary of Coverage of Codes and Standards by Modeling Category

Category Name	Description	Relative Level of Certainty	Initiatives Modeled in This Category
On-the-Books Initiatives	Already adopted Compliance dates have been set. Included in Track 1 modeling	High	» Title 20 (2005, 2006, 2008, 2009, 2011) » Title 24 (2005, 2008, 2013) » Select federal appliance standards
Expected Initiatives	In the process of being adopted; not yet a law Compliance dates and efficiency levels are generally agreed upon.	Medium	» Title 24 (2016) » Future Title 20 » Enhanced C&S compliance for Title 24, Title 20 and federal standards
Possible Initiatives	Have not been adopted Compliance dates and efficiency level may be uncertain.	Low	» Post-2016 updates to Title 24 (2019, 2022) » All future updates to federal appliance standards
Note: The Relative Level of Uncertainty column indicates the amount of uncertainty associated with the measure-level source of the savings and timing of the policy's implementation.			

[52] CPUC D.09-09-047, http://docs.cpuc.ca.gov/PUBLISHED/GRAPHICS/107829.PDF.

CALCULATING SAVINGS FROM CODES AND STANDARDS

Codes and standards affect IOU energy efficiency programs in two different ways. Codes and standards increase energy savings because they require customers to install high-efficiency measures in lieu of baseline equipment. The mandates can cause markets (a) to achieve higher levels of adoption and (b) to achieve those levels faster than possible in the absence of the legal mandate.

However, codes and standards also reduce the savings potential from traditional IOU rebate programs. C&S updates increase the baseline efficiency of utility-rebated measures, thus reducing the savings that IOUs can claim as a result of the rebate. The effects of state and federal standards on voluntary programs were quantified by the percentage impact to unit energy savings of affected voluntary program measures.

This study calculates the estimated savings of codes and standards on both a gross and net basis:

- » **Gross C&S Savings** are the total energy savings estimated to be achieved from the updates to codes and standards since 2006. Gross savings are used to inform demand forecasting, procurement planning, and tracking against greenhouse gas targets.
- » **Net C&S Program Savings** identify the portion of the total codes and standards savings that can be attributed to the advocacy work of the IOU's C&S program. Net savings calculations account for naturally occurring market adoption (NOMAD) of code-compliant equipment and utility attribution factors. The study includes the net program savings in order to inform the IOU-specific goals for portfolio planning.

The energy savings potential of the IOU C&S advocacy program are determined by Annual Net C&S Program Savings and Cumulative Net C&S Program Savings, which are defined based on the C&S energy savings defined in the CPUC 2006-2008 C&S program evaluation report,[53] as shown in Figure 2-10.

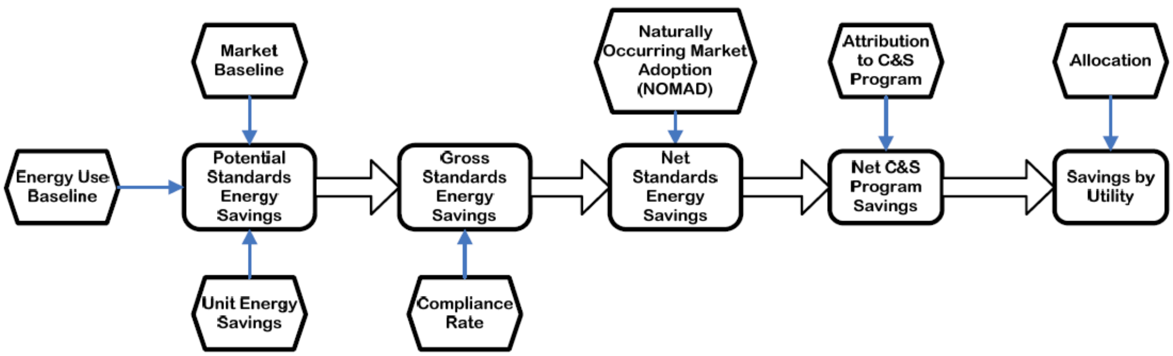
- » **Annual Net C&S Program Savings** are the energy savings attributed to IOU C&S programs from incremental installation of measures that comply with energy efficiency standards each year. They were calculated according to the definition of Net C&S Program Savings shown in Figure 2-10. This definition accounts for all C&S energy savings factors, including compliance rate, NOMAD, and utility attribution. Two types of measure installation are considered as incremental installation: 1) the new installation associated with new construction or first-time appliance purchase and 2) the first "replace-on-burnout" replacement after effective date of a corresponding standard.
- » **Cumulative Net C&S Program Savings** are the energy savings attributed to IOU C&S programs from all incremental installations since 2006. These are attributable to the IOUs as a result of their advocacy work and technical support necessary to develop measures through a market

[53] Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned 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.

adoption process that results in a measure being incorporated into code. They were calculated as the sum of Annual Net C&S Program Savings from 2006 to the year of interest.

Detailed modeling of Annual Net C&S Program Savings and Cumulative Net C&S Program Savings were based on an Excel tool used by the CPUC to develop the 2010-2012 C&S program evaluation plan. The Navigant team replicated the methodology and inputs of this tool in its potential study model for use in this study. Additional modifications to the methodology were made according to the treatment of savings from replace-on-burnout measures defined in this study.

Figure 2-10. Definitions of C&S Program Gross and Net Savings



Source: CPUC 2006-08 C&S Program Evaluation Report.

The 2011 Potential Study also analyzed the impact of C&S. This study continues to use the same methodology as the 2011 Potential Study but updates the scope of C&S included in calculations. Table 2-9 compares how standards have been treated in the 2011 Potential Study and in this study.

Table 2-9. Comparison of C&S Treatment in 2011 and Post-2014 Potential and Goals Study

Standards Group	2011 Potential Study		2013 Potential and Goals Study	
	Impact to Voluntary Programs	C&S Program Savings	Impact to Voluntary Programs	C&S Program Savings
Title 24	2005, 2008, and 2013 Title 24		2005, 2008, 2013, 2016, 2019, and 2022 Title 24; Compliance improvement scenarios included in C&S Program Savings	
Title 20	2005, 2006, 2008, 2009, and 2011 Title 20		2005, 2006, 2008, 2009, and 2011 Title 20 and select future Title 20 Standards	
Federal Appliance Standards	All adopted federal standards	Existing federal standards reported by IOU C&S Programs	All adopted federal standards plus future federal standards	Existing federal standards reported by IOU C&S Programs and updates to these reported standards

Source: Navigant team analysis 2013.

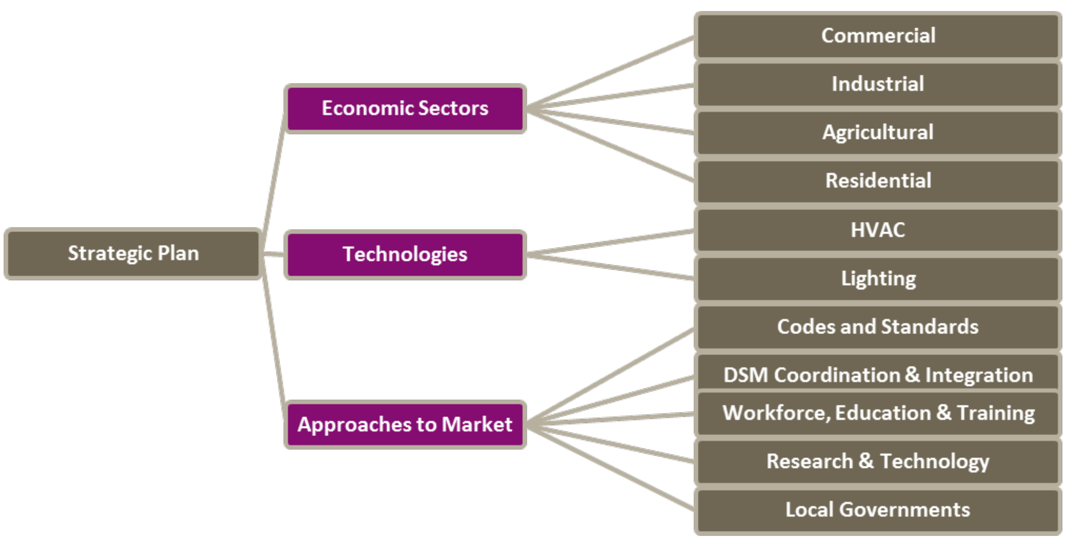
Additional details on the inputs used to model the effects of C&S on IOU programs can be found in Appendix D.

2.3.2.3 Strategic Plan, AB 758, and Whole-Building Initiatives

The Strategic Plan sets a statewide roadmap for 2009 to 2020 and beyond, to reduce energy use and maximize clean energy sources. CPUC spearheaded the development of the Strategic Plan and first released and adopted it in September 2008 with the support from the Governor's Office, the CEC, the CARB, the state's utilities, local government, and others. It contains detailed goals targeted at different economic sectors, addressing a cross section of technologies, and employing various approaches to reaching the market.

The Strategic Plan is a 128-page document organized around 11 focus areas. The Navigant team categorized these 11 focus areas into those that address specific sectors, technologies that cut across sectors, and other approaches to accessing the market, as illustrated in Figure 2-11.

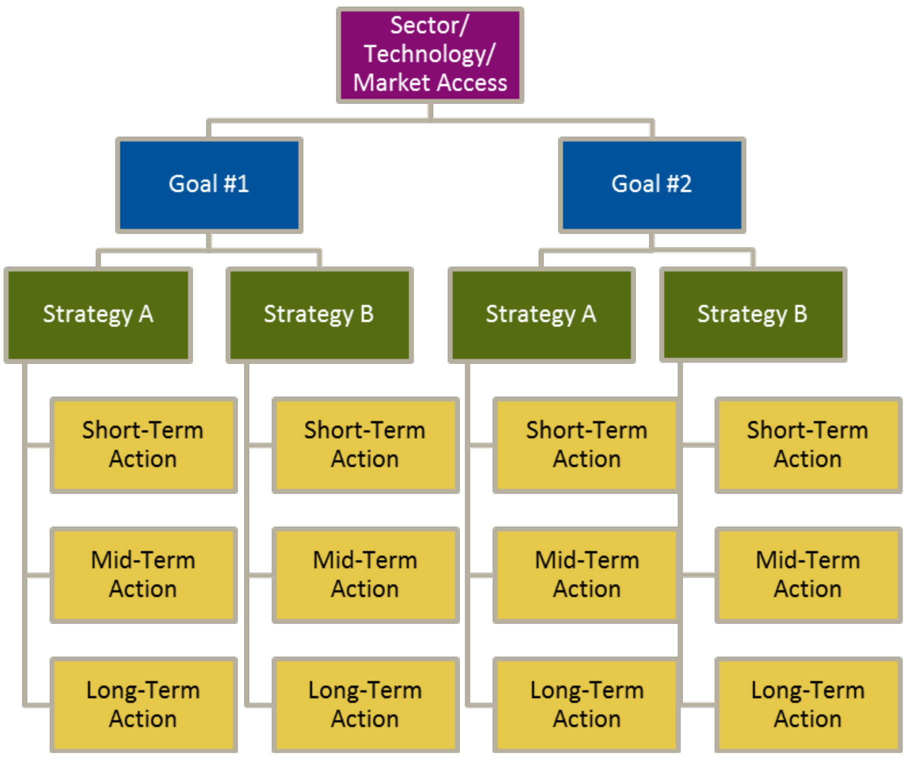
Figure 2-11. Organization of Strategic Plan



Source: Navigant team analysis 2013.

The focus of the Navigant team's analysis was on the Implementation Plan section, specifically on the strategies that are tied to the goals. Figure 2-12 illustrates the relationship between goals, strategies, and actions as they exist in the Strategic Plan. There are a total of 34 goals and 135 strategies. Each goal has one or more strategies associated with it; each strategy has one or more short-, mid-, and long-term actions.

Figure 2-12. Core Aspects of Strategic Plan Analyzed



Source: Navigant team analysis 2013.

The Navigant team employed a two-step process to analyze the Strategic Plan and identify priority goals, which should be analyzed for energy efficiency potential.

» **Step 1: Creating a Strategic Plan Assessment Database.** The assessment database applied a classification framework for the Strategic Plan. It facilitates understanding of the Strategic Plan as a whole or at more granular levels (i.e., goals or strategies). The framework categorizes each strategy along 25 categories that can be rolled up into 4 broader categories (Basic Information, Policy Prioritization Factors, Market Segments Affected, and Technologies/ Measures Affected). The Navigant team reviewed and classified each initiative according to various criteria laid out in the framework. Ultimately, this took the form of an Excel database, which allowed the Navigant team to sort, filter, and reference the data. It also facilitated scoring the strategies to determine the most influential, as described in Step 2.

- **Step 2: Identifying the Most Influential Strategies.** A scorecard was developed to identify the most influential goals for driving energy savings. The scorecard consists of eight criteria on which each strategy was scored. Most of the criteria correspond directly to the Strategic Plan assessment described in Step 1. Each criterion's score was weighted based on its relative importance to creating energy savings. Table 2-10 shows the criteria and corresponding weightings.[54]

Table 2-10. Criteria in Scorecard and Corresponding Weights

Category	Relative Weights	Example Scoring Criteria
Reach of Intervention	2.0	Type of Intervention Number of Sectors Affected
Impact of Technology	3.5	HIMs Impacted MOIs Impacted ETs Impacted
CPUC Priority	2.0	Action Plan Developed Related to Programmatic Initiative Champion Identified
Total Points Possible	7.5	

Source: Navigant team analysis, 2013.

[54] The scorecard also included a pre-screen to exclude any strategies that did not have energy savings as the primary goal. The assessment phase revealed that some Strategic Plan goals were targeted at aspects that are connected to energy savings, but do not lead directly to energy savings themselves. For example, "Coordinate phase-out of utility incentives for CFLs."

Following the scoring of the strategies, the Navigant team presented the top ten goals to the CPUC for consideration. The Navigant team selected these top goals based on: (1) the total number of points earned by all of the strategies that made up a goal and (2) the average number of points earned by the strategies that made up each goal. CPUC selected four goals that would be the most valuable to study further. Table 2-11 includes a list of the four Strategic Plan goals selected for modeling that are expected to drive the future of whole-building initiatives in California.

Table 2-11. Strategic Plan Goals Relating to Whole-Building Initiatives

Abbreviated Goal	Complete Goal
Existing Homes	Transform home improvement markets to apply whole-house energy solutions to existing homes. The Residential Energy Upgrade California program has very similar objectives to this goal.
Existing Buildings	50% of existing buildings will be equivalent to zero net energy (ZNE) buildings by 2030 through achievement of deep levels of energy efficiency and clean distributed generation. The Commercial Energy Upgrade California program has very similar objectives to this goal.
Zero Net Energy Residential Buildings	Residential new construction will reach ZNE performance (including clean, on-site distributed generation) for all new single- and multi-family homes by 2020.
Zero Net Energy Commercial Buildings	New construction will increasingly embrace zero net energy performance (including clean, distributed generation), reaching 100% penetration of new starts in 2030.

Source: California Energy Efficiency Strategic Plan Update, 2011.

These whole-building initiatives aim to deliver savings to residential and commercial customers as a group of multiple efficiency measures that are simultaneously installed. Whole-building initiatives modeled include both the new construction market and the retrofit market for residential and commercial buildings.

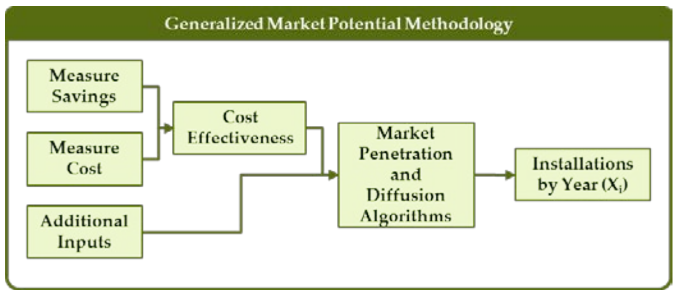
» New Construction: Whole-building initiatives that aim to influence the design and construction stage of a residential or commercial construction project to install multiple efficiency measures that exceed minimum requirements for Title 24 building code. This is intended to model the effects of programs such as Savings by Design and the California Advanced Homes Program. Varying levels of savings are possible ranging from simply exceeding code by 15 percent to constructing a ZNE home or building.

» Retrofit: Whole-building initiatives that aim to influence the whole-house and whole-building renovation projects to install multiple efficiency measures at the time of renovation. This is intended to model the effects of programs and initiatives such as Energy Upgrade California and AB 758. Varying levels of savings are possible depending on the level of investment.

CALCULATING SAVINGS FROM WHOLE-BUILDING INITIATIVES

The whole-building modeling approach uses the same underlying methodology for market adoption as is used to estimate IOU Portfolio Intervention (see section 2.3.2.1). A simple illustration of the method is shown in Figure 2-13. Additional details on the adoption methodology are provided in Section 2.3.1.2.

Figure 2-13. Illustrative IOU Portfolio Intervention Modeling Methodology



Source: Navigant team analysis 2013.

In the case of whole-building initiatives, the “measure” is characterized for the building retrofit or house retrofit rather than for specific end uses. The measure savings is equal to the total building energy savings that could be achieved by an average building participant. The measure cost is equal to the total equipment and installation cost for the whole energy efficiency upgrade. The whole-building measures included in the PG model are listed below in Table 2-12.

Table 2-12. Whole-Building Measures Modeled

Whole-Building Measure Name	Efficiency Level Achieved
Commercial New Construction Level 1	2008 T24 Compliant Building
Commercial New Construction Level 2	2013 T24 Compliant Building
Commercial New Construction Level 3	19% less energy use than 2013 T24 building
Commercial New Construction ZNE	Zero Net Energy Building (35-60% less energy than 2008 T24 building)
Commercial Renovation Level 1	20% less energy use than an average existing building
Commercial Renovation Level 2	35% less energy use than an average existing building
Residential New Construction Level 1	2008 T24 Compliant Home
Residential New Construction Level 2	2013 T24 Compliant Home
Residential New Construction Level 3	2013 T24 Stretch Goal Compliant Home
Residential New Construction ZNE	Zero Net Energy Home (40-50% less energy than 2013 T24 home)
Residential Renovation Energy Upgrade CA - Basic Path (MF only)	5-10% less energy use than an average existing home
Residential Renovation Energy Upgrade CA - Flex Path (SF Only)	15-20% less energy use than an average existing home
Residential Renovation Energy Upgrade CA - Advanced Path (SF Only)	30% less energy use than an average existing home

Source: Navigant team analysis 2013.

The Navigant team developed estimates of energy savings and costs for each whole-building measure listed in Table 2-12 using input data from various sources, including the following:

- Navigant team analysis of CEC Title 24 building code analysis[55] provided data to characterize commercial and residential New Construction Level 1-3.
- Energy Upgrade California (EUC) residential program reports and CPUC analysis[56] of those reported savings provided data for the three residential Renovation Energy Upgrade CA measures.

[55] 2013 Title 24 CASE Analysis and CEC Analysis as presented at CEC pre-rulemaking workshop on July 15, 2011. Package A3.

[56] CPUC. *Advanced Path Disposition Cover Letter.* March 2013.

- PG&E's technical feasibility of ZNE study[57] provided data for both residential and commercial ZNE measures.
- Navigant team analysis of retrofit whole-building savings and costs provided the data for Commercial Renovation Level 1 and 2.

The Navigant team assembled two bundles of conventional measures for Commercial Renovation Level 1 and 2 to determine the representative savings achievable from an average commercial renovation participant. These bundles leveraged conventional and emerging technology measure data found in the MICS. Bundle assembly accounted for reduced savings due to interactive effects across end uses (e.g., the impact of efficient lighting on space conditioning) and within end uses (e.g., the tiered effect of installing HVAC equipment and insulation equipment at the same time). Additional details on the methodology for whole-building measures and detailed sources of data for new construction, Energy Upgrade CA, and ZNE whole-building initiatives can be found in Appendix E.

Modeling whole-building measures required ensuring that savings are not double-counted across whole-building measures and individual measures. The Navigant team applied an approach whereby customers that participate in a whole-building initiative have made their maximum desired investment in energy efficiency and subsequently do not purchase any individual energy efficiency measures beyond those in the bundle. For example, consider a residential customer who renovates their home through Energy Upgrade California, which includes building shell and HVAC equipment upgrades. The model assumes that the homeowner chooses not to make any additional individual HVAC or building shell efficiency investments. This remains the case for the next 20 years (i.e., the applied EUL of the whole-building measure installed). The PG Model reflects this by removing whole-building participants from the general population of eligible participants for individual measures for the remaining duration. By doing so, the model ensures that savings from whole-building participants are not double-counted with individual measure participant savings.

2.3.2.4 Financing

The goal of the PG Model with respect to financing is to estimate the incremental effects of introducing EE financing on energy efficiency market potential and how shifting assumptions about financing affect the potential energy savings. Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective EE measures. This is demonstrated by positive results from the On-Bill Financing (OBF) and American Recovery and Reinvestment Act of 2009 (ARRA)-funded EE financing programs.

The CPUC has recently provided direction to the IOUs on EE financing in various proceedings.[58] Energy efficiency financing is now considered a resource program; this framework holds the IOUs accountable for tracking savings from the financing programs. The goals for the EE Financing Program include the following[59]:

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[57] ARUP. *The Technical Feasibility of Zero Net Energy Buildings in California*. Prepared for PG&E. December 2012.

[58] CPUC Decision 12-05-015, May 8, 2012 and Decision Approving 2013 -14 Energy Efficiency Programs and Budgets, October 9, 2012.

[59] Harcourt Brown & Carey, Inc. 2011. "Energy Efficiency Financing in California Needs and Gaps." July 8, 2011.

» Overcome the first cost of EE upgrades

» Leverage ratepayer funds by bringing in additional private capital

» Increase sales of energy efficient products and services

» Reach a broader set of customers and market segments

» Encourage customers to invest in projects that achieve deeper energy savings

Key challenges associated with modeling the incremental effects of EE financing on market potential include the following:

» The impacts of EE financing are difficult to predict due to lack of robust historical data.

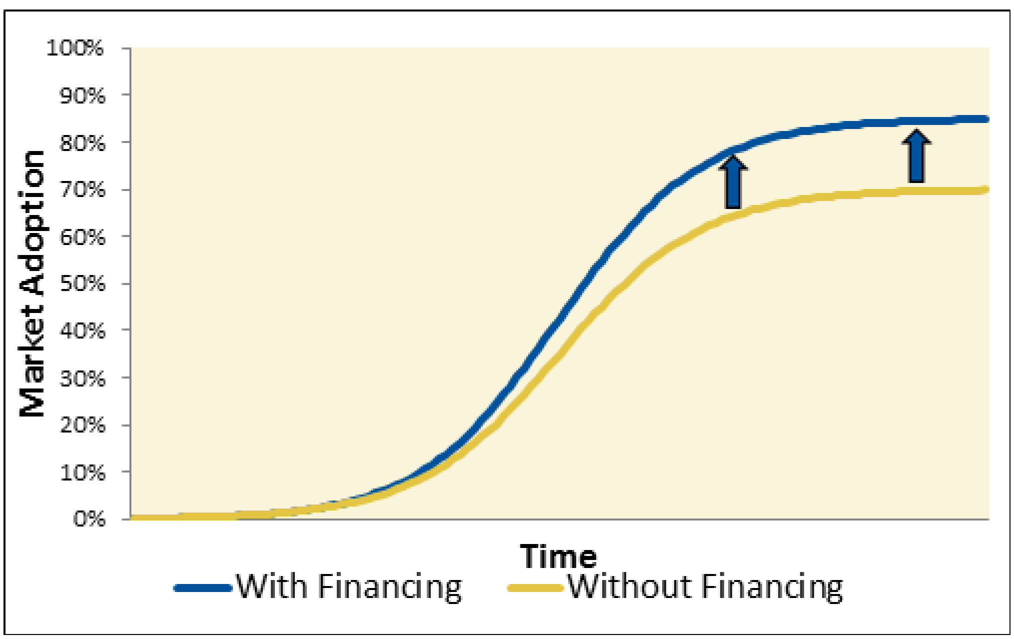
» Wide-scale deployment has not yet occurred in California, so it is not clear how pilot program results should be applied.

» Traditional "payback acceptance" approaches for estimating market potential do not accurately capture the full benefits of EE financing (e.g., avoiding upfront costs and reduced market barriers).

» Currently, there are no established best practices to incorporate financing into EE potential models.

Figure 2-14 displays the expected change in market adoption of energy efficient technologies as a result of introducing EE financing to the market.

Figure 2-14. Effect of Introducing EE Financing on Market Adoption



Source: Navigant team analysis, 2013.

IMPLIED DISCOUNT RATES

The iDR is the effective discount rate that consumers apply when making a purchase decision. It is the amount the customer is willing to pay for an EE investment, given all factors in the consumer's decision. Whereas the standard discount rate only considers the financial trade-off between the upfront cost relative to the longer-term savings, the implied discount rate also considers non-financial attributes. Table 2-13 captures the different elements that are captured by each type of discount rate.

Table 2-13. Components of Standard and Implied Discount Rates

	Decision-Maker Time Value of Money	Market Barriers
Examples of factors considered	Financial trade-off between upfront cost and longer-term savings using a discount rate that closely aligns with market rates of return	Lack of access to capital, split incentives, information search cost, liquidity constraint, and the effort required to secure external capital
Accounted for in standard discount rate?	Yes	No
Accounted for in implied discount rate?	Yes	Yes

Source: Gillingham, Newell, and Palmer. 2009. "Energy Efficiency Economics and Policy," Prepared for Resources for the Future.

Peer-reviewed research demonstrates that the discount rate that consumers apply to EE purchases is higher than market interest rates.[60] The higher iDR applied to energy efficiency purchases indicates that the consumer accounts for a range of perceived risks other than financial risks; such risks may include lack of access to capital, liquidity constraints, split incentives, hassle factor, information search costs, and behavioral failures.[61] The difference between a consumer's implied discount rate and the market interest rate is often referred to as the "e***fficiency gap.***"[62]

The Navigant team has developed a methodology for modeling the incremental effects of financing that is based on adjusting the iDR to account for the likelihood that financing reduces market barriers. The rationale for applying changes in the consumer iDRs when modeling adoption of energy efficiency technologies with and without financing includes the following:

- Consumers of energy efficiency exhibit behavior that is inconsistent when compared to consumer decision making in financial investments unrelated to energy efficiency.
- Payback data indicates that residential customers require a simple payback of less than 2 or 3 years, even for measures where savings persist for more than 20 years. A reasonable

[60] Gillingham, Newell, and Palmer. 2009. "Energy Efficiency Economics and Policy," Prepared for Resources for the Future, p. 7.

[61] Ibid.

[62] Ibid.

interpretation of this is that consumers are acting as though they have a high implied discount rate in their decision making.

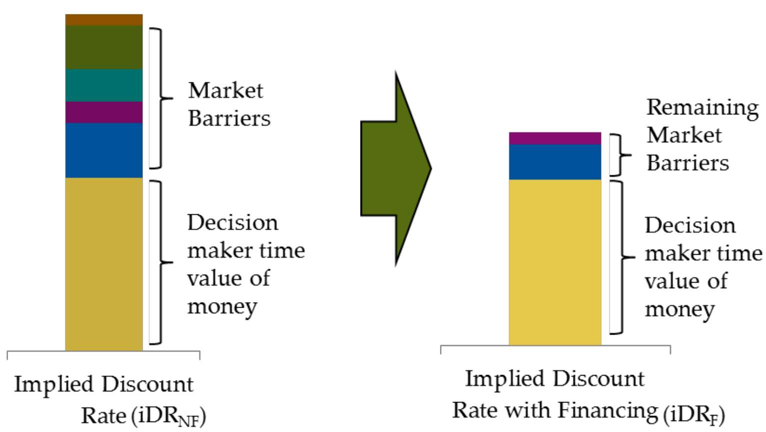
» Empirical evidence suggests that consumers' iDR ranges span from 20 to 100 percent.[63] Other data indicates that residential consumers on average exhibit behavior that implies an iDR_{NF} in excess of 60 percent for the residential sector.

» Research suggests that the efficiency gap (i.e., the discrepancy between the iDR and the market rate) is due to market barriers facing the EE industry.[64]

The PG Model uses primary data collected through an ongoing study in the Midwest to calculate the iDRs for each market sector. This data set represents the most current and comprehensive data set of this type of which the Navigant team is aware; it includes survey responses from over 400 residential and non-residential customers. The Navigant team explains adoption behavior without financing based on these calculated iDRs in the presentation of potential without financing.

The Navigant team models the change resulting from reduced market barriers that result from financing programs to calculate a new iDR when financing is introduced. The process evaluation of California's OBF program indicates that financing reduces (but does not completely eliminate) barriers related to lack of upfront capital, effort required to find a lender to finance the energy efficiency measure, and liquidity constraints.[65] The Mid-Energy Efficiency Penetration scenario considers moderate reductions in these barriers; Appendix F includes additional detail on the analytical methods used to determine those reductions. Figure 2-15 illustrates how EE financing decreases iDR by reducing market barriers.

Figure 2-15. Reduction in iDR Resulting from Introduction of EE Financing



Source: Navigant team analysis, 2013.

[63] Jaffe, Newell, and Robert Stavins. 2004. "Economics of Energy Efficiency," p. 87.
[64] Gillingham, Newell, and Palmer. 2009. "Energy Efficiency Economics and Policy," Prepared for Resources for the Future, p. 7.
[65] The Cadmus Group, Inc. 2012. "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment." Prepared for CPUC.

Research suggests that the discrepancy between the iDR and the market rate is due to market barriers facing the EE industry. The difference demonstrates that these inefficiencies and market barriers are reflected in a higher-than-expected average iDR. Specifying the contribution of the individual market barriers that make up this difference can lead to an estimate of the impact that financing mechanisms may have on reducing the implied discount rate.

The Navigant team estimated the change to the iDR by leveraging market research on EE financing programs to establish reasonable market barrier reduction.

The iDR is an explanatory construct that is used to illustrate why customers would choose the efficient technology over the base technology. It takes into account factors such as the magnitude and timing of the costs and savings associated with the technology choices. Presuming that financing is available and that its availability reduces some market barriers, consumers are likely to evaluate the decision to purchase the efficient technology over the base technology as if they care more about the cash flows in the future (i.e., as if they are applying a lower iDR). This mindset leads them to discount annual energy costs and savings more than they otherwise would, absent the presence of financing. One might argue that this is more rational behavior, or at least more consistent with the way that consumers act regarding other financial decisions.

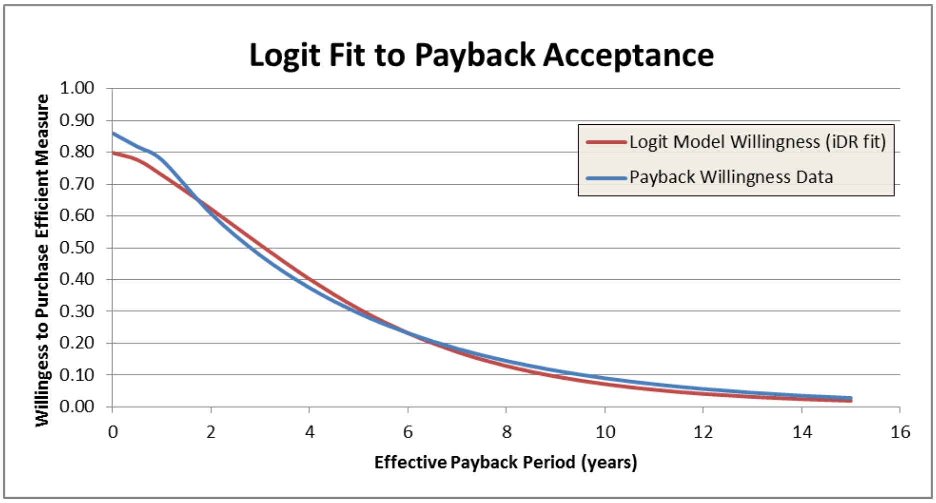
CALCULATING SAVINGS FROM FINANCING

The following steps summarize the Navigant team's approach to modeling the effects of EE financing on market potential. A more detailed discussion of the calculations is provided in Appendix F.

Step 1. Calculate market adoption without EE financing

- » Calculate implied discount rates.
    - o The Navigant team calculated implied discount rates with no financing (iDR_{NF}) for each customer segment[66] using payback curves[67] as a starting point. An illustration of the iDR model fit to payback acceptance data is shown in Figure 2-16. The blue line represents the payback acceptance data from the willingness survey, while the red line represents the logit model result for the best-fit iDR values.

Figure 2-16. Illustration of Logit Model Fit Exercise to Determine iDR Values



Source: Navigant team analysis, 2013.

- o iDR_{NF} and the implied discount rate with financing (iDR_F) are critical inputs to the levelized measure cost approach, which the model uses to project long-term market equilibrium without financing (Step 3 below) and with financing (Step 2 below).

- » The Navigant team calculated market adoption using the iDR_{NF}, measure characteristics, eligible population, rebates, word of mouth, advertising, and other inputs.

Step 2. Calculate market adoption with EE financing

[66] The iDR is available for single family [SF], multifamily [MF], and non-residential [NR].
[67] The Navigant team is using primary data collected through an ongoing study in the Midwest. This data set represents the most current and comprehensive data set of this type of which the Navigant team is aware; it includes survey responses from over 400 residential and non-residential customers.

- The Navigant team projected decreases in iDR resulting from the reduction of market barriers due to EE financing; reducing iDR by this amount results in iDR_F (Appendix F). Applying the reduced iDR increases the weight that consumers apply to future energy savings, which leads to a higher willingness to adopt efficient measures.
- The PG Model is re-run with financing included; instead of discounting the future cash flows by the iDR_{NF}, the PG Model discounts them using the iDR_F. The PG Model calculates adoption using the resulting new levelized measure cost; all other calculations remain the same.
- The PG Model can apply financing to individual measures and to whole-building measures.
- The PG Model can estimate market adoption with (a) rebates only, (b) rebates and financing, and (c) financing only.

Step 3. Calculate the incremental impact of EE financing

- The difference in output in the two model runs – without financing (Step 2) and with financing (Step 3) – determines the incremental impact of EE financing.

Step 4. Calculate the ratepayer funds needed for EE financing

- It is anticipated that this step will come later in the portfolio planning process. Using assumptions on leverage ratios, credit enhancement, and loan loss reserve strategies by sector, estimate the ratepayer funds needed.

Step 5. Review cost-effectiveness of the EE portfolio with financing

- It is anticipated that this step will come later in the portfolio planning process. The PG Model does not make this cost-effectiveness calculation because the approach to making the calculation has not yet been defined in the regulatory process.

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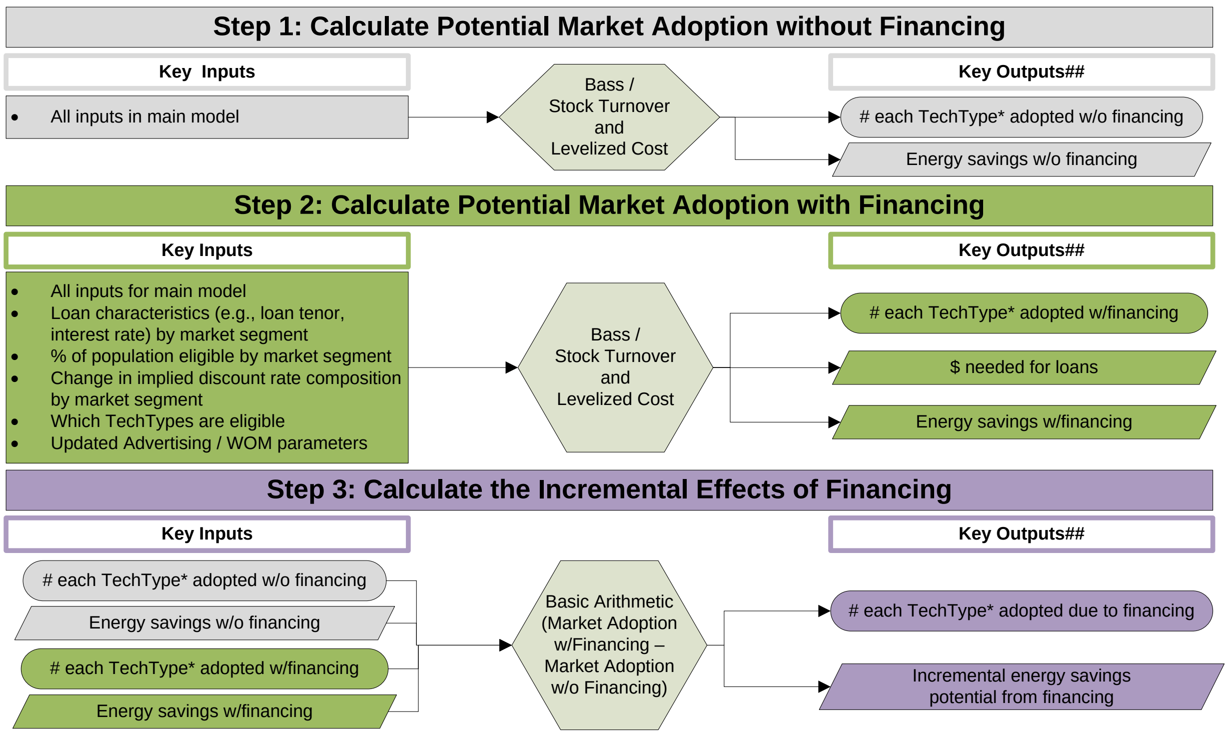
Figure 2-17 provides a more detailed summary of the Navigant team's approach to modeling EE financing.

Figure 2-17. Overview of Approach to Modeling EE Financing



Source: Navigant team analysis, 2013.

Changes to Approach to modeling Financing from the 2011 Potential study

Table 2-14 summarizes how the Navigant team adjusted the approach to modeling EE financing in response to feedback from stakeholders during development of the 2011 Potential Study.[68]

Table 2-14. EE Financing Methodology Adjustments

Feedback from Last Methodology Review	Approach
Financing **reduces the first-cost barrier.** The potential model should attempt to capture the market effect resulting from lowering upfront cost	• Proposing the levelized measure cost methodology. • Proposing to lower the consumer's implied discount rate to reflect the reduction in market barrier due to the lack of capital access.
Model should incorporate the **flexibility to accommodate different incentive scenarios.** For example, combining or isolating rebate and financing programs	• Adding flexibility to the model to incorporate different incentive scenarios.
Discuss the modeling approach's alignment with financing program design	• Financing programs reduce market barriers; the Navigant team is proposing to lower the consumer's implied discount rate to reflect the effects of financing programs. • Incorporating financing product characteristics (e.g., interest rates, loan terms, measure eligibility) proposed by the IOU financing pilot programs into the model.

Source: Navigant team analysis, 2013.

2.3.2.5 *IOU Behavior Programs*

Savings potential from behavior-based initiatives was included in the PG Model. For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions, rather than financial incentives, equipment, or services. These initiatives use a variety of implementation strategies including mass media marketing, community-based social marketing, phone calls, home visits, competitions, training, and feedback.[69]

Outcomes from behavior-based initiatives that result in energy savings can be broadly characterized as equipment-based and usage-based:

» **Equipment-based behavior –** Purchase and installation of higher efficiency equipment, relative to baseline conditions.[70] Examples of equipment-based behavior include the replacement of lights with higher efficiency lights, purchasing ENERGY STAR-qualified appliances, and purchasing premium efficiency motors. In the PG Model, these savings are modeled implicitly at

[68] Stakeholders commented on approaches that the Navigant team proposed to use to model the effects of financing during development of the 2011 Potential Study. Due to changes in the focus of the 2011 Potential Study, the final model and report did not include financing.

[69] For further discussion, see *Evaluation of Consumer Behavioral Research*, Navigant (Summit Blue Consulting) for the Northwest Energy Efficiency Alliance, April 6, 2010, page 4.

[70] This could be either the early retirement of older equipment or the installation of high-efficiency equipment at the natural time of installation or replacement.

the equipment level as contributions to the percentages of the population that are aware of the measure and that are willing to adopt this measure.

Equipment-based behavior can be sub-categorized as:

- **Non-incented equipment-based behavior –** The purchase of higher efficiency equipment for which no incentives are provided.
- **Incented equipment-based behavior –** The purchase of higher efficiency equipment for which incentives are provided. Also known as "channeling."

» **Usage-based behavior –** Changes in usage and maintenance of existing equipment. Examples of usage-based behavior include turning off lights, unplugging electronics and chargers, programming thermostats, and improving the efficiency of equipment through modified maintenance practices. In the PG Model, these savings are modeled as an equipment-independent module with savings unassociated with equipment improvement.

The overall modeling methodology, data sources, inputs, and assumptions for IOU behavior programs in the PG Model are unchanged from the methodology used in the 2011 Potential Study.

2.3.3 Crosscutting Issues

Several issues cut across many parts of the analysis in the 2013 Potential and Goals Study. These issues affect the results of the study. This section describes how the Navigant team addressed the savings accounting framework (Section 2.3.3.1) and market transformation in the context of the stage of market adoption (Section 2.3.3.2).

2.3.3.1 Savings Accounting Framework

The PG Model applies a straightforward approach to accounting for energy savings from the three key drivers (C&S-driven savings, rebate-driven savings, and Strategic Plan-driven savings). IOUs receive credit for all of the savings driven by the Strategic Plan because (1) IOU programs are now aligned with Strategic Plan and (2) IOUs are a key driver of the Strategic Plan goals covered in this study.

Table 2-15. Approach to Accounting for Savings from Three Key Drivers

Key Driver	Rationale	Type of Organization Counting Savings	
		IOUs	Non-IOUs
C&S-Driven Savings	Stakeholder- and CPUC-vetted methodology exists to distribute savings between IOUs and C&S	Allocated as per existing CPUC C&S evaluation methodology	Allocated as per existing CPUC C&S evaluation methodology
Rebate-Driven Savings	IOUs already receiving credit	100%	0%
Strategic Plan-Driven Savings			
Strategic Plan Voluntary Measure-Based Initiatives	Adoption modeled as bundle of measures eligible for incentives	100%	0%
Strategic Plan C&S-Related Initiatives	Stakeholder- and CPUC-vetted methodology exists to distribute savings between IOUs and C&S	Allocated as per existing CPUC C&S evaluation methodology	Allocated as per existing CPUC C&S evaluation methodology

Source: Navigant team analysis, 2013.

2.3.3.2 *Market Transformation: Variable Incentives*

The PG Model provides the capability to consider differential incentive levels according to the stage of technology maturity.[71] The Navigant team uses level of market saturation for individual technologies as the proxy for technology maturity because this data is already available and vetted. This set of scenarios provides the ability to test the hypothesis that providing higher incentives earlier in the market adoption cycle leads to faster market uptake.

The variable percent incentive structure departs from current rebate structures. Current rebate structures tend to give a fixed incentive as a percent (approximately 50 percent) of the incremental cost of an energy efficient measure. When modeling this fixed incentive level over time, the incentive percent level is assumed constant through 2024 (though the actual dollar amount of the incentive could change if equipment costs change). Under the variable incentive structure, the percent incentive level is tied to the technology maturity and can change as a technology becomes more mature.

The reasoning behind offering different incentive levels for different levels of technology maturity is as follows:

» ETs can save significant amounts of energy but can be expensive. Often in early years, ETs have limited market uptake due to high costs, which can slow their ultimate market adoption. As ETs mature, their cost can come down and they can contribute a larger portion of savings to the market. Providing a higher level of incentives than usual for ETs can "kick-start" the market for ETs, decrease their high initial costs, and increase adoption in early years. As these measures become more common in the market and their costs decline, rebate levels can be reduced

» Mature technologies, on the other hand, are already prevalent in the market and may soon be subsumed by appliance standards. These technologies may offer only minor savings as laggard customers eventually adopt these technologies. Incentives for these technologies could be set lower than average as there is significant market awareness of the technologies already.

To implement this variable incentive approach, the Navigant team structures incentives as illustrated in Table 2-16. Table 2-16 also provides a comparison to a fixed incentive structure.

Table 2-16. Variable Incentive Structure

Technology Stage	Nascent Technology	Low Maturity Technology	Mid-Maturity Technology	High Maturity Technology
Market Saturation	0-5%	5-25%	25-75%	75%-100%
Incentive Level (Variable Structure)	100%	90%	75%	50%
Incentive Level (Existing Fixed Structure)	50%	50%	50%	50%

Source: Navigant team analysis, August 2013.

[71] The default assumption in the Mid-Energy Efficiency Penetration scenario is that the rebate covers 50 percent of a measure's incremental cost.

This incentive structure is not new to the California energy landscape. A similar variable incentive structure has been implemented through the California Solar Initiative, which offered high rebates when the program launched with an explicit plan to gradually reduce incentive levels as the market saturation of solar increased in California.

2.3.4 IOU Market Scenario Analysis

The PG model can run numerous scenarios; however, the default scenario presented in this report is based on population, consumption, and economic inputs defined in the mid-case of the California Energy Commission's 2012 IEPR. For IOU market potential, the Navigant team developed two alternate scenarios to estimate potential in the PG Model: The High Energy Efficiency Penetration and the Low Energy Efficiency Penetration scenarios.[72] These scenarios present a range of possible results based on the population, consumption, and economic inputs defined in the high and low energy demand forecasts in the 2012 IEPR, and also different assumptions for a set of variables that either have uncertainty associated with them or that the CPUC can influence through policy making. Figure 2-17 includes a description of the variables for which the assumed values change during scenario analysis.

Table 2-17. Definition of Variables Used in Scenario Analysis

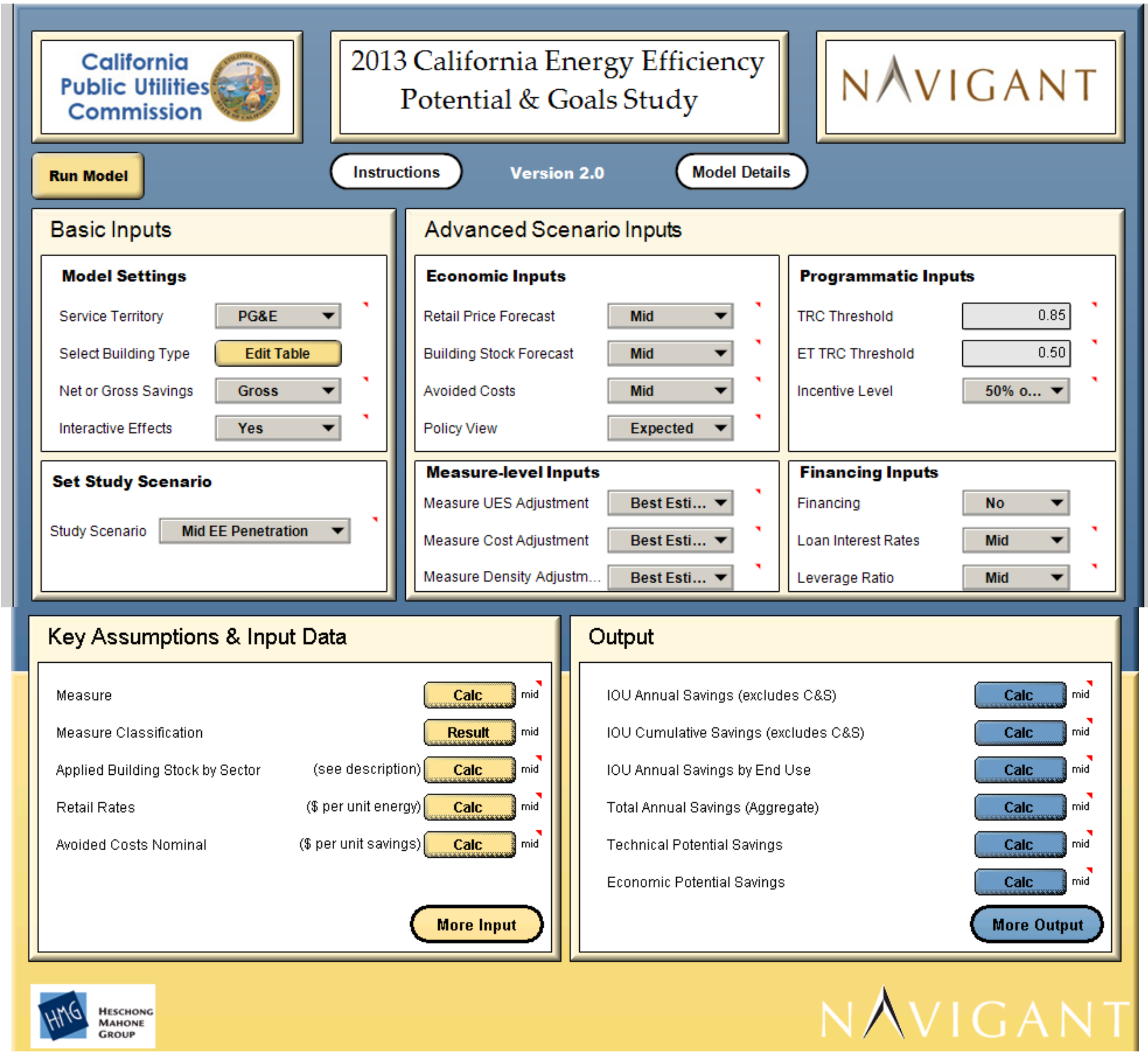
Scenario Element	Definition
Incentive Level	The incentive level refers to the percent of incremental cost that is covered by IOU program rebates.
Measures Cost Adjustment	The incremental costs for efficient technologies are from DEER 2008. Due to their vintage, the multiplier varies incremental costs across all technologies to account for changes over time.
Implied Discount Rate	The implied discount rate is the effective discount rate that consumers apply when making a purchase decision; it is the amount the customer is willing to pay for an EE investment, given all factors in the consumer's decision.
Marketing, Education and Outreach Effect	The ME&O effect moves customers from the unaware group to the aware group.
TRC Threshold	The TRC threshold element varies the cost-benefit threshold that general measures must meet.
Avoided Costs	The avoided costs are the monetary benefit of energy and demand savings for a specific EE measure.
Measure Density Adjustment	Measure densities refer to the baseline and efficient measure densities. By modifying one of these for a given measure, the other is automatically updated in order to ensure that the sum of baseline and efficient measure densities is one.
Measure UES Adjustment	UES are less certain for ETs. The multiplier allows the user to examine the effects of varying the calculated UES for ETs.
Retail Price Forecast	The retail rates are the projected energy rates to the ratepayer.

[72] For a discussion of the scenarios developed for the 2013 IEPR demand forecast see page 76.

Scenario Element	Definition
Word-of-Mouth Effect	The word-of-mouth effect represents the influence of adopters (or other aware end users) on the unaware population by informing them of efficient technologies and their attributes.
Building Stock Forecast	The building stocks forecast is based on the expected development of each sector.
ET TRC Threshold	The ET TRC Threshold varies the cost-benefit threshold that emerging technology measures must meet.
C&S Scenario Name	The C&S Scenario Name refers to the types of C&S included in each scenario.
Note: The PG Model allows the user to adjust the value of any one or all of these user inputs. The values used for each of these scenario elements in each scenario can be found in Section 3. *Source: Navigant team analysis, 2013.*	

Figure 2-18 illustrates how the PG Model captures these scenario elements on the user interface. Users can automatically set the values for all scenario elements to those established in the low and high scenarios by using the "Set Study Scenario" drop-down menu. Alternatively, users can adjust scenario elements individually by using the drop-down menus for each element.

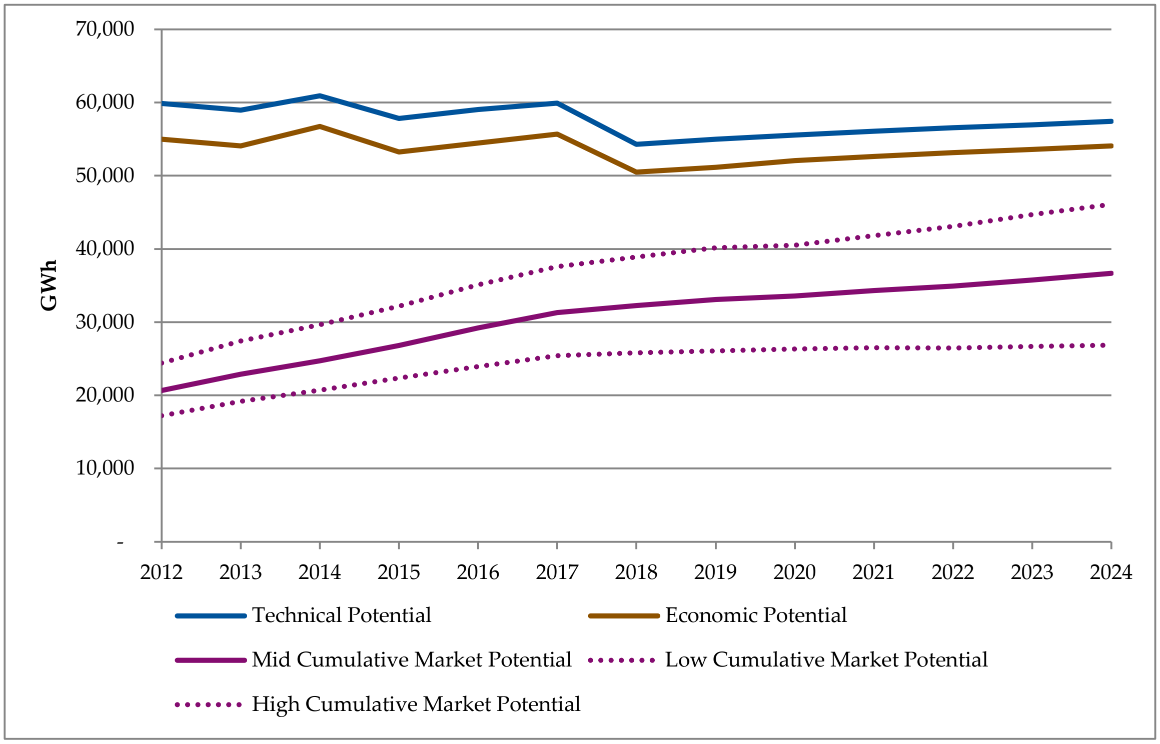
Figure 2-18. Model Interface and User Inputs



Source: PG model release August 2013

The Mid-Energy Efficiency Penetration scenario is intended to reflect the potential under business-as-usual circumstances. The incentive level, TRC threshold, avoided costs, measure-level data, and other variables use data that are consistent with current policies and program designs and widely accepted data sources. The Low and High Energy Efficiency Penetration scenarios adjust the inputs to reflect potential in the event that those underlying assumptions change. Figure 2-19 captures the results of these three IOU market scenario analyses for all sectors and all electricity IOUs. Table 2-18 summarizes the combination of user input values selected for each market potential scenario.

Figure 2-19. Results of the IOU Market Scenario Analysis[73]



Source: PG model release August 2013

In the case of the High Energy Efficiency Penetration scenario, the values for the variables are adjusted to consider a more optimistic future, one in which incentive levels and avoided costs are higher and the financial attractiveness of measures is better (in addition to other changes). The Low Energy Efficiency Penetration scenario includes assumptions that make investment in energy efficiency less favorable. The High Energy Efficiency Penetration scenario represents approximately a 25 percent increase in cumulative market potential by 2024 relative to the Mid-Energy Efficiency Penetration scenario. The Low Energy Efficiency Penetration scenario represents roughly a 25 percent decrease in cumulative market potential relative to the Mid-Energy Efficiency Penetration scenario for that same time frame.

[73] Source: PG Model released in August 2013. This chart shows the High, Mid, and Low scenarios for the cumulative market potential; technical and economic potential are also adjusted in the High and Low scenarios, but those adjustments are omitted from this graph for simplicity.

Table 2-18. Sample of Scenario Composition

Metric	Low EE Penetration	Mid EE Penetration	High EE Penetration
Building Stock	Low Case from 2011 IEPR	Mid Case from 2011 IEPR	High Case from 2011 IEPR
Retail Prices	Low Case from 2011 IEPR	Mid Case from 2011 IEPR	High Case from 2011 IEPR
Avoided Costs	Low Case from 2011 IEPR	Mid Case from 2011 IEPR	High Case from 2011 IEPR
UES	Estimate minus 25%	Best Estimate UES	Estimate plus 25%
Incremental Costs	Estimate plus 20%	Best Estimate Costs	Estimate minus 20%
Incentive Level	25% of incremental cost	50% of incremental cost	Varies by market maturity
TRC Threshold	1	0.85	0.75
ET TRC Threshold	0.85	0.5	0.4
Measure Densities	Best estimate minus 20%	Best Estimate	Best estimate plus 20%
Word of Mouth Effect*	1%	2%	3%
Marketing Effect*	39%	43%	47%
Implied Discount Rate	20%	18%	14%
Code compliance	No compliance enhancements	Compliance enhancements	Compliance enhancements
Title 24 Adoption Dates	2005, 2008, 2013	2005, 2008, 2013, 2016	2005, 2008, 2013, 2016, 2019, 2022
Title 20 Adoption Dates	2005, 2006, 2008, 2009, 2011	2005, 2006, 2008, 2009, 2011, 2013, 2016	2005, 2006, 2008, 2009, 2011, 2013, 2016
Federal Standards	Already adopted	Already adopted	Already adopted and possible future standards

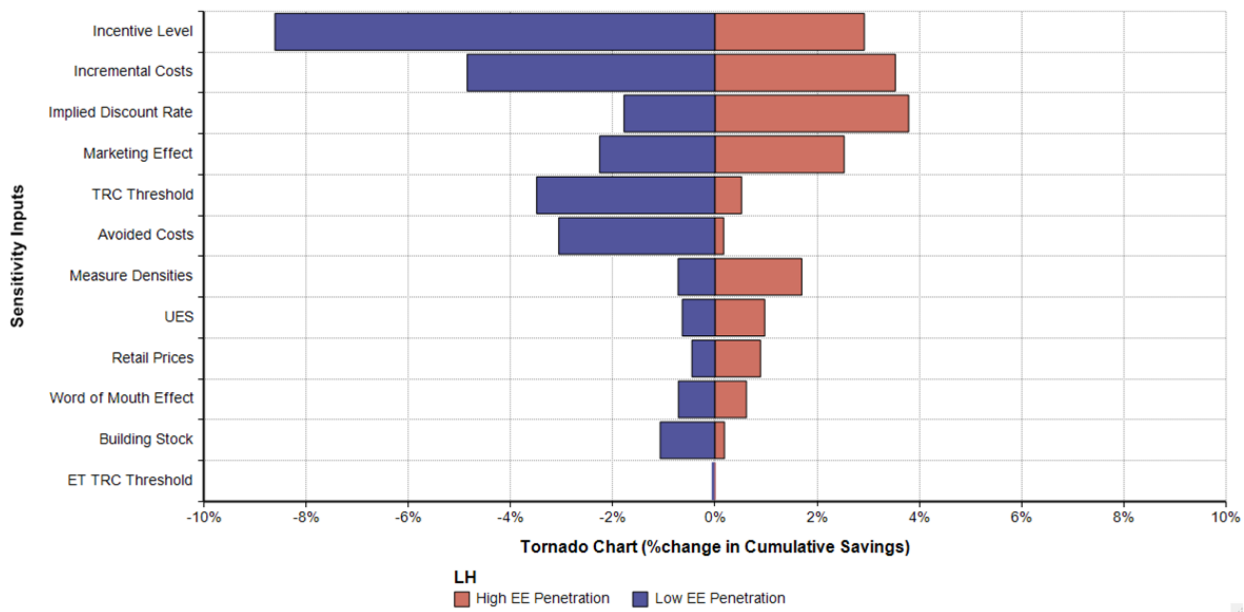
Source: Navigant team analysis, 2013

The range of market potential from the scenarios presented in Figure 2-19 is the result of the influence of a number of drivers and Figure 2-20 shows the relative importance of these drivers. This "tornado chart" was developed by varying one input assumption at a time, leaving the values of all other variables consistent with those in the Mid-Energy Efficiency Penetration scenario. The x-axis in the tornado chart shows the percent change in cumulative market potential in a specific year caused by changing the value of that single variable from the Mid to the High scenario (in red) or the Mid to the Low scenario (in purple). The variables with the bigger bars have a more significant impact on the results of the analysis. The model shows that two types of variables have significant effects on the potential for energy efficiency:

1. **Technical inputs.** There is some uncertainty in some technical inputs (e.g., incremental cost, avoided costs, and measure density).[74] The Navigant team used well-vetted sources (e.g., DEER 2008 and 2011, Commercial End Use Study, and Residential Appliance Saturation Study) to determine appropriate values for these, but future values may not align with these historical values. The accuracy of these inputs is out of the control of policy makers, except to the extent that policy makers dedicate additional resources to studies that improve the accuracy of these values.
2. **Policy variables.** Policy makers can affect the value of other variables (e.g., TRC threshold, incentive level). Figure 2-20 shows the model's sensitivity to these inputs to represent the areas in which policy makers can have the most impact on outcomes. The two policy variables that have the most impact on results are as follows:
    a. **Incentive level.** The Low Energy Efficiency Penetration scenario includes an incentive for 25% of incremental cost for all measures. The High Energy Efficiency Penetration scenario considers an incentive structure in which the incentives vary by stage of market adoption. For example, rebates for measures with up to 5% saturation are at 100% of incremental cost; for measures with 5% to 25% saturation are at 90% of incremental cost; for measures with 25% to 75% saturation are at 75% of incremental cost; for measures with more than 75% saturation are at 50%.
    b. **TRC threshold.** The Low Energy Efficiency Penetration scenario assumes a TRC threshold of 0.75, compared to 0.85 in the Mid-Energy Efficiency Penetration scenario and 1.0 in the High Energy Efficiency Penetration scenario. All non-emerging technology measures must pass this threshold in order to be eligible for adoption.

[74] Historically, DEER updates have focused more resources on energy savings calculations than on incremental costs; consequently, the incremental cost data may be outdated. Avoided costs may change as the key inputs change. The studies that provide measure density data are dated; for example, the Commercial End-Use Survey was released more than seven years ago.

Figure 2-20. Tornado Chart Showing Model Sensitivities to Changes in Key Variables



Note: This chart shows results for the Commercial sector; results in the Residential sector are similar.
Source: PG model release August 2013

The values provided in the high and low scenarios provide a reasonable range of cumulative energy efficiency potential; however, the likelihood that the inputs that define the high and low scenario would align over the ten-year forecast horizon is doubtful. As such, the Navigant team recommends that the values from the mid scenario be considered as the basis for the IOU services territory goals for the portfolio beginning in 2015. Table ES-3 provides the mid-case model outputs for annual, life-cycle, and active cumulative market potential. The Navigant team considers these estimates a viable baseline target for energy efficiency to which program planners, load forecasters, system planners, and resource procurement specialists could agree. This is not, however, intended to define the upper bound on the total amount of energy efficiency that can be achieved during upcoming portfolio cycles. As noted in the discussion on the objectives for this study, that will be determined as the market for innovative products and services continues to evolve.

2.3.5 Forecast Scenarios of Additional Achievable Energy Efficiency

In addition to the IOU market potential scenarios discussed in section 2.3.4, additional scenarios were produced during the third quarter of 2013 to support the 2013 IEPR update process. For these scenarios, referred to as Additional Achievable Energy Efficiency (AAEE) scenarios[75], the CPUC, California Energy Commission (CEC), and the California Independent System Operator (CAISO) collaborated[76] to develop

[75] In previous CEC forecasting efforts, these savings had been referred to as incremental uncommitted savings
[76] The collaboration occurred through the Joint Agency Steering Committee is composed of managerial representatives from the Energy Commission, the California Independent System Operator, and the California

an estimate of the energy efficiency savings forecast that could be realized through utility programs *that are incremental to the savings already incorporated in the Energy Commission's current forecast*[77]. This effort involved estimating the portion of savings from the 2013 Potential Study not accounted for in the baseline forecast. These AAEE estimates form the basis for the energy efficiency potential scenarios to be included in the 2013 IEPR update. The five AAEE scenarios were defined to account for two types of uncertainty:

1. Inputs from the 2012 IEPR demand forecast: specifically, building stock growth rate, retail electricity rates, and avoided cost variables. These same variables are inputs to the IEPR base forecast;
2. Key variable input assumptions: specifically, variables related to emerging technologies, code compliance, Title 24 code adoption dates, incremental measure cost, implied discount rate, marketing effect, cost-effectiveness ("Total Resource Cost") threshold, unit energy savings, word of mouth effect, and other variables. (See Section IV below for detailed descriptions of each of these variables.)

Because the AAEE scenarios are intended to inform the 2013 IEPR demand forecast, they require a set of input assumptions and model outputs that are different from the modeling assumptions used to estimate energy efficiency market potential for IOU activity discussed in section 2.3.5. Specifically, the AAEE forecasts differ from forecasts of IOU market potential in two important ways;

1. The AAEE scenarios used in the IEPR forecast are based on net[78] values for measure savings. The demand forecast requires that net savings be forecast because naturally occurring savings (including free-riders) are expected to be embedded in the forecast. The IOU market potential forecasts in the PGT report, including the scenarios presented in section ES.3, are based on gross measure savings estimates.
2. The C&S savings estimates in the AAEE scenarios include all C&S savings in an IOU territory[79], not just the savings attributable to IOU C&S advocacy. The C&S savings estimated in the PGT report for IOU market potential are focused on savings potential that result from IOU code advocacy, and are therefore a much smaller value than the IEPR C&S potential savings estimates.

Table 2-19 presents a summary of the model inputs for the five AAEE scenarios, and Figure 2-21, Figure 2-22, and Figure 2-23 present the AAEE forecasts for cumulative net energy (GWh and MMThm) and demand (MW) potential. A description of the technical details and a discussion of the stakeholder process used to develop and vet these scenarios, can be found in Appendix M, Estimates of Additional Achievable Energy Savings [80] and Appendix N, Background and Detail on Additional Achievable Energy Efficiency Scenarios. Appendix O provides additional data supporting these graphs.

Public Utilities Commission and is committed to improving coordination and process alignment across state planning processes that use the Energy Commission's demand forecast.

[77] the California Energy Demand 2014-2024 Revised Forecast (CED 2013 Revised)

[78] Net of free riders

[79] Less naturally occurring market addition (NOMAD) estimates.

[80] Estimates of Additional Achievable Energy Savings. Supplement to California Energy Demand 2014-2024 Revised Forecast. Draft Staff Report. California Energy Commission, September 2013. CEC-200-2013-005-SD

Table 2-19. Proposed Scenarios for Additional Achievable Energy Efficiency

Scenario Number	1	2	3	4	5
Scenario Name	**Low case**	**Low-mid case**	**Mid case**	**High-mid case**	**High case**
ET's	25% of model Results	50% of model Results	100% of model results	150% of Model Results	150% of Model Results
Building Stock	High Demand Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Low Demand Case from 2011 IEPR
Retail Prices	High Demand Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Low Demand Case from 2011 IEPR
Avoided Costs	High Demand Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Mid Case from 2011 IEPR	Low Demand Case from 2011 IEPR
UES	Estimate minus 25%	Estimate minus 25%	Best Estimate UES	Estimate plus 25%	Estimate plus 25%
Incremental Costs	Estimate plus 20%	Estimate plus 20%	Best Estimate Costs	Estimate minus 20%	Estimate minus 20%
Incentive Level	50% of incremental cost	50% of incremental cost	50% of incremental cost	50% of incremental cost	50% of incremental cost
TRC Threshold	1	1	0.85	0.75	0.75
ET TRC Threshold	0.85	0.85	0.5	0.4	0.4
Measure Densities	Estimate minus 20%	Estimate minus 20%	Best Estimate Costs	Estimate plus 20%	Estimate plus 20%
Word of Mouth Effect*	39%	39%	43%	47%	47%
Marketing Effect*	1%	1%	2%	3%	3%
Implied Discount Rate	20%	20%	18%	14%	14%
C&S Scenario Name	On-the-Books Initiatives	On-the-Books Initiatives	Expected Initiatives	Possible Initiatives	Possible Initiatives
Standards Compliance	No Compliance Enhancements, Compliance Rates Reduced by 20 percent	No Compliance Enhancements, Compliance Rates Reduced by 20 percent	No Compliance Enhancements	No Compliance Enhancements	Compliance Enhancements
Title 24 Updates	2005, 2008, 2013	2005, 2008, 2013	2016, 2019, 2022	2016, 2019, 2022	2016, 2019, 2022
Title 20 Updates	2005, 2006, 2008, 2009, 2011	2005, 2006, 2008, 2009, 2011	2016-2018 (Staggered introduction)	2016-2018 (Staggered introduction)	2016-2018 (Staggered introduction)
Federal Standards	Already adopted	Already adopted	Already adopted	Future Federal Standards	Future Federal Standards

Figure 2-21. Proposed Scenarios for Additional Achievable Energy Efficiency for the 2013 IEPR Forecast, Cumulative GWh

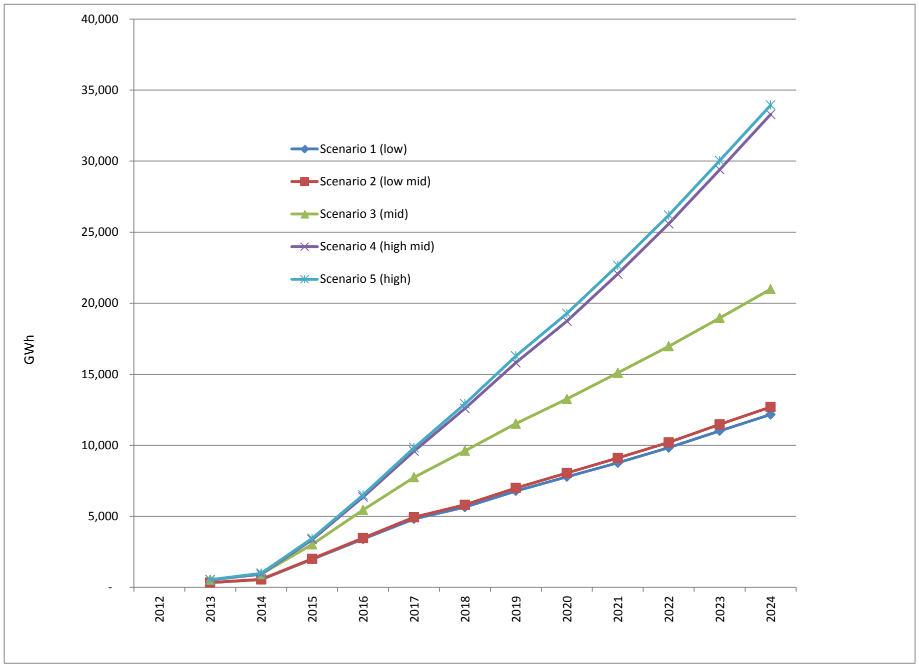


Figure 2-22. Proposed Scenarios for Additional Achievable Energy Efficiency for the 2013 IEPR Forecast, Cumulative MW

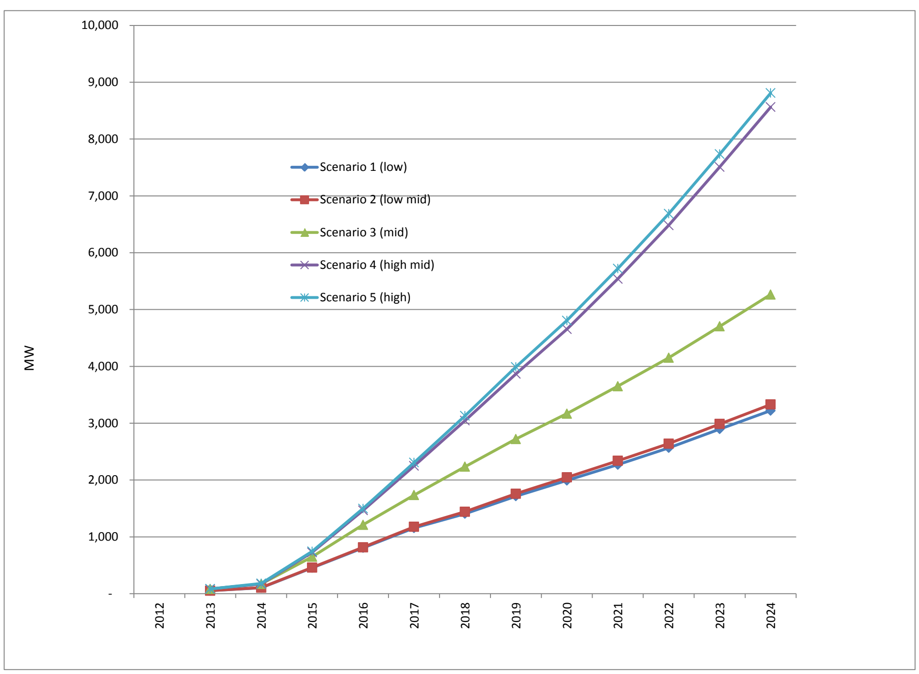
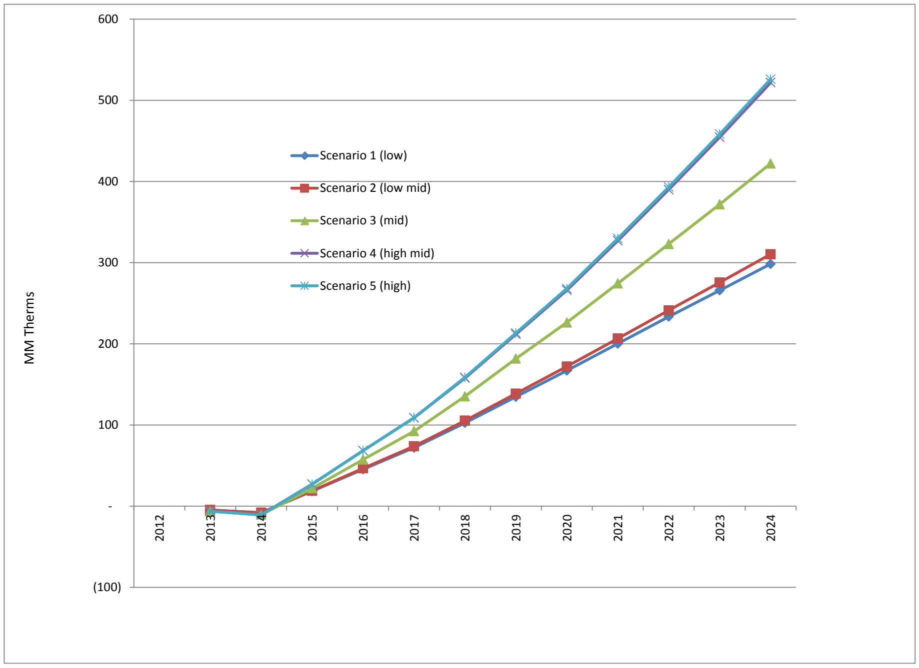


Figure 2-23. Proposed Scenarios for Additional Achievable Energy Efficiency for the 2013 IEPR Forecast, Cumulative MMThm



3 Methodology for the Agriculture, Industrial, Mining, and Street-Lighting Sectors

This section describes the Navigant team's methodology to develop inputs for the PG Model for the AIMS sectors. These sectors were added to the scope of the 2011 Potential Study to more thoroughly model energy efficiency savings potential in California.

Collectively, the AIMS sectors represent approximately 20 percent of electric consumption and 30 percent of natural gas consumption in the four IOU service territories.[81] Table 3-1 shows the breakout for each.

Table 3-1. Percent of Energy Consumed Statewide by Sector

	Agriculture	Industrial	Mining	Street Lighting	Total
Electric	7%	15%	5%	1%	20%
Gas	1%	30%	2%	0%	30%

Source: Navigant team analysis of the California Energy Consumption Data Management System (ecdms.energy.ca.gov/).

Programs tailored to the AIMS sectors differ from their residential and commercial counterparts. Similar to residential and commercial programs, AIMS programs are designed to provide energy/demand savings primarily through changes in equipment (i.e., retrofit and/or replace on burnout). However, AIMS sector programs (with the exception of street lighting) tend to be comprised primarily of custom measures because the diversity of industries within these sectors, and the diversity of establishments within each industry, make prescriptive offerings difficult. For this reason, standardized data on measures and markets are less available for the AIMS sectors than for the residential and commercial sectors, and the Navigant team had to develop custom approaches to analyzing potential in each of these sectors based on available data.

Each of the four AIMS sectors required a slightly different approach to modeling savings potential. The industrial and agricultural sectors used a supply curve approach to calculating savings potential while the mining and street-lighting sectors used the same bottom-up methodology for calculating adoption and energy savings potential as the residential and commercial sectors (described in Section 2.1). These approaches reflected the disparate information available for each sector:

- Section 3.1 describes the approach for the industrial sector. The Navigant team used DOE's Industrial Assessment Center (IAC) database to identify potential and develop energy efficiency supply curves for each end use in each subsector.
- Section 3.1 describes the approach for the agricultural sector. The Navigant team used IOU work papers, statewide inventories of agricultural establishments, and data from similar industrial

[81] http://ecdms.energy.ca.gov/.

facilities (e.g., food processing) to develop energy efficiency supply curves. The Navigant team then used expert interviews to corroborate and refine these findings.

» Section 3.3 describes the approach for the mining sector. The Navigant team used numerous secondary sources, including a statewide inventory of oil and gas extraction activity, to estimate potential. The Navigant team also interviewed a program implementer to further inform this estimate.

» Section 3.4 describes the approach for the street-lighting sector. The Navigant team used IOU-provided inventories of street-lighting equipment in their territories to characterize the existing market, and several secondary sources to characterize the measures applicable to these end uses.

3.1 Approach to the Industrial Sector

The industrial sector accounts for 13 percent of electricity consumption and 30 percent of natural gas consumption across all four IOU service territories.[82] The Navigant team divided energy consumption in the industrial sector into 15 subsectors and 7 end uses, summarized in Table 3-3 and Table 3-4. To develop the subsector categorization, the Navigant team used the CEC's definition of industrial segments as a starting point.[83] The 25 segments identified by the CEC correspond to different North American Industrial Classification System (NAICS) codes and together encompass all industrial energy consumption in California. For the purposes of this potential study, the Navigant team compressed the list of 25 segments into 15 by combining similar industries. For example, the Navigant team combined the "Food Processing" and "Food and Beverage" industries into the single category "Food." Table 3-2 shows the final list of industrial segments (or subsectors), along with the segments' distribution of statewide energy consumption in 2010.

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[82] Based on Quarterly Fuel and Energy Reports (QFER) submitted by California utilities and compiled by the California Energy Commission (CEC). Available online at http://ecdms.energy.ca.gov/.

[83] California Energy Commission. 2005. *Energy Demand Forecast Methods Report*. Accessed at http://www.energy.ca.gov/2005publications/CEC-400-2005-036/CEC-400-2005-036.PDF.

Table 3-2. Industrial Sector Statewide Electric and Gas Consumption by Subsector (%), 2010

Subsector	NAICS Code(s)	Percent of Statewide Industrial Electricity Consumption	Percent of Statewide Industrial Gas Consumption
Petroleum	324	19%	53%
Food	311, 312	18%	19%
Electronics	334, 335	16%	2%
Stone-Glass-Clay	327	7%	5%
Chemicals	325	9%	8%
Plastics	326	6%	1%
Fabricated Metals	332	5%	3%
Primary Metals	331	2%	3%
Industrial Machinery	333	3%	1%
Transportation Equipment	336	4%	2%
Paper	322	4%	2%
Printing & Publishing	323, 511, 516	3%	0%
Textiles	313, 314, 315, 316	1%	1%
Lumber & Furniture	337, 321, 1133	2%	0%
All Other Industrial	339	2%	1%
Total		100%	100%

Source: Navigant team analysis of CEC-provided statewide energy consumption data for 2010.

The Navigant team used the industrial end-use categories defined in DOE's Manufacturing Energy Consumption Survey (MECS) for this analysis,[84] and applied the data from the MECS to estimate the proportions of energy use in each end use for each subsector. Table 3-3 states the portion of industrial sector electricity consumption for each end use in each subsector. Table 3-4 states these proportions for natural gas consumption.

[84] U.S. Energy Information Administration (EIA) Manufacturing Energy Consumption Survey (MECS). 2006 Energy Consumption by Manufacturers –Data Tables. Accessed at http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html.

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Table 3-3. Distribution of Total Industrial Sector Electricity Consumption by End Use and Subsector

Subsector	Lighting	HVAC	Machine Drive	Process Heating	Process Cooling & Refrigeration	Other	TOTAL
Petroleum	0.4%	0.7%	16.5%	0.0%	1.1%	0.1%	18.8%
Food	1.2%	1.4%	7.4%	1.2%	5.1%	1.4%	17.7%
Electronics	1.6%	4.0%	3.3%	1.9%	1.8%	3.0%	15.6%
Stone-Glass-Clay	0.4%	0.4%	4.0%	1.5%	0.0%	0.2%	6.5%
Chemicals	0.3%	0.6%	5.2%	0.4%	0.7%	1.3%	8.6%
Plastics	0.5%	0.6%	2.8%	0.8%	0.5%	0.3%	5.5%
Fabricated Metals	0.5%	0.5%	2.5%	1.0%	0.2%	0.5%	5.2%
Primary Metals	0.1%	0.1%	0.7%	0.7%	0.0%	0.8%	2.4%
Industrial Machinery	0.5%	0.7%	0.9%	0.2%	0.2%	0.2%	2.7%
Transportation Equipment	0.6%	0.8%	1.6%	0.6%	0.3%	0.4%	4.3%
Paper	0.2%	0.2%	3.1%	0.1%	0.1%	0.3%	4.0%
Printing & Publishing	0.4%	0.6%	1.7%	0.1%	0.2%	0.3%	3.2%
Textiles	0.2%	0.3%	0.3%	0.0%	0.0%	0.2%	1.0%
Lumber & Furniture	0.3%	0.4%	0.7%	0.2%	0.1%	0.3%	2.0%
All Other Industrial	0.4%	0.6%	0.8%	0.2%	0.1%	0.2%	2.4%
Total	7.6%	11.8%	51.4%	9.1%	10.5%	9.7%	100.0%

Source: Navigant team analysis of CEC-provided statewide energy consumption data for 2010. End-use distributions based on DOE's MECS data.

Table 3-4. Distribution of Total Industrial Sector Natural Gas Consumption by End Use and Subsector

Subsector	Conventional Boiler Use	Process Heating	HVAC	Other	TOTAL
Petroleum	7.5%	31.4%	0.5%	13.5%	53.0%
Food	11.1%	5.3%	0.9%	1.6%	18.9%
Electronics	0.7%	0.2%	0.6%	0.2%	1.7%
Stone-Glass-Clay	0.1%	4.7%	0.2%	0.3%	5.2%
Chemicals	2.1%	2.2%	0.1%	3.3%	7.8%
Plastics	0.3%	0.2%	0.1%	0.1%	0.7%
Fabricated Metals	0.4%	1.7%	0.4%	0.2%	2.7%
Primary Metals	0.2%	2.3%	0.2%	0.3%	3.0%
Industrial Machinery	0.1%	0.1%	0.3%	0.1%	0.6%
Transportation Equipment	0.2%	0.5%	0.5%	0.3%	1.5%
Paper	0.5%	0.6%	0.1%	1.0%	2.1%
Printing & Publishing	0.1%	0.3%	0.1%	0.0%	0.5%
Textiles	0.3%	0.3%	0.7%	0.2%	1.5%
Lumber & Furniture	0.0%	0.1%	0.2%	0.0%	0.3%
All Other Industrial	0.1%	0.1%	0.3%	0.1%	0.5%
Total	23.7%	49.8%	5.2%	21.2%	100.0%

Source: Navigant team analysis of CEC-provided statewide energy consumption data for 2010. End-use distributions are based on DOE's MECS data.

The Navigant team calculated energy efficiency potential in the industrial sector using a supply curve approach. The sector's broad diversity of activities and the limited availability of measure-level energy efficiency data by industry segment necessitated a different approach than the residential and commercial sectors. Energy efficiency supply curves require fewer input parameters relative to bottom-up modeling approaches used in the residential, commercial, mining, and street-lighting sectors.

The Navigant team notes that other organizations have recently used supply curves to estimate industrial energy efficiency potential. McKinsey & Company recently used supply curves to estimate industrial efficiency potential in the U.S. economy,[85] and the United Nations Industrial Development Organization (UNIDO) used supply curves to estimate the potential of motor systems energy savings worldwide.[86]

[85] McKinsey & Company. 2009. *Unlocking Energy Efficiency in the U.S. Economy*. Accessed at http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy.
[86] United Nations Industrial Development Organization. 2010. *Motor Systems Efficiency Supply Curves*. Accessed at http://www.unido.org/index.php?id=1000596.

To inform the industrial energy efficiency supply curves, the Navigant team used data from DOE's IAC database. The full database contains over 118,000 energy efficiency recommendations, or measures, provided by IAC members at nearly 16,000 individual industrial sites across the U.S.[87] The industrial sites included within the IAC are small to medium sized; have gross annual sales below $100 million; have fewer than 500 employees at the site; have annual energy bills between $100,000 and $2.5 million; and have no professional in-house staff to complete self-assessments.[88] Each IAC recommendation is a record in the database and includes fields such as the NAICS code of the site; a categorization of the measure by end use and character of measure; and estimates of cost and annual energy savings of the measure.

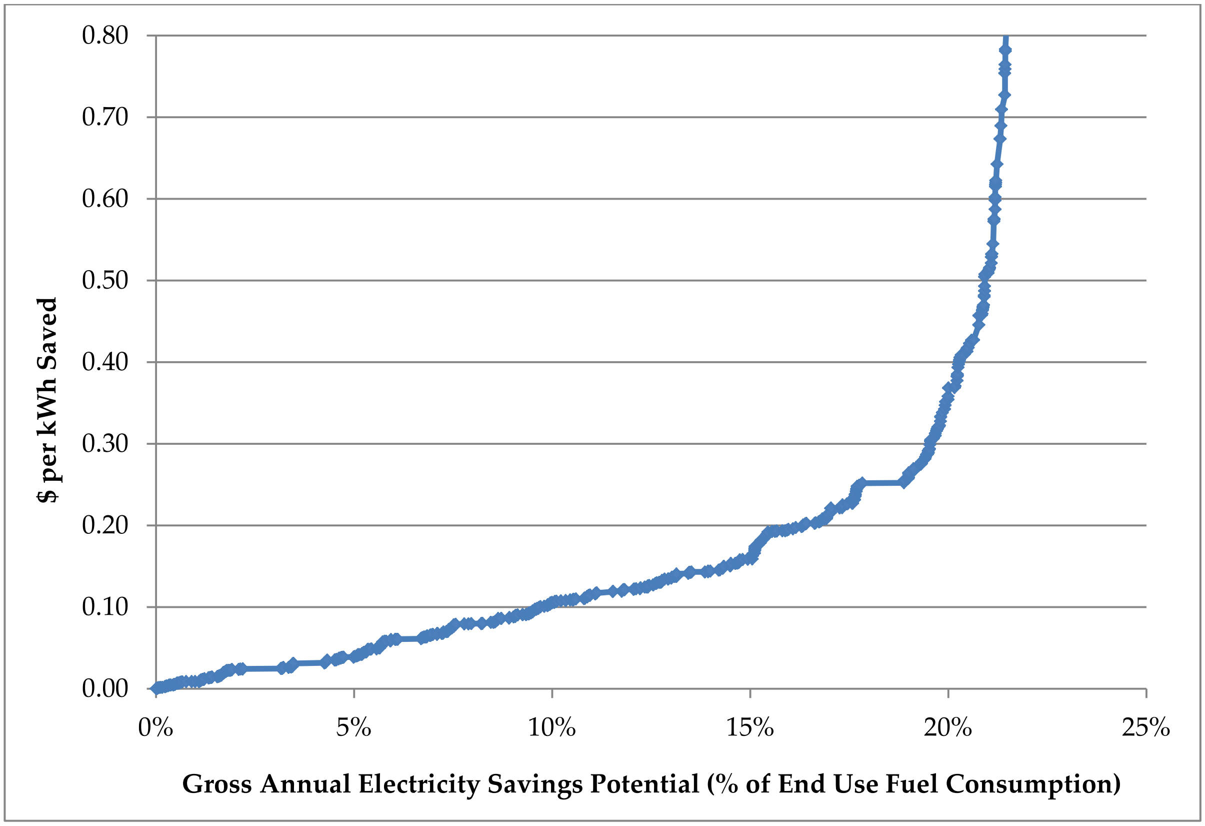
The Navigant team interpreted this collection of recommendations as the energy efficiency potential at the sample of buildings in the database. The Navigant team added an additional layer of functionality to the IAC data by building its own version of the IAC database, mapping data to the industrial subsectors and end uses used for this study. Measures were further categorized as either operation and maintenance (O&M) or equipment-based measures. The Navigant team made this distinction to reflect the wide difference in the EULs of efficient equipment-derived savings and O&M-derived savings (e.g., 10-20 years compared to 3-5 years, respectively).

For each subsector, end use, and measure type (O&M and equipment), the Navigant team compiled all relevant data points in the IAC database, and ordered them from least to highest levelized cost to create energy efficiency supply curves. Although the IAC database contains assessments from the early 1980s through the present, the Navigant team only considered data from 2004 to the present to better estimate current conditions.

Figure 3-1 shows an example EE supply curve generated by the Navigant team using IAC data. This curve illustrates estimated gross, annual electric savings potential for lighting end-use equipment measures in the industrial Food segment (NAICS 311 and 312). Each point on the curve in the figure represents an individual EE recommendation made at an industrial site; in this case, the curve is made up of 673 recommendations made at 335 unique sites in the past eight years. Savings are normalized by total industrial segment end-use consumption; for example, Figure 3-1 shows the percent savings potential of all lighting end-use electricity in the industrial Food segment.

[87] Industrial Assessment Centers Database. Accessed at http://iac.rutgers.edu/database.
[88] U.S. Department of Energy. Industrial Assessment Centers, http://www1.eere.energy.gov/manufacturing/tech_assistance/iacs.html#assessments.

Figure 3-1. Sample Supply Curve of Gross Annual Electric Energy Savings Potential of Lighting in the Industrial Food Segment



Source: Navigant team analysis of DOE's IAC database.

In total, the Navigant team considered over 190 different segment, end-use, and measure-type EE supply curve combinations within the IAC data and ultimately used over 150 different supply curves in the final industrial model. After screening out supply curves with insufficient data, these supply curves, and the Navigant team's analysis, draw from approximately 16,000 recommendations made at over 10,000 sites.

Next, the Navigant team supplemented the IAC data to estimate the energy efficiency potential of Petroleum Process Heat. The Petroleum subsector accounts for nearly a quarter of all IOU territory electric consumption and over half of all IOU territory gas consumption. The largest industry within California's Petroleum subsector, petroleum refining, is represented by large, energy-intensive facilities that fall outside of the scope of the IAC. For these reasons, the Navigant team treated the Petroleum subsector, and particularly the Process Heat end use, which accounts for the majority of Petroleum gas consumption, separately from the other subsectors and end uses in this study.

The Navigant team referred to a 2005 Lawrence Berkeley National Laboratory (LBNL) study of energy efficiency opportunities for petroleum refineries.[89] The Navigant team reviewed the different processes

[89] LBNL. *Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries*, 2005.

involved in petroleum refining and the corresponding EE opportunities available within each process and used this data to develop supply curves for the Petroleum subsector.

The Navigant team then examined the industrial sector to determine whether end uses in each subsector would refresh or saturate. This *refreshment* approach estimates that, for certain measures and subsectors, potential will sustain over the analysis period even as the current stock of baseline equipment reduces due to replacement with efficient equipment. This refreshment represents the introduction of emerging technologies in future years, continuous implementation of O&M best practices, and process improvements that are typically implemented as a part of production changes and equipment retooling. Conversely, the Navigant team estimates that potential will *saturate* for certain end uses and certain subsectors. The Navigant team does not anticipate any emerging technologies or other efficiency improvements to provide further opportunities for potential in these cases.

Table 3-5 shows the Navigant team's refreshment and saturation assumptions that apply to all electric and gas potential results.

The Navigant team specified equipment and O&M measures for each industrial subsector. Additionally, measures are differentiated by the end uses: HVAC, Lighting, Machine Drives, Process Heat, Process Refrigeration, and Service Hot Water.

Table 3-5. Industrial Sector Refreshment and Saturation Assumptions

Refresh/Saturate Assumptions by End Use and Subsector (refresh=1, saturate=0)	Fabricated Metals (NAICS 332)	Food (NAICS 311x, 312)	Electronics (NAICS 334x, 335)	Stone-Glass-Clay (NAICS 327x)	Chemicals (NAICS 325)	Plastics (NAICS 326)	Primary Metals (NAICS 331)	Industrial Machinery (NAICS 333)	Transportation Equipment (NAICS 336)	Paper (NAICS 322x)	Printing & Publishing (NAICS 323, 511, 516	Textiles (NAICS 313, 314, 315, 316)	Lumber & Furniture (NAICS 337, 321, 1133	All Other Industrial (NAICS 339)	Petroleum (NAICS 324)
Equipment															
HVAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MachDr	0	1	1	0	1	1	0	1	1	0	0	1	0	1	0
ProcHeat	0	1	1	0	1	1	0	1	1	0	0	1	0	1	0
ProcRefrig	0	1	1	0	1	1	0	1	1	0	0	1	0	1	0
SHW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M															
HVAC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lighting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MachDr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ProcHeat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ProcRefrig	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SHW	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Source: Navigant team analysis, 2013.

Finally, the EE supply curves provided many of the inputs required for the PG Model, including measure costs, energy savings, and demand savings. Other model inputs not directly taken from the IAC data, such as measure EUL, remaining useful life (RUL), and net-to-gross ratios, were based on standard assumptions used for similar measures in the commercial sector. See Appendix G for a more detailed discussion of the industrial approach.

3.2 *Approach to Agriculture*

The agriculture sector accounts for 4 percent of electricity consumption and 1 percent of natural gas consumption across all four IOU service territories.[90] The agriculture sector refers to energy consumption from activities related to growing, harvesting, and storing of crops, as well as raising and tending of livestock. The Navigant team identified seven subsectors within this sector:

- "Dairies"
- "Irrigated Agriculture"
- "Greenhouses and Nurseries"
- "Vineyards and Wineries"
- "Confined Animal Feeding Operations (CAFOs)"
- "Refrigerated Warehouses"
- "Post-Harvest Processing"

Table 3-6 shows the agriculture subsectors along the distribution of statewide energy consumption in 2011.

Table 3-6. Agriculture Subsectors and Relative Energy Consumption, Statewide

	Portion of Statewide Agriculture Sector Consumption in 2011	
Subsectors	Electricity	Natural Gas
Dairies	15%	2%
Irrigated Agriculture	35%	16%
Greenhouses/Nurseries	4%	29%
Vineyards / Wineries	11%	16%
CAFOs	4%	8%
Refrigerated Warehouses	13%	2%
Post-Harvest Processing	18%	27%

Source: Navigant team analysis, 2013.

The Navigant team further divided energy consumption within each subsector, across seven major end uses:

- "HVAC"
- "Lighting"

[90] Based on Quarterly Fuel and Energy Reports (QFER) submitted by California utilities and compiled by the California Energy Commission (CEC). Available online at http://ecdms.energy.ca.gov/.

» "Motors"

» "Refrigeration"

» "Water heating and cooling"

» "Process"

» "Miscellaneous"

The Navigant team identified these consumption distributions by conducting a detailed review of existing agriculture literature,[91] as well as interviews with agricultural subject matter experts (SMEs).

The Navigant team then focused the analysis on the major end uses within each subsector to ensure an efficient and accurate assessment of the major fuel-consuming activities within the agriculture sector. Across the four service territories, 73 percent of the total electric energy consumption and 78 percent of the total natural gas energy consumption are examined for potential.

Table 3-7 and Table 3-8 show the electric and natural gas energy consumption associated with each end-use and subsector, respectively. Additionally, the outlined values show the end uses included within the scope of this analysis.

Table 3-7. Statewide Agricultural End-Use and Subsector Electrical Consumption Distribution

End-Use Categories	Electricity Consumption Within each Subsector							
	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing	Total
HVAC	1%	0%	2%	1%	3%	0%	1%	7%
Lighting	2%	0%	1%	2%	0%	1%	1%	7%
Motors	0%	33%	0%	1%	0%	0%	0%	34%
Refrigeration	6%	0%	0%	4%	0%	11%	5%	26%
Water Heating and Cooling	1%	0%	0%	1%	0%	0%	0%	2%
Process	3%	0%	0%	2%	0%	0%	11%	16%
Miscellaneous	2%	2%	0%	0%	0%	0%	0%	4%
Total within Subsector	15%	35%	4%	11%	4%	13%	18%	100%

Source: Navigant team analysis, 2013.

[91] For a complete list of Agriculture literature sources see the Agriculture References section within Appendix H.

Table 3-8. Statewide Agricultural End-Use and Subsector Gas Consumption Distribution

End-Use Categories	Gas Consumption Within each Subsector							
	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing	Total
HVAC	0%	8%	29%	6%	1%	1%	0%	45%
Lighting	0%	0%	0%	0%	0%	0%	0%	0%
Motors	0%	0%	0%	0%	0%	0%	0%	0%
Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%
Water Heating and Cooling	2%	0%	0%	8%	8%	0%	0%	18%
Process	0%	0%	0%	1%	0%	0%	27%	28%
Miscellaneous	0%	8%	0%	1%	0%	1%	0%	10%
Total within Subsector	2%	16%	29%	16%	8%	2%	27%	100%

Source: Navigant team analysis, 2013.

Similar to the industrial sector analysis, the Navigant team used a supply curve approach to calculate the energy efficiency potential in the agriculture sector. The agriculture sector is subject to broad diversity of activity within its subsectors, and the limited availability of measure-level energy efficiency data necessitated a different approach than the residential, commercial, mining, and street-lighting sectors.

The Navigant team's analysis approach varied for each subsector and end use and relied on four main sources. In some cases, the Navigant team used data from the industrial supply curves directly.[92] The Navigant team also gathered data from other sources and developed supply curves similar to those used by the industrial analysis that relate the incremental cost of energy efficiency to energy savings for measures grouped into low, mid, and high categories. The sources used by the Navigant team for the agriculture analysis include the following:

- Supply curves from the industrial analysis: Where applicable, the Navigant team assumes the agriculture sector to be comparable to the industrial food-handling sector, and uses select supply curves to represent certain end uses within certain subsectors.
- Subject matter experts: The Navigant team conducted SME interviews in order to better understand the characteristics of various subsectors, the end uses employed within the subsectors, and the individual technologies commonly installed. SMEs also provided information on efficient installation activities among farmers and the strategies typically implemented to save energy and costs.
- Commercial measures: Many energy-consuming technologies in the agriculture sector can also be found in the commercial (and industrial) setting. Where this overlap occurs, previous

[92] See the Industrial methodology for a complete discussion of supply curve methodology.

analysis, assumptions, and characterizations, conducted by the Navigant team in other PG study areas, were applied to the agriculture sector.

» Literature reviews: The Navigant team relied on secondary sources to supplement its analysis for certain measures. For example, the team reviewed work papers to understand costs associated with certain measure implementations.

Table 3-9 shows a summary of the sources associated with each end use and subsector. All blank cells are excluded from the analysis.

Table 3-9. Agriculture Analysis Sources

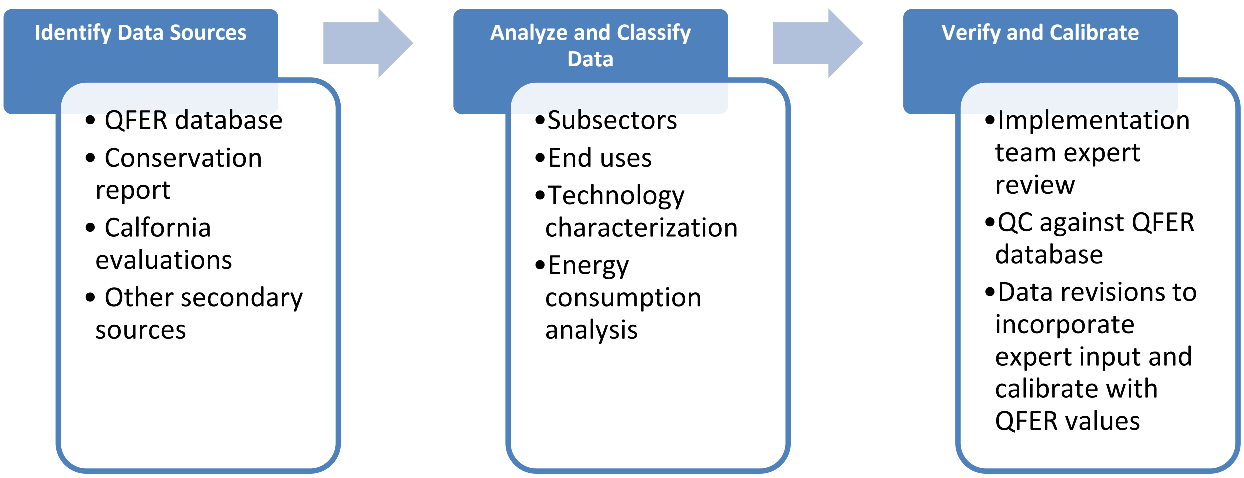
End-Use Categories	Sources by Sub-Sector and End Use						
	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
HVAC			Lit. review, SME (gas)	Commercial measures (gas)			
Lighting							
Motors		Industrial supply curve (electric)					
Refrigeration	Industrial supply curve (electric)			Industrial supply curve (electric)		Industrial supply curve (electric)	Industrial supply curve (electric)
Water Heating and Cooling				Commercial measures (gas)	Commercial measures (gas)		
Process	Industrial supply curve (electric)						Industrial supply curve (electric, gas)
Miscellaneous							

Source: Navigant team analysis, 2013.

3.3 *Approach to Mining*

The mining sector[93] accounts for 2.34 percent of all electricity consumption[94] and 2.19 percent of all natural gas consumption[95] across the four IOUs' service territories. Mining refers to energy consumption from activities related to mineral and metal mining, building construction, and oil and gas extraction. These activities can be categorized into three activity types, or subsectors: mining, construction, and oil and gas extraction.[96] Figure 3-2 depicts the process used for developing inputs for the mining sector. The remainder of this section describes this process.

Figure 3-2. Process for Developing Mining Inputs



Source: Navigant team analysis, 2013.

[93] The Mining sector is referred to as "Mining and Construction" by some organizations that are cited.
[94] 2.84% for PG&E, 0.83% for SDG&E, and 2.19% for SCE, based on 2011 data (most recent year available). California Energy Commission (CEC). Energy Consumption Data Management System (ECDMS). Electric Consumption by Entity. Last accessed on January 11, 2013. http://www.ecdms.energy.ca.gov/elecbyutil.aspx.
[95] 1.05% for PG&E, 0.63% for SDG&E, and 3.35% for SCG, based on 2011 data (most recent year available). California Energy Commission (CEC). Energy Consumption Data Management System (ECDMS). Gas Consumption by Entity. Last accessed on January 11, 2013. http://www.ecdms.energy.ca.gov/gasbyutil.aspx.
[96] To stay consistent with the terminology of the rest of the PG study, the Navigant team considered mining a "sector" and the three types of activities as "subsectors."

The Navigant team focused the analysis on the oil and gas extraction subsector to ensure an efficient and accurate assessment of the major end uses and did not examine the smaller mining and construction subsectors. Across PG&E, SCE, and SDG&E, the majority of electric consumption in this sector (averaging 73 percent) is associated with oil and gas extraction activities while mining and construction activities account for 12 and 15 percent, respectively. Similarly, for natural gas consumption, across PG&E, SCG, and SDG&E, the majority of consumption in this sector (averaging 82 percent) is associated with oil and gas extraction activities while mining and construction activities account for 12 and 6 percent, respectively. Table 3-10 describes each subsector and states the portion of mining sector energy consumption that it represents. The Navigant team used the QFER data[97] to identify the annual energy consumption in each subsector.

Table 3-10. Mining Subsectors and Relative Energy Consumption across IOU Service Territories

	Portion of Mining Sector Consumption	
Subsectors	Electricity	Natural Gas
Oil and Gas Extraction	73%	82%
Mining	12%	12%
Construction	15%	6%

Source: Navigant team analysis of QFER data.

[97] California Energy Commission (CEC). July 2012. Quarterly Fuel and Energy Report (QFER) data. Data transmission from CEC to Navigant team.

Table 3-11 describes the major end uses within the "oil and gas extraction" subsector, states the portion of mining sector energy consumption that it represents, and identifies the baseline and efficient technologies within those major end-use categories. The Navigant team's analysis accounts for 65 percent of the electric and natural gas consumption within the mining sector.

Table 3-11. Oil and Gas Extraction Major End Uses and Relative Energy Consumption across IOU Service Territories

Major End Use	Description	Baseline Technologies	Efficient Technologies	Portion of Mining Sector Consumption	
				Electricity	Natural Gas
Stripper Wells	Electric- motor-driven, low- volume-producing wells	Oversized, low-efficiency motors	Resized motors, efficient motors, pump-off controls, and VFDs	5%	0%
Regular Wells	Electric- motor-driven, regular-volume-producing wells	Oversized, low-efficiency motors	Resized motors, efficient motors, pump-off controls, and VFDs	38%	0%
Injection Wells	Electric- motor-driven pumps for steam/water injection wells that support production	Low- efficiency motors	Efficient motors and VFDs	22%	0%
Boilers	Natural gas process boilers that produce steam for injection wells	Low- efficiency boilers	Efficient boilers, controls, other improvements and tune-ups	0%	65%

Source: Navigant team analysis of QFER data and secondary sources (as listed in Appendix I).)

The Navigant team developed the major end uses described in Table 3-11 using several sources. These included the CEC QFER data in order to quantify the total subsector consumption.[98] The Navigant team also used the *2009 Annual Report of the State Oil and Gas Supervisor* (Conservation Report) to quantify and characterize the types of activities occurring in California (e.g., oil pumping/extraction, steam injection).[99]

Next, the Navigant team collected information from other secondary sources to understand the types of technologies and equipment used to support the activities associated with each major end use and their typical unit energy consumption characteristics. Specifically, the characteristics used to describe each major end use include the following:

» Their locations within the state by oil and gas operation district (as specified by the Conservation Report and mapped to IOU service territories by the Navigant team)

» Types of equipment used (e.g., motor category or design specification)

[98]Ibid, CEC QFER.

[99] California Department of Conservation. 2010. 2009 Annual Report of the State Oil and Gas Supervisor. Last accessed December 10, 2012. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf.

- » Physical and operating characteristics (e.g., motor duty cycle)
- » Class or efficiency level
- » Materials and total volumes processed

Appendix I identifies these sources, which include previous IOU evaluation reports.

The Navigant team reviewed these estimates with staff from Global Energy Partners. Global Energy Partners has implemented previous IOU programs targeting the oil and gas extraction industry.[100] Finally, the Navigant team verified its estimates by multiplying the appropriate inventories by the associated per-unit consumption data and comparing results to the QFER total subsector consumption data.

The Navigant team estimated the remaining model inputs such as material and labor costs, O&M benefits, EUL and RUL, and NTG ratios using data collected from secondary sources such as program evaluations and potential studies previously conducted for the IOUs, CEC, and other state agencies. These are described in greater detail in Appendix I.

3.4 Approach to Street Lighting

The street-lighting "sector" refers to electric energy consumption from lights on roads, highways, public pedestrian thoroughfares, roadway signage, and traffic signal lights that are not metered as part of a building or site account. Across the three electric IOUs, the street-lighting sector accounts for 0.59 percent of all electricity consumption.[101] The Navigant team classified this sector into three categories of lights: lights used to illuminate roads and highways ("streets"); lights used to illuminate road and highway signs ("signs"); and traffic signals ("traffic lights"). To stay consistent with the terminology of the rest of the study, the Navigant team considered street lighting a "sector" and the three types of lighting as "subsectors."

[100] The Navigant team reviewed the preliminary analysis with GEP staff via telephone on November 30, 2012, and revised the analysis to reflect GEP staff's field experience.

[101] 0.54% for PG&E, 0.88% for SDG&E, and 0.56% for SCE, based on 2011 data (most recent year available). California Energy Commission (CEC). Energy Consumption Data Management System (ECDMS). Electric Consumption by Entity. Last accessed on January 11, 2013. http://www.ecdms.energy.ca.gov/elecbyutil.aspx.

Table 3-12 describes each subsector, states the portion of street-lighting sector energy consumption that it represents, and identifies the baseline and efficient technologies in that subsector. The Navigant team used the QFER data[102] to identify the annual energy consumption in each subsector. Across PG&E, SCE, and SDG&E, the majority of consumption (averaging 86 percent) is associated with streetlights used specifically for roads and highways, while sign lights and traffic lights account for 4 and 10 percent of electricity consumption, respectively.

Table 3-12. Street-Lighting Subsectors and Relative Electric Energy Consumption, Statewide

Subsectors	Description	Baseline Technologies	Efficient Technologies	Portion of Sector Electricity Consumption
Streets	Lights used to illuminate roads and highways	High-pressure sodium, low-pressure sodium, metal halide, mercury vapor, incandescent lamps	LED and induction lamps, advanced controls[103]	86%
Signs	Lights used to illuminate road and highway signs	Mercury vapor lamps	LED and induction lamps	4%
Traffic Lights	Lights used in red, yellow, and green traffic signals	LED lamps (code equivalent)	Advanced LED lamps (above code)	10%

Source: Navigant team analysis of QFER data

The Navigant team then analyzed the saturation of the various lighting technologies in each subsector for both existing and new construction. Sources varied for making estimates of saturation by subsector:

» For Streets, the Navigant team requested lighting inventories from the IOUs. In addition to providing the counts and types of street lighting currently installed within their service territories, IOUs provided lighting classes based on electric rate schedules/tariff structures. These allowed the team to assess the wattage, lumens, operating hours, and monthly kilowatt-hour (kWh) charges associated with each lamp type.

» For Signs, the Navigant team leveraged the IOU-supplied street light inventories and secondary sources to estimate the inventories of baseline and efficient lamps. The Navigant team assumed that the level of efficient technology saturation within each IOU's "signs" subsector is equivalent to the rate seen within each "streets" subsector.

» For the traffic lights, the Navigant team assumed that the use of LEDs is standard practice and that there currently is no EE potential in this sector. Current regulations for traffic lights require

[102] California Energy Commission (CEC). 2012. Quarterly Fuel and Energy Report (QFER) data. Data transmission from CEC to Navigant team. July 2012.

[103] Advanced street-lighting controls are defined as controls beyond standard photocells, timers, and astronomical times that generally include activity/motion sensing, network connections for outage monitoring, and remote controlling. Advanced controls can be installed with existing baseline lamps or efficient technology lamps.

LEDs for all new installations as of 2006.[104] Discussions with IOUs confirmed that all current installations are LEDs, and the Navigant team's analysis did not identify any technologies with efficiencies beyond this current code requirement. As a result, the Navigant team assumed that existing stocks would only include baseline technologies and no efficient technologies in the first year of examination. The Navigant team has identified LEDs as an emerging technology. Therefore, increased savings are expected in later years of analysis to reflect the introduction of advanced LEDs with efficiencies above the current code level.

The Navigant team estimated the remaining model inputs needed to use a bottom-up method to calculate savings potential. These inputs include material and labor costs, O&M benefits, EUL and RUL, and NTG ratios. Sources included program evaluations and case studies previously conducted for the IOUs, CEC, and other state agencies. Additional details related to sources, assumptions, and other inputs can be found in Appendix J.

[104] U.S. Department of Energy. 2005. Energy Conservation Standards for Certain Consumer Products and Commercial and Industrial Equipment. Last accessed December 10, 2012. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/technical_amendment_101805.pdf.

4 California Energy Efficiency Potential

4.1 *Overview*

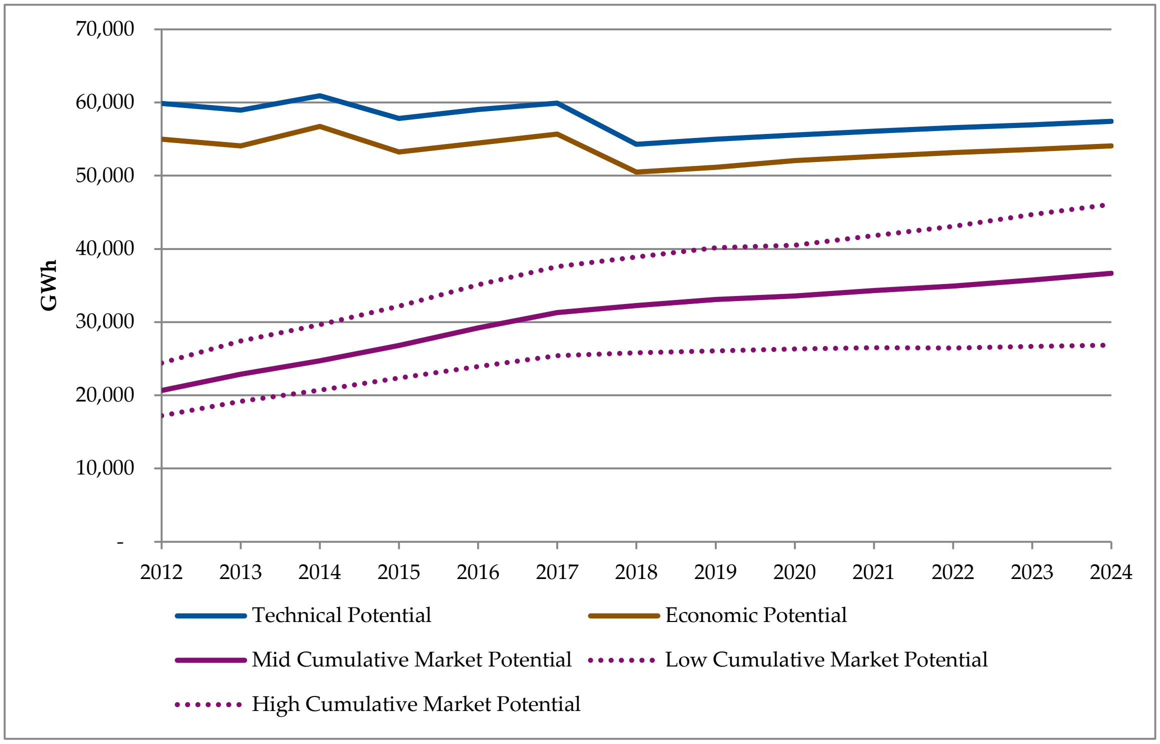
This section provides energy and demand savings potential estimates at the California statewide level. These are estimates of total technical, economic, and gross market potential for all sectors (residential, commercial, industrial, agricultural, mining, and streetlights) and all IOUs (PG&E, SCE, SDGE, and SCG). Sector-level technical, economic, market potential results, and observed trends are detailed in Sections 5 through 8. Utility-specific results are detailed in Appendices K - N.

4.2 *California Statewide Summary of Results*

4.2.1 California IOU Electric Energy Potential

The technical, economic, and cumulative market energy savings potential in California are presented in Figure 4-1. The technical and economic potential follow nearly identical paths, with economic potential consistently at about 90 percent of technical potential. The decreases in technical and economic potential occurring through 2018 are due to changes in codes and standards that result in higher baseline efficiency for affected measures, as discussed in Section 2.3.2.2. By 2018, most of the known codes and standards have been implemented and the technical and economic potential lines begin to increase again as emerging technologies are introduced and become saturated in the market. Cumulative market potential follows a different path and has an increasing trend line. After 2018, the cumulative market potential has slower growth because it includes the cumulative effect of decay and of codes and standards. These trends are discussed in more detail in Sections 5 (Residential Sector Potential Results) and 6 (Commercial Sector Potential Results). Figure 4-1 also provides high and low scenario results for cumulative market potential results. The low scenario is about 20 percent less than the mid scenario and the high scenario is about 20 percent higher.

Figure 4-1. California Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)

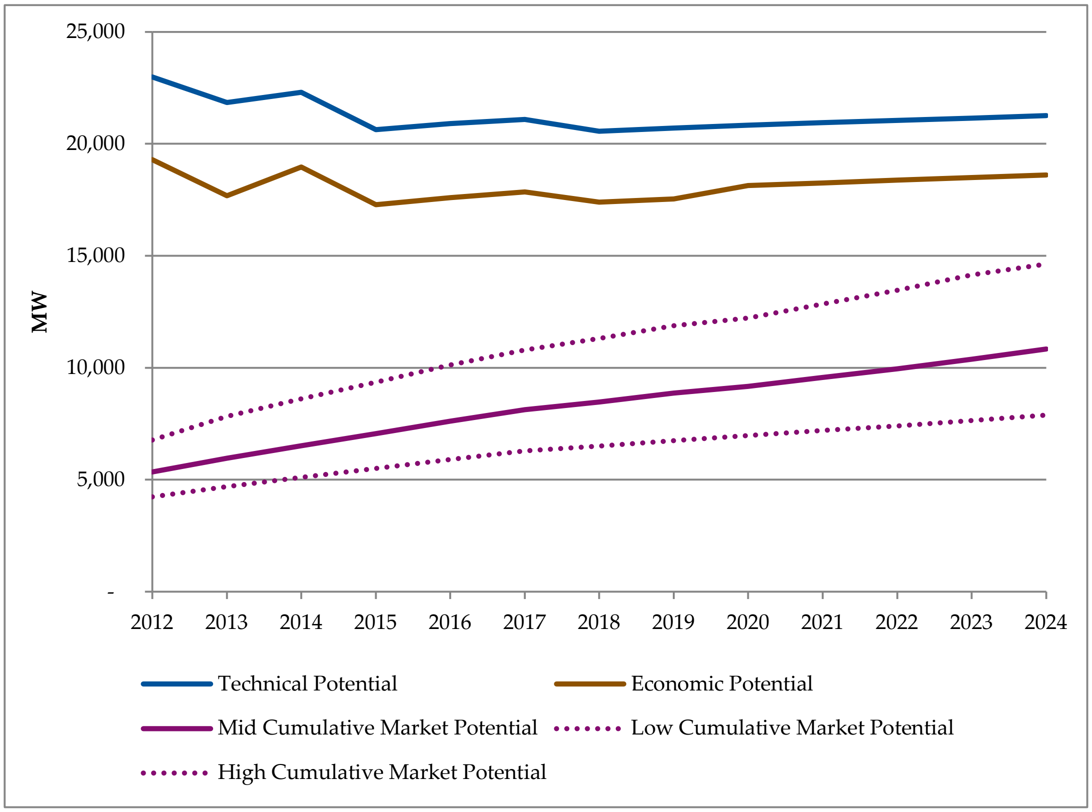


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 4-2 displays similar results for California's technical, economic, and cumulative market demand savings potential for the years 2012 through 2024. The demand savings potential follows similar trends as the energy potentials; however, the scenario runs are a bit more pronounced than the energy scenario results, with the high scenario running about 30 percent higher and the low about 25 percent lower than the mid scenario.

Figure 4-2. California Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2012-2024 (MW)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

California's gross incremental market potential for energy savings including codes and standards is calculated to be 2,556 GWh in 2012 and approximately 2,359 GWh in 2024, as presented in Table 4-1. These results can be compared to Figure 4-3, which shows the incremental market potential without the effects of codes and standards.

End-use categories provide an easy way to categorize and roll up measure-level savings while also providing some high-level information of the measures in that category. For example, only measures that are related to lights would be included in the lighting end use. This is not limited to light bulbs, but encompasses any measure that would affect how much lighting power is being used, including measures like sensors or controls in addition to bulbs and fixtures. The whole-building end use is different however, in that it includes bundles of measures across all the end uses, many of which are HVAC measures that are not cost effective on their own.

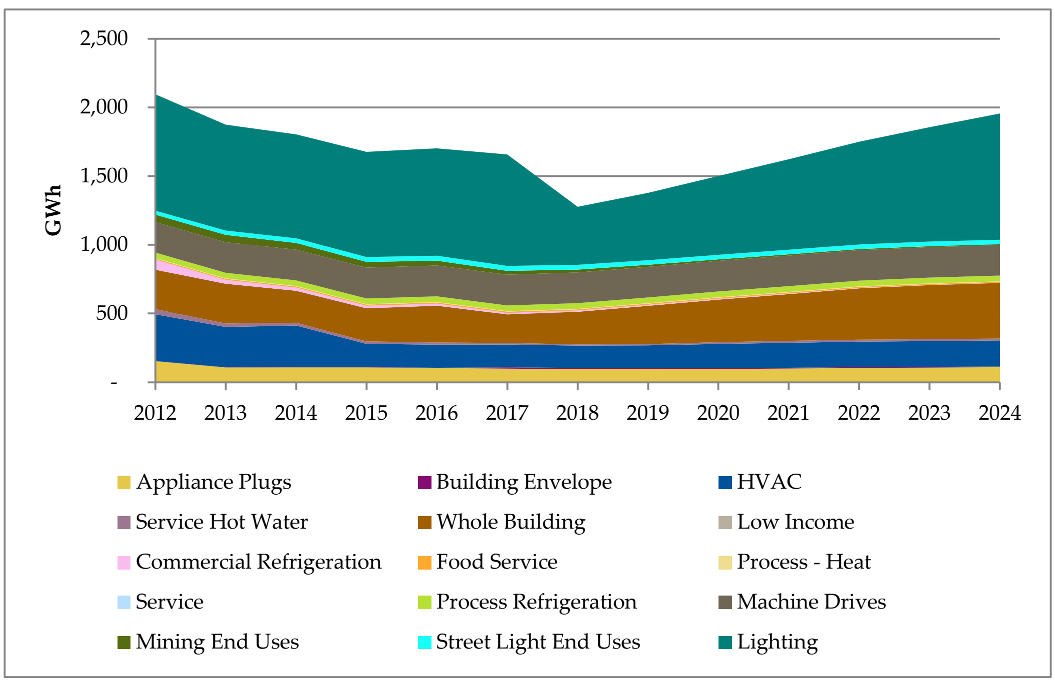
Figure 4-3 shows incremental market potential by end-use category, but this does not include the IOU attributable codes and standards savings. The gross incremental market potential shown here has a similar trend line to that of the technical and economic potential, but the effects of codes and standards are more pronounced in this incremental graph. In 2014, it is estimated that 40 percent of the incremental savings will come from lighting measures, while HVAC and industrial machine drives account for about 17 percent and 12 percent, respectively. HVAC potential going forward has lower market potential in part because whole-building measures absorb some of that potential. Lighting potential sees a noticeable decrease in savings in 2017 and 2018 due to codes and standards for CFLs. After 2018, LED Lighting technologies see increased adoption, which accounts for the increase in lighting savings in the outer years.

Table 4-1. Gross Incremental Market Potential in California (GWh, including codes and standards)

Sector	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
California Statewide	2,556	2,680	2,458	2,366	2,690	2,445	1,994	2,078	2,171	2,199	2,271	2,286	2,359

Source: PG model release August 2013

Figure 4-3. California Gross Incremental Market Potential Savings by End Use for 2012-2024 (GWh)

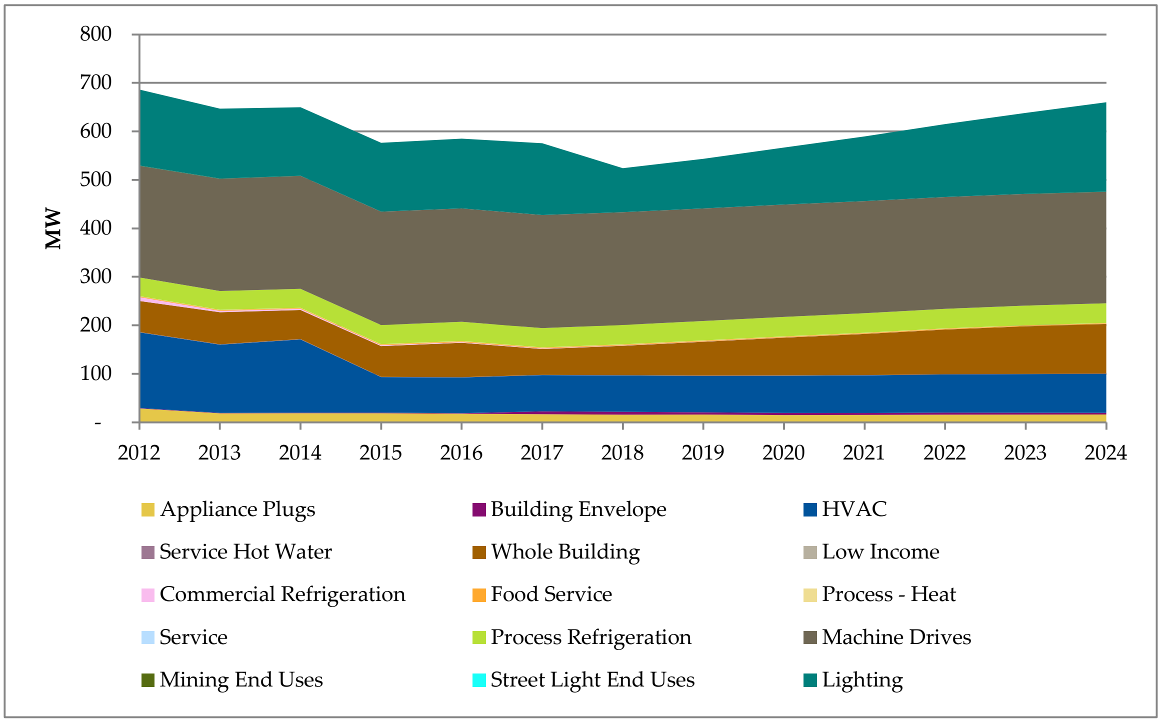


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Gross incremental market demand savings market potential (as seen in Figure 4-4 below) follows a similar trend as the energy savings potential. The estimates shown in this graph do not include savings attributable to codes and standards.

Figure 4-4. California Gross Incremental Demand Savings Market Potential by End Use for 2012-2024 (MW)



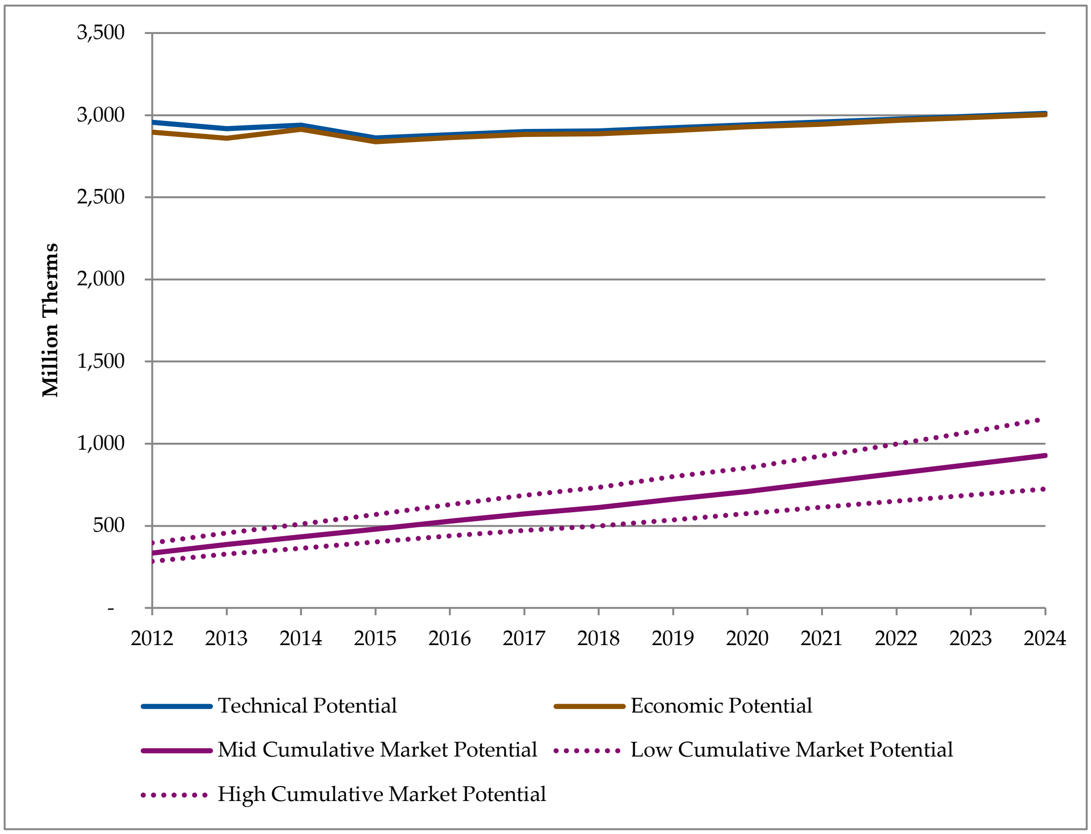
2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

4.2.2 California IOU Natural Gas Potential

California's technical, economic, and cumulative market gas savings potential is presented in Figure 4-5. The available technical and economic potential for savings vary slightly in 2012, with economic potential about 95 percent of technical potential, before quickly reaching about 99 percent of the technical potential. The cumulative market potential steadily increases over the forecast period and high/low scenarios are about 20 percent higher and lower.

Figure 4-5. California Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2012-2024 (Million Therms)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

There is a much larger gap between the market and economic potential for gas savings than electric and there are many underlying reasons for this:

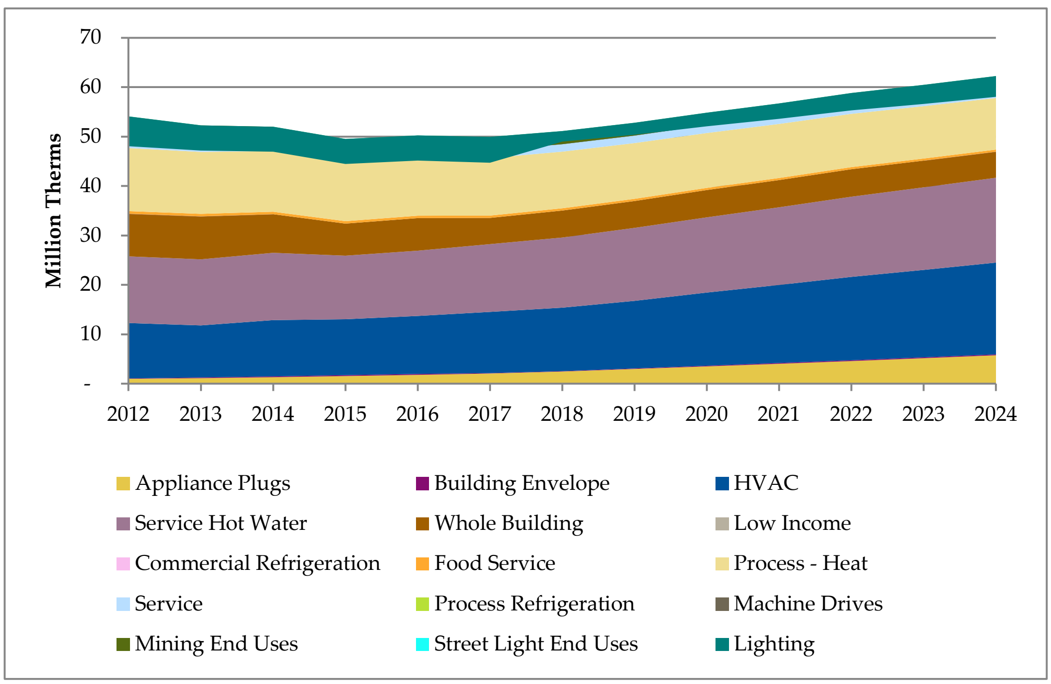
» First, the technical and economic potential in the PG model account for the most efficient measure within a competition group, while the market potential typically includes a mix of high- and low-efficiency technologies, depending on their cost-effectiveness. Also, the economic potential accounts for the incremental measure cost as part of the TRC calculation while market potential considers the levelized measure cost, which is the total cost of ownership and operation. For instance, commercial boilers include a range of competing technologies with different savings and cost profiles. While efficient technology adoption is high for boilers, the most efficient technology is expected to gain only about a quarter of the market with the less costly, efficient technologies taking most of the rest. Thus, it is possible for a high-efficiency gas measure to screen the TRC and be included in the economic potential but look less attractive from a levelized cost perspective and see low adoption in the market.

» Second, a lot of the residential gas measures are modeled as replace on burnout and have larger EULs (upwards of 10 or 15 years). This suggests that these measures turn over slower and therefore constrain the ramp rate for market potential.

» Third, for many residential and commercial gas end uses, especially HVAC, low calibration factors were applied in the model to align with past program achievements, which constrains just how fast market potential for these measures can grow.

Figure 4-6 presents the gross incremental market potential for gas energy savings. The incremental potential for gas savings is much less choppy than the electric incremental savings due to the fact that most codes and standards are aimed at electric measures, not gas measures.

Figure 4-6. California Gross Incremental Gas Energy Savings Market Potential for 2012-2024 (Million Therms)



2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

4.3 *Key Findings*

This section discusses key findings and results of the analysis from different perspectives. It includes a comparison of the overall study results to the 2011 Potential Study (Section 4.3.1 and 4.3.2); opportunities for achieving broader adoption of energy efficiency (Section 4.3.3); the effects of codes and standards (Section 4.3.4); the sector with the most potential (Section 4.3.5); the contribution of lighting to total market potential (Section 4.3.6); whole-buildings results (Section 4.3.7); financing results (Section 4.3.8); emerging technology results (Section 4.3.9); results in the AIMS sectors (Section 4.3.10); and key issues related to findings on C&S and behavior-based savings (Section 4.3.11). Goals and targets scenarios are then discussed in Section 4.4.

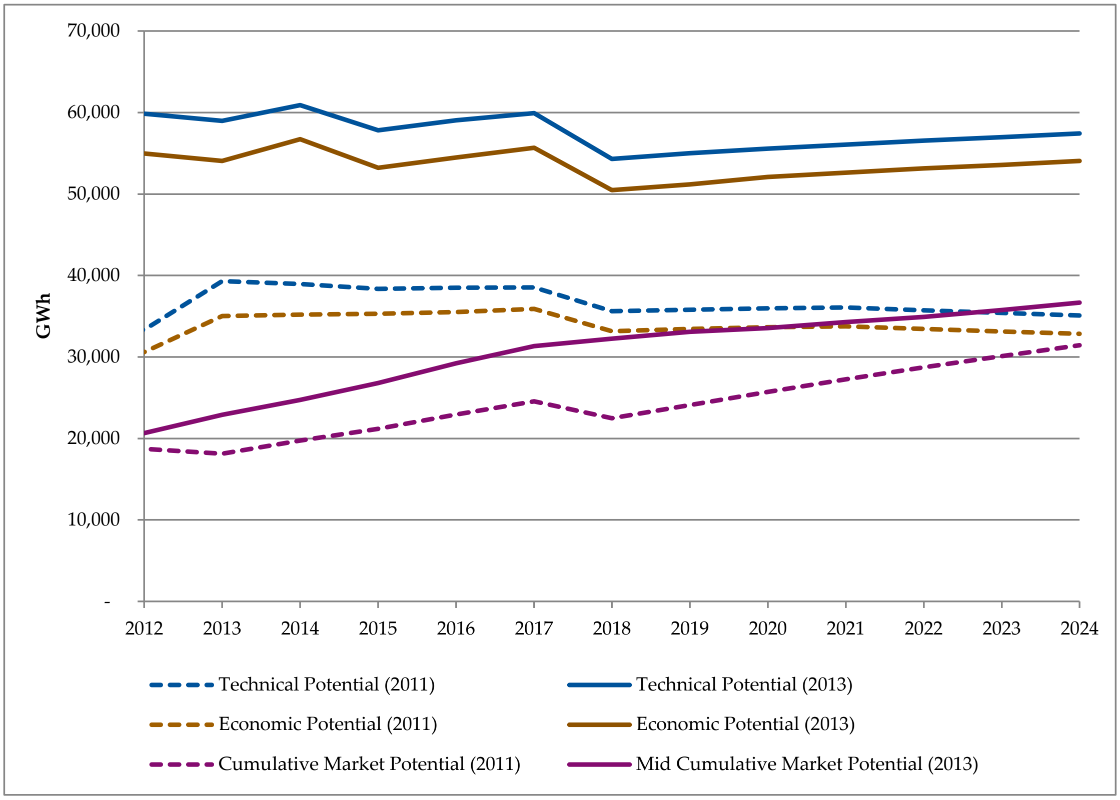
4.3.1 Technical and Economic Potential Increased between the 2011 and 2013 Potential Studies As a Result of the New Measures and Methodologies

Technical and economic potential are about 50 percent higher than reported in the 2011 Potential Study, as seen in Figure 4-7. This increase is primarily driven by a change in the approach to modeling technical and economic potential. The approach to modeling technical potential used in the 2013 Potential and Goals Study demonstrates a best-case scenario for technical potential given what is known about the market today. Due to barriers such as payback considerations or split incentives, it is unlikely that all customers would replace baseline equipment with the most efficient technology in a competition group, but technical potential is intended to represent the savings possible if all technically available changes were made. This change was made to expand our view of potential from emerging technologies.

The 2013 Potential and Goals Study defines technical potential by the most efficient equipment option within a competition group. The technical and economic potential in the 2011 Potential Study was calculated based on the efficiency level of the measure that was most commonly adopted in IOU programs. For example, the 2011 model would assess technical potential for residential HVAC based on the average efficiency being installed through IOU programs, such as a SEER 15 HVAC unit. In comparison, the 2013 Study calculates the potential for all residential HVAC units to be replaced by SEER 22 machines, the most efficient equipment currently visible on the market.

The addition of the mining and street-lighting sectors to the 2013 Potential and Goals Study also added approximately 1,800 GWh to the technical and economic potential. These sectors were not included in the 2011 report.

Figure 4-7. Comparison of Technical, Economic, and Cumulative Market Potential in the 2011 and 2013 Studies



Source: PG model release August 2013

Note: 2013 Cumulative Potential includes behavioral savings and C&S savings to make a consistent comparison with the 2011 results.

4.3.2 California IOU electric and gas incremental market potential increased between the 2011 and 2013 Potential Studies for a variety of reasons.

Table 4-2 and Table 4-3 provide a comparison of the incremental market energy and demand potential (GWh) for forecasts in the previous 2011 study and the 2013 study. There are a number of differences between the two studies that cause the variance in potential. The portfolio of measures has been updated in multiple ways. There have been some measures added or removed (specifically set top boxes in Res), as well as updates to unit energy savings, densities, and cost inputs. The 2011 study included the industrial and agriculture sectors, but the modeling methodology for those sectors has been completely revamped in this study, as discussed in the AIMS section of this report. Additionally, the 2013 study includes the mining and street-lighting sectors, which were not included in the 2011 study. The 2013 study uses updated DEER and FEA data that are more accurate and vetted than the 2011 study. Additionally, the methodologies behind calculating market potential and the calibration process have changed, as discussed in the methodology section. The portfolio of emerging technologies has also been revamped, with many new measures being added.

Table 4-2. Changes in California Incremental Market Energy Potential from the 2011 Study Forecast (GWh)

Year	Incremental Market Potential (Includes Net C&S)		
	2011 Study	2013 Study	Percent Increase or Decrease
2012	2,386	2,556	7%
2013	2,048	2,680	31%
2014	2,021	2,458	22%
2015	2,177	2,366	9%
2016	2,180	2,690	23%
2017	2,055	2,445	19%
2018	1,920	1,994	4%
2019	1,854	2,078	12%
2020	1,835	2,171	18%
2021	1,799	2,199	22%
2022	1,784	2,271	27%
2023	1,710	2,286	34%
2024	1,649	2,359	43%

Source: PG model release August 2013

Table 4-3. Changes in California Incremental Market Demand Potential from the 2011 Study Forecast (MW)

Year	Incremental Market Potential (Includes Net C&S)		
	2011 Study	2013 Study	Percent Increase or Decrease
2012	552	757	37%
2013	382	744	95%
2014	363	739	103%
2015	401	681	70%
2016	394	781	98%
2017	374	706	89%
2018	362	649	79%
2019	347	667	92%
2020	339	687	103%
2021	332	700	111%
2022	330	719	118%
2023	320	733	129%
2024	312	750	141%

Source: PG model release August 2013

Table 4-4 provides a comparison of the market potential for gas energy savings forecasts in the 2011 and 2013 reports for the period from 2012 through 2022. Excepting 2012 and 2013, the incremental market gas savings are higher than the estimates from 2011. Reasons for differences between the 2013 and 2014 study are discussed in Section 4.3.2.

Table 4-4. Changes in California Incremental and Cumulative Market Gas Potential Savings from the Previous Forecast (Millions of Therms)

	Incremental Market Potential (Includes Net C&S)		
Year	2011 Study	2013 Study	Percent Increase or Decrease
2012	55	49	-10%
2013	50	47	-7%
2014	49	51	3%
2015	48	50	4%
2016	48	55	14%
2017	49	57	15%
2018	52	63	21%
2019	54	65	20%
2020	56	67	18%
2021	58	67	17%
2022	60	69	14%
2023	63	70	12%
2024	63	72	14%

Source: PG model release August 2013

4.3.3 Gap between Economic and Cumulative Market Potential Indicates That There are Additional Savings Opportunities not Being Captured by Current Adoption Patterns

The trajectory of cumulative market potential toward economic potential in Figure 4-7 indicates the degree to which the market, using IOU program incentives and financing, is expected to capture the available potential of cost-effective energy efficiency.

The cumulative market potential shown in Figure 4-7 includes voluntary adoption of energy efficient measures due to rebates and behavior-based initiatives from the 2011 and 2013 models. This definition of cumulative market potential does not include savings from C&S that are attributable to IOUs. In addition, cumulative market potential excludes savings from energy efficiency financing programs because those programs are still in the pilot phase. Estimates of savings from financing programs will be better informed by more evaluation data and by more information about the structure of the programs in future program cycles. Considering savings due to financing separately from the cumulative market potential shown in Figure 4-7 enables policy makers and stakeholders to explicitly consider the effects of these factors on the estimated savings. Section 4.3 includes a discussion about the additional potential that could be realized by financing programs.

As shown in Figure 4-7, cumulative market potential in the base forecast achieves approximately 64 percent of the revised technical potential by 2024. This market potential estimate in 2024 is roughly 16 percent higher than the 2011 model estimate due to two initiatives that expanded adoption rates:

1. An expanded set of emerging technologies for which market adoption is expected to be moderately aggressive
2. An incremental gain in the adoption of energy efficiency through whole-building project delivery, including both retrofit and ZNE new construction initiatives

4.3.4 Incremental Market Potential Will Decrease Due to Codes and Standards Updates through 2018, but Increase Due to Emerging Technologies in the Later Years

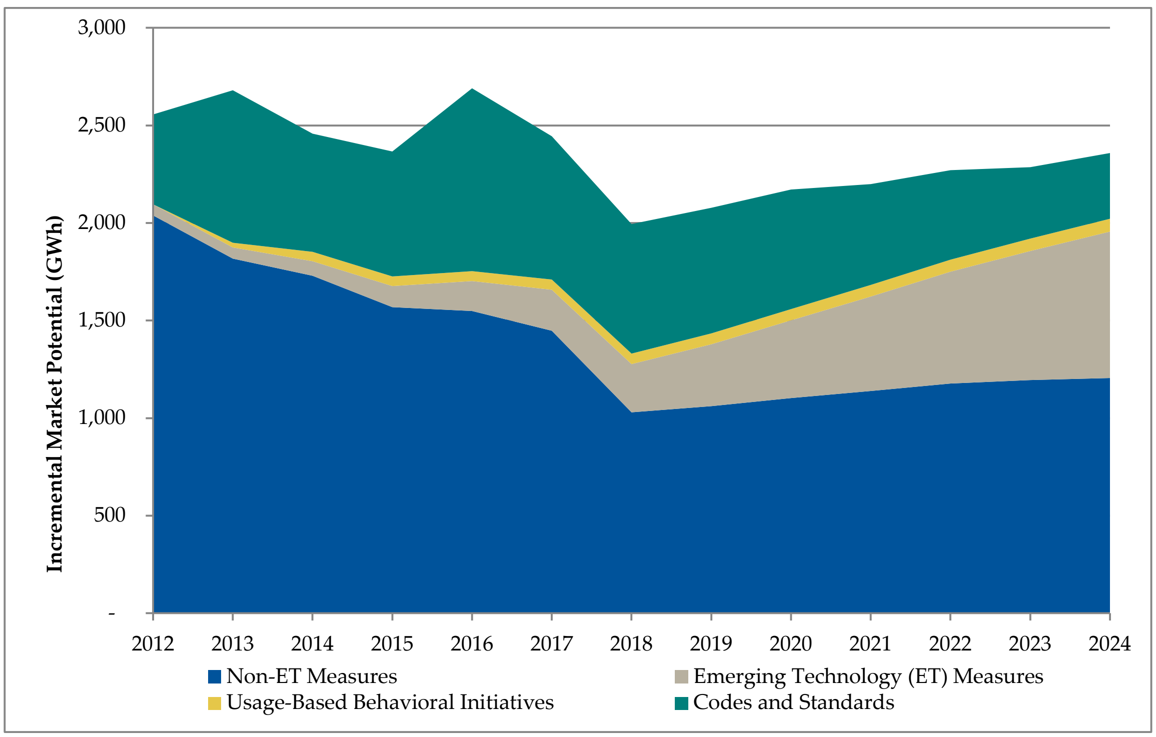
Incremental market potential, which reflects new first-year savings achieved in a given year, is expected to decrease in early years and increase in later years, as illustrated in Figure 4-8. Trends in incremental market potential are driven by the following factors:

» The expansion of the Huffman Bill in 2018 drives the early drop-off in lighting measures in IOU programs. Baselines increase for lighting measures, which are a significant driver of savings, and this adversely affects IOU program savings from non-emerging technologies.

» ETs drive the increase in incremental market potential in the out years. Especially in the commercial sector, customers adopt emerging technologies that have become more financially attractive than their competing base or moderately efficient measures. This increase in savings starts to offset some of the previous losses due to codes and standards.

» The 2016-2022 C&S updates were included in the 2013 study. The approach to calculating these savings remains consistent with previous CPUC evaluations.[105]

Figure 4-8. Incremental Annual Market Potential Impacts 2012–2024 by Measure Type Category



Source: PG model release August 2013

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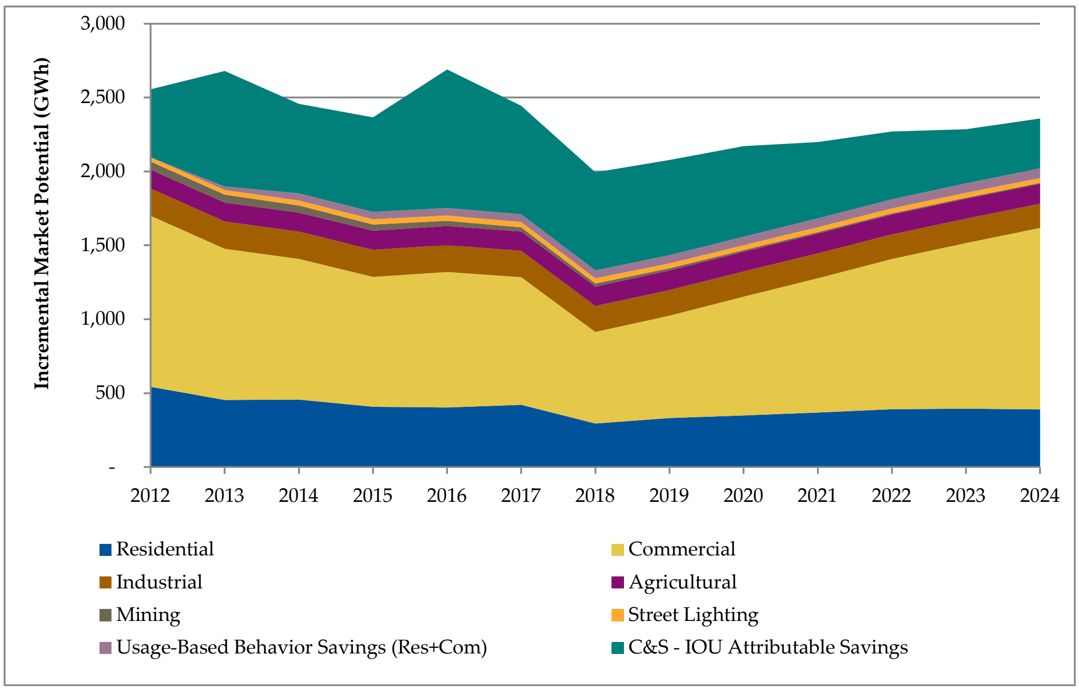
[105] KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc. April 9, 2010. *Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008*. Prepared for CPUC.

4.3.5 The Commercial Sector Provides the Most Significant Untapped Energy Savings.

Figure 4-9 indicates that the commercial sector will continue to drive savings for IOU programs. The anticipation of continued higher market barriers for residential sector adoption of energy efficiency limits the adoption of emerging technologies in the residential sector, limiting its contribution as codes and standards increase baselines. The industrial sector incremental market potential is about the same as reported in the 2011 Potential Study, whereas agricultural incremental market potential increased by nearly 40 percent. Mining and street lighting represent significant cumulative market potential as a fraction of their sector demand forecasted by the CEC (20 percent and 45 percent, respectively, in 2024), but these sectors are relatively small as a fraction of total statewide consumption.

Figure 4-9. Incremental Annual Market Potential by Sector



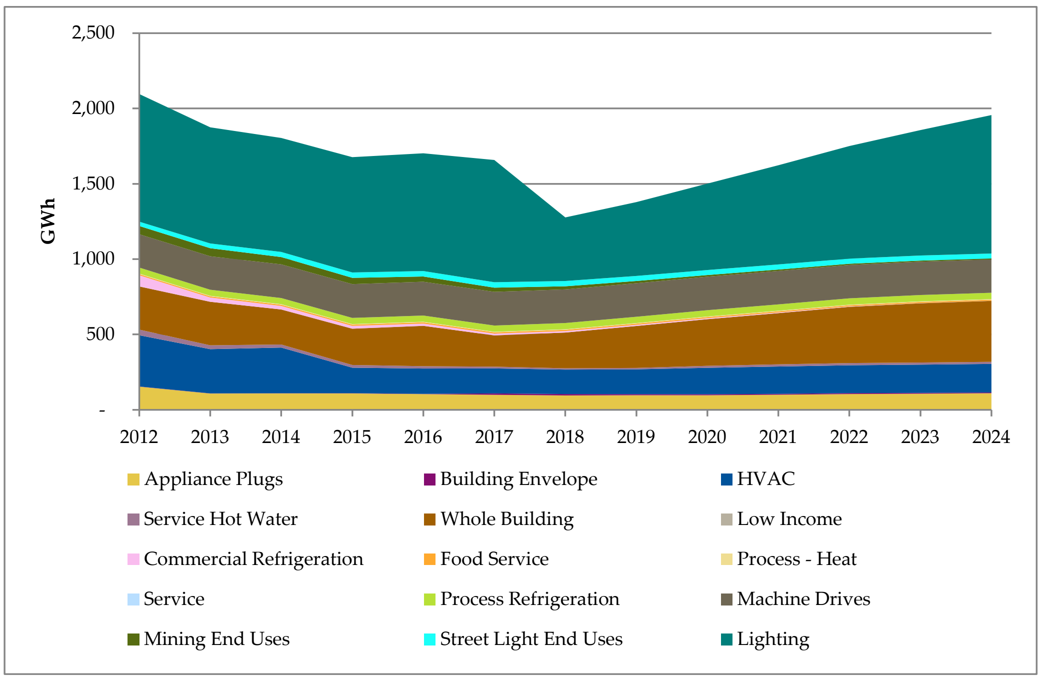
Source: PG model release August 2013

4.3.6 Lighting Will Continue to Be the Dominant End Use to Provide Energy Savings

The PG Model still shows a significant portion of remaining potential available in lighting end uses (particularly in the commercial sector), as shown in Figure 4-10. Historically, CFLs have been the primary driver of IOU program savings. In recent years, IOU-claimable savings from basic CFLs have decreased as standards increased the baseline efficacy of general service lamps. In the near term, savings in the lighting end use are driven by increasing availability of low-wattage linear fluorescents that exceed standards (e.g., 25-watt T8 lamps). Beginning in 2018, however, LEDs will become the primary driver of savings in the lighting end use. In the ensuing years, improvements in LED efficacy, cost, life cycle, and availability will enable this technology to drive energy savings in the lighting end use.

In addition to lighting, machine drives, whole-building approaches, and HVAC will contribute a significant share of incremental market potential. Opportunities for IOU savings also exist among a range of other end uses, including street lighting, mining, process and commercial refrigeration, and Appliance Plug loads.

Figure 4-10. All IOU All Sectors Incremental Electric Savings by End Use



Source: PG model release August 2013

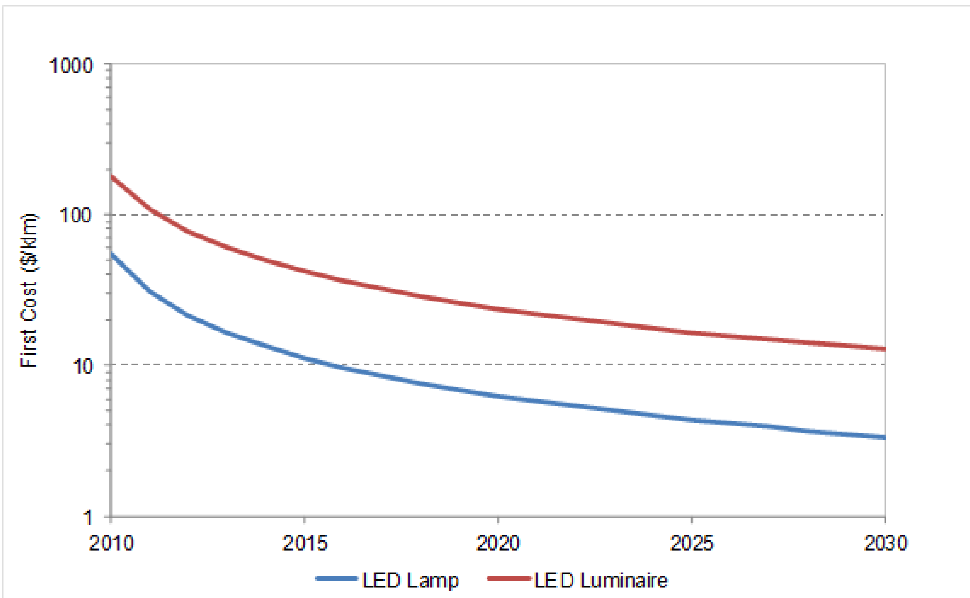
One of the key factors influencing potential for lighting is the rapid development of the LED technology and market. Figure 4-11 provides a price improvement forecast for LED products from 2010 to 2030 for both individual lamps and luminaires (i.e., whole light fixtures). This U.S. Department of Energy analysis[106] forecasts the first cost per kilolumen[107] and shows individual lamps dropping to roughly $7

[106] Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Prepared for:

per kilolumen by 2024, the end point for the potential study. This is an equivalent decrease of about $35.00 per residential light bulb to $3.50 per bulb. Luminaires pursue a similar price trend that will benefit the commercial and industrial markets.

The DOE report also indicates that during this same time the life expectancy for LED bulbs will increase.[108] At the time this report is being written, most commercially available LED bulbs have a lifetime of about 23,000 hours. The targeted lifetime shown in Figure 4-12 is 50,000 hours for indoor LED bulbs and luminaires and 70,000 hours for outdoor lighting such as LED street lights. These improvements in LED lifetime will slow stock turnover, and market potential will drop as long-lived, high-efficacy LEDs saturate the market. For example, a residential CFL bulb currently lasts about seven years. An LED bulb in this same application would last 45 years if run three hours per day every day of the year.

Figure 4-11. Forecasted LED Price ($/klm) Improvement



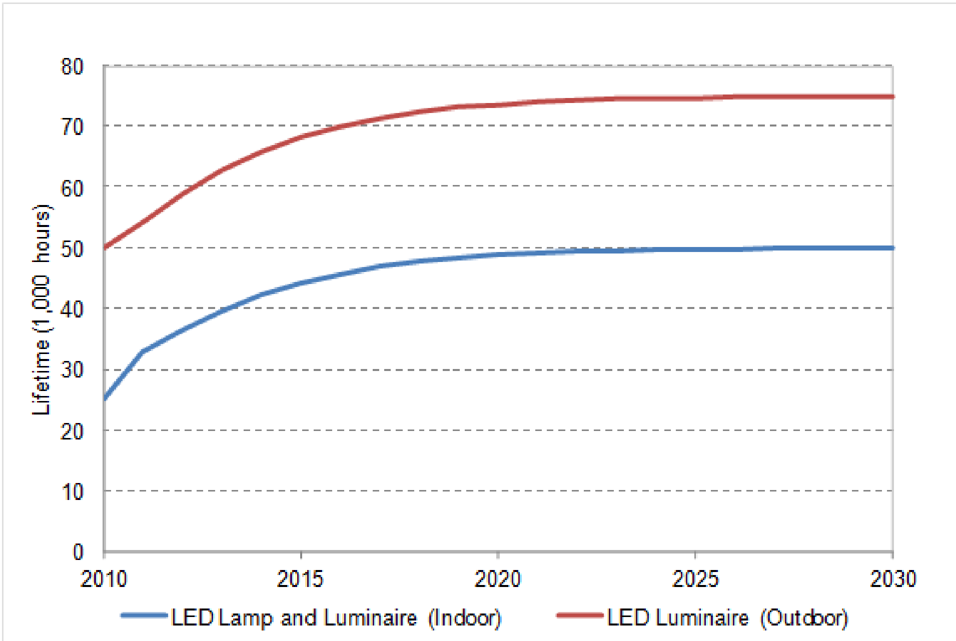
Source: Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Navigant, 2012.

Solid-State Lighting Program, Building Technologies Program. Office of Energy Efficiency and Renewable Energy U.S. Department of Energy. Navigant Consulting, Inc. January 2012. Figure 5.3.

[107] 1 kilolumen = 1,000 lumens. A single residential lamp ranges from between 500 and 800 lumens, or about 0.5 to 0.8 kilolumens.

[108] Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Prepared for: Solid-State Lighting Program, Building Technologies Program. Office of Energy Efficiency and Renewable Energy U.S. Department of Energy. Navigant Consulting, Inc. January 2012. Figure 5.2.

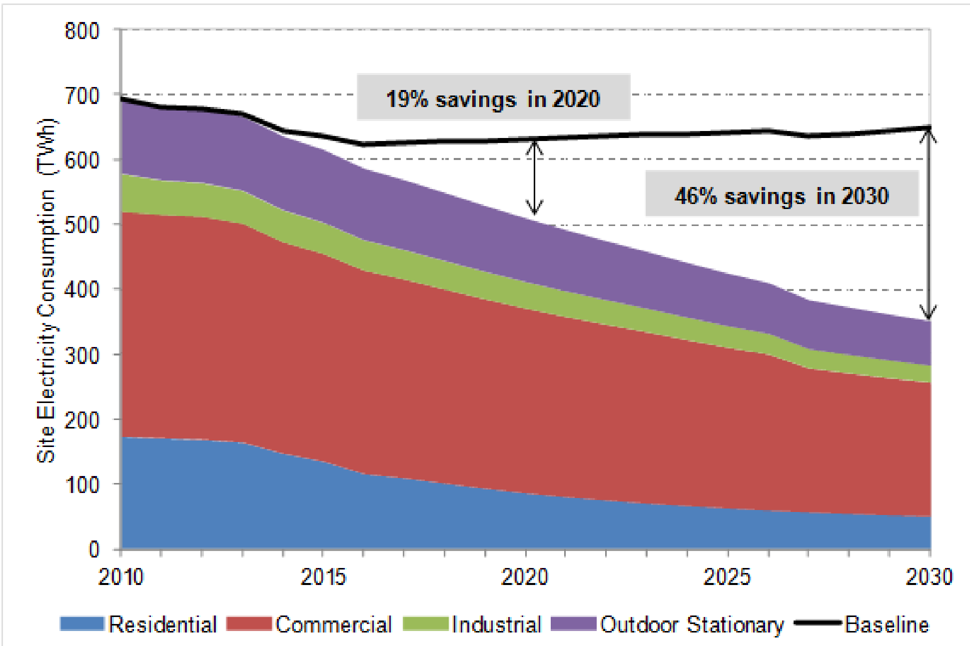
Figure 4-12. Forecasted LED Lifetime Improvement



Source: Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Navigant, 2012.

Figure 4-13 summarizes annual U.S. national electricity consumption of lighting technologies and the electricity savings resulting from the increased use of LEDs in general lighting applications, by building sector.[109] This analysis forecasts that by 2020, LED lighting is expected to represent 36 percent of lumen-hour sales, increasing to 74 percent of sales by 2030. In 2030, the national annual energy savings is about 46 percent below a relatively stable baseline. The 2013 PG model forecasts a similar trend for California, though it is likely to be accelerated through a combination of strategic initiatives that involve voluntary and mandatory programs.

Figure 4-13. Forecasted Annual National Electricity Consumption of Lighting Technologies by Building Sector



Source: Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Navigant, 2012.

4.3.7 AB 758 and Strategic Plan Initiatives Provide Additional Savings through Whole-building Approaches

The 2013 Potential and Goals Study examined the policy initiatives identified in the Strategic Plan[110] and the Scoping Plan to implement the AB 758 initiative to target existing buildings.[111] While many strategies for driving the energy efficiency market are being pursued, most help drive adoption of existing sources of energy savings, and thus do not create a new source of market potential. Whole-building approaches

[109] Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Prepared for: Solid-State Lighting Program, Building Technologies Program. Office of Energy Efficiency and Renewable Energy U.S. Department of Energy. Navigant Consulting, Inc. January 2012. Figure ES-1.

[110] Engage 360. California Energy Efficiency Strategic Plan. January 2011 Update.

[111] *AB 758 Program Update*. Website hosted by CEC, Accessed July 2011. http://www.energy.ca.gov/ab758/

and financing (further discussed below) were the two new initiatives that will produce quantifiable, incremental savings beyond the existing IOU programs and codes and standards.

The 2013 Potential and Goals Study developed a new approach to quantify potential from whole-building initiatives in the residential and commercial sectors. Whole-building initiatives modeled include both the new construction market (buildings and homes that achieve Title 24 reach goals as well as ZNE homes and buildings) and the retrofit market (homes and buildings targeted by initiatives such as AB758 and EUC). The Navigant team developed estimates of energy savings and costs for these individual whole-building initiatives. The model treats each whole-building initiative based on its aggregate characteristics of component technologies as a single decision analysis. Input data for these initiatives were obtained from various sources including the following:

- Navigant team analysis of CEC Title 24 building codes[112]
- EUC residential program reports and CPUC analysis[113] of those reported savings
- PG&E's technical feasibility of ZNE study[114]
- Navigant team analysis of retrofit whole-building savings and costs

The incremental potential from whole building initiatives is illustrated in Figure 4-14. The results show whole-building savings is dominated by commercial new construction initiatives in the near term (such programs as Savings by Design). As California commercial building codes increase efficiency requirements (with schedule standards to come into effect in 2014 and 2017), IOU new construction efficiency initiatives begin to decrease as a source of savings. In the long term, two trends emerge:

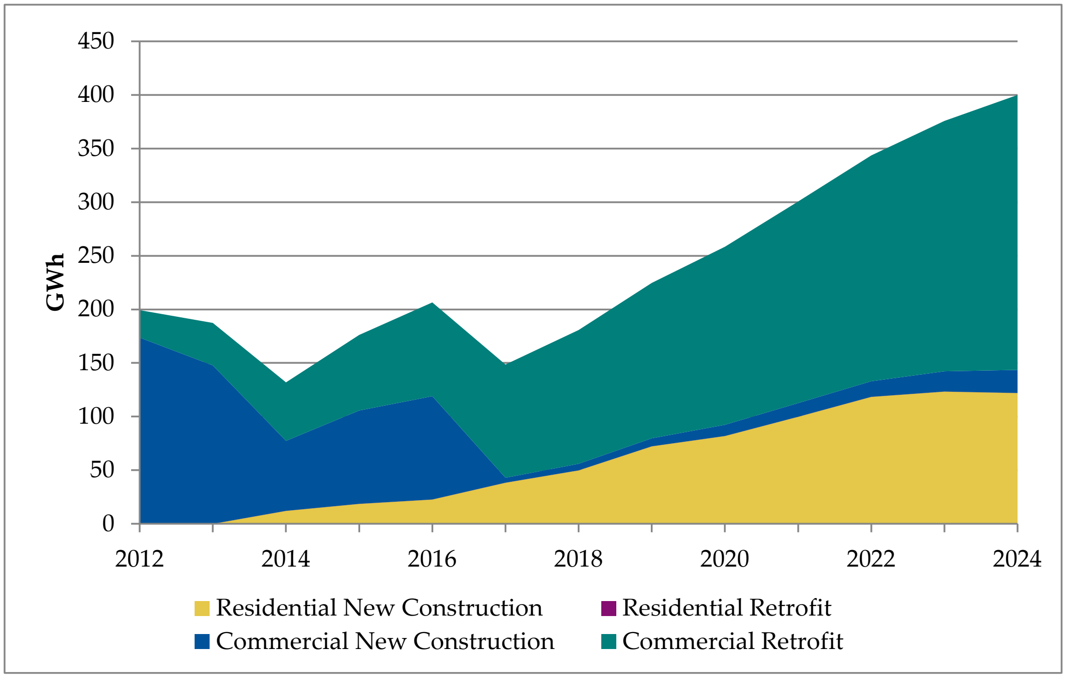
- Commercial existing whole-building renovation begins to replace commercial new construction savings. Some commercial new construction savings opportunity remains (in the form of ZNE buildings); however, the cost-effectiveness of such efforts is low, leading the limited adoption.
- Residential new construction initiatives begin to penetrate the market strongly driven by ZNE initiatives that exceed Title 24 codes.

[112] 2013 Title 24 CASE Analysis and CEC Analysis as presented at CEC pre-rulemaking workshop on July 15, 2011. Package A3.

[113] CPUC. March 2013. "Advanced Path Disposition Cover Letter."

[114] ARUP. *The Technical Feasibility of Zero Net Energy Buildings in California*. Prepared for PG&E. December 2012.

Figure 4-14. All IOU Residential and Commercial Incremental Market Potential from Whole-Building Initiatives



Source: PG model release August 2013

A notable absence from Figure 4-14 is residential retrofit program savings (also known as Energy Upgrade California). The Navigant team used the latest data and intelligence from the CPUC and IOUs on the cost and performance of the current Energy Upgrade California pilot programs. The results show high customer costs with relatively low savings (see Table 4-5). The PG Model calculates a TRC of much less than 0.85 for these initiatives; thus, they screen out of the economic potential and create no market potential savings.

Table 4-5. Energy Upgrade California Report Costs and Savings

Level	Building Type	kWh Savings	kW Savings	Therm Savings	Savings as a Percent Whole-House Energy Use	Average Reported Full Cost	Average EUL
Basic Path	Per Multi-family Unit	74	0.15	21	7%	$850	16
Flex Path	Per Single- Family Home	849	1.15	80	20%	$7,636	16
Advanced Path	Per Single- Family Home	930	1.25	167	36%	$13,453	20

Source: Navigant team analysis, 2013.

Further research, data, and policy discussions could refine the PG Model's results for residential retrofit whole-building initiatives. Data in Table 4-5 shows advanced path participants have spent on average more than $13,000 to reduce home energy use by 36 percent. Based on economics alone, the PG Model determines this is poor energy efficiency investment and that no adoption will occur. However, tracking information from the CPUC and IOUs shows the advanced path is one of the most popular of the EUC options with more than 5,000 participants statewide. Information from the process evaluation of the PG&E and SCE whole-house programs showed: [115]

- Participants listed "home comfort" as a primary driver for participating.
- "Many participants completed an EUC job at a time when they were purchasing a new home and/or when they needed to replace an HVAC system."

These two points led the Navigant team to conclude:

- Reported full cost may not be a true representation of the incremental customer cost.
- Non-energy benefits are highly valued by EUC participants; however, no policy framework exists to monetize these non-energy benefits for the purposes of cost-effectiveness screening or potential study modeling.

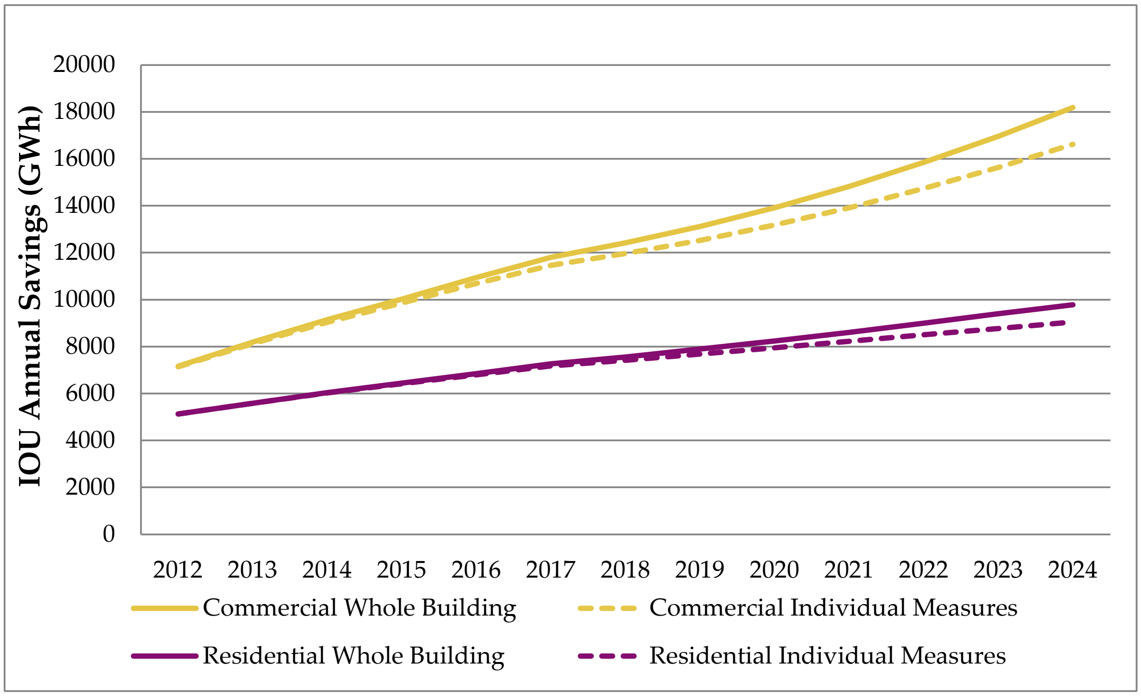
As noted in the methodology section, the PG Model treats participants in whole-building initiatives as exempt from purchasing individual energy efficiency measures. To ensure this modeling decision does not "cannibalize" savings and actually increases overall IOU portfolio savings, the Navigant team conducted a sensitivity analysis. The sensitivity analysis shows cumulative sector savings for residential and commercial sectors under two conditions:

- Whole-building initiatives are made available ("Whole Building").
- Whole-building initiatives are unavailable and customers can only participate in IOU programs by installing individual measures ("Individual Measures").

[115] SBW Consulting. 2012. *2010–2012 PG&E and SCE Whole House Retrofit Program Process Evaluation Study.*

The results show higher program savings when including whole-building initiatives, indicating that such initiatives do in fact increase IOU program savings.

Figure 4-15. All IOU Residential and Commercial Cumulative Potential with and Without Whole-Building Initiatives



Source: PG model release August 2013

4.3.8 First Assessment of Financing Initiatives Indicates Limited Opportunity

Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective EE measures. In particular, new financing mechanisms are expected to play an important role in helping to reduce the market barriers associated with larger scale, deep EE retrofits both in the residential and non-residential sectors. EE financing is expected to reduce market barriers associated with first cost, split incentives, liquidity constraints, and others. This is demonstrated by the results from the OBF Program evaluation and market response to the ARRA-funded EE financing programs.

The Navigant team estimated the effects of introducing EE financing on market potential for the residential and commercial sectors. The team modeled the potential impacts of the California IOU Financing On-Bill Repayment (OBR) Pilot Programs currently proposed for the 2013-2014 program cycle. To develop assumptions on the OBR loan characteristics, the Navigant team relied on expert interviews and pilot program plans. In addition, the Navigant team compared the assumptions on loan characteristics with EE financing programs outside California. The PG Model provides the capability to examine how shifting assumptions about financing might affect energy efficiency savings market potential. This is the first potential study known to include financing as a driver of energy efficiency savings.

The introduction of financing affects adoption of energy efficiency in two ways in the 2013 Potential and Goals Study:

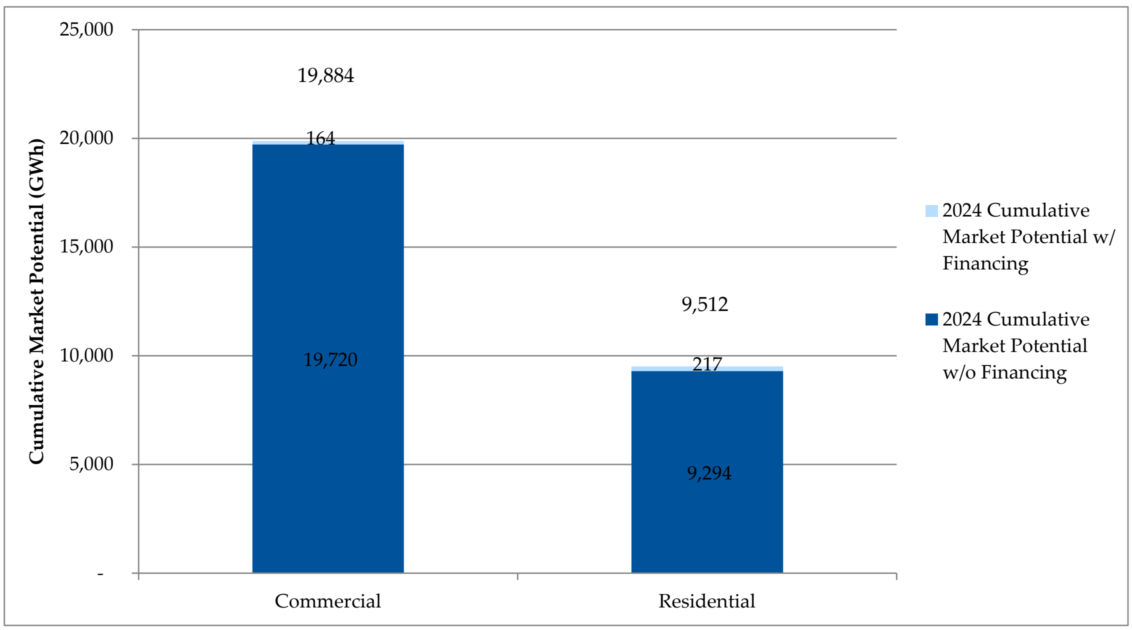
» **Reduces market barriers.** The financing program reduces certain market barriers (e.g., access to capital). The 2013 Potential and Goals Study captures these decreases in market barriers by decreasing the implied discount rate[116] that is applied to purchase decisions.

» **Affects the levelized measure cost.** The levelized measure cost approach uses a discounted cash- flow analysis to calculate the present value of the stream of payments related to a purchase, including upfront cost and operation/maintenance costs. When financing is introduced, the equipment cost plus interest payments are spread over time and discounted back using the implied discount rate. As such, the levelized measure cost is generally lower for the adopter; given the introduction of the interest rate, however, the difference is not significant.

[116] The implied discount rate is the effective discount rate that consumers apply when making a purchase decision. Whereas the standard discount rate only considers the financial trade-off between the upfront cost relative to the longer-term savings, the implied discount rate also considers non-financial factors.

Figure 4-16 displays the effect of adding financing on the cumulative market potential for energy efficiency in 2024. It is important to note that some customers who adopt with rebates alone are also projected to take advantage of financing. However, the cumulative savings represented in Figure 4-16 only represent the incremental savings resulting from financing. In other words, the financing results do not include savings from customers that would have adopted with rebates alone.

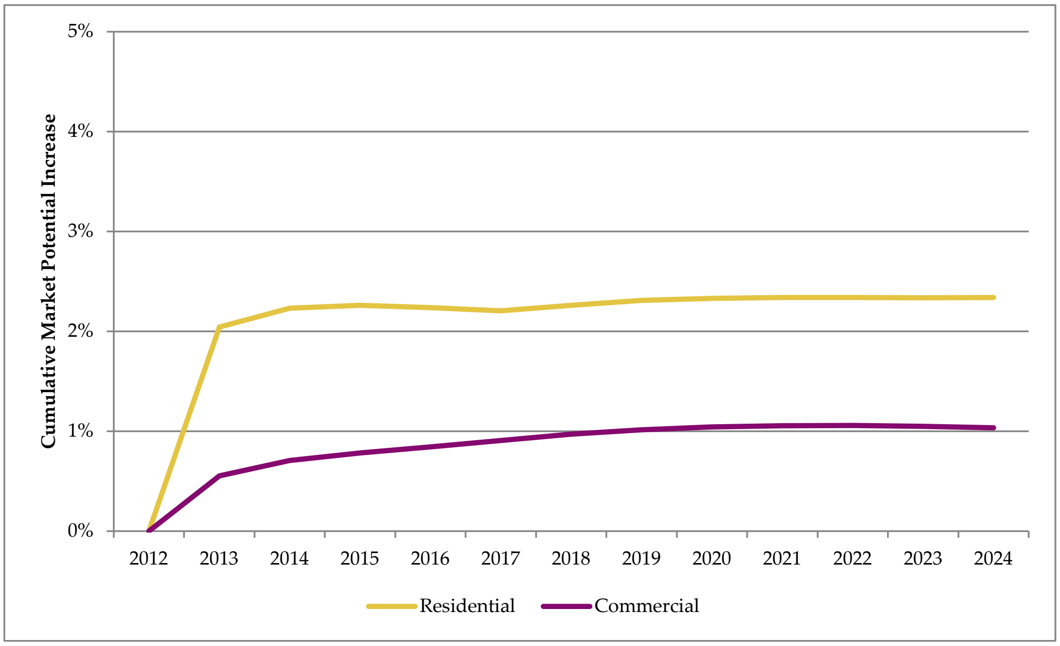
Figure 4-16. California Residential and Commercial Cumulative Market Energy Savings Potential for 2012-2024 (GWh)



Source: PG model release August 2013

As seen in Figure 4-17, OBR has a marginal effect on cumulative market potential for energy efficiency. It is appropriate to look at cumulative market potential because financing is more likely to impact measures with longer effective useful lives, the savings for which are not captured well in incremental market potential.

Figure 4-17. Incremental Effect of Adding Financing on Cumulative Market Potential



Source: PG model release August 2013

The financing model results show that financing delivers a higher impact in the residential sector than the commercial sector. Furthermore, the incremental savings potential due to financing is modest in both sectors. The observations can be explained by two bounding model inputs: population eligibility and implied discount rate (iDR) reduction.[117] Key considerations for each of these factors include:

» **Percent of Population Eligible for Financing.** The size of the eligible population qualified to participate in financing program affects the magnitude of savings. In the proposed California IOU Financing Pilot Programs, both the multi-family and commercial sectors have projected low population eligibility, thereby limiting the application of financing to both residential and commercial sectors. Specific to the multi-family (MF) sector, due to legal and regulatory challenges, OBR is not a viable option except for master-metered properties. Based on the CA IOU financing program design, MF sector financing is applicable to affordable housing, which is estimated to be 5 percent of the MF sector. The projected commercial sector population eligibility considers credit risks. Financing is viable for commercial buildings that are backed by mortgage (owner building) and have good credit. Therefore, only 20 percent of the total commercial

[117] More detailed discussion of these two factors can be found in the Methodology Section (Section 2.3.2.4) and the Financing Appendix (Appendix F).

population is expected to be eligible to participate in the OBR financing programs currently being proposed.

- **Implied Discount Rate Reduction.** As discussed in detail in Section 2.3.2.4, the Navigant team has developed a methodology for modeling the incremental effects of financing that is based on adjusting the iDR to account for the likelihood that financing reduces market barriers. Based on primary market research, residential sector customers have a much higher implied discount rate than commercial customers (63 percent for residential customers and 20 percent for commercial customers) with respect to energy efficiency investments. When financing is introduced, the projected change in implied discount rate is much more significant in the residential sector, which results in a larger incremental savings potential.

The moderate results for financing are also tied to the assumptions regarding interest rates for the California IOU Financing OBR Pilot Programs. The interest rates for the pilot programs are similar to traditional loans. Other factors affecting the moderate savings projections resulting from financing include: single-family customers have easy access to financing through credit cards for small-size retrofit purchases and potential hassle factor associated with any application process to obtain financing.

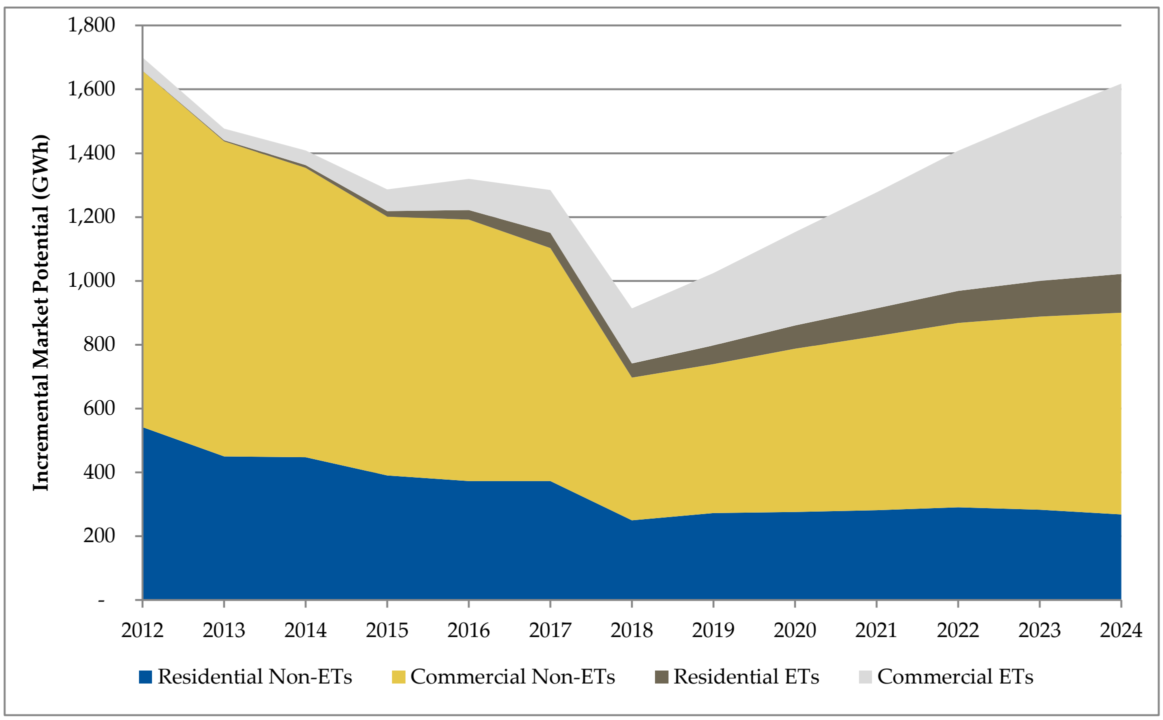
4.3.9 New Approach to Emerging Technologies Expands Potential Savings

The Navigant team expanded the scope of emerging technologies and refined the modeling methodology for ETs in this study, as discussed in Section 2.1.1.1. ETs are defined as meeting one or more of the following criteria:

- Not commercially available in today's market
- Commercially available but representing less than 5 percent of the existing market share
- Costs and/or performance are expected to change/improve in the future.

Figure 4-18 illustrates the electricity savings achievable from ETs relative to conventional (non-ET) measures. ET potential remains small in the near term but is expected to increase to a sizable share of market potential by 2024. The overall trend in electric ET savings is due to three factors: high current costs of ETs that decrease in the future, increases in savings from LEDs due to improving efficacy, and increasing future retail energy prices. Gas ET potential savings are muted due to the interactive effects from electric emerging technologies (LED lighting) that created "negative" gas savings. While the residential sector shows net positive gas savings achievable from ETs, the commercial sector shows almost no net savings.

Figure 4-18. IOU Territory Residential and Commercial Emerging Technology Electric Savings Potential Relative to Conventional Technologies



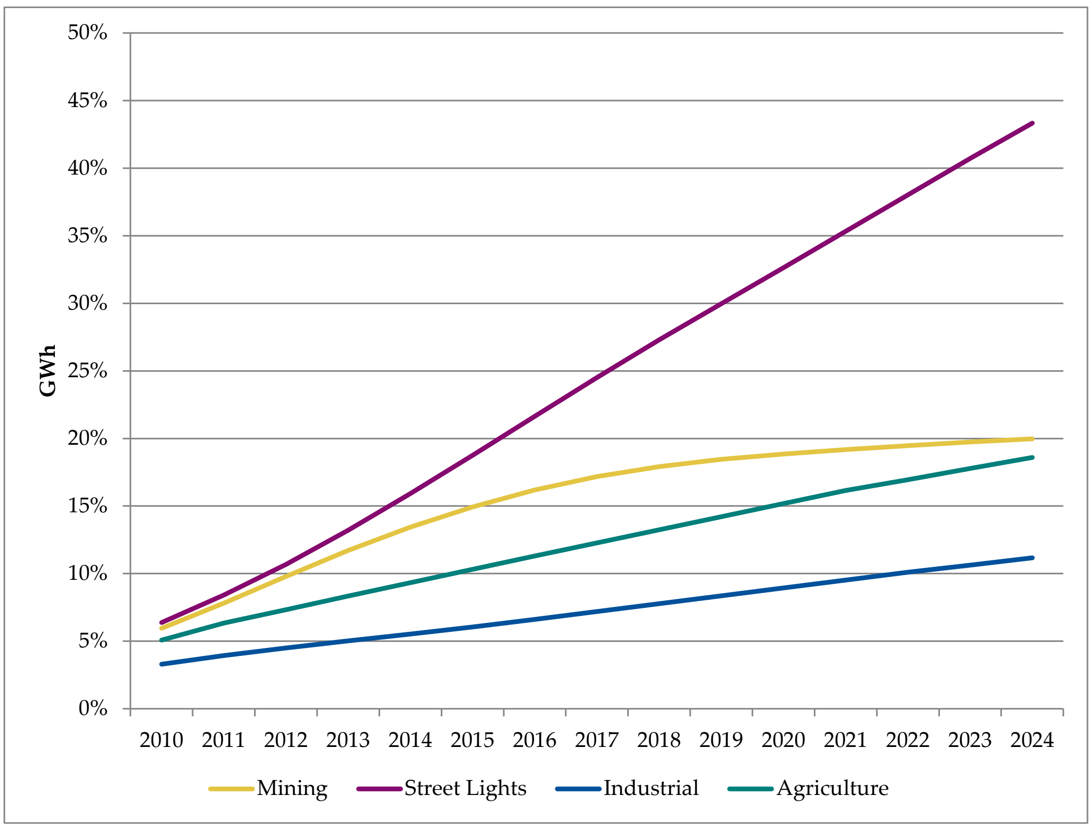
Source: PG model release August 2013

4.3.10 Study Identifies New Energy Savings Potential for the Agricultural, Industrial Mining, and Street-Lighting Sectors

The 2013 Potential and Goals Study includes an updated approach to calculating savings from the agricultural and industrial sectors, and includes the mining and street-lighting sectors for the first time. This section provides a brief overview of the related methodologies and key findings. The industrial and agricultural poses a unique challenge in assessing EE potential because energy improvements are custom rather than using standard measures with established savings values. The 2013 Potential and Goals Study addressed this issue by using a supply curve approach to calculate energy efficiency potential. These calculations relied on a national database[118] of over 15,000 energy efficiency projects completed in the industrial sector, the most current and comprehensive data available to estimate potential in these sectors. The supply curve approach uses this data in conjunction with the sector's consumption data to determine the likely market potential. Potential in the mining and street-lighting sectors relied on the same Bass Diffusion approach utilized for the residential and commercial sectors. The Bass Diffusion approach is discussed in Section 1.

When cumulative market potential is considered as a share of each sector's forecasted consumption, the street-lighting sector shows the most opportunity for energy efficiency, as shown in Figure 4-19. By the end of the study period, energy efficiency is estimated to account for more than 40 percent of the CEC's forecast for street-lighting sector consumption. Energy efficiency in the mining and agricultural sectors is anticipated to account for just under 20 percent of each sector's forecasted consumption. Energy efficiency in the industrial sector may only account for 10 percent of that sector's forecasted energy consumption.

Figure 4-19. Cumulative Market Potential as a Percent of Each Sector's Forecasted Consumption



Source: PG model release August 2013

[118] U.S. Department of Energy. 2013. Industrial Assessment Centers Database. http://iac.rutgers.edu/database.

The revised approach to estimating potential in the industrial and agricultural sectors, and the addition of estimates for the mining and street-lighting sectors, has revised upwards the total market potential for these non-residential sectors. Table 4-6 provides a comparison of market potential for the AIMS sectors for the 2011 and 2013 forecasts.

Table 4-6. Comparison of AIMS Cumulative Market Potential in the 2011 Potential Study and the 2013 Potential and Goals Study

	Total AIMS		
Year	2011	2013	% Difference
2012	2,587	2,889	10%
2013	2,959	3,308	11%
2014	3,315	3,725	11%
2015	3,655	4,137	12%
2016	3,983	4,543	12%
2017	4,265	4,939	14%
2018	4,526	5,325	15%
2019	4,771	5,702	16%
2020	5,006	6,074	18%
2021	5,228	6,443	19%
2022	5,418	6,810	20%
2023	5,601	7,174	22%
2024	5,806	7,536	23%

Source: PG model release August 2013

4.3.11 Potential from Codes and Standards and Behavioral Initiatives Remain Key Areas of Uncertainty

The assessment of codes and standards and usage-based behavioral initiatives was approached in the 2013 Study using the same assumptions and methodology as was used in the 2011 Study. However, these assumptions involve a degree of uncertainty. Primarily, there is some debate about the appropriate compliance rates to use for codes and standards, and, several efforts are occurring at the time of publication that seek to quantify the savings impacts of behavior-based initiatives. The remainder of this section describes these issues in more depth.

4.3.11.1 Potential for Codes and Standards

C&S are implemented and enforced by federal or state government agencies. Codes regulate building design, requiring builders to incorporate high-efficiency measures and design. Standards set minimum efficiency levels for newly manufactured appliances. The Navigant team assessed energy savings potentials for three types of C&S:

» Federal appliance standards

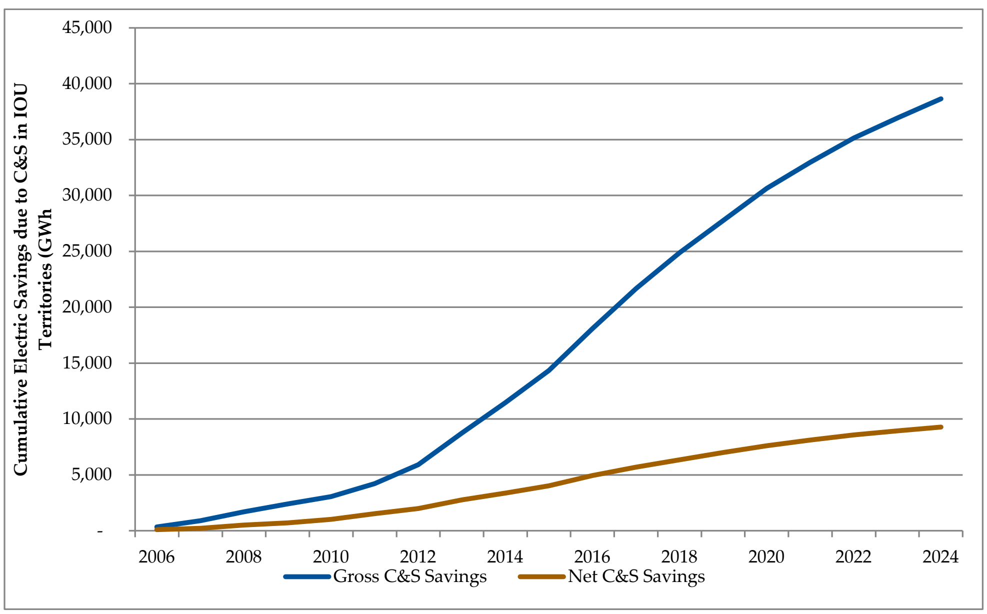
- Title 20 appliance standards
- Title 24 building energy efficiency code

The Navigant team analyzed the savings from C&S using the same methodology as the CPUC evaluation of IOU C&S programs.[119] The Navigant team examined both codified C&S and future (expected and possible) C&S (e.g., future Title 24 building code cycles). The PG Model calculates both gross and net C&S savings. The terms "gross" and "net" savings have a unique meaning in the C&S context:

- **Gross C&S Savings** are the **total** energy savings estimated to be achieved from the updates to codes and standards since 2006. Gross savings are used to inform demand forecasting, procurement planning, and tracking against greenhouse gas targets.
- **Net C&S Program Savings** identify the portion of the total C&S savings that can be attributed to the advocacy work of the IOUs' C&S programs. Net savings calculations account for NOMAD of code-compliant equipment and utility attribution factors.

Figure 4-20 illustrates the C&S savings in both incremental annual and cumulative forms, respectively, in the IOU service territories. The drop in incremental savings from C&S starting in 2017 is an artifact of the lack of data for future appliance standards. When viewing the cumulative savings, it is apparent that C&S will continue to save California a significant amount of energy for years to come.

Figure 4-20. IOU Territories Cumulative Net and Gross Electric Savings from C&S



Source: PG model release August 2013

[119] KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc. April 9, 2010. *Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008*. Prepared for CPUC.

Two uncertainties in the C&S analysis relate to the compliance rate.

- Some stakeholders consider the base compliance rate, which is achieved without IOU support, an uncertain input. The Navigant team's analysis uses the same assumptions about base compliance rates as the CPUC evaluations of C&S programs, which list specific compliance rates for each evaluated code or standard. [120] The Navigant team estimated compliance rates for unevaluated codes and standards using weighted averages from the CPUC evaluation; weighted average compliance rates ranged from 70 to 95 percent, depending on the type of code or standard.
- Also embedded in the C&S results is an assumption that compliance rates will ramp up from their current levels to 100 percent in the next ten years based on goals outlined in the *California Energy Efficiency Strategic Plan*.[121] While this acts to increase cumulative C&S savings by approximately 8 percent, it remains uncertain if the goal will actually be achieved.

4.3.11.2 Potential for Behavioral Initiatives

Based on uncertainties that limit the application of long-term forecasts of savings for behavioral initiatives, the Navigant team did not revise the estimate of market potential for behavioral programs first presented in the 2011 potential model. Uncertainties that limit the ability to forecast the initiatives include the following:

1. Results from the evaluation of some behavior programs include usage-based and equipment-based behavior modifications that customers take as a result of the program. These savings cannot be disaggregated, yet this is necessary to avoid double counting of potentials for savings from equipment and usage-based behavior activity.
2. The behavior-based potential in the 2011 estimate was based on a specific type of behavioral program, while many more types of behavioral programs are possible though undefined. The state of the research into behavioral initiatives is moving forward, but has not produced a construct that could be used to forecast behavioral potential beyond a current program cycle. For example, a working group headed up by SCE is working on a white paper[122] that will be helpful in modeling the potential for behavioral initiatives, but this research will not be issued until later in 2013. The white paper outlines three objectives that may help improve the ability to forecast the impact of behavioral initiatives in future potential models:

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[120] CPUC. *Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned 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. April 9, 2010.

[121] Engage360. January 2011. *California Energy Efficiency Strategic Plan: January 2011 Update.* Prepared for the CPUC.

[122] Paving the Way for a Richer Mix of Residential Behavior Programs. Prepared for the California Investor-Owned Utilities: Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas. Patrice Ignelzi, EnerNOC Utility Solutions, Jane Peters, Research Into Action Katherine Randazzo, Anne Dougherty, Opinion Dynamics Corp., Linda Dethman, The Cadmus Group, Loren Lutzenhiser, Portland State University. May 31, 2013.

a. To frame the discussion about goals and designs of residential behavior programs, including articulation of energy-related behaviors and help in establishing a standard lexicon for use in discussing and developing behavior programs.

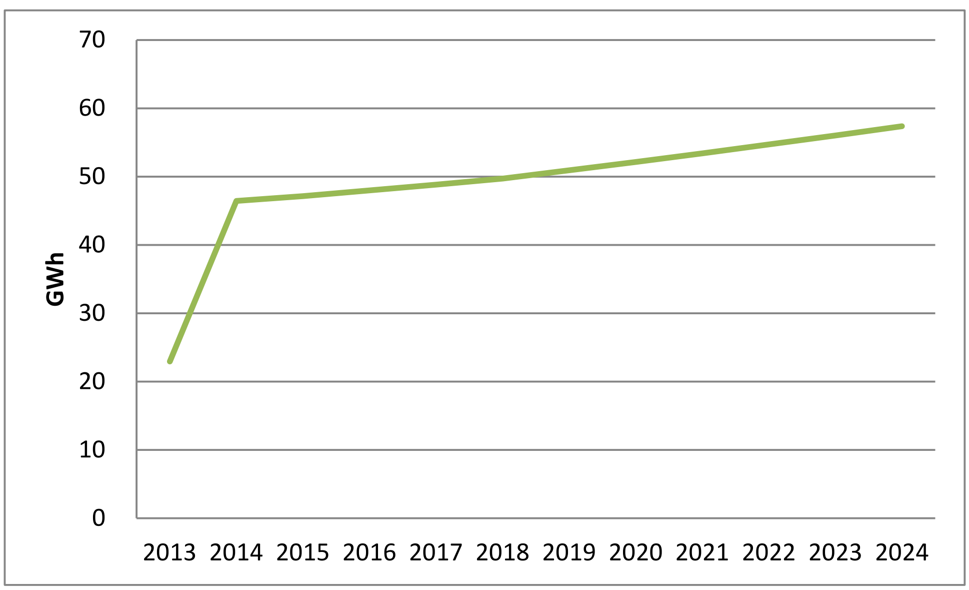
b. To demonstrate that social science disciplines offer a theoretical basis and solid empirical research about behavior that support developing a wide range of behavioral programs.

c. To identify specific, promising behavior intervention strategies grounded in this research that energy efficiency programs can utilize to influence energy-related behaviors.

California's IOUs are continuing to refine their assessments on the role of behavioral initiatives in their portfolios, but there are inconsistencies between utilities in the savings estimates and treatment of behavioral initiatives in the 2013-2014 compliance filing. For example, the 2013-2014 compliance filing shows that 55 percent of the PG&E residential portfolio is associated with home energy reports, but SDG&E, SCE, and SCG show no significant savings from this type of initiatives in the filing. Further, because the PG&E initiative has an EUL of 0.92, it is unclear how these initiatives can be forecast beyond a single portfolio cycle.

Figure 4-21 provides the estimated potential for residential behavioral initiatives originally included in the 2011 potential model, and retained in the 2013 model.

Figure 4-21. 2011 Residential Potential Model Behavior Incremental and Cumulative Market Potential



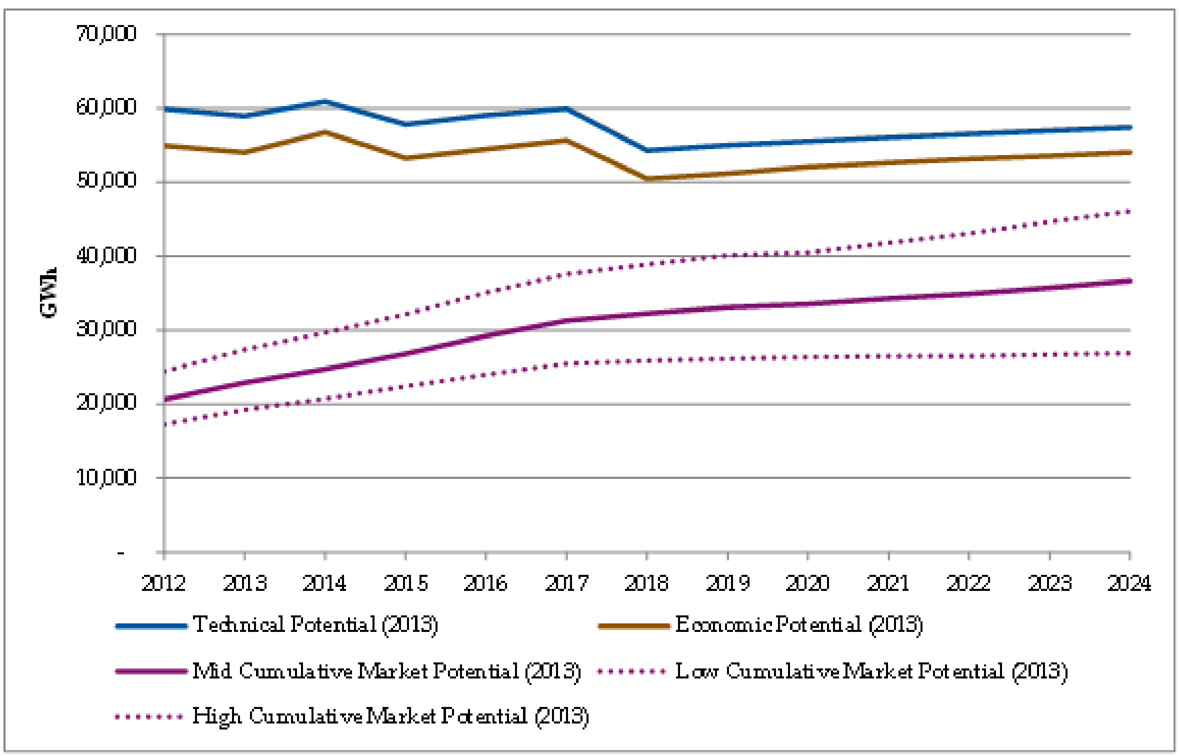
Source: PG model release August 2013

4.4 *Goals and Targets Scenarios*

The Mid-Energy Efficiency Penetration scenario is intended to reflect the potential under business-as-usual circumstances. The incentive level, TRC threshold, avoided costs, measure-level data, and other variables use data that are consistent with current policies and program designs and widely accepted data sources. The Low and High Energy Efficiency Penetration scenarios adjust the inputs to reflect potential in the event that those underlying assumptions change. Figure 4-22 captures the results of these three scenario analyses for all sectors and all IOUs.

In the case of the High Energy Efficiency Penetration scenario, the values for the variables are adjusted to consider a more optimistic future, one in which incentive levels and avoided costs are higher and the financial attractiveness of measures is better (in addition to other changes). The Low Energy Efficiency Penetration scenario includes assumptions that make investment in energy efficiency less favorable. The High Energy Efficiency Penetration scenario represents approximately a 25 percent increase in cumulative market potential by 2024 relative to the Mid-Energy Efficiency Penetration scenario. The Low Energy Efficiency Penetration scenario represents roughly a 25 percent decrease in cumulative market potential relative to the Mid-Energy Efficiency Penetration scenario for that same time frame.

Figure 4-22. Results of Scenario Analysis[123]



[123] Source: PG model released August 2013. This chart shows the High, Mid, and Low scenarios for the cumulative market potential; technical and economic potential are also adjusted in the High and Low scenarios, but those adjustments are omitted from this graph for simplicity.

The values provided in the high and low scenarios provide a reasonable range of cumulative energy efficiency potential; however, the likelihood that the inputs that define the high and low scenario would align over the ten-year forecast horizon is doubtful. As such, the Navigant team recommends that the values from the Mid-EE Penetration scenario be considered as the basis for the IOU service territory goals for the portfolio beginning in 2015. Table 4-7 provides the Mid-EE Penetration scenario model outputs for annual, life-cycle, and active cumulative market potential. The Navigant team considers these estimates a viable baseline target for energy efficiency to which program planners, load forecasters, system planners, and resource procurement specialists could agree. This is not, however, intended to define the upper bound on the total amount of energy efficiency that can be achieved during upcoming portfolio cycles. As noted in the discussion on the objectives for this study, that will be determined as the market for innovative products and services continues to evolve.

Table 4-7. Recommended IOU Program Target Inputs

Year	Annual Incremental			Life-Cycle			Cumulative		
	GWh	MW	MM Therms	GWh	MW	MM Therms	GWh	MW	MM Therms
2015	2,366	673	50	20,785	5,666	567	26,805	7,643	489
2016	2,690	772	55	21,812	5,900	588	29,216	8,389	546
2017	2,445	706	57	19,908	5,619	570	31,312	9,029	600
2018	1,994	649	63	16,879	5,337	629	32,245	9,503	649
2019	2,078	667	65	18,639	5,648	660	33,081	10,014	712
2020	2,171	687	67	20,448	5,981	692	33,552	10,434	771
2021	2,199	699	67	22,336	6,329	724	34,288	10,949	837
2022	2,271	718	69	24,294	6,700	760	34,913	11,426	902
2023	2,286	732	70	25,736	7,014	790	35,757	11,955	967
2024	2,359	749	72	26,984	7,292	820	36,677	12,498	1,032

Source: PG Model release August 2013.

As discussed earlier, the potential model informs many different types of objectives, each with a different technical or temporal requirement. For example, the study serves to inform annual goals for near-term IOU portfolio goals, but also to provide support for system planners considering out-year planning decisions. Some planning exercises might depend on net estimates, while others consider only gross impacts. In addition to the IOU goals, Table 4-8 provides a summary of what types of potential model outputs are most appropriate for the various planning activities supported by this study. Several output definitions remain TBD at the time this report is being published.

Table 4-8. Recommended Potential Model Usage

Electric Goals	IOU Goals	LTPP	CAISO	CEC/IEPR
Annual energy and demand savings				
Model Scenario	Mid Case	TBD	TBD	High/Mid /Low
IOU Rebate/Finance Programs	Gross	TBD	Net	Net
Codes and Standards	Net IOU Attributable	TBD	Total Net IOU Service Territory	Total Net IOU Service Territory
Behavioral Initiatives	Gross	NA	NA	NA

5 Energy Efficiency Potential in California's Residential Sector

This section provides the estimates of potential energy and demand savings at the statewide level for residential buildings, including single-family (SF) homes and multi-family (MF) structures.

5.1 Overview

The residential sector will see significant changes in coming years. Codes and standards changes for residential lighting and the introduction of new measures into the utility portfolio affect the residential energy and demand savings potential. The technical and economic savings potential both see a significant reduction in 2018 due to codes and standards but begin to recover in later years due to the emerging technologies. Cumulative market potential begins to decline in 2018 due to the codes and standards and flattens in the outer years as it accounts for decay in savings potential as measures reach their end of life.

5.2 California Residential Summary of Results

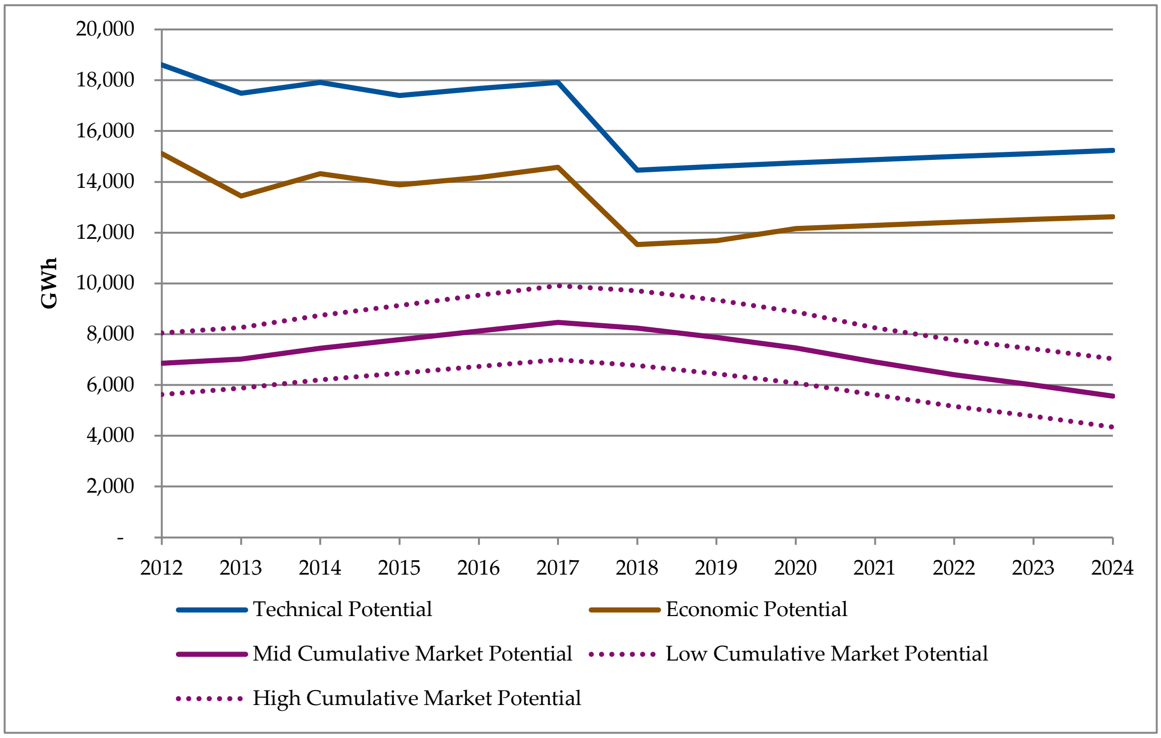
5.2.1 California Residential Electric Energy Potential

Figure 5-1 presents the technical, economic, and cumulative market energy savings potential in the residential sector. The economic potential stays at approximately 80 percent of the technical potential throughout the forecast while the cumulative market follows its own curve, decreasing in later years. High and low scenario runs are also shown, with the high run about 20 percent higher and the low run about 20 percent lower than the mid scenario.

The technical and economic savings potential decreases significantly in 2018 as lightings codes and standards are put into effect. These codes and standards affect the residential sector more than other sectors because the codes target residential lighting equipment such as incandescent and CFLs more than other lighting equipment. The cumulative market savings rise in the early years because many of the early measures were installed before codes and standards occur and continue to yield the same savings even after a code has affected the measures, until they reach their useful life. For example, a CFL bulb installed before increased lamp efficiency standards came into effect will continue to generate savings even after new code is in effect.

The decrease in savings in the later years is because of the combined effect of decay and codes and standards. To account for decay, the cumulative savings do not assume that savings will persist at the end of a measure life. When a measure reaches the end of its useful life, if that measure were to be replaced with the exact same measure, the lower code savings must now be applied. Most of the lighting savings in the early years come from CFLs, which have EULs in the range of five to ten years, and as the CFL stock turns over, the cumulative savings is adjusted to keep current with code. In all cases, CFL lighting measures will either have dramatically reduced savings at the end of their useful lives or no longer yield savings at all. While there is adoption of LED lighting measures and other emerging technologies in the outer years, their adoption rate is not enough to backfill the decrease in CFL lightings savings after codes and standards, thus resulting in a gradual decrease in cumulative savings in later years. Further detail on the cumulative effects of decay and codes and standards is provided in the methodology section.

Figure 5-1. California Residential Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)

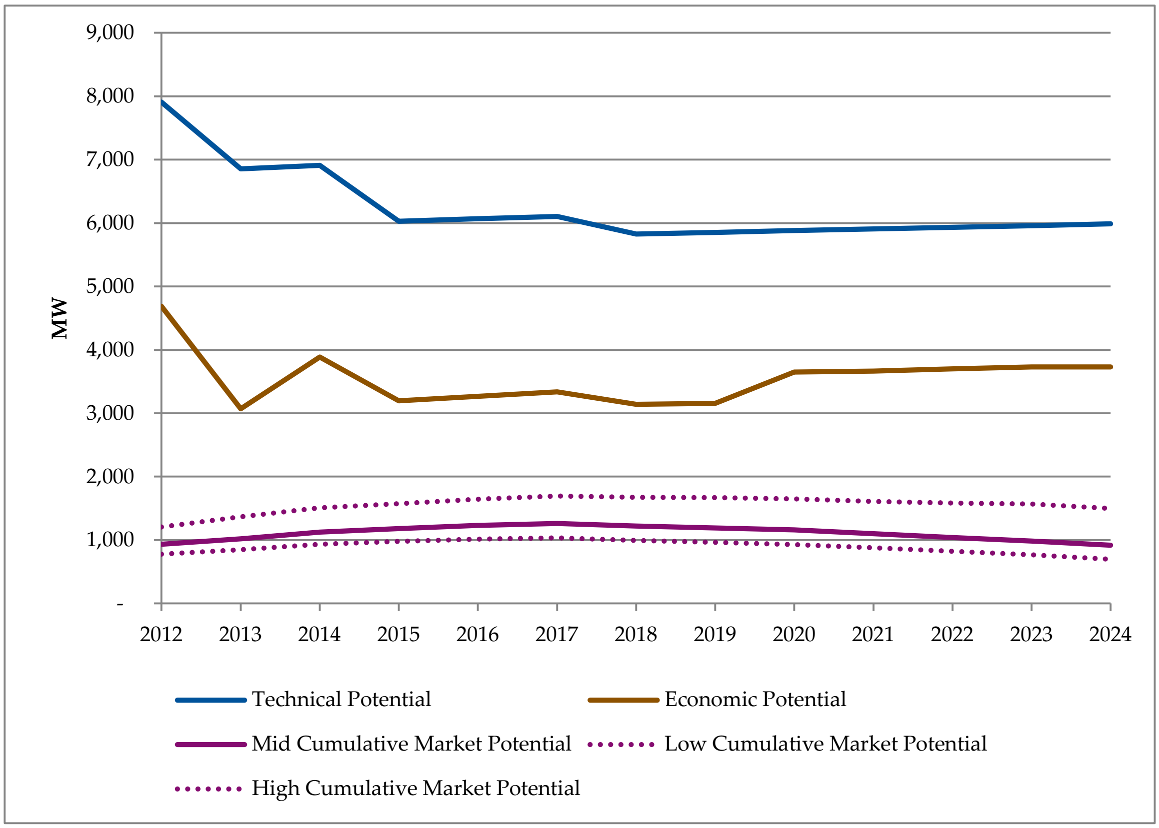


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 5-2 presents the gross technical, economic, and cumulative market demand savings potential for California's residential sector from 2012 through 2024. The technical and economic savings potential are less impacted in 2018 by the lighting standards for demand than energy, as the coincidence factors are not as high for lighting measures as an HVAC measure. However, potential in early years is impacted more by HVAC codes and standards for demand than energy because of the higher HVAC coincidence factors.

Figure 5-2. California Residential Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2012-2024 (MW)

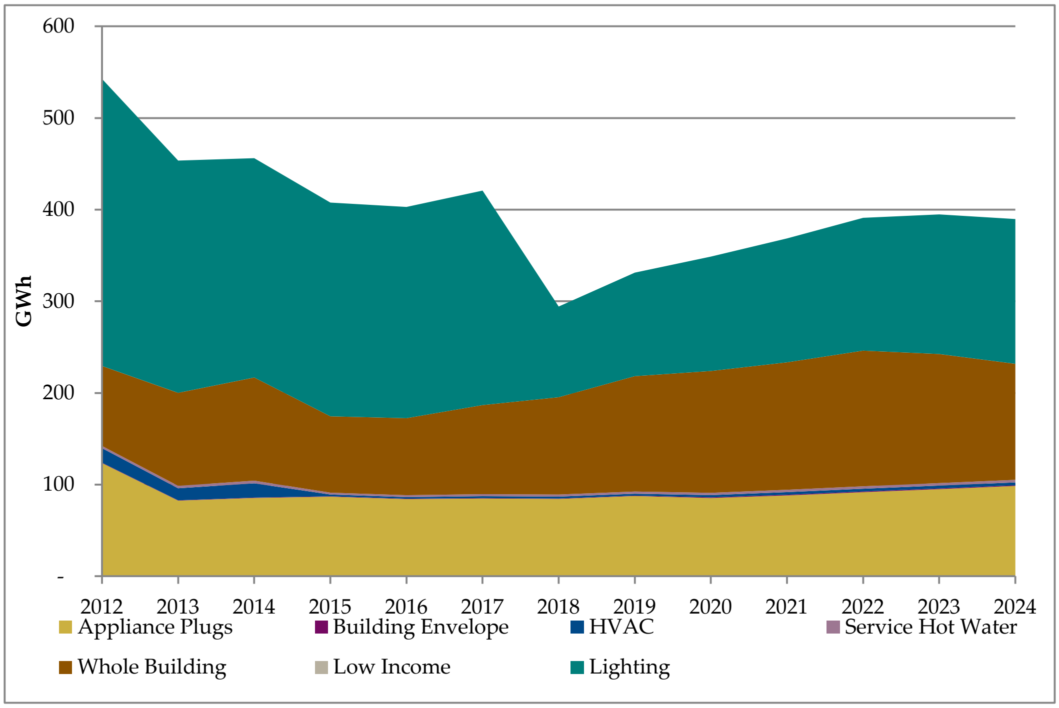


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

California's residential sector incremental market potential decreases in a similar fashion to the technical and economic savings potential, as presented in Figure 5-3. This figure breaks out the savings by end-use category and shows the extreme effect of codes and standards on lighting in 2013 and 2018.

Figure 5-3. California Residential Gross Incremental Market Potential for 2012-2024 (GWh)

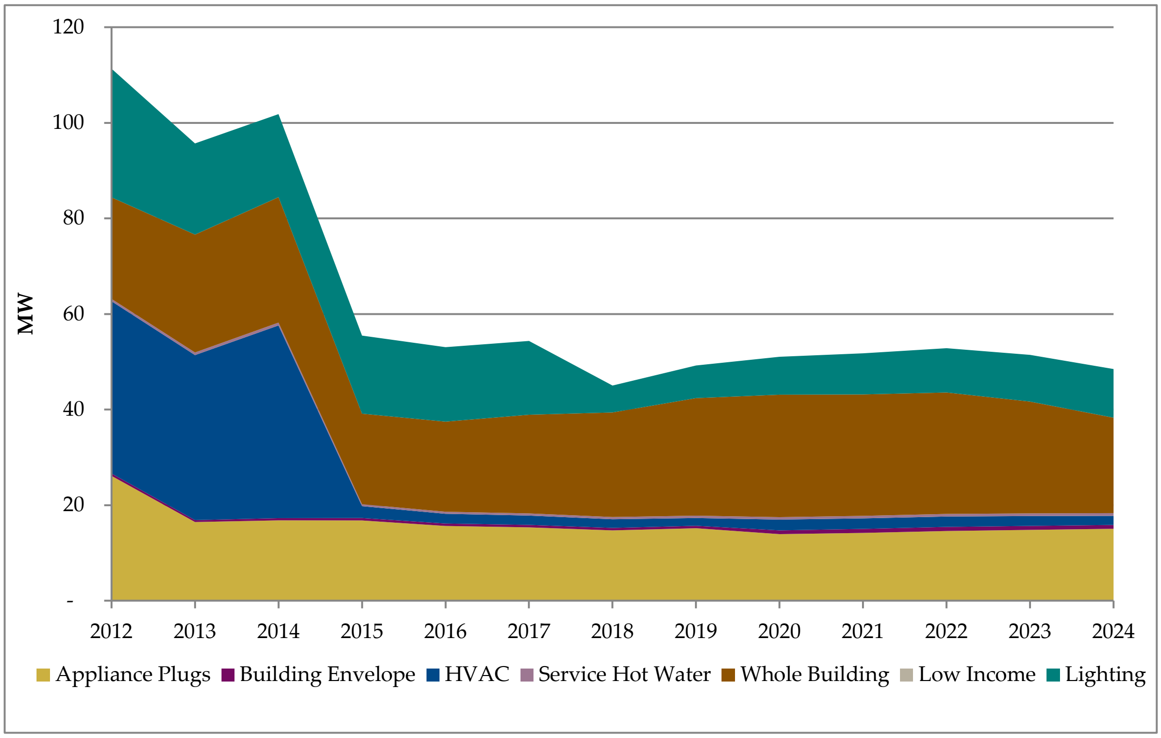


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 5-4 presents the gross incremental market potential for demand savings in California's residential sector from 2012 through 2024. The market potential decreases here too, but in much earlier years, which is discussed below Figure 5-4.

Figure 5-4. California Residential Gross Incremental Demand Savings Market Potential for 2012-2024 (MW)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

Figure 5-3 and Figure 5-4 break out the incremental market potential of residential energy and demand savings by end-use category. Lighting, Whole-Building, and Appliance Plugs have the largest energy savings potential. There are many new Appliance Plug measures that are coming into the market and modeled in this study. The results show that these new Appliance Plug measures have a significant impact on energy savings potential and make up nearly a quarter of the potential savings in 2020. Whole-building bundles are a new modeling development this year and are the second largest source of savings in later years. Whole-building, HVAC, and Appliances have the largest demand savings potential, due to their peak hours of use. Although Lighting measures are large contributors to both energy and demand savings potential, changes in codes and standards decrease their savings contribution over time, most significantly in years 2013 and 2018. The effects of HVAC codes and standards can be seen in 2015, most significantly in the HVAC demand potential. These 2015 HVAC codes and standards affect both split SEER AC systems and direct evaporative coolers. In addition, some HVAC potential gets absorbed into whole-building activity, which sees increased savings after 2015.

5.2.2 California Residential Electric Comparative Metrics

This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 Residential sector analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For residential, the following comparative metrics are provided:

- Comparison of the 2011 and 2013 potential studies
- Residential Appliance Saturation Study (RASS) per household consumption by end-use category as compared to 2013 technical, economic, and market potential savings end-use category forecasts
- Cumulative savings potential by end use as compared to the total CEC residential consumption forecast
- Incremental annual forecast potential for 2013/2014 compared to the IOU residential sector program savings estimates for the 2013/2014 portfolio

5.2.2.1 Comparison between 2011 and 2013 Potential Study Residential Results

Table 5-1 and Table 5-2 compare the incremental and cumulative market potential savings estimates of the 2011 Potential Study and the 2013 Potential Study. Reasons for overall modeling differences between the 2013 and 2014 study are discussed in Section 4.3.2. Specifically regarding residential differences between the two studies, Set Top Boxes were a major measure that provided over 25 percent of incremental savings in the later years in the 2011 study. This measure was not included in the 2013 study as the measure is not feasible for the utilities to add to their portfolios.

Table 5-1. Changes in California Residential Incremental Energy Market Potential from the Previous Forecast (GWh) (Excludes C&S)

Year	Incremental Market Potential		
	2011 Study	2013 Study	Percent Increase or Decrease
2012	522	543	4%
2013	398	477	20%
2014	418	503	20%
2015	459	455	-1%
2016	486	451	-7%
2017	498	470	-6%
2018	450	344	-24%
2019	450	382	-15%
2020	454	401	-12%
2021	466	422	-9%
2022	461	446	-3%
2023	445	451	1%
2024	423	447	6%

Source: PG model release August 2013

Table 5-2. Changes in California Residential Incremental Demand Market Potential from the Previous Forecast (MW) (Excludes C&S)

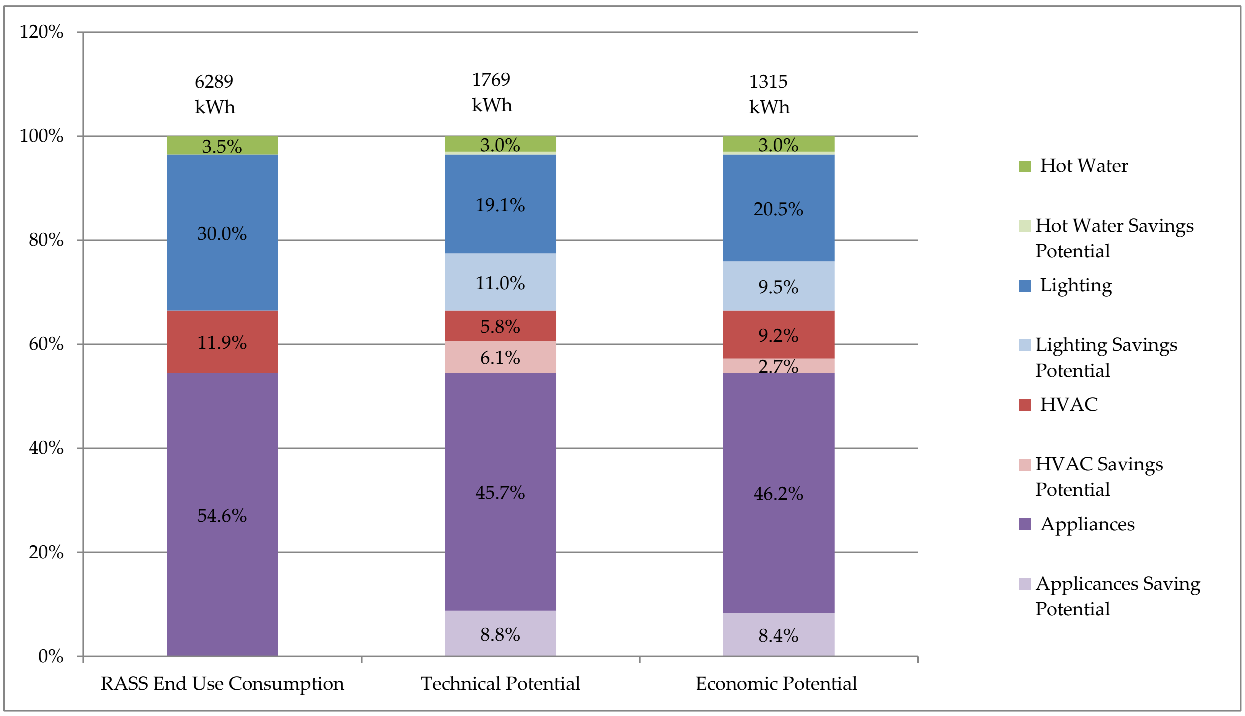
Year	Incremental Market Potential		
	2011 Study	2013 Study	Percent Increase or Decrease
2012	522	111	8%
2013	398	96	49%
2014	418	102	67%
2015	459	55	-14%
2016	486	53	-19%
2017	498	54	-12%
2018	450	45	-12%
2019	450	49	-1%
2020	454	51	8%
2021	466	52	8%
2022	461	53	12%
2023	445	51	11%
2024	423	48	3%

Source: PG model release August 2013

5.2.2.2 *RASS Comparative Metrics*

The RASS provides per-home savings by end use for each of the IOUs in California. This provides a strong metric for comparison purposes of this study. Figure 5-5 displays the average kWh consumption per home as provided by RASS and the technical and economic potential per home as provided by this study. The first bar is a stack of the RASS consumption with splits based on end use. The next two bars show the same RASS consumption end-use splits, but also embed the percent of that end use that the 2014 technical or economic savings encompass. At the top of each bar is the kWh consumption or potential savings. Incremental market potential (shown in Figure 5-6) is not shown on this chart because the percentage splits, which are at much smaller a scale of savings potential, would not register on this chart.

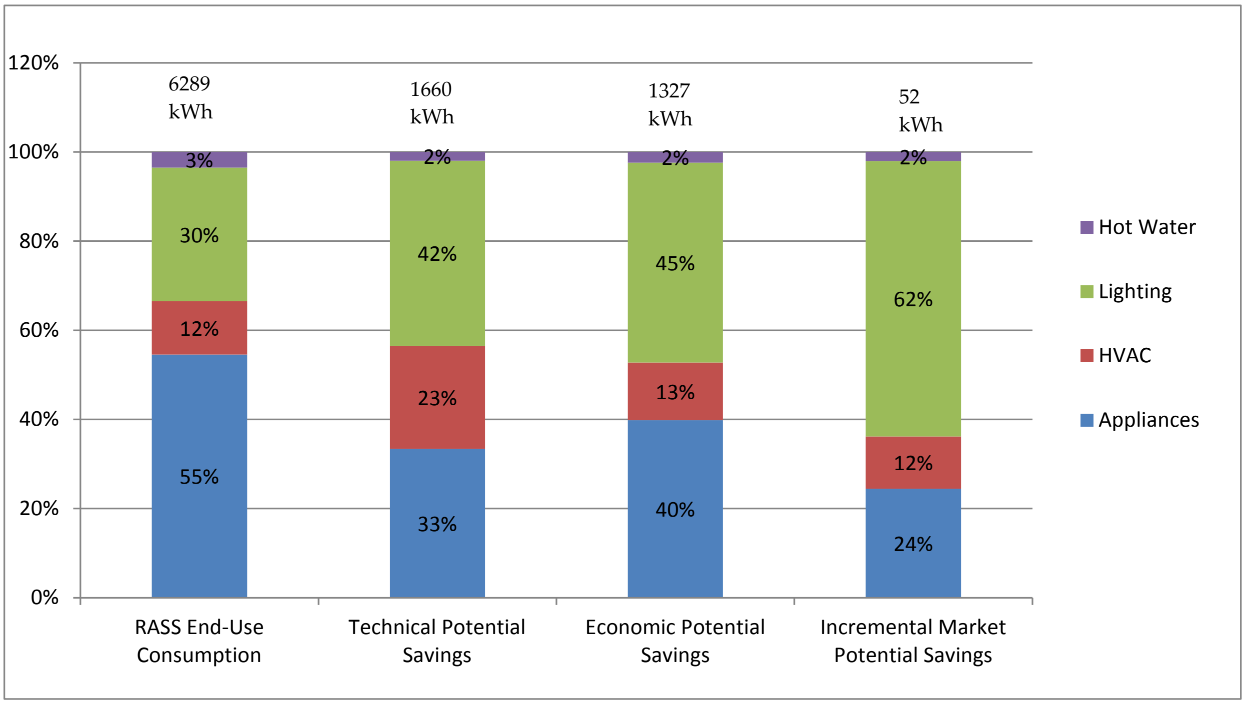
Figure 5-5. California Breakdown of RASS Consumption and 2014 Savings Potential Embedded in End-Use Consumption*



*Number at the top of each bar is the total consumption or savings potential in kWh/home.

Figure 5-6 provides a breakout of RASS consumption by end use and an end-use breakout for technical, economic, and incremental market potential. It is important to show this graph as well to compare how much of the savings potential are coming from each end use against RASS consumption. The numbers at the top of each bar graph represent the total per household consumption and the total savings per household (technical, economic, and market). This shows that 30 percent of an average household's consumption comes from lighting (30 percent of 6,289 kWh), while 45 percent of the economic savings potential comes from lighting (45 percent of 1,325 kWh) and 62 percent of incremental market potential savings come from lighting (62 percent of 52 kWh). Most of the actual achievable market savings in 2014 are from lighting, even though most of the consumption for a household is from appliances.

Figure 5-6. California Breakdown of Consumption and 2014 Savings Potential by End Use

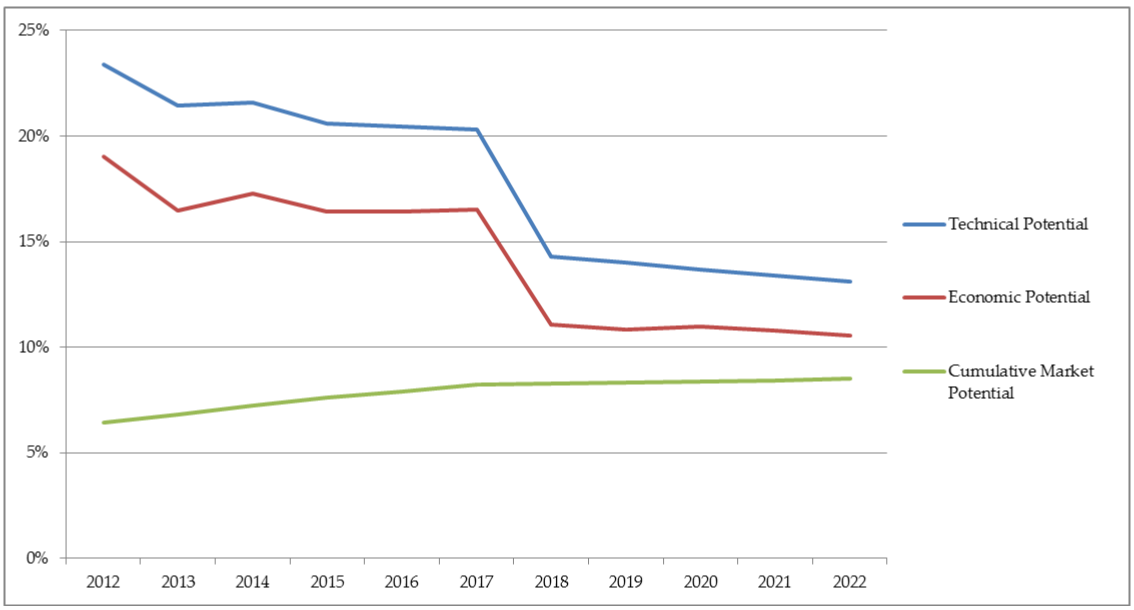


*Number at the top of each bar is the total consumption or savings potential in kWh/home.

5.2.2.3 *CEC Forecast Comparative Metrics*

CEC consumption forecasts are one of the foundational inputs for the 2013 Potential Study. The consumption forecasts also serve as a useful and important comparative metric. Figure 5-7 shows the technical, economic, and cumulative market potential savings as a percent of the CEC residential forecast. Technical potential is about 24 percent of the CEC residential consumption forecast in 2012, but drops down to about 14 percent in 2022 as codes and standards come into effect and consumption continues to increase. Cumulative market potential rises from about 6 percent in 2012 up to approximately 8 percent by 2022.

Figure 5-7. California Residential Savings Potential as a Percent of CEC Residential Forecast (Technical, Economic, and Cumulative Market Potential)

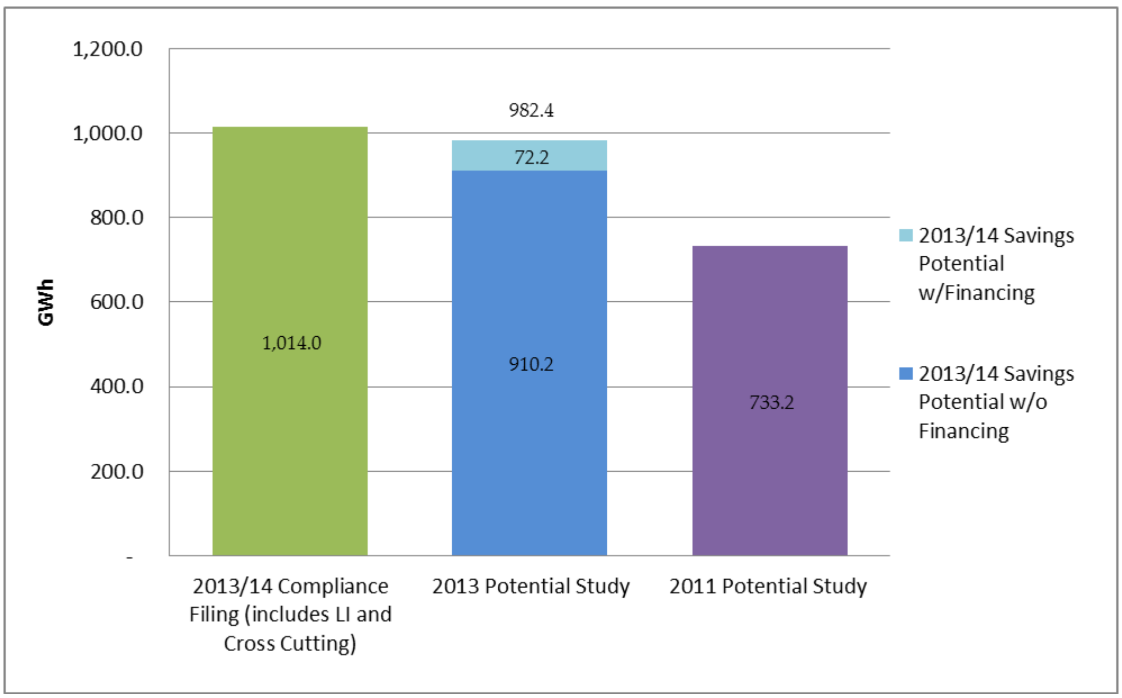


Source: PG model release August 2013

5.2.2.4 *IOU 2013/14 Compliance Filing Comparative Metrics*

During this study, IOUs provided their compliance filings that were submitted to the state for their 2013/2014 goals. These provided another comparative metric and the residential compliance numbers in the compliance filings were compared to the 2013 Potential Study residential results as well as the 2011 Potential Study results, as shown in Figure 5-8. These were an integral part of the Navigant team's quality control and calibration process in order to calibrate to the utilities' portfolio plan in addition to historical data. The 2013 study is slightly below the compliance filings for residential, but both the compliance filings and the 2013 study potential are significantly higher than the potential provided in the 2011 study. Part of the calibration process was to assess the PG Model's results relative to the 2013-2014 compliance filings and the 2011 Potential Study; Figure 5-8 provided the basis for this comparison. It should be noted that the second bar in the graph below, which is from the 2013 Potential and Goals Study, also accounts for Low-Income and Crosscutting Savings.

Figure 5-8. California Comparison of IOU Residential Compliance Filings and Potential Study Results for Program Years 2013 and 2014 (Electric)

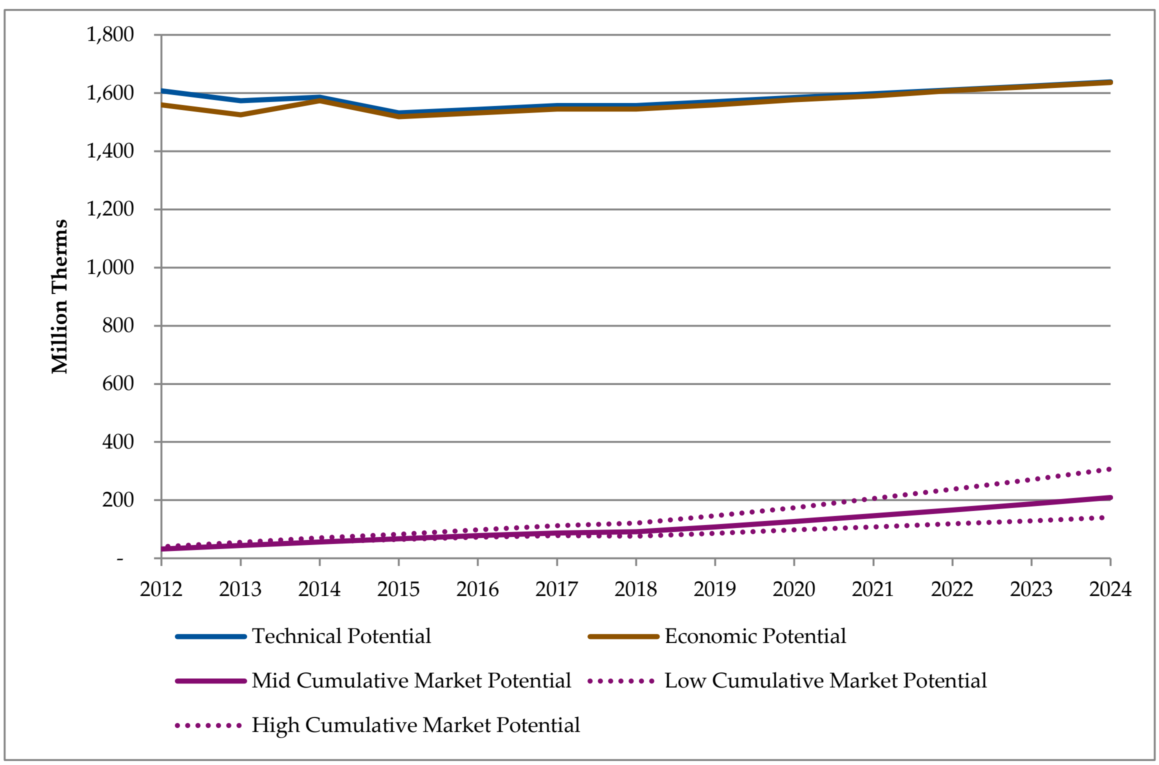


Source: PG model release August 2013

5.2.3 California Residential Natural Gas Potential

Figure 5-9 provides a view of California's residential technical, economic, and cumulative market potential for gas savings. Technical and economic savings are essentially the same throughout the forecast and remain fairly constant. The cumulative market savings increase over time with the high scenario showing about 35 percent higher savings and the low scenario about 20 percent lower than the mid line. The effect of decay in cumulative savings is less noticeable for gas potential compared with residential electric savings because most of the gas savings come from HVAC and Service Hot Water measures, which have useful lives that are longer than the modeling horizon of the study; decay is only relevant at the end of a measure's useful life. Unlike the technical, economic, and cumulative market potential for energy savings (Figure 5-1), these potentials for gas savings do not decrease over time, as there are no significant codes and standards changes that affect gas measures. Cumulative market potential starts very low, but this is due to this study's inclusion of interactive effects between therms and energy.

Figure 5-9. California Residential Gross Technical, Economic, and Cumulative Market Potential for 2012-2024 (Million Therms)

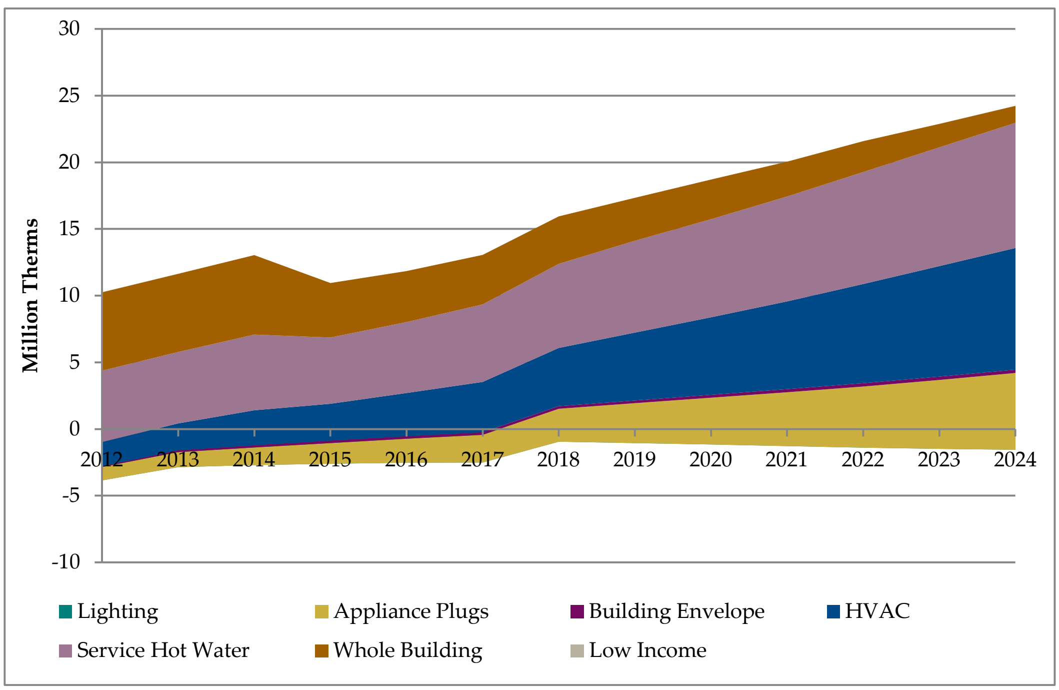


2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

Figure 5-9 shows a large disparity gap between the cumulative market potential and the technical and economic potential savings. A key reason for this gap has to do with the fact that most of the gas measures (especially HVAC) had to be calibrated down to align with past program achievements. In some cases, as with gas clothes washers, the measures are just financially unattractive, especially when considering their levelized measure costs. Finally, because a lot of the gas potential is from HVAC and Service Hot Water measures with very large EULs, the growth of market potential is constrained by their stock turnover rate. A detailed description of the reasons why cumulative market potential is well below technical and economic potential is provided in Section 4.2.2.

Figure 5-10 presents the residential incremental market potential for gas savings measures in California. The graph shows some savings area that is negative; this is due to interactive effects with efficient lighting measures and plug load measures. This figure breaks out the potential therms savings by end-use category and shows that the main causes of the increase are HVAC and water heating. This increase is because some very-high-efficiency HVAC and Service Hot Water emerging technology measures become cost effective in later years and begin to show larger savings.

Figure 5-10. California Residential Gross Incremental Market Potential for 2012-2024 (Million Therms)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

5.2.4 California Residential Gas Comparative Metrics

This section provides a series of comparative metrics in order to analyze the gas savings potential from the 2013 study. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. Due to the availability of data, there are less comparative metrics for gas than there are for electric. The gas comparative metrics are:

» Comparison of the 2011 and 2013 potential studies

» Cumulative savings potential by end use as compared to the total CEC residential consumption forecast

» Incremental annual forecast potential for 2013/2014 compared to the IOU residential sector program savings estimates for the 2013/2014 portfolio

5.2.4.1 Comparison between 2011 and 2013 Potential Studies

Table 5-3 compares the incremental market gas potential savings estimates of the 2011 Potential Study and the 2013 Potential Study. Reasons for overall modeling differences between the 2011 and 2013 study are discussed in Section 4.3.2 and residential differences are discussed in Section 5.2.2.1.

Table 5-3. Changes in California Residential Incremental Gas Market Potential from the Previous Forecast (MM Therms)

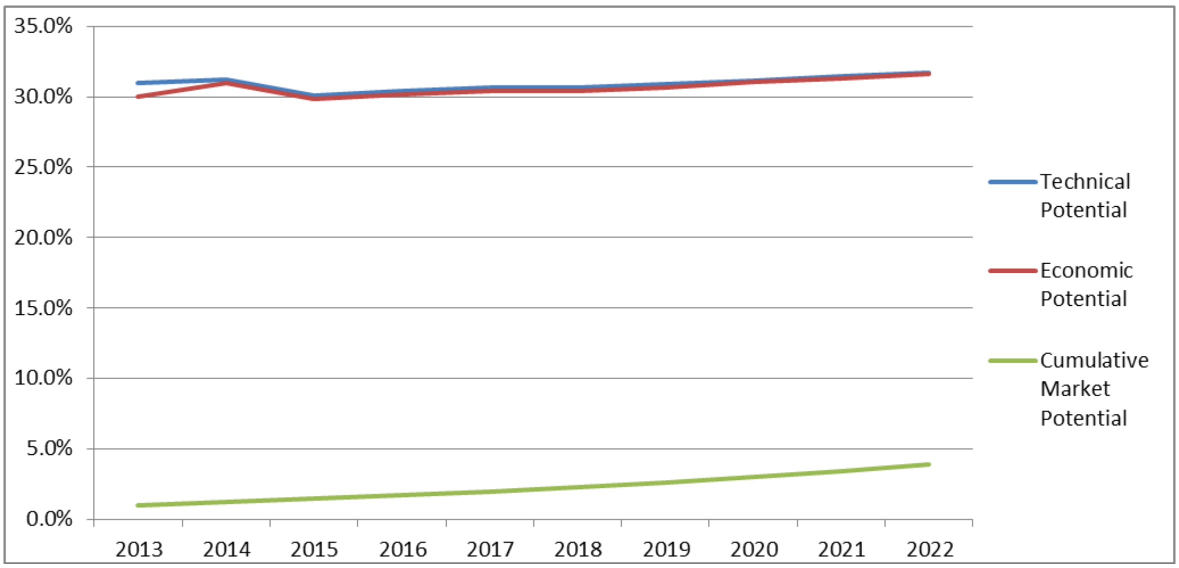
	Incremental Market Potential (Excludes C&S)		
Year	2011 Study	2013 Study	Percent Increase or Decrease
2012	10	10	6%
2013	11	12	3%
2014	13	13	3%
2015	13	11	-18%
2016	15	12	-23%
2017	17	13	-23%
2018	20	16	-19%
2019	23	17	-23%
2020	26	19	-27%
2021	29	20	-30%
2022	32	22	-32%
2023	34	23	-33%
2024	35	24	-31%

Source: PG model release August 2013

5.2.4.2 CEC Forecast Comparative Metrics

Figure 5-11 shows the technical, economic, and cumulative market gas potential savings as a percent of the CEC residential gas forecast. Technical and economic potential remain steady between 30 and 32 percent of the CEC forecast. Cumulative market potential rises from about 1.5 percent in 2013 to just under 5 percent by 2022. The gap between cumulative market and economic potential for residential gas savings is explained in Section 5.2.3.

Figure 5-11. California Residential Gas Savings Potential as a Percent of CEC Residential Gas Forecast (Technical, Economic, and Cumulative Market Potential)

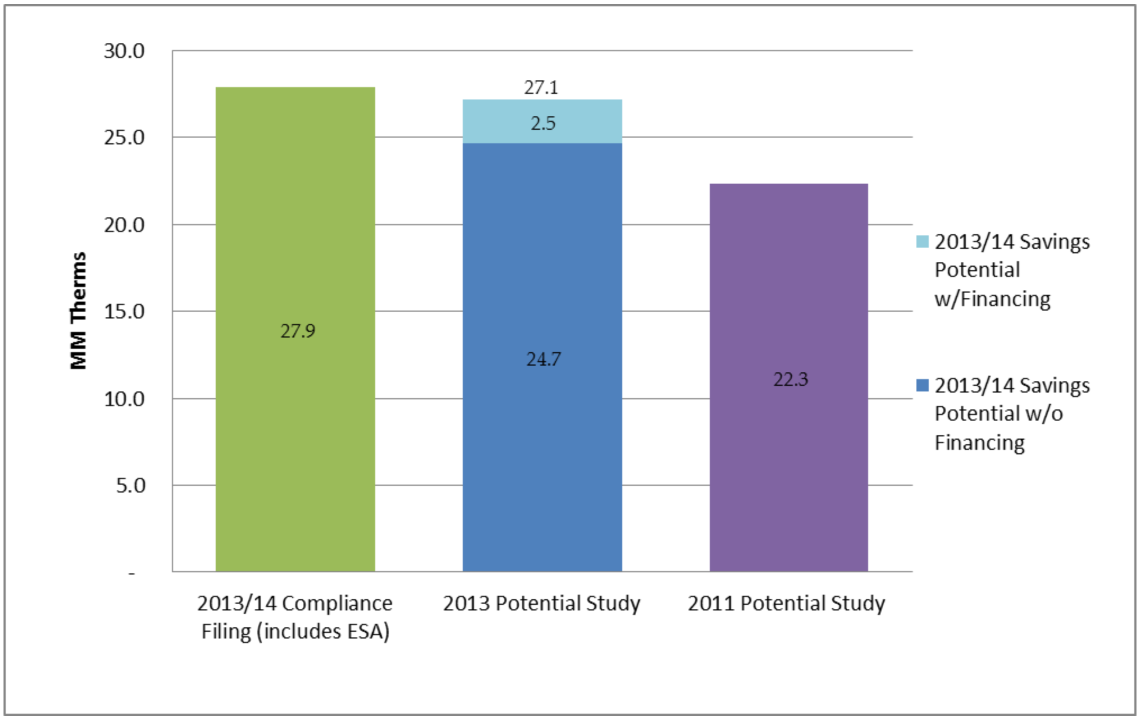


Source: PG model release August 2013

5.2.4.3 *IOU 2013/2014 Compliance Filing Comparative Metrics*

Figure 5-12 shows all the IOU gas savings presented in the compliance filings as compared to the 2013 study residential gas results and the 2011 study. The 2013 study is slightly below the compliance filings for residential, but both the compliance filings and the 2013 study potential are significantly higher than the potential provided in the 2011 study.

Figure 5-12. California Comparison of IOU Residential Compliance Filings and Potential Study Results for Program Years 2013 and 2014 (Gas)



Source: PG model release August 2013

6 Energy Efficiency Potential in California's Commercial Sector

This section summarizes the estimates of potential energy and demand savings at the statewide level for all commercial buildings, including existing and new construction buildings.

6.1 Overview

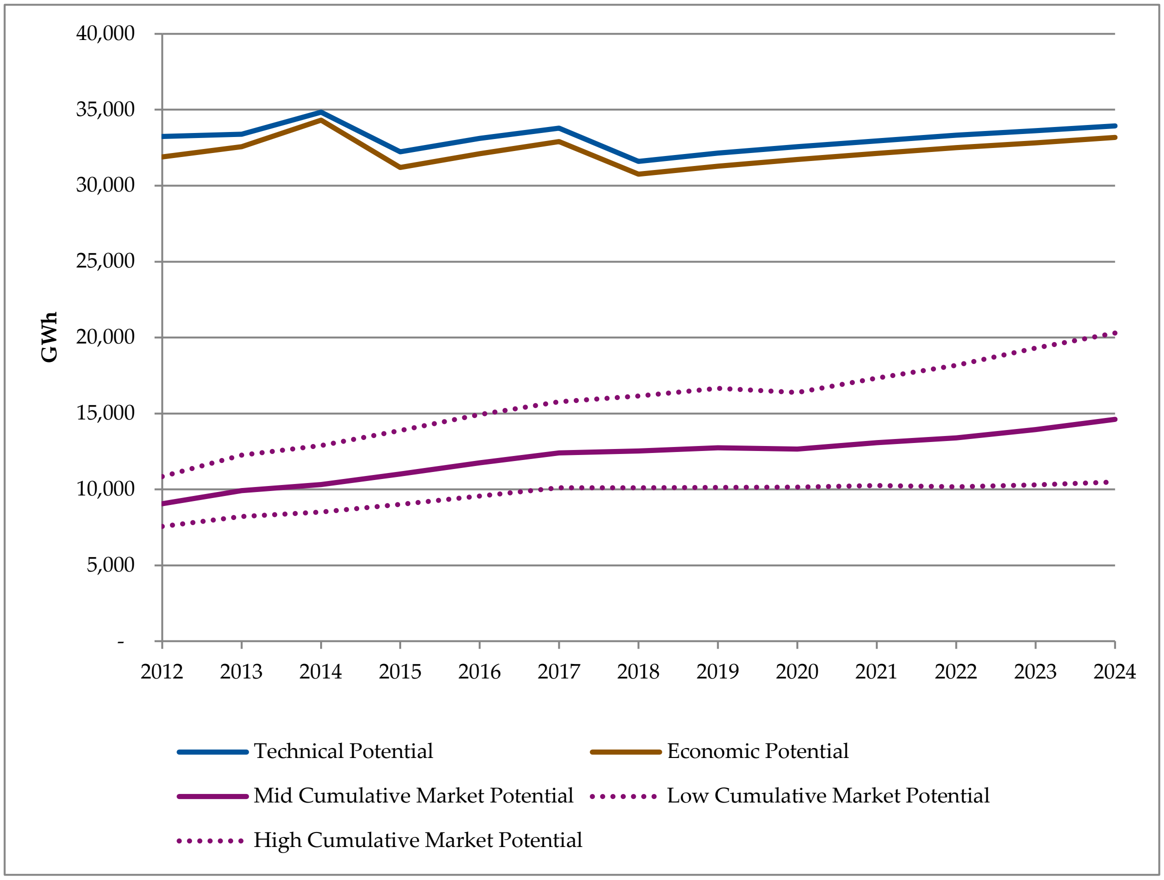
The potential energy savings in the commercial sector are impacted by upcoming codes and standards changes (especially lighting) and the expansion of emerging technologies to utility portfolios. These impacts are explained in detail below.

6.2 California Commercial Summary of Results

6.2.1 California Commercial Electric Energy Potential

Figure 6-1 presents the technical, economic, and cumulative market electric energy savings potential in California from 2012 through 2024. The early increases are attributed to the introduction of new emerging technologies and increased adoption of efficient lighting measures (notably CFLs). The decreases are associated with codes and standards on HVAC measures in 2015 and lighting measures in 2018, before starting to steadily rise again in 2018 after the last of the lighting standards are implemented and the emerging technologies begin to saturate the market more. Cumulative market savings see a noticeable decrease after 2019 due to the effect of decay. Compared with the residential cumulative line, the commercial market potential sees a modest increase in potential in the out years as emerging technologies (especially in LED lighting) see a more pronounced increase in potential as they are comparatively more cost effective. This increase in lighting potential offsets any decrease in cumulative savings due to decay and code and standards of incandescent and CFL savings. The trend line shows this offset as the cumulative market potential lines increase rapidly in outer years. Three different scenario runs are displayed for the cumulative market potential; with the high scenario approximately 30 percent higher than the mid scenario (the percentage is higher in out years as adoption of emerging technologies is amplified) and the low scenario is approximately 20 percent lower.

Figure 6-1. California Commercial Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)

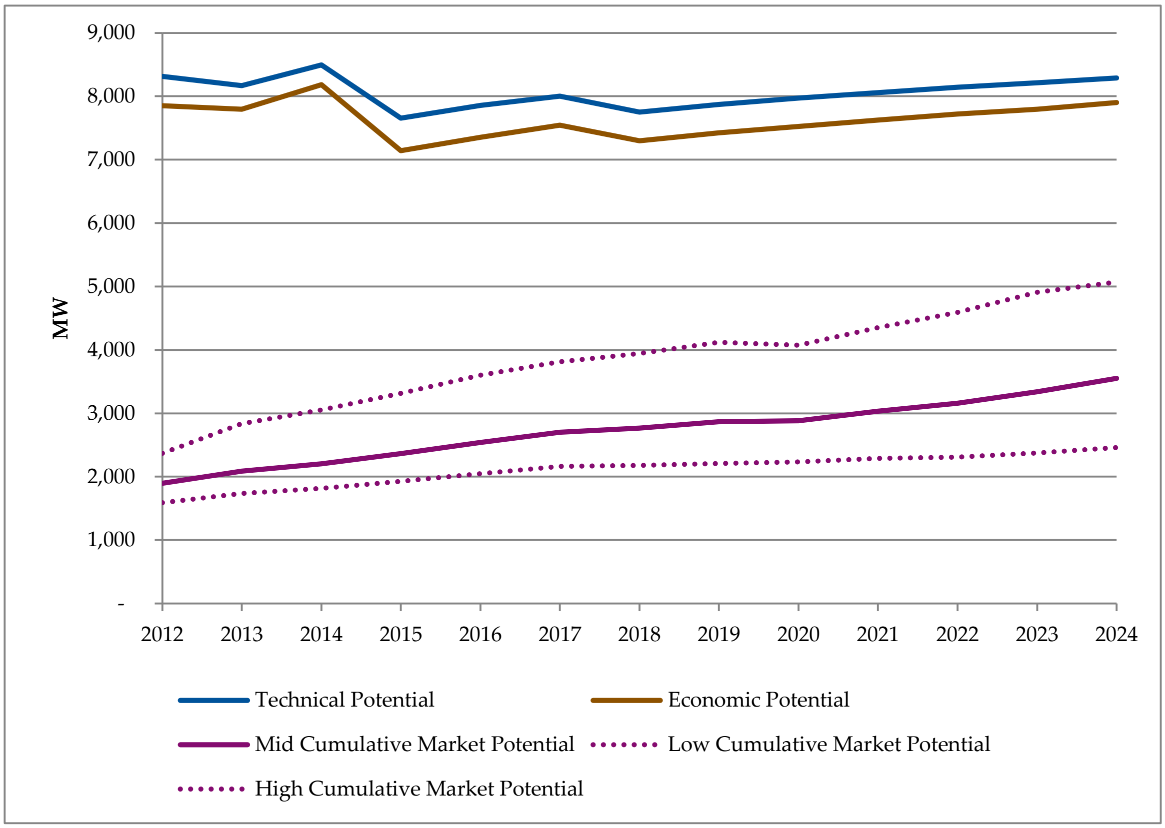


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 6-2 presents the technical, economic, and cumulative market demand savings potential in the commercial sector. The technical and economic potential have different curves in the beginning due to many of the emerging technologies in the HVAC end use, which bring higher coincidence factors with them. The cumulative market potential follows a very similar trend to the energy market potential, and the high and low scenarios are about the same percentage higher and lower (30 percent and 20 percent, respectively) compared to the mid-scenario potential.

Figure 6-2. California Commercial Gross Technical, Economic, and Cumulative Market Potential for Demand Savings in 2012-2024 (MW)



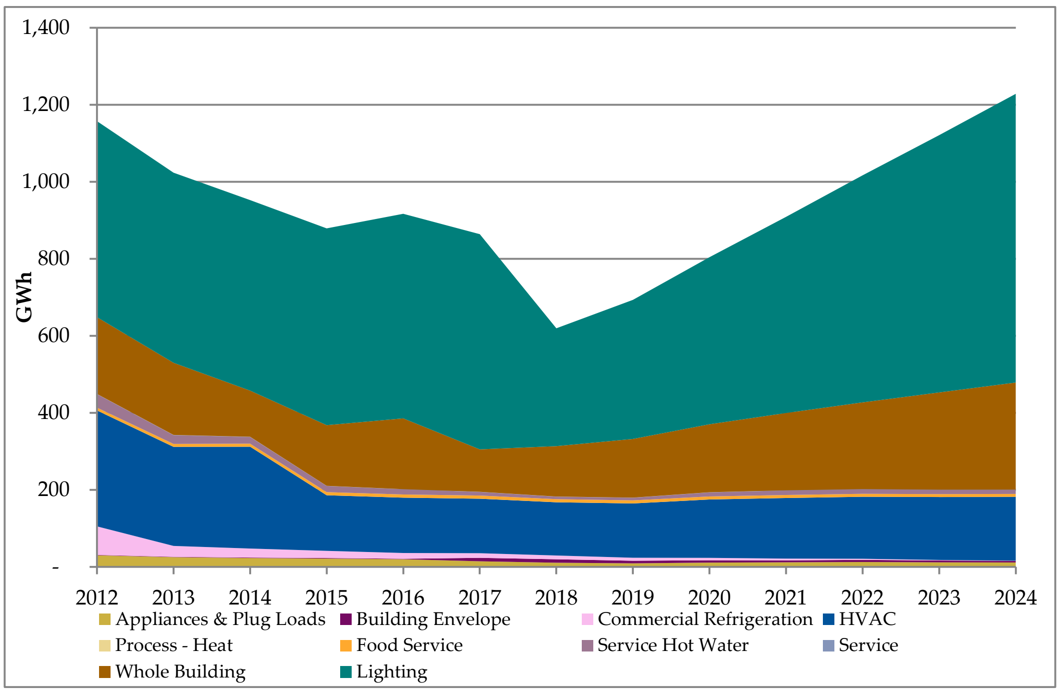
2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 6-3 presents the incremental market potential for California's commercial sector. The initial decrease in incremental market potential is due to codes and standards changes improving the baseline efficiency of commercial measures, hence decreasing measure savings. Emerging technologies become a significant contributor to incremental market savings potential in 2015 and again in 2019, as the market becomes more aware of and willing to implement these measures.

The initial decrease in lighting potential from 2012-2015 is attributed to the first round of Energy Independence and Security Act (EISA) Lighting standards. In 2016, there is a jump in lighting savings, as LEDs, low-wattage T-8s, and other more efficient lighting measures begin to be adopted. There is another large drop in lighting potential in 2018 as the next wave of EISA lighting standards rolls out. However, the adoption of newer technologies, like the LEDs, increases savings potential for lighting to levels as high as the 2012 incremental lighting savings.

Figure 6-3. California Commercial Gross Incremental Market Energy Savings Potential by End Use in 2012-2024 (GWh)

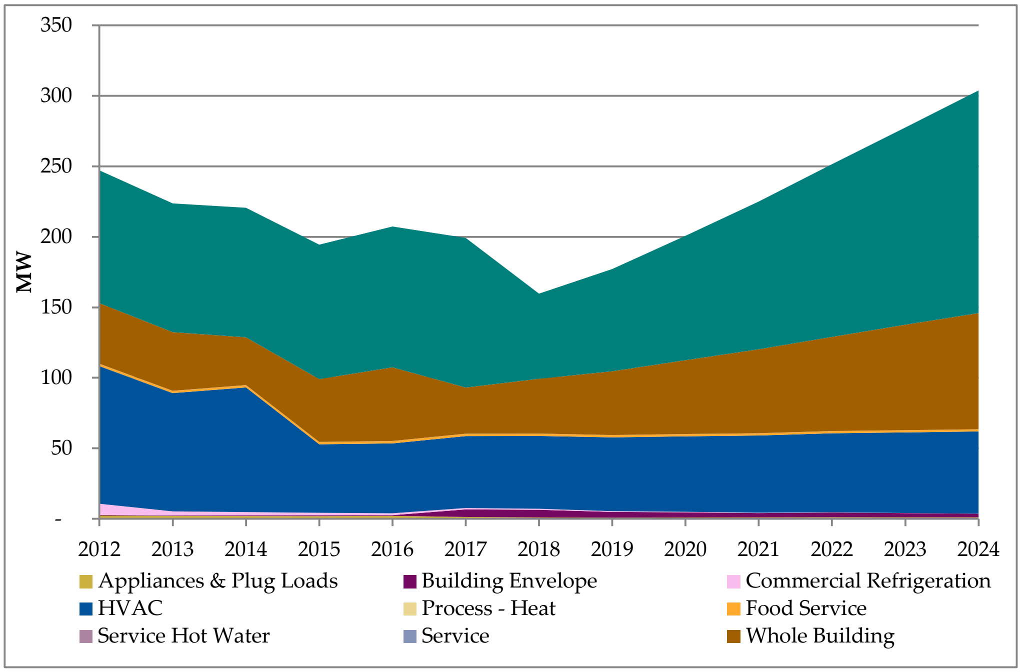


2013 Cumulative results exclude C&S savings and behavioral savings.

Source: PG model release August 2013

Figure 6-4 presents the gross incremental market demand savings potential for the commercial sector. The incremental market demand potential follows a very similar trend to that of the incremental market energy potential.

Figure 6-4. California Commercial Gross Incremental Demand Savings Market Potential by End Use for 2012-2024 (MW)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

Figure 6-3 and Figure 6-4 break out the incremental market potential for energy and demand, respectively. Lighting, HVAC, and Whole-Building have the largest potential savings for both energy and demand. These figures show the effects of codes and standards on the potential savings. The biggest decrease comes in 2018 due to the last of the EISA lighting standards that come into effect that year. The increase in savings potential in later years is due to an increase in indoor lighting potential from LEDS, low- wattage T-8s, and other emerging technology measures. This is explained in the text accompanying Figure 6-3.

6.2.2 California Commercial Electric Comparative Metrics

This section provides a series of comparative metrics in order to analyze and calibrate the commercial savings potential from the 2013 study. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For commercial, the following comparative metrics are provided:

» Comparison of the 2011 and 2013 potential studies

» Cumulative savings potential by end use as compared to the total CEC commercial sector consumption forecast

» Commercial End Use Study (CEUS) Energy Use Intensities (EUIs) per 1,000 sq. ft. as compared to technical, economic, and market potential savings in terms of EUIs

» Incremental annual forecast potential for 2013/2014 compared to the IOU commercial sector program savings estimates for the 2013/2014 portfolio

6.2.2.1 Comparison between 2011 and 2013 Potential Study Commercial Results

Table 6-1 and Table 6-2 compare the incremental market energy and demand potential savings estimates of the 2011 study and the 2013 study in the commercial sector. Reasons for overall modeling differences between the 2011 and 2013 study are discussed in Section 4.3.2. In addition to these overall modeling differences that cause most of the changes between the two studies, calibration for commercial took a special form. The commercial calibration targets also include the compliance filing targets and the calibration targets in 2013 are therefore higher than in 2011.

Table 6-1. Changes in California Commercial Incremental Market Energy Potential from the Previous Forecast (GWh)

	Incremental Market Potential (excluding C&S)		
Year	2011 Study	2013 Study	Percent Increase or Decrease
2012	985	1,157	18%
2013	646	1,025	59%
2014	648	954	47%
2015	659	881	34%
2016	660	920	39%
2017	668	867	30%
2018	739	624	-16%
2019	748	698	-7%
2020	777	810	4%
2021	802	915	14%
2022	823	1,024	24%
2023	816	1,129	38%
2024	792	1,237	56%

Source: PG model release August 2013

Table 6-2. Changes in California Commercial Incremental Market Demand Potential from the Previous Forecast (MW)

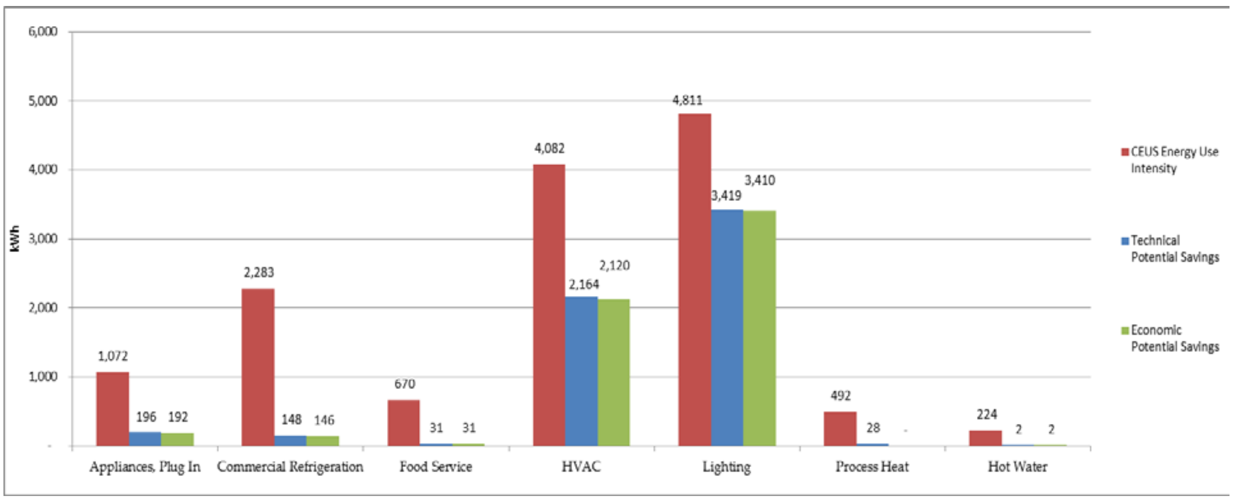
Year	Incremental Market Potential (excluding C&S)		
	2011 Study	2013 Study	Percent Increase or Decrease
2012	310	247	-20%
2013	172	224	30%
2014	154	221	43%
2015	156	194	24%
2016	156	207	33%
2017	157	199	27%
2018	177	160	-10%
2019	174	177	2%
2020	178	201	13%
2021	180	225	25%
2022	182	252	38%
2023	178	278	56%
2024	172	304	76%

Source: PG model release August 2013

6.2.2.2 *CEUS Comparative Metrics*

The CEUS provides energy use intensities by end use per 1,000 sq. ft. of commercial building space for each of the IOUs in California. These energy use intensities by use category show how much energy (kWh) is being used for each end use per 1,000 sq. ft. of commercial floor space. This is similar to the residential data from RASS that provides end-use intensities per home. EUIs provide a strong metric for comparison purposes with the commercial results in this study. Figure 6-5 displays the CEUS average EUIs per 1,000 sq. ft. by end use next to the technical and economic EUI potential per 1,000 sq. ft. Lighting and HVAC end uses have the highest EUIs from CEUS and have the highest technical and economic potential.

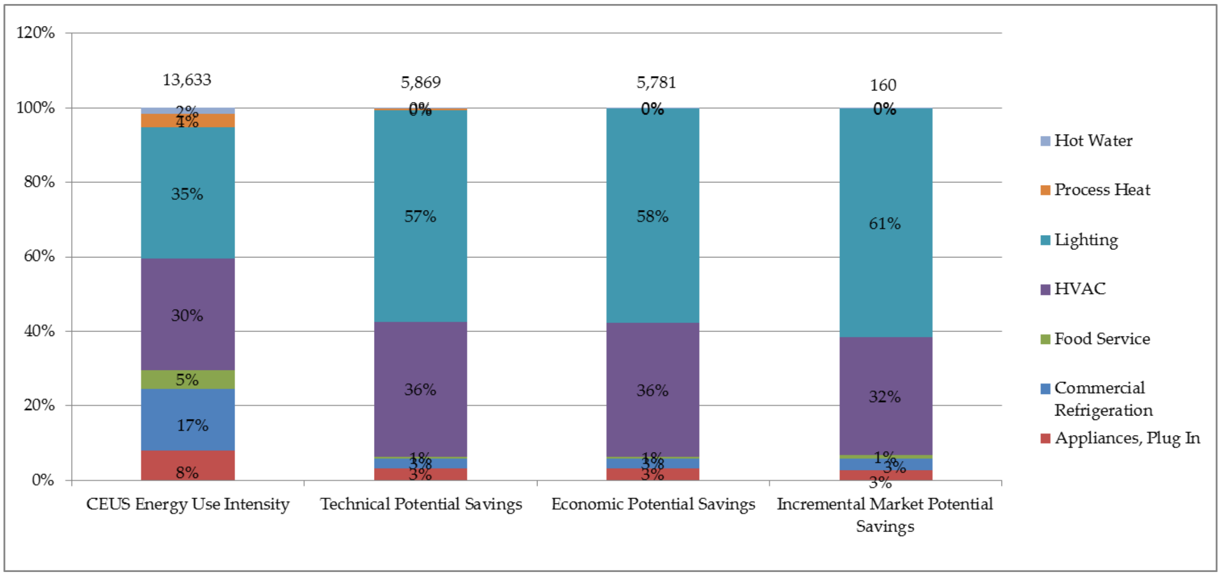
Figure 6-5. California Commercial EUIs from CEUS and 2014 Savings Potential EUIs (Technical and Economic Potential)*



*Number at the top of each bar is the total consumption or savings potential in kWh/home.

Figure 6-6 provides a percentage breakout of CEUS EUIs by end use within a stacked bar graph. Also provided is the EUI percentage breakout of technical, economic, and incremental market potential. The numbers at the top of each bar graph represent the total per 1,000 sq. ft. EUI and the total per 1,000 sq. ft. EUI savings potential (technical, economic, and incremental market). The CEUS bar shows that 35 percent of an average buildings energy use comes from lighting (35 percent of the 13,633 kWh/home CEUS EUS). The graph shows that a much larger percentage of savings come from lighting. Each percentage is a breakout of the total kWh/home number that is above each bar.

Figure 6-6. California Breakdown of Commercial EUIs and 2014 Savings Potential by End Use

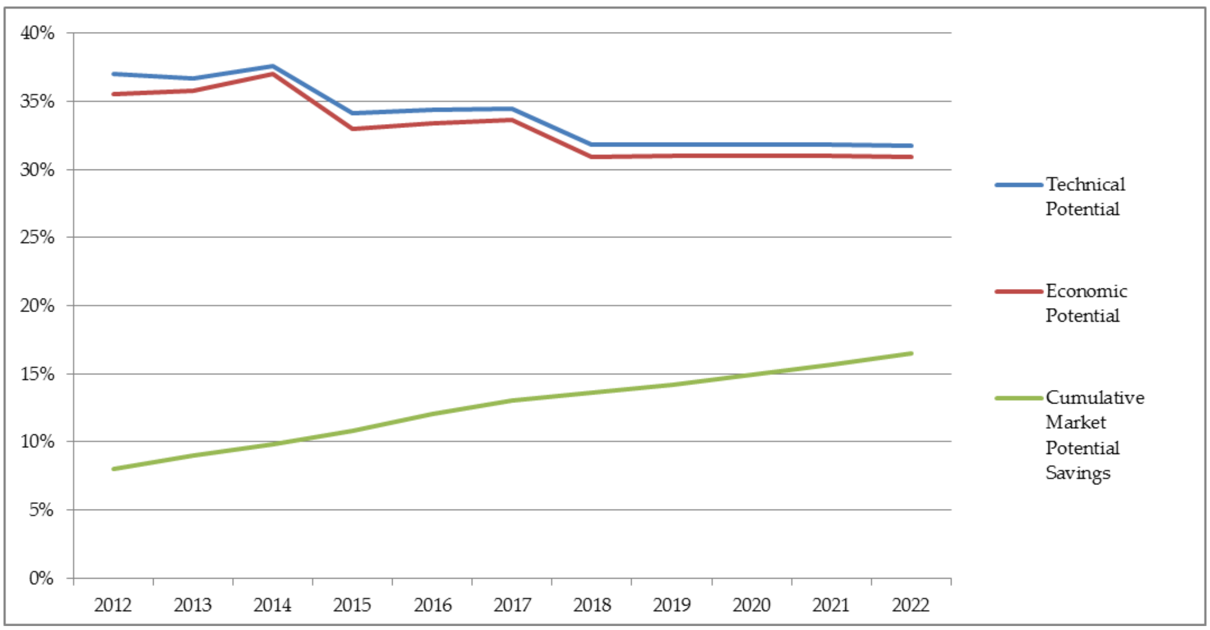


**Number at the top of each bar is the total consumption or savings potential in kWh/home.*

6.2.2.3 CEC Forecast Comparative Metrics

CEC consumption forecasts are one of the foundational inputs for the 2013 Potential Study. Comparing savings as a percent of the CEC consumption forecast is an important comparative metric. Figure 6-7 shows the commercial technical, economic, and cumulative market potential savings as a percent of the CEC commercial forecast. Technical potential is about 37 percent of the CEC commercial consumption forecast in 2012, but drops down to about 32 percent in 2022 as codes and standards come into effect and consumption continues to increase. Cumulative market potential rises from about 8 percent in 2012 up to about 16 percent by 2022.

Figure 6-7. California Commercial Savings Potential as a Percent of CEC Commercial Forecast (Technical, Economic, and Cumulative Market Potential)

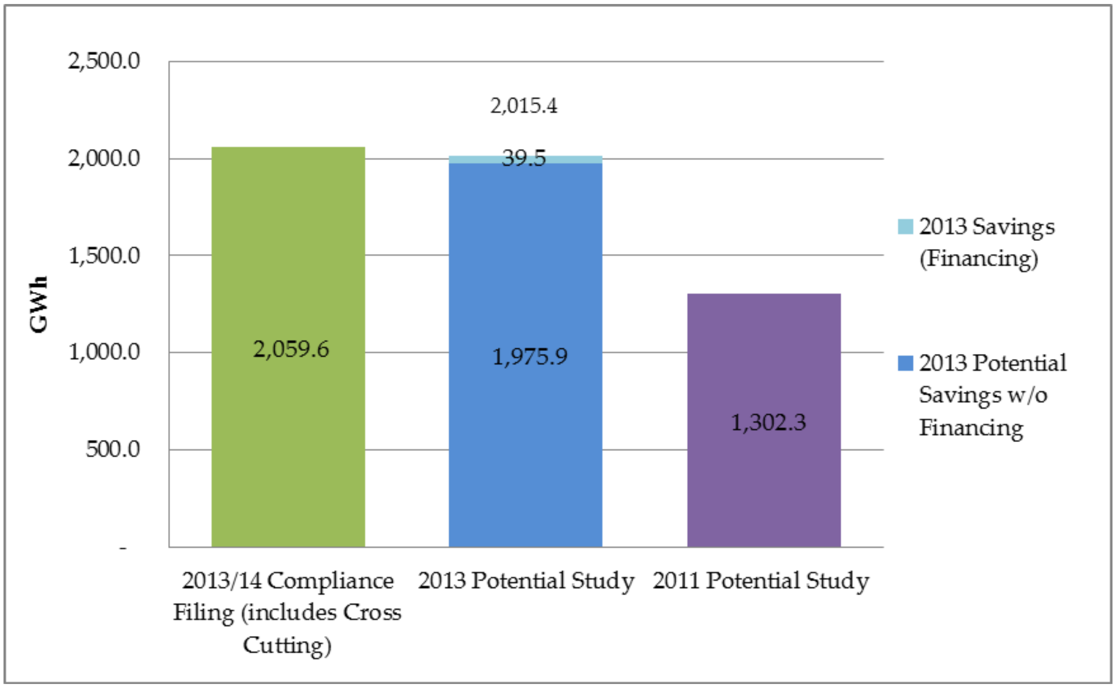


Source: PG model release August 2013

6.2.2.4 IOU 2013/2014 Compliance Filing Comparative Metrics

During this study, IOUs provided their compliance filings that were submitted to the state for their 2013/2014 goals. These provided an important comparative metric and the commercial numbers in the compliance filings were compared to the 2013 Potential Study commercial forecasts as well as the 2011 Potential Study, as shown in Figure 6-8. These comparisons were an integral part of the Navigant team's quality control and calibration process in order to calibrate to the utilities' portfolio plan in addition to historical data. The 2013 study is slightly below the compliance filings for commercial, but both the compliance filings and the 2013 study potential are significantly higher than the potential provided in the 2011 study.

Figure 6-8. California Comparison of IOU Commercial Compliance Filings and Potential Study Results for Program Years 2013 and 2014 (Electric)

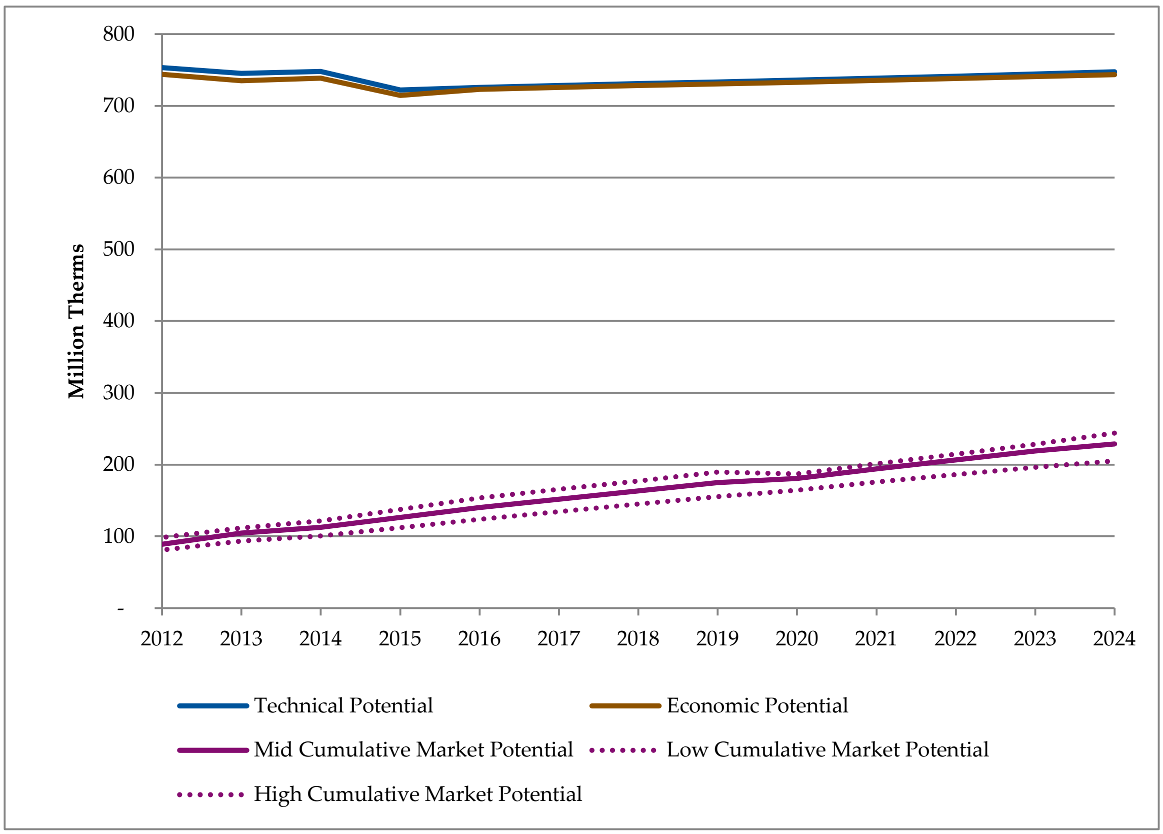


Source: PG model release August 2013

6.2.3 California Commercial Natural Gas Potential

California commercial gas technical energy savings potential stays fairly constant throughout the forecast and the gas economic energy savings potential is about equal to the technical gas potential. The cumulative market gas potential steadily increases from 2012-2024, with the high scenario about 5 percent higher than the mid scenario and the low scenario about 10 percent lower. This is presented in Figure 6-9.

Figure 6-9. California Commercial Gross Technical, Economic, and Cumulative Market Gas Energy Savings Potential for 2012-2024 (Million Therms)

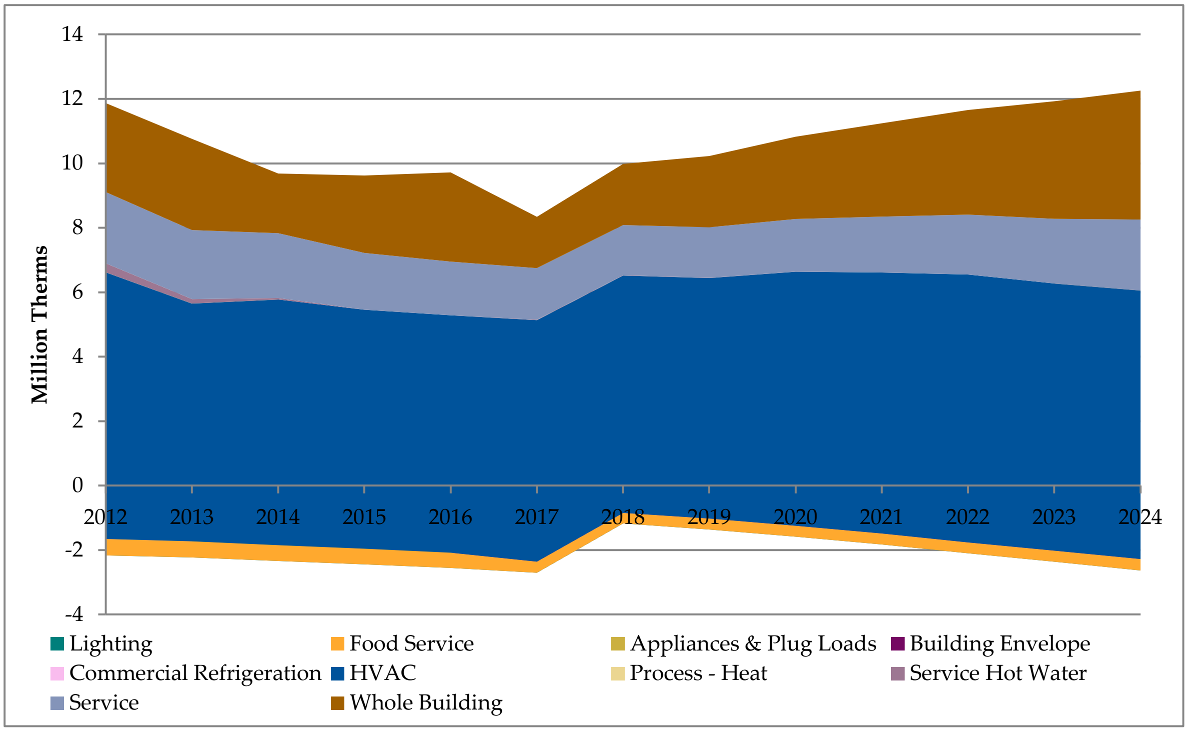


2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

The technical and economic gas potential savings remain fairly constant over time, as there are fewer codes and standards changes that affect gas measures, with potential dropping some in 2015 due to HVAC codes and standards. The cumulative potential gas lines increase steadily over time because most HVAC and Service Hot Water gas measures have useful lives that exceed the modeling horizon so the effects of decay are muted. In addition, IOU-rebated measures will show gas savings even after they go to code until they reach the end of their useful lives.

Figure 6-10 presents the gross incremental market potential in California from 2012 through 2024 for the commercial sector. The incremental gross market potential remains fairly constant, with a dip in the middle years due to codes and standards. The increase in incremental gas savings in later years is due to the increased adoption of emerging technologies in the HVAC end use and increased adoption of whole-building measures, especially commercial retrofit measures. The graph shows savings below the x-axis as well for all years, and this is due to interactive effects between gas and electric measures. Efficient lighting measures produce less heat and therefore the lighting savings are all in the negative.

Figure 6-10. California Commercial Gross Incremental Market Potential by End Use for 2012-2024 (Million Therms)



2013 Cumulative results exclude C&S savings and behavioral savings.
Source: PG model release August 2013

6.2.4 California Commercial Gas Comparative Metrics

This subsection provides a series of comparative metrics in order to analyze the gas savings potential from the 2013 study. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. Due to the availability of data, there are less comparative metrics for gas than there are for electric. The gas comparative metrics are:

- Comparison of the 2011 and 2013 potential studies
- Cumulative savings potential by end use as compared to the total CEC commercial sector consumption forecast

» Incremental annual forecast potential for 2013/2014 compared to the IOU commercial sector program savings estimates for the 2013/2014 portfolio

6.2.4.1 Comparison between 2011 and 2013 Potential Studies

Table 6-3 compares the incremental market gas potential savings estimates of the 2011 Potential Study and the 2013 Potential Study. Reasons for overall modeling differences between the 2011 and 2013 study are discussed in Section 4.3.2 and commercial differences are discussed in Section 6.2.2.1.

Table 6-3. Changes in California Commercial Incremental Market Gas Potential from the Previous Forecast (MM Therms)

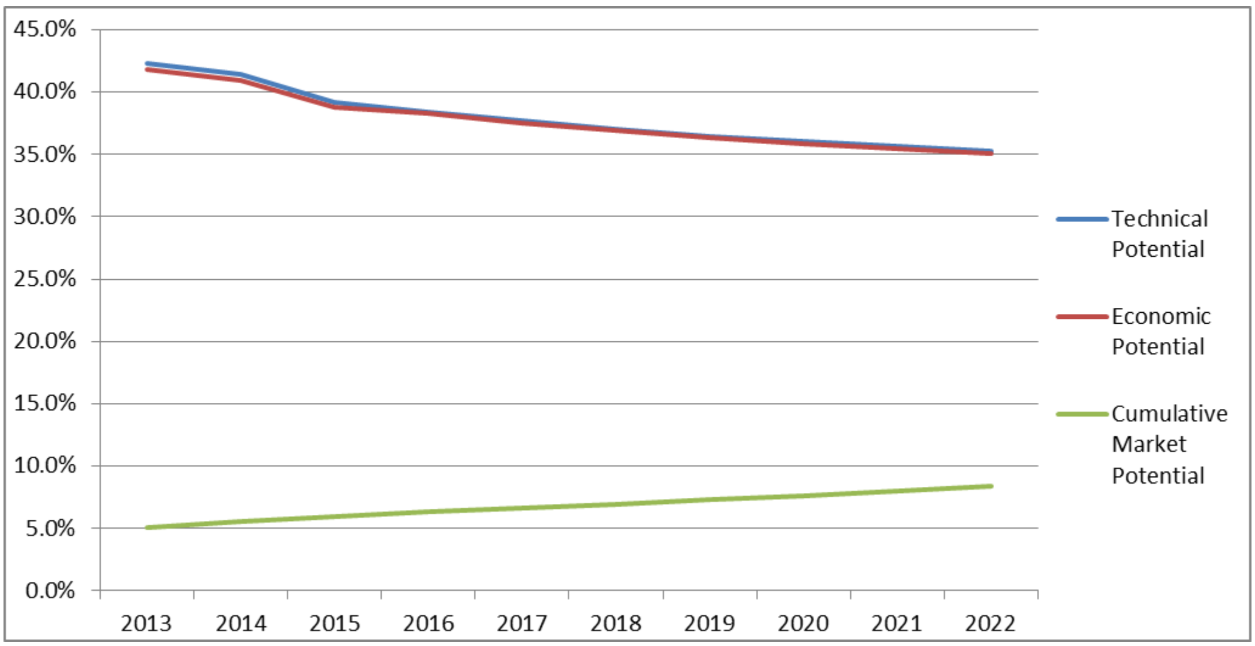
	Incremental Market Potential (Excludes C&S)		
Year	2011 Study	2013 Study	Percent Increase or Decrease
2012	15	12	-21%
2013	14	11	-21%
2014	14	10	-28%
2015	15	10	-32%
2016	16	10	-35%
2017	16	9	-45%
2018	16	11	-35%
2019	16	11	-33%
2020	17	12	-30%
2021	16	12	-24%
2022	16	13	-19%
2023	16	13	-15%
2024	15	14	-8%

Source: PG model release August 2013

6.2.4.2 *CEC Gas Forecast Comparative Metrics*

Figure 6-11 shows the technical, economic, and cumulative market gas potential savings as a percent of the CEC commercial gas forecast. Technical and economic potential both decrease from about 43 percent of the CEC commercial gas forecast in 2013 to about 35 percent of the forecast by 2022. Cumulative market potential increases from about 5 percent in 2013 to approximately 8 percent by 2022. A detailed explanation of the reasons why a gap exists between economic and market potential is provided in Section 4.2.2.

Figure 6-11. California Commercial Gas Savings Potential as a Percent of CEC Residential Gas Forecast (Technical, Economic, and Cumulative Market Potential)

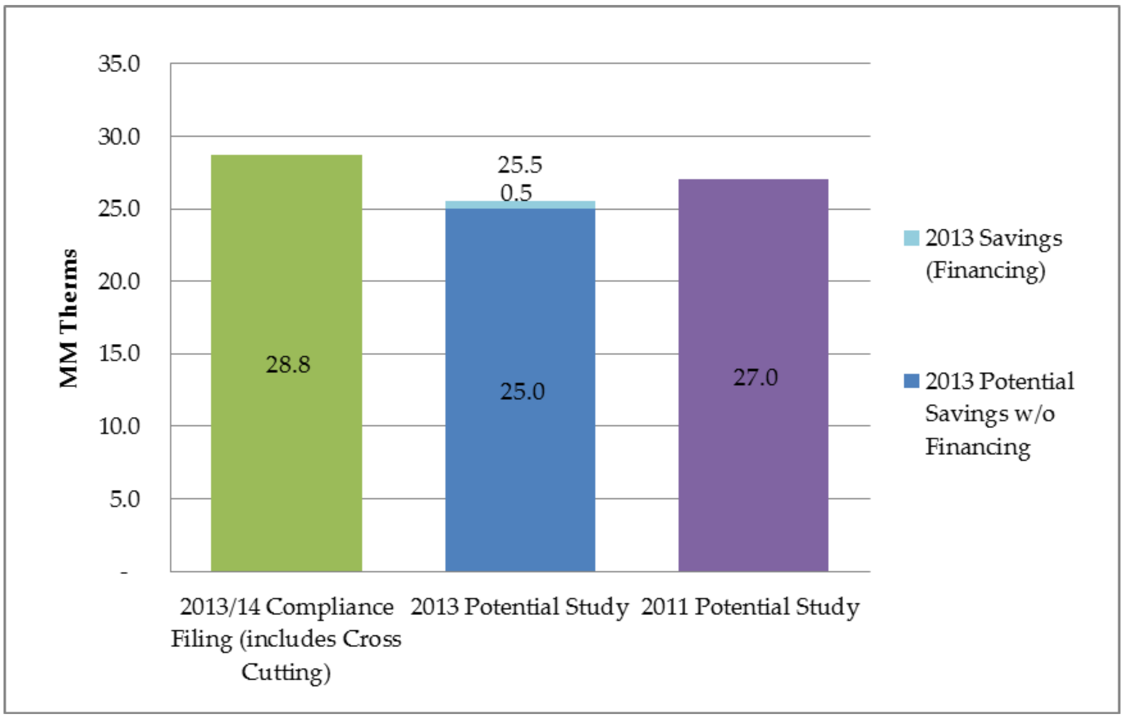


Source: PG model release August 2013

6.2.4.3 IOU 2013/2014 Compliance Filing Comparative Metrics

Figure 6-12 shows all the IOU gas savings presented in the compliance filings as compared to the 2013 study commercial gas results and the 2011 study. The 2013 study is slightly below the compliance filings for commercial in part because some of the gas end uses had to be calibrated down to align with past program achievements. The 2011 study numbers are slightly higher than the 2013 model because the 2013 model excluded steam traps as a measure, which were historically a huge saver but there is little potential for them going forward.

Figure 6-12. California Comparison of IOU Commercial Compliance Filings and Potential Study Results for Program Years 2013 and 2014 (Gas)



Source: PG model release August 2013

7 Energy Efficiency Potential in California's AIMS Sectors

This section provides the estimates of potential energy and demand savings at the statewide level for the combined agricultural, industrial, mining, and street-lighting (AIMS) sectors. Results for the individual sectors within AIMS can be found within the appendices.

7.1 Overview

The potential energy savings in the AIMS sector do not include an assessment of the impact of upcoming codes and standards changes because the diverse nature of end uses in the AIMS sectors makes it difficult to predict these impacts with any level of certainty. Additionally, while some equipment deployed throughout the AIMS sectors may be subject to federal standards, the majority of equipment in all four sectors are generally not subject to the same codes and standards (e.g., Title 24) that apply to the residential and commercial sectors. This model also does not include a forecast for new construction in the AIMS sectors, as reports reviewed by the Navigant team do not indicate substantial new construction in these sectors. This assumption may need to be reviewed over time for the mining sector, which is largely made up of oil and gas extraction, which may be undergoing substantial changes in extraction processes that affect growth in that industry.

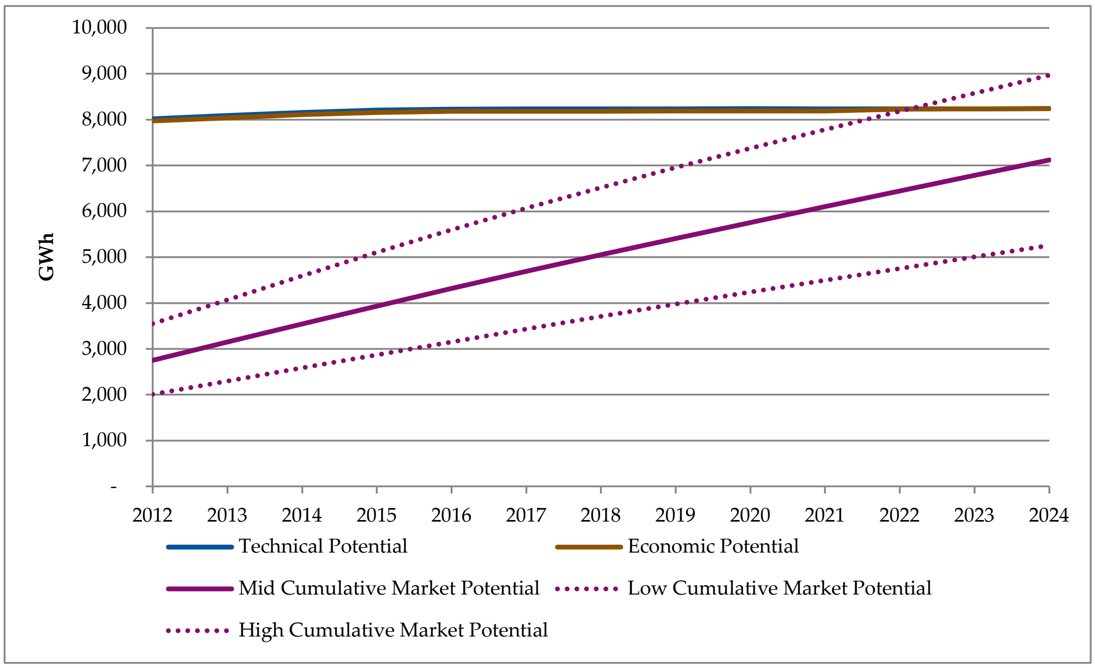
7.2 California AIMS Summary of Results

7.2.1 California AIMS Electric Energy Potential

As shown in Figure 7-1, the AIMS technical and economic energy savings potential remains fairly constant from 2012 through 2024. The PG Model's technical and economic potential results are generally the same value because the Navigant team's analysis used supply curves for the industrial and agricultural sectors (that account for the majority of the potential) that rely on actual energy efficiency improvement recommendations made within facilities found throughout the U.S. Therefore, the majority of the data used to develop the results has acceptable benefit-cost ratios and passes an economic potential screen. Technical and economic energy savings potential in the state of California stay steady between 8,000 and 8,300 GWh from 2012 through 2024. The technical and economic energy savings potential are informed by IOU retail rate forecasts for each sector ($/kWh) and energy sales forecasts for each sector (kWh by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The overall AIMS cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year within the industrial and agricultural sectors. The Navigant team estimates that savings potential for certain end uses within certain industrial and agricultural segments will replenish with each stock turnover event occurring within the analysis period. That is, the majority of increasing cumulative market energy savings potential accounts for new process improvements within both sectors and future equipment emerging technologies within the industrial sector that sustain savings achievements. The street-lighting and mining sectors also contribute to cumulative market energy savings potential, but to a lesser extent as these sectors represent only a small portion of total statewide electric and gas consumption. Cumulative market energy savings potential trails economic and technical energy savings potential and increases between around 2,700 GWh (in 2012) to around 7,100 GWh (in 2024) for the Mid EE Penetration scenario. Cumulative market potential for the high-case scenario slightly exceeds the mid-case technical potential. High-case technical potential is slightly higher than the mid-case technical potential shown in Figure 7-1 due to an increase in the CEC AIMS consumption forecast. High-case cumulative market does not exceed high- case technical potential, though this comparison has been omitted from the graph.

Figure 7-1. California AIMS Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)

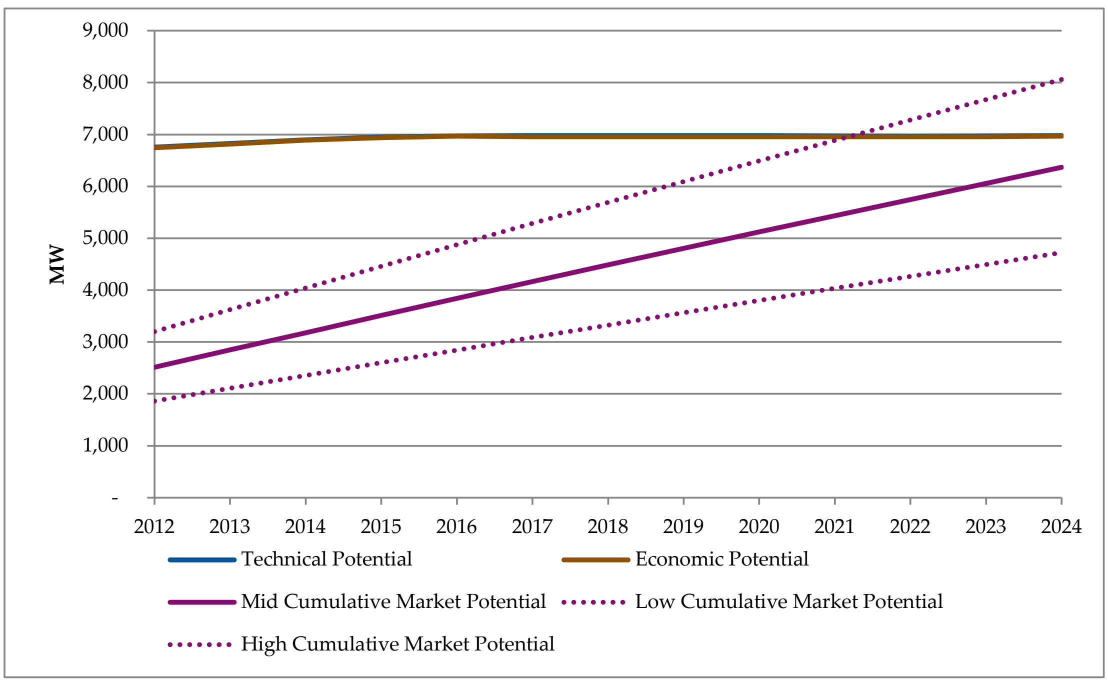


Source: PG model release August 2013

The Navigant team's AIMS cumulative market potential reflects a steady refreshment of savings potential for certain end uses within certain subsectors of the industrial and agricultural sectors. As a result, potential will sustain over the analysis period even as the current stock of baseline equipment reduces due to replacement with efficient equipment.

For many industrial subsectors, refreshment represents the introduction of emerging technologies in future years, ongoing implementation of O&M best practices, and process improvements that are typically implemented as a part of production changes and equipment retooling. For the industrial and agricultural sectors in particular, these refreshment assumptions are consistent with the continuous improvement nature of for-profit enterprises that generally view energy expense as a substantial cost that has a direct impact on operating margins. Conversely, the Navigant team estimates that potential will saturate for certain end uses and certain subsectors within the four AIMS sectors. For example, within the industrial sector, the existing stock of baseline HVAC (shell), lighting, and service hot water measures and the existing stock of baseline measures within less dynamic industries that produce the same product consistently over time (e.g., paper, lumber, and stone producers) represent the full extent of potential remaining within those areas. The Navigant team does not anticipate any emerging technologies or other efficiency improvements to provide further opportunities for potential. Figure 7-2 presents the total technical, economic, and cumulative market demand savings potential through 2024. Technical and economic demand savings potential stay steady between 6,700 MW and 7,000 MW from 2012 through 2024. The cumulative market potential increases from approximately 2,500 MW in 2012 to 6,400 MW in 2024 for the Mid EE Penetration market potential scenario. Consistent with the discussion on electric energy, cumulative demand market potential for the high-case scenario slightly exceeds the mid-case technical potential for various reasons. High-case cumulative market does not exceed high-case technical potential, though this comparison has been omitted from the graph.

Figure 7-2. California AIMS Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2012-2024 (MW)

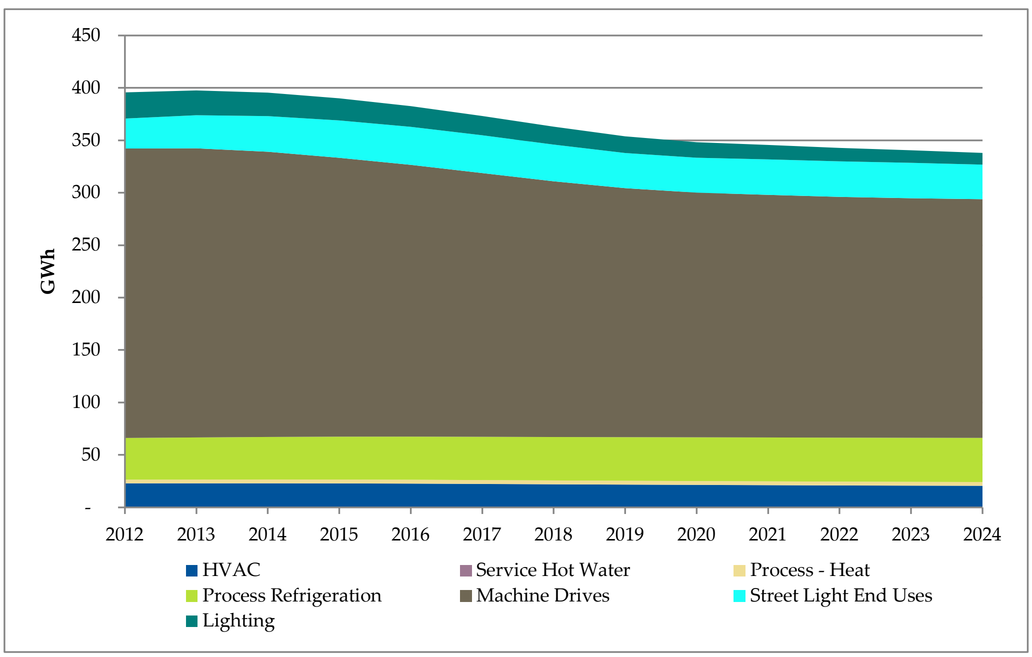


Source: PG model release August 2013

Figure 7-3 presents the incremental market energy savings potential for the end uses within AIMS. The individual end uses (e.g., HVAC, Service Hot Water, Process Heat, Process Refrigeration, Machine Drives, and Lighting) represent the combined potential for end uses within the industrial, agricultural, and mining sectors. Mining sector electric measures include Machine Drives only. End uses are shown in aggregate for the street-lighting sector. The incremental energy savings potential remains fairly constant for the industrial and agricultural end uses, such as machine drives and process refrigeration, estimated to have refreshing savings potential. The majority of the savings in the AIMS sectors come from Machine Drives that represent both equipment measures (e.g., motor replacements) and O&M measures (e.g., repairing leaks on a facility-wide compressed air system) within the industrial and agricultural sectors. The Navigant team estimates that potential decreases for saturating measures and for machine drive measures within the mining sector. For example, the mining sector incremental market potential decreases from 55 GWh in 2012 to 7 GWh in 2024. This decrease reflects the reduction in the existing baseline equipment stock as replacements with efficient options are made. Additionally, the Navigant team estimates the mining sector is not affected by emerging technology efforts. Conversely, the street-lighting sector includes potential associated with LED emerging technologies. Additionally, the street-lighting sector consists almost entirely of baseline equipment. The Navigant team does not estimate that this sector will experience the same refreshment as industrial or agricultural. However, potential is sustained for the analysis period (and cumulative market potential reaches 40 percent of consumption by 2024) due to the significant baseline stock and significant savings opportunities associated with the measures.

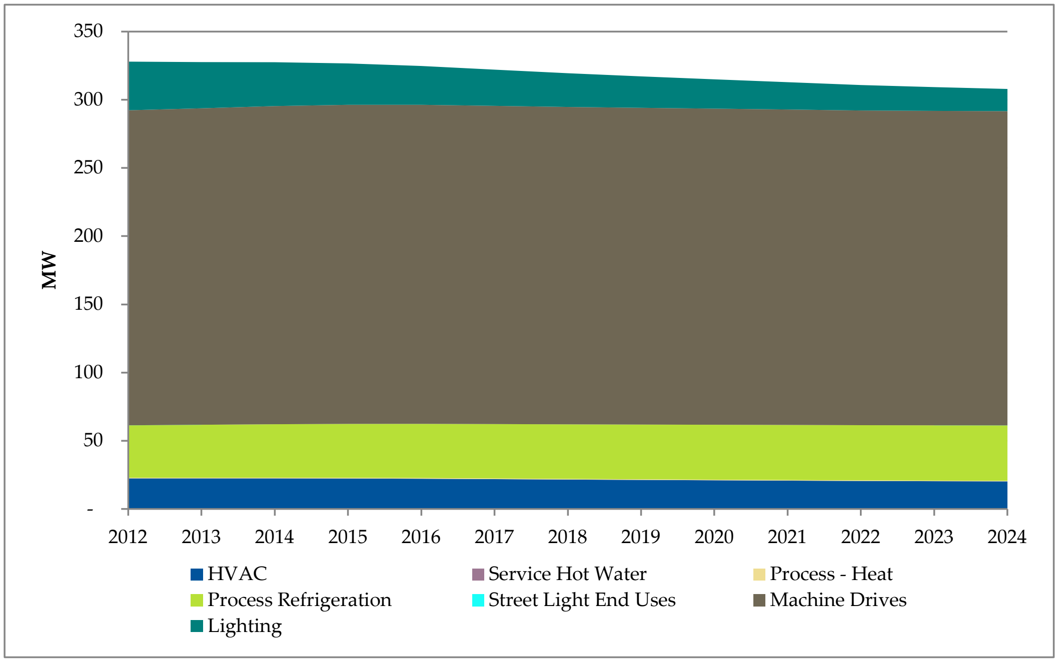
Figure 7-4 presents the incremental market demand savings potential in the AIMS sectors. The demand savings potential follows a similar trend to the energy savings potential, where refreshing end uses remain steady and saturating end uses decrease. Overall, demand potential decreases from 328 MW in 2012 to 308 MW in 2024. The Navigant team examined the street-lighting sector for demand (MW) potential. The Navigant team's analysis concluded that demand potential is negligible for this sector as the significant majority of lamps within the streets subsector operate during nighttime hours and not during the peak demand period.

Figure 7-3. California AIMS Gross Incremental Market Energy Savings Potential by End Use for 2012-2024 (GWh)



Note: Mining sector savings are included in the Machine Drives end use in this chart.
Source: PG model release August 2013

Figure 7-4. California AIMS Gross Incremental Market Demand Savings Potential by End Use for 2012-2024 (MW)

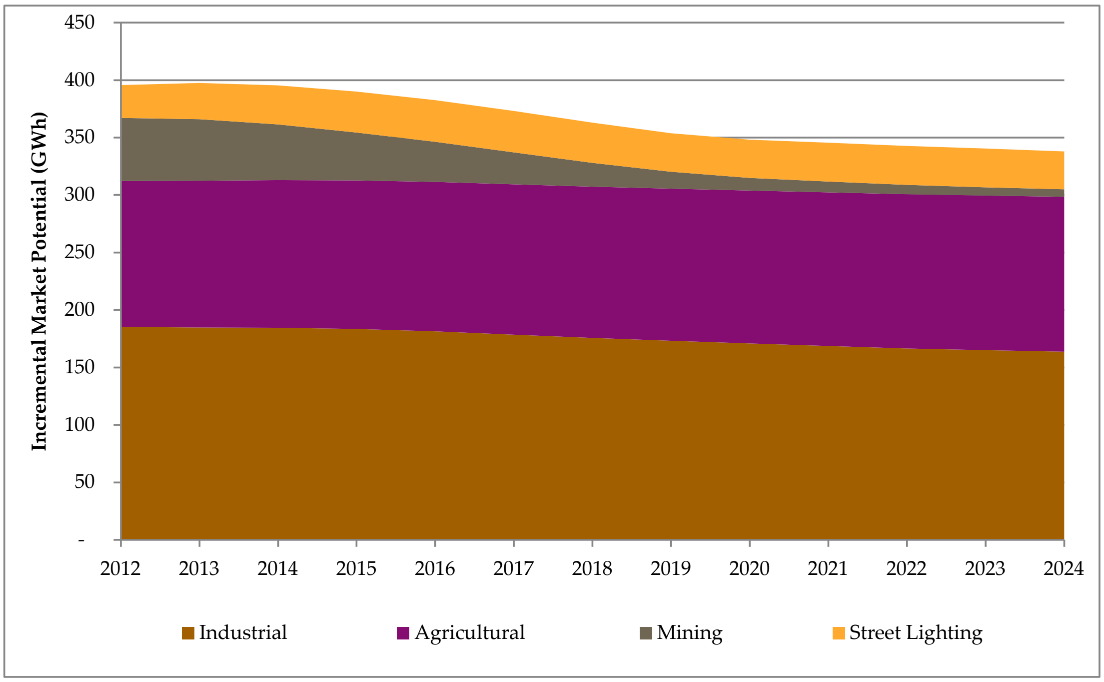


Note: Mining sector savings are included in the Machine Drives end use in this chart.

Source: PG model release August 2013

Figure 7-5 presents another view of the data shown in Figure 7-3, the incremental market energy savings potential for each sector within the AIMS sectors group. For the 2012 to 2024 period, on average, the industrial sector accounts for 48 percent of potential, agricultural accounts for 36 percent, mining accounts for 7 percent, and street lighting accounts for 9 percent.

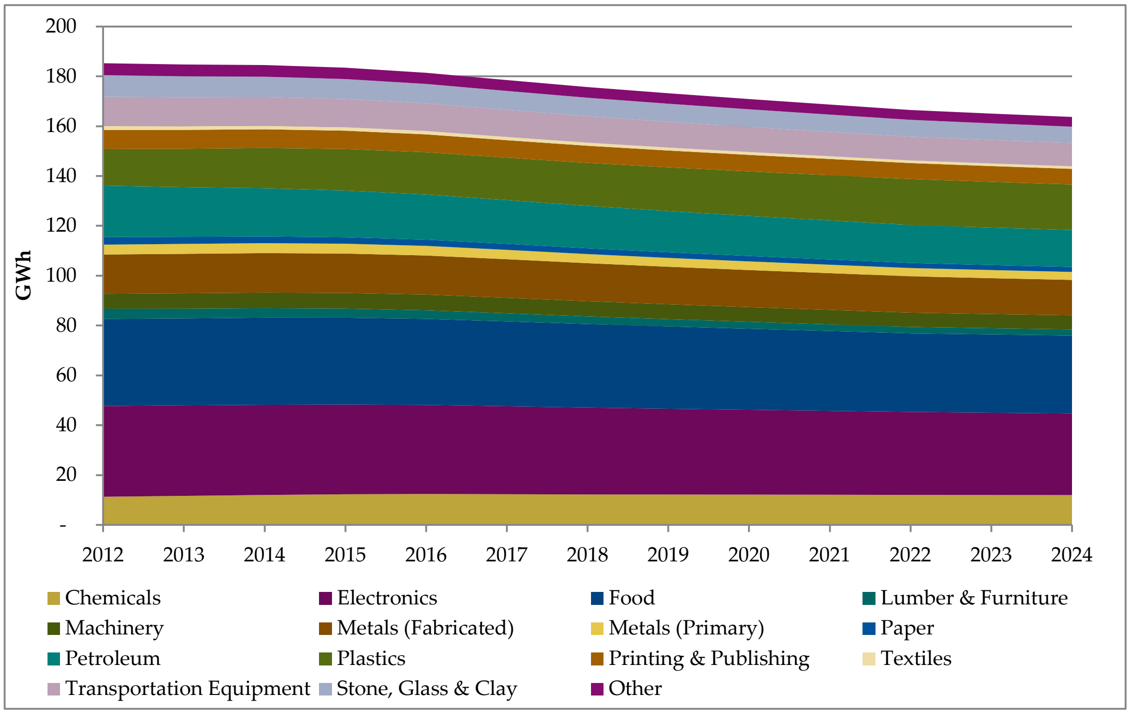
Figure 7-5. California AIMS Gross Incremental Market Energy Savings Potential by Sector for 2012-2024 (GWh)



Source: PG model release August 2013

Figure 7-6 further disaggregates the industrial sector results by subsector. Industrial is the largest sector by electric consumption and by contribution to potential within the AIMS sectors. This view by subsector shows how the refreshment and saturation of potential within certain industrial segments affects the overall industrial market potential.

Figure 7-6. California Industrial Gross Incremental Market Energy Savings Potential by End Use for 2012-2024 (GWh)



Source: PG model release August 2013

7.2.2 California AIMS Electric Comparative Metrics

This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 AIMS analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For AIMS, the following comparative metrics are provided:

» Comparison of the 2011 and 2013 potential studies

» Cumulative market potential as compared to the total CEC consumption forecast for the AIMS sectors

» Incremental annual forecast potential for 2013/2014 compared to the IOU Industrial and Agricultural Compliance Filings for the 2013/2014 portfolio

» Industrial sector 2013 technical potential by end use compared to similar metrics provided by KEMA's recent Industrial Sectors Market Characterization studies for several high-use industries

7.2.2.1 *Comparison between 2011 and 2013 Potential Studies*

Table 7-1 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The 2011 analysis effort included a review of the industrial and agricultural sectors and excluded mining and street lighting. Therefore, Table 7-1 compares the 2011 results to both the full AIMS results as well as the results for only the industrial and agricultural sectors (labeled as "AI" in Table 7-1). These two comparisons show the effect of the expanded 2013 project scope and the refinements in the analysis approaches and data sources that were not employed in the 2011 model.

Table 7-1. Changes in California AIMS Incremental and Cumulative Market Energy Potential from the Previous Forecast (GWh)

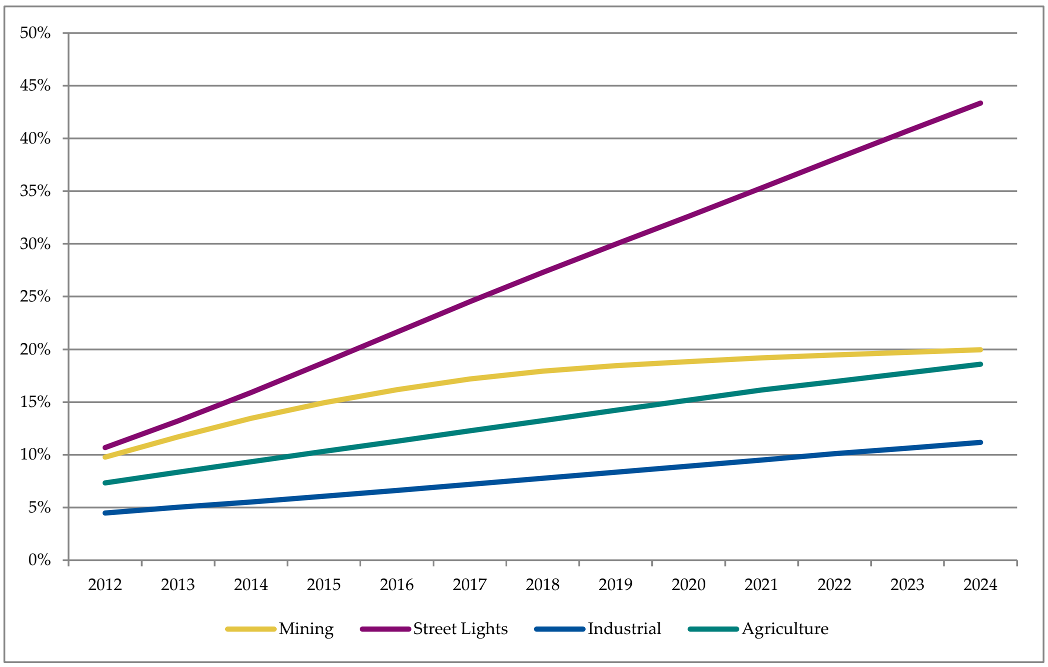
Year	Incremental Market Potential					Cumulative Market Potential				
	2011 Study (AI Only)	2013 AIMS Study	Percent Change (2011 to 2013 AIMS)	2013 AI Only	Percent Change (2011 to 2013 AI)	2011 Study (AI Only)	2013 AIMS Study	Percent Change (2011 to 2013 AIMS)	2013 AI Only	Percent Change (2011 to 2013 AI)
2012	375	396	5%	312	-17%	3,066	2,751	-10%	2,343	-24%
2013	376	398	6%	312	-17%	3,441	3,148	-9%	2,656	-23%
2014	361	395	10%	313	-13%	3,802	3,544	-7%	2,969	-22%
2015	346	390	13%	313	-10%	4,149	3,934	-5%	3,282	-21%
2016	334	383	15%	311	-7%	4,482	4,316	-4%	3,593	-20%
2017	315	373	18%	309	-2%	4,798	4,690	-2%	3,902	-19%
2018	304	363	19%	307	1%	5,102	5,052	-1%	4,210	-17%
2019	285	354	24%	306	7%	5,387	5,406	0%	4,515	-16%
2020	269	348	29%	304	13%	5,656	5,754	2%	4,819	-15%
2021	253	346	37%	302	20%	5,909	6,100	3%	5,121	-13%
2022	249	343	38%	301	21%	6,157	6,443	5%	5,422	-12%
2023	247	340	38%	300	21%	6,404	6,783	6%	5,722	-11%
2024	257	338	32%	298	16%	6,660	7,121	7%	6,020	-10%

Source: PG model release August 2013

7.2.2.2 *CEC Forecast Comparative Metrics*

CEC consumption forecasts are one of the foundational inputs for the 2013 potential study. Comparing savings as a percent of that CEC consumption forecast is an important comparative metric. Figure 7-7 shows the cumulative market potential savings as a percent of the CEC forecasts for the four AIMS sectors. Cumulative market potential for the industrial sector rises from about 3 percent in 2012 up to 11 percent by 2024. Agricultural cumulative market potential is slightly higher and ranges from 5 to 18 percent for the 2012 to 2024 time frame. Additionally, mining sector cumulative market potential starts at 10 percent in 2012 and increases to 20 percent in 2024, and the street-lighting sector achieves the most potential as a percent of consumption with 11 percent in 2012 and 41 percent achieved in 2024. Currently, nearly all streetlights in California are baseline high-pressure sodium lamps, and significant savings opportunities are present in the form of LEDs that are continually improving as a result of emerging technology efforts.

Figure 7-7. California AIMS Cumulative Market Potential as a Percent of CEC Forecasts

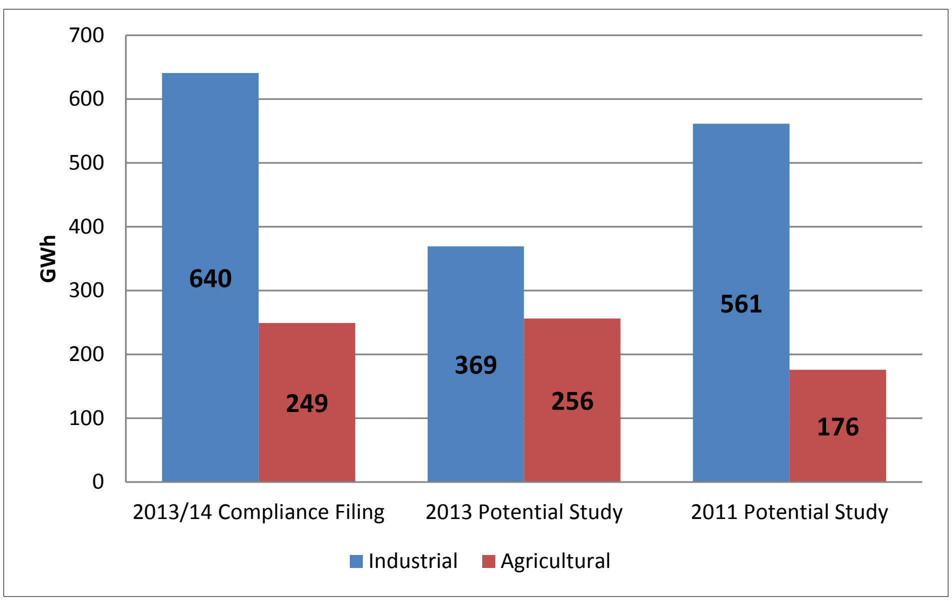


Source: PG model release August 2013

7.2.2.3 *IOU 2013/2014 Compliance Filing Comparative Metrics for Industrial and Agricultural*

During this study, IOUs provided their compliance filings that were submitted to the state for their 2013/2014 goals. These provided another comparative metric, and the industrial and agricultural numbers in the compliance filings were compared to the industrial and agricultural results from the 2013 Potential and Goals Study as well as the 2011 Potential Study, as shown in Figure 7-8. For the industrial sector, the 2013 Potential and Goals Study results are less than both the compliance filings and 2011 study. For the agricultural sector, the 2013 Potential and Goals Study results are slightly greater than the compliance filing and greater than the 2011 study. The Navigant team's analysis assumes consistent savings potential and program activity across IOUs, relative to gross sales, for the duration of the analysis period in order to represent a typical year. However, the Navigant team notes that this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, the Navigant team notes those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, the PG Model uses a supply curve approach and relies on a more robust data set that draws more information from sources that are specific to the industrial and agricultural sectors.

Figure 7-8. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Electric)



Source: PG model release August 2013

The Navigant team further investigated the IOU filing data in order to understand the differences between the estimates. Table 7-2 shows each IOU's industrial potential assumptions (ex ante), 2013 and 2014 program budgets, forecasted sales (GWh), and the Navigant team's analysis results. Table 7-3 shows the same information for the agricultural sector. The Navigant team's analysis assumes consistent savings potential and program activity across IOUs, relative to gross sales, for the duration of the analysis period in order to represent a typical year. However, this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario. Each table's $/kWh values provide a further comparison of how each IOU's program budgets relate to expected savings, and these vary significantly. The compliance filing budgets do not separate dollars by electric and gas savings. However, to aid this specific comparative metrics analysis, the Navigant team has assigned all dollars to electric savings.

Table 7-2. 2013-2014 Industrial Sector IOU Filings and Savings Comparison, Electric

IOU	PG Model Savings (GWh)	Filing Ex Ante Electric Savings (GWh)	Filing Program Budget (Million $)	Filing $/kWh	2013-2014 Consumption Forecast (GWh)
All	369	640	$152	$0.24	35,640
PG&E	176	195	$69	$0.35	17,398
SCE	174	429	$77	$0.18	16,687
SDG&E	19	17	$6.2	$0.37	1,556

Table 7-3. 2013-2014 Agricultural Sector IOU Filings and Savings Comparison, Electric

IOU	PG Model Savings (GWh)	Filing Ex Ante Electric Savings (GWh)	Filing Program Budget (Million $)	Filing $/kWh	2013-2014 Consumption Forecast (GWh)
All	256	249	$33	$0.13	24,646
PG&E	149	206	$29	$0.14	14,296
SCE	102	35	$1.4	$0.04	9,798
SDG&E	6	8	$2.2	$0.28	553

7.2.2.4 *KEMA's Industrial Sectors Market Characterizations Comparison*

The industrial sector represents the largest portion of potential within the AIMS sectors. Additionally, unlike other AIMS sectors, the industrial sector has been analyzed by other potential studies efforts within California. Therefore, the Navigant team further verified the potential model results for this sector by comparing its analysis to other recent studies completed by KEMA.[124] KEMA's industrial reports can be found on CALMAC.org. KEMA estimated savings potential for various end uses found within the chemical, plastics, primary metals, stone, glass, and clay, and paper industrial subsectors. The Navigant team compared the distribution of 2013 end-use market potential to similar estimates provided in the KEMA reports. As shown in Table 7-4, the end-use potential generally aligned between studies though the KEMA reports showed higher motor potential while the PG Model indicated slightly higher potential in lighting based on an analysis of LED lighting, and HVAC.

Table 7-4. Share of Electric Potential in each End-Use Category for the Industrial Sector

KEMA		PG Model	
Electric End Use	Percent of Electric Potential (%)	Percent of Electric Potential (%)	Electric End Use
HVAC	17%	21%	HVAC, process heat, process refrigeration
Lighting	7%	13%	Lighting
Motors, compressed air, pumps, fans	75%	66%	Machine drives
Other	1%	N/A	N/A
Total	100%	100%	Total

[124] KEMA Industrial Sectors Market Characterizations, Released January to February 2012, Calmac.org. At the following links:
http://calmac.org/publications/Final_Industrial_Sector_Market_Characterization_Chemicals_Report.pdf;
http://calmac.org/publications/Final_Plastics_Market_Characterization.pdf;
http://calmac.org/publications/Final_metalworking_market_characterization_report.pdf;
http://calmac.org/publications/Final_Industrial_Glass_Sector_Characterization_Report.pdf;
http://www.calmac.org/publications/Final_Cement_Industrial_Market_Characterization_Report.pdf;
http://calmac.org/publications/Final_Minerals_Market_Characterization_Report.pdf;
http://calmac.org/publications/Final_Paper_Industrial_Sector_Market_Characterization.pdf.

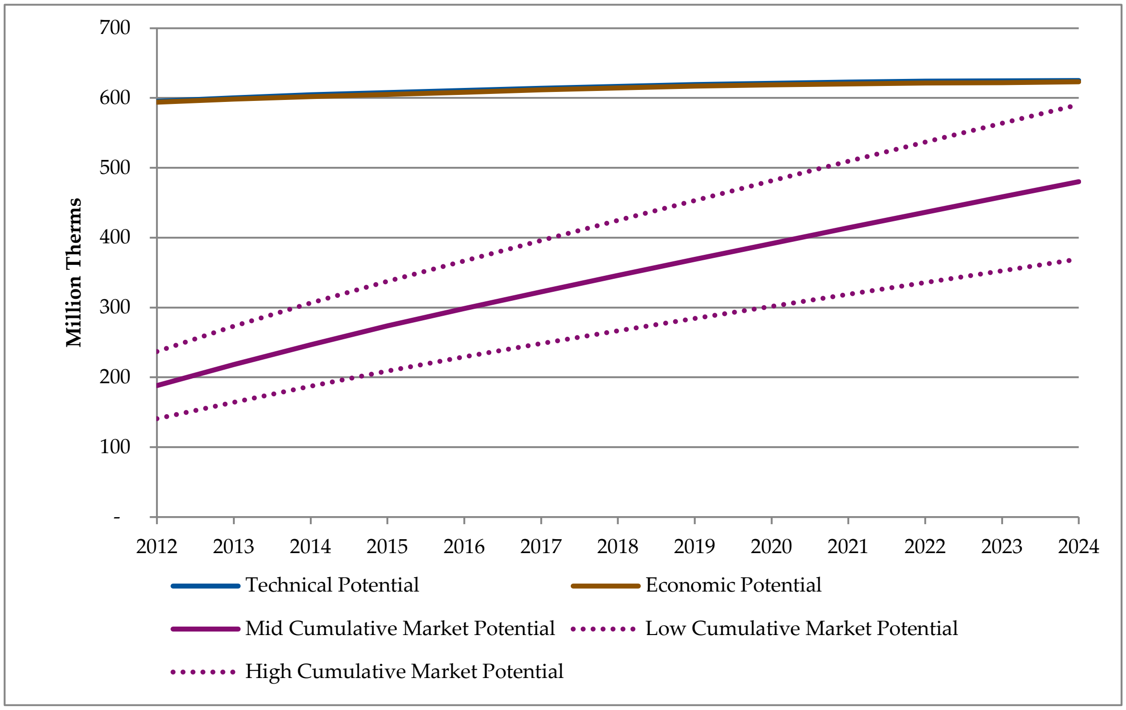
7.2.3 California AIMS Natural Gas Potential

The industrial sector contributes the majority of the natural gas potential estimated for the California AIMS sectors. The agricultural and mining sectors contribute some potential and the street-lighting sector includes only electric measures.

As shown in Figure 7-9, the AIMS technical and economic energy savings potential remains fairly constant from 2012 through 2024. The Navigant team's technical and economic potential results are generally the same value because the Navigant team's analysis used supply curves for the industrial and agricultural sectors (that account for the majority of the potential) that rely on actual energy efficiency improvement recommendations made within facilities found throughout the U.S. Therefore, the majority of the data used to develop the results has acceptable benefit-cost ratios and passes an economic potential screen. Technical and economic energy savings potential in the state of California stay steady between 600 and 630 million therms from 2012 through 2024. The technical and economic energy savings potential are informed by IOU retail rate forecasts for each sector ($/kWh) and energy sales forecasts for each sector (kWh by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The overall AIMS cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year within the industrial sector, and to a lesser extent, the agricultural sector. The Navigant team estimates that savings potential for certain end uses within certain industrial and agricultural segments will replenish with each stock turnover event occurring within the analysis period. That is, the majority of increasing cumulative market energy savings potential accounts for new process improvements within both sectors and future equipment emerging technologies within the industrial sector that sustain savings achievements. The mining sector also contributes to cumulative market energy savings potential, but to a lesser extent similar to the agricultural sector. Further, the Navigant team estimates that no replenishment will occur in the mining sector. The cumulative market potential lags the technical and economic potentials and increases from around 190 million therms in 2012 to around 480 million therms in 2024 for the Mid EE Penetration market potential scenario.

Figure 7-9. California AIMS Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2012-2024 (Million Therms)

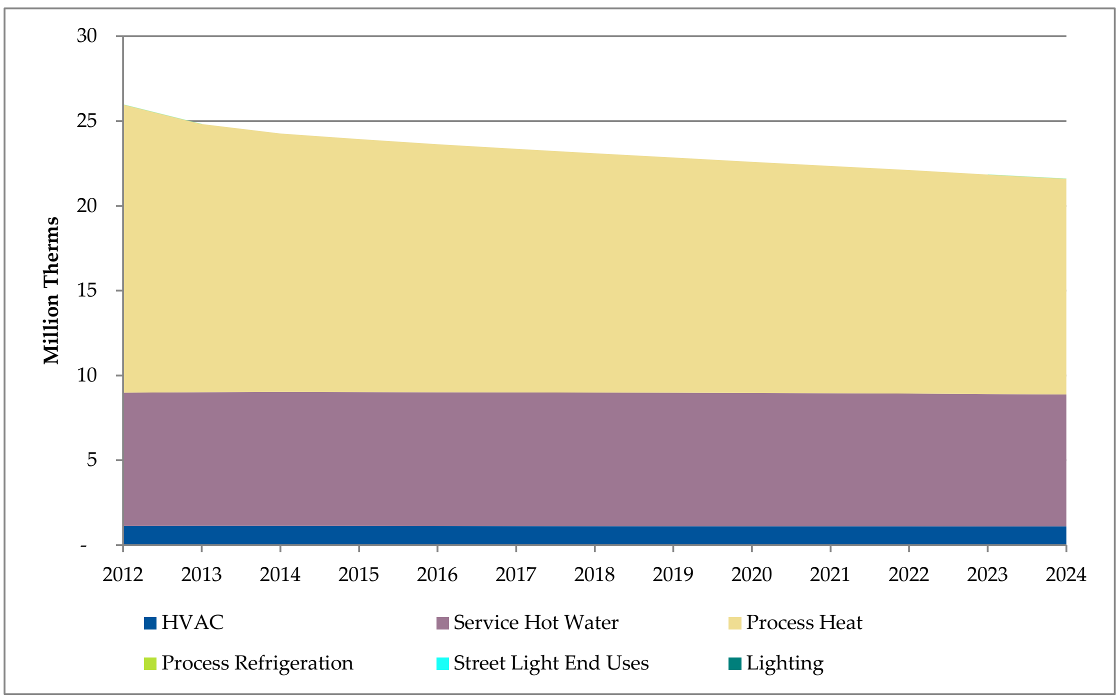


Source: PG model release August 2013

The Navigant team's analysis approach used for gas potential mirrors the approach used for estimating electric potential. Specifically, the Navigant team identified refreshing and saturating gas measures within certain end uses and certain subsectors of the industrial and agricultural sectors. As a result, potential for these measures will sustain over the analysis period even as the current stock of baseline equipment reduces due to replacement with efficient equipment.

Figure 7-10 presents the incremental market potential gas savings by end use in the AIMS sectors through 2024. The individual end uses (e.g., HVAC, Service Hot Water, and Process Heat) represent the combined potential for end uses within the industrial, agricultural, and mining sectors. End uses in mining represent process boiler measures shown under the Process Heat end use. The street- lighting sector does not contribute to the natural potential results. For many industrial subsectors, refreshment represents the introduction of emerging technologies in future years, ongoing implementation of O&M best practices, and process improvements that are typically implemented as a part of production changes and equipment retooling. For the industrial and agricultural sectors in particular, these refreshment assumptions are consistent with the continuous improvement nature of for-profit enterprises that generally view energy expense as a substantial cost that has a direct impact on operating margins. Conversely, significant portions of gas measures within the industrial and agricultural sectors are estimated to saturate and not replenish savings over the analysis period. For example, a significant portion of process heat end-use measures within the industrial sector's Petroleum subsector is estimated to saturate during the 2012 to 2024 time frame. As a result, the incremental gas savings potential decreases steadily from approximately 26 million therms in 2012 to 22 million therms in 2024.

Figure 7-10. California AIMS Gross Incremental Market Gas Savings Potential by End Use for 2012-2024 (Million Therms)

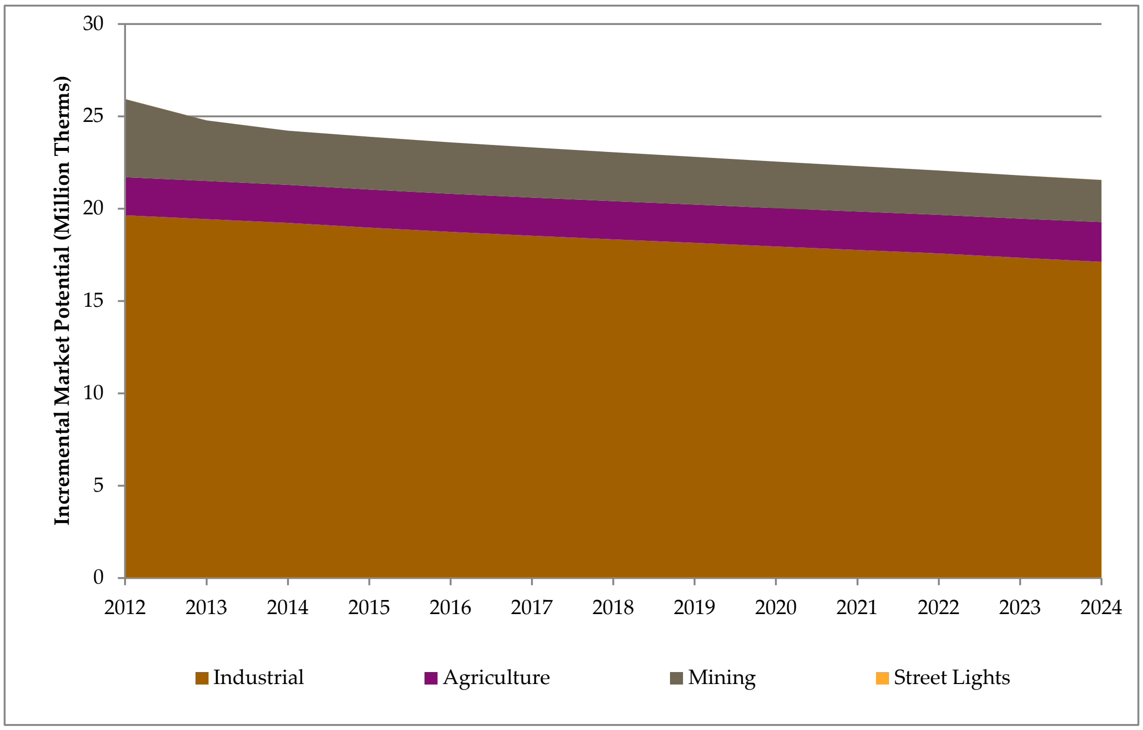


Note: Mining sector savings are included in the Process Heat end use in this chart.

Source: PG model release August 2013

Figure 7-11 presents another view of the data shown in Figure 7-10, the incremental market energy savings potential for each sector within the AIMS sectors group. For the 2012 to 2024 period, on average, the industrial sector accounts for 79 percent of potential, agricultural accounts for 9 percent, mining accounts for 12 percent, and street lighting accounts for 0 percent.

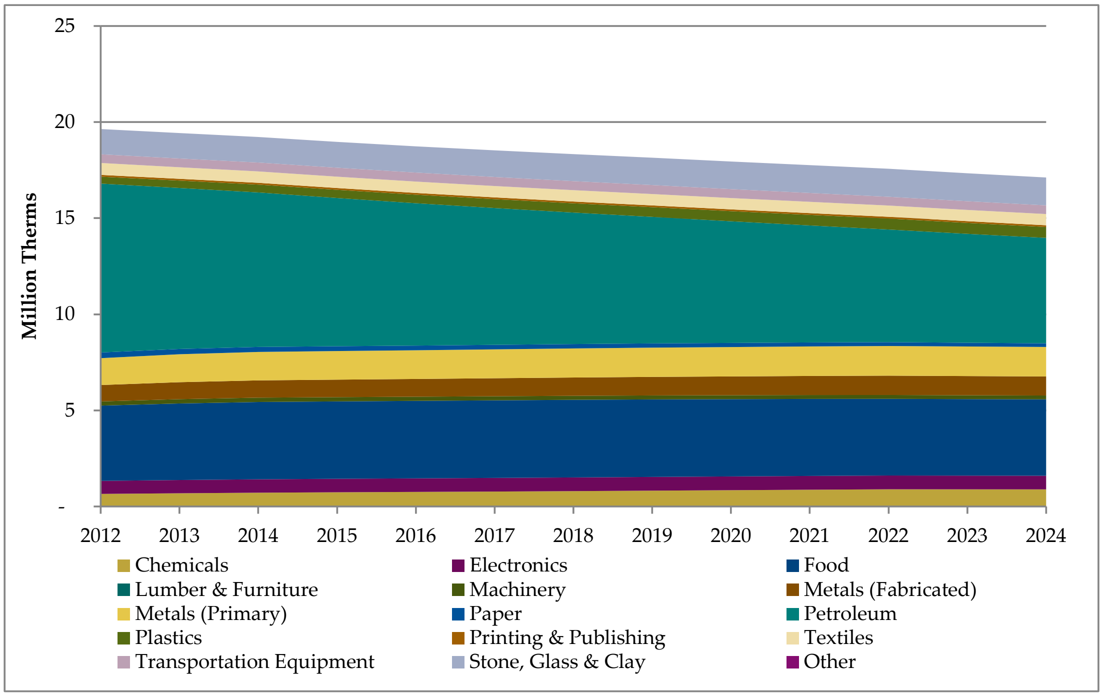
Figure 7-11. California AIMS Gross Incremental Market Energy Savings Potential by Sector for 2012-2024 (Million Therms)



Source: PG model release August 2013

Figure 7-12 further disaggregates the industrial sector results by subsector. Industrial is the largest sector by gas consumption and by contribution to potential within the AIMS sectors. This view by subsector shows how the refreshment and saturation of potential within certain industrial segments affects the overall industrial market potential. Notably, the Petroleum subsector is estimated to saturate.

Figure 7-12. California Industrial Gross Incremental Market Energy Savings Potential by Subsector for 2012-2024 (Million Therms)



Source: PG model release August 2013

7.2.4 California AIMS Gas Comparative Metrics

This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 AIMS analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For AIMS, the following comparative metrics are provided:

» Comparison of the 2011 and 2013 potential studies

» Incremental annual forecast potential for 2013/2014 compared to the IOU AIMS sector program savings estimates for the 2013/2014 portfolio

» Cumulative market potential as compared to the total CEC consumption forecast for the AIMS sectors

» Industrial sector 2013 technical potential by end use compared to similar metrics provided by KEMA's recent Industrial Sectors Market Characterization studies for several high-use industries

7.2.4.1 Comparison between 2011 and 2013 Potential Studies

Table 7-5 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The 2011 analysis effort included a review of the industrial and agricultural sectors and excluded mining and street lighting. Therefore, Table 7-5 compares the 2011 results to both the full AIMS results as well as the results for only the industrial and agricultural sectors (labeled as "AI" in Table 7-5). These two comparisons show the effect of the expanded 2013 project scope and the refinements in the analysis approaches and data sources that were not employed in the 2011 model.

Table 7-5. Changes in California AIMS Incremental and Cumulative Market Energy Potential from the Previous Forecast (Million Therms)

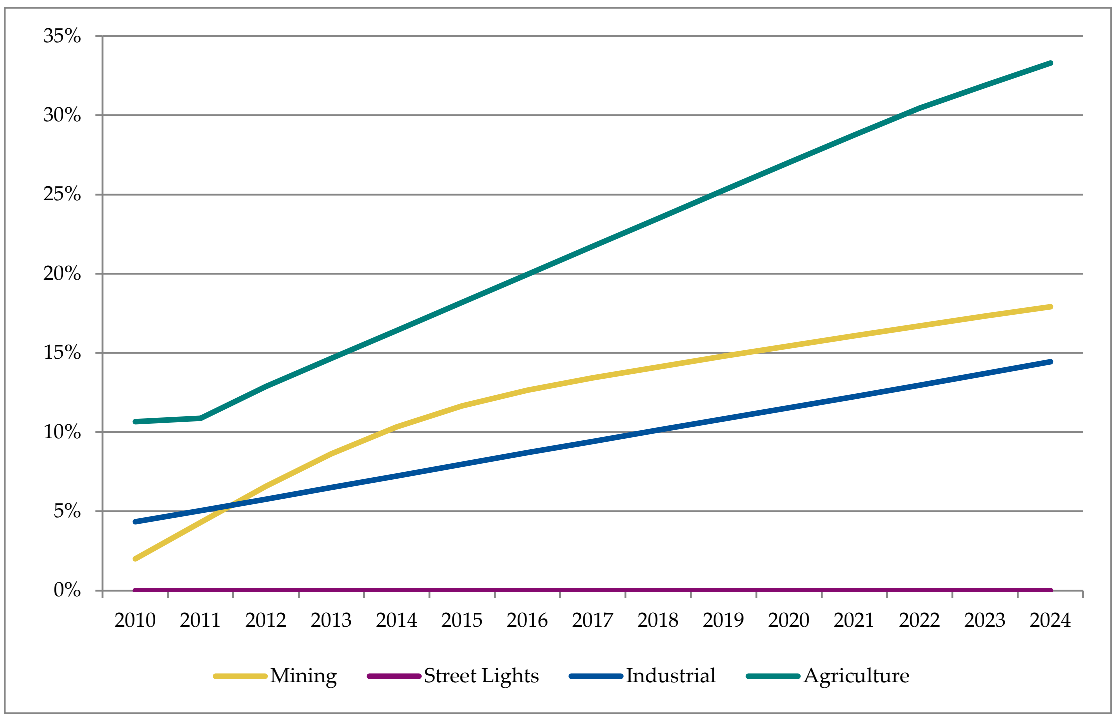
Year	Incremental Market Potential					Cumulative Market Potential				
	2011 Study (AI Only)	2013 AIMS Study	Percent Change (2011 to 2013 AIMS)	2013 AI Only	Percent Change (2011 to 2013 AI)	2011 Study (AI Only)	2013 AIMS Study	Percent Change (2011 to 2013 AIMS)	2013 AI Only	Percent Change (2011 to 2013 AI)
2012	22	26	18%	22	-1%	184	214	16%	160	-13%
2013	20	25	26%	21	9%	204	239	17%	182	-11%
2014	17	24	46%	21	28%	220	263	19%	203	-8%
2015	14	24	76%	21	55%	234	287	23%	224	-4%
2016	11	24	105%	21	81%	245	310	26%	245	0%
2017	9	23	147%	21	118%	255	334	31%	265	4%
2018	8	23	174%	20	143%	263	357	35%	286	9%
2019	6	23	258%	20	217%	270	380	41%	306	13%
2020	6	23	255%	20	215%	276	402	46%	326	18%
2021	5	22	319%	20	272%	281	424	51%	346	23%
2022	5	22	313%	20	269%	287	446	56%	366	28%
2023	5	22	308%	19	264%	292	468	60%	385	32%
2024	5	22	302%	19	260%	297	490	65%	404	36%

Source: PG model release August 2013

7.2.4.2 *CEC Forecast Comparative Metrics*

CEC consumption forecasts are one of the foundational inputs for the 2013 potential study. Comparing savings as a percent of that CEC consumption forecast is an important comparative metric. Figure 7-13 shows the cumulative market potential savings as a percent of the CEC forecasts for the four AIMS sectors. Cumulative market potential for the industrial sector rises from about 6 percent in 2012 up to 14 percent by 2024. Agricultural cumulative market potential is higher and ranges from 13 to 33 percent for the 2012 to 2024 time frame. The gas measures within the agricultural sector include equipment and O&M improvements to HVAC, process heat, and service hot water end uses. The agricultural analysis also estimates that these measures will refresh over the analysis period and maintain savings potential. Additionally, mining sector cumulative market potential starts at 7 percent in 2012 and increases to 18 percent in 2024, and the street-lighting sector achieves no gas potential.

Figure 7-13. California AIMS Cumulative Market Potential as a Percent of CEC Forecasts

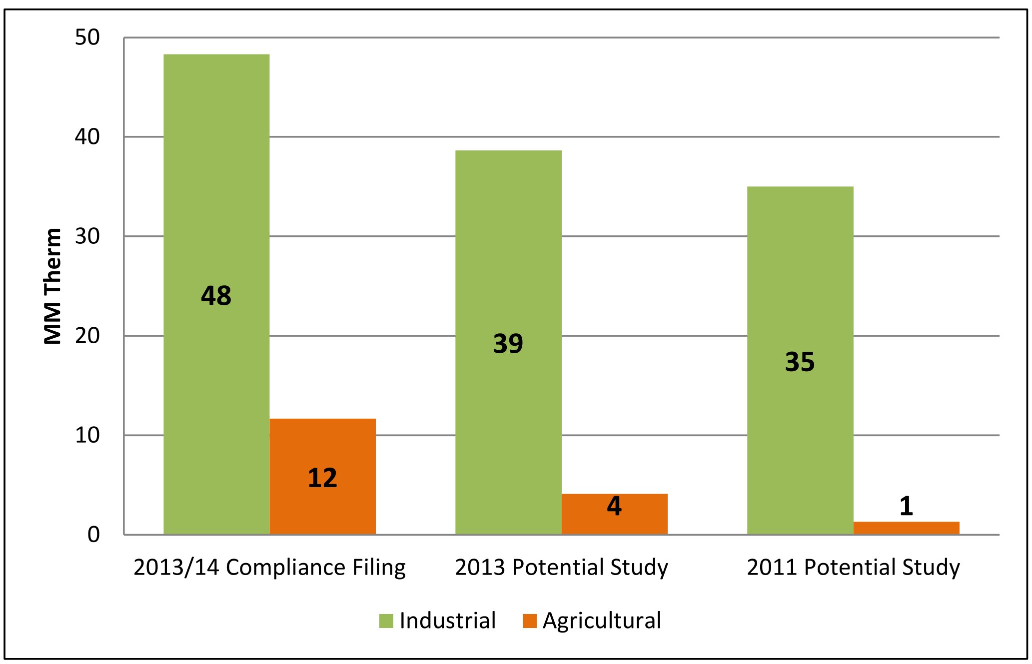


Source: PG model release August 2013

7.2.4.3 *IOU 2013/2014 Compliance Filing Comparative Metrics*

During this study, IOUs provided their compliance filings that were submitted to the state for their 2013/2014 goals. These provided another comparative metric and the industrial and agricultural numbers in the compliance filings were compared to the industrial and agricultural results from the 2013 Potential Study as well as the 2011 Potential Study, as shown in Figure 7-14. For the industrial sector, the 2013 study is less than the compliance filings and slightly more than the 2011 study. For the agricultural sector, the 2013 study is significantly less than the compliance filings and significantly greater than the 2011 study. The Navigant team's analysis assumes consistent savings potential and program activity across IOUs, relative to gross sales, for the duration of the analysis period in order to represent a typical year. However, this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, the PG Model uses a supply curve approach and relies on a more robust data set that draws more information from sources that are specific to the industrial and agricultural sectors.

Figure 7-14. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Gas)



The Navigant team further investigated the IOU filing data in order to understand the differences between the estimates. Table 7-6 shows each IOU's industrial potential assumptions (ex ante), forecasted sales, and the Navigant team's analysis results. Table 7-7 shows the same information for the agricultural sector. The Navigant team also calculated the savings potential as a percent of consumption in order to observe the variation in normalized savings between the IOUs. This provided an additional QC check for the analysis. The Navigant team's analysis assumes consistent savings potential and program activity across IOUs, relative to gross sales, for the duration of the analysis period in order to represent a typical year. However, this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario.

Table 7-6. 2013-2014 Industrial Sector Savings Comparison, Gas

IOU	PG Model Savings (MM Therm)	Filing Ex Ante Gas Savings (MM Therm)	2013-2014 Consumption Forecast (MM Therm)	PG Model Percent Savings (%)	Filing Percent Savings (%)
All	39	48	6,567	0.59%	0.73%
PG&E	18	22	3,140	0.58%	0.70%
SDG&E	0.4	0.4	56.4	0.78%	0.71%
SCG	20	26	3,371	0.59%	0.77%

Table 7-7. 2013-2014 Agricultural Sector Savings Comparison, Gas

IOU	PG Model Savings (MM Therm)	Filing Ex Ante Gas Savings (MM Therm)	2013-2014 Consumption Forecast (MM Therm)	PG Model Percent Savings (%)	Filing Percent Savings (%)
All	4	11	240	1.7%	4.7%
PG&E	1	9	71	1.7%	12.7%
SDG&E	0.1	0.2	8	1.7%	2.4%
SCG	3	2	160	1.8%	1.3%

7.2.4.4 KEMA's Industrial Sectors Market Characterizations Comparison

The industrial sector represents the largest portion of potential within the AIMS sectors. Additionally, unlike other AIMS sectors, the industrial sector has been analyzed by other potential studies efforts within California. Therefore, the Navigant team further verified the potential model results for this sector by comparing its analysis to other recent studies completed by KEMA.[125] KEMA's industrial reports can be found on CALMAC.org. KEMA estimated savings potential for various end uses found within the chemical, plastics, primary metals, stone, glass, and clay, and paper industrial subsectors. The Navigant team compared the distribution of 2013 end-use market potential to similar estimates provided in the KEMA reports. As shown in Table 7-8, the end-use potential generally aligned between studies though the KEMA reports showed slightly less HVAC potential while the PG Model indicated slightly less service hot water (boiler) potential.

Table 7-8. Share of Gas Potential in each End Use Category for the Industrial Sector

KEMA		PG Model	
Gas End Use	Percent of Gas Potential (%)	Percent of Gas Potential (%)	Gas End Use
HVAC	2%	4%	HVAC
Process (varies)	59%	60%	Process Heat
Boilers	39%	36%	Service Hot Water
Total	100%	100%	Total

[125] Ibid, KEMA reports on CALMAC.org.

List of Appendices

See the "Potential Goals Study - Appendices" files for the following appendices: