NAVIGANT

2013 California Energy Efficiency Potential and Goals Study

APPENDIX VOLUME I
Appendices A- J

Prepared for:
California Public Utilities Commission

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Appendix A Emerging Technologies

The Navigant team expanded the scope of emerging technologies (ETs) and refined the modeling methodology for ETs in this 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 3-5 years
» Commercially available but representing less than 5% of the existing market share
» Costs and/or performance are expected to improve in the future

ETs were only examined for the residential, commercial, and street lighting sectors.[1] These sectors are modeled using individual measures for specific applications.

The rest of this section describes the approach to ET analysis in the residential and commercial sectors.

For the 2013 Potential and Goals Study, the Navigant team took a systematic approach to identify the end uses within the residential and commercial sectors that account for the largest energy use. ETs could then be examined for these largest end uses to maximize the technical potential savings from ETs. 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 A-1.

Table A-1. End Uses Included in the CEC Energy Demand Forecast Model and in the 2013 Potential and Goals Study

	Included in CEC Energy Demand Forecast Model		Included in 2013 Potential and Goals ET Analysis	
Sector	Electric End Uses	Gas End Uses	Electric End Uses	Gas End Uses
Residential	18	10	6	4
Commercial	10	6	6	3
Total	28	16	12	7

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

The Navigant team analyzed the energy consumed by each end use and determined that 12 electric end uses account for 83% of residential and commercial electric consumption; seven gas end uses account for

[1] The Industrial and Agricultural sectors are modeled using the supply curve approach
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

87% of residential and commercial gas consumption. These end uses, listed in Table A-2, were those that the Navigant team examined for possible ETs.

Table A-2. 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 researched possible emerging technologies for each of the 19 end uses listed in Table A-2. To seek out ETs, the Navigant team consulted its own internal databases as well as third-party reports and U.S. Department of Energy analyses to seek out 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, SEER 15 and SEER 18 residential ACs are modeled as conventional measures (data available from DEER), a SEER 22 AC 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.[2]
- The Navigant team extrapolated cost data from DEER where possible.
- IOU work papers and other case studies provided additional savings and cost estimates.

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

Table A-3 and Table A-4 include lists of the technologies analyzed for each of the sector/end use combinations. The 2013 Potential and Goals Study included ETs in 31 sector-end use combinations; for comparison, the 2011 Potential Study only assessed the potential of 23 ETs that were most likely expected to be adopted in the market.

Table A-3. ETs Analyzed by Sector-End Use Combination (Electric)

Electric Sector and End Use	Percent Residential + Commercial Electricity Use	Technologies Modeled	
		2011 Potential Study	2013 PG Model
Com Indoor Lighting	16.55%	LEDs	LEDs
Com Miscellaneous	12.63%		Smart strip plug load controls
Res Miscellaneous	10.37%		Smart strip plug load controls
Com Cooling	8.29%	Fault Detection and diagnostics, advanced rooftop AC unit	Advance package rooftop AC unit
Res Refrigerator	8.22%		35% savings relative to code refrigerator
Res Lighting	7.38%	LEDs	LEDs
Com Ventilation	5.64%		Energy recovery ventilation
Com Refrigeration	4.37%		Refrigeration display case
Res Cooling	3.58%	Ductless cooling, night ventilation, evap. cooling	SEER 22 AC, SEER 21 HP
Com Outdoor Lighting	3.09%	LEDs	LEDs
Res Dryer	2.44%		Heat Pump Dryer
Res Water heater	0.93%	Heat Pump Water Heaters	Heat Pump Water Heaters
Total	**83.5%**		

Source: Navigant team analysis, 2013.

Table A-4. ETs Analyzed by Sector-End Use Combination (Gas)

Gas Sector and End Use	Percent Residential + Commercial Gas Use	Technologies Modeled	
		2012	2013
Res Space heat	31.92%		98 AFUE Furnace
Res Water heater	16.07%	Condensing Gas Water Heater	Condensing Gas Water Heater
Com Heating	10.88%	Automatic Steam Trap Monitoring	High Efficiency Boilers (conventional)
Com Water Heating	9.51%	Combined space and water heating	Condensing Gas Water Heater
Res Clothes washer (demand on water heating)	7.39%		MEF 2.87 Clothes Washers
Com Cooking	6.76%		*None*
Res Dishwasher (demand on water heating)	4.60%		EF 1.19 Dishwasher
Total	**87.1%**		

Source: Navigant team analysis, 2013.

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, avoid having multiple ET products that effectively do the same thing compete against each other, and examine more sector-end use combinations.

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. Actual future adoption of ETs will vary depending on technology. Some ETs will gain large customer acceptance, capture significant market shares, and generate large savings, while others will falter achieving no market share and no savings. It is impossible to pre-determine which ETs will succeed and which will fail. The ET risk factor acts to de-rate the market adoption of each individual ET. The result is a total ET savings value that is representative of what can be expected of the group of ETs.

The risk factor was determined based on qualitative metrics that included market risk, technical risk, and data source risk. The framework for assigning the risk factor is shown in Table A-5. 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. Modeling ETs without any risk factor would produce unrealistic savings forecasts as it would assume every single ET: overcomes market barriers, establishes strong distribution channels, resolves remaining technology issues, and produces evaluated energy savings that are equal to current (unevaluated) savings claims.

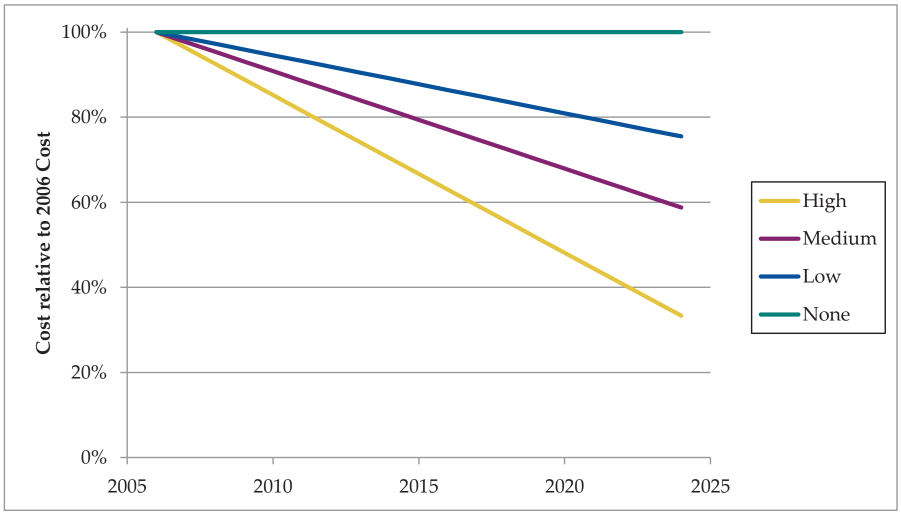
Table A-5. Emerging Technology Risk Factor Score Card

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

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.[3] Using this data, the Navigant team developed four cost reduction profiles that could apply to various ETs (and non-ETs) in the model (Figure A-1).

Figure A-1. Cost Reduction Profiles

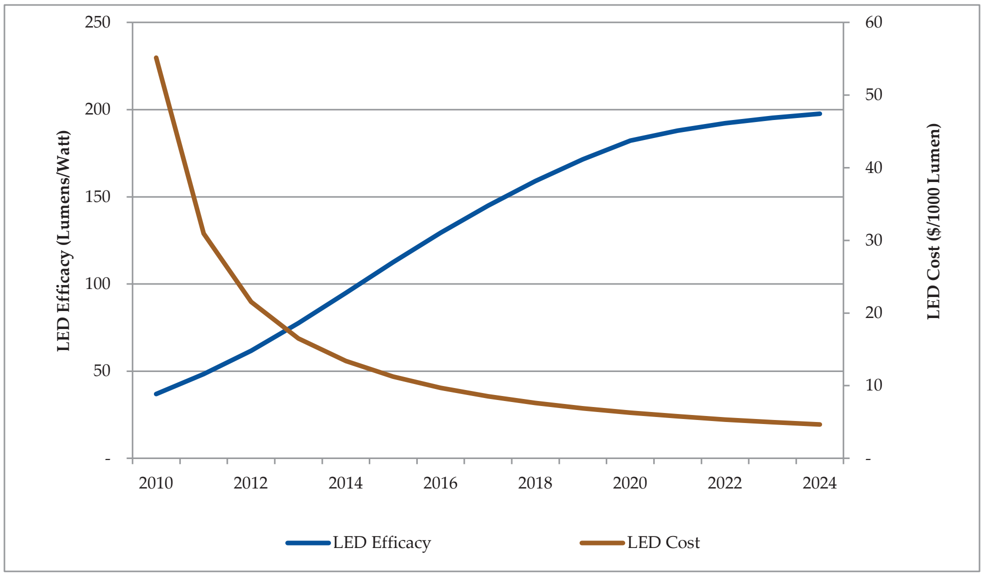


Source: Navigant team analysis, 2013.

[3] 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 for LED technologies (Figure A-2). LED costs have declined rapidly in recent years (a 70% 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 reflects both of these trends.

Figure A-2. 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.[4] Many ETs compete with lower efficiency conventional technologies (e.g. CFLs vs. LED) for market share.

Table A-6 includes a full list of the ETs modeled, their descriptions, and key ET inputs. The table is organized by End Use category (e.g., Appliance Plug Loads, HVAC).

[4] The Methodology section of the main report includes details on this approach.

Table A-6. Measure-Level Details of ETs Included in the 2013 Potential and Goals Study

Measure Name	Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile
AppPlug – Clothes Washer (Electric) – Emerging	Res	Electric	Clothes Washer All Sizes, Electric DHW, Electric or Gas Dryer – Average MEF = 2.87, Average Capacity = 2.93 Gallons	Clothes Washer All Sizes, Electric DHW, Electric or Gas Dryer – Average MEF = 0.78, Average Capacity = 2.93 Gallons	2012	100%	30%	High
AppPlug – Clothes Washer (Gas) – Emerging	Res	Gas	Clothes Washer All Sizes, Gas DHW, Electric or Gas Dryer – Average MEF = 2.87, Average Capacity = 2.93 Gallons	Clothes Washer All Sizes, Gas DHW, Electric or Gas Dryer – Average MEF = 0.78, Average Capacity = 2.93 Gallons	2012	100%	30%	High
AppPlug – Dishwasher (Electric) – Emerging	Res	Electric	Energy Star® Dish Washer – Standard Size w/Electric Water Heater – 160 Cycles per Year – EF = 1.19	Dish Washer – Standard Size w/Electric Water Heater – 160 Cycles per Year – Average EF = 0.45	2012	100%	30%	High
AppPlug – Dishwasher (Gas) – Emerging	Res	Gas	Energy Star® Dish Washer – Standard Size w/Gas Water Heater – 160 Cycles per Year – EF = 1.19	Dish Washer – Standard Size w/Gas Water Heater – 160 Cycles per Year – Average EF = 0.45	2012	100%	30%	High
AppPlug – HP Clothes Dryer – Emerging	Res	Electric	Heat Pump Electric Clothes Dryer	Average Market Baseline Clothes Dryer	2016	100%	55%	Medium
AppPlug – Self-Contained Refrigerator – Emerging	Res	Electric	Emerging Tech Refrigerator – 35% less energy than code	Code Refrigerator	2012	100%	30%	High
AppPlug – Smart Strip Home Office – Emerging	Res	Electric	Home office – Smart Strip with one control outlet, four controlled outlets, and two contant outlets	Power Strip	2008	100%	40%	Medium

Measure Name	Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile
AppPlug – Smart Strip Home Theater – Emerging	Res	Electric	Home theater – Smart Strip with one control outlet, four controlled outlets, and two contant outlets	Power Strip	2008	100%	40%	Medium
ComRefrig – Fiber Optic Display Case LED lighting - Emerging	Com	Electric	Fiber Optic Refrigerated Display Case LED lighting	OEM lighting in Display cases	2008	100%	50%	Low
HVAC – Advanced Package Rooftop AC (> EER 12) – Emerging	Com	Electric	Advanced Rooftop Unit AC, EER 12, COP 3.52, Advanced Economizer and Controls	Multiple base efficiency levels used, example: Pkg AC EER = 9.50; Clg EIR = 0.275; Supply Fan W/cfm = 0.419; Cond Fan W/Btuh = 0.0079; w/ econo	2014	100%	45%	Medium
HVAC – Energy Recovery Ventilation – Emerging	Com	Electric	Energy Recovery Ventilation system for commercial HVAC	No Energy Recovery Ventilation system	2009	12%	50%	Medium
HVAC – Gas Furnace – Emerging	Res	Gas	Furnace Upgrade to Efficienct Furnace – Average AFUE = 98	Base Case Furnace – Average AFUE = 76.8, Average HIR = 1.25	2015	100%	35%	Medium
HVAC – SEER Rated Split System AC (SEER 22) – Emerging	RES	Electric	22 SEER Split-System Air Conditioner	10 SEER (9.31 EER) Split System Air Conditioner	2015	100%	50%	Medium
HVAC – SEER Rated Split System HP (SEER 21) – Emerging	Res	Electric	Split SEER-Rated Heat Pump – Average SEER = 21	Split SEER-Rated Heat Pump – Average SEER = 13	2015	100%	50%	Medium

Measure Name	Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile
Lighting – LED Fixture (Replacing T8) – Emerging	Com	Electric	LED fixture: 34W, 3912 lumens	LF fixture: T8, 48inch, 32W lamp (2), Total fixture Watts = 59; Ballast specs: Instant Start, Electronic, NLO, 2 per lamp; Lamp specs: 3175 lumens, CRI=70, rated hours = 20000	2011	100%	35%	LED
Lighting – LED Lamp (Basic High – Indoor) – Emerging	Com	Electric	LED interior lamp: 31W, 3600 lumens	Indoor CFL Lamp (Screw-In >= 25W) – Average Lamp Watts = 217.77W, Average Lamp CFL Ratio = 0.357	2011	100%	30%	LED
Lighting – LED Lamp (Basic High – Indoor) – Emerging	Res	Electric	LED Screw-In Indoor Lamp: 19W, 1500 lumens	Incandescent, Screw-In Indoor 171W	2011	100%	30%	LED
Lighting – LED Lamp (Basic High – Outdoor) – Emerging	Res	Electric	LED Screw-In Outdoor Lamp: 19W, 1500 lumens	Incandescent Screw-In Outdoor, 173.5W	2011	100%	30%	LED
Lighting – LED Lamp (Basic Low – Indoor) – Emerging	Com	Electric	LED interior lamp: 7W, 800 lumens	Indoor CFL Lamp (Screw-In < 25W) – Average Lamp Watts = 48.19W Average Lamp CFL Ratio = 0.357	2011	100%	30%	LED
Lighting – LED Lamp (Basic Low – Indoor) – Emerging	Res	Electric	LED Screw-In Indoor Lamp: 13W, 1000 lumens	Incandescent Screw-In Indoor, 64W	2011	100%	30%	LED
Lighting – LED Lamp (Basic Low – Outdoor) – Emerging	Res	Electric	LED Screw-In Outdoor Lamp: 13W, 1000 lumens	Incandescent Screw-In Outdoor, 65W	2011	100%	30%	LED
Lighting – LED Lamp (Reflector – Indoor) – Emerging	Res	Electric	LED Screw-In Indoor Reflector Lamp: 9W, 700 lumens	Incandescent Screw-In Indoor, 77.5W	2011	100%	30%	LED

Measure Name	Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile
Lighting – LED Lamp (Reflector – Outdoor) – Emerging	Res	Electric	LED Screw-In Outdoor Reflector Lamp: 15.5W, 1200 lumens	Incandescent Screw-In Outdoor, 85.5W	2011	100%	30%	LED
Lighting – LED Lamp (Specialty – Indoor) – Emerging	Res	Electric	LED Screw-In Indoor Specialty Lamp: 8.7W, 675 lumens	Incandescent Screw-In Indoor, 43W	2011	100%	30%	LED
Lighting – LED Lamp (Specialty – Outdoor) – Emerging	Res	Electric	LED Screw-In Outdoor Specialty Lamp: 9W, 720 lumens	Incandescent Screw-In Outdoor, 60W	2011	100%	30%	LED
Lighting – LED Plug-In Indoor Fixture – Emerging	Com	Electric	LED interior fixture: 9W, 1050 lumens	Incandescent interior fixture 98.8W	2011	100%	30%	LED
Lighting – LED Plug-In Indoor Fixture – Emerging	Res	Electric	LED Indoor Fixture: 9W, 700 lumens	Incandescent Indoor Fixture, 79W	2011	100%	30%	LED
Lighting – LED Plug-In Outdoor Fixture – Emerging	Res	Electric	LED Outdoor Fixture: 5W, 618 lumens	Incandescent Outdoor Fixture, 114W	2011	100%	30%	LED
SHW – EF Rated Storage Water Heater (Gas) – Emerging	Com	Gas	Condensing Small Gas Storage Water Heater with low Nox burner – Average Size = 51 Gal, Average EF = 0.77	multiple base efficiency levels used, example: Small Gas Storage Water Heater – Average Size = 51 Gal; Average EF = 0.57; Average Recov Eff = 0.76	2015	80%	50%	Low
SHW – EF Rated Storage Water Heater (Gas) – Emerging	Res	Gas	Condensing Small Gas Storage Water Heater with low Nox burner – Average Size = 51 Gal, Average EF = 0.77	Small Gas Storage Water Heater – Average Size = 51 Gal; Average EF = 0.55; Average Recov Eff = 0.76	2015	80%	50%	Low

Measure Name	Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile
SHW – ET Rated Storage Water Heater – Emerging	Com	Gas	Condensing Large Gas Storage Water Heater – Average Et = 0.99	multiple base efficiency levels used, example: Large Gas Storage Water Heater; Et = 0.80; Stdby Loss = 0.56%/hr	2012	100%	30%	Low

Source: Navigant team analysis, 2013.

Appendix B Online Measure Level Inputs

B.1 Overview of the MICS

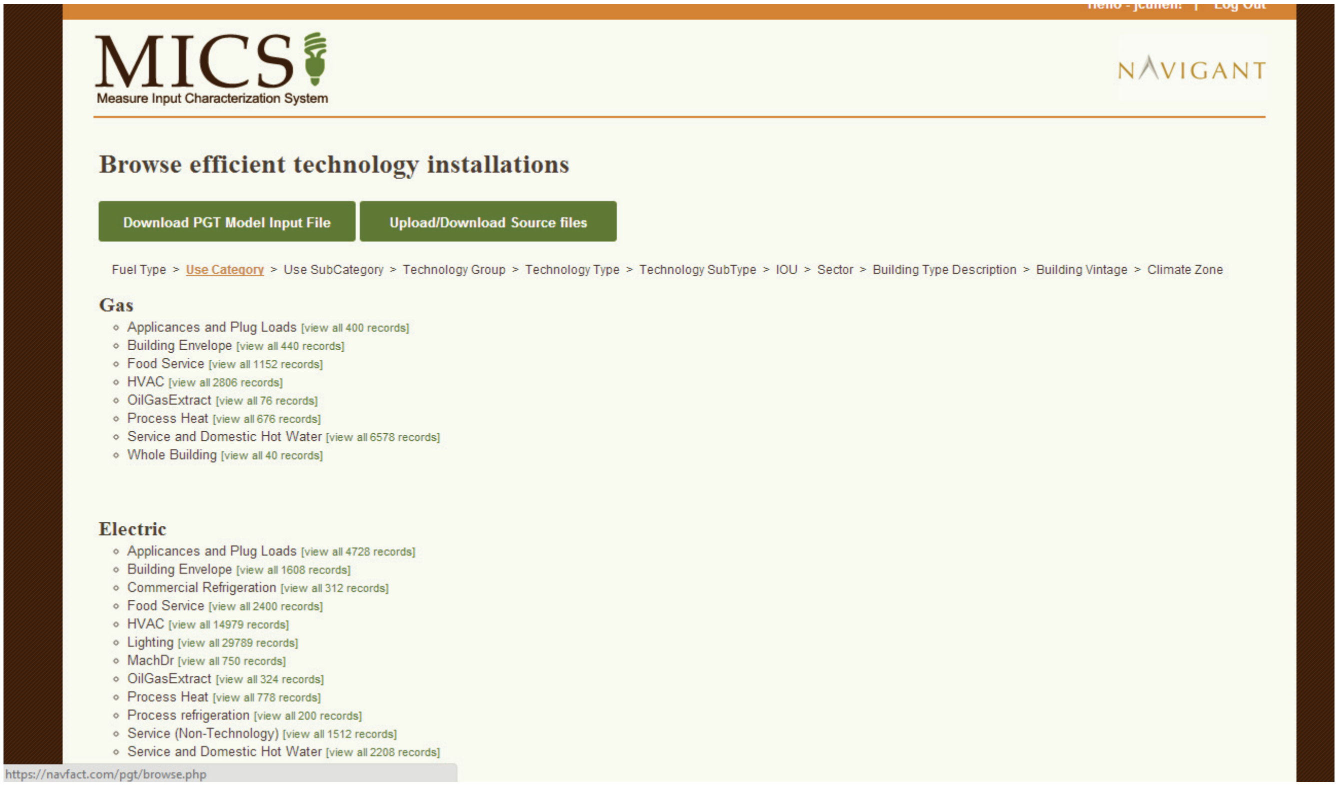
The Navigant team developed an online database, the Measure Input Characterization System (MICS), to house all of the measure-level inputs. Those inputs include base, efficient and code measure energy consumptions; densities; costs; and measure descriptions. The online database is designed to provide program planning inputs for utilities and be easily accessible for viewers to find specific inputs by utility, building type and climate zone. The website can be viewed at the following link: https://navfact.com/pgt/browse.php

This appendix outlines how to access the online MICS and navigate through the site (Sections B.1 and B.2), view measure specific details (Section B.2) and download that data (Section B.3). Details on the sources and types of inputs are discussed at length in the Technical Potential section of the main report.

B.2 Site Navigation

To begin using the MICS online site, a new user must follow the sign-up instructions to create a unique login and password. In addition to tracking usage and keeping the site secure, requiring a login is necessary to allow users to provide feedback on measure inputs. After the user has successfully logged in, the homepage provides access to all measures, organized by fuel type and use category. A listing across the top of the screen shows the hierarchy of how data is organized beyond fuel type and use category. Finally, there are links to download the PG Model Input File, and another link to upload or download source files. Figure B-1 shows a screen shot of the MICS homepage.

Figure B-1. MICS Website Homepage

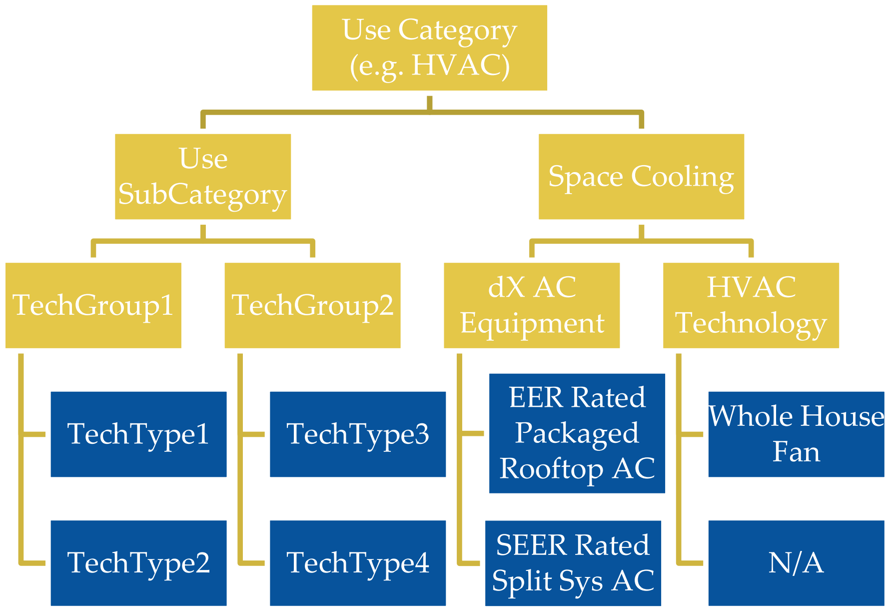


Source: MICS Online website, https://navfact.com/pgt/browse.php

Underneath the two green buttons, there is a line that includes the different categories and subcategories into which the measures are rolled up, beginning with the largest grouping (fuel type) and down to the climate zone level. The default homepage brings users to a split of gas and electric measures with the fuel type specific end use categories. At this point, the user can download the entire database (60,000+ line items in Microsoft Excel), download all of the measures in a use category, or continue to navigate further into the end use to get more specific results. Downloading data is explained in Section B.3.

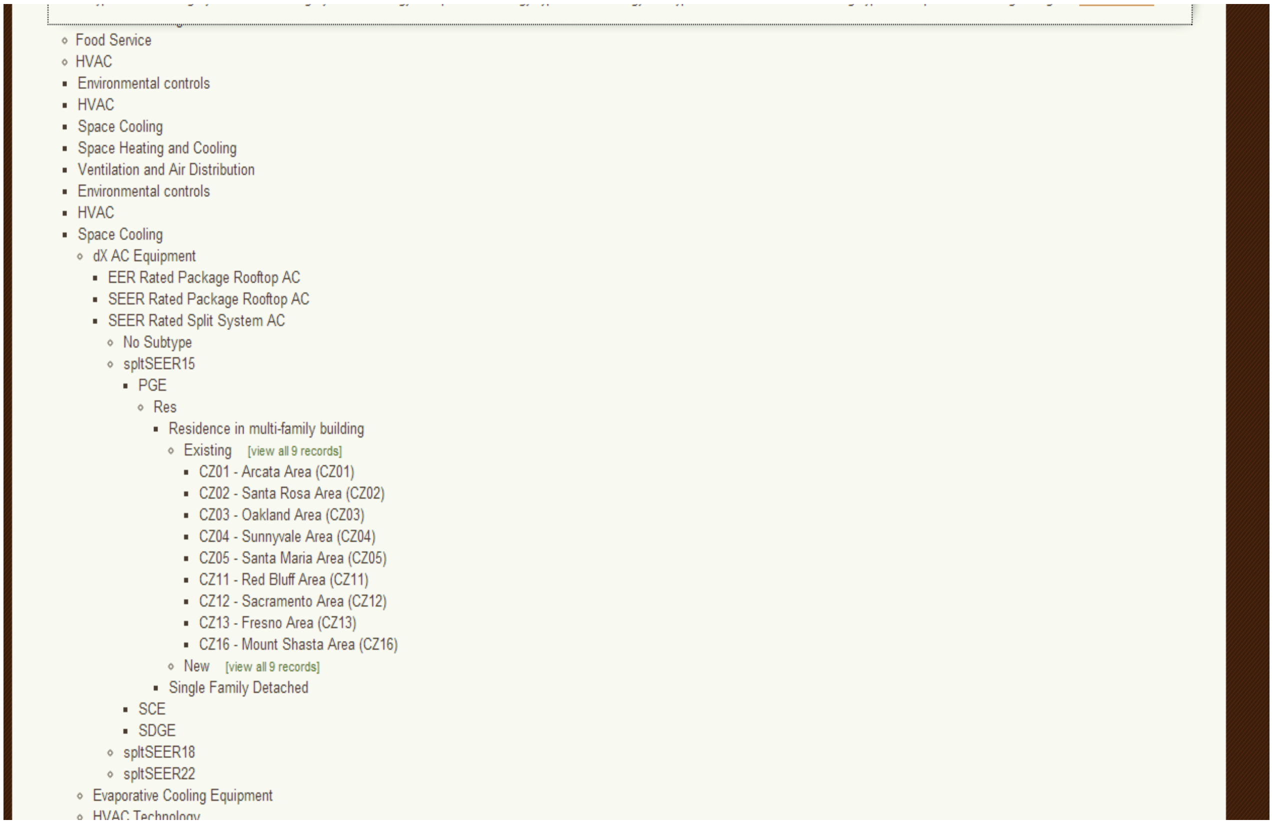
To continue to navigate further in the website, the viewer must first identify under which end-use category the measure will be listed. For example, if the user is looking for data on electric air conditioning units, they would scroll to end uses under the "electric" designation, find and click on the HVAC end use. This brings up the subcategory list, which for this example, brings up five different sub-categories. The user may then click on the space cooling use sub category, which brings up a list of technology groups. The user would then click on the appropriate technology group, which is the dX AC Equipment Technology Group in this example, bringing up another list of categories, known as technology types. These are otherwise known as an efficiency measures in this study.

Figure B-2. Illustration of the Measure Nomenclature



Although once the viewer has reached the technology type level, the measure list has been reached, more specific results are available. These additional breakouts begin by IOU, sector (residential, commercial or AIMS), building type/vintage and climate zone. Only the data that is available will appear. Measure data at the building type and climate zone levels is shown where appropriate. Figure B-3 shows what the user can expect to see after selecting all desired data through the nomenclature tree.

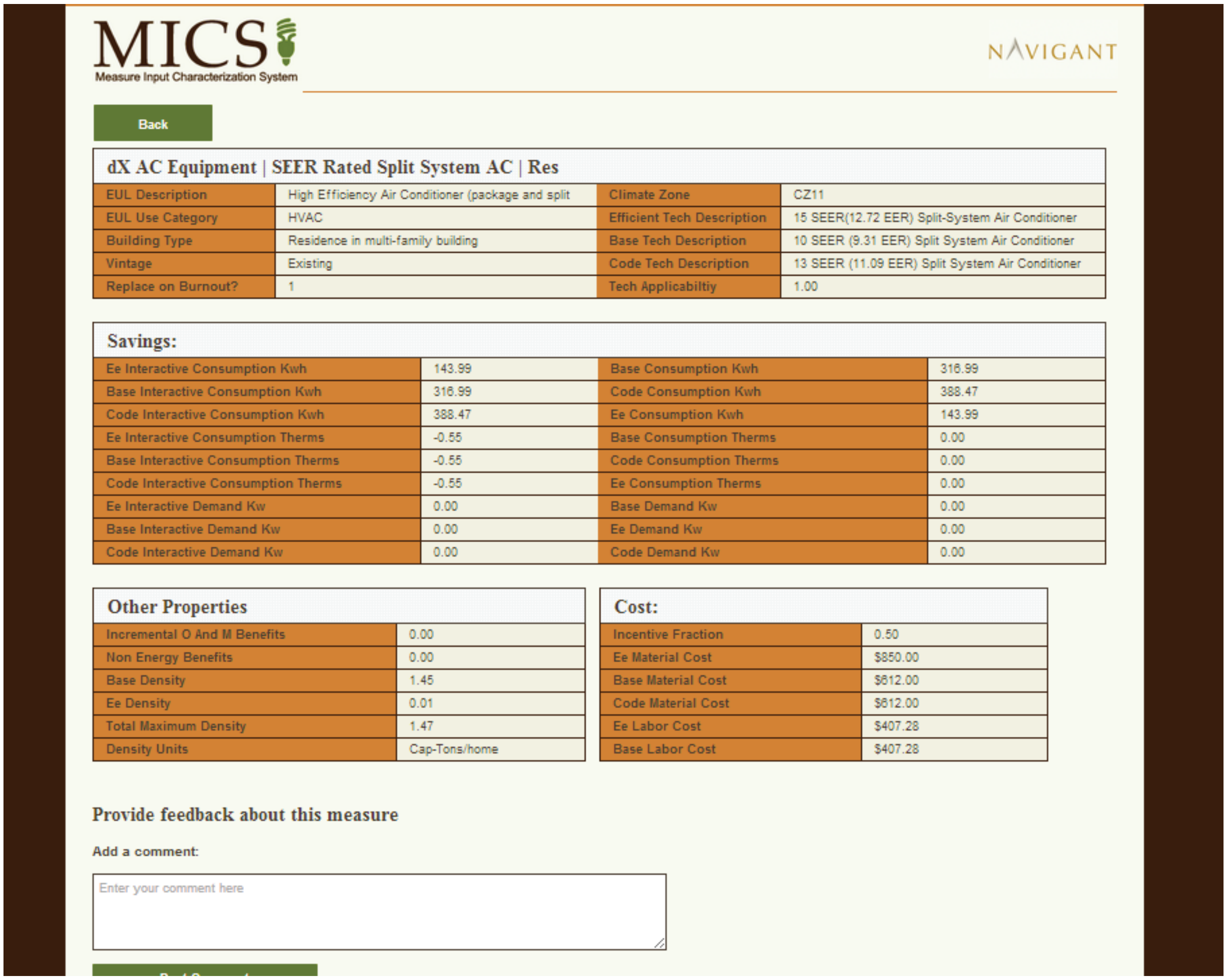
Figure B-3. MICS Website Screenshot – All Categories Open



Source: MICS Online website, https://navfact.com/pgt/browse.php

Once the user gets to the screen shown in Figure B-3, the user can click one of the climate zones, and the following screen will show measure-specific data for that measure in the specified IOU, sector, building type, vintage and climate zone, as show in Figure B-4. This page is also where users can provide feedback on the measure data, via the *comments* section. These comments can be viewed by all registered users.

Figure B-4. MICS Website – Measure Input Details Page



Source: MICS Online website, https://navfact.com/pgt/browse.php

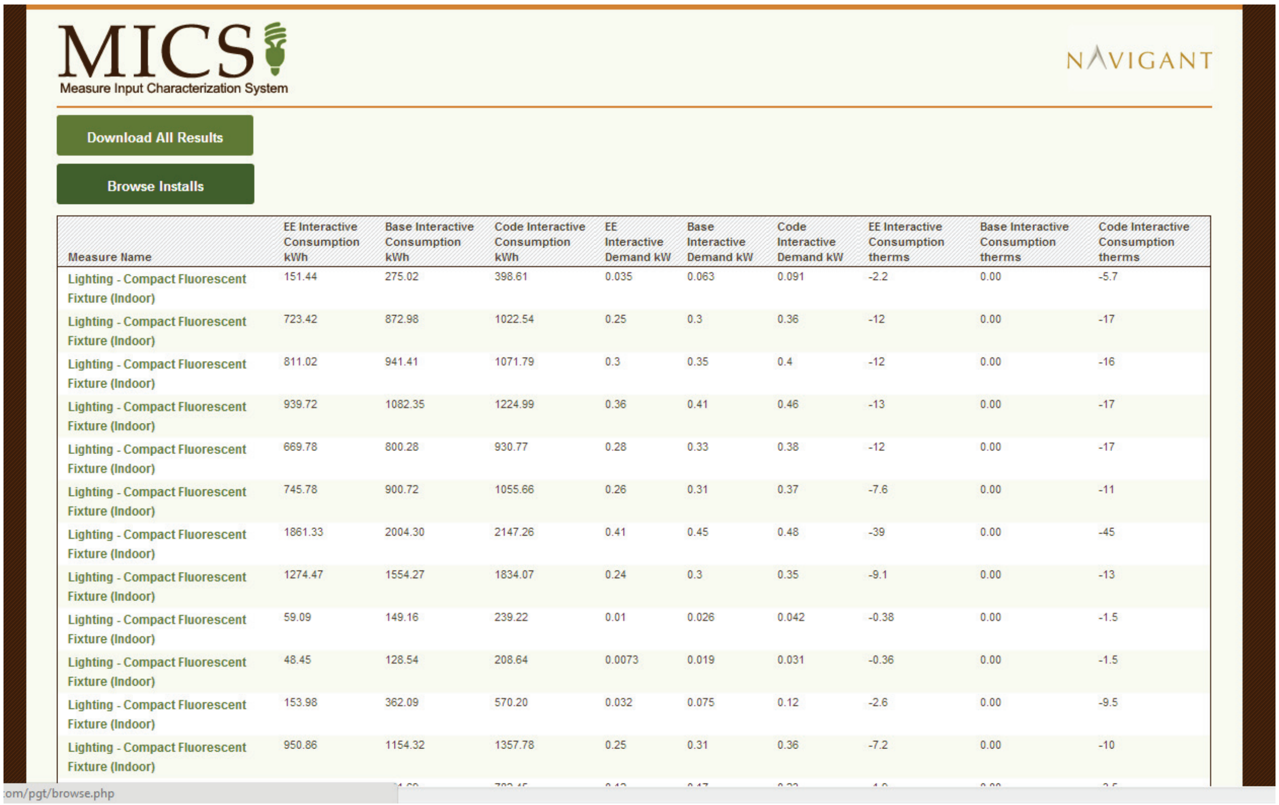
At any point during the navigation process, the user will see an option next to the categories that says "view all xxxxx records," where xxxxx is a number of records. This feature allows users to see all inputs of different measures side by side in different categories, by clicking on any category or grouping of measures. The number of records available decreases as the navigation progresses to greater levels of granularity.

B.3 Downloading Measure Inputs

The full database of all measure inputs can be downloaded into a comma separated value (.csv) file at the homepage screen using the green icon on the top in Figure B-1. When downloaded, this file contains about 60,000 line items in Excel.

As the user navigates through the data hierarchy, groups of results can be downloaded at any level. To complete a more customized download, the user must click on the link next to whichever category they wish to download that says "view all xxxxx records." This brings up a page with the grouped measures and allows for a group download. The icon to download is on the top left of this page, as shown in Figure B-5.

Figure B-5. MICS Website – Group Download Page



Measure Name	EE Interactive Consumption kWh	Base Interactive Consumption kWh	Code Interactive Consumption kWh	EE Interactive Demand kW	Base Interactive Demand kW	Code Interactive Demand kW	EE Interactive Consumption therms	Base Interactive Consumption therms	Code Interactive Consumption therms
Lighting - Compact Fluorescent Fixture (Indoor)	151.44	275.02	398.61	0.035	0.063	0.091	-2.2	0.00	-5.7
Lighting - Compact Fluorescent Fixture (Indoor)	723.42	872.98	1022.54	0.25	0.3	0.36	-12	0.00	-17
Lighting - Compact Fluorescent Fixture (Indoor)	811.02	941.41	1071.79	0.3	0.35	0.4	-12	0.00	-16
Lighting - Compact Fluorescent Fixture (Indoor)	939.72	1082.35	1224.99	0.36	0.41	0.46	-13	0.00	-17
Lighting - Compact Fluorescent Fixture (Indoor)	669.78	800.28	930.77	0.28	0.33	0.38	-12	0.00	-17
Lighting - Compact Fluorescent Fixture (Indoor)	745.78	900.72	1055.66	0.26	0.31	0.37	-7.6	0.00	-11
Lighting - Compact Fluorescent Fixture (Indoor)	1861.33	2004.30	2147.26	0.41	0.45	0.48	-39	0.00	-45
Lighting - Compact Fluorescent Fixture (Indoor)	1274.47	1554.27	1834.07	0.24	0.3	0.35	-9.1	0.00	-13
Lighting - Compact Fluorescent Fixture (Indoor)	59.09	149.16	239.22	0.01	0.026	0.042	-0.38	0.00	-1.5
Lighting - Compact Fluorescent Fixture (Indoor)	48.45	128.54	208.64	0.0073	0.019	0.031	-0.36	0.00	-1.5
Lighting - Compact Fluorescent Fixture (Indoor)	153.98	362.09	570.20	0.032	0.075	0.12	-2.6	0.00	-9.5
Lighting - Compact Fluorescent Fixture (Indoor)	950.86	1154.32	1357.78	0.25	0.31	0.36	-7.2	0.00	-10

Source: MICS Online website, https://navfact.com/pgt/browse.php

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Appendix C Analysis of Legislative Initiatives

The Navigant Consulting, Inc. (Navigant) team evaluated the targeted energy savings from eight major legislative initiatives at the federal and state levels in order to identify the associated goals and targets driven by these initiatives between 2013 and 2024. The initiatives were chosen because they are among the most prominent energy efficiency initiatives expected to influence the potentials and goals to be set by the California Public Utilities Commission (CPUC) for the investor-owned utilities (IOUs). This research was initiated during the development of the 2011 Potential Study; this appendix contains information that was current as of January 2012. Findings in this analysis were used to inform the development of the potential study for the 2013 Potential and Goals Study.

The remainder of this appendix will describe the purpose of the analysis, the methodology, and the findings related to each legislative initiative's associated energy savings. Each initiative's section provides a basic description, identifies the technologies and measures potentially associated with the initiative, and describes the savings potential.

C.1 Purpose of This Analysis

The process of setting goals and targets is challenging, in part, because it is intertwined with the efforts of other agencies. The CPUC and the IOUs are not the only entities engaged in energy efficiency resource acquisition in California. In the years since the current CPUC/IOU energy savings goals were established, there have been numerous goals, initiatives, and programs put in place by other entities. These not only provide resources for energy efficiency that can complement or compete with the CPUC/IOU efforts but are based on differing sets of assumptions, baselines, and estimates of potential savings. This challenge is compounded by other factors that influence savings in California, such as federal initiatives and spillover from efforts in other states.

The purpose of this analysis is twofold:

1. To identify those legislative initiatives with the most potential to impact California savings estimates
2. To determine savings targets that those legislative initiatives can be expected to achieve between 2013 and 2024

By better understanding their savings potential and doing so in a consistent manner across all initiatives, the team will be able to assess their impact on the energy savings goals for the entire state and to recognize their contribution to or competition with CPUC/IOU energy savings.

C.2 Methodology

This section describes the approach to the legislative initiatives portion of this study. This entailed a thorough literature review followed by a series of interviews with experts on the various initiatives. A comparison of our approach to that applied by the previous study is also provided.

C.2.1 Overview of Approach

The objective of the legislative initiatives review was to collect relevant facts to inform and help establish energy savings associated with each of the identified initiatives. The team employed a two-step strategy to achieve the objective: literature review and expert interviews.

LITERATURE REVIEW

During the initial literature review step, the team aimed to accomplish the following:

- Gather basic descriptions of the legislative initiatives, including initiative scope, agencies in charge, applicable sectors, implementation schedules, and delivery mechanisms
- Identify the technologies involved
- Provide initial assessments on savings estimates, including data sources and calculation methodologies
- Describe the relationships between initiatives
- Identify expert and key personnel for the interviews

Most of the documents the team investigated during the literature review step came directly from the responsible agencies' websites. These agencies included the California Energy Commission (CEC), CPUC and the Air Resources Board (ARB). For codes and standards (C&S), the team relied on information provided by the statewide C&S program, on the team's involvement in recent statewide C&S development efforts, and the U.S. Department of Energy's (DOE's) website for the information. Facts and figures related to the American Recovery and Reinvestment Act of 2009 (ARRA) initiative were found on the dedicated ARRA website.[5] Sources of literature examined for each initiative are listed at the end of each findings section in the report.

Upon finishing the literature review, the team delivered a literature review summary report to document initial findings. That information is also included in this report. Information synthesized and presented in the summary report was then used to formulate questions and provide content for the next step: expert interviews.

EXPERT INTERVIEWS

The expert interviews were an important next step following the literature review. Experts and key personnel involved in the development or implementation of the initiatives are in unique positions and possess knowledge to accomplish the following:

- Confirm and clarify findings from the literature review
- Provide progress updates on current activities from the initiatives
- Estimate energy savings achieved and document their calculation methods and any tracking efforts

[5] http://www.recovery.gov/Pages/default.aspx

» Discuss/speculate on future plans that may generate energy savings

After the initial literature review, the team compiled a list of potential interview candidates and developed an expert interview template for all eight initiatives. The interview template contained questions in three basic categories: initiative scope, status, and quantification of energy savings. The interview template is included in Attachment A: Expert Interview .

Just as most literature review resources came from the responsible agencies, most interviewees identified were staff members who work on developing or implementing these initiatives at their respective agencies. The team conducted 12 expert interviews from various agencies; a list of the parties interviewed is included in Attachment B: Experts Interviewed. The team conducted most of the interviews over the phone.

C.2.2 Relationship between Current Approach and 2008 Approach

The most recent report to help inform CPUC establish energy efficiency savings goals was authored by Itron. For its 2008 report, Itron's team conducted research and performed analysis for 2012 and beyond.[6] The team used this report as a point of comparison to the current study approach in assessing the impacts of legislative initiatives on setting IOU energy efficiency goals. Itron's 2008 study considered four distinctive legislative initiatives. For each of these efforts, Itron's team formulated modeling assumptions and the associated savings inputs, based either on the actual initiative language or their interpretations of the established objective. The current goals and targets study includes analysis of all of these legislative initiatives.

Table C-1 includes a summary of the initiatives included and the approach that Itron used in its 2008 study to estimate energy savings.

[6] Itron, Inc., *Assistance in Updating the Energy Efficiency Savings Goals for 2012 and Beyond*, prepared for the CPUC Energy Division (ED), March 2007.

Table C-1. Summary of the 2008 Goals Study's Coverage of and Approach to Analyzing Codes and Standards

Codes and Standards Components (categorized by Itron's 2008 study)	Approach to Estimating Energy Savings	
	Itron 2008	Current Approach
AB1109 (Huffman Bill)	Translated the "percentage-better" goals into UEC and EUI reduction goals for residential and nonresidential lighting sectors; modeled the savings as the phase-out of the general service CFLs from IOU program portfolios over the 2011-2015 period	Account for associated savings under general C&S efforts, since C&S programs are the main delivery mechanism, as explained in more detail in the 2011 Potential Study
Strengthening of Title 24	Used the 2008 Title 24 as the baseline and modeled the effort as the phase-out of the IOU new construction programs after effective date (typically one year after adoption)	Tap the statewide C&S program experience to model energy savings levels beyond the assumption of phasing out of the IOU new construction programs
IOU Code Compliance programs	Utilized the Title 24 noncompliance rates, the share of program-eligible savings potential captured through code compliance programs, and annual residential new construction rates	Consider compliance rate improvement scenarios of building and appliance standards through C&S programs
Federal Appliance Standards	Assumed a 100% market penetration in the annual replacement-on-burnout market starting in the first year of implementation through the end of the forecast period	Use the same approach based on identifying major changes planned in the coming years. The analysis in this current proposal will also include savings from California's Title 20.

Note: The current goals and targets study includes analysis of all referenced legislative initiatives.
Source of Itron 2008 column: Itron, Inc., *Assistance in Updating the Energy Efficiency Savings Goals for 2012 and Beyond*, prepared for the CPUC Energy Division, March 2007.

Our current study approach is similar to that established in Itron's 2008 study. This study once again examines all four of the legislative initiatives included in the 2008 Goals Study. In addition, the team expanded the range to consider five additional initiatives:

- Wide-reaching Initiatives
    - AB 32 (California Global Warming Solutions Act)
    - AB 758 (Comprehensive Energy Efficiency Program for Existing Buildings)

- Technology- or Topic-Specific Initiatives
    - AB 1103 (Commercial Building Energy Use Disclosure Program)
    - AB 2404 (Water Efficiency Program)
    - ARRA efforts

For several reasons, this initial review covers more legislative initiatives than did the 2008 Goals Study. First, a new set of relevant legislative initiatives has been passed since the 2008 study. In addition, more definition now exists for AB 32. Energy savings and other market effects from AB 32 were purposely not included in the 2008 study because the effect of the envisioned greenhouse gas (GHG) emission cap-and-trade mechanism was unclear. This study provides a review of its scope and energy savings implications, details of which are provided in section C.2.5.

C.2.3 Findings

This section details each legislative initiative explored, the technologies or measures contained in the scope of the initiative, and the resulting estimated energy savings during the time frame of the study (2013-2024). Legislative initiatives are ordered according to potential energy efficiency impact.

C.2.4 Codes and Standards

Codes and standards serve as a minimum requirement for the energy saving expected in any individual IOU service territory. This section identifies the various types of codes and standards requirements, describes their energy savings goals, and explains their differences and prospective update schedules. This section is organized starting with the legislative initiatives that are anticipated to have the greatest impact on energy savings during the 2013-2024 period.

BASIC DESCRIPTION

Energy efficiency codes and standards are promulgated by governmental entities, and have the force of law (through the building permitting and inspection processes). Federal, state, and local governmental C&S apply to all targeted market sectors and products, as opposed to voluntary energy efficiency programs. Standards established by nongovernmental entities are voluntarily adopted by individual entities or local governments; these were not included in this report because they do not have the force of law.

Energy savings associated with governmental C&S are relatively predictable, depending on the specific C&S requirements, market baselines, and compliance rates. Governmental C&S are used as baselines for assessing energy savings from relevant utility incentive programs.[7] IOU C&S programs only claim energy savings from enforced governmental C&S for which they were a significant force in adoption, even though they also support the development of other voluntary standards.

[7] C&S baselines are actually "convenience" baselines used for deemed savings estimates, program planning, and other purposes. When full-scale impact evaluations are done, the true baseline—conventional practice or "what would have been done"— is estimated. This true baseline may be better or worse than the C&S baseline.

Applicable sector: residential and commercial buildings[8] and appliances

Vintage: New and existing[9] buildings

Subsector segments likely impacted: All

End uses affected: All

Start date: California and federal energy efficiency standards have been established since the 1970s. IOU C&S programs have claimed energy savings since 2006.

Implementation path/time line: Addressed for each C&S type

Savings goals and associated key date: Addressed for each C&S type

Delivery mechanism: Addressed below for each C&S type

Secondary delivery mechanisms: None

INITIATIVES TECHNOLOGIES/MEASURES

In California, energy efficiency C&S include mandatory C&S enforced by governmental agencies.[10]

Federal Appliance Standards: Federal appliance standards are established through either DOE rulemaking processes or legislation. DOE sets these efficiency standards at levels to achieve maximum improvement in energy efficiency that is technically feasible and economically justified."[7] Manufacturers of the regulated residential and commercial product categories can only manufacture and sell products that meet the standards once the rules take effect. DOE rulemaking schedules are available from the DOE website.[11]

California Title 20 Appliance Standards (Title 20): Title 20 regulates the energy efficiency of different types of appliances and equipment sold or offered for sale in the state of California. This effort is analogous to DOE's federal appliance standards on the national level. However, Title 20 cannot impose requirements on appliances that are already regulated by federal standards.[12] Title 20 standards are adopted by the CEC according to its internal schedules. IOU C&S programs claim energy savings for

[8] Note that California's Title 24 Building Energy Efficiency Standards do not apply to certain building types, such as hospitals, prisons, and federal buildings.
[9] Note that energy code requirements for existing buildings are less comprehensive than those for new buildings, and only take effect when the existing buildings are being remodeled or renovated.
[10] Voluntary standards are listed and described in Attachment C: Summary of Voluntary Standards. Any savings associated with voluntary standards have not been included in this study.
[11] http://www1.eere.energy.gov/buildings/appliance_standards/
[12] United States Code, Title 42, 6297(a)-(c).

Title 20 standards adopted since 2005, where they contributed materially to the development and adoption of the standard.[13]

California Title 24 Part 6 Building Energy Code (Title 24): Title 24 regulates residential and nonresidential building energy efficiency, and includes mandatory and prescriptive requirements. Mandatory requirements must be installed in applicable buildings, while prescriptive requirements can be met by other alternatives as long as total building energy consumption is not increased. When alternative compliance methods are used, energy performance of the building needs to be verified. This is done by following the Title 24 performance method using compliance software tools. Title 24 is updated by the CEC approximately every three years. The 2005 and 2008 Title 24 are the two versions of Title 24 codes adopted by the last two code cycles.

IOU C&S programs claim energy savings for both these two versions of Title 24 because they contributed materially to the development and adoption of the code measure. The CEC is currently in the process of developing the next version, 2013 Title 24 (not 2011), with the assistance of IOU C&S programs.

California Green Building Standards Code, Title 24 Part 11 (CalGreen): The CalGreen Code was recently adopted by California's State Building Standards Commission (SBSC) and has been in effect since January 1, 2011. The energy efficiency requirements imposed by the CalGreen code include both a mandatory and a voluntary component. Compliance with the current Title 24 standards is mandatory; Tier 1 and Tier 2, defined by exceeding 2008 California energy code (Title 24 Part 6) requirements by 15% and 30%, respectively, are voluntary. The CEC is coordinating with the SBSC to develop reach code packages that can be used to meet the two tier requirements.

Local Green Building and Energy Efficiency Ordinances (Reach Codes): Local jurisdictions can adopt building energy standards that are more stringent than Title 24. Such local ordinances are required to be approved by the CEC based on supporting analysis that demonstrates energy savings and cost-effectiveness of the proposed standards. Under the authority of Section 10-106 Title 24, only those local ordinances that have been approved by the CEC are legally enforceable.

The team's current understanding from the CPUC's ED is that buildings in jurisdictions with local green building ordinances can still receive IOU incentives, and IOUs may still claim savings associated. Therefore, these reach codes do not affect IOU baselines and savings. To date, at least 14 jurisdictions have adopted local ordinances that have been approved by the CEC. The CEC plans to develop reach code packages to provide more unified solutions for local jurisdictions who want to adopt more stringent building standards than Title 24.

ENERGY SAVINGS ESTIMATE

[13] 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.

All existing federal appliance standards, California Title 24 codes, and Title 20 standards provide specific compliance methods, which are based on extensive feasibility and cost-effectiveness assessment prior to adoption. Requirements in some standards are based on an overall percentage improvement from baseline without specifying specific technology/measure options. Because of this, it is a challenge to predict which technologies or measures will be considered as the basis for standards to be adopted in the near future.

Energy savings estimates from codes and standards by governmental agencies are being developed as part of the work described in the Residential and Commercial Sector Methodology section of the main report.

SOURCES

2005 Title 24 Impact Study: http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/2003-07-11_400-03-014.PDF

2005 Title 24: http://www.energy.ca.gov/title24/rulemaking_archive.html

2008 Title 24 Impact Study: http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF

2008 Title 24: http://www.energy.ca.gov/title24/2008standards/rulemaking/index.html

2013 Title 24: http://www.energy.ca.gov/title24/2013standards/prerulemaking/notices/

Codes and Standards White Paper on Methods for Estimating Savings: http://www.cpuc.ca.gov/NR/rdonlyres/6E783BC7-3467-484E-AD2A-29EF4A50432B/0/Mahone_2005_CS_White_Paper_SavingsEstimatingSavings.pdf

Federal Appliance Standards: http://www1.eere.energy.gov/buildings/appliance_standards/

Final Evaluation Report, C&S Programs Impact Evaluation (for Program Years 2006-2008), prepared by KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc. for the California Investor Owned Utilities' Codes and Standards Program Evaluation, February 4, 2010.

Title 20 Appliance Standards: http://www.energy.ca.gov/appliances/

Title 24 (Part 6) Building Codes: http://www.energy.ca.gov/title24/

C.2.5 AB 32: California Global Warming Solutions Act of 2006

AB 32 requires all state agencies to develop GHG emission reduction plans. It gives the ARB the responsibility of monitoring GHG emissions to see if they comply with the plans and to penalize organizations whose GHG emissions do not comply with ARB-approved thresholds.

The AB 32 scoping plan savings estimates are based on savings from a variety of programs. These include renovations of state buildings, renovations of schools, renovations of existing buildings, savings from more stringent codes and standards, equipment upgrades, and combined heat and power (CHP). No single state agency oversees all these activities. The savings will mainly be achieved by the CPUC, CEC, and Department of Community Services and Development (CSD).

The AB 32 scoping plan published by the ARB calls for energy efficiency measures leading to annual savings of 32,000 gigawatt-hours (GWh) of electricity and 800 million therms of gas. These savings were expected to reduce GHG emissions by 19.5 million metric tons (MMT) carbon dioxide equivalents (CO_2E). In addition, the scoping plan calls for installation of 4,000 megawatts (MW) of CHP, which is projected to save 30,000 GWh of electricity and 6.7 MMT CO_2E. According to the 2008 AB 32 scoping plan, total savings from energy efficiency and combined heat and power was expected to reduce carbon emissions by 26.3 MMT CO_2E. However, the economic downturn has forced the ARB to revise these savings downwards and the new goals are not available as of this writing in late October 2011.

BASIC DESCRIPTION

AB 32 is a directive requiring a reduction in California's GHG emissions to 1990 levels by December 31, 2020. AB 32 required the California ARB to establish the 1990 level of GHG emissions.[14] AB 32 directs ARB to adopt rules and regulations to achieve the maximum cost-effective and technically feasible reductions.

AB 32 also requires all state agencies to create GHG emission reduction plans. AB 32 does not give ARB jurisdiction over other agencies' plans, but it requires ARB to track emissions and monitor progress towards meeting AB 32. AB 32 also provides the ARB the authority to issue criminal penalties for organizations that emit GHGs in excess of their permitted maximum.

AB 32 does not give any new authority to the CEC or CPUC. AB 32 requires the CEC and CPUC, like all state agencies, to develop GHC emission reduction plans. AB 32 directs ARB to consult with the CPUC to ensure there is no overlap or conflicting requirements between the CPUC and ARB regulations. Staff from ARB, CPUC, and CEC coordinated to ensure that their AB 32 implementation plans are consistent with each other.[15] Interagency meetings have ensured, to the degree possible, that the ARB is correctly accounting for savings that should occur as a results of CEC and CPUC plans.

ARB's mandate under AB 32 is written almost identically to the Warren-Alquist Act[16], in that it requires measures to be technically feasible and cost-effective; however, ARB may be able to exercise its authority in areas in which energy efficiency is not currently regulated (e.g., over publicly owned utilities).

[14] In December 2007, the ARB established the 1990 level of emissions at 427 $MMTCO_2E$ of greenhouse gases.

[15] Dana Papke interview, California Air Resources Board, Air Pollution Specialist, September 29, 2011.

Applicable sector: All

Vintage: New and existing buildings

Subsector segments likely impacted: All building types, via one of two methods:

- Supply side:

  AB32 authorized ARB to create a cap-and-trade system. This system is expected to reduce emissions by 35 MMT of CO_2E per year, a major component of the total required reduction of 174 MMT. Only large site-specific generation (which emits at least 25,000 metric tons CO_2E per year) will be regulated from 2012 through 2015. Starting January 1, 2015, all site-specific generated power will be regulated in the cap-and-trade market. Facilities emitting less than 25,000 MMT CO_2E will be indirectly regulated through their fuel supplier.[17] Thus, large CHP systems will be governed by cap-and-trade starting in 2012, and all CHP systems will be accounted for in the cap-and-trade market after 2015.

  End users/uses affected: Cap-and-trade may directly affect all gas and electric utility consumers because of the costs associated with the utilities' participation in the cap-and-trade system. Utilities will likely seek to pass these cost increases to consumers through rate changes. A rulemaking proceeding began March 30, 2011, to address this and other issues (CPUC, 2011). Residential consumers who stay within Tier I and II rates are currently shielded from these changes by statute. However, large residential, commercial, and industrial customers will be paying higher rates as a result of cap-and-trade regulations.[18]

- Demand side:

  The cap-and-trade system will directly regulate the carbon emissions of large cogeneration systems (e.g., those supplying city buildings and campuses).

  CPUC plans, partly written to comply with AB 32, will push the new construction market towards zero-net-energy (ZNE) buildings[19] and incentivize existing building efficiency programs administered by the IOUs. Many of these programs predate AB 32. However, expected savings from these programs are included in AB 32 savings estimates.

  CEC is also responsible for increasing savings from existing buildings under AB 758. Additional details can be found in Section C.2.7.

  AB 32 gives authority over GHG emissions from buildings to the ARB. The ARB does not have authority to change programs administered by other agencies to reduce GHG

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[16] California Energy Commission, Warren-Alquist State Energy Resources Conservation and Development Act, Document number CEC-140-2009-001-REV1, July 2009.

[17] Steven Cliff interview, California Air Resources Board, Chief of the GHG Market Development and Oversight Branch, September 27, 2011.

[18] Ibid.

[19] Dana Papke interview, California Air Resources Board, Air Pollution Specialist, September 29, 2011.

emissions. However, it does give the ARB authority to verify and enforce voluntary GHG emission reductions authorized by the ARB to comply with the GHG emissions limit.[20]

End users/uses affected: All electricity, natural gas, and propane users will be indirectly affected by the regulations.

Start date: Full regulations go into effect January 1, 2012.

Implementation path/time line:

» The "Approved Scoping Plan"[21] was adopted December 11, 2008. It explains how savings will be achieved from significant sources of GHGs via regulations, market mechanisms, and other actions.

» The "Scoping Plan Measures Implementation Timeline"[22] was published in October 2010. The document details changes in savings attributable to the economic downturn. However, it does not break them down between electricity and natural gas savings nor does it break them down by utility territory.

» In addition, early action measures took effect January 1, 2010, although none directly affect buildings.

» By January 1, 2012, the GHG rules and market mechanisms should take effect and become legally enforceable. The development of final cap-and-trade regulations is ongoing at this time. Final cap-and-trade regulations will go before the Air Resource Board for approval on October 20 and 21, 2011.[23] The cap-and-trade market will regulate large GHG emitters, and a cap will be in place. This cap will be reduced each year. As stated earlier, this may affect end users to the extent that IOUs pass on the costs of compliance with AB 32 to ratepayers.

Estimates for savings: Estimates for savings in the Scoping Plan are based on savings potential estimates published by the CEC and CPUC.

Savings goals and associated key date: By 2020, annual statewide emissions must be 174 MMT CO_2E less than 2007 emissions. According to the 2008 AB 32 Scoping plan, only 19.5 MMT CO_2E of the 174 MMT CO_2E emissions reductions is from electricity and gas efficiency measures, and 6.7 MMT CO_2E comes from increasing combined heat and power production by 30,000 GWh. Other unrelated measures such as transportation, forest management, and high-speed rail make up the remainder of savings. However, as previously mentioned, the economic downturn has forced the ARB to revise these savings downwards and new GWh and therms estimates are not currently available.

[20] *Assembly Bill 32, as signed by Governor Schwarzenegger.* Assembly Bill 32, Chapter 488, Sections 38500-38599 of the Health and Safety Code, September 27, 2006.
[21] *Climate Change Scoping Plan,* California Air Resources Board for the State of California, December 2008. http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf
[22] *Scoping Plan Measures Implementation Timeline, Air Resources Board of California, October 28, 2010.* http://www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf
[23] Steven Cliff interview, California Air Resources Board, Chief of the GHG Market Development and Oversight Branch, September 27, 2011.

Delivery mechanism: ARB in collaboration with all other state regulatory agencies

Secondary delivery mechanisms (if applicable): All major consumers and distributors of electricity or GHG-producing fuels

INITIATIVE TECHNOLOGIES/MEASURES

AB 32 addresses two areas applicable to this study: green building measures and combined heat and power. Each of these is addressed below.

Combined Heat and Power

Under AB 32, the ARB will regulate site-specific generation of power as part of the cap-and-trade market. In addition, combined heat and power provides efficiency improvements. The original scoping plan called for 30,000 GWh of combined heat and power to be installed, which will reduce emissions by 6.7 MMT CO_2E.

Heat from combined heat and power is generally used for industrial processes. As such, efficiency savings from combined heat and power probably fit more cleanly in the industrial sector under process loads. Therefore, no analysis of combined heat and power is presented here.

GREEN BUILDING MEASURES

The ARB's scoping plan states that new buildings must reach ZNE to achieve the stated savings. The California Energy Commission regulates building energy efficiency requirements. Therefore, CEC rulemaking would be required to mandate zero net energy across the entire building stock. However, this may not be possible due to the Warren-Alquist Act.[24] Under this act, the CEC can only require efficiency measures that are cost effective. Currently, insufficient cost-effective measures are available to reach zero net energy. The AB 32 scoping document recommends:

> *All new construction will need to comply with the California Green Building Standards Code. California should work with local jurisdictions to set and meet targets for new homes and commercial buildings to exceed the Green Building Standards Code[25].*

The ARB's scoping plan counts on energy savings in existing buildings because the amount of existing building stock far exceeds that of new construction. Savings from the existing building stock will be achieved by working with existing state programs. These include CPUC, CEC, CSD, and Property Assessed Clean Energy (PACE) Finance Districts:

» The CPUC authorizes IOUs to pay incentives for energy efficiency retrofits in existing buildings. Currently, the CPUC goal is to reduce energy use by 40% in single-family and multifamily buildings (*Existing Building Retrofits, Air Resources Board website)*. CPUC goals for commercial buildings were not specified.

[24] California Energy Commission, Warren-Alquist State Energy Resources Conservation and Development Act, Document number CEC-140-2009-001-REV1, July 2009.

[25] AB 32 Scoping Plan, Appendix C, page C-145.

- The CSD serves low-income households. Using $187 million of ARRA funding, CSD expects to provide energy efficiency retrofits in 43,000 low-income homes between 2009 and 2012. After ARRA ends in 2012, CSD funding is likely to return to its previous level of approximately $5 million per year. (Additional details on ARRA are presented in section C.2.9.)
- The CEC was directed to increase its energy efficiency efforts in existing buildings by AB 758. Development of these efforts is described below in section C.2.7.
- PACE districts were expected to provide funding for energy efficiency retrofits. According to the ARB:
  PACE districts were established in 2009 by AB 811, a law that provides cities and counties with the legal authority to designate geographic areas within which they will offer low interest loans to willing residential, commercial and industrial property owners to finance energy and water efficiency improvements and distributed renewable generation.

  At this time, PACE appears to be abandoned for the residential sector and is not expected to result in any savings in that sector. Rules from the Federal Housing Financing Authority (FHFA) directed Fannie Mae and Freddie Mac "to take punitive actions against homeowners who live in communities that participate in PACE financing programs."[26] This caused the CEC to cancel funding of PACE programs in 23 counties. Following the decision, Sonoma County sued FHFA. It appears FHFA may be forced to revisit the decision, and proponents of PACE hope for a reversal of the earlier decision.[27]

  A survey of websites revealed mixed results for commercial PACE programs in California. For example, the Berkeley First program is no longer taking new applicants. Sonoma County's PACE program is still active[28] and Sacramento just signed a contract with Ygrene Energy to begin a PACE program for commercial customers.[29]
- *Greening of new buildings - Green Building Code*:
  A greening of new buildings effort commenced with adoption of the green building code, which took effect in 2010. The ARB, along with other actors, is encouraging local jurisdictions to adopt reach codes. These codes include features such as CALGREEN, green ratings systems such as Leadership in Energy Efficiency and Design (LEED) and GreenPoint Rated, prescriptive requirements, and performance standards (typically requiring buildings to exceed Title 24 by at least 15%).
- *Greening of existing buildings* will be accomplished by multiple actors:
  The state is required to design new and renovate existing state-owned facilities to the LEED-Silver

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[26] *Energy Commission Acts to Protect and Expand Property-Assessed Clean Energy Financing Options Strongly Rejects FHFA Faulty Logic*, California Energy Commission, July 29, 2010.

[27] *Update on County of Sonoma vs. FHFA Litigation*, Sonoma County Energy press release, September 7, 2011. http://www.sonomacountyenergy.org/article.php?title=update-on-county-of-sonoma-vs-fhfa-litigation-2011-09-07

[28] *Sonoma County Energy Independence Program*, Accessed September 29, 2011, Sonoma County. http://www.sonomacountyenergy.org/

[29] *Carbon War Room-brokered consortium set to unlock multi- billion dollar global commercial property retrofit market*, Carbon War Room News & Analysis, Accessed September 28, 2011. http://news.carbonwarroom.com/?s=PACE&x=24&y=15

level (Executive Order S-20-04, signed December 2004 by Governor Schwarzenegger).
Savings from private buildings will be facilitated by several state organizations including the CPUC, CSD, CEC, and PACE Finance Districts. (Additional detail on the specific responsibilities of these agencies is included in the next section).

A transformation of building and maintenance practices will require changes in regulations and significant investment in energy-upgrade incentives offered to existing building owners. The CEC and CPUC have indicated they will provide funding through mechanisms at their disposal including directing utilities to run incentive programs, administering incentive programs in-house, and updating both the building and appliance energy performance standards.

The ARB may use the regulatory authority embodied in AB32 to force local governments to adopt reach codes or zero net energy building codes rather than Title 24, which is tied to cost-effectiveness tests used by the California Energy Commission. However, ARB staff declined to comment on the ARB's ability to compel any other governmental organization to alter its plans.[30]

Energy Savings Estimates

ARB savings estimates presented here are entirely based on programs run under the auspices of other state agencies, including codes and standards and those that are utility-sponsored. Consequently, these savings will not be attributed to AB 32 for the purposes of this goals and targets study. To convey the magnitude of savings AB 32 is relying on, we have included ARB's energy savings estimates as of early October 2011.

Carbon savings but not kilowatt-hours (kWh) or therms savings have been updated since the economic downturn. ARB staff is in the process of revising savings estimates based on the economic downturn as shown in Table C-2. Top-down results from the revision have reduced the quantity of GHG emissions that will be saved. However, equivalent electricity and natural gas savings are not yet available.

The original AB 32 scoping plan estimates energy efficiency measures will save 32,000 GWh of electricity and 800 million therms of gas (Table C-2). These savings were expected to reduce GHG emissions by 26 MMT CO_2E (Table C-2). With the economic downturn, both electricity and natural gas savings estimates declined. However, the ARB has not published any data describing how the declines will be split between electricity and natural gas measures.

[30] Dana Papke interview, California Air Resources Board, Air Pollution Specialist, September 29, 2011.

Table C-2. ARB's Expected Savings from Energy Efficiency in Buildings

Measure	Description	Original 2020 Reductions	Updated 2020 Estimates	Agency Responsible for Achieving	Included in Goals and Targets Modeling?
Energy Efficiency	Reduced Electricity Demand	15.2 MMT CO_2E[31] 32,000 GWh[32]	11.9 MMT CO2E[33] Split between GWh and therms is unknown (October 2011)	CEC, CPUC[31]	Yes
	Reduced Natural Gas Consumption	4.3 MMT CO_2E[31] 800 Million Therms[34]		CPUC, CEC[31]	Yes
Combined Heat and Power	Increase CHP Use to 4,000 MW	6.7 MMT CO_2E[35] 30,000 GWh[36]	4.8 MMT CO_2E[33]	CPUC, CEC[35]	No
Solar Water Heating	AB 1470 incentives (install 200,000 systems by 2017)	0.1 MMT CO_2E[37]	0.1 MMT CO_2E[33]	CPUC[37]	No
	Totals	26.3 MMT CO_2E	16.8 MMT CO_2E		

SOURCES

Anderson, Sharon. California Air Resources Board. AB 32 Manager. Phone interview, July 12, 2011.
Assembly Bill 32, as signed by Governor Schwarzenegger. Assembly Bill 32, Chapter 488, Sections 38500-38599 of the Health and Safety Code, September 27, 2006. http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf

California Green Building Strategy. California Air Resources Board, November 2, 2010. http://www.arb.ca.gov/cc/greenbuildings/greenbuildings.htm

[31] AB 32 Scoping Plan, Appendix C, Page C-117, Table 12.
[32] AB 32 Scoping Plan, Appendix C, Page C-99.
[33] Scoping Plan Measures Implementation Timeline
[34] AB 32 Scoping Plan, Appendix C, Page C-99.
[35] AB 32 Scoping Plan, Appendix C, Page C-126, Table 15.
[36] AB 32 Scoping Plan, Appendix C, Page C-122.
[37] AB 32 Scoping Plan, Appendix C, Page C-120, Table 13.

Carbon War Room-brokered consortium set to unlock multi- billion dollar global commercial property retrofit market. Carbon War Room News & Analysis, Accessed September 28, 2011. http://news.carbonwarroom.com/?s=PACE&x=24&y=15

Cliff, Steven, Ph. D. California Air Resources Board. Chief of the GHG Market Development and Oversight Branch. Phone interview, September 27, 2011.

Climate Change Scoping Plan Appendices Volume I: supporting documents and measure detail. California Air Resources Board for the State of California, December 2008. http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf

Climate Change Scoping Plan. California Air Resources Board for the State of California, December 2008. http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf

Energy Commission Acts to Protect and Expand Property-Assessed Clean Energy Financing Options Strongly Rejects FHFA Faulty Logic, California Energy Commission, July 29, 2010. http://www.energy.ca.gov/releases/2010_releases/2010-07-29_clean_energy_finanacing.html

Existing Building Retrofits, California Air Resources Board for the State of California, Accessed September 22, 2011. http://www.arb.ca.gov/cc/greenbuildings/retrofits.htm

Order Instituting Rulemaking to Address Utility Cost and Revenue Issues Associated with Greenhouse Gas Emissions, California Public Utilities Commission, March 30, 2011. http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/132932.pdf

Papke, Dana. California Air Resources Board. Air Pollution Specialist. Phone interview, September 23, 2011 and September 29, 2011.

Scoping Plan Measures Implementation Timeline. Air Resources Board of California, October 28, 2010. *http://www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf*

Sonoma County Energy Independence Program, Accessed September 29, 2011, Sonoma County. http://www.sonomacountyenergy.org/

State and Local Government Green Building Ordinances in California. Attorney General's Office, June 18, 2010. http://ag.ca.gov/globalwarming/pdf/green_building.pdf

Update on County of Sonoma vs. FHFA Litigation. Sonoma County Energy press release, September 7, 2011. http://www.sonomacountyenergy.org/article.php?title=update-on-county-of-sonoma-vs-fhfa-litigation-2011-09-07

C.2.6 AB 1109: Lighting Efficiency and Toxics Reduction Act (Huffman Bill)

AB 1109 directs the CEC to reduce residential lighting energy use by 50% and commercial/outdoor energy use by 25% by 2018. The CEC estimates that achieving the savings goals set out in AB 1109 would result in an 11% reduction in residential electricity consumption and an 8.6% reduction in commercial electricity consumption. Because energy savings from AB 1109 are expected to be achieved through codes and standards, these savings have been calculated as part of codes and standards savings as reported in the main report.

Basic Description

AB 1109 is a directive addressing lighting energy use, and toxic material content in lighting products:

» The legislation directs the CEC to develop efficiency and appliance standards in order to reduce residential lighting energy use by 50% and commercial/outdoor lighting energy use by 25% by 2018.

» To address the levels of toxic materials such as mercury and lead found in some lighting products, the legislation requires all lighting products sold in California to adhere to the limits established in the European Union's Restriction of Hazardous Substances (RoHS) directive, and it directs the Department of Toxic Substances Control to convene a task force to examine and make recommendations on issues surrounding end-of-life lamp collection and recycling.[38]

Applicable sector: Residential and commercial

Vintage: New and existing buildings

Subsector segments likely impacted: All building types

End uses affected: Lighting

Start date: 2008

Implementation path/time line: The legislation went into effect in 2008, with toxic materials restrictions phasing in from January 1, 2010, through January 1, 2014. Building and appliance standards are expected to be updated regularly in order to meet the savings targets by the 2018 deadline.

Savings goals and associated key date: 50% residential lighting energy savings and 25% commercial/outdoor lighting energy savings by 2018

Delivery mechanism: The CEC is tasked with revising energy and appliance standards to meet the energy savings targets set out in the bill. Utilities are also encouraged to provide programs that help meet the savings targets, but no specific goals or mandates are established. Federal rulemaking may also impact the energy savings targets.
Secondary delivery mechanisms: None

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[38] No additional discussion of the toxics and recycling components of the legislation will be included because these portions are not directly linked to energy savings.

INITIATIVES TECHNOLOGIES/MEASURES

The CEC was tasked with adopting minimum efficiency standards for general purpose lights by December 31, 2008. In response, the CEC adopted new appliance standards for screw-base general service lamps, portable luminaires, and metal halide luminaires on December 3, 2008, as part of the regular Title 20 update process.

In addition to these standards, lighting savings targets for residential and commercial buildings will be achieved through building energy efficiency standards (Title 24) and utility programs. The bill does not prescribe how savings targets must be met. The energy savings estimation process used by the IOUs in the Codes and Standards Enhancement (CASE) initiatives will provide a useful basis for estimating and "widgetizing" the potential savings of various efficiency and appliance standards.

Separately, the bill requires the state Department of General Services and all other state agencies to cease purchasing general purpose lighting that does not meet the established standards within two years of their adoption.

ENERGY SAVINGS ESTIMATES

The CEC is in the process of determining the appropriate 2007 lighting energy use baseline that will be used to determine the amount of savings required to meet the goals outlined in AB 1109.[39] While the CEC has not established a baseline for the energy savings goals, the 2011 Potential Study and the main body of the 2013 Potential and Goals Study have established a 2007 energy use baseline that may provide insight into the savings targets established by AB1109.

Although the CEC has yet to establish an official baseline for the energy use targets, they have estimated that achieving the goals established in AB 1109 would result in an 11% reduction in residential electricity use, and an 8.6% reduction in commercial electricity use. Overall, the CEC estimates that statewide electricity consumption would be reduced by 6.75 percent if the energy-saving targets of AB 1109 are met.

Any changes to the federal standards should not have an effect on the savings estimates provided here that are associated with AB 1109.[40] Because the federal standards were adopted into Title 20 in 2008, California will continue to enforce the federal lamp standards even if the U.S. Department of Energy does not have the funding to enforce them nationally.

SOURCES

AB 1109 (Huffman) Lighting Efficiency & Toxics Reduction Act. Californians Against Waste. http://www.cawrecycles.org/issues/current_legislation/ab1109_07

[39] Ken Rider, Electrical Engineer, Appliances and Process Energy Office, CEC, telephone interview, August 25, 2011.
[40] Ken Rider, Electrical Engineer, Appliances and Process Energy Office, CEC, telephone interview, December 19, 2011.

AB 1109: Lighting Task Force Report. Recommendations for Collection and Recycling of Spent Fluorescent Bulbs in California, AB 1109 – Lighting Efficiency and Toxics Reduction Act Task Force Report. Department of Toxic Substances Control and California Environmental Protection Agency Integrated Waste Management Board, September 1, 2008. http://www.dtsc.ca.gov/HazardousWaste/UniversalWaste/upload/ab1109_final.pdf

Assembly Bill 1109 language, as approved by Governor Schwarzenegger. Assembly Bill 1109, Chapter 534. Section 25210.9 of the Health and Safety Code, and Section 25402.5.4 of the Public Resources Code, October 12, 2007. http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1101-1150/ab_1109_bill_20071012_chaptered.pdf

Brook M., B. Chrisman, P. David, T. Ealey, D. Eden, K. Moore, K. Rider, P. Strait, G. D. Taylor, and J. Wu. July 2011. *Draft Staff Report: Achieving Energy Savings in California Buildings (11-IEP-1F)*. California Energy Commission, Efficiency and Renewables Division. Publication number: CEC-400-2011-007-SD.

Bui, Teresa. Californians Against Waste. Telephone Interview, August 24, 2011.

Rider, Ken. California Energy Commission. Telephone Interview, August 25, 2011.

RoHS Compliance in the EU. http://www.rohs.eu/english/index.html

What is RoHS. http://www.bis.gov.uk/nmo/enforcement/rohs-home

C.2.7 AB 758: Comprehensive Energy Efficiency Program for Existing Buildings

AB 758 requires the CEC to develop and implement a comprehensive program to achieve greater energy savings in existing residential and nonresidential buildings through energy assessments, benchmarking, building energy use ratings and labels, energy efficiency financing, public outreach and education, green workforce training, and more.

There are no energy savings goals associated with AB 758 that fall within the scope and time frame of this study, nor are there current plans to track any savings accomplishments in the future.[41] While there are a number of programs that are expected to produce energy savings, they are all either funded by ARRA (which expire prior to the scope of this study), are accounted for elsewhere, or are not yet developed enough to allow for savings estimates.

Basic Description

AB 758 is a directive requiring the California Energy Commission to develop and implement a comprehensive program to achieve greater energy savings in existing residential and nonresidential buildings. Proposed program strategies[42] include the following:

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[41] Interview with Justin Regnier, California Energy Commission, August 24, 2011.

[42] AB 758 Statute Summary, CEC website: www.energy.ca.gov/ab758/documents/AB-758_Statute_Summary.pdf

- Energy assessments
- Building benchmarking
- Building energy use ratings and labels
- Cost-effective energy efficiency improvements
- Public- and private-sector energy efficiency financing
- Public outreach and education
- Green workforce training

The program will develop over three distinct and overlapping phases, including development of the (1) infrastructure and implementation plan, (2) market key partnerships, and (3) statewide ratings and upgrade requirements. CEC will coordinate with the CPUC and representatives from key stakeholder groups in developing and implementing the program.

Applicable sector: Residential and commercial

Vintage: Existing buildings

Subsector segments likely impacted: All building types

End uses affected: All

Start date: The bill was approved by the governor and filed with the secretary of state on October 11, 2009; however, requirements written into the bill indicate that proceedings must be started by the CEC by March 1, 2010. The first documented workshop under the proceeding docket is dated September 28, 2010.

Implementation path/time line: There are three phases planned for the program. While an actual implementation date has not yet been disclosed, the ARRA-funded program piloting is currently occurring as part of Phase 1.

- Phase 1: Infrastructure Development & Implementation Plan (2010- 2012)
- Phase 2: Market Development & Partnerships (2012-2014)
- Phase 3: Statewide Rating &Upgrades Requirements (2014-2015 and beyond)

Savings goals and associated key date: There are no set numerical savings goals, just "… to achieve greater energy savings in California's existing residential and nonresidential building stock."[43]

Delivery mechanism: Programs developed by the CEC for AB 758 will be comprised of a complementary portfolio of techniques, applications, and practices.[44] This remains largely undefined at this point. Phase

[43] AB 758(1): http://www.energy.ca.gov/ab758/documents/ab_758_bill_20091011_chaptered.pdf

3 seems to imply that the CEC could potentially establish requirements for mandating retrofit upgrades. CEC staff explained that while both residential and nonresidential ratings and upgrades may be required, the end requirement and delivery mechanism remain largely undefined at this point.

Secondary delivery mechanisms: N/A

INITIATIVES TECHNOLOGIES/MEASURES

AB 758 programs could use any and all technologies available currently or in the future to upgrade existing residential or commercial buildings. The purpose of AB 758 is to develop and implement a comprehensive program to achieve greater energy savings in existing residential and nonresidential buildings. As previously described, proposed program strategies include energy assessments, building benchmarking, building energy use ratings and labels, cost-effective energy efficiency improvements, public- and private-sector energy efficiency financing, public outreach and education, and green workforce training.

CEC will rely on CPUC/IOU programs to integrate these measures and technologies.[45] However, the CEC and their contractors are not far enough along in their pilots and scoping to have a definitive plan for their role within programs. It is evident, though, that this range of possible programs incorporates a wide variety of measures and technologies, from lighting upgrades to heating, ventilating, and air conditioning (HVAC) replacements to whole-building performance improvements.

ENERGY SAVINGS ESTIMATES

There are no energy savings goals associated with AB 758 that fall within the scope and time frame of this study, nor current plans to track any savings accomplishments in the future.[46]

Phase 1 of the comprehensive program consists of the efforts listed below. The "**X**" sign denotes efforts with no direct energy savings estimate associated, and the "**√**" sign denotes efforts where savings are accounted for elsewhere already (ARRA and AB 1103).

- ARRA-funded pilot programs: All but the PACE have established energy savings goals.
    - **√** Comprehensive Residential Retrofit Programs
    - **√** Commercial/Municipal Targeted Measures Retrofit Programs
    - **√** Energy Upgrade California Contract (Local Government Commission)
    - **X** PACE Financing Pilots

X HERS II Program Integration

- **X** Commercial Building Energy Asset Rating Systems (BEARS) Development

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[44] AB 758, Section 25943(a)(1) of the Public Resources Code: http://www.energy.ca.gov/ab758/documents/ab_758_bill_20091011_chaptered.pdf
[45] Interview with Justin Regnier, California Energy Commission, August 24, 2011.
[46] Interview with Justin Regnier, California Energy Commission, August 24, 2011.

» **X** Clean Energy Workforce Training (CEWT) Program

» **√** AB 1103 Commercial Building Energy Use Disclosure Regulations – see Section 0.

The residential, commercial/municipal retrofit programs and Energy Upgrade California contracts under Phase I activities all are expected to produce energy savings.[47] However, as further described in the Stimulus/ARRA section, funding for ARRA-related activities and programs will expire at the end of 2012, outside the scope of this study. The CEC's AB758 scoping paper previously stated the possibility of "seeking approval to use [Energy Resources Programs Account] ERPA funds" to continue the ongoing development and implementation of the pilot programs. CEC staff indicated that they have made no further progress in securing those funds for this effort.[48] Thus, savings associated with those programs are not accounted for in this study.

The direction and content in Phases 2 and 3 are highly dependent on the progress made and lessons learned in Phase 1, which is not finalized at this point. CEC is in the process of coordinating with its contractors to provide technical support on developing the Implementation Plan.[49] The CEC is focused on determining the deliverables of the contract, the main scope of which is energy assessment. Because the CEC is still in the process of developing the programs included in Phases 2 and 3, insufficient information exists to determine potential energy savings that could be associated with them.

SOURCES

AB 758 Program Update, website hosted by CEC, last accessed July 14, 2011.
http://www.energy.ca.gov/ab758/

Assembly Bill 758 language, as approved by Governor Schwarzenegger. Assembly Bill 758, Chapter 470, adding Section 25943 to the Public Resources Code, and adding Sections 381.2 and 385.2 to the Public Utilities Code, relating to energy, October 11, 2010.
http://www.energy.ca.gov/ab758/documents/ab_758_bill_20091011_chaptered.pdf
Regnier, Justin. California Energy Commission. Telephone interview, August 24, 2011.

C.2.8 AB 1103: Commercial Building Energy Use Disclosure Program

AB 1103 requires all commercial building owners to disclose their energy use data for the most recent 12 months to the other party in a transaction in which an entire building is sold, leased, or financed. At this time, we are unable to associate any potential savings goals with this initiative. Currently, the CEC has no savings goals associated with AB 1103 or their enabling regulations and no way of quantifying potential savings from the initiative. Aside from the difficulty in actually determining savings associated with benchmarking, there's the complication of attempting to associate energy savings to AB 1103 specifically because it has yet to be implemented.

[47] Projected electricity, gas savings and GHG emission reduction associated with each of the pilot programs are available from CEC's website at http://www.energy.ca.gov/ab758/pilot-programs.html. Accessed September 2011.
[48] Interview with Justin Regnier. California Energy Commission. 24 Aug. 2011.
[49] Interview with Justin Regnier. California Energy Commission. 24 Aug. 2011.

Basic Description

AB 1103 is a directive requiring all commercial building owners to disclose their energy use data for the most recent 12 months to the other party in the transaction when an entire building is sold, leased, or financed using the U.S. Environmental Protection Agency's (EPA's) Portfolio Manager benchmarking tool. Current guidelines state that the building owner must disclose the required data to a prospective buyer, lessee, or lender as soon as practicable before execution of the sales contract, lease, or submittal of the loan application. They also require all utilities in California to store this data in a manner compatible with Portfolio Manager and to upload it to the tool at the request of the building owner.

Applicable sector: Commercial

Vintage: Existing buildings

Subsector segments likely impacted: All nonresidential buildings

End uses affected: While AB 1103 does not directly affect any end uses, if a building owner were to use the data disclosed under the initiative to improve his/her building, or if the initiative motivated the building owner to improve the energy efficiency of the building, any end use could be affected, including indoor lighting, outdoor lighting, refrigeration, HVAC, process, plug loads, food service, building envelope, water heating, laundry, and appliances.

Start date: July 1, 2012[50]
Implementation path/time line: A building owner must disclose their most recent 12 months of energy data to the other party in a transaction for all nonresidential buildings according to the following time line:

» As of July 1, 2012 - total floor space of at least 50,000 square feet

» As of January 1, 2013 - total floor space of at least 10,000 square feet

» As of July 1, 2013 - total floor space of at least 5,000 square feet

Savings goals and associated key date: None specified

Delivery mechanism: California Energy Commission, California utilities, EPA Portfolio Manager

Secondary delivery mechanisms (if applicable): Nonresidential building owners, buyers, lessees, lenders

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[50] The original legislation adopted in 2007 required building owners to comply with AB 1103 starting January 1, 2010. This implementation start date has been pushed back due to delays in the adoption of the enabling regulations. A work group comprised of stakeholders including the CEC, the IOUs, Sacramento Municipal Utility District (SMUD), the EPA, CPUC, and various real estate industry representatives has been working to define the compliance process since 2009. A number of challenges, primarily revolving around utility customer confidentiality, however, have hindered the ability of the regulations to progress to a full rulemaking. As of September 2011, the draft enabling regulations require building owner compliance in a phased schedule beginning July 1, 2012.

Initiatives Technologies/Measures

While AB 1103 is commonly described as a bill for benchmarking nonresidential buildings, it only requires building owners to disclose their energy use data. A large portion of California buildings will not even be eligible to receive a Portfolio Manager benchmark rating because of restrictions in the types of buildings that can qualify.[51] Even then, there are additional constraints placed on the building and its ability to receive a rating, including those that are mixed use.

There are no requirements for the building owner to actually improve the performance of their building through AB 1103. The intent of this initiative is to transform the market and integrate building energy performance into the decision-making process for a prospective buyer, lender, or financier. Building owners only need to disclose the actual energy use data, which does not necessarily trigger action by a buyer who is not familiar with a typical building's energy use; however, it may facilitate the buyer's comparison of different properties being considered. In order to facilitate this comparison, the Commission is providing a summary sheet to accompany the disclosure. This summary sheet details the contents of the disclosure, as well as giving median values for Energy Use Intensity for a large number of space usages.

Because it solely requires disclosure of energy use data, not any actual enhancements to the building, there are no specific technologies or measures that would be associated with the initiative. If a building owner chose to upgrade his/her building in order to have a more energy-efficient building reflected in his/her disclosure documents, that upgrade could take the form of any measure possible—from HVAC to windows, to lighting, appliances, and controls. The building owner could use any or all or none.

Energy Savings Estimates

An ongoing challenge with benchmarking in California, and throughout the country, is the ability to associate it with energy savings. Because benchmarking is providing information to the building owner about the performance of the building and the way in which its occupants are using the space, it is widely believed and expected that the owner will act on the results of a poorly performing building and upgrade systems or measures. There is little literature proving this theory, though, and no clear standard for what savings can be attributed to benchmarking. Using the analogy of blood pressure, knowing you have high blood pressure makes you much more likely to do something about it, but the act of getting your blood pressure taken alone doesn't do anything. Benchmarking a building is likely to make someone act, but benchmarking itself doesn't actually save any energy. Additionally, in California, it is unlikely that savings would be attributed solely to benchmarking; rather, it would likely go to the utility programs associated with the measure upgrades.

[51] There are only 15 building types eligible to receive an ENERGY STAR® Rating in Portfolio Manager—bank/financial institution, courthouse, data center, hospital, hotel, house of worship, K-12 school, medical office, municipal wastewater treatment plant, office, residence hall/dormitory, retail store, senior care facility, supermarket, and warehouse. While they can still collect building energy use data and disclose it under AB 1103, universities, public assembly spaces (health/fitness centers, libraries, museums, movie theaters), and restaurants are examples of some types of buildings not eligible to receive a benchmark rating in Portfolio Manager.

Key industry leaders have not performed quantitative analysis of typical savings for benchmarking or reporting-type programs; they only have anecdotal evidence that benchmarking motivates building upgrades. This finding is based on interviews with Justin Regnier at the CEC, Theda Silver-Pell at PG&E, and Tracy Narel at EPA that discussed the methods with which they are familiar or that their organizations use to associate energy savings with benchmarking.

Currently, the CEC has no savings goals associated with AB 1103 or their enabling regulations, and no way of quantifying potential savings from the initiative. Aside from the difficulty in actually determining savings associated with benchmarking, there's the complication of attempting to associate energy savings to AB 1103 specifically because it has yet to be implemented. The CEC is still working on the draft regulations and plans to begin the formal rulemaking process for the fall of 2011; however, the regulations are not yet final and changes are still being made to the language.

SOURCES

AB 1103 enabling regulations proceeding information, including California Energy Commission notices and announcements, documents, reports, and public comments. California Energy Commission. AB 1103 Commercial Building Energy Use Disclosure Program. Docket #09-AB1103-1. http://www.energy.ca.gov/ab1103/

AB 1103 Work Group meeting notes, dating back to their start in March 13, 2009. Heschong Mahone Group. AB 1103 Working Group Meeting Notes. http://www.h-m-g.com/downloads/EnergyBenchmarking/Meetings/AB1103WorkGroupMeetings.htm

Assembly Bill 1103 language, as signed by Governor Schwarzenegger. Assembly Bill 1103, Chapter 533, Section 25402.10 of the Public Resources Code, October 12, 2007. http://www.energy.ca.gov/ab1103/documents/ab_1103_bill_20071012_chaptered.pdf

Assembly Bill 531 language, as signed by Governor Schwarzenegger. AB 531 grants the California Energy Commission rights to determine a schedule of compliance for AB 1103. Assembly Bill 531, Chapter 323, Section 25402.10 of the Public Resources Code, October 11, 2009.

Narel, Tracy. United States Environmental Protection Agency. "Energy Savings Associated with Benchmarking." E-mail interview, August 16, 2011.

Regnier, Justin. California Energy Commission. Telephone interview, August 24, 2011.

Silver-Pell, Theda. Pacific Gas and Electric Company. "Energy Savings Associated with Benchmarking." E-mail interview July 18, 2011.

C.2.9 Stimulus/ARRA

ARRA project funding will not occur during the potential savings time frame (2013-2023) because funds must be expended by the end of 2012. Therefore, there will be no direct savings attributed to ARRA.

However, ARRA-related indirect savings may be realized through market effects. To this end, only market transformation activities would generate savings that could be realized in future years.

BASIC DESCRIPTION

The American Recovery and Reinvestment Act of 2009 was a federal legislative initiative enacted in February 2009 with funds to be expended by the end of 2012. ARRA includes federal tax incentives, expansion of unemployment benefits and other social welfare provisions, and domestic spending in education, health care, and infrastructure, including the energy sector. A direct response to the economic crisis, the ARRA has three immediate goals:

» Create new jobs and save existing ones

» Spur economic activity and invest in long-term growth

» Foster unprecedented levels of accountability and transparency in government spending

Applicable sector: All

Vintage: New and existing buildings

Subsector segments likely impacted: All

End uses affected: All

Start date: February 2009

I*mplementation path/time line:* Funding must be expended by December 31, 2012

Savings goals and associated key date: Not applicable—ARRA's goals are tied to job creation instead of energy savings.

Delivery mechanism: ARRA programs are delivered through a variety of mechanisms—direct incentives and rebates; marketing, education, and outreach; and research and policy-setting.

For the California energy efficiency sector, ARRA funding is administered through three avenues:

1. California Energy Commission – Administers the State Energy Program, Energy Efficiency Conservation Block Grant Program, and the Appliance Rebate Programs
2. California Department of Community Services and Development – Administers the Weatherization Assistance Program
3. U.S Department of Energy Funding – Administers Direct Funding through Competitive Bids

Secondary delivery mechanisms: None

INITIATIVES TECHNOLOGIES/MEASURES

Most of the ARRA-funded savings will be realized before 2013, and so are not applicable to the Potential and Goals (PG) study. In terms of measures for the PG study, the following technologies and measures may have an impact for the 2013-2023 period. Additional description of each of these technologies and measures is included in the next subsection, Energy Savings Estimates.

- Baseline/Saturation Impacts
  - State Energy Program
  - Energy Efficiency Conservation Block Grant Program
  - Appliance Rebate Program
  - Department of Community Services and Development's Weatherization Assistance Program
- Education and Training Behavioral Impacts
  - State Energy Program
  - Energy Efficiency Conservation Block Grant Program
  - Industrial Assessment Centers and Plant Best Practices
  - Buildings and Appliance Market Transformation
- Emerging Technologies Impacts
  - Improved Energy Efficiency for Information and Communication Technology
  - Solid-State Lighting

ENERGY SAVINGS ESTIMATES

In terms of the PG study, ARRA project funding will not occur during the potential savings time frame (2013-2023). Therefore, there will be no direct savings attributed to ARRA. However, ARRA-related indirect savings may be realized through market effects. To this end, the following impacts are the types of market transformation activities in which savings may be generated in future years.

- Baseline/Saturation Impacts
  - State Energy Program - The CEC is investing in state-level energy efficiency and renewable energy priorities. The program provides an energy efficiency retrofit program and cost-effective clean energy system for residential, commercial, and industrial buildings and facilities.
  - Energy Efficiency Conservation Block Grant Program - Three hundred and seven communities in California have received a total of $355.1 million to develop, promote, implement, and manage local energy efficiency programs. These grants support a wide variety of energy efficiency planning, audits, and projects all across the state.
  - Appliance Rebate Program - The CEC received $35.3 million to offer consumer rebates for purchasing certain ENERGY STAR® appliances, replacing inefficient appliances. Three

residential appliance categories were selected to be eligible to receive rebates: clothes washers, refrigerators, and room/window air conditioners.

- » Department of Community Services and Development's Weatherization Assistance Program - California received $185.8 million to scale up existing weatherization efforts with the goal to weatherize approximately 43,400 homes.

» Education and Training Behavioral Impacts

- » State Energy Program - ARRA funding is being used to develop a workforce through its Green Jobs Training Program. Additionally, the program is implementing a public education, marketing, and outreach effort to ensure the benefits and value of energy efficiency are well understood.
- » Energy Efficiency Conservation Block Grant Program - These grants support a wide variety of energy efficiency planning, audits, and projects all across the state. Energy efficiency education, marketing, and outreach effort is included as part of these efforts.
- » Other small funded projects with minimal or negligible savings[52]

» Emerging Technologies Impacts

- » Improved Energy Efficiency for Information and Communication Technology - Awarded $25.2 million, this project will select and fund applicants to conduct research, development, and demonstration projects to promote new technologies that improve energy efficiency in the information and communication technology sector.
- » Solid-State Lighting - Six research projects were provided with a combined total of $13,700,000 for solid-state lighting research.

Sources

ARRA Funded Energy Programs - Investing in California's Energy Future. California Energy Commission, July 1 2010. http://www.energy.ca.gov/2010publications/CEC-180-2010-003/CEC-180-2010-003.PDF

Broderick, James. Department of Energy Buildings Technologies Program. Lighting Program Manager. telephone interview, September 12, 2011.

California Economic Recovery Energy-Related Programs, California Energy Commission, Accessed September 2011. http://www.energy.ca.gov/recovery/

Gemmer, Bob. Department of Energy. Technology Manager. telephone interview, September 8, 2011.

[52] *Industrial Assessment Centers and Plant Best Practices* - San Diego State University received $100,000 to provide eligible small and medium-size manufacturers with no-cost energy assessments and serve as a training ground for engineers. *Buildings and Appliance Market Transformation* – Awarded $14,000, the Buildings and Appliance Market Transformation project expands building codes, accelerates the pace of Appliance Standard test procedure development, and improves the efficiency of commercial buildings' operations by training building operators and commissioning agents.

Recover.org, Federal Recovery Accountability and Transparency Board, Accessed September 2011. http://www.recovery.gov/About/Pages/The_Act.aspx

Schledorn, Michael. Department of Energy. Technology Manager. telephone interview September 8, 2011.

C.2.10 AB 2404: Water Efficiency Programs

AB 2404 requires the CPUC to report to the legislature on the outcomes of the water-energy pilots, providing conclusions on the cost-effectiveness of the pilots, and recommendations for the implementation of water conservation programs. They intend to create an estimate of statewide savings by extrapolating the results of these pilots to statewide initiatives. As yet, however, there are no quantified statewide savings estimates from this group. Thus, we are unable to provide energy savings estimates for AB 2404.

BASIC DESCRIPTION

Energy is required to filter, treat, and pump water and wastewater. Existing energy efficiency programs address the energy used by pumps and water treatment facilities, but there is currently no accounting for the embedded energy of water in water *conservation* programs.

In Decision 07-12-050, the Public Utilities Commission approved pilot programs for the state's largest electrical and gas corporations, through which they were to develop partnerships with water agencies to undertake water conservation programs, measure the results, and fund studies necessary to understand the relationship between water savings and the reduction of energy use, and the extent to which those reductions would vary for different water agencies.

AB2404 requires the CPUC to report to the Legislature by March 31, 2010, on two issues:

1. The outcome of pilot projects conducted by the IOUs to determine whether cost-effective energy efficiency improvements can be achieved by water conservation projects
2. Recommendations as to whether the utilities would or could achieve cost-effective energy efficiency improvements through water conservation programs

Applicable sector: Commercial, industrial, and residential buildings, and agriculture

Vintage: New and existing buildings

Subsector segments likely impacted: All nonresidential and residential buildings

End uses affected: Food service, water heating, laundry, irrigation, potable water.

Start date: No start date is specified in the bill. The CPUC has convened a group of representatives from the electric and water utilities to set out next steps for this initiative, but they have not yet set target dates for any activities.

I*mplementation path/time line:* The bill required CPUC to submit a report on pilot projects to the legislature by March 31, 2010. This report was submitted on time, although the pilot projects were not complete and were not evaluated until March 9, 2011.

The bill requires that if the CPUC finds that water efficiency improvement programs can achieve cost-effective energy efficiency savings, IOUs should consider potential energy savings that could be achieved through water efficiency improvements and, where cost effective, incorporate those measures into their energy efficiency programs. Therefore, statewide savings models should include a placeholder for energy savings from water, if the measures are found to be cost-effective and technically feasible.

Because water may be transported from or through one electrical utility's service territory to another, the bill authorizes IOUs to partner with water efficiency programs outside their service territory.

The bill also requires the CPUC to provide conclusions drawn from the pilot programs and make recommendations as to whether the IOUs could achieve cost-effective energy efficiency improvements through water conservation programs. Note that the final evaluation report from the CPUC does not appear to make these specific recommendations.

Savings goals and associated key date: None specified

Delivery mechanism: CPUC, California electric, gas and water utilities, water wholesalers and purveyors

Secondary delivery mechanisms (if applicable): Commercial and residential building developers, owners, maintenance and irrigation contractors

Initiative Technologies/Measures

Table C-3 includes the pilot programs conducted by the IOUs.

Table C-3. IOU Water-Energy Pilots

Utility	Program
SCE	Low Income Direct Install High Efficiency Toilet (HET) – Multifamily Express Water Efficiency Lake Arrowhead Water Conservation Water Leakage
PG&E	Large Commercial Customer Audits Low Income Single Family High Efficiency Toilet (HET) Emerging Technologies in Water Utility Efficiency
SDG&E	Managed Landscape Large Industrial Customer Audits Recycled Water
SoCalGas	CLAWA/EMWD Gas Pump Testing

Of these programs, the CPUC evaluation found that SCE's Water Leakage program was the most cost-effective and offered the highest potential for total water/energy savings. However, the evaluation report did not specifically quantify the cost-effectiveness of any of the programs. The SCE Water Leakage program saved 178,000 kWh/yr for a program cost of $300,000. Allowing a rate of $0.20/kWh, this equates to a simple payback of 8.4 years. For comparison, the PG&E High Efficiency Toilet program had a simple payback of 70 years.

A more accurate estimate of cost-effectiveness could be calculated using the Water-Energy Calculator developed by CPUC consultants JJ Hirsch (see link below).

Specific technologies included in these utility programs are listed in Attachment D: AB 2404 IOU Water-Energy Pilot Measures. However, AB2404 does not limit water efficiency pilots or programs to any specific technologies, so any approach could potentially be used and still comply with the bill.

Energy Savings Estimates

The group of utility representatives convened by the CPUC intends to create an estimate of statewide savings by extrapolating the results of the utility water pilots to statewide initiatives. As yet there are no quantified statewide savings estimates available, so the statewide savings model should include a placeholder for these savings.

Because the pilot programs indicated a need for additional research, and gave no specific direction on how the savings could be captured, the time frame for implementation of these measures is probably in at least the 3-5-year range.

Because the savings achievable from the energy in water are typically very small compared to other achievable savings in buildings, any adopted measures would likely have to "piggyback" on existing programs in order to be cost-effective.

In the near term, Southern California Edison is proposing to include some water agency leak detection projects in its industrial or agriculture programs. These may be the first attempt to capture embodied energy savings from water.

Sources

Assembly Bill 2404 (Salas): http://docs.cpuc.ca.gov/published/Report/81928.htm
Bill analysis prepared by Assembly Utilities and Commerce Committee consultant:
ftp://leginfo.public.ca.gov/pub/07-08/bill/asm/ab_2401-2450/ab_2404_cfa_20080527_203431_asm_floor.html

CPUC Final Report—Embedded Energy in Water Pilot Programs Impact Evaluation. Prepared by ECONorthwest, March 2011.
http://www.energydataweb.com/cpucFiles/33/FinalEmbeddedEnergyPilotEMVReport_1.pdf

Download of *Water-Energy Calculator* software: http://www.doe2.com/download/Water-Energy/

End-use Water Demand Profiles ("Study 3") Draft 2011 Aquacraft, Inc.
http://www.energydataweb.com/cpucFiles/topics/80/Study%203%20End%20Use%20Water%20Demand%20Profiles%20DRAFT%20for%20posting.docx

Energy Down the Drain: The Hidden Costs of California's Water Supply. Published by the Pacific Institute, August 2004. http://www.pacinst.org/reports/energy_and_water/index.htm

Process Evaluation of the PG&E, SCE SDG&E and SCG Water Pilot Programs – Final Report. Study ID: SCE0294.01. Prepared by ECONorthwest, December 6, 2010.
http://www.calmac.org/publications/FINAL_Water_Pilots_Process_Rpt_12-6-10_wStudy_ID.pdf

Report to the legislature by CPUC staff, required by AB2404:
http://www.cpuc.ca.gov/NR/rdonlyres/23B3B3DD-682D-44EB-BF0A-14298018C664/0/AB2404_Report_re_WaterEE_Pilots_4_1_10.pdf

Senate Bill SBx7-7, 2009: http://www.water.ca.gov/wateruseefficiency/sb7/
State Water Conservation Plan:
http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/docs/20x2020plan.pdf

Statewide Regional Water-Energy Relationship ("Study 1"). 2010. GEI Consultants, Inc. and Navigant Consulting, Inc.
http://www.calmac.org/publications/CALMAC_CA_Statewide_Regional_Water_Energy_Relationship_Vol_1_of_15_-_Main_Report.pdf

Water Agency and Function Component Study and Embedded Energy-Water Load Profiles ("Study 2"). 2010. GEI Consultants, Inc. and Navigant Consulting, Inc.
http://www.calmac.org/publications/CALMAC_Water_Agency_and_Function_Component_Vol_1_of_6_-_Main_Report.pdf

C.2.11 AB 2021: Publicly Owned Utility (POU) Potential Estimates, Goals, and Targets

AB 2021 requires Publicly Owned Utilities (e.g., municipal utilities, irrigation districts) to adopt energy efficiency programs, and to report to the CEC. POUs are beyond the scope of this project.

C.3 Attachment A: Expert Interview Guide

The team used the following interview guide to conduct interviews with experts on the legislative initiatives covered in this report.

C.3.1 Opening Statements

PROJECT DESCRIPTION

HMG is a subcontractor to Navigant Consulting, who is the lead contractor helping the CPUC to update the technical potential estimates for California energy efficiency from 2013-2023, and to develop the goals and targets for IOUs efficiency programs.

For this portion of the project, HMG is analyzing the various federal and state legislative mandates for energy efficiency in California and estimate the savings targeted by each. The savings targeted by legislative mandates form the "floor" to the energy savings that can be achieved by IOU efficiency programs.

INITIATIVE INTRODUCTION

We have prepared an initial assessment of <initiative>, based on published sources, which is provided here:

<Insert brief description of the initiative and cite/mention some of the literatures sources the team has already explored, for example for AB 758:

AB 758 is a directive requiring the California Energy Commission (CEC) to develop and implement a comprehensive program to achieve greater energy savings in existing residential and nonresidential buildings. The team has learned about the general scope of AB 758 mainly through CEC's dedicated webpage. Information provided by the webpages include the implementation timeline for the 3 phases planned for the program and some *of the activities in Phase 1 (infrastructure development implementation plan). These included the wide variety of ARRA-funded pilot programs. >*

Our purpose today is to confirm with you the accuracy of this assessment, and to ask for additional information and updates so that we can account for the effects of this initiative on the energy savings technical potential.

C.3.2 Questions

General Background

- Interviewee:
- Organization/Department:
- Position held in relationship to initiative:
- Main responsibilities:

Initiative Scope

- Confirm current understanding of initiative
  - Lead organization
  - Goals
  - Impacted sectors/building types/end uses/measures
- Potential overlap with other federal/state initiatives
  - <AB 1103 requires commercial building to disclose energy use data during building transaction events>
  - <AB 32:AB 32's scoping plan calls for "aggressive actions for existing buildings, including mandatory disclosure of building energy use ratings, efficiency improvement requirements for under-performing buildings, and creative financing options such as on-bill financing">

Initiative Status

- Please provide an update on the current status of the initiative; what are some on-going activities?
- What are some next steps and key dates anticipated for implementation of the initiative?

Quantifying Savings

- What energy savings goals are associated with the initiative?
- Has there been any tracking of savings accomplishments for the initiative?
  - If yes, can you share where the savings are being tracking and its methodology?
  - If no, are there plans to track savings?
    - If yes, can you share the savings methodology?

- If no, do you have recommendations on how savings could be estimated for the initiative?

<insert topic specific questions provided by each initiative lead, see examples below

- » Are there direct energy savings estimate attached to each of the three programs during Phase 1 of the program? And if so, how could they be quantify or who are some contacts with such specific knowledge?
- » Will and how will the ARRA-SEP funded pilot programs continue after April 2012? (there was mention of CEC "seeking approval to use ERPA funs to continue the ongoing development and implementation of the program")
- » And if so, which of the pilot programs are likely to continue (perhaps programs requiring longer term efforts and commitment)?
- » What are some directions and content (new or continuation of Phase 1) the CEC is anticipating from Phase 2 and 3 of the program?
- » With Phase 3's title, "Statewide Rating &Upgrades Requirement," is the CEC looking to establish requirement for mandating retrofit upgrades? And if so, through what mechanism and under what time frame would such requirements take effect?>

C.3.3 Concluding Remarks

Thank you for your time and effort in providing useful information to the implementation of the initiative. We would like to contact you in the future for more questions. Do you have any questions?

- » Are there others within or outside of your organization who would be good candidates for providing insights to questions raised in this interview?
  If so, please kindly provide contact information.

C.4 Attachment B: Experts Interviewed

Initiative	Interviewee	Organization	Date
AB 32	Sharon Anderson	Air Resources Board	July 12, 2011
AB 32	Steven Cliff	Air Resources Board	September 27, 2011
AB 32	Dana Papke	Air Resources Board	September 23, 2011 September 29, 2011
AB 1109	Teresa Bui	Californians Against Waste	August 24, 2011
AB1109	Ken Rider	California Energy Commission	August 25, 2011
AB 758	Justin Regnier	California Energy Commission	August 24, 2011
AB 1103	Justin Regnier	California Energy Commission	August 24, 2011
AB 1103	Theda Silver-Pell	Pacific Gas and Electric Company	July 18, 2011
AB 1103	Tracy Narel	US Environmental Protection Agency	August 16, 2011
Stimulus/ARRA	Michael Schledorn	Department of Energy	September 8, 2011
Stimulus/ARRA	Bob Gemmer	Department of Energy	September 8, 2011
Stimulus/ARRA	James Broderick	Department of Energy Building Technologies Program	September 12, 2011

C.5 Attachment C: Summary of Voluntary Standards

EPA ENERGY STAR® programs: The ENERGY STAR® programs administered by the United States Environmental Protection Agency (EPA) provide high efficiency criteria for a broad range of residential and commercial appliances and equipment, as well as new homes. These criteria are not officially considered standards, but have been a major market force driving market efficiency improvements. To a large degree, the California IOU programs promote, and claim savings for, these programs.

ASHRAE Standards: ASHRAE standards are developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) using the ANSI consensus process. ASHRAE develops a variety of standards, which are used as a basis for federal appliance standards, Title 24 codes and Title 20 standards. Most of the ASHRAE standards provide performance measurement and rate methods, instead of energy efficiency performance requirements. The following three ASHARE standards are the most influential ones, which provide specific building energy efficiency performance requirements. In general Title 24 standards are more stringent, or at least equivalent, to ASHARE standards.

» ASHRAE 90.1 - ANSI/ASHRAE/IESNA Standard 90.1 Energy Standard for Buildings except Low-Rise Residential Buildings

- ASHRAE 90.2 - ANSI/ASHRAE 90.2: Energy Efficient Design of Low-Rise Residential Buildings
- ASHRAE 189.1 - ASHRAE 189.1: Standard for the Design of High-Performance Buildings except Low-Rise Residential Buildings

ICC Codes: International Energy Conservation Code (IECC) is developed by the International Code Council (ICC) as one of the 14 model codes for building construction regulations. IECC address energy efficiency of both residential and commercial buildings. Similar to the ASHRAE standards, ICC codes are developed though a consensus process involving a broad range of interested stakeholders. The IECC references ASHRAE 90.1 for commercial building energy efficiency performance.

ICC is in the process of developing the International Green Construction Code (IgCC). Currently, the IgCC Public Version 2.0 is under public review and the final version is expected to be issued in early 2012. IgCC is developed with cooperation from several other organizations, including ASHRAE, American Institute of Architects (AIA), ASTM International, US Green Building Council (USGBC), and the Illuminating Engineering Society (IES). The IgCC applies to new and existing buildings. ASHRAE 189.1 is used as a compliance option. A Zero Energy Performance Index (ZEPI) is proposed to measure building energy performance. For compliance, it is recommended that buildings energy consumption should be less than 51 percent of the energy consumption allowed by the 2000 International Energy Conservation Code.

Green Building Standards: Leadership in Energy and Environmental Design (LEED) is a third-party certification program and rating system developed by the United States Green Building Council (USGBC). LEED for New Construction and Major Renovations (LEED-NC) requires a minimum energy performance of exceeding ASHRAE 90.1 2007 by 10% (in California the equivalent is Title 24). Some jurisdictions require that buildings be built to LEED-NC standards, but do not require costly USGBC certification.

LEED for Homes covers single family homes and multi-family buildings up to 3 stories. LEED for Homes references the ENERGY STAR® New Homes criteria for energy efficiency performance. GreenPoint Rated (GPR) is a third-party green building certification program and rating system developed by the Alameda County Waste Management Authority in partnership with California non-profit Build it Green (BIG). GPR includes ratings for single- and multi-family new homes. Under GPR each project receives an individual scorecard where points are earned for performance in six sustainability categories, and each home must be verified by a GreenPoint Rater. For energy performance, each home must exceed 2008 Title 24 by a minimum of 15%. For each additional percent in excess of 15%, an additional 2 points are awarded.

C.6 Attachment D: AB 2404 IOU Water-Energy Pilot Measures

This appendix sets out the specific measures that were investigated by the utilities' water-energy pilot programs, as called for under AB 2404. Due to the large number of measures on this list, we chose to present it as an appendix instead of in the body of the report.

This list comes from the process evaluation of the programs conducted by ECONorthwest for Southern California Edison[53].

PG&E Large Commercial Customers Program

- Water recirculation systems
- New ozone laundry systems
- Winery and food processing changes
- Commercial kitchen retrofits
- Toilet and shower upgrades
- Recycled water retrofit projects

PG&E (Single Family) Low Income High Efficiency Toilets Program

- Toilets that flush at 3.5 gallons per flush or greater

PG&E Emerging Technologies Program

- Energy data in a new water-pumping algorithm to automatically control a subset of system pumps
- System operators that manually change the pump operations in response to displayed energy consumption

SCE (Multifamily) Low Income High Efficiency Toilet Program

- Toilets that flush at 3.5 gallons per flush or greater

SCE Express Water Efficiency Program

- pH controllers for cooling towers
- Weather Based Irrigation Controllers (WBICs)

SCE Leak Detection Program

- Detailed, top down water audits that comply with International Water Association and American Water Works Association protocols

SDG&E Managed Landscapes Program

- Proprietary equipment and software that dynamically controls the amount of water used

SDG&E Recycled Water Retrofits Program

- Recycled water (converted from potable water source)

SDG&E Large Customer Audits Program

- Water/energy audit
- Boiler water reuse system
- Autoclaves equipment and process changes

[53] http://www.calmac.org/publications/FINAL_Water_Pilots_Process_Rpt_12-6-10_wStudy_ID.pdf

- Reverse osmosis process changes
- Water savings toilets and urinals
- Toilet flush timers

SCG Gas Pump Testing Program

- Measure pump performance
- Identify equipment maintenance and upgrades
- Gas pump testing protocol

Appendix D Codes and Standards

This appendix presents additional methodology discussion of modeling the impacts of codes and standards (C&S) on voluntary programs (Section **Error! Reference source not found.** and **Error! ference source not found.**) as well as key inputs to estimating the IOU claimable savings from C&S (Section D.3).

D.1 Impact Calculation Methods

A new energy efficiency standard may reduce the energy savings from an affected incentive program measure if the baseline efficiency is increased by the standard. The energy savings impact is quantified as the ratio of the measure unit energy savings (UES) under the new standard to the measure UES using the 2013 baseline efficiency, as shown in the following equation:

$$Impact\ Percentage_{Year} = \frac{UES\ under\ new\ standard}{UES\ under\ the\ 2013\ baseline}$$

Impact percentages vary by year because standards take effect in different years. Therefore, a "vector" of impact percentages was developed for each incentive program measure to capture the impact in each year from 2013 to 2024. C&S impact vectors are used as the input to the PG Model to assess the total impact of new state and federal standards to potentials of incentive programs. For incentive program measures not affected by any new standards, values of the impact percentages are 100%.

For program measures that are impacted by codes and standards, the Navigant team accounted for compliance enhancement, per the Strategic Plan goal to "dramatically improve code compliance and enforcement." The Navigant team assumes code compliance ramps up from its current levels to 100% over a set period of time as noted in Table D-1. This assumption is consistent with past sensitivity analysis on compliance rates conducted by CPUC contractors examining C&S savings.

Table D-1. Assumptions Related to Compliance Enhancement

C&S Type	Time to reach 100% compliance
Federal Standards	5 years
Title 20	10 years
Title 24	6 years
Source: Navigant team analysis 2013.	

There are two ways to calculate impact percentages based on the types of efficiency metric used for the affected measure:

1. **Measures with an energy usage rating.** The first calculation method is used for measures with an efficiency metric based on energy usage rating (e.g. light bulb wattage rating). The Navigant

team assumed that neither program measures nor standards would change operation schedules. The C&S impact percentage for measures with an energy usage rating is calculated as follows:

$$Impact\ Percentage_{Year} = \frac{Power_{New\ Standard} - Power_{Program\ Measure}}{Power_{Baseline} - Power_{Program\ Measure}}$$

2. **Measures with an efficiency or efficacy measurement.** The second calculation method is used for measures with an efficiency or efficacy measurement (e.g. clothes washer energy factor [cycles/kWh]). In most cases, the Navigant team assumed that the annual loads (e.g. cooling/heating loads or clothes washing loads) were the same under existing and new standards. In other cases, like dishwasher cycles per year, the loads changed from existing to new standards according to DOE test standard updates. The following equation is used to determine these impact percentages for measures with an efficiency or efficacy measurement:

$$Impact\ Percentage_{Year} = \frac{Load/\eta_{New\ Standard} - Load/\eta_{Program\ Measure}}{Load/\eta_{Baseline} - Load/\eta_{Program\ Measure}} = \frac{1/\eta_{New\ Standard} - 1/\eta_{Program\ Measure}}{1/\eta_{Baseline} - 1/\eta_{Program\ Measure}}$$

In these equations, the baseline technology efficiency ratings, $Power_{Baseline}$ and $b_{aseline}$, are based on effective standards in baseline year of 2013 or average market practices if there was not an applicable efficiency standard in 2013.

D.2 *C&S Impact Vectors*

Table D-1 summarizes the C&S impact vectors for all incentive measures used in the 2013 Potential and Goals Study. For measures affected by new standards, detailed standard and measure efficiency data are provided in referenced tables. For incentive program measures not affected by any new standards, values of the impact percentages are 100%.

Table D-2. C&S Impact Vectors for All Measures 2013-2024

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
AppPlug - Clothes Washer (Electric)	Table D-2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Clothes Washer (Gas)	Table D-2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Electric)	Table D-3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Gas)	Table D-3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Com - Power Management)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Res - ES)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Res - ES Plus)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Computer Monitor	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Computer Monitor	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Occupancy Sensor Plug Strip	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Vending Machine Controls	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Recycle Refrigerator	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Set Top Box	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Self-Contained Refrigerator	Table D-6	100%	100%	39%	39%	39%	39%	39%	39%	39%	39%	39%	39%
AppPlug - Self-Contained Refrigerator - Emerging	Table D-6	100%	100%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%
AppPlug - Clothes Washer (Electric) - Emerging	Table D-2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Clothes Washer (Gas) - Emerging	Table D-2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
AppPlug - HP Clothes Dryer - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Electric) - Emerging	Table D-3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Gas) - Emerging	Table D-3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Smart Strip Home Theater - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Smart Strip Home Office - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Window Film	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Window Film	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Attic Batt Insulation (Res R-38)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Attic Batt Insulation (Res R-30)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Attic Batt Insulation (Com)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Wall Spray On Insulation	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Wall Spray On Insulation	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Door Gasket (Walk-In Refrigerator)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Door Gasket (Reach-In Refrigerator)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Refrigerated Case Night Cover (Low Temp)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Refrigerated Case Night Cover (Med Temp)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Fiber Optic Display Case LED lighting - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Strip Curtain for Walk In Refrigerator	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Fryer (Electric)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Fryer (Gas)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Electric Griddle	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
FoodServ - Grill to Order Cabinet	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Oven (Electric)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Oven (Gas)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Electric Steamer	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Gas Furnace	Table D-7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - AFUE Rated Boiler (High)	Table D-8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - AFUE Rated Boiler (Standard)	Table D-8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - ET Rated Boiler (High)	Table D-8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - ET Rated Boiler (Standard)	Table D-8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Centrifugal)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Reciprocating)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Screw)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - EER Rated Package Rooftop AC (EER 11)	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop AC (Recharge)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop AC (SEER 14)	Table D-4	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - SEER Rated Package Rooftop AC (SEER 13)	Table D-4	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - SEER Rated Split System AC (SEER 13)	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (Recharge)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 15)	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
HVAC - SEER Rated Split System AC (SEER 18)	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - EER Rated Package Rooftop HP (EER 11)	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop HP (SEER 14)	Table D-4	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - SEER Rated Package Rooftop HP (SEER 15)	Table D-4	100%	100%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
HVAC - SEER Rated Split System HP (SEER 14)	Table D-4	100%	100%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
HVAC - SEER Rated Split System HP (SEER 15)	Table D-4	100%	100%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
HVAC - SEER Rated Split System HP (SEER 14)	Table D-4	100%	100%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
HVAC - SEER Rated Split System HP (SEER 15)	Table D-4	100%	100%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
HVAC - Direct Evaporative Cooler	Table D-4	100%	100%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
HVAC - Direct Evaporative Cooler	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Repair Duct System	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Repair Duct System	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Demand Controlled Ventilation	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Whole House Fan	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Energy Management System	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Gas Furnace - Emerging	Table D-7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 22) - Emerging	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 21) - Emerging	Table D-4	100%	100%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
HVAC - Energy Recovery Ventilation - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Advanced Package Rooftop AC (> EER 12) - Emerging	Table D-4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Thermostat	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Fixture (Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Exit Fixture (LED)	Table D-5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Linear Fluorescent Fixture	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Linear Fluorescent Fixture (Low Wattage)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - High Intensity Discharge Fixture (from Incandescent)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - High Intensity Discharge Fixture (from Mercury Vapor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Night Light Fixture (LED)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Seasonal Lighting	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Basic High - Outdoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Outdoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Reflector - Outdoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Specialty - Outdoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Reflector - Indoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Specialty - Indoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Indoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Outdoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Outdoor)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Light Sensor	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Occupancy Sensor	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Exterior)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Plug-In Fixture (Linear Fluorescent)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (A-Line)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (Reflector)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (A-Line)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (Reflector)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Wall Spray On Insulation	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Occupancy Sensor	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Compact Fluorescent)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Plug-In Fixture (PSMH with Electronic Ballast)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Induction)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (MH Directional)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (PSMH)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Exterior)	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Lighting - Plug-In Fixture (Linear Fluorescent)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Cold Cathode Lamp	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Linear Fluorescent Delamping	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Linear Fluorescent Delamping	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Fixture (Indoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Fixture (Outdoor)	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	None	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Fixture (Replacing T8) - Emerging	Table D-5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Basic High - Outdoor) - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Lamp (Basic Low - Outdoor) - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Plug-In Indoor Fixture - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Plug-In Indoor Fixture - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Plug-In Outdoor Fixture - Emerging	Table D-5	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - LED Lamp (Reflector - Indoor) - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Reflector - Outdoor) - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Lighting - LED Lamp (Specialty - Indoor) - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Specialty - Outdoor) - Emerging	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ProcHeat - Boiler Draft Fan	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ProcHeat - Boiler Controls	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Electric)	Table D-9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Gas)	Table D-9	100%	100%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
SHW - EF Rated Instantaneous Water Heater (Gas)	Table D-9	100%	100%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
SHW - ET Rated Instantaneous Water Heater	Table D-9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Storage Water Heater (Electric)	Table D-9	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SHW - EF Rated Storage Water Heater (Gas)	Table D-9	100%	100%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
SHW - EF Rated Storage Water Heater (Gas)	Table D-9	100%	100%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
SHW - ET Rated Storage Water Heater	Table D-9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Heat Pump Water Heater	Table D-9	100%	100%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
SHW - EF Rated Storage Water Heater (Gas) - Emerging	Table D-9	100%	100%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
SHW - EF Rated Storage Water Heater (Gas) - Emerging	Table D-9	100%	100%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
SHW - ET Rated Storage Water Heater - Emerging	Table D-9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Service - Retro-Commissioning	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Service - HVAC Fault Detection & Diagnostics	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Low Income	None	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Measure	Standard Data*	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024

Notes:

* "None" indicates that products related to the measure are not regulated.
For incentive program measures not affected by any new standards, values of the impact percentages are 100%.

Source: Navigant team analysis, 2013.

Table D-3. Impact Percentages for Energy Star Clothes Washer

Measure Type	Effective Standard in 2013	Measure Efficiency	New Standard	% Impact
Source	DOE[1]	MICS	None	
Efficiency Metric		MEF (cycles/kWh)		
Clothes washer (electric or gas)	1.26	2.1	-	100%
Clothes washer (electric or gas)	1.26	2.87	-	100%
Average				100%

Source:

1. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39

Table D-4. Impact Percentages for Energy Star Dishwashers

Measure Type	Effective Standard in 2013	Measure Efficiency	New Standard	% Impact
	DOE[1,2]	MICS	None	
Efficiency Metric	EF (cycle/kwh)	EF (cycle/kwh)	EF (cycle/kwh)	
Standard size (electric or gas)	0.61	0.67	-	100%
Standard size (electric or gas)	0.61	1.19	-	100%
Average				100%

The new dishwasher standard is based on maximum annual energy consumption (<355kWh/year for standard sizes models). EF is calculated based on the assumption of 215 cycle/year specified in the DOE dishwasher test standard.

Sources:

1. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67
2. http://www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers

Table D-5. Impact Percentages for High Efficiency AC Measures

Measure Type	Effective Standard in 2013 DOE[1]		Measure Efficiency MICS		New Standard DOE[2] (Effective 1/1/2015)		% Impact
Efficiency Metric	SEER	EER	SEER	EER	SEER	EER	
EER 11 Rated Packaged Rooftop AC	-	10.8	-	10.92	-	-	100%
EER 11 Rated Packaged Rooftop AC	-	10.8	-	12	-	-	100%
SEER 13 Rated Packaged Rooftop AC	13	-	13.2	-	14	-	0%
SEER 14 Rated Packaged Rooftop AC	13	-	14	-	14	-	0%
SEER 13 Rated Split System AC	13	-	13.2	-	13	-	100%
SEER 15 Rated Split System AC	13	-	15	-	13	-	100%
SEER 15 Rated Split System AC	13	-	18	-	13	-	100%
SEER 21 Rated Split System AC	13	-	21	-	13	-	100%
EER 11 Rated Packaged Rooftop HP	-	10.4	-	11.2	-	-	100%
SEER 14 Rated Packaged Rooftop HP	13	-	14	-	14	-	0%
SEER 15 Rated Packaged Rooftop HP	13	-	15	-	14	-	46%
SEER 14. Rated Split System HP	13	-	14.17	-	14	-	13%
SEER 14 Rated Split System HP	13	-	14.5	-	14	-	31%
SEER 15 Rated Split System HP	13	-	15	-	14	-	46%
SEER 22 Rated Split System HP	13	-	22	-	14	-	81%
Direct Evaporative Cooler			483 kWh savings/yr		384 kWh savings/yr		21%
Direct Evaporative Cooler			1517 kWh savings/yr		None		100%

Sources:

1. *http://www.energy.ca.gov/2012publications/CEC-400-2012-019/CEC-400-2012-019-CMF.pdf, Tables C-2 and C-3*
2. *http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75*

Table D-6. Impact Percentages for CFL/LED Measures

			Measure Efficiency	2013 Standard	New Standard	% Impact
				Title 20	Title 20 (Effective 1/1/2018)	
Measure Name	Measure lamp type	Baseline lamp type	Watts	Watts	Watts	%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	Indoor CFL Lamp (Screw-In < 25W)	48W Incandescent	13.5	48.19	13.5	0%
Lighting - Compact Fluorescent Fixture (Outdoor)	CFL Outdoor Fixture, 16W	82W Incandescent	16	82	16	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	CFL Screw-In Indoor Lamp, 17.5W	46W Incandescent	17.5	46	17.5	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Outdoor)	CFL Screw-In Outdoor Lamp, 17.5W	47W Incandescent	17.5	47	17.5	0%
Lighting - Compact Fluorescent Fixture (Indoor)	CFL Indoor Fixture, 17.5W	57W Incandescent	17.5	57	17.5	0%
Lighting - Compact Fluorescent Fixture (Indoor)	Indoor CFL Fixture (Any Shape Lamp)	23W Incandescent	23	46	23	0%
Lighting - Compact Fluorescent Lamp (Basic High - Outdoor)	CFL Screw-In Outdoor Lamp, 27W	125W Incandescent	27	125	27	0%
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	CFL Screw-In Indoor Lamp, 27W	123W Incandescent	27	123	27	0%
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	Indoor CFL Lamp (Screw-In ≥ 25W)	61W Incandescent	61	217.77	61	0%
Lighting - Plug-In Fixture (Linear Fluorescent)	ES compact fluorescent interior 28W	98.8W Incandescent	17.5	57	17.5	0%
Lighting - Plug-In Fixture (Compact Fluorescent)	ES compact fluorescent interior 28W	98.8W Incandescent	28	98.8	28	0%

			Measure Efficiency	2013 Standard	New Standard	% Impact
Lighting - Plug-In Fixture (Exterior)	Exterior CFL Fixture 39W	137W Incandescent	39	137	39	0%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	LED interior lamp: 7W	48.19W Incandescent	7	48.19	7	0%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	LED Screw-In Indoor Lamp: 13W	46W Incandescent	13	46	13	0%
Lighting - LED Lamp (Reflector - Outdoor) - Emerging	LED Screw-In Outdoor 15.5W	51.5W Incandescent	15.5	51.5	15.5	0%
Lighting - LED Lamp (Basic Low - Outdoor) - Emerging	LED Screw-In Outdoor Lamp: 13W	47W Incandescent	19	47	19	0%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	LED Screw-In Indoor Lamp: 19W	123W Incandescent	19	123	19	0%
Lighting - LED Lamp (Basic High - Outdoor) - Emerging	LED Screw-In Outdoor Lamp: 19W	125W Incandescent	19	125	19	0%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	LED interior lamp: 31W	217.8W Incandescent	31			0%
Lighting - LED Plug-In Outdoor Fixture - Emerging	LED Outdoor Fixture: 5W	82W Incandescent	5	82	5	0%
Lighting - LED Plug-In Indoor Fixture - Emerging	LED interior fixture: 9W	98.8W Incandescent	9	98.8	9	0%
Lighting - LED Plug-In Indoor Fixture - Emerging	LED Indoor Fixture: 9W	57W Incandescent	9	57	9	0%
Lighting - LED Fixture (Replacing T8) - Emerging	LED fixture: 34W	Linear T8	34	59	-	100%
Lighting - Cold Cathode Lamp	Cold cathode lamp 3W	15W Incandescent	16	82	16	0%
Lighting - Exit Fixture (LED)	Lighting - Exit Fixture (LED)	Exit fixture: Single-Sided Code Fixture	4	7.5	-	100%

			Measure Efficiency	2013 Standard	New Standard	% Impact
Lighting - High Intensity Discharge Fixture (from Incandescent)	HID fixture: 208 Watt Mercury Vapor	500W Incandescent	208	500	208	0%
Lighting - High Intensity Discharge Fixture (from Mercury Vapor)	HID fixture: 288 Watt Mercury Vapor	455W Incandescent	288	455	288	0%

The above impacts only apply to measures targeting general service incandescent lamps. While annual lamp energy consumptions depend on lamp wattage and annual, C&S impact percentages only depend on lamp wattages. Therefore, the C&S impact percentages in the above table are applicable to measures targeting single family, multi-family, and nonresidential buildings and indoor and outdoor applications.

Data Sources:

1. http://www.energy.ca.gov/2012publications/CEC-400-2012-019/CEC-400-2012-019-CMF.pdf, K-10

Table D-7. Impact Percentages for Refrigerator Measures

	Effective Standard in 2013	Measure Efficiency	New Standard	% Impact
Source	DOE[1]	MICS	DOE[1] (Effective 9/14/2014)	
Efficiency Metric	Maximum Daily Energy Consumption (kWh/yr)			
Emerging Tech Refrigerator - 20% less energy than code	499	409	449	39%
Emerging Tech Refrigerator - 35% less energy than code	499	332	449	71%

We assumed the average refrigerator volume was 20.5 cu.ft. for standard sized models and 7.75 cu.ft. for compact sized refrigerators, based on Energy Star documentation.

Source:

1. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43

Table D-8. Impact Percentages for Central Furnace Measures

	Effective Standard in 2013	Measure Efficiency	New Standard	% Impact
	DOE[1,2]	MICS	None	
Efficiency Metric	AFUE	AFUE	AFUE	
Gas Furnace	80%	90.6%	-	100%
Gas Furnace - Emerging	80%	98%	-	100%

Sources:

1. http://www.energy.ca.gov/2012publications/CEC-400-2012-019/CEC-400-2012-019-CMF.pdf, *Table E-4*
2. http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/cacfurn_dfr_confirmation.pdf

Table D-9. Impact Percentages for Commercial Boilers Measures

	Effective Standard in 2013	Measure Efficiency	New Standard	% Impact
	Title 20		None	
Efficiency Metric	AFUE[1] or ET[2]	AFUE or ET	AFUE or ET	
High AFUE Efficiency Boiler	80%	94%	-	100%
Standard AFUE Efficiency Boiler	80%	83%	-	100%
High ET Rated Boiler	80%	94%	-	100%
Standard ET Rated Boiler	80%	85%	-	100%

Sources:

1. http://www.energy.ca.gov/2012publications/CEC-400-2012-019/CEC-400-2012-019-CMF.pdf, *Table E-5*
2. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/74

Table D-10. Impact Percentages for High Efficiency Water Heaters

	Effective Standard in 2013 DOE[1]	Measure Efficiency MICS	New Standard DOE[1] (Effective 4/16/2015)	% Impact
Efficiency Metric	AFUE	AFUE	AFUE	
EF Rated Instantaneous Water Heater (Electric)	92%*	93%	82%	100%
EF Rated Instantaneous Water Heater (Gas)	59%*	82%	62%	87%
EF Rated Large Instantaneous Water Heater (Gas)	80%	85%	-	100%
EF Rate Storage Water Heater (Electric)	90%**	93%	94%	0%
EF Rated Storage Water Heater (Gas)	57%**	66%	60%	68%
EF Rated Large Storage Water Heater (Gas)	80%	87%	-	100%
EF Rated Large Storage Water Heater (Gas)	80%	99%	-	100%
EF Rated Storage Water Heater (Gas)	57%**	77%	60%	84%
EF Rated Heat Pump Water Heater	92%***	200%	95%	95%

For instantaneous water heaters, a 2 gallon tank was used in calculating efficiencies. Water heaters with '*' symbol indicate a 40 gallon tank assumption, '**' a 51 gallon tank assumption, and '***' a 37 gallon tank assumption.

Source:

1. *http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27*

D.3 Key Inputs for IOU C&S Claimable Savings

Table D-11 documents the individual C&S included in the PG model; these C&S generate IOU claimable savings. Table D-11 lists C&S name, compliance date, compliance rate, and C&S Policy View. Additional inputs can be found in the PG Model.

Table D-11. Key Inputs for C&S Savings Calculation

C&S Name	Compliance Date	Baseline Complaince Rate	C&S Policy View
2005 T-20: Commercial Refrigeration Equipment, Solid Door	1/1/2006	70%	On-the-books
2005 T-20: Commercial Refrigeration Equipment, Transparent Door	1/1/2007	70%	On-the-books
2005 T-20: Commercial Ice Maker Equipment	1/1/2008	70%	On-the-books
2005 T-20: Walk-In Refrigerators / Freezers	1/1/2006	88%	On-the-books
2005 T-20: Refrigerated Beverage Vending Machines	1/1/2006	37%	On-the-books
2005 T-20: Large Packaged Commercial Air-Conditioners, Tier 1	10/1/2006	70%	On-the-books
2005 T-20: Large Packaged Commercial Air-Conditioners, Tier 2	1/1/2010	0%	On-the-books
2005 T-20: Residential Pool Pumps, High Eff Motor, Tier 1	1/1/2006	100%	On-the-books
2005 T-20: Portable Electric Spas	1/1/2006	70%	On-the-books
2005 T-20: General Service Incandescent Lamps, Tier 1	1/1/2006	68.70%	On-the-books
2005 T-20: Pulse Start Metal Halide HID Luminaires, Tier 1	1/1/2006	100%	On-the-books
2005 T-20: Pulse Start Metal Halide HID Luminaires, Tier 2	1/1/2008	100%	On-the-books
2005 T-20: Modular Furniture Task Lighting Fixtures	1/1/2008	70%	On-the-books
2005 T-20: Hot Food Holding Cabinets	1/1/2006	70%	On-the-books
2005 T-20: External Power Supplies, Tier 1	1/1/2007	100%	On-the-books
2005 T-20: External Power Supplies, Tier 2	7/1/2008	98.70%	On-the-books
2005 T-20: Consumer Electronics - Audio Players	1/1/2007	100%	On-the-books
2005 T-20: Consumer Electronics - TVs	1/1/2006	96.10%	On-the-books
2005 T-20: Consumer Electronics - DVDs	1/1/2006	31%	On-the-books
2005 T-20: Water Dispensers	1/1/2006	70%	On-the-books
2005 T-20: Unit Heaters and Duct Furnaces	1/1/2006	100%	On-the-books
2005 T-20: Commercial Dishwasher Pre-Rinse Spray Valves	1/1/2006	100%	On-the-books
2006 T-20: Residential Pool Pumps, 2-speed Motors, Tier 2	1/1/2008	93.60%	On-the-books
2006 T-20: General Service Incandescent Lamps, Tier 2	1/1/2008	43.60%	On-the-books
2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Residential	1/8/2008	84.57%	On-the-books
2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Commercial	1/8/2008	84.57%	On-the-books
2008 T-20: Metal Halide Fixtures	1/1/2010	84.57%	On-the-books
2008 T-20: Portable Lighting Fixtures	1/1/2010	84.57%	On-the-books
2008 T-20: General Purpose Lighting -- 100 watt	1/1/2011	84.57%	On-the-books
2008 T-20: General Purpose Lighting -- 75 watt	1/1/2012	84.57%	On-the-books
2008 T-20: General Purpose Lighting -- 60 and 40 watt	1/1/2013	84.57%	On-the-books
2009 T-20: Televisions - Tier 1	1/1/2011	84.57%	On-the-books
2009 T-20: Televisions - Tier 2	1/1/2013	84.57%	On-the-books
2011 T-20: Battery charger - consumer - Tier 1	2/1/2013	84.57%	On-the-books

C&S Name	Compliance Date	Baseline Complaince Rate	C&S Policy View
2011 T-20: Battery charger - large - Tier 1	1/1/2014	84.57%	On-the-books
2011 T-20: Battery charger - large - Tier 2 incremental	1/1/2017	84.57%	On-the-books
Future T-20: Air Filter Labeling	1/1/2016	84.57%	Expected
Future T-20: Commercial Clothes Dryers	1/1/2016	84.57%	Expected
Future T-20: Computers - Tier 1 | Desktops, Notebooks	6/1/2016	84.57%	Expected
Future T-20: Dimming Ballasts	1/1/2016	84.57%	Expected
Future T-20: Electronic Displays	1/1/2016	84.57%	Expected
Future T-20: Faucets (Residential)- Gas Water Heaters	1/1/2016	84.57%	Expected
Future T-20: Faucets (Residential)- Electric Water Heaters	1/1/2016	84.57%	Expected
Future T-20: Game Consoles (Tier 1)	1/1/2016	84.57%	Expected
Future T-20: Game Consoles (Tier 2)	1/1/2019	84.57%	Expected
Future T-20: Pool Pumps & Spas	1/1/2016	84.57%	Expected
Future T-20: Set Top Boxes (Tier 1)	1/1/2016	84.57%	Expected
Future T-20: Small Diameter Directional Lamps (Tier 1)	1/1/2016	84.57%	Expected
Future T-20: Small Diameter Directional Lamps (Tier 2)	1/1/2016	84.57%	Expected
Future T-20: Small Network Equipment	1/1/2016	84.57%	Expected
Future T-20: Toilets (Commercial)	1/1/2016	84.57%	Expected
Future T-20: Toilets (Residential)	1/1/2016	84.57%	Expected
Future T-20: Urinals	1/1/2016	84.57%	Expected
Future T-20: Water Meters	1/1/2016	84.57%	Expected
Fed Appliance: Electric Motors 1-200HP	12/19/2010	95%	On-the-books
Fed Appliance: Refrigerated Beverage Vending Machines	8/31/2011	95%	On-the-books
Fed Appliance: Commercial Refrigeration	1/1/2012	95%	On-the-books
Fed Appliance: Residential Electric & Gas Ranges	4/9/2012	95%	On-the-books
Fed Appliance: General Service Fluorescent Lamps	7/14/2012	95%	On-the-books
Fed Appliance: Incandescent Reflector Lamps	7/25/2012	95%	On-the-books
Fed Appliance: Commercial Clothes Washers	1/8/2013	95%	On-the-books
Fed Appliance: Residential Pool Heaters	4/16/2013	95%	On-the-books
Fed Appliance: Residential Direct Heating Equipment	4/16/2013	95%	On-the-books
Fed Appliance: Residential Refrigerators & Freezers	9/15/2014	95%	On-the-books
Fed Appliance: Residential Room AC	6/1/2014	95%	On-the-books
Fed Appliance: Flourescent Ballasts	11/14/2014	95%	On-the-books
Fed Appliance: Residential Clothes Dryers	1/1/2015	95%	On-the-books
Fed Appliance: Residential Gas Fired Water Heaters	4/16/2015	95%	On-the-books
Fed Appliance: Residential Electric Storage Water Heaters	4/16/2015	95%	On-the-books

C&S Name	Compliance Date	Baseline Complaince Rate	C&S Policy View
Fed Appliance: Residential Gas Instant Water Heaters	4/16/2015	95%	On-the-books
Fed Appliance: Residential Oil Fired Water Heaters	4/16/2015	95%	On-the-books
Fed Appliance: Small Electric Motors	3/9/2015	95%	On-the-books
Fed Appliance: Residential Clothes Washers (Front Loading)	3/7/2015	95%	On-the-books
Fed Appliance: Residential Clothes Washers (Top Loading) Tier I	3/7/2015	95%	On-the-books
Fed Appliance: Residential Clothes Washers (Top Loading) Tier II	1/1/2018	95%	On-the-books
Fed Appliance: Residential Central AC and Heat Pumps	1/1/2015	95%	On-the-books
Fed Appliance: External Power Supplies	3/1/2015	95%	Possible
Fed Appliance: Battery Chargers	3/1/2015	95%	Possible
Fed Appliance: Walk-in Coolers & Freezers	12/1/2016	95%	Possible
Fed Appliance: Distribution Transformers	6/1/2016	95%	Possible
Fed Appliance: Commercial Refrigeration (Cycle 2)	1/1/2017	95%	Possible
Fed Appliance: Metal Halide Lamp Fixtures	4/1/2017	95%	Possible
Fed Appliance: High-Intensity Discharge Lamps	6/1/2017	95%	Possible
Fed Appliance: General Service Fluorescent Lamps	7/1/2017	95%	Possible
2005 T-24: Time dependent valuation, Residential	1/1/2006	0%	On-the-books
2005 T-24: Time dependent valuation, Nonresidential	8/1/2006	0%	On-the-books
2005 T-24: Duct improvement	1/1/2006	59%	On-the-books
2005 T-24: Window replacement	1/1/2006	80%	On-the-books
2005 T-24: Lighting controls under skylights	1/1/2006	8.30%	On-the-books
2005 T-24: Ducts in existing commercial buildings	8/1/2006	75%	On-the-books
2005 T-24: Cool roofs	1/1/2006	75%	On-the-books
2005 T-24: Relocatable classrooms	8/1/2006	100%	On-the-books
2005 T-24: Bi-level lighting control credits	1/1/2006	78.70%	On-the-books
2005 T-24: Duct testing/sealing in new commercial buildings	1/1/2006	81.50%	On-the-books
2005 T-24: Cooling tower applications	1/1/2006	87.50%	On-the-books
2005 T-24: Multifamily Water Heating	1/1/2006	78.10%	On-the-books
2005 T-24: Composite for Remainder - Res	1/1/2006	120%	On-the-books
2005 T-24: Composite for Remainder - NonRes	1/1/2006	85.30%	On-the-books
2005 T-24: Whole Building - Res New Construction (Electric)	1/1/2006	120%	On-the-books
2005 T-24: Whole Building - Res New Construction (Gas)	1/1/2006	235%	On-the-books
2008 T-24: Envelope insulation	10/1/2010	70%	On-the-books
2008 T-24: Overall Envelope Tradeoff	10/1/2010	83.40%	On-the-books
2008 T-24: Skylighting	10/1/2010	83.40%	On-the-books
2008 T-24: Sidelighting	10/1/2010	83.40%	On-the-books

C&S Name	Compliance Date	Baseline Complaince Rate	C&S Policy View
2008 T-24: Tailored Indoor lighting	10/1/2010	70%	On-the-books
2008 T-24: TDV Lighting Controls	10/1/2010	83.40%	On-the-books
2008 T-24: DR Indoor Lighting	10/1/2010	83.40%	On-the-books
2008 T-24: Outdoor Lighting	10/1/2010	83.40%	On-the-books
2008 T-24: Outdoor Signs	10/1/2010	83.40%	On-the-books
2008 T-24: Refrigerated warehouses	10/1/2010	83.40%	On-the-books
2008 T-24: DDC to Zone	10/1/2010	83.40%	On-the-books
2008 T-24: Residential Swimming pool	7/1/2010	70%	On-the-books
2008 T-24: Site Built Fenestration	10/1/2010	83.40%	On-the-books
2008 T-24: Residential Fenestration	7/1/2010	83.40%	On-the-books
2008 T-24: Cool Roof Expansion	10/1/2010	70%	On-the-books
2008 T-24: MF Water heating control	9/1/2010	83.40%	On-the-books
2008 T-24: Composite for Remainder	9/1/2010	70%	On-the-books
2013 T-24 - Single family NC	7/1/2014	83.40%	On-the-books
2013 T-24 - Multi-family NC	9/1/2014	83.40%	On-the-books
2013 T-24 - Nonres NC	10/1/2014	83.40%	On-the-books
2013 T-24 - others	9/1/2014	70%	On-the-books
2016 T-24 - Single family NC	7/1/2017	83.40%	Expected
2016 T-24 - Multi-family NC	9/1/2017	83.40%	Expected
2016 T-24 - Nonres NC	10/1/2017	83.40%	Expected
2019 T-24 - Single family NC	7/1/2020	83.40%	Possible
2019 T-24 - Multi-family NC	9/1/2020	83.40%	Possible
2019 T-24 - Nonres NC	10/1/2020	83.40%	Possible
2022 T-24 - Single family NC	7/1/2023	83.40%	Possible
2022 T-24 - Multi-family NC	9/1/2023	83.40%	Possible
2022 T-24 - Nonres NC	10/1/2023	83.40%	Possible

Source: Navigant team analysis, 2013.

Appendix E Analysis of Whole-Building Initiatives

Whole-building initiatives aim to deliver savings to residential and commercial customers as a group of multiple efficiency measures that are all installed at the same time. 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; the goal is to have the project install multiple efficiency measures that exceed minimum requirements for Title 24 building code. This approach 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 exceeding code by 15% to constructing a Zero Net Energy (ZNE) home or building.

» Retrofit: Whole-building initiatives that aim to influence the whole house and whole-building renovation projects; the goal is to install multiple efficiency measures at the time of renovation. This approach 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.

The whole-building initiatives included in the PG model are listed in Table E-1.

Table E-1. 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 E-1 using input data from various sources including the following:

» Navigant team analysis of CEC Title 24 building code analysis[54] provided data to characterize commercial and residential New Construction Level 1-3
» Energy Upgrade California (EUC) residential program reports and CPUC analysis[55] of those reported savings provided data for the three residential Renovation Energy Upgrade California measures
» PG&E's technical feasibility of ZNE study[56] provide 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 rest of this appendix provides details on the analysis of each whole-building measure listed in Table E-1.

[54] 2013 Title 24 CASE Analysis and CEC Analysis as presented at CEC pre-rulemaking workshop on July 15, 2011. Package A3.
[55] CPUC. *Advanced Path Disposition Cover Letter*. March 2013
[56] ARUP. *The Technical Feasibility of Zero Net Energy Buildings in California*. Prepared for PG&E. December 2012

E.1 Approach to Modeling non-ZNE New Construction Initiatives

This section describes the sources and methodology for the following whole building initiatives:

» Residential New Construction Level 1
» Residential New Construction Level 2
» Residential New Construction Level 3
» Commercial New Construction Level 1
» Commercial New Construction Level 2
» Commercial New Construction Level 3

E.2 Approach to Residential New Construction

The PG Model uses the same approach and inputs for residential new construction measures as the 2011 Potential Study. This section provides a summary of the approach and inputs. For additional details, see the 2011 Potential Study.

To estimate energy savings potential in this study, the Navigant team used the measures and technologies proposed for the 2013 Title 24 (Part 6) building energy codes update. In order to meet the EE Strategic Plan's stated goals of ZNE residential buildings by 2020, the CEC target is at least a 15% improvement over the existing code in each code cycle.

Energy Savings were estimated for three levels compared to 2005 Title 24 Baseline:

» Level 1: defined as the 2008 Title 24
» Level 2: defined as the 2013 Title 24, Part 6 base code
» Level 3: defined as the proposed 2013 Title 24, Part 11 reach code (Tier 1)

Savings are expressed as savings per prototypical home, as described below. Savings were initially calculated by climate zone and subsequently rolled into utility service territory specific savings.

E.2.1 Level 1 – 2008 Title 24 Compliant Building

Level 1 energy savings and costs were taken from the CEC's Impact Analysis 2008 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings prepared by AEC, November 7, 2007.[57]

The impact of implementing the residential envelope, HVAC, and water heating measures of the 2008 Standards as compared to the 2005 Standards was estimated using a prototype approach. The single-family prototype was made to minimally comply with the 2005 and 2008 Standards. The changes to the Standards (2005 to 2008) that are assumed to result in savings are as follows:

» Residential Fenestration: The fenestration requirements are lower U-factor and solar heat gain coefficient (SHGC). The U-factor was reduced to 0.40 Btu/(hr x ft2 x deg F) in all climate zones from 0.57 Btu/(hr x ft2 x deg F) in climate zones 1-2, 10-15 and from 0.67 Btu/(hr x ft2 x deg F) in climate zones 3-9 and 0.55 Btu/(hr x ft2 x deg F) in climate zone 16. SHGC was reduced from 0.40 to 0.35 in climate zone 15 and was changed from 'not required' to 0.40 in climate zones 5 and

[57] http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF

6. SHGC is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation.

» Cool Roofs: Requires cool roofs with a minimum aged reflectance of 0.25 in climate zones 10,11,13,14, and 15. The default aged reflectance is 0.08. Solar Reflectance is the ratio of the reflected solar flux to the incident solar flux. Aged solar reflectance is the ratio for a cool roof that has been exposed to the elements for three years and thus has a lower reflectance than the same product when initially installed.

» Residential Indoor Air Quality (IAQ) Ventilation: This measure requiring mechanical ventilation adopts requirements of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 62.2-2007, requiring that residential buildings have mechanical ventilation, such as a whole-house exhaust, or ducted supply system.

To provide average energy and demand savings per single-family (SF) home for the PG Model, the Navigant team calculated savings by dividing total savings by house starts. The resulting first-year electricity and gas and savings are shown in the last three columns of Table E-2.

Table E-2. Level 1 (15%) Average Statewide Savings per Single-Family House

		Total Energy and Demand Savings			Average Savings per SF house		
Climate Zone	SF Housing Starts	Electricity (MWh)	Demand (MW)	Gas Savings (MBTh)	Electricity (kWh)	Demand (kW)	Gas Savings (Therms)
1	422	47	0.02	3,759	111	0.05	89
2	2,351	738	0.33	19,245	314	0.14	82
3	3,486	355	0.46	29,566	102	0.13	85
4	3,081	414	-0.09	29,923	134	-0.03	97
5	996	261	1.22	1,676	262	1.22	17
6	3,103	920	3.92	1,119	296	1.26	4
7	2,805	(87)	0.1	13,535	(31)	0.04	48
8	4,454	542	0.17	22,561	122	0.04	51
9	4,226	1,212	0.91	21,867	287	0.22	52
10	18,661	12,828	4.75	79,886	687	0.25	43
11	6,433	5,855	1.88	55,045	910	0.29	86
12	18,641	10,587	4.03	147,352	568	0.22	79
13	14,095	17,879	3.47	85,707	1,268	0.25	61
14	12,300	14,328	4.99	107,981	1,165	0.41	88
15	9,472	30,142	6.64	16,882	3,182	0.70	18
16	3,494	1,891	0.66	48,352	541	0.19	138
Total	108,020	97,912	33.46	684,456	906	0.31	63

Source: Impact Analysis 2008 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings prepared by AEC, November 7, 2007.58 Tables 1, 9 and 11.

[58] http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF

E.2.2 Level 2 – 2013 Title 24 Compliant Building

Level 2 savings and costs were estimated based on the 2013 Codes and Standards Enhancement (CASE) reports, completed by the IOUs, and submitted to the CEC in September 2011. The 2013 code update represents more than a 20% improvement over 2008 Title 24 in terms of source energy savings, though the savings vary by climate zone. Because utility new construction incentive programs are designed to ready the market for the next code cycle, using the 2013 code proposals to represent current (2010/2011) new construction program measures and opportunities is a logical approach. The 2013 code update savings and associated incremental costs are documented in CASE reports submitted to the CEC by the IOUs.

Level 2 measures include the following:

- Ceiling and roof deck insulation
- Radiant barrier
- Cool roof
- Wall insulation
- Windows
- Quality Insulation Installation (QII)
- Duct insulation
- Reduced infiltration
- Reduced duct leakage/tighter ducts
- Whole-house fan
- High-efficiency air conditioner
- High-efficiency furnace
- High-efficiency water heater
- Water heater pipe insulation

The Level 2 measures result in per single-family house savings and associated costs as shown in Table E-3.

Table E-3. Level 2 (25%) Average Statewide Savings per Single-Family House

Climate Zone	kWh	kW	Therms	Added Cost
1	187.26	-	69.38	$ 2,159
2	299.10	0.32	78.48	$ 2,415
3	156.88	0.15	62.68	$ 2,004
4	369.64	0.64	49.78	$ 1,759
5	217.99	-	147.58	$ 2,004
6	294.42	0.54	39.52	$ 2,041
7	202.78	0.47	27.34	$ 2,041
8	530.73	1.17	32.58	$ 2,335
9	890.37	1.60	41.06	$ 3,364
10	1,000.59	1.66	54.85	$ 3,820
11	1,298.44	1.59	78.41	$ 3,820
12	867.21	1.55	78.04	$ 3,820
13	1,356.77	1.45	73.96	$ 3,820
14	1,094.66	1.31	60.56	$ 3,564
15	1,907.42	1.55	31.55	$ 3,613
16	816.36	1.45	(14.11)	$ 2,159

Source: 2013 Title 24 CASE Analysis and CEC Analysis as presented at CEC pre-rulemaking workshop on July 15, 2011[59]. Package A3.

E.2.3 Level 3 – 2013 Title 24 Stretch Goal Compliant Building

Level 3 savings and costs were estimated based on the 2013 CASE reports, completed by the IOUs, and submitted to the CEC in September 2011. For the residential new construction program, the Navigant team was able to use the California Reach Standards (Title 24, Part 11) to represent a 30% improvement over the base (2005 Title 24). The 2013 Reach code, which can be implemented by local jurisdictions as part of CALGreen, represents more than a 15% improvement over the base 2013 Title 24 (Part 6) requirements. The Level 3 measures result in per single-family house savings and associated costs as shown in Table E-4.

[59] http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-07-15_workshop/presentations/02_Res_PackageA.pdf

Table E-4. Level 3 (30%) Average Statewide Savings per Single-Family House

Climate Zone	kWh	kW	Therms	Added Cost
1	266.66	-	154.87	$ 4,953
2	407.88	0.41	163.76	$ 5,414
3	228.61	0.17	137.33	$ 5,503
4	406.87	0.95	140.18	$ 5,954
5	296.24	-	232.49	$ 5,660
6	366.33	0.63	84.81	$ 5,544
7	240.54	0.54	44.06	$ 4,476
8	679.43	1.56	67.68	$ 5,839
9	1,073.47	1.96	80.66	$ 5,954
10	1,183.38	1.96	91.44	$ 5,754
11	1,566.56	1.85	115.25	$ 5,853
12	981.24	1.72	116.53	$ 5,303
13	1,658.38	1.74	105.71	$ 5,853
14	1,300.19	1.53	95.50	$ 5,446
15	2,083.06	1.78	34.65	$ 4,906
16	949.33	1.55	89.21	$ 4,924

Source: 2013 Title 24 CASE Analysis and CEC Analysis as presented at CEC pre-rulemaking workshop on July 15, 2011[60]. Package A1.

E.2.4 Rollup Savings to IOU Territory

The Navigant team converted the savings expressed as savings per home by climate zone to savings per home by utility territory for the PG Model using the following methodology. The CEC climate zones were first mapped to CEC forecast zones using information available from the CEC forecast. The forecast climate zones were then mapped to utility territories using a forecast zone-to-ZIP code mapping. Thus, each CEC climate zone was mapped to one or more utilities based on the number of ZIP codes served by each utility. Since this study is limited to the IOU programs, the areas/ZIP codes not served by IOU were excluded from the mapping exercise; thus, the total of savings for all IOU combined is less than the total for all climate zones in the tables above.

E.3 Approach to Commercial New Construction

The PG Model uses the same approach and inputs for commercial new construction measures as the 2011 Potential Study. This section provides a summary of the approach and inputs. For additional details, see the 2011 Potential Study. The PG Model adds a measure not included in the 2011 Potential study (Level 3) which is described in this section.

[60] http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-07-15_workshop/presentations/02_Res_PackageA.pdf

Energy savings were estimated for three levels compared to 2005 Title 24 Baseline:

- Level 1: defined as the 2008 Title 24
- Level 2: defined as 2013 Title 24, Part 6 base code
- Level 3: estimated as a building incrementally better than 2013 Title 24

Savings are expressed as savings per square foot.

E.3.1 Level 1 – 2008 Title 24 Compliant Building

The Level 1 savings estimates from Itron's 2008 energy efficiency potential study were used for the Level 1 energy savings and incremental costs. Because Level 1 represents current code (implemented in 2010), the actual savings potential from the new construction program is zero. For this reason, the team assumed that the existing estimates are valid and no further refinement was warranted for this update analysis.

The Level 1 measures result in the per-square-foot savings and associated costs as shown in Table E-5. Measures designed as "load avoidance" strategies, such as efficient lighting, high-performance glazing, cool roofs, and demand-controlled ventilation, can reduce the peak cooling loads and size of the mechanical systems. The cost savings resulting from downsizing HVAC systems were included in the 2008 potential study and in some climate zones completely offset or exceeded the incremental costs of the measures, as indicated by a negative number in the incremental cost column.

Table E-5. Level 1 (15%) Average Statewide Savings

	Savings per Sq Ft		
Climate Zone	Electric Savings (kWh)	Gas Savings (Therms)	Incremental Cost per Sq Ft
1	2.08	0.04	($0.63)
2	2.08	0.04	($0.63)
3	2.08	0.04	($0.63)
4	2.08	0.04	($0.63)
5	2.08	0.04	($0.63)
6	2.28	0.02	($0.91)
7	2.28	0.02	($0.91)
8	1.61	0.02	($0.20)
9	1.61	0.02	($0.20)
10	1.61	0.02	($0.20)
11	1.39	0.01	$0.36
12	1.39	0.01	$0.36
13	1.39	0.01	$0.36
14	1.39	0.01	$0.36
15	1.39	0.01	$0.36
16	2.08	0.04	($0.63)

Source: 2008 California Energy Efficiency Potential Study, CALMAC Study ID: PGE0264.01. Tables F-22 through F-25

E.3.2 Level 2 – 2013 Title 24 Compliant Building

To estimate the Level 2 energy savings potential, the Navigant team used the measures and technologies in the 2013 Title 24 (Part 6) building energy codes update. In order to meet the California Strategic Plan's stated goals of ZNE nonresidential buildings by 2030, the CEC target is a 15% improvement over the existing code in each code cycle. The 2013 code update represents a 15% improvement over 2008 Title 24.

Because utility new construction incentive programs are designed to ready the market for the next code cycle, using the 2013 code proposals to represent current (2010/2011) new construction program measures and opportunities is a logical approach. The 2013 code update savings and associated incremental costs are documented in CASE reports submitted to the CEC by the IOUs. Level 2 savings and costs were estimated based on the 2013 CASE reports applied to the same building types as the 2008 potential study for consistency. Level 2 measures include the following:

» Glazing update
» Cool roof
» Daylighting - side lighting and top lighting
» Indoor lighting including lower LPDs and lighting controls
» Package HVAC controls and economizers
» Built-up HVAC controls
» Refrigerated warehouse insulation and equipment controls (Refr. WHS)
» Supermarket refrigeration equipment efficiency requirements and controls
» Hotel guest room occupancy sensors for HVAC and lighting controls

The measures are mapped to the building types, as shown in Table E-6.

Table E-6. Mapping of Measures to Building Type

Building Type	Glazing	Cool Roofs	Daylighting	Indoor Lighting	Package HVAC	Built-Up HVAC	Refrig. WHS	Super-markets	Hotel Guest Room Occ. Sensors
College	X	X	X	X	X	X			
Grocery		X	X	X	X	X	X	X	
Hospital	X	X			X				
Hotel	X	X	X	X	X				X
Large Office	X	X	X	X	X	X			
Ref. Warehouse		X	X	X	X		X		
Restaurant	X	X	X	X	X	X			
Retail	X	X	X	X	X	X			
School	X	X	X	X	X	X			
Small Office	X	X	X	X	X	X			
Warehouse		X	X	X	X	X			
Misc.	X		X	X	X	X			

Source: Navigant team analysis, 2013

The Level 2 measures result in per-square-foot savings and associated costs as shown in Table E-7.

Table E-7. Level 2 Average Statewide Savings

	Savings per Sq Ft			
Climate Zone	Electric Savings (kWh)	Peak Electric Savings (kW)	Gas Savings (Therms)	Incremental Cost per Sq Ft
1	2.80	0.00054	0.07	$0.39
2	2.52	0.00012	0.05	$0.39
3	2.54	0.00023	0.04	$0.39
4	2.48	0.00025	0.05	$0.39
5	2.27	0.00029	0.05	$0.39
6	2.55	0.00030	0.04	$0.39
7	2.64	0.00030	0.03	$0.39
8	2.53	0.00028	0.03	$0.39
9	2.33	0.00025	0.03	$0.39
10	2.50	0.00029	0.03	$0.39
11	2.53	0.00030	0.03	$0.39
12	2.39	0.00026	0.02	$0.39
13	2.48	0.00027	0.02	$0.39
14	2.39	0.00031	0.02	$0.39
15	2.43	0.00035	0.04	$0.39
16	3.07	0.00038	0.07	$0.39

Source Data: 2013 Title 24 CASE analysis reports posted on CEC website at http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/ with additional HMG analysis

E.3.3 Level 3 – Incrementally Better than 2013 Title 24

To estimate savings and costs for Level 3, the Navigant team extrapolated costs and savings from Level 1 and Level 2 to estimate an incrementally higher tier of savings. The savings were estimated by climate zone using the following equation:

Level 3 Savings = Level 2 Savings + (Level 2 savings – Level 1 savings)

Costs were estimated by calculating the average cost per kWh saved for Level 1 and Level 2 and linearly extrapolating the cost for Level 3 (given the estimated savings for Level 3). An additional 50% cost adder was used assuming the marginal cost of new construction energy efficiency savings increases as higher savings are sought.

The resulting data used in the PG Model is summarized below in Table E-8.

Table E-8. Level 3 Average Statewide Savings

Climate Zone	Savings per Sq Ft: Electric Savings (kWh)	Savings per Sq Ft: Peak Electric Savings (kW)	Savings per Sq Ft: Gas Savings (Therms)	Incremental Cost per Sq Ft
1	3.52	0.00108	0.10	$1.58
2	2.96	0.00024	0.06	$1.58
3	3.00	0.00046	0.04	$1.58
4	2.88	0.00050	0.06	$1.58
5	2.46	0.00058	0.06	$1.58
6	2.82	0.00060	0.06	$1.58
7	3.00	0.00060	0.04	$1.58
8	3.45	0.00056	0.04	$1.58
9	3.05	0.00050	0.04	$1.58
10	3.39	0.00058	0.04	$1.58
11	3.67	0.00060	0.05	$1.58
12	3.39	0.00052	0.03	$1.58
13	3.57	0.00054	0.03	$1.58
14	3.39	0.00062	0.03	$1.58
15	3.47	0.00070	0.07	$1.58
16	4.06	0.00076	0.10	$1.58

Source: Navigant team analysis, 2013

E.4 Approach to Modeling ZNE New Construction Initiatives

This section describes the data sources and methodology for the following whole building initiatives:

- Commercial New Construction ZNE
- Residential New Construction ZNE

In its simplest definition, a building achieves ZNE by maximizing energy efficiency measures and deploying on-site generation to produce energy equivalent to the remaining building energy consumption. A deeper dive into the definition of ZNE requires considerations of the time that energy is used and the fuel types consumed (electric vs. gas). Time-Dependent Valuation (TDV) is a measure of energy consumption that considers time of use and fuel type, such that electricity used during peak hours is measured as higher consumption than off-peak electric use. TDV is expressed in terms of kBTU; it provides a single measure for considering both gas and electric consumption. The CEC and CPUC use TDV as the key measure in their consideration of ZNE. Under this more precise definition, a building has reached ZNE status when annual net TDV has reached zero kBTU, accounting for consumption and production from both gas and electric. This definition allows for a building to be a net producer of electricity (with a negative annual kWh consumption value) and a net consumer of gas, while still being classified as ZNE if the TDV kBTU values of both fuel types combined sum to zero annually.

The California Long Term Energy Efficiency Strategic Plan set goals for achieving ZNE in all residential new construction by 2020, and in all commercial new construction by 2030.[61] The CEC and CPUC have adopted these goals as part of their planning, through the Integrated Energy Policy Report (IEPR) and regulatory measures.[62]

E.4.1 ZNE Data Sources

The CEC is currently working to set Title 24 codes that will incorporate the ZNE goals for residential new construction. One option under consideration is to move to building-performance-based codes requiring the level of energy savings needed for buildings to achieve ZNE. As part of this effort to update codes, the CEC is considering the total building loads and energy savings under the projected 2016 and 2019 codes, across multiple residential and commercial building types and all California climate zones. Under its current jurisdiction, Title 24 may not be able to require full achievement of ZNE. Title 24 only regulates a portion of building loads and may remain unable to require savings within un-regulated end uses (e.g., appliances and plug loads, which often fall under federal code jurisdiction). As such, the Navigant team expects ZNE savings to be achieved through a combination of mandatory and voluntary programs.

In addition to the work being conducted by the CEC, the architectural firm ARUP (on behalf of California's IOUs) has prepared a study titled "The Technical Feasibility of Zero Net Energy Buildings."[63] The study aims to test the technical feasibility of achieving the ZNE goal in 12 residential and commercial building types across seven wide-ranging California climate zones. The study uses California-calibrated building simulation models to:

- Analyze the energy savings from all available energy efficiency measures that meet a cost-effectiveness test.
- Determine the maximum installable capacity of solar photovoltaic panels, for each building type, to indicate what portion of net energy consumption can be reduced, in each climate zone.
- Project the cost per square foot of the measures installed.

An illustration of the type of data available from the ARUP study can be found in Figure E-1, Figure E-2, and Figure E-3.

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[61] California Public Utilities Commission. "Long Term Strategic Energy Efficiency Plan, January 2011 Update". 2011. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

[62] California Public Utilities Commission. "2012 Integrated Energy Policy Report Update". Draft Lead Commissioner Report. 2012.

[63] ARUP (on behalf of Pacific Gas & Electric Company). "The Technical Feasibility of Zero Net Energy Buildings in California". Draft Report. ZNE/219664. 2013.

Figure E-1. Example of Building Prototype Information and Baseline Load by Climate Zone, ARUP 2013

Single Family Residential

Size: **2,116** ft^2

Number of Floors: **1** floor

		Climate Zones						
		15	**13**	**12**	**10**	**7**	**3**	**16**
Site-kBtu /ft^2	**Load:**	12.9	16.4	16.6	12.9	11.5	12.7	17.3
	Solar:	-12.9	-16.4	-16.6	-12.9	-11.5	-12.7	-17.3
	Net:	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
TDV$/ft^2 (30yr NPV)	**Load:**	12.23	9.66	9.77	8.74	8.01	7.97	10.32
	Solar:	-12.23	-9.66	-9.77	-8.74	-8.01	-7.97	-10.32
	Net:	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Source: ARUP 2013

Figure E-2. Example of Energy Efficiency Measure Implementation Log, Results, and Costs Table, ARUP 2013

Single Family Residential Change Log — CZ12 Sacramento

	Strategy *(Baseline is T24 2013 Unless Noted Otherwise)*	kBtu/ft2 savings	TDV$/ft2 (30yr) savings	TDV$ reduction
	Starting EUI:	30.4	18.4	0%
1	Improved Wall Construction: 2x6 walls, R-21 w/ R-4 rigid ext. sheathing. Advanced framing, 24" o.c.	-1.94	-1.15	6%
2	Ceiling Insulation: R-60 blown-in insulation w/ raised heel trusses	-0.43	-0.23	7%
3	Reduced Building Infiltration: 1.8 SLA / 3.15 ACH50	-0.91	-0.24	9%
4	Improved Windows: U-Factor=0.25 / SHGC=0.20	-0.78	-0.16	10%
5	Cool Roof: Reflectivity=0.40 / Emissivity=0.85	0.06	-0.14	10%
6	Additional Thermal Mass	-0.15	-0.20	11%
7	Improved Lighting: High efficacy LED lighting and vacancy controls	-1.32	-2.20	23%
8	High Efficiency Appliances: Clothes washer, Dishwasher, Refrigerator	-1.12	-0.52	26%
9	Reduced Plug Loads & Plug Load Control 20%	-0.71	-1.09	32%
10	Low-Flow Shower & Sinks	-1.84	-0.49	34%
11	Ducts in Conditioned Space	-0.86	-0.54	37%
12	High Efficiency 2-speed AC, SEER 21 w/ Integrated Ventilation Cooling	-0.23	-0.55	40%
13	Condensing Gas Space Heating	-0.78	-0.22	42%
14	Condensing Gas Water Heater	-2.53	-0.85	46%
15	Improved HW Distribution: Compact Design, Insulated HW Pipes	-0.18	-0.06	46%
16	Rooftop PV (see "Solar PV (kW)" in "Building Performance Data" table for PV system sizes)	-16.65	-9.77	100%
	Ending EUI:	0.0	0.00	

Total TDV$ Savings:	-$18.43
Incremental First Cost:	$9.25*
Net Life Cycle Cost:	-$9.19*

Source: ARUP 2013

Figure E-3. Example of Building Performance After Efficiency and Solar Measures, ARUP 2013

Building Performance Data — *Single Family Residential*

Square feet: **2,116**

Avail. Roof: **1,040**

Total Building Energy Metrics		Climate Zone 15	13	12	10	7	3	16
kWh/ft²	Load	2.57	2.02	1.87	1.90	1.82	1.69	1.85
	Minimized Site-kBtu	-1.21	-2.79	-3.01	-1.89	-1.56	-2.04	-3.21
	Minimized TDV	-0.59	-0.38	-0.55	-0.22	-0.13	-0.17	-0.71
kW/bldg (250 hr method)	Load	1.59	0.46	0.51	0.63	0.44	0.42	0.76
	Minimized Site-kBtu	0.23	-1.86	-1.84	-0.93	-0.96	-1.52	-1.66
	Minimized TDV	0.45	-0.70	-0.66	-0.25	-0.37	-0.55	-0.46
Therms/ft²	Load	2.57	2.02	1.87	1.90	1.82	1.69	1.85

Source: ARUP 2013

E.4.2 ZNE Technical Methodology

This study models ZNE achievement through a combination of mandatory and voluntary programs. Title 24 will require a certain level of efficiency improvement that moves California buildings towards the ZNE goal, but Title 24 may not fully achieve the ZNE goal. Voluntary utility programs will be needed to achieve the remaining savings. This scope of this study only focuses on the energy savings due to the efficiency measures installed in a ZNE building. It does not quantify the energy production potential of on-site generation.

To quantify the potential of California's ZNE goals, the Navigant team used the following sources of data:

- ARUP, The Technical Feasibility of Zero Net Energy Buildings, 2013
  - Building simulations show the energy savings and costs per square foot for the maximum bundle of cost-effective measures available to achieve the energy efficiency portion of ZNE goals.
  - Data available for multiple building types and climate zones
- CEC, Title 24 Code Update Analysis, 2013
  - Data includes regulated vs. unregulated load of various building types and baseline energy use of code compliance buildings in each California climate zone.

Navigant used these data sources to characterize the ZNE measures. The measures include all relevant data, including base case, code case and efficient case (ZNE) energy consumption levels, and total cost and effective useful life parameters.

E.4.3 ZNE Energy Consumption Values

The energy consumption values are obtained from the ARUP study, CEC data, and Navigant team projections of future Title 24 code levels.

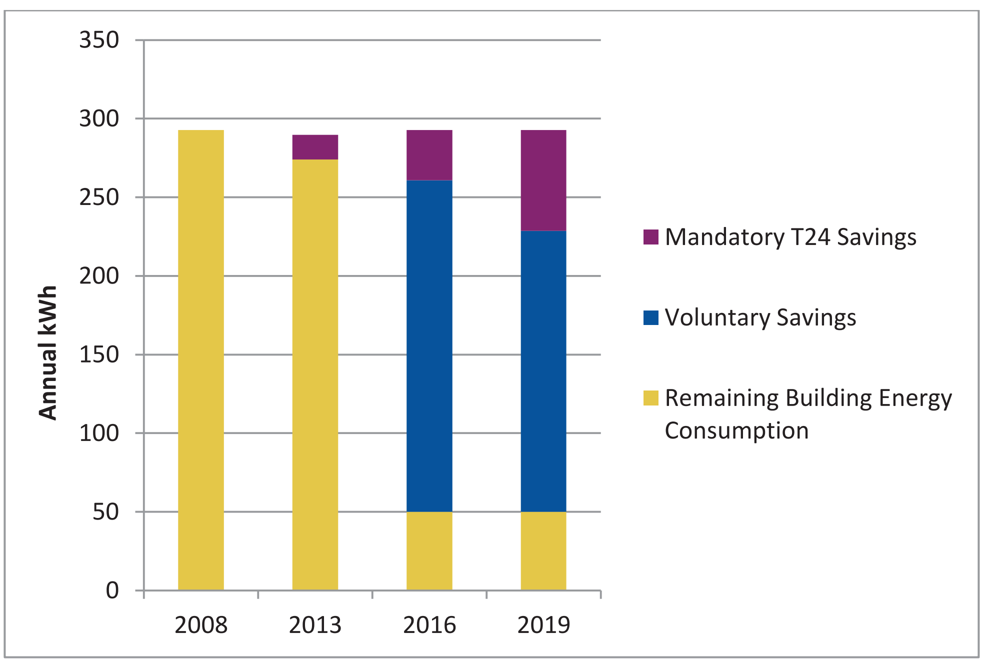
» Efficient case consumption (energy consumption of a ZNE building prior to accounting for any on-site generation) is obtained from simulation results in the 2013 ARUP study. The Navigant team assumes the maximum technical feasibility can be reached.

» Base case energy consumption levels are assumed to be equal to a 2013 Title 24 compliant building. Data on baseline energy use is obtained from data contained in the 2013 CEC Title 24 Update Analysis provided to the Navigant team by the CEC.

» Code case energy consumption levels are estimated by the Navigant team after extensive discussions with CEC building standards staff. The Navigant team estimated future code levels for Title 24 in 2016 and 2019 based on preliminary insight from CEC staff on the residential sector and trends in code levels for the commercial sector. As codes become more stringent in 2016 and 2019 code case energy use will decrease; as the portion of savings from mandatory programs increases, the savings credited to voluntary programs decreases.

Figure E-4 illustrates the base case energy consumption, efficient case consumption and code consumption over the study years as Title 24 increases in stringency.

Figure E-4. Example of ZNE Energy Savings Portion Chart from PG Team Analysis



Source: Navigant team analysis, 2013

E.4.4 ZNE Measure Cost

Measure cost for the ZNE measures was estimated by the Navigant team using high-level extrapolations of market data. While the ARUP study did include analysis of cost, discussions with the study lead revealed the costs should not be used for policy analysis as very little data was available to develop those costs. The incremental costs of the voluntary portion of ZNE savings reduces over time as Title 24 building codes increase efficiency requirements (and costs) of new construction. The Navigant team recommends additional studies be conducted to better understand the cost of ZNE buildings.

E.4.4.1 ZNE Measure Cost: Residential

The Navigant team estimated residential ZNE costs by extrapolating CEC cost analysis of 2013 Title 24 residential code compliance.[64] The incremental costs for ZNE buildings (relative to a 2013 Title 24) are reported in Table E-9.

Table E-9. Residential ZNE Cost

Residential Building Type	Incremental Cost per square foot
Single Family	$3.06
Multi Family	$2.62

Source: Navigant team analysis, 2013

E.4.4.2 ZNE Measure Cost: Commercial

The Navigant team estimated Commercial ZNE costs using high-level information from the New Buildings Institute and average new construction building costs in California.[65] The incremental costs for ZNE commercial buildings (relative to current construction practices) are reported in Table E-10.

Table E-10. Commercial ZNE Cost

Commercial Building Type	Incremental Cost per square foot
All Commercial Buildings	$7.39

Source: Navigant team analysis, 2013

E.4.5 ZNE: Additional Parameters

The PG team will make several assumptions regarding additional ZNE parameters needed for modeling:

- Effective useful life is assumed to be 25 years
- The Navigant team assumed that, as of 2006 (the start year of the model), no ZNE buildings were in the California market.

[64] http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/2013_Building_Energy_Efficiency_Standards_FAQ.pdf

[65] http://newbuildings.org/getting-zero-2012-status-update-first-look-costs-and-features-zero-energy-commercial-buildings
http://www.thecommercialrealestatespecialists.com/cpsf.html

E.5 Commercial Buildings Renovation

This section describes the methodology for the following whole building initiatives:

- » Commercial Renovation Level 1
- » Commercial Renovation Level 2

Comprehensive measure bundles were developed by the Navigant team for these two whole-building initiatives. Data was developed for each IOU territory and each building type. A "bundle" of measures was assembled for each initiative that represents the weighted average installation of measures by a typical participant. In assembling these bundles, only measures from the MICS were eligible for inclusion in these bundles.[66]

In developing the measure bundles, the Navigant team chose all appropriate measures that maximize energy savings. Thus, multiple measures were combined into a measure package while avoiding duplication of efficiency measures for the same base measure. As an example, if an LED is chosen as a replacement for an incandescent lamp, a CFL was not selected to replace the same incandescent lamp. Bundle savings include adjustments to specific measure savings based on other measures in the bundle. Adjusted measure savings were calculated using two distinct adjustment factors, one for competing measures and one for interactive measures (described in more detail later). Where multiple technologies compete with each other but have different applications (such as chillers), the Navigant team reduced the weight of those measures, adjusting the individual measure savings and costs so that the weighting sums to 100%.

Each bundle was developed to include gas and electric measures, assuming no overlap between the two fuel types.[67] An attempt was made to develop a bundle of measures that would help achieve the deep savings in retrofits required to meet the goal of 50% of existing buildings achieving ZNE levels by 2030. The team defined ZNE as a 60% reduction in energy use from energy efficiency measures, with the remainder of the building load (the last 40%) being provided by renewable energy technologies. This definition is consistent with the CEC working definition of ZNE. This analysis included only the energy efficiency element of ZNE; distributed generation was outside of the scope of this study.

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[66] See Appendix Section E.1 for additional context on the sources of data for measures eligible for the bundles.

[67] DEER v4.0 includes a negative gas heating interactive impact from lighting measures Several of the lighting replacement measures estimated an interactive therms/kWh savings ratio of -0.01 therms/kWh. The interactive gas space heating impacts of fluorescent and LED lighting replacing incandescent bulbs have not been accounted for in these calculations. Because the impact of this interactive effect on heating in commercial buildings is estimated to be negative 0.01 therms per kWh of savings, this negligible interactive effect is not accounted for in the savings analysis.

E.6 Estimating Measure Savings

Measure savings values are reported per 1,000 sqft of building stock, differentiated by commercial building type and climate zone. Savings are calculated using MICS data and applying the following formula

$$Measure\ Savings_{Early\ Retirement} = \left(Consumption_{Base} - Consumption_{Efficient}\right) \times BaseMeasureDensity \times (1 - CompetitionFactor)$$

$$Measure\ Savings_{ROB} = \left(Consumption_{Code} - Consumption_{Efficient}\right) \times BaseMeasureDensity \times (1 - CompetitionFactor)$$

Where:

$Consumption_{Base}$ = Energy consumption per unit of the base technology
$Consumption_{Code}$ = Energy consumption per unit of the code required technology
$Consumption_{Efficient}$ = Energy consumption per unit of the efficient technology
$BaseMeasureDensity$ = Density (units/1000sqft) of baseline measure
$CompetitionFactor$ = Any factor needed to correct for other measures in the bundle with competing/overlapping applications

E.7 Interactive Measure Adjustments

The measure savings as a percent of the end-use baseline consumption were adjusted by two factors, when applicable:

» **Competing measures factor** accounts for the condition when two competing efficiency technologies could replace the same base technology (such as HVAC system controls).
» **Interactive measures factor** accounts for the condition when multiple efficiency measures could reduce energy use by the same end use (such as lighting controls and efficient lighting fixtures).

The competing measures adjustments were applied to each competing measure, such that the factor weight summed to 100%. The team used various approaches to calculate the factor weights:

» When readily available, the team used information about the prevalence of one technology or the other.
» In the absence of specific data, the team typically used relative total maximum measure densities ("Total Max Density" from MICS) to calculate measure factor weights. When competing measures have the same total maximum densities, the factor weights are even.

The interactive measures factors accounts for the interactive effects of savings from different technologies that claim to save energy for the same end use. For example, the unit energy savings from window film or insulation is calculated assuming the baseline efficiency for an HVAC system. If an upgraded, high efficiency HVAC system has been installed as part of the bundle of measures, the incremental savings from also updating the insulation will be smaller than initially stated. This adjustment is made using interactive savings factors independently calculated for kWh, kW, and Therms. The calculation sums the savings calculated for the competing HVAC end use measures as a percent of their collective end-use base consumption, and reduces the envelope measures savings by that same percent. This results in a more realistic estimate of bundle energy savings.

$$Measure\ Consumption_{Early\ Retirement} = (Consumption_{Base}) \times BaseMeasureDensity \times (1 - CompetitionFactor)$$

$$Measure\ Consumption_{ROB} = (Consumption_{Code}) \times BaseMeasureDensity \times (1 - CompetitionFactor)$$

Where:

$Consumption_{Base}$ = Energy consumption per unit of the base technology
$Consumption_{Code}$ = Energy consumption per unit of the code required technology
$BaseMeasureDensity$ = Density (units/1000sqft) of baseline measure
$CompetitionFactor$ = Any factor needed to correct for other measures in the bundle with competing/overlapping applications

$$InteractiveFactor_{HVAC} = \frac{\sum_{HVAC} Measure\ Savings}{\sum_{HVAC} Measure\ Consumption}$$

A unique Interactive Factor is developed for kWh, kW, and Therms for each collective end use (i.e. HVAC). The interactive factor is then applied to the measures savings calculated previously, producing the adjusted savings value which is summed to calculate the savings from the bundle in its entirety.

$$Adjusted\ Savings = Measure\ Savings_{WindowFilm} \times (1 - InteractiveFactor_{HVAC})$$

E.7.1 Measure Costs

Similar to the measure savings estimates, the Navigant team calculated average measure costs by weighting the difference between the base measure cost and efficient measure cost by base measure density and any competing measures factor as described above. Total bundle cost was calculated by summing the individual costs for all the measures included

E.7.2 Demand Savings

The Navigant team used the estimated demand consumption values provided in the MICS to calculate unit demand savings for each measure. These units demand savings have been multiplied by the base measure density to accurately estimate the savings potential available, and when applicable, reduced by interactive factors as described in the previous sections.

E.7.3 Measure Bundles

Once the measure-level savings were derived accounting for interactive effects and the measure costs were derived, the Navigant team selected measures that maximized savings while minimizing first costs. If a measure appeared to have little impact on savings but a large impact on increasing cost, it was not selected. As a general rule, if a measure existed in both the electric and gas savings MICS, both measures were selected. The kWh, kW, and Therms savings for the selected measures were then summed to generate the total savings estimate for a given building type and IOU service territory. Likewise, the costs were summed to generate the estimated total measure package cost.

E.7.4 Bundle Results

While MICS contains the detailed costs and savings for each bundle in each IOU and building type, Table E-11 and Table E-12 present the average savings and cost across all commercial building types for Level 1 and Level 2 respectively.

Table E-11. Average Commercial Renovation Level 1 Data

IOU	kWh Savings	kW Savings	Therms Savings	Equipment Cost	Labor Cost	Weighted Average EUL
PG&E	2,728	0.86	53.7	$4,007	$2,057	13.2
SCE	2,895	0.91	5.8	$3,435	$1,960	12.1
SCG	73	0.00	40.9	$539	$393	14.1
SDGE	2,932	0.94	48.1	$3,989	$2,106	13.5

Source: Navigant team analysis, 2013

Table E-12. Average Commercial Renovation Level 2 Data

IOU	kWh Savings	kW Savings	Therms Savings	Equipment Cost	Labor Cost	Weighted Average EUL
PG&E	4,730	1.17	86.0	$6,031	$2,261	13.9
SCE	5,095	1.26	9.6	$5,332	$2,190	12.7
SCG	154	0.00	97.4	$837	$394	17.4
SDGE	5,095	1.32	91.3	$6,224	$2,310	14.5

Source: Navigant team analysis, 2013

E.8 Residential Buildings Renovation

This section describes the methodology for the following whole building initiatives:

» Residential Renovation Energy Upgrade CA – Basic Path (multifamily only)
» Residential Renovation Energy Upgrade CA – Flex Path (single family only)
» Residential Renovation Energy Upgrade CA – Advanced Path (single family only)

The Residential whole building initiatives modeled include three tiers that represent the Energy Upgrade California (EUC) programs. Data from EUC residential program reports as well as a workpaper from SCE provided the data needed to characterize EUC initiatives.

E.8.1 Energy Savings

Reported savings data for the Flex and Advanced path is made available from the CPUC. These savings reports were available from each of the IOUs as well as Los Angeles County. Reported savings represent the estimated savings of actual program participants. Savings are estimated by implementation contractors using EnergyPro modeling software in an approved manner. The CPUC has reviewed this

EnergyPro model process and concluded the energy savings may be overstated.[68] Subsequently, the CPUC suggested de-rating model results by 60% for electric savings and 20% for gas savings. The Navigant team de-rated reported savings for use in the PG Model.

The energy savings for the Basic Path were made available from an SCE draft workpaper submitted to the CPUC. While the workpaper covers single-family homes, the Navigant team scaled the savings down to represent savings of multifamily participants. Discussions with CPUC staff indicate that the Basic Path for single family homes will be discontinued in the future but that a multi-family program may start.

E.8.2 Cost

Costs for the Flex and Advanced Path were obtained from CPUC reporting data and were not adjusted. Reported costs represent the final invoice costs presented by contractors to customers; they are inclusive of equipment and labor cost and represent a "full" equipment cost rather than an incremental cost. These costs may not represent the true incremental customer cost of EUC.

Costs for the Basic Path were made available from an SCE draft workpaper submitted to the CPUC. While the workpaper covers single-family homes, the Navigant team scaled the costs down to represent savings of multifamily participants.

E.8.3 Summary Data

The MICS contains EUC data by building type (single family vs. multifamily), IOU, and climate zone. However a summary of this data is presented below in Table E-13.

Table E-13. Energy Upgrade California Costs and Savings Used in PG Model

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 Multifamily 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

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

Appendix F Financing Assumptions and Market Overview

This Appendix is organized as follows:

- Literature review: impacts of energy efficiency financing programs
- Overview of the California energy efficiency financing market and emerging topics
- Summary of energy efficiency financing programs in other states
- Influence of financing on energy efficiency technology adoption
- Additional discussion modeling methodology and model inputs
- PG Model assumptions for financing
- Financing bibliography.

F.1 Literature Review: Impacts of Energy Efficiency Financing Programs

The Navigant team conducted a literature search to capture key research findings related to energy efficiency financing and related topics that might factor into estimating energy efficiency potential attributed to energy efficiency financing programs. Table F-1 provides the current status of the Navigant team's findings:

Table F-1. Literature Research Key Findings

Topic	Key Findings
Market Barriers Addressed by Financing	Market barriers lead to slower technology diffusion. Key market barriers include: lack of capital access, hassle factor, lack of information, information search cost, liquidity, split incentives, and rate structures.[a]
High Implied Discount Rates	Evidence shows that current consumer implied discount rates for decisions related to energy efficiency technology range from 20% to 100%.[b] The difference between the implied discount rate and market interest rate signifies the ***efficiency gap,*** including the following factors: hidden cost, reduction in other product attributes, uncertain future energy savings (implying consumers place more weight on initial cost), and irreversibility of investment.[a]
Market Assessment	The average rate of customer willingness to pay (WTP) for financing is 3.27% annual percentage rate (APR) with a maximum WTP of 7.4% APR in the non-residential sector.[c] Residential customers consider $1 of financing to be equivalent to about a third of a dollar price reduction for energy efficiency technology (Train and Atherton 1995). [d]
Third-Party Financing	Banks are more likely to provide financing, especially long-term financing, if their interest can be resold on the secondary market. [e] Data from the approximately 90,000 loans made through the Fannie Mae Energy Loan program could provide valuable, long-term data for the analysis of loan performance under many different loan and borrower characteristics.[f] The data has not yet been made available to researchers,[e] but it is being sought by NYSERDA GJGNY to aid in securitization. The lack of standardization of energy efficiency loan terms is a significant barrier to the functioning of a secondary market for these loans.[e]
Emerging Topics	Proposed changes in accounting standards would recognize leases on the balance sheet. This may reduce overall energy efficiency investment in the market, as business owners would have to rely on their own limited debt capacity to complete efficiency upgrades.[g] Shut-off service is sometimes viewed by consumer advocacy groups as a positive because the process when a utility bill goes into delinquency is more consumer-friendly than for bank loans.[f]

Sources:

a. Gillingham, Newell, and Palmer. (2009). "Energy Efficiency Economics and Policy". RFF DP 09-13.
b. Adam Jaffe, Richard Newell, and Robert Stavins. (2004). "Economics of Energy Efficiency". *Encyclopedia of Energy* Vol. 2: 79-89.
c. The Cadmus Group, Inc. (2012). *2010-2012 California IOU On-Bill Financing Process Evaluation and Market Assessment*.
d. Kenneth Train and Terry Atherton. (1995). "Rebates, Loans, and Customers' Choice of Appliance Efficiency Level: Combining Stated- and Revealed-Preference Data."
e. Karen Palmer, Margaret Walls, and Todd Gerarden. (April 2012). "Borrowing to Save Energy: An Assessment of Energy-Efficiency Financing Programs." Resources for the Future.
f. Interview with Jeff Pitkin, NYSERDA. (October 2012).
g. Institute for Building Efficiency. (2010). "Mind the GAAP: A Study on the Effects of Proposed Changes in Accounting Standards for Leases on Investment in Energy Efficiency Retrofits in the United States."

F.2 Overview of the California Energy Efficiency Financing Market and Emerging Topics

F.2.1 California Market Assessment

Energy efficiency financing programs are designed to increase investment in energy efficiency upgrades by removing the up-front cost barrier. Financing programs will likely lead to increased energy-efficient equipment installation and participation in energy efficiency programs. Under the direction of the California Public Utilities Commission (CPUC), California investor owned utilities (IOUs) are offering 0% interest rate on-bill financing (OBF) to non-residential customers for the 2010-2012 program cycle.

According to the 2010-2012 CA IOU OBF Process Evaluation and Market Assessment, 72% of the survey respondents would not have been able to proceed with an energy efficiency project in the absence of on-bill financing. Furthermore, 80% of respondents indicated they would be more likely to pursue energy efficiency in the future as a result of their experience with OBF.

The growing interest in infusing third-party capital to energy efficiency financing has generated discussion of having on-bill repayment as a financing option among the CPUC and the CA IOUs. On-bill repayment will increase the pool of funds available for energy efficiency financing while customers will have to pay a higher interest rate than 0%.

Over half of the surveyed California non-residential customers view financing as more important than rebates and are willing to pay interest charges on energy efficiency loans. The willingness to pay (WTP) according to the survey has a mean 3.27% annual percentage rate (APR), with a maximum WTP of 7.4% APR.[69]

The CA IOU OBF programs have collectively loaned out $16 million since the beginning of the programs. Most projects have been lighting-only projects, since most venders specialize in lighting retrofits and customers seem not to have realized the benefit of bundling lighting measures with other retrofit measures.

[69] 90% confidence interval between 2.87% APR and 4.04% APR. The Cadmus Group, Inc. (2012). "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment". Final Report.

Table F-2 summarizes the proposed CA IOU financing programs for program year 2013-2014.

Table F-2. Summary of Recommendations for CA IOU EE Financing Programs, 2013-2014

Sector	Pilot Program	OBR	OBF	LLR	SD	Description	Recommended Funding Level
Single Family	WHEEL	X			X	Unsecured loan product leveraging secondary markets' capital. This program offers mid-interest rate dealer loans, opening capital markets to residential EE financing.	$24 million for both pilot programs
	Local Lending Products	X		X		Range of loan products leveraging local capital. This program offers low-interest direct loans, ability of local lenders to deliver capital across broad geographies.	
	Line-Item Billing	X				A sub-pilot program setting up OBR without bill-related loan security. This program tests the attractiveness of repaying loan on bill and its impact on loan performance.	$ 1 million
	Middle Income Targeted	X				A sub-pilot program to expand access to capital and energy efficiency. This program tests if the expanded access to capital for middle- income household could increase EE uptake. Credit enhancement feature to be determined.	$1 million
Multi-family	Master-Metering	X		X	X	OBR without shut-off for master-metered affordable housing properties.	$2.9 million
Non-Residential	On-Bill Financing		X			The continuation of the existing IOU OBF programs, offering 0% interest rates for energy efficiency upgrades in the non-residential sector. Lighting measures may not exceed 20% of total project cost except for the Government & Institutional customers.	$123 million
	On-Bill Repayment	X		X	X	OBR for projects not qualified for OBF in the non-residential sector.	$21 million

This table is modified from "Summary of Recommendations for EE Financing Pilot Programs" of the recommendation report prepared by Harcourt Brown & Carey, submitted to the California Investor-Owned Utilities on October 19th, 2012. Table can be found on page 15 of the report.

F.2.2 Emerging Topics

The Financial Accounting Standards Board (FASB) and International Accounting Lease Standards Board (IASB) proposed changes to lease accounting standards under the joint leases project. The proposed change would end off-balance sheet reporting for leases which may slow energy efficiency investments in the non-residential sector. Eliminating off-balance sheet recording will lower attractiveness of energy efficiency investments, as energy efficiency projects will have to compete with other business priorities for the organization's limited debt capacity.[70]

F.3 Summary of Energy Efficiency Financing Programs in Other States

The Navigant team reviewed EE financing initiatives across the United States. Since financing has been perceived as an enabler of demand rather than a driver of demand, there is a lack of impact evaluation attributing energy savings to financing programs. While financing programs are treated as non-resource programs, financing could be a market driver in some market segments, for example, residential customers without access to standard unsecured loan products. If financing is delivered to customers who could not have gained access to capital prior to the existence of financing programs, then energy savings could be attributed to the program. Table F-3 summarizes the programs that the Navigant team reviewed.

[70] Institute for Building Efficiency. (2010). "Mind the GAAP: A Study on the Effects of Proposed Changes in Accounting Standards for Leases on Investment in Energy Efficiency Retrofits in the United States".

Table F-3. Summary of financing Programs in the United States

Program Name (State) Years	Key Findings
Small Business Energy Advantage Program (CT, MA) 2000–Present	93% of small business customers qualify for financing. Rebates typically cover 20-40% of the project cost, with the loan covering the remaining amount. Of those projects that qualify for financing, about 54% decide to participate. In comparison, of the remaining 7% of customers that do not qualify for financing, only 19% decide to participate. [a]
Pay As You Save (PAYS) Pilot (NH) 2002–2003	In response to participant telephone survey question, "How much energy efficient measures and equipment would participant have purchased if not for the Pilot program?" over 91% of respondents (31 of the 34 participants interviewed) said that they would have installed none or only some of the measures without PAYS. [b]
How$mart (KS) Began in 2007	Program accomplishments: 637,000 kWh (2007-2009), 8,806 MMBtu (2007-2009), 350 customers reached. Value of home improvements: $2,288,664 (The source of this data provided no discussion about impacts from incentives received from other sources.) [c]
ClimateSmart Loan Program (CO) 2009 (on hold)	Average participant savings of 1,786 kWh and 74.9 therms [d] (Upgrades received incentives from many sources, and the source of this data provided no discussion about impact from incentives received from other sources.)
Green Jobs-Green New York (NY) 2009–present	Targets middle-income residential customers in the single- family sector; the program approved 496 loans. Loan amount ranges from $3,000-$13,000 with a 3.99% interest rate for unsecured loans. [e]
Home Energy Loan Program[71] (PA) 2005–present	Targets residential customers with income less than $150,000. The program has approved 5,500 loans to date. The majority of the financed projects are HVAC systems and windows upgrade. Comprehensive upgrades represent 10% of the program. [f]
CA IOU On-Bill Financing Programs (CA) 2010–present	Provides On-Bill Financing for Non-Residential customers for efficiency upgrades. Financing is offered at 0% interest rate. 72% of program participants would not have completed efficiency upgrades if OBF were not available. [g]
EGIA Loan for High-Efficiency HVAC (CA)	"When asked what consumers would have done in the absence of the loan, roughly 58% of consumers indicated that they would not have done the project, would have postponed the project, or would have proceeded with standard efficiency equipment." [h]

Program Name (State) Years	Key Findings

Sources:

a. Dennis O'Connor . (2011). "Energy Efficiency and On-Bill Financing for Small Businesses and Residential," Presentation for the Second U.S.-China Energy Efficiency Forum, May 6, 2011.
b. GDS Associates. (December 2003). "Process Evaluation of the Pilot "Pay As You Save" (PAYS) Energy Efficiency Program.
c. K. Johnson et al. (2010)."Lessons Learned from the Field: Key Strategies for Implementing Successful On-The-Bill Financing Programs." Johnson Consulting Group.
d. Marshall Goldberg. (April 2011). "Economic Impacts from the Boulder County, Colorado, ClimateSmart Loan Program: Using Property Assessed Clean Energy Financing."
e. Lawrence Berkeley National Laboratory. (2011). "NYSERDA's Green Jobs-Green New York Program: Extending Energy Efficiency Financing To Underserved Households."
f. Lawrence Berkeley National Laboratory. (2011). "Driving Demand for Home Energy Improvements. Pennsylvania's Keystone HELP."
g. The Cadmus Group, Inc. (2012). "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment."
h. 90% confidence interval between 2.87% APR and 4.04% APR. The Cadmus Group, Inc. (2012). "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment". Final Report.

F.3.1 Detailed Summary of Statewide Energy Efficiency Financing Programs in New York and Pennsylvania

This section provides a detailed summary of two specific EE financing programs programs—the NYSERDA Green Jobs Green New York (GJGNY) program and the Pennsylvania Keystone Home Energy Loan Program (HELP). Both programs cater to residential customers. Table F-4 summarizes program characteristics and underwriting standards of the GJGNY and HELP programs.

Table F-4. Program Characteristics of Green Jobs Green New York and Home Energy Loan Program

	Green Jobs-Green New York [a, b]	Home Energy Loan Program – Pennsylvania [c]
Target Market	Middle-income residential customers	Residential customers with income less than $150,000
Rejection Rate	30% rejection	20-50% rejection
Total Program Funding and Number of Loans	• $9 million funding from DOE and $51 million from Regional Green House Gas Initiative (RGGI). Roughly $20 million in federal QECB money is being used to buy down interest rates. • Roughly 7,000 loans made per year	• $40 million funding • 5,500 loans approved
Loan Amount and Interest Rate	Unsecured loan: $3,000- $13,000 (average loan size $9,200-$9,400) with a 2.99%-3.99% interest rate	Secured Loan: $5,000 to $35,000 loan with a 3.875% interest rate Unsecured Loan: $1,000 to $15,000 loan with a 4.99% interest rate
Credit Standards	Tier-1: A minimum of 640 credit score Tier-2: Current for 2 consecutive months during each of the last 2 years. No utility bill payments more than 60 days late in the last 2 years. Current on mortgage payments for the last year. No mortgage payments more than 60 days late in the last 2 years	A minimum of 640 credit score
Eligible Properties	Single-Family Home	1-2 Unit Owner-Occupied Residential Properties
Notes	Additional underwriting criteria include a maximum 50% Debt-to-Income Ratio and no bankruptcy in the last 7 years. The terms of the loans include a shut-off provision.	Majority of the financed projects are HVAC systems and windows upgrade; comprehensive upgrades represent 10% of the program projects.

Sources:

a. Lawrence Berkeley National Laboratory. (2011). "NYSERDA's Green Jobs-Green New York Program: Extending Energy Efficiency Financing To Underserved Households."
b. NYSERDA. (October 2012). Interview with Jeff Pitkin.
c. Lawrence Berkeley National Laboratory. (2011). "Delivering Energy Efficiency to Middle Income Single Family Households.

F.4 Influence of Financing on Energy Efficiency Technology Adoption

This section provides further explanation to how energy efficiency financing programs could change energy efficiency technology adoption by reducing market barriers and by increasing the size of potential technology adopters.

Adoption of technology is not instantaneous. Often times, the technology adoption rate increases gradually in the beginning, rapidly as market share increases, and slowly as adoption approaches market saturation. Market barriers contribute to the slow technology diffusion, the technology diffusion path changes when some of these market barriers are eliminated. Some examples of market failures and barriers[72] include:

- **Information Search Cost** - Even when information of new technologies is publicly available, it is costly for consumers to learn about the innovation.
- **Lack of Capital Access and Liquidity Constraint -** Lack of up-front capital or credit for energy efficiency investments.
- **Un-internalized Externalities** - Energy is heavily subsidized; consumers are not aware of the true cost of energy.
- **Split Incentives** - Party making the efficiency investment decision is not the party benefitting from the decision.
- **Hassle Factor -** This includes efforts invested in completing transactions such as the application process.
- **Behavioral Failures** - Consumers are not perfectly rational, resulting in consumer behavior inconsistent with utility maximization or energy cost minimization.

The effect of market barriers is reflected in the high consumer implied discount rate, which ranges from 20% to 100%.[73] In addition to the above-mentioned factors, consumer uncertainty for future energy prices and the irreversibility of investment also contribute to the high consumer implied discount rate. The difference between the consumer implied discount rate and the market rate signifies the "efficiency gap."[74] A high consumer implied discount rate reduces value of future cash flow, thus lengthening the payback period of an investment compared to when the future is valued equally as the present.

Financing programs intervene by lowering the high consumer implied discount rate. Table F-5 draws parallels to how the California financing programs are addressing market barriers.

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[72] Jaffe, Newell, and Stavins. (2004). "Economics of Energy Efficiency." *Encyclopedia of Energy* Vol. 2: 79-89. [83]
[73] Gillingham, Newell, and Palmer, 2009. "Energy Efficiency Economics and Policy". RFF DP 09-13
[74] Ibid.

Table F-5. Mechanisms of Financing Program Addressing EE Technologies Market Barriers

Market Barriers	Examples of CA Financing Program Influence
Hassle Factor	• OBF and OBR eliminate an additional step for customers to repay their loan by incorporating payment on utility bills. • The WHEEL program pilot in the residential sector provides fast underwriting standards, eliminating difficulty associated with the loan application process.
Lack of Capital Access	• OBF and OBR provide capital to customers who were willing to invest in energy efficiency but lack the up-front cost. • The credit enhancement feature of the financing programs extends third-party lending to the population that was previously ineligible for standard loan products.
Liquidity	• With OBF, there is 0% financing. With the other programs, liquidity market barrier is reduced if the interest rate is attractive relative to other market options.

Source: Navigant team analysis, 2013.

As mentioned in Section 2, financing provides capital access to a subpopulation that previously did not have access to capital for energy efficiency investments. The availability of capital access increases the pool size of potential adopters and thus increases the market equilibrium. As an example, the market penetration of residential efficient washing machines in California is estimated to have been reduced by 12% due to the capital access constraint. For every $100 of additional cost between a baseline technology and an energy-efficient technology, a certain percentage of the population will not be able to obtain financing, estimated to be 10% for low-income households and 5% for middle-income households.[75]

F.5 Additional Discussion on Modeling Methodology and Model Inputs

This section provides an overview of several topics that influenced the development of the modeling methodology and model inputs for this study.

F.5.1 Relationship between Interest Rate and Market Adoption

Prior to the 2011 Potential Study, no attempt had been made to model the effects of financing on energy efficiency technology adoption in California. Data showing a relationship between interest rate reduction and quantity demanded of energy efficiency technology is severely lacking. As such, the Navigant team used the findings from a study of consumers' interest in financing incentives in response to interest rate reduction in the automobile industry as a proxy for model input in our 2011 analysis. The automobile industry study concluded that there was "a 0.34 percent change in quantity demanded for every one percent change in interest rate for a new car loan."[76]

The Navigant team found two additional examples demonstrating relationships between interest rates and quantity demanded since the 2011 analysis. The two examples were drawn from the monetary market and the housing market.

[75] LBNL. November 2004. *Market Failures, Consumer Preferences, and Transaction Costs in Energy Efficiency Purchase Decisions.* Prepared for the CPUC, report number CEC-500-2005-020. p. 25.
[76] Catesby Beck. (2003). "Are Consumers More Interested in Financing Incentives or Price Reductions".

In the monetary market, financial technology adoption is positively related to the level of financial asset and negatively related to financial rate. At an interest rate of 5%, quantity demanded for loans increases by 0.3% as interest rate decreases by 1%. At an interest rate of 15%, quantity demanded for loans increases by 0.4% as interest rate decreases by 1%.[77]

Similarly, an inverse relationship between finance interest rate and quantity demanded can be observed in the housing market. Lowering mortgage rates by nearly 1% would raise housing quantity demanded by about 10% to 17%.[78] However, housing price, credit availability, and approval rates also respond to mortgage rate change, which in turn impacts housing demand.[79]

The newly available data points are evidence supporting the hypothesis that financing has a positive effect on technology uptake. However, we recognize that the energy efficiency technology market is not necessarily comparable to the monetary, housing, and automobile markets. Demand for energy efficiency loans is likely to be less robust compared to the financial products in the other industries examined.

F.5.2 Relationship between Financing and Rebates

In order to include model flexibility of having different incentive combinations (e.g., financing-only option, rebate-only option, and having both finance and rebate option), the finance model requires an input for relationship between financing dollars and rebate dollars. Customers seem to value rebate and financing dollars differently in the residential and non-residential markets. According to Train and Atherton (1995), residential customers consider one dollar of financing to be equivalent to about a third of a dollar price reduction for energy efficiency technology. In contrast, over half of the non-residential customers responding to the CA IOU OBF program evaluation expressed a preference in financing over rebate.[80]

F.5.3 Factors Limiting the Market for Energy Efficiency Financing

There are several factors that discourage lenders and depress the proper functioning of secondary markets for energy efficiency loans. These factors, in turn, reduce the availability of third-party financing for energy efficiency loan programs. Probably the most significant factor on the supply side is the perceived credit risk. Energy efficiency loans are usually unsecured and there is a general lack of data regarding the long-term performance of these loans.

Such uncertainty makes it difficult for financial institutions to adequately model portfolios of energy efficiency loans, thus reducing their willingness to fund these loans. The Fannie Mae Energy loan program has data on approximately 90,000 loans made since 1994 that could help to inform the market about the characteristics of energy efficiency loans under different circumstances; however, as of yet this

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[77]Casey Mulligan, Casey and Sala-i-Martin. (1996). "Adoption of Financial Technologies: Implications for Money Demand and Monetary Policy".
[78] Christopher Mayer. (2009). "House Prices, Interest Rates, and the Mortgage Market Meltdown"
[79] Edward Glaeser et al. (2011). "Can Cheap Credit Explain the Housing Bloom?".
[80] The Cadmus Group, Inc. (2012). "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment". Final Report.

data has not been made publicly available.[81] Some parties, including the NYSERDA Green Jobs Green New York program, have negotiated with Fannie Mae for limited access to this pool of data to help inform the securitization of their outstanding loans.[82] However, the data is not publicly available at this time.

Another significant barrier for the energy efficiency loan market is the relative size of transaction and administrative costs relative to the average loan size. Loan sizes in the residential market are generally less than $10,000 with origination fees as high as $300 to $400 and monthly service fees in the range of $10.[83] The high proportion of fees relative to the principal amount of the loan makes it difficult for the loan to be economical for both the financial institution and the borrower. Standardization of loan terms or centralization of loan processing and servicing could help to reduce the ratio loan principal to fees and have a beneficial impact on the primary and secondary markets for energy efficiency loans.

F.5.4 Example of reducing iDR in the Commercial Sector

The following discussion illustrates approach to modeling the change in **Implied Discount Rates** (iDR) as a result of the availability and utilization of financing in the Commercial sector. The 2012 CA On-Bill Financing (OBF) Process Evaluation provided an indication of the relative impact of market barriers.[84] Figure F-1 displays the reasons customers cited for using OBF.

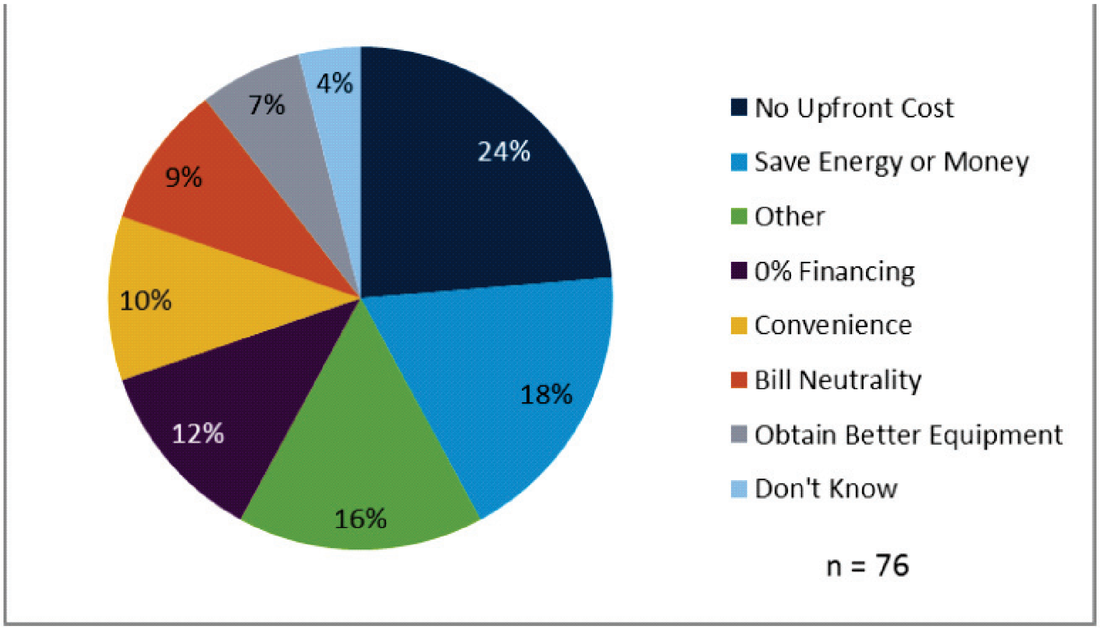
[81] Research Into Action. (2011). "Clean Energy Works Portland Pilot: Process Evaluation Wave 4." Final Report. June 24, 2011.

[82] NYSERDA. (October 2012). Interview with Jeff Pitkin.

[83] Research Into Action. (2011b). "Clean Energy Works Portland Pilot: Process Evaluation Wave 4." Final Report. State Energy Efficiency Action Network, June 24, 2011.

[84] The Cadmus Group, Inc. (2012). "2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment Final Report."

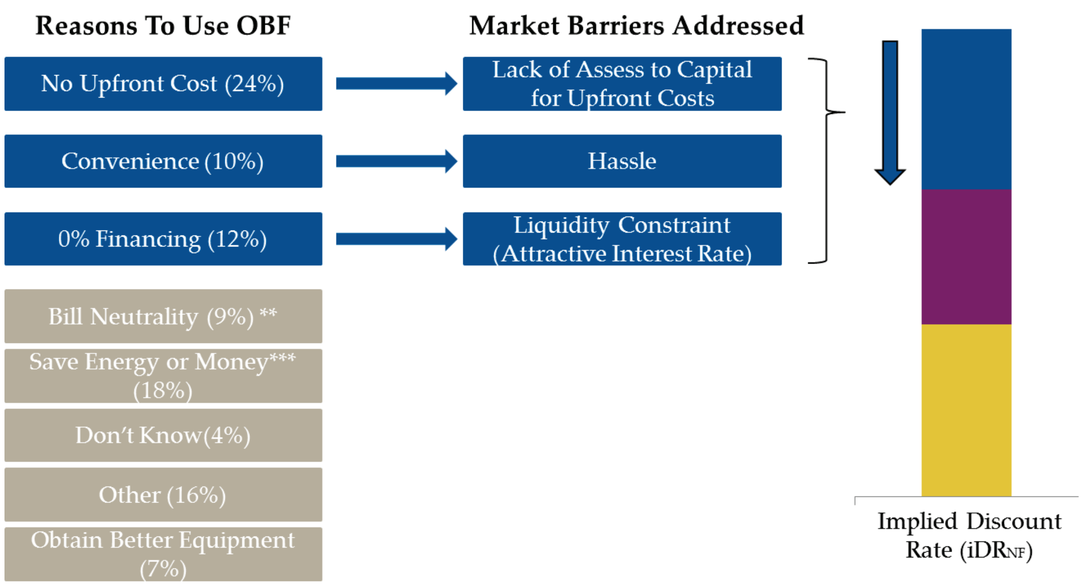
Figure F-1. Reasons for Using OBF



Source: Navigant team analysis, 2013.

The Navigant team mapped the survey results to market barriers addressable by IOU EE financing initiatives, as displayed in Figure F-2

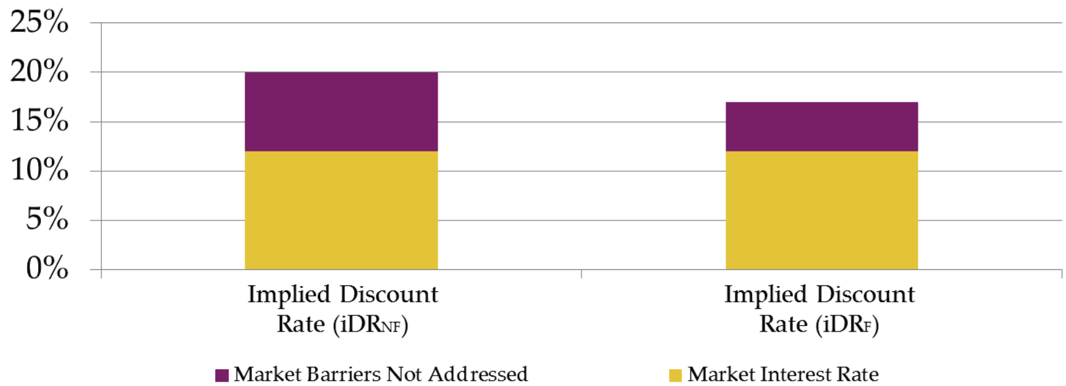
Figure F-2 Non-Residential Sector Market Barriers Addressable by IOU Financing Programs



Source: Navigant team analysis, 2013.

This approach acknowledges the fact that EE financing may not fully address all of the market barriers identified as drivers to participation in the OBF program. The likelihood that EE financing programs will reduce each market barrier is reflected in a "likelihood value." Figure F-3 illustrates this approach by using the Cadmus market survey data, the three market barriers identified in Figure F-4, and the likelihood values. In this example (provided for illustrative purposes only), the total reduction in the iDR resulting from financing is 3%.

Figure F-3. Non-Residential iDR Example



Non-Residential: Likelihood that Financing Programs Would Reduce Market Barriers (Medium Scenario)	
Lack of Capital/ No Upfront Costs	High (80%)
Hassle	Low (20%)
Liquidity (Attractive Interest Rate)	High (80%)
Total iDR Reduction	**3%**

Source: Navigant team analysis, 2013.

F.6 PG Model Assumptions for Financing

This section presents the model assumptions for financing. The two categories of financing model inputs are loan characteristics and market assumptions.

- **Loan characteristics**- the key assumptions on the features of energy efficiency loans specific to the California energy efficiency financing market, including interest rate, loan tenor, leverage ratio, population eligible for financing, and measure eligibility by sector.

- **Market assumptions**- the key assumptions that modify the energy efficiency measure adoption curves, namely the implied discount rates with and without financing, market rates, and changes to marketing and word of mouth parameters.

Navigant utilized multiple sources to derive and triangulate model assumptions. Key data sources are summarized below:

- California Energy Efficiency Project Reports and Workshops- CA IOU EE financing pilot program design resources for Program year 2013-2014; Resources include the final recommendations for CA EE financing programs, supplemental information submitted to Administrative Law Judge, and workshop presentations. http://www.caleefinance.com

- California IOU 2010-2012 On-Bill Financing (OBF) Process Evaluation and Market Assessment Final Report- This report examines the implementation of IOU's OBF 0% financing programs. http://www.calmac.org/publications/On_Bill_Financing_Process_Evaluation_Report_2010-2012.pdf
- Expert Interviews- Navigant identified and conducted in-depth interviews with experts in the CA EE financing field; experts include IOU financing program managers from California and other States and the CA EE financing pilot program consultants.
- Literature Research- Consists of published resources on EE financing for example research on implied discount rate, financing loan characteristics, and the efficiency gap. Refer to bibliography for the full list of literature.
- Primary Data- Research data from a mid-west utility on consumer's implied discount rate.
- Navigant Analysis- Assumptions made by the Navigant analysis team.

Table F-6 summarizes the data sources for each of the financing model input categories.

Table F-6. Summary of Financing Model Assumptions Data Sources

		Data Sources					
	Input	Pilot Program Resources	OBF Report	Expert Interviews	Literature Research	Primary Data	Navigant Analysis
Loan Characteristics	Interest Rate	x		x	X		
	Loan Tenor			x	X		
	Leverage Ratio	x		x			
	Population Eligible for Financing	x		x			
	Measure Eligibility	x					
Market assumptions	iDR without Financing					x	
	iDR Reduction with Financing		x		X		
	Market Rate						x
	Change to Marketing parameter						x
	Change to WOM parameter						x

Source: Navigant team analysis, 2013.

F.6.1 Loan Characteristics

Navigant relied on expert interviews and pilot program resources to develop assumptions on loan characteristics. In addition, Navigant compared the assumptions on loan characteristics with EE financing programs outside California. As displayed in Table F-7, the assumptions on the loan characteristics vary depending on the EE penetration scenario.

Table F-7. Loan Characteristics Assumptions for Low, Medium and High EE Penetration Scenarios

Sector	Interest Rate (L/M/H)	Loan Tenor	% of Population Eligible	Measure Eligibility
Single Family	10%/9%/8%	10 years	65%	Option 1: All Measures Option 2: Bundled Measures Only Option 3: Measures Exceeding a Cost Threshold
Multifamily	10%/8%/7%	10 years	5%	
Non-Res	15%/10%/6%	unsecured: 6 years secured: 15 years	20%	

Source: Navigant team analysis, 2013.

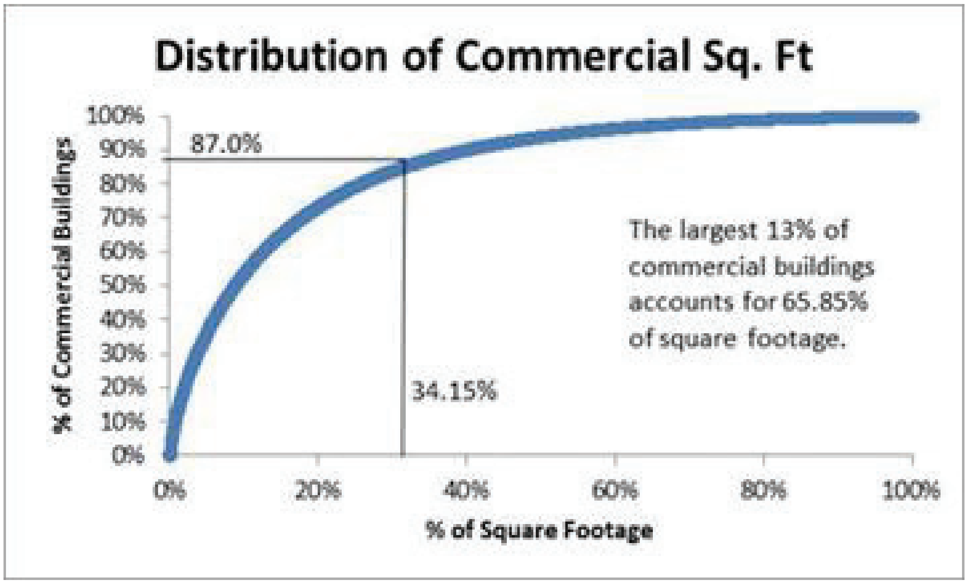
Details on key assumptions include the following:

- Interest Rates through IOU-funded Programs: The range of loan interest rates differs by sector. Navigant takes the upper bound of the possible interest rate range for the low EE penetration scenario; mid-point of the range for medium penetration scenario; and the lower bound of the interest rate range for high penetration scenarios.
- Percent of Population Eligible for Financing:
  - **Single family sector** - eligibility is estimated to be 65% and is determined by minimum FICA score of 640 and a debt-to-income ratio of 50%.
  - **Multi-family sector** - eligibility is estimated to be 5% based on the proportion of the MF market segment that is affordable housing. The affordable housing market segment is the current focus of the proposed EE financing programs. Due to legal and regulatory issues, OBR is not a viable option except master-metered properties.
  - **Commercial sector –** eligibility is estimated to be roughly 20% of commercial floor stock. To derive this figure, Navigant examined the CEUS data on floor stock and applied an adjustment factor to the floor stock data for each market segment to derive a weighted adjustment factor.[85] The California EE financing pilot program consultants estimated that 50% of businesses are backed by mortgages (owners) and, of this, approximately 25% have good credit.[86] This represents an adjustment factor of 13%. The 13% adjustment factor was applied to the commercial square footage estimates for all market segments except large commercial. For the large commercial market segment, we

[85] California Commercial End-Use Survey (CEUS), Itron, 2006.
[86] Interview with David Carey and David Nemtzow

examined a dataset that allowed us to estimate the percent floor stock that the largest commercial buildings represented. Through this analysis, we determined that the largest 13% of commercial buildings account for approximately 66% of commercial square footage.[87] The resulting weighted adjustment factor is 20%.

Figure F-4. Distribution of Commercial Sq. Ft.



Source: Navigant team analysis, 2013 based on 2006 CEUS

- **Measure Eligibility**: All energy efficiency measures are covered under OBF or OBR according to the pilot program final recommendation. Navigant implemented flexibility in the model to allow analysis assuming:
  - All measures are eligible
  - Only bundled measures are eligible
  - Only measures exceeding a certain cost threshold are eligible.

[87] Pacific Northwest dataset

F.6.2 Market Assumptions

Market assumptions are derived from primary data, pilot program resources, OBF report, literature research, and Navigant team analysis. The input parameters vary by sector, with iDR reduction and change to marketing parameter varying by sector and EE penetration scenario.

Table F-8. Market Assumptions Input for Low, Medium and High EE Penetration Scenarios

Sector	iDR without Financing	iDR Reduction with Financing (L/M/H)	Market Rate	Change to Marketing Parameter (L/M/H)	Change to Word of Mouth Parameter
Single Family	63%	9%/11%/13%	15%	+/+/++	No change
Multifamily	63%	11%/13%/16%	12%	+/+/++	No change
Non-Res	20%	2%/3%/3%	12%	+/+/++	No change

Source: Navigant team analysis, 2013.

- iDR without Financing: Navigant calculated the iDR without financing using primary data from a Mid-West utility.
- iDR Reduction with Financing: Navigant identified market barriers cited in the OBF report that were most likely to be reduced by EE financing programs. For each sector, Navigant estimated the likelihood in which the cited market barrier would be reduced by financing programs. Table F-9 captures the likelihood assumptions.

Table F-9. Likelihood of Market Barriers Reduction by Financing Programs

Market Barrier	NR	MF	SF
Lack of Capital/Liquidity	High	High	Medium
Hassle	Low	Medium	Medium
Attractive Interest Rate	Medium	Low	Medium

Source: Navigant team analysis, 2013.

- Market Rate: Navigant assumption consistent with a common hurdle rate for non-residential sector, and credit card interest rate for single-family and multi-family sectors.
- Change to Marketing parameter: $20 million has been proposed for EE financing program marketing expenditures for program years 2013-2014. This investment should have a positive impact on energy efficient measure marketing.
- Change to WOM parameter: No change for all scenarios.

F.7 Financing Bibliography

Beck, Catesby. (2003). "Are Consumers More Interested in Financing Incentives or Price Reductions?" *Issues in Political Economy*, Vol. 12, August 2003. Available at: http://org.elon.edu/ipe/beck%20FINAL.pdf

Gillingham, Newell, and Palmer. (2009). "Energy Efficiency Economics and Policy." *Resources for the Future*, 2009. Available at: http://www.rff.org/documents/RFF-DP-09-13.pdf

Glaeser, Edward et al. (2011). "Can Cheap Credit Explain the Housing Bloom?" NBER Working Paper No. 16230, July 2010. Available at: http://www.nber.org/papers/w16230

GDS Associates. (2003). "Process Evaluation of the Pilot "Pay As You Save" (PAYS) Energy Efficiency Program." December 2003.

Goldberg, Marshall. (2011). "Economic Impacts from the Boulder County, Colorado, ClimateSmart Loan Program: Using Property Assessed Clean Energy Financing." April 2011.

Harcourt Brown & Carey. (2012). "Recommendations for Energy Efficiency Finance Pilot Programs." October 2012. Available at: http://www.caleefinance.com/wp-content/uploads/2012/10/EE-Finance-Pilot-Recommendations-Report4.pdf

Institute for Building Efficiency. (2010). "Mind the GAAP: A Study on the Effects of Proposed Changes in Accounting Standards for Leases on Investment in Energy Efficiency Retrofits in the United States." September 2010.

Jaffe, Newell, and Robert Stavins. (2004), "Economics of Energy Efficiency." 2004.

Johnson, K., et al. (2010). "Lessons Learned from the Field: Key Strategies for Implementing Successful On-The-Bill Financing Programs." Johnson Consulting Group.

Lawrence Berkeley National Laboratory. (2011). "Delivering Energy Efficiency to Middle Income Single Family Households." December 2012. Available at: http://eetd.lbl.gov/EAP/EMP/reports/lbnl-5244e.pdf

Lawrence Berkeley National Laboratory. (2011). "Driving Demand for Home Energy Improvements. Pennsylvania's Keystone HELP." Available at: http://drivingdemand.lbl.gov/reports/lbnl-3960e-help.pdf

Lawrence Berkeley National Laboratory. (2011). "NYSERDA's Green Jobs-Green New York Program: Extending Energy Efficiency Financing to Underserved Households." January 2011. Available at.: http://eetd.lbl.gov/ea/emp/reports/ee-policybrief_012411final.pdf

Mayer, Christopher. (2009). "House Prices, Interest Rates, and the Mortgage Market Meltdown." Available at: http://www.law.yale.edu/documents/pdf/cbl/Mayer_Hubbard_House_Prices.pdf

Mulligan, Casey, and Sala-i-Martin. (1996). “Adoption of Financial Technologies: Implications for Money Demand and Monetary Policy.” NBER Working Paper No. 5504, March, 1996. Available at: http://www.nber.org/papers/w5504

O’Connor, Dennis. (2011), “Energy Efficiency and On-Bill Financing for Small Businesses and Residential.” Presentation for the Second U.S.-China Energy Efficiency Forum, May 6, 2011.

Palmer, Karen, Margaret Walls, and Todd Gerarden. (2012). “Borrowing to Save Energy: An Assessment of Energy-Efficiency Financing Programs.” *Resources for the Future*, April 2012.

Research Into Action. (2011). “Clean Energy Works Portland Pilot: Process Evaluation Wave 4.” Final Report. June 24, 2011.

The Cadmus Group, Inc. (2012). “2010-2012 CA IOU On-Bill Financing Process Evaluation and Market Assessment.” Final Report, May, 2012. Available at: http://www.energydataweb.com/cpucFiles/pdaDocs/846/OBF%20Final%20Report,%20May%202012.pdf

Train, Kenneth, and Terry Atherton (1995). “Rebates, Loans, and Customers' Choice of Appliance Efficiency Level: Combining Stated- and Revealed-Preference Data.” *The Energy Journal*, January 1995.

Appendix G Approach to Industrial Sector Analysis

This appendix provides a detailed explanation of the steps used to determine energy efficiency (EE) potential in the Industrial sector.

The Navigant Consulting, Inc. (Navigant) team applied a top-down approach to calculate Industrial-sector potential based on EE supply curves for the sector. The supply curve approach is an attractive option for calculating energy efficiency potential in the Industrial sector because state databases, such as the Database for Energy Efficient Resources (DEER), contain insufficient Industrial measures to estimate total sector potential. The supply curve approach is particularly well suited to modeling energy efficiency potential in the Industrial sector because it generally requires fewer model inputs than the measure-based, bottom-up approaches applied in estimating Residential and Commercial potential.

The supply curve approach estimates efficiency potential by grouping all of the efficiency options for each use category into a single curve, rather than by assessing each unique measure individually. This approach is applied to estimate potential for each use category and each Industrial subsector. Efficiency supply curves comprise two key pieces of information: 1) the *amount* of energy efficiency potential available for a particular end use or system and 2) the *cost* at which the energy efficiency potential can be achieved.

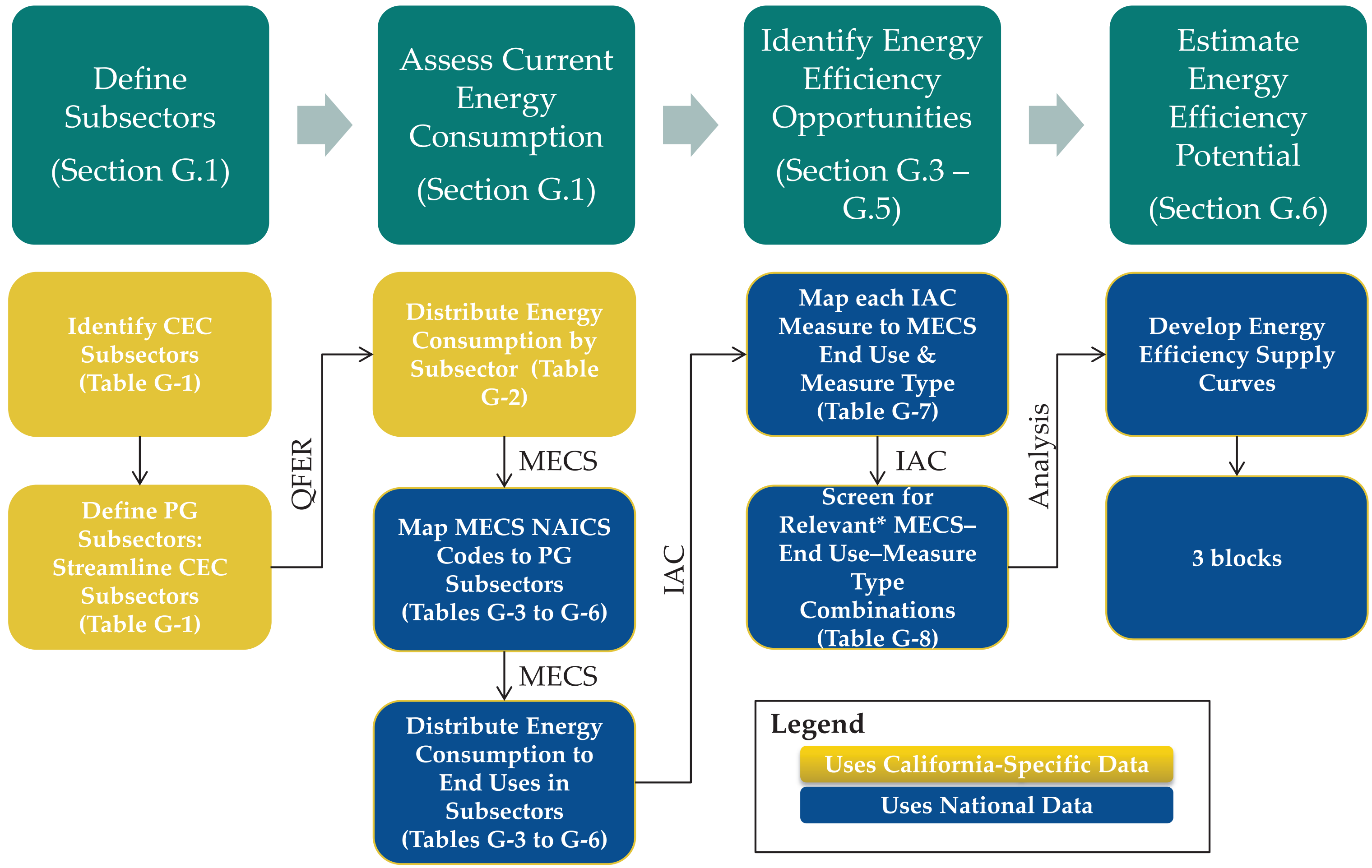
The Navigant team's approach to developing the supply curves included the following four steps:

1. Define a framework for conducting the analysis at the subsector level
2. Estimate current energy consumption in each subsector
3. Identify energy efficiency opportunities in each subsector using existing national data
4. Estimate energy efficiency potential for each subsector using the supply curve approach

Figure G-1 provides an overview of the Industrial approach that reflects the structure of this appendix:

- » Detailed analysis that contributed to each of the four main steps outlined in the previous paragraph (in each yellow or blue box)
- » Indications of the content in each of the tables in this section (in the yellow and blue boxes)
- » Key data sources that informed each detailed step in the analysis (captured along the connector lines) and whether this data was specific to California's Industrial sector (yellow) or was national in origin
- » A map for the rest of the section (section numbers included in the top row of boxes)

Figure G-1. Overview of the Navigant Team's Approach to Calculating Industrial Sector Potential



* Relevant IAC Measures defined as those implemented from 2004-2012 **and** have been installed in at least 8 industrial facilities

G.1 *Define Subsectors and Assess Current Energy Consumption*

The Industrial sector accounts for 13 percent of electricity consumption and 30 percent of natural gas consumption across the four investor-owned utility (IOU) service territories.[88] The Navigant team divided energy consumption in the Industrial sector into 15 subsectors. The team applied the California Energy Commission's (CEC's) definition of Industrial subsectors as a starting point for defining the Industrial subsectors for this study.[89] Each of the 25 CEC subsectors corresponds to different North American Industry Classification System (NAICS) codes; together, the CEC subsectors encompass all Industrial energy consumption in the four service territories. The team aggregated the CEC subsectors into 15 by combining similar industries. For example, the Navigant team combined the Food Processing and Food and Beverage industries into a single Food subsector. Table G-1shows a mapping of the CEC Industrial subsector categories to the subsectors used in this study.

[88] 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/.
[89] 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 G-1. Industrial Mapping from CEC Subsectors to Navigant Subsectors

CEC Subsector Identifier	Corresponding CEC NAICS Code(s)	Navigant Subsector Identifier
Petroleum and Coal Products Manufacturing	324	Petroleum
Food Processing	311x, 312	Food
Food & Beverage	3113, 3114	
Semiconductor and Other Electronic Component Manufacturing	334x	Electronics
Computer and Electronic Product Manufacturing	3344	
Electrical Equipment, Appliance, and Component Manufacturing	335	
Nonmetallic Mineral Product Manufacturing (excluding glass and cement)	327x	Stone-Clay-Glass
Glass Manufacturing	3272	
Cement	3273	
Chemical Manufacturing	325	Chemicals
Plastics and Rubber Products Manufacturing	326	Plastics
Fabricated Metal Product Manufacturing	332	Fabricated Metals
Primary Metal Manufacturing	331	Primary Metals
Machinery Manufacturing	333	Industrial Machinery
Transportation Equipment Manufacturing	336	Transportation Equipment
Pulp, Paper, and Paperboard Mills	322x	Paper
Paper Manufacturing (excl. Mills)	3221	
Printing and Related Support Activities	323	Printing & Publishing
Publishing Industries (except Internet)	511, 516	
Textile Mills	313	Textiles
Textile Product Mills	314	
Apparel & Leather Product Manufacturing	315, 316	
Logging & Wood Product Manufacturing	1133, 321	Lumber & Furniture
Furniture and Related Product Manufacturing	337	
Miscellaneous Manufacturing	339	All Other Industrial

Source: Navigant team analysis, 2013.

Navigant used Quarterly Fuel and Energy Report (QFER) data provided by CEC to generate a subsector-level view of Industrial consumption in each service territory; QFER data is reported by NAICS code. Table G-2 shows the percent distribution of electric and gas consumption by subsector across all four service territories.

Table G-2. Industrial Sector IOU Territory Electric and Gas Consumption by Subsector (%), 2010

Subsector	Percent of IOU Territory Industrial Electricity Consumption	Percent of IOU Territory Industrial Gas Consumption
Petroleum	19%	53%
Food	18%	19%
Electronics	16%	2%
Stone-Glass-Clay	7%	5%
Chemicals	9%	8%
Plastics	6%	1%
Fabricated Metals	5%	3%
Primary Metals	2%	3%
Industrial Machinery	3%	1%
Transportation Equipment	4%	2%
Paper	4%	2%
Printing & Publishing	3%	0%
Textiles	1%	1%
Lumber & Furniture	2%	0%
All Other Industrial	2%	1%
TOTAL	100%	100%

Source: Navigant team analysis of CEC-provided statewide energy consumption data (QFER) for 2010

G.2 Assess Existing Energy Consumption

G.2.1 Distribute Energy Consumption by End Uses by Subsectors

The Navigant team used the Industrial end-use categories defined in the U.S. Department of Energy's (DOE's) Manufacturing Energy Consumption Survey (MECS) to disaggregate consumption in the Industrial use categories.[90] Although MECS provides a national-level view of end-use distribution within

[90] 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.

industry, it currently represents the most consistent and reliable resource for Industrial end-use disaggregation.

The Navigant team mapped the appropriate MECS NAICS codes to each subsector used in this study. Table G-3 shows the MECS NAICS codes applied to each Industrial subsector and the corresponding estimated distribution of *electric* end-use consumption. Table G-4 shows the estimated distribution of *gas* end-use consumption.

MECS divides Industrial end-use energy according to the categories shown in Table G-3 and Table G-4. The Navigant team defined Industrial end-use categories that are well defined and consistent across the various subsectors.

- Electric end uses:
    - Electric end-use categories include lighting, heating, ventilating, and air conditioning (HVAC), machine drive,[91] process heating, and process cooling and refrigeration. These five categories account for over 90 percent of all electric consumption for the majority of Industrial subsectors.
    - The Navigant team combined the remaining MECS electric end-use categories as "Other" in Table G-3. For these, the Navigant team did not estimate energy efficiency potential. These "Other" categories, including "Other Process Use," "Other Non-Process Use," and "Other Facility Support," are highly heterogeneous amongst subsectors and thus difficult to represent.

- Natural gas end uses:
    - The Navigant team considered three efficiency end uses: conventional boiler use, process heating, and HVAC. These three efficiency categories account for over 87 percent of all gas consumption for the majority of Industrial subsectors.
    - The Navigant team combined the remaining MECS electric end-use categories as "Other" in Table G-4. For these, the Navigant team did not estimate energy efficiency potential. These "Other" categories, including "Other Process Use," "Other Non-Process Use," "Other Facility Support" or combined heat and power (CHP)/cogeneration, are highly heterogeneous amongst subsectors and thus difficult to represent.

For subsectors that could be represented by multiple MECS NAICS codes, the Navigant team applied an energy consumption-weighted average to arrive at the estimated end-use distribution. For example, the Stone-Clay-Glass subsector includes three separate efficiency NAICS codes offered in MECS: 327 (Nonmetallic Mineral Products), 327213 (Glass Containers), and 327310 (Cements). For this subsector, the Navigant team used IOU energy consumption in the Nonmetallic Mineral Products, Glass, and Cement industries to construct a weighted end-use distribution average. In this way, the Navigant team was able to apply California-specific market characteristics to the nationally derived MECS data.

[91] Machine drive energy includes most major industrial motor applications including pumps, process fans, compressed air, materials handling, and materials processing.

Table G-3. Distribution of Industrial Subsector Electricity Consumption by End Use

Subsector	Representative MECS NAICS Code(s) Used*	Lighting	HVAC	Machine Drive	Process Heating	Process Cooling & Refrigeration	Other**	TOTAL
Petroleum	324	2%	4%	88%	0%	6%	1%	100%
Food	311, 3114	7%	8%	42%	7%	29%	8%	100%
Electronics	334, 334413	10%	26%	21%	12%	12%	19%	100%
Stone-Clay-Glass	327, 327213, 327310	6%	6%	61%	24%	1%	3%	100%
Chemicals	325	4%	7%	61%	5%	9%	15%	100%
Plastics	326	9%	11%	51%	15%	9%	5%	100%
Fabricated Metals	332	9%	10%	49%	20%	3%	9%	100%
Primary Metals	331	3%	3%	29%	29%	1%	34%	100%
Industrial Machinery	339	18%	24%	33%	9%	6%	9%	100%
Transportation Equipment	336	14%	19%	37%	13%	6%	10%	100%
Paper	322	4%	5%	77%	4%	2%	9%	100%
Printing & Publishing	323511	11%	18%	52%	2%	7%	9%	100%
Textiles	315	16%	26%	31%	5%	3%	19%	100%
Lumber & Furniture	337	16%	21%	36%	8%	4%	15%	100%
All Other Industrial	339	18%	24%	33%	9%	6%	9%	100%

* The Navigant team matched the potential model subsectors to the most representative MECS NAICS code(s) available. For subsectors where multiple NAICS codes applied, the Navigant team calculated a weighted end-use distribution average based on California IOU service territory consumption.

** "Other" end-use energy includes all other MECS categories, including "Other Process Use," "Other Non-Process Use," and "Other Facility Support."

Source: Navigant team analysis based on DOE's 2006 MECS data

Table G-4. Distribution of Industrial Subsector Gas Consumption by End Use

Subsector	Representative MECS NAICS Code(s) Used*	Conventional Boiler Use	Process Heating	HVAC	Other**	TOTAL
Petroleum	324	14%	59%	1%	26%	100%
Food	311, 3114	59%	28%	5%	9%	100%
Electronics	334, 334413	42%	10%	36%	12%	100%
Stone-Clay-Glass	327, 327213, 327310	1%	90%	3%	6%	100%
Chemicals	325	28%	28%	2%	43%	100%
Plastics	326	46%	24%	19%	11%	100%
Fabricated Metals	332	15%	65%	15%	6%	100%
Primary Metals	331	5%	78%	6%	10%	100%
Industrial Machinery	339	16%	20%	52%	12%	100%
Transportation Equipment	336	15%	30%	34%	21%	100%
Paper	322	25%	26%	3%	46%	100%
Printing & Publishing	323511	13%	64%	18%	5%	100%
Textiles	315	18%	19%	50%	13%	100%
Lumber & Furniture	337	12%	28%	48%	12%	100%
All Other Industrial	339	16%	20%	52%	12%	100%

* The Navigant team matched the potential model subsectors to the most representative MECS NAICS code(s) available. For subsectors where multiple NAICS codes applied, the Navigant team calculated a weighted end-use distribution average based on California IOU service territory consumption.

** "Other" end-use energy includes all other MECS categories, including "Other Process Use," "Other Non-Process Use," "Other Facility Support," and "CHP and/or Cogeneration Process."

Source: Navigant team analysis based on DOE's 2006 MECS data

The Navigant team paired the estimated subsector end-use distribution data of Table G-3 and Table G-4 with the subsector energy consumption data of Table G-2 to generate estimates of total Industrial energy consumption by subsector and end use. Table G-5 states the portion of Industrial sector electricity consumption for each end use in each subsector, and Table G-6 states these proportions for natural gas consumption. The consumption values in these two tables aid in providing reasonable bounds on estimated efficiency potential for a given subsector and end use. For example, it would be unreasonable for Fabricated Metal lighting measures to provide savings potential of 0.5 percent or above (of all Industrial consumption), as this would indicate that *all* Fabricated Metal lighting end-use energy consumption could be conserved.

Table G-5. 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-Clay-Glass	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%

* "Other" end-use energy includes all other MECS categories, including "Other Process Use," "Other Non-Process Use," and "Other Facility Support."

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

Table G-6. 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-Clay-Glass	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%

** "Other" end-use energy includes all other MECS categories, including "Other Process Use," "Other Non-Process Use," "Other Facility Support," and "CHP and/or Cogeneration Process."

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

G.3 Supply Curve Development Using IAC Database

The Navigant team generated all Industrial supply curves except for one[92] using the Industrial Assessment Center (IAC) database. The DOE-sponsored IAC database provides thousands of actual Industrial measure recommendations and installments based on engineering efficiency audits on thousands of Industrial facilities. This data served as the basis for developing efficiency supply curves. This section pertains only to the creation of efficiency supply curves from IAC data. The remainder of this section is organized as follows:

- Section G.4 describes the approach to organizing the IAC data for the purpose of estimating Industrial sector potential.
- In the Subsection **Developing Industrial Supply Curves from IAC Data,** beginning on page G-24 the approach to developing supply curves using the organized IAC data is described.

[92] Process Heating in the Petroleum subsector is described in Section 1.4.

G.4 Data Organization

The Navigant team created a Microsoft Access database to store and process the IAC measure data, and mapped each IAC energy efficiency recommendation to a MECS end-use and measure type. For modeling and reporting purposes, the Navigant team considered two main Industrial measure types: equipment, and operation and maintenance (O&M).

» Equipment measures include the replacement of existing system hardware (e.g., a boiler replacement) or an upgrade/addition to existing system hardware (e.g., the addition of lighting controls to an existing lighting system). In general, these measures are capital intensive and have estimated useful lives (EULs) of approximately 10-20 years.
» O&M measures are changes in building operator behavior (e.g., improve motor lubrication practices) or changes in system operation (e.g., adjust process heat burners for efficient operation). In general, these measures are labor intensive and have shorter estimated EULs of three to five years.

Table G-7 lists the IAC measures used in this study and the corresponding MECS end use and equipment type assignment. First, the table is organized by MECS end use and measure type (i.e., equipment or O&M) to remain consistent with the frameworks presented in this appendix. Within that framework, the table is organized by IAC's Assessment Recommendation Code (ARC). The ARC is a number representing a specific Industrial measure, typically tied to a particular end use or building system. For example, the ARC 2.7122 represents the lighting measure "disconnect ballasts." The ARC provides a consistent identifier for efficiency accounting and tracking purposes. Although the ARCs provide a consistent definition of efficiency measures, they lack the specificity of some other energy efficiency databases, such as the DEER. For example, ARC 2.7122 does not specify what type of ballast is disconnected. See the IAC database manual for additional detail.[93]

The addition of the MECS end-use and measure-type (equipment/O&M) data fields within the Microsoft Access database allowed the Navigant team to query the database for measures within a particular Industrial subsector, end use, and measure type. Although the IAC database contains assessments from the early 1980s through the present, the Navigant team only included data from 2004 to 2012 to better estimate current conditions. In total, the Navigant team considered over 190 different subsector, end-use, and measure type (e.g., equipment or O&M) combinations for each service territory. The Navigant team generated Access queries of all combinations. Of the 190 combinations, 25 returned EE measures from fewer than eight unique Industrial sites, which the Navigant team deemed insufficient to generate an efficiency supply curve. The Navigant team exported the remaining 165 query data sets as comma-separated values (.CSV) files to be imported by a Microsoft Excel-based Industrial measure development model. The measure development model, used to generate the Industrial Measure Input Characterization Sheet, is described in the Subsection **Developing Industrial Supply Curves from IAC Data,** beginning on page G-24.

[93] Access the IAC database manual at http://iac.rutgers.edu/manual_database.php.

Table G-7. IAC Measure Recommendations with Corresponding MECS End Use and Measure Type

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.7131	ADD AREA LIGHTING SWITCHES	Lighting	Equipment
2.7132	INSTALL TIMERS ON LIGHT SWITCHES IN LITTLE-USED AREAS	Lighting	Equipment
2.7133	USE SEPARATE SWITCHES ON PERIMETER LIGHTING, WHICH MAY BE TURNED OFF WHEN NATURAL LIGHT IS AVAILABLE	Lighting	Equipment
2.7134	USE PHOTOCELL CONTROLS	Lighting	Equipment
2.7135	INSTALL OCCUPANCY SENSORS	Lighting	Equipment
2.7142	UTILIZE HIGHER EFFICIENCY LAMPS AND/OR BALLASTS	Lighting	Equipment
2.7143	USE MORE EFFICIENT LIGHT SOURCE	Lighting	Equipment
2.7144	INSTALL SPECTRAL REFLECTORS/DELAMP	Lighting	Equipment
2.7145	INSTALL SKYLIGHTS	Lighting	Equipment
2.7111	REDUCE ILLUMINATION TO MINIMUM NECESSARY LEVELS	Lighting	O&M
2.7112	REDUCE EXTERIOR ILLUMINATION TO MINIMUM SAFE LEVEL	Lighting	O&M
2.7121	UTILIZE DAYLIGHT WHENEVER POSSIBLE IN LIEU OF ARTIFICIAL LIGHT	Lighting	O&M
2.7122	DISCONNECT BALLASTS	Lighting	O&M
2.7123	KEEP LAMPS AND REFLECTORS CLEAN	Lighting	O&M
2.7124	MAKE A PRACTICE OF TURNING OFF LIGHTS WHEN NOT NEEDED	Lighting	O&M
2.7141	LOWER LIGHT FIXTURES IN HIGH CEILING AREAS	Lighting	O&M
2.7491	INSULATE GLAZING, WALLS, CEILINGS, AND ROOFS	HVAC	Equipment
2.7492	USE PROPER THICKNESS OF INSULATION ON BUILDING ENVELOPE	HVAC	Equipment
2.7493	USE DOUBLE- OR TRIPLE-GLAZED WINDOWS TO MAINTAIN HIGHER RELATIVE HUMIDITY AND TO REDUCE HEAT LOSSES	HVAC	Equipment
2.7496	INSTALL PARTITIONS TO REDUCE SIZE OF CONDITIONED SPACE	HVAC	Equipment
2.7421	REDUCE GLAZED AREAS IN BUILDINGS	HVAC	Equipment
2.7423	REDUCE HEAT GAIN BY WINDOW TINTING	HVAC	Equipment

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.7441	REPLACE BROKEN WINDOWS AND/OR WINDOW SASH	HVAC	Equipment
2.7443	INSTALL AIR SEALS AROUND TRUCK LOADING DOCK DOORS	HVAC	Equipment
2.7445	INSTALL WEATHER STRIPPING ON WINDOWS AND DOORS	HVAC	Equipment
2.7447	INSTALL VINYL STRIP / HIGH SPEED / AIR CURTAIN DOORS	HVAC	Equipment
2.7261	INSTALL TIMERS AND/OR THERMOSTATS	HVAC	Equipment
2.7271	REPLACE ELECTRIC REHEAT WITH HEAT PIPES	HVAC	Equipment
2.7272	INSTALL HEAT PIPES / RAISE COOLING SETPOINT	HVAC	Equipment
2.7273	INSTALL DESICCANT HUMIDITY CONTROL SYSTEM	HVAC	Equipment
2.7293	INSTALL DRY SPRINKLER SYSTEM OR OTHER METHOD TO REDUCE HEATING REQUIREMENTS	HVAC	Equipment
2.7212	INSTALL OR UPGRADE INSULATION ON HVAC DISTRIBUTION SYSTEMS	HVAC	Equipment
2.7231	USE RADIANT HEATER FOR SPOT HEATING	HVAC	Equipment
2.7232	REPLACE EXISTING HVAC UNIT WITH HIGH-EFFICIENCY MODEL	HVAC	Equipment
2.7233	USE PROPERLY DESIGNED AND SIZED HVAC EQUIPMENT	HVAC	Equipment
2.7234	USE HEAT PUMP FOR SPACE CONDITIONING	HVAC	Equipment
2.7235	INSTALL FOSSIL FUEL MAKE-UP AIR UNIT	HVAC	Equipment
2.7241	INSTALL OUTSIDE AIR DAMPER / ECONOMIZER ON HVAC UNIT	HVAC	Equipment
2.7242	CHANGE ZONE REHEAT COILS TO VARIABLE AIR VOLUME BOXES	HVAC	Equipment
2.7243	IMPROVE AIR CIRCULATION WITH DESTRATIFICATION FANS / OTHER METHODS	HVAC	Equipment
2.7244	REVISE SMOKE CLEANUP FROM OPERATIONS	HVAC	Equipment
2.7245	USE DIRECT AIR SUPPLY TO EXHAUST HOODS	HVAC	Equipment
2.7252	UTILIZE AN EVAPORATIVE AIR PRE-COOLER OR OTHER HEAT EXCHANGER IN AC SYSTEM	HVAC	Equipment
2.2435	RECOVER HEAT FROM COMPRESSED AIR DRYERS	HVAC	Equipment
2.2491	USE COOLING AIR, WHICH COOLS HOT WORK PIECES FOR SPACE HEATING	HVAC	Equipment

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2492	USE "HEAT WHEEL" OR OTHER HEAT EXCHANGER TO CROSS-EXCHANGE BUILDING EXHAUST AIR WITH MAKE-UP AIR	HVAC	Equipment
2.2493	USE RECOVERED HEAT FROM LIGHTING FIXTURES FOR USEFUL PURPOSE	HVAC	Equipment
2.2494	RECOVER HEAT IN DOMESTIC HOT WATER GOING TO DRAIN	HVAC	Equipment
2.2112	USE CORRECT SIZE STEAM TRAPS	HVAC	Equipment
2.6213	TURN OFF STEAM / HOT WATER LINES LEADING TO SPACE HEATING UNITS	HVAC	O&M
2.6215	SHUT OFF AIR CONDITIONING IN WINTER HEATING SEASON	HVAC	O&M
2.6218	TURN OFF EQUIPMENT WHEN NOT IN USE	HVAC	O&M
2.7424	SHADE WINDOWS FROM SUMMER SUN	HVAC	O&M
2.7425	CLEAN OR COLOR ROOF TO REDUCE SOLAR LOAD	HVAC	O&M
2.7442	KEEP DOORS AND WINDOWS SHUT WHEN NOT ON USE	HVAC	O&M
2.7444	CLOSE HOLES AND OPENINGS IN BUILDING SUCH AS BROKEN WINDOWS	HVAC	O&M
2.7446	UTILIZE SENSORS CONTROLLING ROOF AND WALL OPENINGS	HVAC	O&M
2.7262	SEPARATE CONTROLS OF AIR HANDLERS FROM AC/ HEATING SYSTEMS	HVAC	O&M
2.7263	LOWER COMPRESSOR PRESSURE THROUGH A/C SYSTEM MODIFICATION	HVAC	O&M
2.7264	INTERLOCK HEATING AND AIR CONDITIONING SYSTEMS TO PREVENT SIMULTANEOUS OPERATION	HVAC	O&M
2.7291	RESCHEDULE AND REARRANGE MULTIPLE-SOURCE HEATING SYSTEMS	HVAC	O&M
2.7292	LOWER CEILING TO REDUCE CONDITIONED SPACE	HVAC	O&M
2.7311	VENTILATION SYSTEM TO SHUT OFF WHEN ROOM IS NOT IN USE	HVAC	O&M
2.7312	MINIMIZE USE OF OUTSIDE MAKE-UP AIR FOR VENTILATION, EXCEPT WHEN USED FOR ECONOMIZER CYCLE	HVAC	O&M
2.7313	RECYCLE AIR FOR HEATING, VENTILATION, AND AIR CONDITIONING	HVAC	O&M
2.7314	REDUCE VENTILATION AIR	HVAC	O&M
2.7315	REDUCE BUILDING VENTILATION AIR TO MINIMUM SAFE LEVELS	HVAC	O&M
2.7316	CENTRALIZE CONTROL OF EXHAUST FANS TO ENSURE THEIR SHUTDOWN, OR ESTABLISH PROGRAM TO ENSURE MANUAL SHUTDOWN	HVAC	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.7211	CLEAN AND MAINTAIN REFRIGERANT CONDENSERS AND TOWERS	HVAC	O&M
2.7221	LOWER TEMPERATURE DURING THE WINTER SEASON AND VICE VERSA	HVAC	O&M
2.7222	AIR CONDITION ONLY SPACE IN USE	HVAC	O&M
2.7223	CONDITION SMALLEST SPACE NECESSARY	HVAC	O&M
2.7224	REDUCE SPACE CONDITIONING DURING NON-WORKING HOURS	HVAC	O&M
2.7225	CLOSE OUTDOOR AIR DAMPERS DURING WARM-UP / COOL-DOWN PERIODS	HVAC	O&M
2.7226	USE COMPUTER PROGRAMS TO OPTIMIZE HVAC PERFORMANCE	HVAC	O&M
2.7227	USE WATER ON AIR CONDITIONING EXCHANGER TO IMPROVE HEAT TRANSFER AND INCREASE AIR CONDITIONER EFFICIENCY	HVAC	O&M
2.7228	AVOID INTRODUCING HOT, HUMID, OR DIRTY AIR INTO HVAC SYSTEM	HVAC	O&M
2.7251	REDUCE AIR CONDITIONING LOAD BY EVAPORATING WATER FROM ROOF	HVAC	O&M
2.2495	USE EXHAUST HEAT FROM BUILDING FOR SNOW AND ICE REMOVAL	HVAC	O&M
2.2426	USE WASTE HEAT FROM FLUE GASES TO HEAT SPACE CONDITIONING AIR	HVAC	O&M
2.2521	ISOLATE STEAM LINES TO AVOID HEATING AIR CONDITIONED AREAS	HVAC	O&M
2.2522	ISOLATE HOT OR COLD EQUIPMENT	HVAC	O&M
2.2692	USE OUTSIDE COLD WATER SOURCE AS A SUPPLY OF COOLING WATER	HVAC	O&M
2.6123	REMOVE UNNEEDED SERVICE LINES TO ELIMINATE POTENTIAL LEAKS	HVAC	O&M
2.6124	ESTABLISH EQUIPMENT MAINTENANCE SCHEDULE	HVAC	O&M
2.6125	KEEP EQUIPMENT CLEAN	HVAC	O&M
2.4221	INSTALL COMPRESSOR AIR INTAKES IN COOLEST LOCATIONS	Machine Drive	Equipment
2.4222	INSTALL ADEQUATE DRYERS ON AIR LINES TO ELIMINATE BLOWDOWN	Machine Drive	Equipment
2.4223	INSTALL DIRECT ACTING UNITS IN PLACE OF COMPRESSED AIR PRESSURE SYSTEM IN SAFETY SYSTEM	Machine Drive	Equipment
2.4224	UPGRADE CONTROLS ON COMPRESSORS	Machine Drive	Equipment

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.4225	INSTALL COMMON HEADER ON COMPRESSORS	Machine Drive	Equipment
2.4226	USE / PURCHASE OPTIMUM-SIZED COMPRESSOR	Machine Drive	Equipment
2.4227	USE COMPRESSOR AIR FILTERS	Machine Drive	Equipment
2.4112	INSTALL SOFT-START TO ELIMINATE NUISANCE TRIPS	Machine Drive	Equipment
2.4113	INSTALL MOTOR VOLTAGE CONTROLLER ON LIGHTLY LOADED MOTORS	Machine Drive	Equipment
2.4131	REPLACE OVER-SIZE MOTORS AND PUMPS WITH OPTIMUM SIZE	Machine Drive	Equipment
2.4132	SIZE ELECTRIC MOTORS FOR PEAK OPERATING EFFICIENCY	Machine Drive	Equipment
2.4133	USE MOST EFFICIENT TYPE OF ELECTRIC MOTORS	Machine Drive	Equipment
2.4134	REPLACE ELECTRIC MOTOR WITH FOSSIL FUEL ENGINE	Machine Drive	Equipment
2.4141	USE MULTIPLE-SPEED MOTORS OR AFD FOR VARIABLE PUMP, BLOWER, AND COMPRESSOR LOADS	Machine Drive	Equipment
2.4142	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MOTOR-GENERATOR SET	Machine Drive	Equipment
2.4143	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE THROTTLING SYSTEM	Machine Drive	Equipment
2.4144	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MECHANICAL DRIVE	Machine Drive	Equipment
2.4145	INSTALL ISOLATION TRANSFORMER ON ADJUSTABLE FREQUENCY DRIVE	Machine Drive	Equipment
2.4321	UPGRADE OBSOLETE EQUIPMENT	Machine Drive	Equipment
2.4322	USE OR REPLACE WITH ENERGY-EFFICIENT SUBSTITUTES	Machine Drive	Equipment
2.4323	USE OPTIMUM SIZE AND CAPACITY EQUIPMENT	Machine Drive	Equipment
2.4324	REPLACE HYDRAULIC / PNEUMATIC EQUIPMENT WITH ELECTRIC EQUIPMENT	Machine Drive	Equipment
2.4325	UPGRADE CONVEYORS	Machine Drive	Equipment
2.5122	REPLACE HIGH-RESISTANCE DUCTS, PIPES, AND FITTINGS	Machine Drive	Equipment
2.5124	USE GRAVITY FEEDS WHEREVER POSSIBLE	Machine Drive	Equipment
2.4231	REDUCE THE PRESSURE OF COMPRESSED AIR TO THE MINIMUM REQUIRED	Machine Drive	O&M
2.4232	ELIMINATE OR REDUCE COMPRESSED AIR USED FOR COOLING, AGITATING LIQUIDS, MOVING PRODUCT, OR DRYING	Machine Drive	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.4233	ELIMINATE PERMANENTLY THE USE OF COMPRESSED AIR	Machine Drive	O&M
2.4234	COOL COMPRESSOR AIR INTAKE WITH HEAT EXCHANGER	Machine Drive	O&M
2.4235	REMOVE OR CLOSE OFF UNNEEDED COMPRESSED AIR LINES	Machine Drive	O&M
2.4236	ELIMINATE LEAKS IN INERT GAS AND COMPRESSED AIR LINES/ VALVES	Machine Drive	O&M
2.4237	SUBSTITUTE COMPRESSED AIR COOLING WITH WATER OR AIR COOLING	Machine Drive	O&M
2.4238	DO NOT USE COMPRESSED AIR FOR PERSONAL COOLING	Machine Drive	O&M
2.4111	UTILIZE ENERGY-EFFICIENT BELTS AND OTHER IMPROVED MECHANISMS	Machine Drive	O&M
2.4151	DEVELOP A REPAIR/REPLACE POLICY	Machine Drive	O&M
2.4152	USE ONLY CERTIFIED MOTOR REPAIR SHOPS	Machine Drive	O&M
2.4153	AVOID EMERGENCY REWIND OF MOTORS	Machine Drive	O&M
2.4154	AVOID REWINDING MOTORS MORE THAN TWICE	Machine Drive	O&M
2.4155	STANDARDIZE MOTOR INVENTORY	Machine Drive	O&M
2.4156	ESTABLISH A PREVENTATIVE MAINTENANCE PROGRAM	Machine Drive	O&M
2.4157	ESTABLISH A PREDICTIVE MAINTENANCE PROGRAM	Machine Drive	O&M
2.2434	RECOVER HEAT FROM AIR COMPRESSOR	Machine Drive	O&M
2.4311	RECOVER MECHANICAL ENERGY	Machine Drive	O&M
2.4312	IMPROVE LUBRICATION PRACTICES	Machine Drive	O&M
2.4313	PROVIDE PROPER MAINTENANCE OF MOTOR-DRIVEN EQUIPMENT	Machine Drive	O&M
2.4314	USE SYNTHETIC LUBRICANT	Machine Drive	O&M
2.5121	REDESIGN FLOW TO MINIMIZE MASS TRANSFER LENGTH	Machine Drive	O&M
2.5123	REDUCE FLUID FLOW RATES	Machine Drive	O&M
2.5125	SIZE AIR HANDLING GRILLS/DUCTS/COILS TO MINIMIZE AIR RESISTANCE	Machine Drive	O&M
2.6127	MAINTAIN AIR FILTERS BY CLEANING OR REPLACEMENT	Machine Drive	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.1123	INSTALL AUTOMATIC STACK DAMPER	Process Heating	Equipment
2.1124	REPLACE DIRECT-FIRED WITH STEAM HEAT	Process Heating	Equipment
2.1125	CONVERT TO OXYFUEL BURNERS	Process Heating	Equipment
2.2221	USE IMMERSION HEATING IN TANKS, MELTING POTS, ETC.	Process Heating	Equipment
2.2222	CONVERT LIQUID HEATERS FROM UNDERFIRING TO IMMERSION OR SUBMERSION HEATING	Process Heating	Equipment
2.2314	REPLACE HEAT TREATING OVEN WITH MORE EFFICIENT UNIT	Process Heating	Equipment
2.2125	REPLACE BAROMETRIC CONDENSERS WITH SURFACE CONDENSERS	Process Heating	Equipment
2.2142	UPGRADE DISTILLATION HARDWARE	Process Heating	Equipment
2.2421	INSTALL WASTE HEAT BOILER TO PROVIDE DIRECT POWER	Process Heating	Equipment
2.2437	RECOVER WASTE HEAT FROM EQUIPMENT	Process Heating	Equipment
2.2441	PREHEAT BOILER MAKEUP WATER WITH WASTE PROCESS HEAT	Process Heating	Equipment
2.2442	PREHEAT COMBUSTION AIR WITH WASTE HEAT	Process Heating	Equipment
2.2443	RE-USE OR RECYCLE HOT OR COLD PROCESS EXHAUST AIR	Process Heating	Equipment
2.2444	USE HOT PROCESS FLUIDS TO PREHEAT INCOMING PROCESS FLUIDS	Process Heating	Equipment
2.2445	RECOVER HEAT FROM EXHAUSTED STEAM	Process Heating	Equipment
2.2446	RECOVER HEAT FROM HOT WASTE WATER	Process Heating	Equipment
2.2447	HEAT WATER WITH EXHAUST HEAT	Process Heating	Equipment
2.2511	INSULATE BARE EQUIPMENT	Process Heating	Equipment
2.2512	INCREASE INSULATION THICKNESS	Process Heating	Equipment
2.2513	COVER OPEN TANKS WITH FLOATING INSULATION	Process Heating	Equipment
2.2514	COVER OPEN TANKS	Process Heating	Equipment
2.2515	USE OPTIMUM THICKNESS INSULATION	Process Heating	Equipment
2.2531	RE-SIZE CHARGING OPENINGS OR ADD MOVABLE COVER OR DOOR	Process Heating	Equipment

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2533	REPLACE AIR CURTAIN DOORS WITH SOLID DOORS	Process Heating	Equipment
2.5111	CONVERT FROM INDIRECT- TO DIRECT-FIRED SYSTEMS	Process Heating	Equipment
2.5112	USE CONTINUOUS EQUIPMENT, WHICH RETAINS PROCESS HEATING CONVEYORS WITHIN THE HEATED CHAMBER	Process Heating	Equipment
2.5113	USE DIRECT FLAME IMPINGEMENT OR INFRARED PROCESSING FOR CHAMBER-TYPE HEATING	Process Heating	Equipment
2.5114	USE SHAFT-TYPE FURNACES FOR PREHEATING INCOMING MATERIAL	Process Heating	Equipment
2.5115	REPOSITION OVEN WALLS TO REDUCE HEATED SPACE	Process Heating	Equipment
2.5117	CONVERT TO INDIRECT TEMPERATURE CONTROL SYSTEM	Process Heating	Equipment
2.1111	CONTROL PRESSURE ON STEAMER OPERATIONS	Process Heating	O&M
2.1112	HEAT OIL TO PROPER TEMPERATURE FOR GOOD ATOMIZATION	Process Heating	O&M
2.1113	REDUCE COMBUSTION AIRFLOW TO OPTIMUM	Process Heating	O&M
2.1114	LIMIT AND CONTROL SECONDARY COMBUSTION AIR IN FURNACE	Process Heating	O&M
2.1115	ELIMINATE COMBUSTIBLE GAS IN FLUE GAS	Process Heating	O&M
2.1116	IMPROVE COMBUSTION CONTROL CAPABILITY	Process Heating	O&M
2.1117	RELOCATE OVEN/FURNACE TO MORE EFFICIENT LOCATION	Process Heating	O&M
2.1121	USE INSULATION IN FURNACES TO FACILITATE HEATING/COOLING	Process Heating	O&M
2.1122	RE-SIZE CHARGING OPENINGS OR ADD A MOVABLE DOOR ON EQUIPMENT	Process Heating	O&M
2.1131	REPAIR FAULTY INSULATION IN FURNACES, BOILERS, ETC.	Process Heating	O&M
2.1132	REPAIR FAULTY LOUVERS AND DAMPERS	Process Heating	O&M
2.1133	ADJUST BURNERS FOR EFFICIENT OPERATION	Process Heating	O&M
2.1134	ELIMINATE LEAKS IN COMBUSTIBLE GAS LINES	Process Heating	O&M
2.1135	REPAIR FURNACES AND OVEN DOORS SO THAT THEY SEAL EFFICIENTLY	Process Heating	O&M
2.2223	ENHANCE SENSITIVITY OF TEMPERATURE CONTROL AND CUTOFF	Process Heating	O&M
2.2311	HEAT-TREAT PARTS ONLY TO REQUIRED SPECIFICATIONS OR STANDARDS	Process Heating	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2312	MINIMIZE NONESSENTIAL MATERIAL IN HEAT TREATMENT PROCESS	Process Heating	O&M
2.2313	USE BATCH FIRING WITH KILN "FURNITURE" SPECIFICALLY DESIGNED	Process Heating	O&M
2.2211	USE OPTIMUM TEMPERATURE	Process Heating	O&M
2.2212	USE MINIMUM SAFE OVEN VENTILATION	Process Heating	O&M
2.2114	SHUT OFF STEAM TRAPS ON SUPER-HEATED STEAM LINES WHEN NOT IN USE	Process Heating	O&M
2.2126	LOWER OPERATING PRESSURE OF CONDENSER (STEAM)	Process Heating	O&M
2.2141	OPERATE DISTILLATION COLUMNS EFFICIENTLY	Process Heating	O&M
2.2151	CLEAN STEAM COILS IN PROCESSING TANKS	Process Heating	O&M
2.2152	MAINTAIN STEAM JETS USED FOR VACUUM SYSTEM	Process Heating	O&M
2.2411	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT COMBUSTION AIR	Process Heating	O&M
2.2413	USE HOT FLUE GASES TO PREHEAT WASTES FOR INCINERATOR BOILER	Process Heating	O&M
2.2422	USE WASTE HEAT FROM HOT FLUE GASES TO GENERATE STEAM	Process Heating	O&M
2.2424	USE HEAT IN FLUE GASES TO PREHEAT PRODUCTS OR MATERIALS	Process Heating	O&M
2.2425	USE FLUE GASES TO HEAT PROCESS OR SERVICE WATER	Process Heating	O&M
2.2427	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT INCOMING FLUIDS	Process Heating	O&M
2.2428	USE FLUE GASES IN RADIANT HEATER FOR SPACE HEATING, OVENS, ETC.	Process Heating	O&M
2.2431	RECOVER HEAT FROM TRANSFORMERS	Process Heating	O&M
2.2432	RECOVER HEAT FROM OVEN EXHAUST/KILNS	Process Heating	O&M
2.2433	RECOVER HEAT FROM ENGINE EXHAUSTS	Process Heating	O&M
2.2161	OPTIMIZE OPERATION OF MULTISTAGE VACUUM STEAM JETS	Process Heating	O&M
2.2162	REDUCE EXCESS STEAM BLEEDING	Process Heating	O&M
2.2524	AVOID COOLING OF PROCESS STREAMS OR MATERIALS THAT MUST SUBSEQUENTLY BE HEATED	Process Heating	O&M
2.2525	ELIMINATE COOLING OF PROCESS STREAMS, WHICH SUBSEQUENTLY MUST BE HEATED AND VICE VERSA	Process Heating	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2532	USE ONLY AMOUNT OF AIR NECESSARY TO PREVENT EXPLOSION HAZARD	Process Heating	O&M
2.6121	REDUCE HOT WATER TEMPERATURE TO THE MINIMUM REQUIRED	Process Heating	O&M
2.6122	ADJUST VENTS TO MINIMIZE ENERGY USE	Process Heating	O&M
2.6126	KEEP SOLID FUELS/RAW MATERIALS DRY	Process Heating	O&M
2.6214	SHUT OFF PILOTS IN STANDBY EQUIPMENT	Process Heating	O&M
2.2622	REPLACE EXISTING CHILLER WITH HIGH-EFFICIENCY MODEL	Process Cooling	Equipment
2.2436	RECOVER HEAT FROM REFRIGERATION CONDENSERS	Process Cooling	Equipment
2.2516	USE ECONOMIC THICKNESS OF INSULATION FOR LOW TEMPERATURES	Process Cooling	Equipment
2.2695	USE CASCADE SYSTEM OF RECIRCULATING DURING COLD WEATHER TO AVOID SUB-COOLING	Process Cooling	Equipment
2.2611	MODERATE COOLING TOWER OUTLET TEMPERATURE	Process Cooling	O&M
2.2612	USE COOLING TOWER WATER INSTEAD OF REFRIGERATION	Process Cooling	O&M
2.2613	USE ANTIFREEZE IN COOLING TOWERS TO ALLOW WINTER USE	Process Cooling	O&M
2.2614	USE COOLING TOWER OR ECONOMIZER TO REPLACE CHILLER COOLING	Process Cooling	O&M
2.2615	CLEAN CONDENSER TUBES	Process Cooling	O&M
2.2621	MODIFY REFRIGERATION SYSTEM TO OPERATE AT A LOWER PRESSURE	Process Cooling	O&M
2.2623	MINIMIZE CONDENSER COOLING WATER TEMPERATURE	Process Cooling	O&M
2.2624	USE COLD WASTE WATER TO COOL CHILLER FEED WATER	Process Cooling	O&M
2.2625	CHILL WATER TO THE HIGHEST TEMPERATURE POSSIBLE	Process Cooling	O&M
2.2626	AVOID FROST FORMATION ON EVAPORATORS	Process Cooling	O&M
2.2627	USE MULTIPLE-EFFECT EVAPORATORS	Process Cooling	O&M
2.2628	UTILIZE A LESS EXPENSIVE COOLING METHOD	Process Cooling	O&M
2.2523	REDUCE INFILTRATION TO REFRIGERATED AREAS; ISOLATE HOT EQUIPMENT FROM REFRIGERATED AREAS	Process Cooling	O&M
2.2691	SHUT OFF COOLING IF COLD OUTSIDE AIR WILL COOL PROCESS	Process Cooling	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2693	USE WASTE HEAT STEAM FOR ABSORPTION REFRIGERATION	Process Cooling	O&M
2.2694	USE HIGHEST TEMPERATURE FOR CHILLING OR COLD STORAGE	Process Cooling	O&M
2.2696	USE EXCESS COLD PROCESS FLUID FOR INDUSTRIAL COOLING NEEDS	Process Cooling	O&M
2.6212	TURN OFF EQUIPMENT DURING BREAKS, REDUCE OPERATING TIME	Process Cooling	O&M
2.6216	SHUT OFF COOLING WATER WHEN NOT REQUIRED	Process Cooling	O&M
2.6222	USE DRYING OVEN (BATCH TYPE) ON ALTERNATE DAYS OR OTHER OPTIMUM SCHEDULE TO RUN EQUIPMENT WITH FULL LOADS	Process Cooling	O&M
2.5192	MODIFY TEXTILE DRYERS	Process Cooling	O&M
2.2711	UTILIZE OUTSIDE AIR INSTEAD OF CONDITIONED AIR FOR DRYING	Process Cooling	O&M
2.2111	INSTALL STEAM TRAP	Conv. Boiler Use	Equipment
2.2113	REPAIR OR REPLACE STEAM TRAPS	Conv. Boiler Use	Equipment
2.2123	INSULATE FEEDWATER TANK	Conv. Boiler Use	Equipment
2.2124	INSTALL DE-AERATOR IN PLACE OF CONDENSATE TANK	Conv. Boiler Use	Equipment
2.2131	INSULATE STEAM /HOT WATER LINES	Conv. Boiler Use	Equipment
2.2423	INSTALL WASTE HEAT BOILER TO PRODUCE STEAM	Conv. Boiler Use	Equipment
2.1221	REPLACE OBSOLETE BURNERS WITH MORE EFFICIENT ONES	Conv. Boiler Use	Equipment
2.1222	INSTALL TURBULATORS	Conv. Boiler Use	Equipment
2.1223	INSTALL SMALLER BOILER (INCREASE HIGH FIRE DUTY CYCLE)	Conv. Boiler Use	Equipment
2.1224	REPLACE BOILER	Conv. Boiler Use	Equipment
2.2121	INCREASE AMOUNT OF CONDENSATE RETURNED	Conv. Boiler Use	O&M
2.2122	INSTALL/REPAIR INSULATION ON CONDENSATE LINES	Conv. Boiler Use	O&M
2.2127	FLASH CONDENSATE TO PRODUCE LOWER PRESSURE STEAM	Conv. Boiler Use	O&M
2.2128	USE STEAM CONDENSATE FOR HOT WATER SUPPLY (NON-POTABLE)	Conv. Boiler Use	O&M

ARC Code*	IAC Recommendation Description	MECS End Use	Measure Type
2.2132	REPAIR FAULTY INSULATION ON STEAM LINES	Conv. Boiler Use	O&M
2.2133	REPAIR LEAKS IN LINES AND VALVES	Conv. Boiler Use	O&M
2.2134	ELIMINATE LEAKS IN HIGH-PRESSURE REDUCING STATIONS	Conv. Boiler Use	O&M
2.2135	REPAIR AND ELIMINATE STEAM LEAKS	Conv. Boiler Use	O&M
2.2153	CLOSE OFF UNNEEDED STEAM LINES	Conv. Boiler Use	O&M
2.2163	USE MINIMUM STEAM OPERATING PRESSURE	Conv. Boiler Use	O&M
2.2164	TURN OFF STEAM TRACING DURING MILD WEATHER	Conv. Boiler Use	O&M
2.2165	SUBSTITUTE AIR FOR STEAM TO ATOMIZE OIL	Conv. Boiler Use	O&M
2.2191	SUBSTITUTE HOT PROCESS FLUIDS FOR STEAM	Conv. Boiler Use	O&M
2.2192	USE HEAT EXCHANGE FLUIDS INSTEAD OF STEAM IN PIPELINE TRACING SYSTEMS	Conv. Boiler Use	O&M
2.2412	USE FLUE GAS HEAT TO PREHEAT BOILER FEEDWATER	Conv. Boiler Use	O&M
2.1211	MOVE BOILER TO MORE EFFICIENT LOCATION	Conv. Boiler Use	O&M
2.1212	OPERATE BOILERS ON HIGH FIRE SETTING	Conv. Boiler Use	O&M
2.1213	DIRECT WARMEST AIR TO COMBUSTION INTAKE	Conv. Boiler Use	O&M
2.1231	ESTABLISH BURNER MAINTENANCE SCHEDULE FOR BOILERS	Conv. Boiler Use	O&M
2.1232	KEEP BOILER TUBES CLEAN	Conv. Boiler Use	O&M
2.1233	ANALYZE FLUE GAS FOR PROPER AIR/FUEL RATIO	Conv. Boiler Use	O&M
2.1241	REDUCE EXCESSIVE BOILER BLOWDOWN	Conv. Boiler Use	O&M
2.1242	MINIMIZE BOILER BLOWDOWN WITH BETTER FEEDWATER TREATMENT	Conv. Boiler Use	O&M
2.1243	USE HEAT FROM BOILER BLOWDOWN TO PREHEAT BOILER FEEDWATER	Conv. Boiler Use	O&M

* The IAC database organizes recommendations by their Assessment Recommendation Code.

Source: Navigant team analysis of IAC measures comprising the DOE IAC database (http://iac.rutgers.edu/database)

G.4.1 Developing Industrial Supply Curves from IAC Data

The 165 data sets from the IAC database served as the primary basis for constructing the efficiency supply curves. Table G-8 shows the list of the 165 data sets representing Industrial subsector, end-use, and measure-type combinations. Each IAC data set contains actual efficiency recommendations made at Industrial sites across the U.S. The IAC data tracked whether or not each project was implemented. Each IAC project contains cost and energy savings data, in addition to facility-level data such as facility type (i.e., NAICS code), facility location (state), and annual facility energy/demand consumption.

Table G-8. List of IAC Data Queries Used to Generate Industrial Efficiency Supply Curves

Query ID	Subsector	End Use	Measure Type	Fuel Type
1	Fabricated Metals	Lighting	O&M	Electric
2	Food	Lighting	O&M	Electric
3	Electronics	Lighting	O&M	Electric
4	Stone-Clay-Glass	Lighting	O&M	Electric
5	Chemicals	Lighting	O&M	Electric
6	Plastics	Lighting	O&M	Electric
7	Primary Metals	Lighting	O&M	Electric
8	Industrial Machinery	Lighting	O&M	Electric
9	Transportation Equipment	Lighting	O&M	Electric
10	Paper	Lighting	O&M	Electric
11	Printing & Publishing	Lighting	O&M	Electric
12	Textiles	Lighting	O&M	Electric
13	Lumber & Furniture	Lighting	O&M	Electric
14	All Other Industrial	Lighting	O&M	Electric
15	Fabricated Metals	Lighting	Equipment	Electric
16	Petroleum	Lighting	Equipment	Electric
17	Food	Lighting	Equipment	Electric
18	Electronics	Lighting	Equipment	Electric
19	Stone-Clay-Glass	Lighting	Equipment	Electric
20	Chemicals	Lighting	Equipment	Electric
21	Plastics	Lighting	Equipment	Electric
22	Primary Metals	Lighting	Equipment	Electric
23	Industrial Machinery	Lighting	Equipment	Electric
24	Transportation Equipment	Lighting	Equipment	Electric
25	Paper	Lighting	Equipment	Electric
26	Printing & Publishing	Lighting	Equipment	Electric

Query ID	Subsector	End Use	Measure Type	Fuel Type
27	Textiles	Lighting	Equipment	Electric
28	Lumber & Furniture	Lighting	Equipment	Electric
29	All Other Industrial	Lighting	Equipment	Electric
30	Fabricated Metals	HVAC	O&M	Electric
31	Food	HVAC	O&M	Electric
32	Electronics	HVAC	O&M	Electric
33	Stone-Clay-Glass	HVAC	O&M	Electric
34	Chemicals	HVAC	O&M	Electric
35	Plastics	HVAC	O&M	Electric
36	Primary Metals	HVAC	O&M	Electric
37	Industrial Machinery	HVAC	O&M	Electric
38	Transportation Equipment	HVAC	O&M	Electric
39	Paper	HVAC	O&M	Electric
40	Printing & Publishing	HVAC	O&M	Electric
41	Textiles	HVAC	O&M	Electric
42	Lumber & Furniture	HVAC	O&M	Electric
43	All Other Industrial	HVAC	O&M	Electric
44	Fabricated Metals	HVAC	Equipment	Electric
45	Food	HVAC	Equipment	Electric
46	Electronics	HVAC	Equipment	Electric
47	Chemicals	HVAC	Equipment	Electric
48	Plastics	HVAC	Equipment	Electric
49	Primary Metals	HVAC	Equipment	Electric
50	Industrial Machinery	HVAC	Equipment	Electric
51	Transportation Equipment	HVAC	Equipment	Electric
52	Paper	HVAC	Equipment	Electric
53	Printing & Publishing	HVAC	Equipment	Electric
54	Textiles	HVAC	Equipment	Electric
55	Lumber & Furniture	HVAC	Equipment	Electric
56	All Other Industrial	HVAC	Equipment	Electric
57	Fabricated Metals	Machine Drive	O&M	Electric
58	Petroleum	Machine Drive	O&M	Electric
59	Food	Machine Drive	O&M	Electric
60	Electronics	Machine Drive	O&M	Electric
61	Stone-Clay-Glass	Machine Drive	O&M	Electric

Query ID	Subsector	End Use	Measure Type	Fuel Type
62	Chemicals	Machine Drive	O&M	Electric
63	Plastics	Machine Drive	O&M	Electric
64	Primary Metals	Machine Drive	O&M	Electric
65	Industrial Machinery	Machine Drive	O&M	Electric
66	Transportation Equipment	Machine Drive	O&M	Electric
67	Paper	Machine Drive	O&M	Electric
68	Printing & Publishing	Machine Drive	O&M	Electric
69	Textiles	Machine Drive	O&M	Electric
70	Lumber & Furniture	Machine Drive	O&M	Electric
71	All Other Industrial	Machine Drive	O&M	Electric
72	Fabricated Metals	Machine Drive	Equipment	Electric
73	Petroleum	Machine Drive	Equipment	Electric
74	Food	Machine Drive	Equipment	Electric
75	Electronics	Machine Drive	Equipment	Electric
76	Stone-Clay-Glass	Machine Drive	Equipment	Electric
77	Chemicals	Machine Drive	Equipment	Electric
78	Plastics	Machine Drive	Equipment	Electric
79	Primary Metals	Machine Drive	Equipment	Electric
80	Industrial Machinery	Machine Drive	Equipment	Electric
81	Transportation Equipment	Machine Drive	Equipment	Electric
82	Paper	Machine Drive	Equipment	Electric
83	Printing & Publishing	Machine Drive	Equipment	Electric
84	Textiles	Machine Drive	Equipment	Electric
85	Lumber & Furniture	Machine Drive	Equipment	Electric
86	All Other Industrial	Machine Drive	Equipment	Electric
87	Fabricated Metals	Process Heating	O&M	Electric
88	Primary Metals	Process Heating	O&M	Electric
89	Fabricated Metals	Process Heating	Equipment	Electric
90	Food	Process Heating	Equipment	Electric
91	Electronics	Process Heating	Equipment	Electric
92	Chemicals	Process Heating	Equipment	Electric
93	Plastics	Process Heating	Equipment	Electric
94	Primary Metals	Process Heating	Equipment	Electric
95	Industrial Machinery	Process Heating	Equipment	Electric
96	Transportation Equipment	Process Heating	Equipment	Electric

Query ID	Subsector	End Use	Measure Type	Fuel Type
97	Fabricated Metals	Process Cooling and Refrigeration	O&M	Electric
98	Food	Process Cooling and Refrigeration	O&M	Electric
99	Electronics	Process Cooling and Refrigeration	O&M	Electric
100	Chemicals	Process Cooling and Refrigeration	O&M	Electric
101	Plastics	Process Cooling and Refrigeration	O&M	Electric
102	Industrial Machinery	Process Cooling and Refrigeration	O&M	Electric
103	Transportation Equipment	Process Cooling and Refrigeration	O&M	Electric
104	Food	Process Cooling and Refrigeration	Equipment	Electric
105	Fabricated Metals	Conventional Boiler Use	O&M	Gas
106	Petroleum	Conventional Boiler Use	O&M	Gas
107	Food	Conventional Boiler Use	O&M	Gas
108	Electronics	Conventional Boiler Use	O&M	Gas
109	Chemicals	Conventional Boiler Use	O&M	Gas
110	Plastics	Conventional Boiler Use	O&M	Gas
111	Primary Metals	Conventional Boiler Use	O&M	Gas
112	Transportation Equipment	Conventional Boiler Use	O&M	Gas
113	Textiles	Conventional Boiler Use	O&M	Gas
114	Fabricated Metals	Conventional Boiler Use	Equipment	Gas
115	Petroleum	Conventional Boiler Use	Equipment	Gas
116	Food	Conventional Boiler Use	Equipment	Gas
117	Electronics	Conventional Boiler Use	Equipment	Gas
118	Chemicals	Conventional Boiler Use	Equipment	Gas
119	Plastics	Conventional Boiler Use	Equipment	Gas
120	Primary Metals	Conventional Boiler Use	Equipment	Gas
121	Transportation Equipment	Conventional Boiler Use	Equipment	Gas
122	Textiles	Conventional Boiler Use	Equipment	Gas
123	Fabricated Metals	Process Heating	O&M	Gas
124	Food	Process Heating	O&M	Gas
125	Electronics	Process Heating	O&M	Gas
126	Stone-Clay-Glass	Process Heating	O&M	Gas
127	Chemicals	Process Heating	O&M	Gas
128	Plastics	Process Heating	O&M	Gas
129	Primary Metals	Process Heating	O&M	Gas
130	Industrial Machinery	Process Heating	O&M	Gas
131	Transportation Equipment	Process Heating	O&M	Gas

Query ID	Subsector	End Use	Measure Type	Fuel Type
132	Paper	Process Heating	O&M	Gas
133	Printing & Publishing	Process Heating	O&M	Gas
134	Textiles	Process Heating	O&M	Gas
135	Fabricated Metals	Process Heating	Equipment	Gas
136	Food	Process Heating	Equipment	Gas
137	Electronics	Process Heating	Equipment	Gas
138	Stone-Clay-Glass	Process Heating	Equipment	Gas
139	Chemicals	Process Heating	Equipment	Gas
140	Plastics	Process Heating	Equipment	Gas
141	Primary Metals	Process Heating	Equipment	Gas
142	Industrial Machinery	Process Heating	Equipment	Gas
143	Transportation Equipment	Process Heating	Equipment	Gas
144	Paper	Process Heating	Equipment	Gas
145	Printing & Publishing	Process Heating	Equipment	Gas
146	Textiles	Process Heating	Equipment	Gas
147	Fabricated Metals	HVAC	O&M	Gas
148	Electronics	HVAC	O&M	Gas
149	Chemicals	HVAC	O&M	Gas
150	Plastics	HVAC	O&M	Gas
151	Primary Metals	HVAC	O&M	Gas
152	Industrial Machinery	HVAC	O&M	Gas
153	Transportation Equipment	HVAC	O&M	Gas
154	Paper	HVAC	O&M	Gas
155	Fabricated Metals	HVAC	Equipment	Gas
156	Food	HVAC	Equipment	Gas
157	Electronics	HVAC	Equipment	Gas
158	Stone-Clay-Glass	HVAC	Equipment	Gas
159	Chemicals	HVAC	Equipment	Gas
160	Plastics	HVAC	Equipment	Gas
161	Primary Metals	HVAC	Equipment	Gas
162	Industrial Machinery	HVAC	Equipment	Gas
163	Transportation Equipment	HVAC	Equipment	Gas
164	Paper	HVAC	Equipment	Gas
165	Printing & Publishing	HVAC	Equipment	Gas

Source: 2012 Navigant team analysis of Industrial Assessment Center data

The Navigant team applied each IAC query data set as a representation of the energy efficiency potential at the sample of buildings in the database. For each subsector, end use, and project type (O&M and equipment), the Navigant team compiled all relevant data points in the IAC database, and ordered them from least to highest cost, per kilowatt-hour (kWh) or therm savings, to create energy efficiency supply curves. A Visual Basic for Applications (VBA) routine embedded within the Navigant team's Industrial measure development model systematically generated the supply curves from the 165 .CSV Microsoft Access data query input files. The VBA program also updated the Industrial data file each time the efficiency supply curves were modified or updated.

The Navigant team also examined electric demand reductions (kW) associated with each IAC data point, where applicable. IAC defines demand as the total annual coincident peak demand reduction (i.e., monthly peak demand reduction multiplied by 12). This provides facility owners receiving IAC recommendations an understanding of potential annual cost savings associated with utility demand charges. Therefore, Navigant divided all IAC demand raw data points by 12 before incorporating into the model.

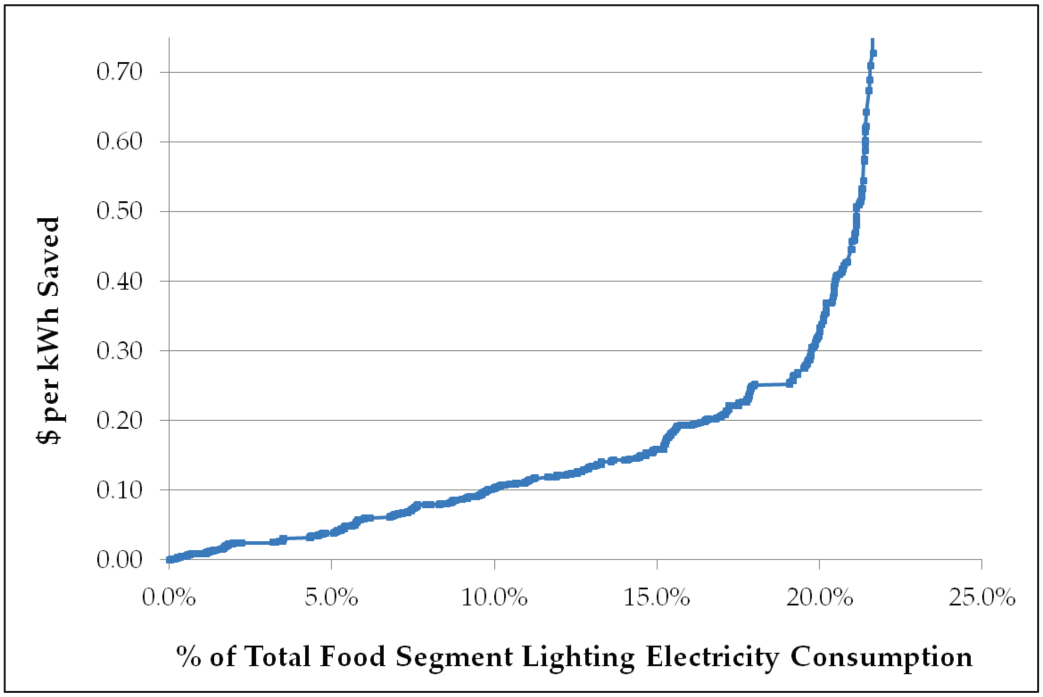
Figure G-2 shows an example efficiency supply curve generated by the Navigant team using IAC data. This curve illustrates estimated cumulative electric savings potential for lighting end-use equipment measures in the Industrial Food subsector. Each point on the curve in the figure represents an individual efficiency recommendation made at an Industrial site; in this case, the curve is made up of 673 recommendations made at 335 unique sites. Savings are normalized by total Industrial subsector end-use consumption; for example, Figure G-2 shows the percent savings potential of all lighting end-use electricity in the Industrial Food subsector.

In summary, the Navigant team took the following steps to create the efficiency supply curve shown in Figure G-2 from IAC data:

1. Generated a dataset from the IAC database consisting of all lighting equipment projects in the Industrial Food subsector
2. Calculated the initial cost per kWh (for electric measures) or therm (for gas measures) for each IAC project
3. Ordered projects from lowest cost per kWh or therm to highest cost per kWh or therm
4. Graphed the cost per kWh or therm versus the *cumulative* savings (kWh or therm) of the projects
5. Divided the cumulative kWh or therm savings by the total kWh or therm consumption of all Food subsector sites in the IAC database (from 2004 to 2012), thereby providing the percent electric or gas savings of all Food consumption

Divided the percent electric or gas savings of *all* Food consumption by the Food lighting end-use split (7 percent, as shown in Figure G-2) to estimate the cumulative percent savings of lighting end use, shown in Figure G-2.

Figure G-2. Sample Supply Curve of Cumulative Electric Energy Savings Potential of Lighting in the Industrial Food Subsector



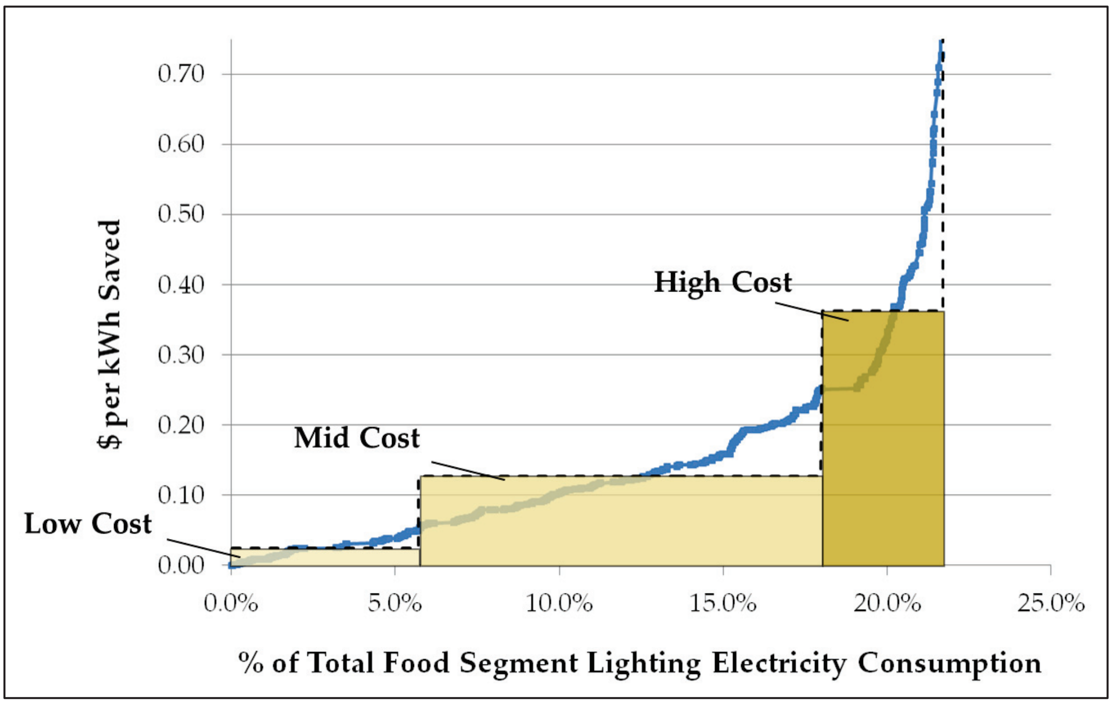
Source: Navigant team analysis of DOE's IAC database

After generating the full efficiency supply curve, the Navigant team summarized the curve by identifying three distinct cost-effectiveness levels—low cost, mid cost, and high cost—based on the unique shape of each curve. The levels graphically represent three efficiency "blocks" of savings, as shown in Figure G-3. The blocks were generated by the VBA routine and are sized such that their areas are equivalent to the area under the supply curve. The Navigant team condensed the efficiency supply curves into blocks for two main reasons. First, the blocks allow projects to be grouped into bins representing varying degree efficiency of cost-effectiveness. For example, the Navigant team set the high cost level ceiling to include only measures contributing to economic potential, or measures meeting a total resource cost screen of 0.85 or above. This means that all three efficiency levels (low, mid, and high cost) currently contribute to both economic and technical potential. Second, approximating the efficiency supply curve with three blocks greatly reduces the amount of inputs and computational effort required by the potential model.

In summary, the Navigant team took the following steps to create the savings levels shown in Figure G-3:

1. Set level ceilings for cost ($) per kWh or therm savings. In Figure G-3, the Navigant team set the ceilings for low cost, mid cost, and high cost levels at $0.05, $0.25, and $0.87/kWh savings, respectively.
2. Calculated the *average cost* of all measures falling within one level. This dictates the height of the savings blocks shown in Figure G-3.
3. Calculated the *cumulative savings* of all measures falling within one level. This dictates the width of the savings blocks shown in Figure G-3.

Figure G-3. Sample Supply Curve of Cumulative Electric Energy Savings Potential of Lighting in the Industrial Food Subsector, with Low/Mid/High Cost Measures Highlighted



Source: Navigant team analysis of DOE's IAC database

G.5 Measure Development Using Non-IAC Data

The Petroleum subsector accounts for nearly a quarter of all IOU territory electric consumption in the Industrial sector and over half of all IOU territory gas consumption in the Industrial sector.[94] 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.

[94] See Table 4.

To estimate the energy efficiency potential of Petroleum Process Heat, the Navigant team referred to a 2005 Lawrence Berkeley National Laboratory (LBNL) study of energy efficiency opportunities for petroleum refineries.[95] The Navigant team reviewed the different processes involved in petroleum refining and the corresponding efficiency opportunities available within each process. Table G-9 provides a summary of refinery processes and efficiency opportunities. While many efficiency measures are very specific to one refinery process, process integration, or "pinch," can be applied to all refinery processes. Process integration "refers to the exploitation of potential synergies that are inherent in any system that consists of multiple components working together. In plants that have multiple heating and cooling demands, the use of process integration techniques may significantly improve efficiencies."[96]

Table G-9. Petroleum Refinery Processes and the Availability (Yes/No) of Efficiency Measures within Each

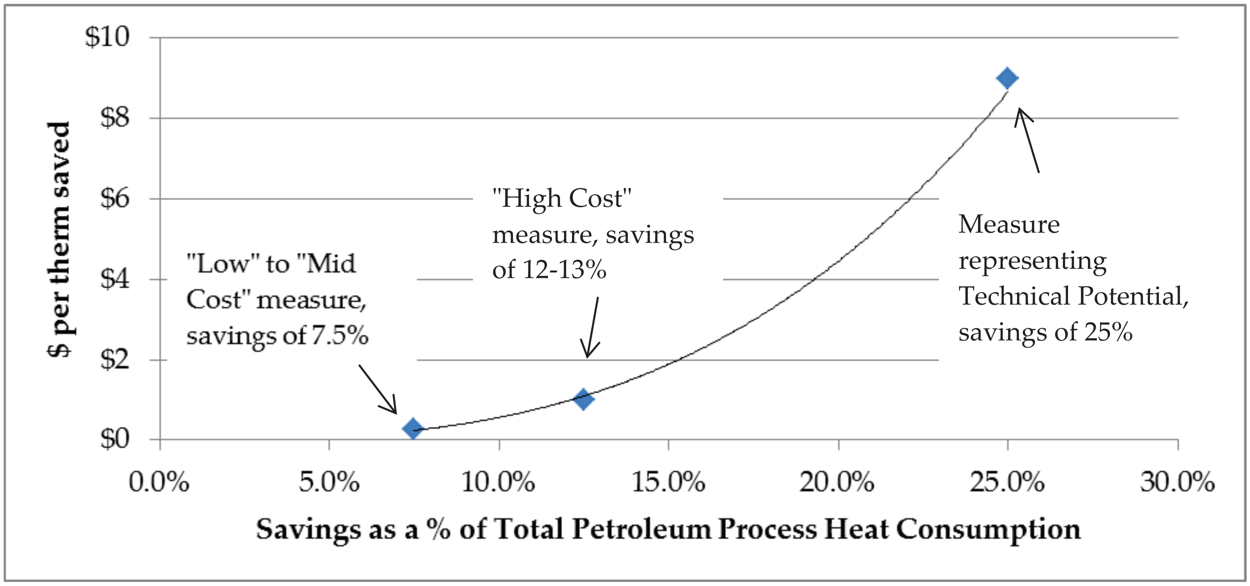
Efficiency Measure	Hydrogen	Crude Distillation Unit (CDU)	Reforming	Hydrotreater	Vacuum Distillation Unit (VDU)	Hydrocracker
Process controls	No	Yes	No	Yes	Yes	No
Furnace controls	Yes	Yes	Yes	No	Yes	Yes
Air preheating	Yes	Yes	Yes	No	Yes	Yes
Progressive crude distillation	No	Yes	No	No	No	No
Optimization distillation	No	Yes	Yes	Yes	Yes	Yes
Process integration (pinch)	Yes	Yes	Yes	Yes	Yes	Yes
New hydrotreater design	No	No	No	Yes	No	No
Adiabatic pre-reformer	Yes	No	No	No	No	No
Power recovery	No	No	No	No	No	Yes

Source: Navigant team analysis of LBNL, Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries, 2005

[95] LBNL. (2005). *Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries*.
[96] Ibid.

According to LBNL, successful process integration implementations have saved between 7.5 and 25 percent of process energy consumption in the Petroleum subsector, with cost-effective savings reaching nearly 12 to 13 percent. The Navigant team applied this data to create a general curve outlining the approximate cost/benefit break points of the process integration technology. The Navigant team set the savings axis of the chart in Figure G-4 according to the savings levels highlighted in the LBNL study (7.5 to 25 percent) and the cost axis according to their varying levels of cost-effectiveness. Figure G-4 shows that between 7.5 and 12.5 percent can be obtained cost effectively as economic potential, while 25 percent savings can be achieved as technical potential. This approach could be replicated for other large, energy-intensive subsectors that may be underrepresented by the IAC data.

Figure G-4. General Supply Curve Showing Efficiency Potential for Petroleum, Process Heat



Source: Navigant team analysis of LBNL, Energy Efficiency Improvement and Cost-Saving Opportunities for Petroleum Refineries, 2005

G.6 Estimating Industrial Market Potential from the Efficiency Supply Curves

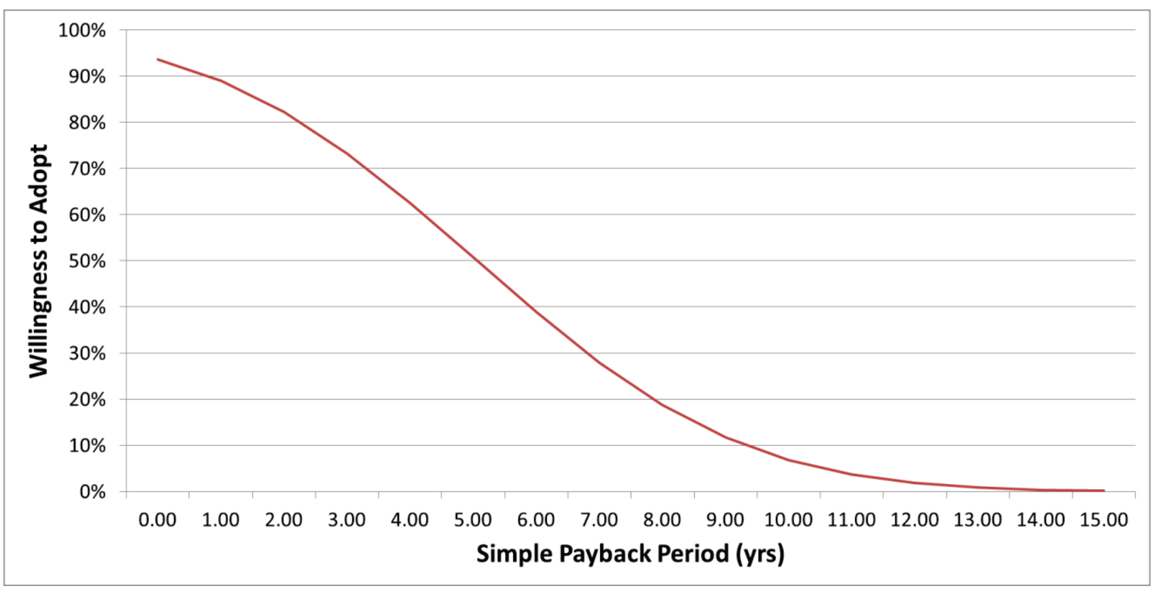
The IAC database represents the best available data to estimate Industrial technical and economic potential. However, it does not provide any information that could be used to establish the timing of efficiency adoption. Estimating market potential from the supply curves precluded using the Bass adoption framework that was applied to the Residential, Commercial, Mining, and Street-Lighting sectors because of the diversity of projects, technologies, and applications that comprised each supply curve. Each project on the supply curve would have a different level of maturity and saturation. Instead, the Navigant team created a simple approach to estimate market potential based on some simplifying assumptions and additional research.

The Navigant team applied a three-step approach to establish the market potential of each supply curve block:

1. Determine the willingness to adopt each block based on the payback acceptance data for Industrial customers.[97] Willingness is multiplied by the economic potential of each block to estimate the *eventual* market adoption.
2. Establish the adoption horizon for each use category. The eventual market adoption is divided by the time horizon to estimate the average annual market adoption rate.
3. Determine whether the supply curves are expected to experience continuous improvements or saturation for each use category and Industrial subsector. A continually improving supply curve implies that emerging efficient technologies, long term, intelligent process-focused improvement strategies, evolving industrial processes, process optimizations, and/or new efficiency opportunities emerge at a rate sufficient to maintain annual industrial efficiency levels through 2024, the time frame of this study. A saturating supply curve implies that the achievement of the efficiency potential contained within each block will not be replaced by new efficiency opportunities, and that the potential will decay over the applied adoption horizon. *(Note: Release 1 of the Industrial model applied the continuous improvement assumption to each use category and Industrial subsector. The Navigant team refined its approaches to apply continuous improvement characteristics only to those use categories and Industrial subsectors where continuous improvement activities are likely to occur.)*

The payback acceptance data that is used to determine the eventual market adoption is presented in Figure G-5. This data indicate the percent of Industrial customers that would eventually adopt an efficient measure based on the simple payback—upfront incremental costs divided by annual incremental benefits.

Figure G-5. Industrial Customer Payback Acceptance Curve



Source: Navigant team analysis in the PG model

[97] This is the same data set used to establish the implied discount rates in the Residential and Commercial sectors, but specific to industrial customers.

The appropriate adoption horizon for each end-use category and measure type was established based on the assessment of average EUL, code-to-code durations (or standards from other governing bodies such as ASHRAE), and historic Industrial program accomplishments.

For many Industrial subsectors, continuous improvement supply curves represents the introduction of emerging technologies in future years, long-term, intelligent process-focused improvement strategies, ongoing implementation of O&M best practices, and process improvements and optimizations that are typically implemented as a part of production changes and equipment retooling. These continuous improvement assumptions are consistent with the proactive nature of for-profit enterprises that generally view energy expense as a substantial cost that has a direct impact on operating margins. Conversely, Navigant estimates that potential will saturate for certain end-uses and certain subsectors. For example, 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, stone producers) represent the full extent of potential remaining within those areas. Navigant does not anticipate any emerging technologies, process optimizations, or other efficiency improvements to provide further opportunities for potential. Table G-10 shows the subsectors and end-uses, by measure type, that are estimated to experience continuous improvements (represented with a 1) or saturation (represented with a 0).

Table G-10. Industrial Sector Continuous Improvement Assumptions

Continuous Improvement Assumptions by End Use and Sub-Sector (continuous improvement = 1, saturation = 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.

G.7 Data Sources Used to Support the Top-Down Analysis Approach

The Navigant team reviewed publicly available Industrial literature and data sources for the purposes of vetting its potential study approaches. The Navigant team found state-level Industrial data to be limited for the purposes of estimating the fullest scope of Industrial potential, particularly when compared to the available data for the Residential and Commercial sectors. No sufficient state-level source could be identified that would contain the quantitative data needed for a bottom-up, measure-based potential estimate similar to the method used for the Residential and Commercial sectors.

The Navigant team found that several recent studies had used a top-down efficiency supply curve methodology to estimate energy efficiency potential in the Industrial sector:

- McKinsey & Company. (2009). Unlocking Energy Efficiency in the U.S. Economy
- Northwest Power Conservation Council (NWPCC). (2008). 6th Power Plan
- Lawrence Berkeley National Laboratory. (2010). Bottom-up Representation of Industrial Energy Efficiency Technologies in Integrated Assessment Models for the Cement Sector
- United Nations Industrial Development Organization. (2010). Motor Systems Efficiency Supply Curves

In addition to the four efficiency supply curve references above, the Navigant team identified an additional data resource that could serve as the basis of efficiency supply curve generation—DOE's Industrial Assessment Center database.[98] The IAC database is a web-based Industrial energy data repository that is developed and maintained by research institutions across the U.S. The database contains more than118,000 energy efficiency recommendations, or measures, provided by IAC member institutions at nearly 16,000 individual Industrial sites. The Navigant team determined that this data source is suitable for supporting its top-down approach to the Industrial sector. In Section G.3, the Navigant team presents a method of using IAC data to estimate Industrial potential for various subsectors, end uses, and measure types. In Section G.8, the Navigant team presents further details on the IAC, its vetting process to determine the appropriateness of the data for this study, and refinements made for this analysis.

G.8 Industrial Source Characterization and Refinement

This section describes the processes and tools selected to support and refine the Industrial sector analysis of the PGT efforts. It covers the initial data resource decisions and how Navigant staff approached characterizing the Industrial sector. It also describes the IAC database: why it was chosen, how it was used, and the process used to validate that the data represents the California Industrial sector. Finally, it describes the modifications applied to the IAC data in order to refine the representation of the California-specific regulatory markets, industry standard practices (ISPs), and energy efficiency program requirements and limitations.

G.8.1 Initial Data Resource Decisions

The Navigant team gathered resources from a variety of locations to characterize Industrial energy use and energy efficiency opportunities. Navigant used these resources to understand energy consumption, identify the different industrial types and subsectors, identify the major energy end-uses, and to estimate the distribution of energy use among both subsectors and end-uses. The data Navigant gathered also provided additional details about specific equipment and maintenance measures implemented in the industrial sector.

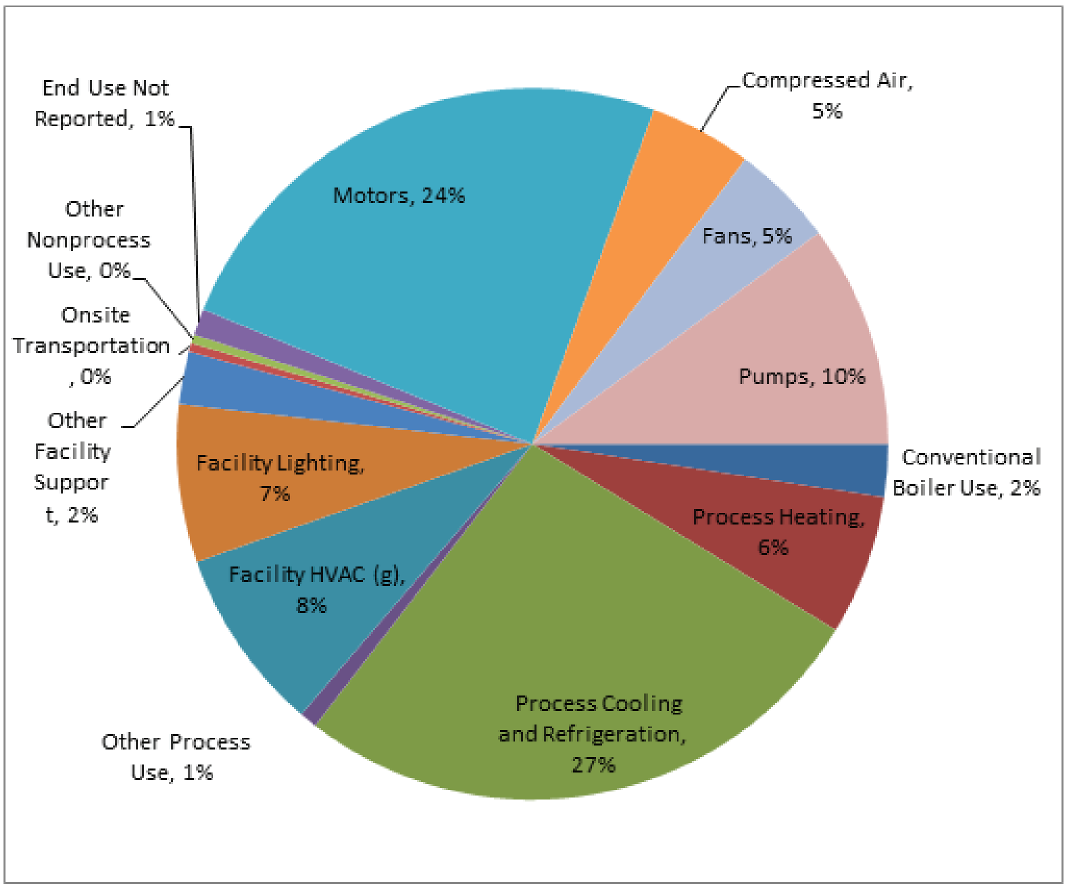
[98] Industrial Assessment Centers Database. Accessed at http://iac.rutgers.edu/database.

G.8.1.1 *Quarterly Fuel and Energy Report (QFER) and Manufacturing Energy Consumption Survey (MECS)*

The Navigant team first relied on the Quarterly Fuel and Energy Report (QFER) data to understand Industrial energy consumption in California.[99] The QFER data provided electric and natural gas consumption by North American Industry Classification System (NAICS) code. Next, Navigant reviewed Manufacturing Energy Consumption Survey (MECS)[100] data to understand the distribution of energy consumption by end-use across the different Industrial subsectors, as defined by NAICS code.

Figure G-6 shows example results of the initial MECS research that shows energy distribution found in the Food and Beverage subsector (NAICS 311 and 312). Navigant completed this exercise for all NAICS codes considered within the analysis.

Figure G-6. Example of MECS Electric Consumption Distribution [Food Industry by End-Use]



[99] California Energy Commission. QFER CEC-1304 Power Plant Owner Reporting Database. Accessed November 18, 2013. http://energyalmanac.ca.gov/electricity/web_qfer/

[100] Energy Information Administration. Manufacturing Energy Consumption Survey (MECS). Accessed November 18, 2013. http://www.eia.gov/consumption/manufacturing/index.cfm

G.8.1.2 Industrial Literature Search

Next, Navigant conducted a literature review to determine the availability of secondary sources and to identify previous research activities in the area of Industrial energy efficiency. The literature search helped the team further understand the Industrial market, its specific energy end-uses, and the general energy efficiency opportunities available to this sector.

Table G-11. Summary of Industrial Sector Literature Search

Source	Citation
LBNL	LBNL (2008). Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry.
NRDC	Natural Resources Canada (2001). Energy Performance Indicator Report: Fluid Milk Plants.
DOE	US DOE Industrial Technologies Program (ITP) (2004). Technology Roadmap, Energy Loss Reduction and Recovery in Industrial Energy Systems.
NEEA	NEEA (2012). NEEA Market Progress Evaluation Report #7: Evaluation of NEEA's Industrial Initiative.
LBNL	Brush, Adrian et al, LBNL (2011). Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry. Accessed at http://www.energystar.gov/ia/business/industry/downloads/Dairy_Guide_Final.pdf?a5bc-34fe.
DOE	US DOE Advanced Manufacturing Office (AMO) (2012). Manufacturing Energy and Carbon Footprint for Computers and Electronics (NAICS 334, 335). Accessed at http://www1.eere.energy.gov/manufacturing/pdfs/elecapps_footprint_2012.pdf.
PG&E	PG&E (2009). Process Evaluation of Pacific Gas & Electric Company's 2006-2008 High-Tech Program. Accessed at http://calmac.org/publications/HighTechProcessEval_Rpt_FINAL_2009May20.pdf.
ECO Northwest	ECONorthwest (2010). Process Evaluation of the 2006-08 Statewide Technical Assistance and Technology Incentive Program. Accessed at http://www.calmac.org/publications/Final_2008_TA-TI_Update_Report_3-8-10.pdf
KEMA	KEMA (2012). Industrial Sectors Market Characterization, Chemical Industry.
LBNL	LBNL (2000). Energy Use and Energy Intensity of the U.S. Chemical Industry.
DOE	US DOE Industrial Technologies Program (ITP) (2006). Chemical Bandwidth Study.
LBNL	Neelis, Maarten et al., LBNL (2008). Energy Efficiency Improvement and Cost Savings Opportunities for the Petrochemical Industry. Accessed at http://www.energystar.gov/ia/business/industry/Petrochemical_Industry.pdf?fcaf-6b43
LBNL	LBNL (2006). Improving Energy Efficiency In Pharmaceutical Manufacturing Operations.
Galitsky	Galitsky, Christina et al. (2008). Energy Efficiency Improvement and Cost Saving Opportunities for the Pharmaceutical Industry. Accessed at http://www.energystar.gov/ia/business/industry/in_focus/Pharmaceutical_Energy_Guide.pdf?f897-34d1.
KEMA	KEMA (2012). Industrial Sectors Market Characterization. Industrial Sectors Market Characterization. Plastics Industry (Prepared for Southern California Edison Company). Accessed at: http://www.calmac.org
DOE	US DOE Advanced Manufacturing Office (AMO) (2012). Manufacturing Energy and Carbon Footprint - Onsite Energy Use (Advanced Manufacturing Office) - PLASTICS (NAICS 326). Accessed at: http://www1.eere.energy.gov.
DOE	US DOE Industrial Technologies Program (ITP) (2008). Improving Energy Efficiency at U.S. Plastics Manufacturing Plants - Summary Report and Case Studies. Accessed at: http://files.harc.edu.
KEMA	KEMA (2012). Industrial Sectors Market Characterization. Metalworking Industry. (Developed for Pacific Gas & Electric Company and Southern California Edison Company). Accessed at: http://www.calmac.org
LBNL	LBNL (2010). Energy Efficiency Improvement and Cost Saving Opportunities for the U.S. Iron and Steel Industry. Accessed at: www.energystar.gov
BCS	BCS Incorporated (2007). U.S. Energy Requirements for Aluminum Production. Accessed at: www1.eere.energy.gov.
BCS	BCS Incorporated (2007). Implementation of Metal Casting Best Practices. Accessed at: http://www1.eere.energy.gov.
CPUC	CPUC (2010). 2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group. Accessed at http://www.calmac.org/publications/PG&E_Fab_06-08_Eval_Final_Report.pdf.

Source	Citation
DOE	US DOE Advanced Manufacturing Office (AMO) (2012). Manufacturing Energy and Carbon Footprint - Onsite Energy Use (Advanced Manufacturing Office) - PETROLEUM REFINING (NAICS 324110). Accessed at: http://www1.eere.energy.gov
LBNL	LBNL (2005). Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries. Accessed at: www.energystar.gov
Energetics	Energetics Incorporated (2004). Energy Efficiency Roadmap for Petroleum Refineries in California. Accessed at: http://www1.eere.energy.gov.
Energetics	Energetics Incorporated (2004). Impacts of Condition Assessment on Energy Use: Selected Applications in Chemicals Processing and Petroleum Refining. Accessed at: http://www1.eere.energy.gov.
DOE	US DOE Advanced Manufacturing Office (AMO) (2012). Manufacturing Energy and Carbon Footprint - Onsite Energy Use (Advanced Manufacturing Office) - TRANSPORTATION EQUIPMENT (NAICS 336). Accessed at: http://www1.eere.energy.gov
LBNL	LBNL (2008). Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry. Accessed at: www.energystar.gov.
USCAR	U.S. Council for Automotive Research (2008). Technology Roadmap for Energy Reduction in Automotive Manufacturing. Accessed at: http://www1.eere.energy.gov.
LBNL	Masanet, Eric et al., LBNL (2008). Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry. Accessed at http://www.energystar.gov/ia/business/industry/Food-Guide.pdf?ba92-033f.
PG&E	PG&E (2010). Energy Use in Wastewater Treatment in the Food and Beverage Industry. Accessed at http://www.calmac.org/publications/PGE_Energy-Use-WW-Treatment-Food-Bev-Industry_10-15-10_ (unlocked).pdf.
KEMA	KEMA (2012). Industrial Sectors Market Characterization: Cement and Concrete Industry. Accessed at http://www.calmac.org/publications/Final_Cement_Industrial_Market_Characterization_Report.pdf
LBNL	Kermeli, Katerina, et al, LBNL (2011). Energy Efficiency Improvements and Cost Saving Opportunities for the Concrete Industry. Accessed at http://www.energystar.gov/ia/business/industry/downloads/Energy_Efficieny_Improvement_Cost_Saving_Opportunities_Concrete.pdf?4e3f-0f62.
LBNL	Galitsky, Christina and Ernest Worrell, LBNL (2008). Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making. Accessed at http://www.energystar.gov/ia/business/industry/LBNL-54036.pdf?b59f-bf83.
EPA	US EPA (2007). Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes. Accessed at http://www.epa.gov/sectors/pdf/energy/report.pdf
KEMA/LBNL	KEMA/LBNL (2005). Industrial Case Study: The Cement Industry. Accessed at http://www.calmac.org/publications/IndustrialCementFinalKEMA.pdf.
LBNL	LBNL (2005). Case Study of the California Cement Industry. Accessed at http://ies.lbl.gov/iespubs/59938.pdf.
DOE	US DOE (2004). Energy Use, Loss and Opportunities: US Manufacturing & Mining. Accessed at http://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/energy_use_loss_opportunities_analysis.pdf.
KEMA	KEMA (2012). Industrial Sectors Market Characterization: Glass Industry. Accessed at http://calmac.org/publications/Final_Industrial_Glass_Sector_Characterization_Report.pdf.
LBNL	Worrell, Ernst et al, LBNL (2008). Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry. Accessed at http://www.energystar.gov/ia/business/industry/Glass-Guide.pdf?3d99-6be2.
KEMA	KEMA (2012). Industrial Sectors Market Characterization: Mineral Product Manufacturing Industry. Accessed at http://calmac.org/publications/Final_Minerals_Market_Characterization_Report.pdf.

Source	Citation
KEMA	KEMA (2012). Industrial Sectors Market Characterization: Paper Industry. Accessed at http://www.calmac.org/publications/Final_Paper_Industrial_Sector_Market_Characterization.pdf.
LBNL	Kramer, Klaas et al., LBNL (2009). Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp and Paper Industry. Accessed at http://www.energystar.gov/ia/business/industry/downloads/Pulp_and_Paper_Energy_Guide.pdf?e2e8-17d9.

G.8.2 Multi-Source Analysis Approach

Next, Navigant conducted research in order to identify specific measures implemented within the Industrial sector that could be used to inform the Industrial potential model. Navigant research drew from the sources shown in Table G-11 as well as from a range of other secondary sources. The initial resources Navigant staff collected presented data challenges:

- Sources lack the quantity of measure details needed in order to properly map the measures in the final model. For example, a source would report energy savings, but not installation cost information.
- Information is inconsistent from source to source and relies on different analysis methods and assumptions. For example, Navigant was unable to compare motor savings between sources if motor size ranges (horsepower) differed.
- Sources sometimes provide a range (and not point estimates) of energy benefits and costs that require interpretation.
- Research efforts are often very narrowly focused on a single measure or technology that was difficult to apply across the entire Industrial sector.

G.8.2.1 Multi-Source Analysis Strategy

In light of the aforementioned data challenges the Navigant team revised its analysis approach. Specifically, the Navigant team relied primarily on the Industrial Assessment Center (IAC)[101] database to provide Industrial sector energy efficient measures used in the potential model. Where data gaps existed the Navigant team relied on other secondary sources to supplement its research. For example, the IAC lacked information on Petroleum subsector Process Heating improvements. Therefore, Navigant turned to an LBNL energy efficiency study for additional information.[102]

The Navigant team also relied on multiple sources to vet the results developed for Industrial potential. Navigant refers to these vetting results as comparative metrics. For example, Navigant developed the following comparative metrics:

- A comparison of 2013 and 2014 incremental market potential to 2013 and 2014 IOU compliance filings

[101] Department of Energy. Industrial Assessment Centers (IACs). Accessed November 18, 2013. http://www1.eere.energy.gov/manufacturing/tech_assistance/iacs.html
[102] IBID. LBNL 2005 Petroleum Study.

- A comparison of the distribution of end-use incremental market potential to end-use potential distributions reported by KEMA Industrial sector market characterizations.[103]

Navigant reviewed the approaches and results with stakeholders, including IOUs, to ensure that the model accurately reflected the California energy efficiency Industrial market.

The Navigant team's multi-source analysis strategy can be summarized with the following:

- Use IAC data for bulk of analysis activities
- Identify data gaps in IAC and supplement with other secondary sources
- Vet model results against other secondary sources for reasonableness and accuracy
- Vet model results with stakeholders

G.8.3 Department of Energy Industrial Assessment Center Database

The following section provides an overview of the main source used by Navigant to inform the Industrial potential analysis. Additionally, this section describes how the characteristics of the sites and recommendations captured within IAC compare to California's Industrial sector characteristics.

G.8.3.1 IAC Database Eligibility and Assessment Process

The IAC is an initiative taken by the Department of Energy (DOE) in order to identify potential energy savings in small and medium sized Industrial facilities. There are 24 centers around the country. These centers provide free energy efficient assessment to the qualifying facilities in their vicinity. According to IAC's website, manufacturers may be eligible to receive an IAC assessment if they meet the following criteria:

- Within Standard Industrial Codes (SIC) 20-39
- Located less than 150 miles of a participating university (Industrial Assessment Center Locations)
- Gross annual sales below $100 million
- Fewer than 500 employees at the plant site
- Annual energy bills more than $100,000 and less than $2.5 million
- No professional in-house staff to perform the assessment

IAC assessments are in-depth energy evaluations of a facility. These assessments are conducted by graduate students from their participating universities who are overseen by experienced and trained engineering faculty with years of energy efficiency experience. The IAC has developed and improved their assessment techniques over their 30 years. To-date they have conducted over 15,000 assessments, and teams located across 24 universities are anticipating a $30 million budget for 2012 to 2016 to continue their operations.

The IAC team conducts a remote survey of the plant, followed by a one to two day site visit to take engineering measurements. The team performs a detailed process analysis to generate specific

[103] IBID. KEMA 2012 Industrial Sectors Market Characterization, various subsectors.

recommendations with estimates of costs, energy savings, and payback times. The plant receives a report detailing the analysis, findings, and recommendations. These estimates are also uploaded into the central IAC database maintained by DOE (and accessed by Navigant for the potential analysis).

Navigant staff identified the IAC database as a resource for the potential analysis. The IAC offers several benefits identified by Navigant.

- Detailed measure data across multiple Industrial subsectors, energy end-uses, and fuel types
- Comprehensive details that cover energy benefits as well as associated implementation costs; all the necessary inputs for the potential model
- Public database information dating back to the 1980s that is regularly updated (Navigant is using data from 2004 and after)
- A single source for measure inputs facilitates an efficient analysis and avoids data compatibility issues
- A proven resource that Navigant notes is often referenced by other research papers as a data source

G.8.3.2 Navigant Searchable IAC Database

Navigant provided an Access version of the IAC database information to stakeholders. As previously mentioned within this Appendix, this database was the source of information that created the potential model for the Industrial sector. While the IAC provides a significantly large data structure, Navigant's database provides a user-friendly interface. This database can provide very detailed information to support the stakeholders' review of Navigant's analysis, approaches, assumptions, and data sources. For example, data can be sorted to obtain information on specific measures, subsectors (by NAICS code), or end-uses. The level of specificity provided within this database structure represents the highest level of granularity found within the IAC database.

G.8.4 IAC Database Application to the California Industrial Sector

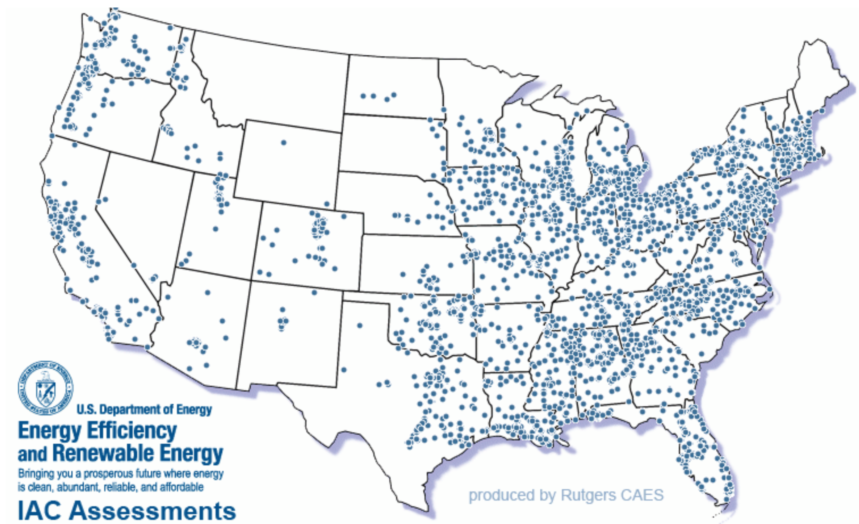
Navigant assessed how the IAC national data represents the specific California market targeted by this potential study effort. This process sought to identify any potential shortcoming of the IAC and determine mitigation strategies where needed. This vetting process involved Navigant's own review in addition to input from various stakeholders involved with the potential effort. Navigant conducted the following mitigation actions that are detailed within this report:

- Navigant supplemented the IAC data with information from an LBNL report for the Petroleum sector for Process Heating measures
- Navigant characterized certain measures with long term, continual potential. This was done to reflect continuous improvements and intelligent efficiency decisions implemented by facility managers
- Navigant derated the potential associated with several measures to reflect California-specific code and regulatory constraints, industry standard practices, and IOU program eligibility criteria

G.8.4.1 IAC National Data Compared to California

Navigant's analysis relied on national-level IAC data in order to develop the Industrial potential estimate. The Navigant team first reviewed California-only IAC data, but determined that expanding the dataset to the national-level would provide a sufficiently robust pool of information from which to draw.

Figure G-7. IAC Assessment Activities



http://iac.rutgers.edu/database/geography/

In terms of national data, Navigant estimates that manufacturing processes do not vary significantly across states. Navigant estimates that measure implementation strategies and energy efficiency approaches also do not vary significantly across states. Further, California is the second most active state after Ohio for the IAC and from 2004 to 2013. A total of 2,711 recommendations were made through 346 assessments completed throughout California.

Navigant correlated the subsectors that were audited by the IAC with the subsectors that are located in California. The Navigant team reviewed California-specific QFER data for each Industrial subsector and compared the energy consumption of these subsectors to the energy consumption reported by the IAC. The following figures show the energy distribution by NAICS code for both QFER data and IAC data for a variety of subsectors. Navigant conducted this exercise for all subsectors.

Navigant determined that the IAC represents the California Industrial market based on this review. Navigant also notes that this review was conducted at the six digit NAICs code level. This level of detail is beyond the three digit NAICS code specificity used by Navigant to characterize Industrial subsectors. For example in Figure G-8, the six digit NAICS codes differentiate products rather than processes such as Cheese Manufacturing (NAICS: 311513) versus Fluid Milk Manufacturing (NAICS: 311511).[104]

[104] U.S. Census. North American Industry Classification System. Accessed November 18, 2013. http://www.census.gov/eos/www/naics/

Through Navigant's conversations with ACEEE, the evaluation team learned that the six digit NAICS code assigned to a facility can change throughout the year in order to represent the commodity with the largest shipment volume. Due to this variation Navigant did not expect a perfect match in every Industrial subsector. Navigant concluded that the IAC represented facility types closely resembles the California facility types.

Figure G-8. Electricity use by NAICS Code for the Food Industry

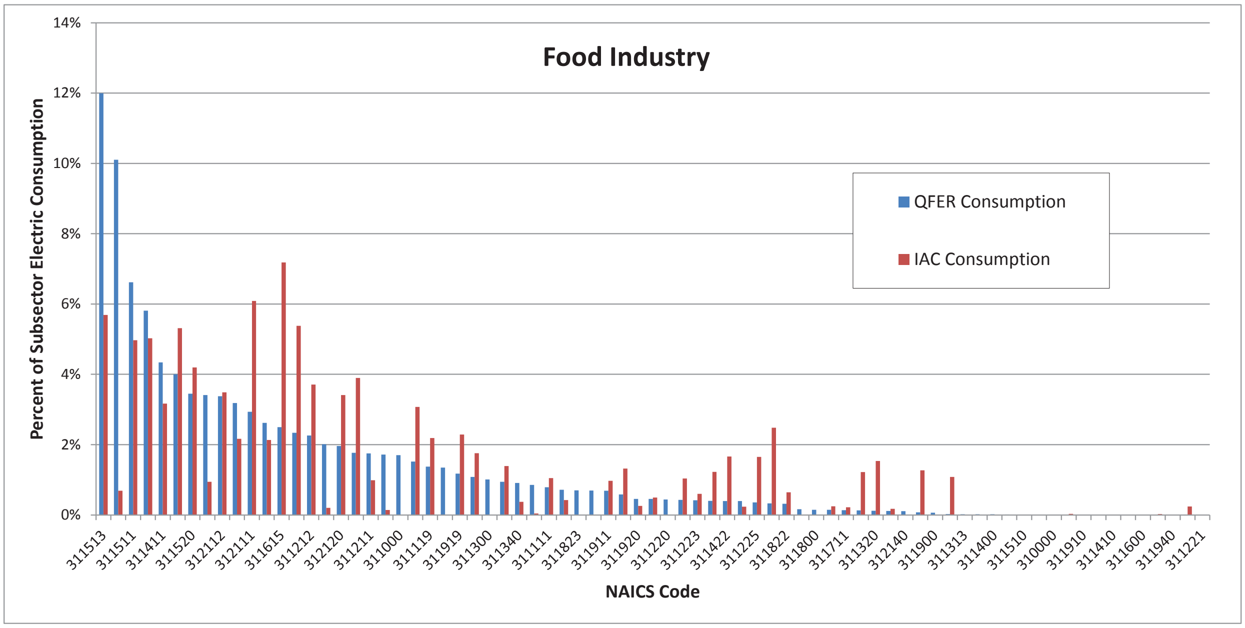


Figure G-9. Electricity use by NAICS Code for the Electronic Industry

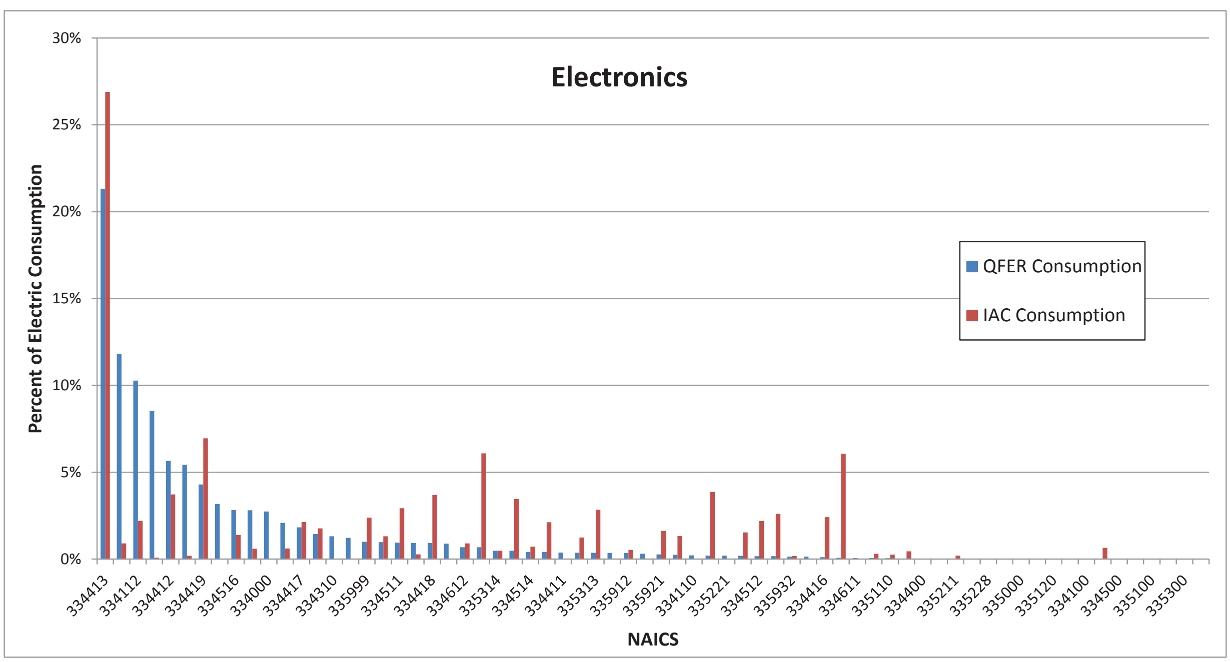
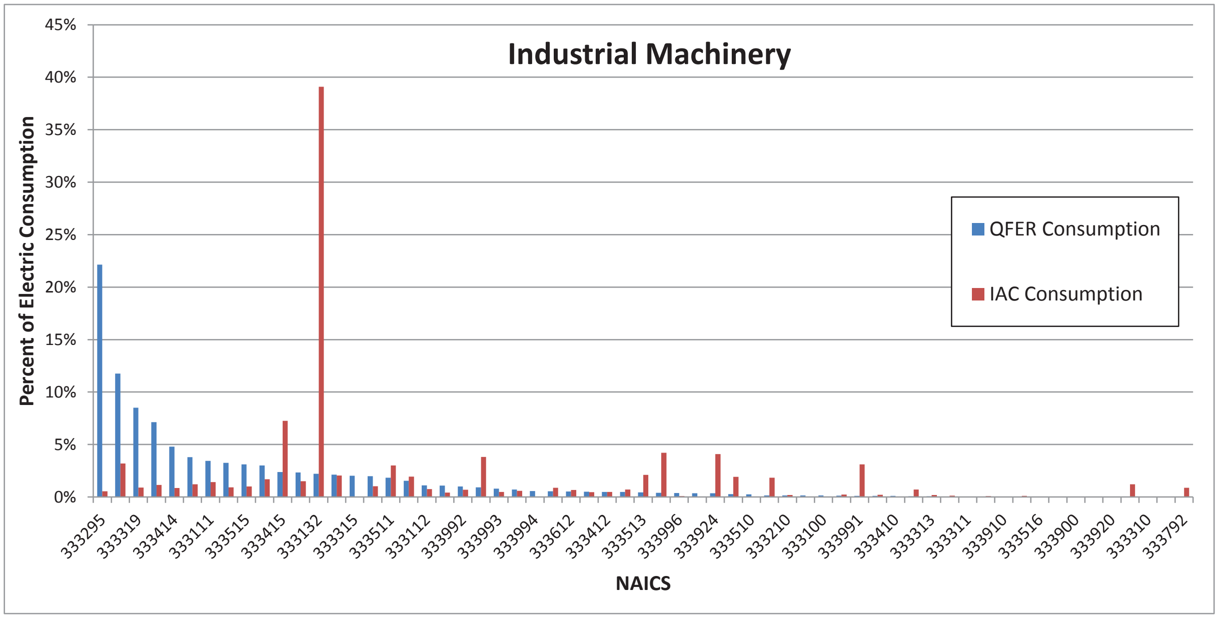
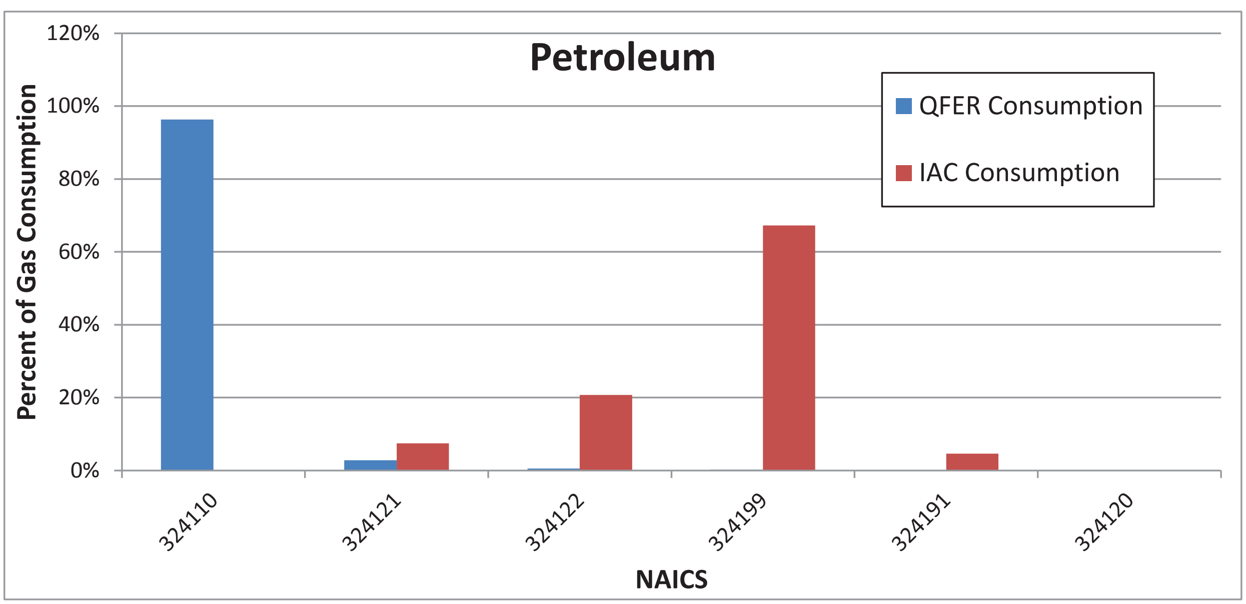


Figure G-10. Electricity use by NAICS Code for the Industrial Machinery Industry



The Navigant team noted one exception during this exercise for the Petroleum subsector. As previously mentioned, information is lacking within IAC for this subsector. Therefore, Navigant mitigated this data gap by supplementing the IAC data with information from an LBNL report.

Figure G-11. Gas use by NAICS Code for the Petroleum Industry

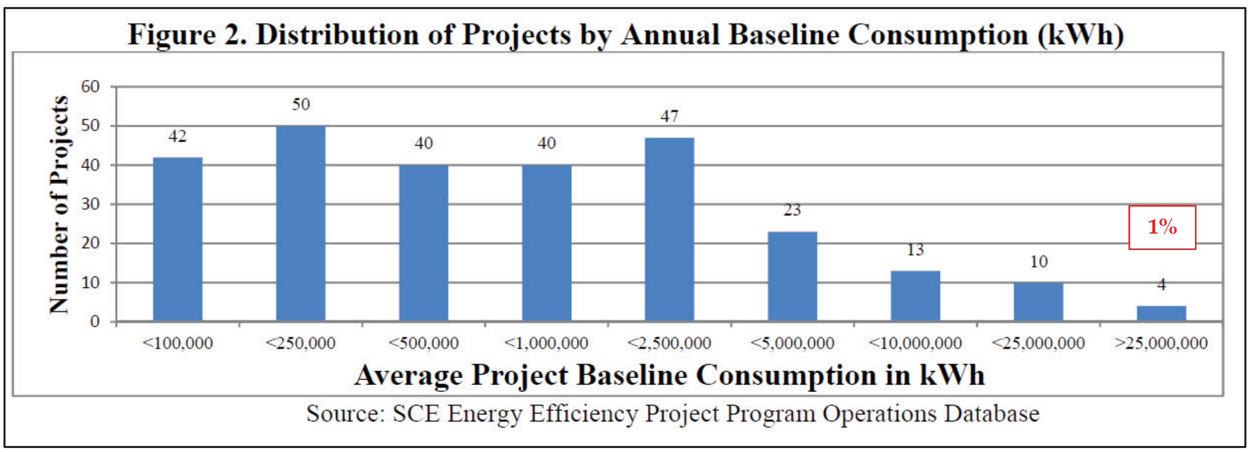


G.8.4.2 *IAC Site Requirements*

Navigant notes that, according to their website, the IAC only visits facilities that meet certain size and operational requirements (i.e., annual sales caps, employee count caps, and energy bill caps). Therefore, Navigant collected information from ACEEE and other secondary sources to make several comparisons for the facilities within the IAC database to California facilities.

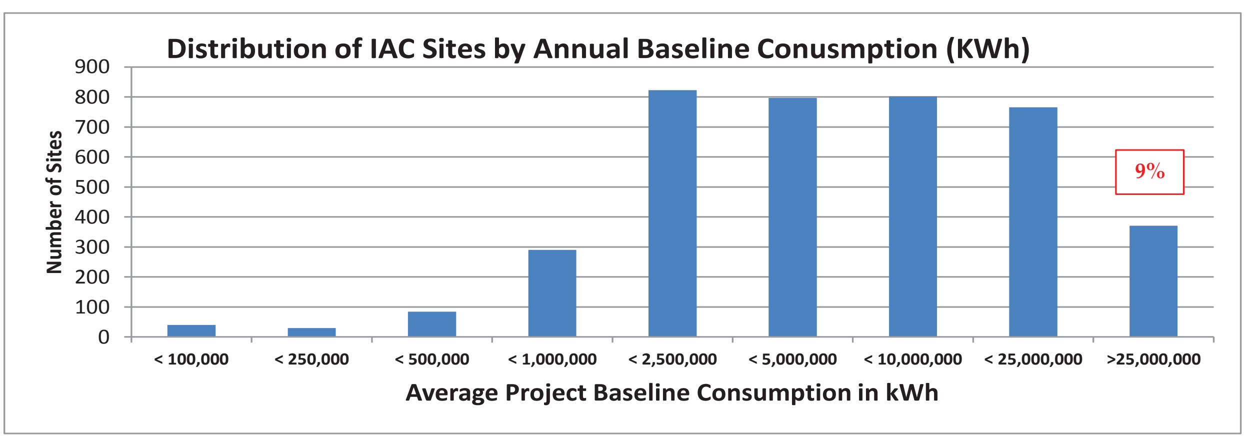
The following shows program activity in a recent SCE Industrial program compared to the IAC database facility sizes for audits completed during 2004 and after. Within Figure G-12, Navigant notes that facilities consuming more than 25 GWh annually represent approximately 1 percent of program participants. Additionally, Figure G-13 shows that approximately 9 percent of facilities receiving audits from IAC consume more than 25 GWh annually. Therefore, Navigant concludes that the IAC database sufficiently represents the full range of facility sizes present in California.

Figure G-12. Facility Sizes in SCE Industrial Programs



Provided by ACEEE: Technology Drivers of Improved Energy Productivity in Manufacturing Process Enhancement Projects, 2013

Figure G-13. Facility Sizes in IAC Database for 2004 to 2013



Navigant also gathered information from the U.S. Census to understand how the California Industrial market place compares to the other eligibility criteria established by IAC. For example, the IAC only visits establishments with 500 employees or fewer and those with gross annual sales less than $100MM. Navigant reviewed Census data from 2010 and 2007 to estimate the number of Industrial facilities that meet these requirements.

Table G-12 shows that the vast majority of sites in California qualify for IAC audits under the guidelines. The one exception is the Petroleum subsector where average sales per facility are above the $100MM cap. However, Navigant notes that the team supplemented the Petroleum subsector with LBNL data.

Table G-12. Census Industrial Data: Employees, Sales, Consumption (2007 and 2010)[105]

Industrial Subsector	Count of Establishments (2010 data)			Sales, Receipts, or Value of Shipments (2007 data)		QFER Consumption per Establishment (kWh)
	Total	With 500 employees or less	Percent of total	Total ($MM)	Average (using 2010 counts) ($MM)	
Petroleum (NAICS 324)	203	195	96.1%	$82,793	$407.85	7,681,537
Food (NAICS 311x, 312)	4,517	4,468	98.9%	$80,134	$17.74	931,403
Electronics (NAICS 334x, 335)	3,867	3,811	98.6%	$93,250	$24.11	1,099,866
Stone-Glass-Clay (NAICS 327x)	1,323	1,321	99.8%	$13,513	$10.21	1,407,770
Chemicals (NAICS 325)	1,515	1,493	98.5%	$45,268	$29.88	1,358,796
Plastics (NAICS 326)	1,405	1,403	99.9%	$15,980	$11.37	1,160,428
Fabricated Metals (NAICS 332)	6,614	6,609	99.9%	$31,351	$4.74	238,334
Primary Metals (NAICS 331)	436	434	99.5%	$8,605	$19.74	1,645,047
Industrial Machinery (NAICS 333)	2,326	2,315	99.5%	$21,317	$9.16	337,954
Transportation Equipment (NAICS 336)	1,386	1,356	97.8%	$43,746	$31.56	1,032,040
Paper (NAICS 322x)	444	444	100.0%	$8,616	$19.41	N/A
Printing & Publishing (NAICS 323, 511, 516)	7,042	6,986	99.2%	$60,491	$8.59	N/A
Textiles (NAICS 313, 314, 315, 316)	4,338	4,328	99.8%	$13,590	$3.13	N/A
Lumber & Furniture (NAICS 337, 321, 1133)	3,363	3,360	99.9%	$16,951	$5.04	N/A
All Other Industrial (NAICS 339)	3,906	3,889	99.6%	$22,679	$5.81	N/A

[105] U.S. Census FactFinder. Accessed November 25, 2013. http://factfinder2.census.gov/

G.8.4.3 Industrial Consumption Representation

Navigant quantified the representation of QFER consumption by the IAC. Table G-13 shows the total energy consumption associated with those Industrial subsectors and end-uses where 10 or more IAC recommendations are used to characterize the energy efficiency potential. That is, Navigant only used those supply curves (that represent a subsector, fuel type, end-use, and measure type) represented by 10 data points or more to ensure that sufficient information is used to characterize the energy potential for that portion of the Industrial market. Based on this screen, Navigant's analysis is left with 165 supply curves that represent approximately 86 percent of electric consumption and 75 percent of gas consumption.

Table G-13 continues the screening exercise. Sixty three percent of electric consumption and 22 percent of gas consumption is represented by 100 or more measures.

The gas sector has less representation for a number of reasons. The Navigant team found that approximately 16 percent of gas consumption is classified as cogeneration and outside the scope of this analysis. Additionally, Petroleum Process Heating accounts for approximately 34 percent of total California Industrial gas consumption. Due to the large size of these facilities, the IAC does not regularly visit Petroleum sites. Therefore as previously discussed, Navigant supplemented the IAC data with additional information from LBNL for these Petroleum measures.

Table G-13. IAC Measure Coverage for Varying Sample Constraints

Required Minimum number of IAC Measures for Each Subsector and End-Use	Resulting QFER Electric Consumption Representation	Resulting QFER Gas Consumption Representation
10*	86.2%	74.9%
25	80.9%	39.9%
50	73.8%	30.9%
100	62.6%	22.3%

*Navigant used a minimum of 10 data points for the analysis requirement.

G.8.4.4 Continuous Improvements and Energy Savings

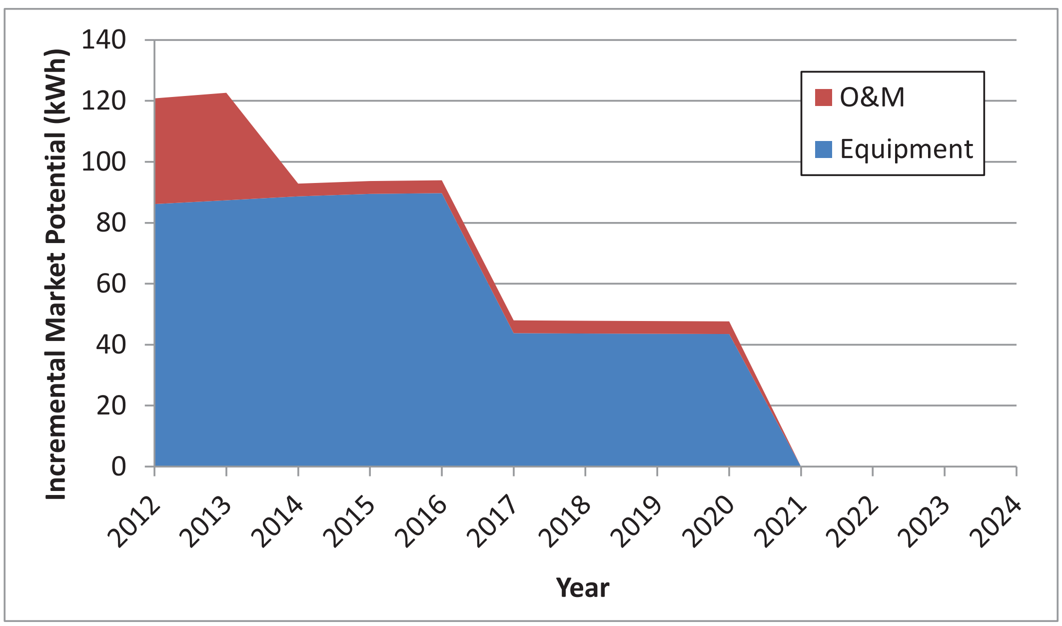
The IAC database provides a snapshot of annual savings resulting from measure implementation. It does not provide details on multi-year activities occurring at facilities such as continuous improvement initiatives or process optimizations. Navigant recognized that long term process improvements exist and accounted for this with its continuous improvement factors for several of the subsectors and end-uses. Measures, such as building shell improvements are expected to experience saturation over time, where no more savings are achievable. However, Navigant determined that Industrial sector measures are mostly process-focused and likely to experience continual improvements as facility operations change.

Navigant identified a portion of subsectors and end-uses where these continuous improvement characteristics are present. Navigant estimates these characteristics will apply to a portion of equipment measures and the majority of O&M measures. These measures savings were modeled to occur on a continuous basis during the analysis period. This approach to process-related efficiency is informed by a recent ACEEE paper[106] that states "system efficiency opportunities produce energy savings that dwarf component-based efficiency improvements by an order of magnitude." Examples of these measures include process improvements, large capital projects, and set point/control adjustments.

Navigant applied these continuous improvement approaches to its model. The following two figures illustrate the significance of these savings by showing modeled savings with and without this factor included.

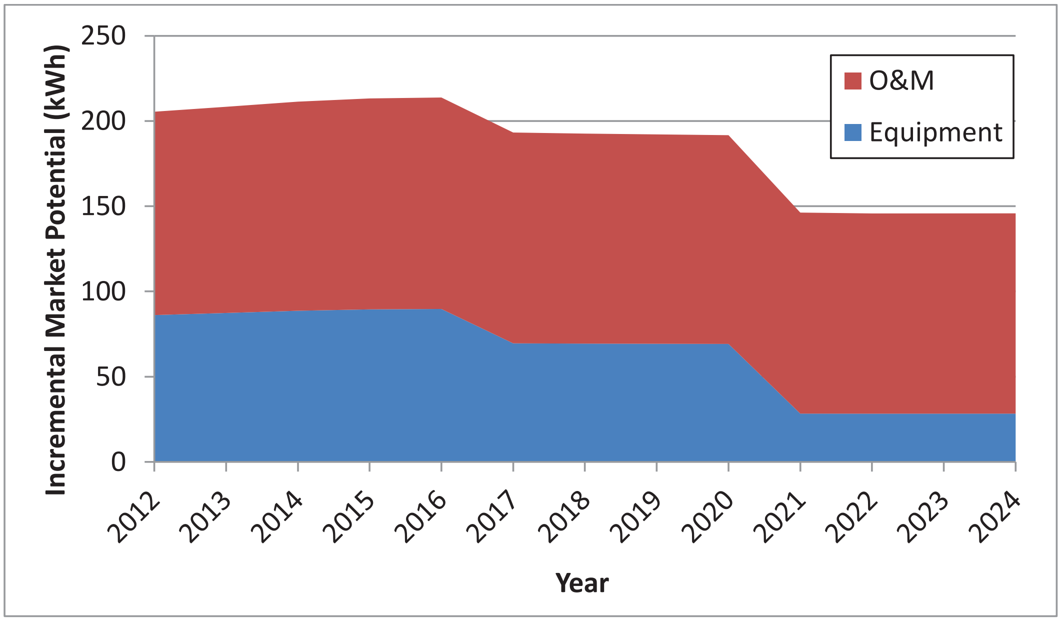
Without the inclusion of the continuous improvement factor long term energy savings quickly drop off in the model as measures are estimated to saturate, as show in Figure G-14. This factor is significant for long term planning as Navigant estimates that energy savings opportunities will decrease somewhat in the future but not completely dissipate, as show in Figure G-15.

Figure G-14. Modeled Energy Savings without Continuous Improvement



[106] ACEEE, A Defining Framework for Intelligent Efficiency, June 2012

Figure G-15. Modeled Energy Savings with Continuous Improvement



The Navigant team also analyzed the IAC data to determine if large term capital investment projects are included within the database of recommendations. While the presence of low-cost/no-cost recommendations can represent continuous and active multi-year O&M initiatives, the presence of large projects would also represent long term and multi-year energy efficiency initiatives. That is, large expensive projects would support the previous claims for continuous improvements.

Therefore, Navigant reviewed IAC data to determine the range of costs and payback periods represented. Generally, Navigant found that a substantial number of projects are present in IAC that inform the potential analysis. These are high-cost measures with long payback periods.

Figure G-16. IAC Project Costs

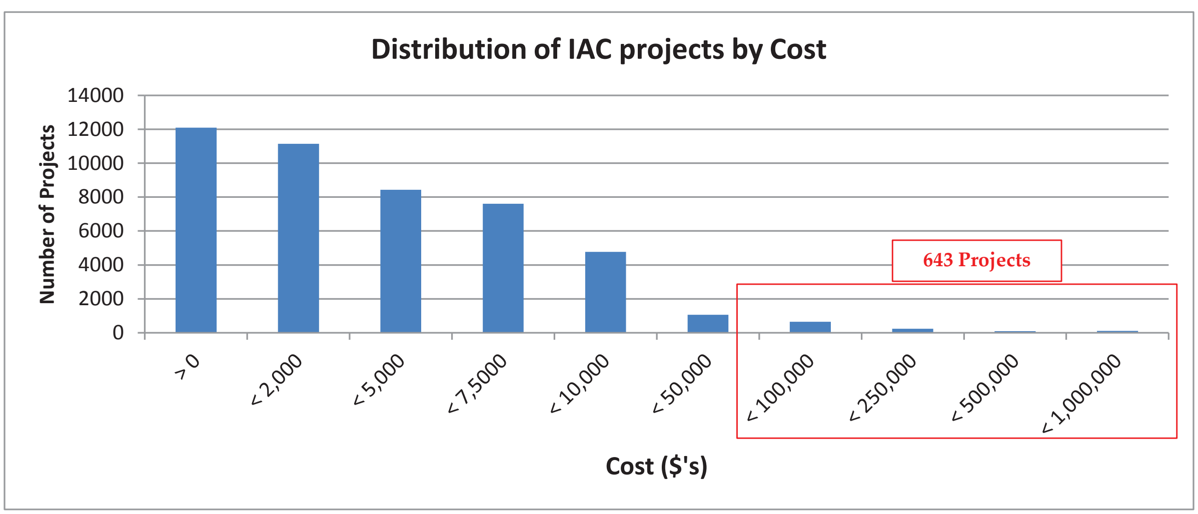
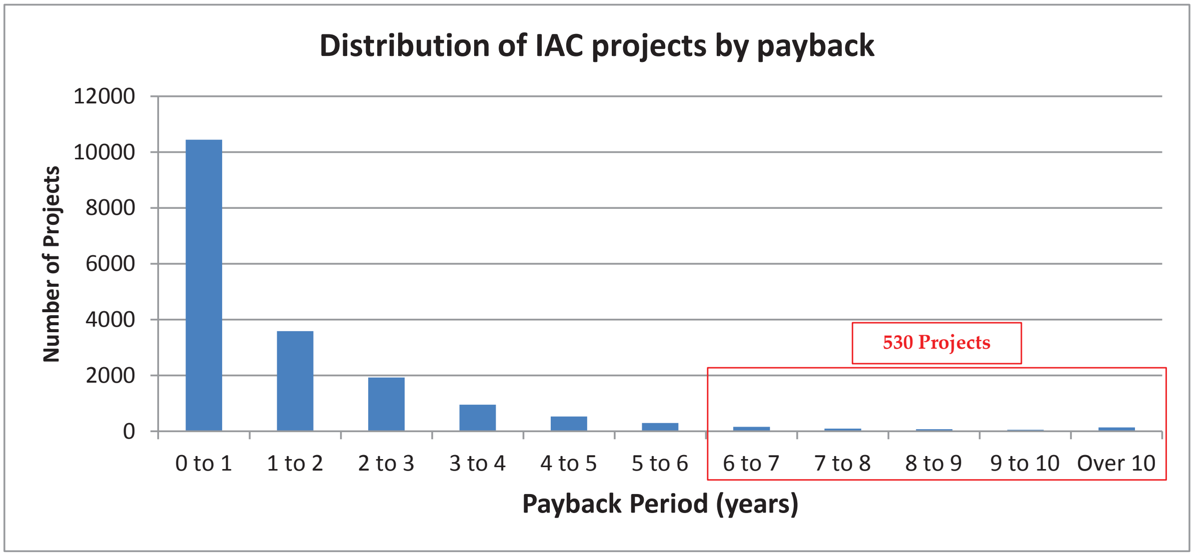


Figure G-17. IAC Project Paybacks



G.8.4.5 Measure Derating

After reviewing the IAC measures incorporated into Navigant's model the team vetted them with stakeholders. Stakeholders, particularly IOUs, commented that some of the measures would not be included in their programs as they were considered industry standard practice, or measures consisting of operations and maintenance activities, select equipment installations considered to be 'typical equipment or commonly-used practice' measures, or measures being installed in response to code or regulatory mandate. Therefore, the Navigant team provided interested stakeholders with a process to identify measures within the Industrial model for removal or savings reduction. The process specifically entailed providing individual rating factors for the 275 unique IAC recommendations found within Navigant's potential model. The ratings ranged from 0 to 1. A 0 means a measure is disallowed and 1 means a measure is fully allowed. For example, a rating of 0.60 would only allow 60 percent of a measure's potential, or in other words, the measure would be derated by 40 percent.

PG&E, SCE, SCG and Commission Staff all provided input on which measures should be removed or derated from the modeled energy savings results. The stakeholders also provided reasons and comments for their input, including:

- Code compliance with such regulations as 2008 Title 24, Title 20, or Federal Standards
- Specific measure studies such as Strip Curtains NTG
- Ineligibility based on standard practice or standard maintenance (ISP) criteria established within existing Industrial energy efficiency programs[107]
- Air district (ARB), OSHA, AB32 requirements

[107] 2013-2014 Statewide Customized Retrofit Offering Procedures Manual for Business. PG&E, SDG&E, SCE. July 14, 2013. Accessed January 7, 2014. http://www.aesc-inc.com/download/spc/2013SPCDocs/PGE/Customized%201.0%20Policy.pdf

- Adjustments to reflect historical gross savings achievements

Navigant developed a final derating factor for each measure based on all provided input and while considering the purpose of the model and the individual characteristics of the Industrial measures. Generally, Navigant took the following specific steps in developing the derating factors:

- Code compliance was considered to an extent with an understanding that above-Code energy efficiency potential exists
- Navigant considered study citations individually
- ISP was considered with an understanding that above-ISP energy efficiency potential exists
- Other regulatory compliance issues were considered and incorporated into deratings
- Navigant did not derate the model specifically to reflect historical gross savings achievements, rather, deratings were applied to account for shifts in ISP and Code to reflect a progressive and dynamic Industrial sector

This derating process reduced the overall Industrial potential significantly. For the 2013 incremental market potential results, the savings for electric was reduced by 32 percent while gas was reduced by 38 percent. Although this does reduce savings potential within the California Industrial sector, Navigant estimates that the results are refined and offer a better representation of potential from the IOU perspective.

The following table provides a summary of the derating inputs and results.

Table G-14. IAC Measure Derating Exercise

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Conventional Boiler Use	Equipment	INSTALL STEAM TRAP	2.2111	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	REPAIR OR REPLACE STEAM TRAPS	2.2113	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSULATE FEEDWATER TANK	2.2123	0.75			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	Equipment	INSTALL DE-AERATOR IN PLACE OF CONDENSATE TANK	2.2124	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSULATE STEAM / HOT WATER LINES	2.2131	0	0.5	0.2	0.50	**0.40**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL WASTE HEAT BOILER TO PRODUCE STEAM	2.2423	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	Equipment	REPLACE OBSOLETE BURNERS WITH MORE EFFICIENT ONES	2.1221	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL TURBULATORS	2.1222	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL SMALLER BOILER (INCREASE HIGH FIRE DUTY CYCLE)	2.1223	0.75			0.33	**0.54**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	REPLACE BOILER	2.1224	0.75			0.33	**0.54**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	O&M	INCREASE AMOUNT OF CONDENSATE RETURNED	2.2121	0			0.50	**0.50**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	O&M	INSTALL / REPAIR INSULATION ON CONDENSATE LINES	2.2122	0			0.00	**0.00**	Consensus

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Conventional Boiler Use	O&M	FLASH CONDENSATE TO PRODUCE LOWER PRESSURE STEAM	2.2127	0			1.00	**1.00**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	O&M	USE STEAM CONDENSATE FOR HOT WATER SUPPLY (NON-POTABLE)	2.2128	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	REPAIR FAULTY INSULATION ON STEAM LINES	2.2132	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	REPAIR LEAKS IN LINES AND VALVES	2.2133	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	ELIMINATE LEAKS IN HIGH PRESSURE REDUCING STATIONS	2.2134	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	REPAIR AND ELIMINATE STEAM LEAKS	2.2135	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	CLOSE OFF UNNEEDED STEAM LINES	2.2153	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	USE MINIMUM STEAM OPERATING PRESSURE	2.2163	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	TURN OFF STEAM TRACING DURING MILD WEATHER	2.2164	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	SUBSTITUTE AIR FOR STEAM TO ATOMIZE OIL	2.2165	0			1.00	**1.00**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	O&M	SUBSTITUTE HOT PROCESS FLUIDS FOR STEAM	2.2191	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	USE HEAT EXCHANGE FLUIDS INSTEAD OF STEAM IN PIPELINE TRACING SYSTEMS	2.2192	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	USE FLUE GAS HEAT TO PREHEAT BOILER FEEDWATER	2.2412	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Conventional Boiler Use	O&M	MOVE BOILER TO MORE EFFICIENT LOCATION	2.1211	0			1.00	**1.00**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	O&M	OPERATE BOILERS ON HIGH FIRE SETTING	2.1212	0			0.50	**0.50**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	O&M	DIRECT WARMEST AIR TO COMBUSTION INTAKE	2.1213	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	ESTABLISH BURNER MAINTENANCE SCHEDULE FOR BOILERS	2.1231	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	KEEP BOILER TUBES CLEAN	2.1232	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	ANALYZE FLUE GAS FOR PROPER AIR/FUEL RATIO	2.1233	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	REDUCE EXCESSIVE BOILER BLOWDOWN	2.1241	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	MINIMIZE BOILER BLOWDOWN WITH BETTER FEEDWATER TREATMENT	2.1242	0			0.50	**0.50**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	O&M	USE HEAT FROM BOILER BLOWDOWN TO PREHEAT BOILER FEED WATER	2.1243	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Facility HVAC	Equipment	INSULATE GLAZING, WALLS, CEILINGS, AND ROOFS	2.7491	0	0.5	0.5	0.50	**0.38**	Average rating for these HVAC related measures
Facility HVAC	Equipment	USE PROPER THICKNESS OF INSULATION ON BUILDING ENVELOPE	2.7492	0	0.5	0.2	0.50	**0.30**	Average rating for these HVAC related measures
Facility HVAC	Equipment	USE DOUBLE OR TRIPLE GLAZED WINDOWS TO MAINTAIN HIGHER RELATIVE HUMIDITY AND TO REDUCE HEAT LOSSES	2.7493	0	0.5	0.5	0.50	**0.38**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL PARTITIONS TO REDUCE SIZE OF CONDITIONED SPACE	2.7496	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	Equipment	REDUCE GLAZED AREAS IN BUILDINGS	2.7421	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	REDUCE HEAT GAIN BY WINDOW TINTING	2.7423	0	0.5	0.5	1.00	**0.50**	Average rating for these HVAC related measures
Facility HVAC	Equipment	REPLACE BROKEN WINDOWS AND/OR WINDOW SASH	2.7441	0	0	0	0.00	**0.00**	Consensus
Facility HVAC	Equipment	INSTALL AIR SEALS AROUND TRUCK LOADING DOCK DOORS	2.7443	0	0	0	1.00	**0.25**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL WEATHER STRIPPING ON WINDOWS AND DOORS	2.7445	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL VINYL STRIP / HIGH SPEED / AIR CURTAIN DOORS	2.7447	0	0	0	1.00	**0.25**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL TIMERS AND/OR THERMOSTATS	2.7261	0	0.5	0.1	1.00	**0.40**	Average rating for these HVAC related measures
Facility HVAC	Equipment	REPLACE ELECTRIC REHEAT WITH HEAT PIPES	2.7271	0.75	1			**1.00**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Facility HVAC	Equipment	INSTALL HEAT PIPES / RAISE COOLING SETPOINT	2.7272	0	0.5	0.25	1.00	**0.44**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL DESICCANT HUMIDITY CONTROL SYSTEM	2.7273	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL DRY SPRINKLER SYSTEM OR OTHER METHOD TO REDUCE HEATING REQUIREMENTS	2.7293	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL OR UPGRADE INSULATION ON HVAC DISTRIBUTION SYSTEMS	2.7212	0	0.5	0.1	1.00	**0.10**	Code driven, ISP related, deferring to ED input
Facility HVAC	Equipment	USE RADIANT HEATER FOR SPOT HEATING	2.7231	0.75				**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Facility HVAC	Equipment	REPLACE EXISTING HVAC UNIT WITH HIGH EFFICIENCY MODEL	2.7232	0	0.5	0.5	0.30	**0.50**	A more aggressive approach is assumed to account for above-Code and above-ISP savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	Equipment	USE PROPERLY DESIGNED AND SIZED HVAC EQUIPMENT	2.7233	0	0.5	0.25	0.30	**0.38**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	Equipment	USE HEAT PUMP FOR SPACE CONDITIONING	2.7234	0	0.5	0.5		**0.50**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	Equipment	INSTALL FOSSIL FUEL MAKE-UP AIR UNIT	2.7235	0			1.00	**0.50**	Average rating for these HVAC related measures
Facility HVAC	Equipment	INSTALL OUTSIDE AIR DAMPER / ECONOMIZER ON HVAC UNIT	2.7241	0	0.5	0.2	1.00	**0.43**	Average rating for these HVAC related measures
Facility HVAC	Equipment	CHANGE ZONE REHEAT COILS TO VARIABLE AIR VOLUME BOXES	2.7242	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	IMPROVE AIR CIRCULATION WITH DESTRATIFICATION FANS / OTHER METHODS	2.7243	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	REVISE SMOKE CLEANUP FROM OPERATIONS	2.7244	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	USE DIRECT AIR SUPPLY TO EXHAUST HOODS	2.7245	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	UTILIZE AN EVAPORATIVE AIR PRE-COOLER OR OTHER HEAT EXCHANGER IN AC SYSTEM	2.7252	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	Equipment	USE CORRECT SIZE STEAM TRAPS	2.2112	1			0.50	**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	Equipment	RECOVER HEAT FROM COMPRESSED AIR DRYERS	2.2435	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	Equipment	USE COOLING AIR WHICH COOLS HOT WORK PIECES FOR SPACE HEATING	2.2491	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	Equipment	USE "HEAT WHEEL" OR OTHER HEAT EXCHANGER TO CROSS-EXCHANGE BUILDING EXHAUST AIR WITH MAKE-UP AIR	2.2492	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	USE RECOVERED HEAT FROM LIGHTING FIXTURES FOR USEFUL PURPOSE	2.2493	0.75	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	Equipment	RECOVER HEAT IN DOMESTIC HOT WATER GOING TO DRAIN	2.2494	0.75	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Facility HVAC	O&M	TURN OFF STEAM / HOT WATER LINES LEADING TO SPACE HEATING UNITS	2.6213	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	SHUT OFF AIR CONDITIONING IN WINTER HEATING SEASON	2.6215	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	O&M	TURN OFF EQUIPMENT WHEN NOT IN USE	2.6218	0	1		0.00	**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	O&M	SHADE WINDOWS FROM SUMMER SUN	2.7424	0.25	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	O&M	CLEAN OR COLOR ROOF TO REDUCE SOLAR LOAD	2.7425	0	0	0		**0.00**	Consensus
Facility HVAC	O&M	KEEP DOORS AND WINDOWS SHUT WHEN NOT ON USE	2.7442	0	0	0		**0.00**	Consensus
Facility HVAC	O&M	CLOSE HOLES AND OPENINGS IN BUILDING SUCH AS BROKEN WINDOWS	2.7444	0	0	0	0.00	**0.00**	Consensus
Facility HVAC	O&M	UTILIZE SENSORS CONTROLLING ROOF AND WALL OPENINGS	2.7446	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	SEPARATE CONTROLS OF AIR HANDLERS FROM AC/ HEATING SYSTEMS	2.7262	0	1		1.00	**0.67**	Average rating for these HVAC related measures

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	O&M	LOWER COMPRESSOR PRESSURE THROUGH A/C SYSTEM MODIFICATION	2.7263	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Facility HVAC	O&M	INTERLOCK HEATING AND AIR CONDITIONING SYSTEMS TO PREVENT SIMULTANEOUS OPERATION	2.7264	0	1		1.00	**0.67**	Average rating for these HVAC related measures
Facility HVAC	O&M	RESCHEDULE AND REARRANGE MULTIPLE-SOURCE HEATING SYSTEMS	2.7291	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	LOWER CEILING TO REDUCE CONDITIONED SPACE	2.7292	0	1		1.00	**0.67**	Average rating for these HVAC related measures
Facility HVAC	O&M	VENTILATION SYSTEM TO SHUT OFF WHEN ROOM IS NOT IN USE	2.7311	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	MINIMIZE USE OF OUTSIDE MAKE-UP AIR FOR VENTILATION EXCEPT WHEN USED FOR ECONOMIZER CYCLE	2.7312	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	RECYCLE AIR FOR HEATING, VENTILATION AND AIR CONDITIONING	2.7313	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	REDUCE VENTILATION AIR	2.7314	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	REDUCE BUILDING VENTILATION AIR TO MINIMUM SAFE LEVELS	2.7315	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	CENTRALIZE CONTROL OF EXHAUST FANS TO ENSURE THEIR SHUTDOWN, OR ESTABLISH PROGRAM TO ENSURE MANUAL SHUTDOWN	2.7316	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	CLEAN AND MAINTAIN REFRIGERANT CONDENSERS AND TOWERS	2.7211	0	0	0		**0.00**	Consensus
Facility HVAC	O&M	LOWER TEMPERATURE DURING THE WINTER SEASON AND VICE-VERSA	2.7221	0	1		1.00	**0.67**	Average rating for these HVAC related measures

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	O&M	AIR CONDITION ONLY SPACE IN USE	2.7222	0	1		1.00	**0.67**	Average rating for these HVAC related measures
Facility HVAC	O&M	CONDITION SMALLEST SPACE NECESSARY	2.7223	0	1		1.00	**0.67**	Average rating for these HVAC related measures
Facility HVAC	O&M	REDUCE SPACE CONDITIONING DURING NON-WORKING HOURS	2.7224	0	1		1.00	**0.67**	Average rating for these HVAC related measures
Facility HVAC	O&M	CLOSE OUTDOOR AIR DAMPERS DURING WARM-UP / COOL-DOWN PERIODS	2.7225	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	USE COMPUTER PROGRAMS TO OPTIMIZE HVAC PERFORMANCE	2.7226	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	USE WATER ON AIR CONDITIONING EXCHANGER TO IMPROVE HEAT TRANSFER AND INCREASE AIR CONDITIONER EFFICIENCY	2.7227	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	AVOID INTRODUCING HOT, HUMID, OR DIRTY AIR INTO HVAC SYSTEM	2.7228	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	REDUCE AIR CONDITIONING LOAD BY EVAPORATING WATER FROM ROOF	2.7251	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	USE WASTE HEAT FROM FLUE GASES TO HEAT SPACE CONDITIONING AIR	2.2426	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Facility HVAC	O&M	USE EXHAUST HEAT FROM BUILDING FOR SNOW AND ICE REMOVAL	2.2495	0	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Facility HVAC	O&M	ISOLATE STEAM LINES TO AVOID HEATING AIR CONDITIONED AREAS	2.2521	0			1.00	**0.88**	Average rating for these HVAC related measures
Facility HVAC	O&M	ISOLATE HOT OR COLD EQUIPMENT	2.2522	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	USE OUTSIDE COLD WATER SOURCE AS A SUPPLY OF COOLING WATER	2.2692	0	0	0		**0.00**	Consensus

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility HVAC	O&M	REMOVE UNNEEDED SERVICE LINES TO ELIMINATE POTENTIAL LEAKS	2.6123	0	1		1.00	**0.92**	Average rating for these HVAC related measures
Facility HVAC	O&M	ESTABLISH EQUIPMENT MAINTENANCE SCHEDULE	2.6124	0	0	0	0.00	**0.00**	Consensus
Facility HVAC	O&M	KEEP EQUIPMENT CLEAN	2.6125	0	0	0	0.00	**0.00**	Consensus
Facility Lighting	Equipment	ADD AREA LIGHTING SWITCHES	2.7131	0	0.75	0.75		**0.75**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	INSTALL TIMERS ON LIGHT SWITCHES IN LITTLE USED AREAS	2.7132	0	0.5	0.5		**0.50**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	USE SEPARATE SWITCHES ON PERIMETER LIGHTING WHICH MAY BE TURNED OFF WHEN NATURAL LIGHT IS AVAILABLE	2.7133	0	0.5	0.5		**0.50**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	USE PHOTOCELL CONTROLS	2.7134	0	0.5	0.5		**0.50**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	INSTALL OCCUPANCY SENSORS	2.7135	0.15	0.15	0.1		**0.13**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	UTILIZE HIGHER EFFICIENCY LAMPS AND/OR BALLASTS	2.7142	0	0.1	0.1		**0.10**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	USE MORE EFFICIENT LIGHT SOURCE	2.7143	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	INSTALL SPECTRAL REFLECTORS / DELAMP	2.7144	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	Equipment	INSTALL SKYLIGHTS	2.7145	0	0.5	0.5		**0.50**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	O&M	REDUCE ILLUMINATION TO MINIMUM NECESSARY LEVELS	2.7111	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Facility Lighting	O&M	REDUCE EXTERIOR ILLUMINATION TO MINIMUM SAFE LEVEL	2.7112	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	O&M	UTILIZE DAYLIGHT WHENEVER POSSIBLE IN LIEU OF ARTIFICIAL LIGHT	2.7121	0	0	0.5		**0.30**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Facility Lighting	O&M	DISCONNECT BALLASTS	2.7122	0	0	0		**0.00**	Consensus
Facility Lighting	O&M	KEEP LAMPS AND REFLECTORS CLEAN	2.7123	0	0	0		**0.00**	Consensus
Facility Lighting	O&M	MAKE A PRACTICE OF TURNING OFF LIGHTS WHEN NOT NEEDED	2.7124	0	0	0		**0.00**	Consensus
Facility Lighting	O&M	LOWER LIGHT FIXTURES IN HIGH CEILING AREAS	2.7141	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	INSTALL COMPRESSOR AIR INTAKES IN COOLEST LOCATIONS	2.4221	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	INSTALL ADEQUATE DRYERS ON AIR LINES TO ELIMINATE BLOWDOWN	2.4222	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	INSTALL DIRECT ACTING UNITS IN PLACE OF COMPRESSED AIR PRESSURE SYSTEM IN SAFETY SYSTEM	2.4223	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	UPGRADE CONTROLS ON COMPRESSORS	2.4224	0.5	0.75	0.5		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	INSTALL COMMON HEADER ON COMPRESSORS	2.4225	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	USE / PURCHASE OPTIMUM SIZED COMPRESSOR	2.4226	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	USE COMPRESSOR AIR FILTERS	2.4227	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Machine Drive	Equipment	INSTALL SOFT-START TO ELIMINATE NUISANCE TRIPS	2.4112	0	0	0		**0.00**	Consensus
Machine Drive	Equipment	INSTALL MOTOR VOLTAGE CONTROLLER ON LIGHTLY LOADED MOTORS	2.4113	0.1	0.1	0		**0.00**	Baseline level
Machine Drive	Equipment	REPLACE OVER-SIZE MOTORS AND PUMPS WITH OPTIMUM SIZE	2.4131	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	SIZE ELECTRIC MOTORS FOR PEAK OPERATING EFFICIENCY	2.4132	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	USE MOST EFFICIENT TYPE OF ELECTRIC MOTORS	2.4133	0	0.1	0.75		**0.43**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	REPLACE ELECTRIC MOTOR WITH FOSSIL FUEL ENGINE	2.4134	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	USE MULTIPLE SPEED MOTORS OR AFD FOR VARIABLE PUMP, BLOWER AND COMPRESSOR LOADS	2.4141	1	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MOTOR-GENERATOR SET	2.4142	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE THROTTLING SYSTEM	2.4143	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MECHANICAL DRIVE	2.4144	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	INSTALL ISOLATION TRANSFORMER ON ADJUSTABLE FREQUENCY DRIVE	2.4145	0	0	0		**0.00**	Consensus
Machine Drive	Equipment	UPGRADE OBSOLETE EQUIPMENT	2.4321	0	0	0		**0.00**	Consensus
Machine Drive	Equipment	USE OR REPLACE WITH ENERGY EFFICIENT SUBSTITUTES	2.4322	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Machine Drive	Equipment	USE OPTIMUM SIZE AND CAPACITY EQUIPMENT	2.4323	0.75	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	Equipment	REPLACE HYDRAULIC / PNEUMATIC EQUIPMENT WITH ELECTRIC EQUIPMENT	2.4324	0	0	0.5		**0.50**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	UPGRADE CONVEYORS	2.4325	0.75	0.75	0.75		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	REPLACE HIGH RESISTANCE DUCTS, PIPES, AND FITTINGS	2.5122	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	Equipment	USE GRAVITY FEEDS WHEREVER POSSIBLE	2.5124	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Machine Drive	O&M	REDUCE THE PRESSURE OF COMPRESSED AIR TO THE MINIMUM REQUIRED	2.4231	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	ELIMINATE OR REDUCE COMPRESSED AIR USED FOR COOLING, AGITATING LIQUIDS, MOVING PRODUCT, OR DRYING	2.4232	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	ELIMINATE PERMANENTLY THE USE OF COMPRESSED AIR	2.4233	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	COOL COMPRESSOR AIR INTAKE WITH HEAT EXCHANGER	2.4234	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	REMOVE OR CLOSE OFF UNNEEDED COMPRESSED AIR LINES	2.4235	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	ELIMINATE LEAKS IN INERT GAS AND COMPRESSED AIR LINES/ VALVES	2.4236	0	0.75	0.75		**0.75**	Consensus
Machine Drive	O&M	SUBSTITUTE COMPRESSED AIR COOLING WITH WATER OR AIR COOLING	2.4237	1	1			**1.00**	Consensus
Machine Drive	O&M	DO NOT USE COMPRESSED AIR FOR PERSONAL COOLING	2.4238	0	0	0		**0.00**	Consensus

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Machine Drive	O&M	UTILIZE ENERGY-EFFICIENT BELTS AND OTHER IMPROVED MECHANISMS	2.4111	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	DEVELOP A REPAIR/REPLACE POLICY	2.4151	0	0	0		**0.00**	Consensus
Machine Drive	O&M	USE ONLY CERTIFIED MOTOR REPAIR SHOPS	2.4152	0	0	0		**0.00**	Consensus
Machine Drive	O&M	AVOID EMERGENCY REWIND OF MOTORS	2.4153	0	0	0		**0.00**	Consensus
Machine Drive	O&M	AVOID REWINDING MOTORS MORE THAN TWICE	2.4154	0	0	0		**0.00**	Consensus
Machine Drive	O&M	STANDARDIZE MOTOR INVENTORY	2.4155	0	0	0		**0.00**	Consensus
Machine Drive	O&M	ESTABLISH A PREVENTATIVE MAINTENANCE PROGRAM	2.4156	0	0	0		**0.00**	Consensus
Machine Drive	O&M	ESTABLISH A PREDICTIVE MAINTENANCE PROGRAM	2.4157	0	0	0		**0.00**	Consensus
Machine Drive	O&M	RECOVER HEAT FROM AIR COMPRESSOR	2.2434	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	RECOVER MECHANICAL ENERGY	2.4311	0	0	0		**0.00**	Consensus
Machine Drive	O&M	IMPROVE LUBRICATION PRACTICES	2.4312	0	0	0		**0.00**	Consensus
Machine Drive	O&M	PROVIDE PROPER MAINTENANCE OF MOTOR DRIVEN EQUIPMENT	2.4313	0	0	0		**0.00**	Consensus
Machine Drive	O&M	USE SYNTHETIC LUBRICANT	2.4314	0	0	0		**0.00**	Consensus
Machine Drive	O&M	REDESIGN FLOW TO MINIMIZE MASS TRANSFER LENGTH	2.5121	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	REDUCE FLUID FLOW RATES	2.5123	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Machine Drive	O&M	SIZE AIR HANDLING GRILLS/ DUCT/S COILS TO MINIMIZE AIR RESISTANCE	2.5125	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Machine Drive	O&M	MAINTAIN AIR FILTERS BY CLEANING OR REPLACEMENT	2.6127	0	0	0		**0.00**	Consensus
Other Nonprocess Use	Equipment	INSTALL STORM WINDOWS AND DOORS	2.7494	0.75	1		1.00	**0.92**	Average of non-zero values, accounting for process optimization, shifting ISP
Other Nonprocess Use	Equipment	INSTALL REPLACEMENT DOORS	2.7495	0.75	1		1.00	**0.92**	Average of non-zero values, accounting for process optimization, shifting ISP
Other Nonprocess Use	O&M	HEAT SERVICE HOT WATER WITH AIR CONDITIONING EQUIPMENT	2.2496	0	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Cooling and Refrigeration	Equipment	REPLACE EXISTING CHILLER WITH HIGH EFFICIENCY MODEL	2.2622	0	0.5	0.5		**0.50**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	Equipment	RECOVER HEAT FROM REFRIGERATION CONDENSERS	2.2436	0	0.75	0.75		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	Equipment	USE ECONOMIC THICKNESS OF INSULATION FOR LOW TEMPERATURES	2.2516	0	0.75	0.75		**0.75**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Process Cooling and Refrigeration	Equipment	USE CASCADE SYSTEM OF RECIRCULATING DURING COLD WEATHER TO AVOID SUB-COOLING	2.2695	0.75	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	MODERATE COOLING TOWER OUTLET TEMPERATURE	2.2611	0	0.5	0.75		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE COOLING TOWER WATER INSTEAD OF REFRIGERATION	2.2612	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE ANTIFREEZE IN COOLING TOWERS TO ALLOW WINTER USE	2.2613	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE COOLING TOWER OR ECONOMIZER TO REPLACE CHILLER COOLING	2.2614	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings

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Process Cooling and Refrigeration	O&M	CLEAN CONDENSER TUBES	2.2615	0	0	0		**0.00**	Consensus
Process Cooling and Refrigeration	O&M	MODIFY REFRIGERATION SYSTEM TO OPERATE AT A LOWER PRESSURE	2.2621	0	0.75	0.75		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	MINIMIZE CONDENSER COOLING WATER TEMPERATURE	2.2623	0	0.75	0.75		**0.75**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE COLD WASTE WATER TO COOL CHILLER FEED WATER	2.2624	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	CHILL WATER TO THE HIGHEST TEMPERATURE POSSIBLE	2.2625	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	AVOID FROST FORMATION ON EVAPORATORS	2.2626	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE MULTIPLE-EFFECT EVAPORATORS	2.2627	0	1			**1.00**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Process Cooling and Refrigeration	O&M	UTILIZE A LESS EXPENSIVE COOLING METHOD	2.2628	0	0	0		**0.00**	Consensus
Process Cooling and Refrigeration	O&M	REDUCE INFILTRATION TO REFRIGERATED AREAS; ISOLATE HOT EQUIPMENT FROM REFRIGERATED AREAS	2.2523	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	SHUT OFF COOLING IF COLD OUTSIDE AIR WILL COOL PROCESS	2.2691	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE WASTE HEAT STEAM FOR ABSORPTION REFRIGERATION	2.2693	0			0.00	**0.00**	Consensus
Process Cooling and Refrigeration	O&M	USE HIGHEST TEMPERATURE FOR CHILLING OR COLD STORAGE	2.2694	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE EXCESS COLD PROCESS FLUID FOR INDUSTRIAL COOLING NEEDS	2.2696	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings

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Process Cooling and Refrigeration	O&M	TURN OFF EQUIPMENT DURING BREAKS, REDUCE OPERATING TIME	2.6212	0	0	0		**0.00**	Consensus
Process Cooling and Refrigeration	O&M	SHUT OFF COOLING WATER WHEN NOT REQUIRED	2.6216	0	1			**1.00**	A more aggressive approach is assumed, accounting for Early Retirement savings and/or Retrocommissioning savings
Process Cooling and Refrigeration	O&M	USE DRYING OVEN (BATCH TYPE) ON ALTERNATE DAYS OR OTHER OPTIMUM SCHEDULE TO RUN EQUIPMENT WITH FULL LOADS	2.6222	0	1		1.00	**0.92**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Cooling and Refrigeration	O&M	MODIFY TEXTILE DRYERS	2.5192	0	1		1.00	**0.92**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Cooling and Refrigeration	O&M	UTILIZE OUTSIDE AIR INSTEAD OF CONDITIONED AIR FOR DRYING	2.2711	0	1		1.00	**0.67**	A more aggressive approach is assumed to account for above-Code and above-ISP savings
Process Heating	Equipment	INSTALL AUTOMATIC STACK DAMPER	2.1123	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	REPLACE DIRECT FIRED WITH STEAM HEAT	2.1124	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	CONVERT TO OXYFUEL BURNERS	2.1125	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	USE IMMERSION HEATING IN TANKS, MELTING POTS, ETC	2.2221	0.75	1		0.00	**0.58**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	CONVERT LIQUID HEATERS FROM UNDERFIRING TO IMMERSION OR SUBMERSION HEATING	2.2222	0.75			0.00	**0.38**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	REPLACE HEAT TREATING OVEN WITH MORE EFFICIENT UNIT	2.2314	0.75			0.30	**0.53**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	REPLACE BAROMETRIC CONDENSERS WITH SURFACE CONDENSERS	2.2125	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	Equipment	UPGRADE DISTILLATION HARDWARE	2.2142	0.75			0.30	**0.53**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	INSTALL WASTE HEAT BOILER TO PROVIDE DIRECT POWER	2.2421	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	COVER OPEN TANKS WITH FLOATING INSULATION	2.2513	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	COVER OPEN TANKS	2.2514	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	USE OPTIMUM THICKNESS INSULATION	2.2515	0.75			0.00	**0.38**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	RECOVER WASTE HEAT FROM EQUIPMENT	2.2437	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	PREHEAT BOILER MAKEUP WATER WITH WASTE PROCESS HEAT	2.2441	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	PREHEAT COMBUSTION AIR WITH WASTE HEAT	2.2442	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	RE-USE OR RECYCLE HOT OR COLD PROCESS EXHAUST AIR	2.2443	0.75	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	USE HOT PROCESS FLUIDS TO PREHEAT INCOMING PROCESS FLUIDS	2.2444	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	RECOVER HEAT FROM EXHAUSTED STEAM	2.2445	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	RECOVER HEAT FROM HOT WASTE WATER	2.2446	0.75	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	Equipment	HEAT WATER WITH EXHAUST HEAT	2.2447	0.75	1		1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	Equipment	INSULATE BARE EQUIPMENT	2.2511	0.75	1		0.50	**0.75**	Average of non-zero values, accounting for process optimization, shifting ISP
Process Heating	Equipment	INCREASE INSULATION THICKNESS	2.2512	0	0.75	1	0.50	**0.56**	Average rating
Process Heating	Equipment	RE-SIZE CHARGING OPENINGS OR ADD MOVABLE COVER OR DOOR	2.2531	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	Equipment	REPLACE AIR CURTAIN DOORS WITH SOLID DOORS	2.2533	0	0	0	1.00	**0.25**	Average rating
Process Heating	Equipment	CONVERT FROM INDIRECT TO DIRECT FIRED SYSTEMS	2.5111	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	Equipment	USE CONTINUOUS EQUIPMENT WHICH RETAINS PROCESS HEATING CONVEYORS WITHIN THE HEATED CHAMBER	2.5112	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	Equipment	USE DIRECT FLAME IMPINGEMENT OR INFRARED PROCESSING FOR CHAMBER TYPE HEATING	2.5113	0.75			1.00	**0.88**	Average rating
Process Heating	Equipment	USE SHAFT TYPE FURNACES FOR PREHEATING INCOMING MATERIAL	2.5114	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	Equipment	REPOSITION OVEN WALLS TO REDUCE HEATED SPACE	2.5115	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	Equipment	CONVERT TO INDIRECT TEMPERATURE CONTROL SYSTEM	2.5117	0.75	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	CONTROL PRESSURE ON STEAMER OPERATIONS	2.1111	0			1.00	**0.88**	Average rating
Process Heating	O&M	HEAT OIL TO PROPER TEMPERATURE FOR GOOD ATOMIZATION	2.1112	0	0.05	1	0.50	**0.75**	Average rating (excluding SCE market comment)
Process Heating	O&M	REDUCE COMBUSTION AIR FLOW TO OPTIMUM	2.1113	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	O&M	LIMIT AND CONTROL SECONDARY COMBUSTION AIR IN FURNACE	2.1114	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	ELIMINATE COMBUSTIBLE GAS IN FLUE GAS	2.1115	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	IMPROVE COMBUSTION CONTROL CAPABILITY	2.1116	0			1.00	**0.88**	Average rating
Process Heating	O&M	RELOCATE OVEN / FURNACE TO MORE EFFICIENT LOCATION	2.1117	0			1.00	**0.88**	Average rating
Process Heating	O&M	USE INSULATION IN FURNACES TO FACILITATE HEATING / COOLING	2.1121	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	RE-SIZE CHARGING OPENINGS OR ADD A MOVABLE DOOR ON EQUIPMENT	2.1122	0	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	REPAIR FAULTY INSULATION IN FURNACES, BOILERS, ETC	2.1131	0	0.05	1	0.00	**0.88**	Average rating (excluding SCE market comment)
Process Heating	O&M	REPAIR FAULTY LOUVERS AND DAMPERS	2.1132	0	0.05	1	0.00	**0.88**	Average rating (excluding SCE market comment)
Process Heating	O&M	ADJUST BURNERS FOR EFFICIENT OPERATION	2.1133	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	ELIMINATE LEAKS IN COMBUSTIBLE GAS LINES	2.1134	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	REPAIR FURNACES AND OVEN DOORS SO THAT THEY SEAL EFFICIENTLY	2.1135	0	0.05	1	0.00	**0.88**	Average rating (excluding SCE market comment)
Process Heating	O&M	ENHANCE SENSITIVITY OF TEMPERATURE CONTROL AND CUTOFF	2.2223	0	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	HEAT TREAT PARTS ONLY TO REQUIRED SPECIFICATIONS OR STANDARDS	2.2311	0	0	0	1.00	**1.00**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	O&M	MINIMIZE NON-ESSENTIAL MATERIAL IN HEAT TREATMENT PROCESS	2.2312	0	0.05	1	0.50	**0.75**	Average rating (excluding SCE market comment)
Process Heating	O&M	USE BATCH FIRING WITH KILN "FURNITURE" SPECIFICALLY DESIGNED	2.2313	0	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	USE OPTIMUM TEMPERATURE	2.2211	0	0.05	1	0.00	**0.58**	Average rating (excluding SCE market comment)
Process Heating	O&M	USE MINIMUM SAFE OVEN VENTILATION	2.2212	0			0.50	**0.63**	Average rating
Process Heating	O&M	SHUT OFF STEAM TRAPS ON SUPER HEATED STEAM LINES WHEN NOT IN USE	2.2114	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	LOWER OPERATING PRESSURE OF CONDENSER (STEAM)	2.2126	0			0.50	**0.63**	Average rating
Process Heating	O&M	OPERATE DISTILLATION COLUMNS EFFICIENTLY	2.2141	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	CLEAN STEAM COILS IN PROCESSING TANKS	2.2151	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	MAINTAIN STEAM JETS USED FOR VACUUM SYSTEM	2.2152	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	OPTIMIZE OPERATION OF MULTI-STAGE VACUUM STEAM JETS	2.2161	0			0.50	**0.63**	Average rating
Process Heating	O&M	REDUCE EXCESS STEAM BLEEDING	2.2162	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT COMBUSTION AIR	2.2411	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	USE HOT FLUE GASES TO PREHEAT WASTES FOR INCINERATOR BOILER	2.2413	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	USE WASTE HEAT FROM HOT FLUE GASES TO GENERATE STEAM	2.2422	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	O&M	USE HEAT IN FLUE GASES TO PREHEAT PRODUCTS OR MATERIALS	2.2424	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	USE FLUE GASES TO HEAT PROCESS OR SERVICE WATER	2.2425	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT INCOMING FLUIDS	2.2427	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	USE FLUE GASES IN RADIANT HEATER FOR SPACE HEATING, OVENS, ETC	2.2428	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	RECOVER HEAT FROM TRANSFORMERS	2.2431	0	1			**0.75**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	RECOVER HEAT FROM OVEN EXHAUST / KILNS	2.2432	0	0.05	1	1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	RECOVER HEAT FROM ENGINE EXHAUSTS	2.2433	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Process Heating	O&M	AVOID COOLING OF PROCESS STREAMS OR MATERIALS THAT MUST SUBSEQUENTLY BE HEATED	2.2524	0	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	ELIMINATE COOLING OF PROCESS STREAMS WHICH SUBSEQUENTLY MUST BE HEATED AND VICE VERSA	2.2525	0	0.05	1	1.00	**0.92**	Average rating (excluding SCE market comment)
Process Heating	O&M	USE ONLY AMOUNT OF AIR NECESSARY TO PREVENT EXPLOSION HAZARD	2.2532	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Heating	O&M	REDUCE HOT WATER TEMPERATURE TO THE MINIMUM REQUIRED	2.6121	0	0.05	1	0.00	**0.88**	More aggressive average rating (excluding SCE market comment)
Process Heating	O&M	ADJUST VENTS TO MINIMIZE ENERGY USE	2.6122	0	0.05	1	0.00	**0.88**	More aggressive average rating (excluding SCE market comment)
Process Heating	O&M	KEEP SOLID FUELS / RAW MATERIALS DRY	2.6126	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Process Heating	O&M	SHUT OFF PILOTS IN STANDBY EQUIPMENT	2.6214	0			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Process Manufacturing	Equipment	REPLACE HYDRAULIC INJECTION MOLDING MACHINE WITH ELECTRIC OR HYBRID	2.6214	0	0	0.5		**0.00**	Baseline per ISP study
Oil Production	Equipment	ELECTRIC SUBMERSIBLE PUMPS IN OIL INDUSTRY	2.6214	0.5	0.5	0.5		**0.50**	Average rating
Conventional Boiler Use	Equipment	INSTALL STEAM TRAP	2.2111	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	REPAIR OR REPLACE STEAM TRAPS	2.2113	0.75			0.50	**0.63**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSULATE FEEDWATER TANK	2.2123	0.75			0.00	**0.75**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	Equipment	INSTALL DE-AERATOR IN PLACE OF CONDENSATE TANK	2.2124	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSULATE STEAM / HOT WATER LINES	2.2131	0	0.5	0.2	0.50	**0.40**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL WASTE HEAT BOILER TO PRODUCE STEAM	2.2423	0.75			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	Equipment	REPLACE OBSOLETE BURNERS WITH MORE EFFICIENT ONES	2.1221	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL TURBULATORS	2.1222	0.75			1.00	**0.88**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	INSTALL SMALLER BOILER (INCREASE HIGH FIRE DUTY CYCLE)	2.1223	0.75			0.33	**0.54**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	Equipment	REPLACE BOILER	2.1224	0.75			0.33	**0.54**	Average of non-zero values, accounting for process optimization, shifting ISP

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Conventional Boiler Use	O&M	INCREASE AMOUNT OF CONDENSATE RETURNED	2.2121	0			0.50	**0.50**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	O&M	INSTALL / REPAIR INSULATION ON CONDENSATE LINES	2.2122	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	FLASH CONDENSATE TO PRODUCE LOWER PRESSURE STEAM	2.2127	0			1.00	**1.00**	Average of non-zero values, accounting for process optimization, shifting ISP
Conventional Boiler Use	O&M	USE STEAM CONDENSATE FOR HOT WATER SUPPLY (NON-POTABLE)	2.2128	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	REPAIR FAULTY INSULATION ON STEAM LINES	2.2132	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	REPAIR LEAKS IN LINES AND VALVES	2.2133	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	ELIMINATE LEAKS IN HIGH PRESSURE REDUCING STATIONS	2.2134	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	REPAIR AND ELIMINATE STEAM LEAKS	2.2135	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	CLOSE OFF UNNEEDED STEAM LINES	2.2153	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	USE MINIMUM STEAM OPERATING PRESSURE	2.2163	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	TURN OFF STEAM TRACING DURING MILD WEATHER	2.2164	0			0.00	**0.00**	Consensus
Conventional Boiler Use	O&M	SUBSTITUTE AIR FOR STEAM TO ATOMIZE OIL	2.2165	0			1.00	**1.00**	A more aggressive approach is assumed (take none-zero between PGE, SCG, and/or SCE), process improvement related
Conventional Boiler Use	O&M	SUBSTITUTE HOT PROCESS FLUIDS FOR STEAM	2.2191	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery

End-Use	Measure Type	Industrial Assessment Centers (IAC) EE Measure	IAC ARC Code	PGE	SCE	ED Ex-Ante	SCG	Final value	Note on decisions and final value selection
Conventional Boiler Use	O&M	USE HEAT EXCHANGE FLUIDS INSTEAD OF STEAM IN PIPELINE TRACING SYSTEMS	2.2192	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery
Conventional Boiler Use	O&M	USE FLUE GAS HEAT TO PREHEAT BOILER FEEDWATER	2.2412	0			1.00	**1.00**	Aggressive savings approach concluded, exhaust/waste heat recovery

G.9 Industrial Sector Results

This section provides the estimates of potential energy and demand savings at the statewide level for the industrial sector.

G.9.1 Overview

The potential energy savings in the industrial sector do not include an assessment of the impact of upcoming codes and standards changes because the diverse nature of end uses in the industrial sector makes it difficult to predict these impacts with any level of certainty. Additionally, while some equipment deployed throughout the industrial sector may be subject to Federal standards, the majority of equipment 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 as reports reviewed by Navigant do not indicate substantial new construction in this sector.

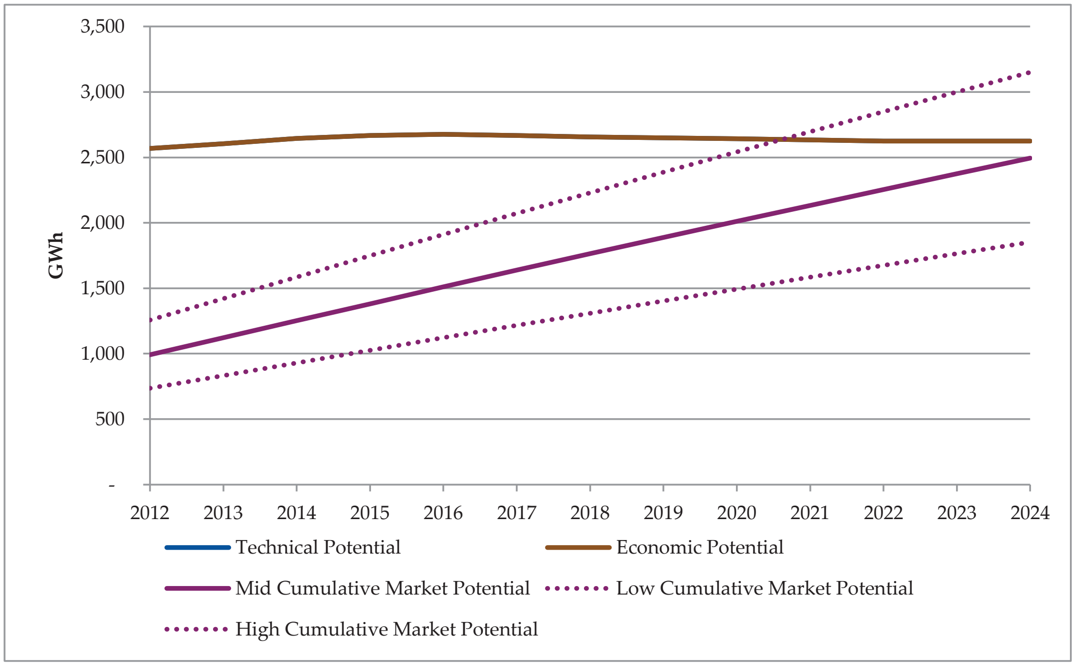
G.9.2 California Industrial Summary of Results

G.9.2.1 California Industrial Electric Energy Potential

As shown in Figure G-18, the industrial technical and economic energy savings potential remains fairly constant from 2012 through 2024. Navigant's technical and economic potential results are generally the same value because Navigant's analysis used supply curves for the industrial sectors 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 2,500 and 2,700 GWh from 2012 and 2024. The technical and economic energy savings potential are informed by IOU retail rate forecasts ($/kWh) and energy sales forecasts (kWh by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The industrial cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year. The Navigant team estimates that savings potential for certain end uses within certain segments will maintain incremental savings levels 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 and future equipment emerging technologies that sustain savings achievements. Cumulative market energy savings potential trails economic and technical energy savings potential and increases between around 1,000 GWh (in 2012) to around 2,500 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 G-18 due to an increase in the CEC AIMS consumption forecast. High case cumulative market potential does not exceed high case technical potential, though this comparison has been omitted from the graph.

Figure G-18. California Industrial Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)



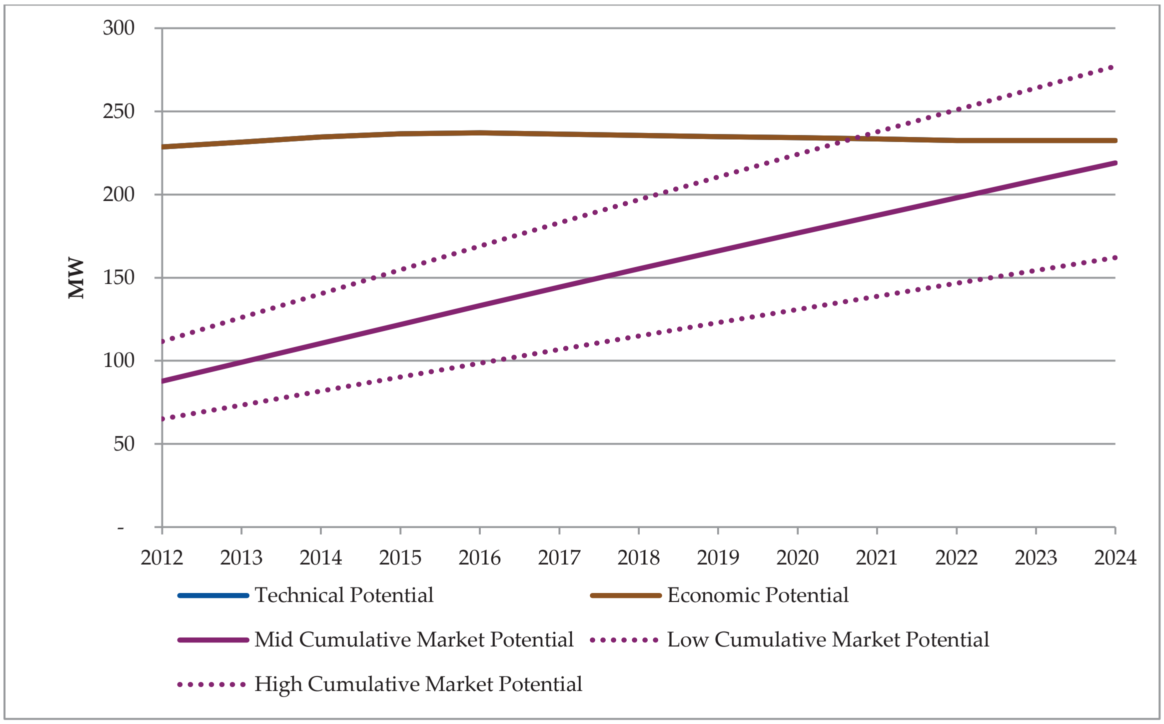
Source: PG model release February 2014

The Navigant team's cumulative market potential reflects a steady recurrence of savings potential for certain end-uses within certain subsectors. 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, this savings recurrence represents the introduction of emerging technologies in future years, ongoing and continuous implementation of O&M best practices, long term and large capital strategic improvements, and process improvements that are typically implemented as a part of production changes and equipment retooling. These continuous improvement 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, Navigant estimates that potential will saturate for certain end-uses and certain subsectors. For example, 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, stone producers) represent the full extent of potential remaining within those areas. Navigant does not anticipate any emerging technologies or other efficiency improvements to provide further opportunities for potential.

Figure G-19 presents the total technical, economic and cumulative market demand savings potential through 2024. Technical and economic demand savings potential stay steady between 230 MW and 240 MW from 2012 through 2024. The cumulative market potential increases from approximately 90 MW in 2012 to 220 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 potential does not exceed high case technical potential, though this comparison has been omitted from the graph.

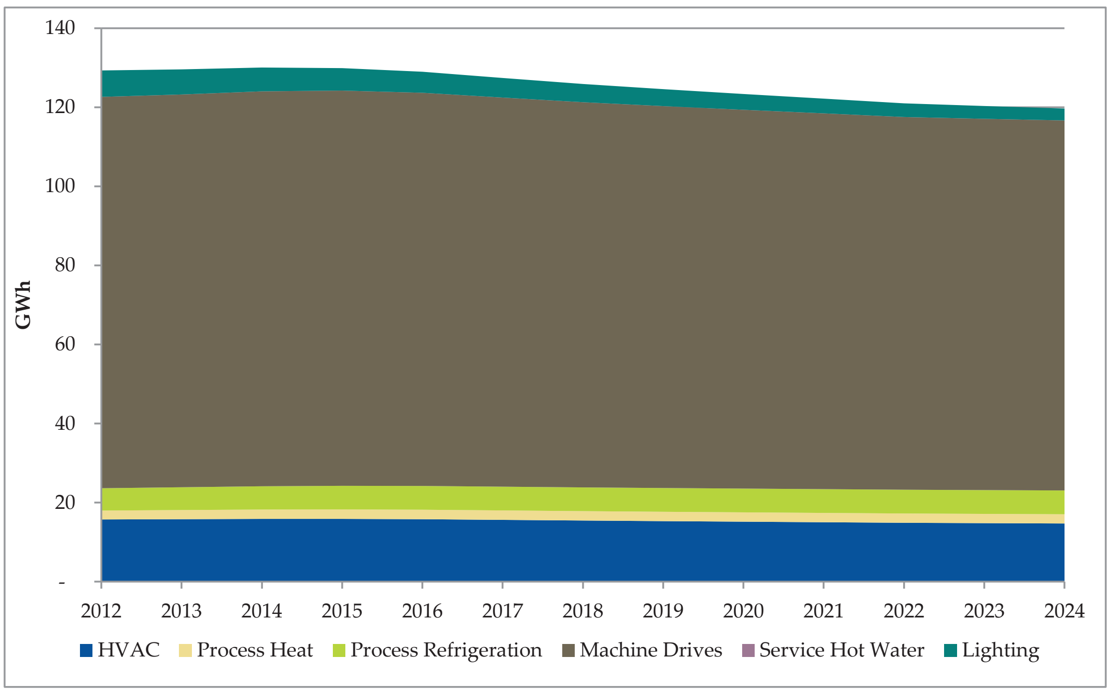
Figure G-19. California Industrial Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2012-2024 (MW)



Source: PG model release February 2014

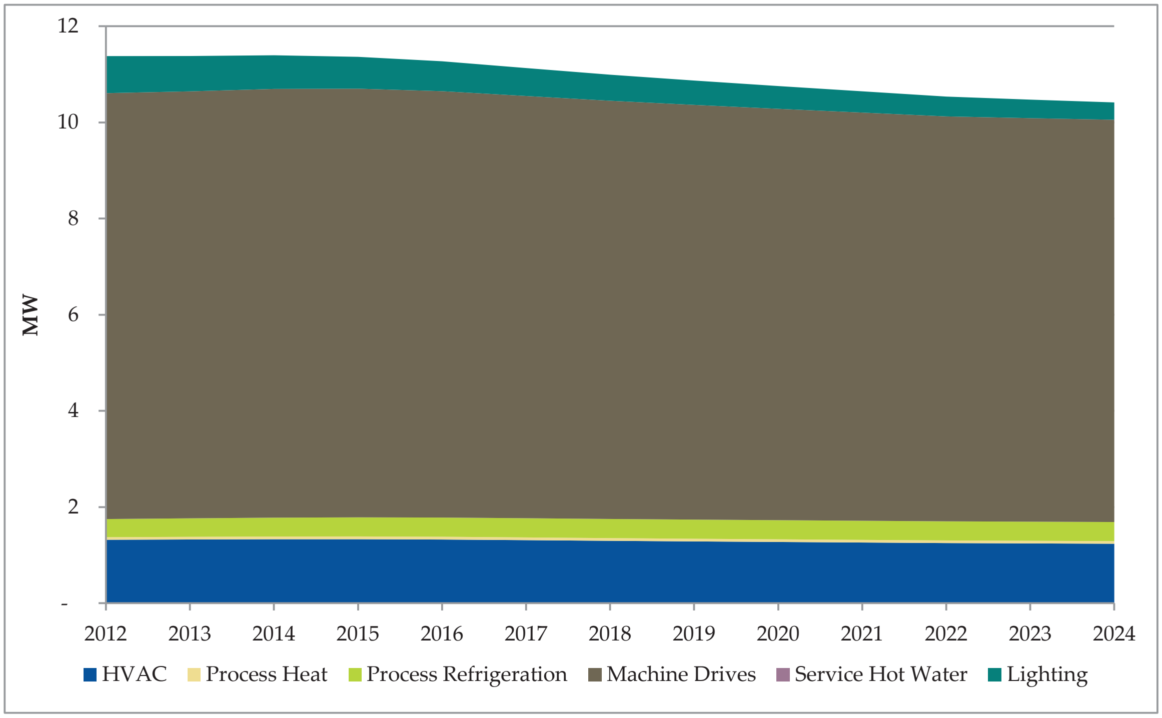
Figure G-20 presents the incremental market energy savings potential in the industrial sector by end use. The incremental energy savings potential remains fairly constant for those end uses, such as machine drives and process refrigeration, estimated to have savings potential associated with continuous improvement activities. Potential decreases for saturating measures. For example, lighting incremental market potential decreases from 7 GWh in 2012 to 2 GWh in 2024. The majority of the savings in the industrial sector 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), Figure G-21 presents the incremental market demand savings potential in the industrial sector. The demand savings potential follows a similar trend to the energy savings potential, where recurring end uses remain steady and saturating end uses decrease. Overall, demand potential decreases from 11 MW in 2012 to 10 MW in 2024.

Figure G-20. California Industrial Gross Incremental Market Energy Savings Potential by End Use for 2012-2024 (GWh)



Source: PG model release February 2014

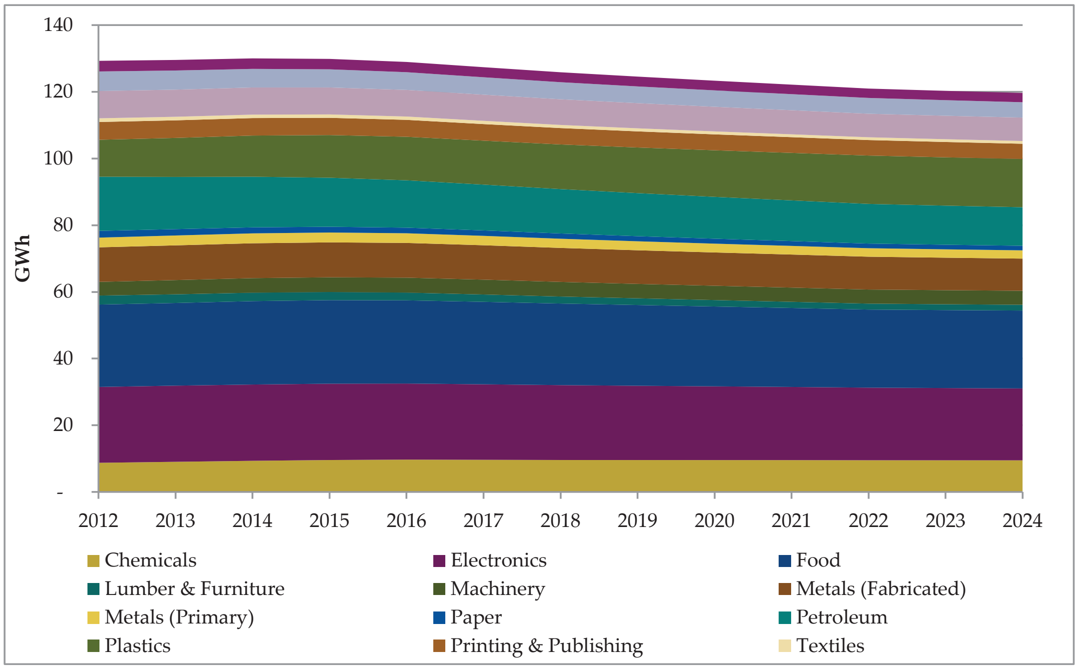
Figure G-21. California Industrial Gross Incremental Market Demand Savings Potential by End Use for 2012-2024 (MW)



Source: PG model release February 2014

Figure G-22 presents the incremental market energy savings potential in the industrial sector by subsector. This view by subsector shows how the continuous improvement and saturation of potential within certain industrial segments affects the overall industrial market potential.

Figure G-22. California Industrial Gross Incremental Market Energy Savings Potential by End Use for 2012-2024 (GWh)



Source: PG model release February 2014

G.9.3 California Industrial 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 industrial 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 industrial, 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 industrial sector
- Incremental annual forecast potential for 2013/14 compared to the IOU Industrial Compliance Filings
- 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

G.9.3.1 Comparison between 2011 and 2013 Potential Studies

Table G-15 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The potential energy savings estimates calculated by both studies vary due to the change in analyses approaches used between studies. The 2013 effort that relied on supply curves developed an expanded scope and relied on a more robust dataset. 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 G-15. Changes in California Industrial Incremental and Cumulative Market Energy Potential from the Previous Forecast (GWh)

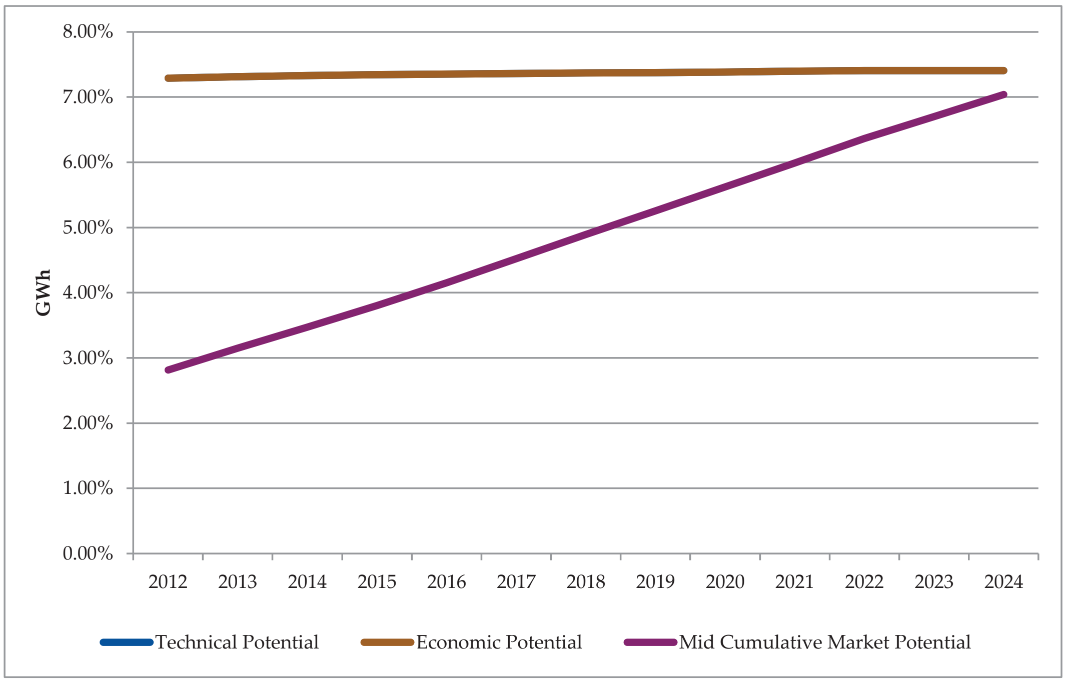
	Incremental Market Potential			Cumulative Market Potential		
Year	2011 Study	2013 Study	Percent Change	2011 Study	2013 Study	Percent Change
2012	284	129	-54%	2,284	992	-57%
2013	287	130	-55%	2,571	1,122	-56%
2014	274	130	-53%	2,845	1,252	-56%
2015	261	130	-50%	3,106	1,382	-56%
2016	248	129	-48%	3,354	1,511	-55%
2017	233	127	-45%	3,587	1,638	-54%
2018	224	126	-44%	3,811	1,764	-54%
2019	207	125	-40%	4,018	1,889	-53%
2020	194	123	-36%	4,212	2,012	-52%
2021	180	122	-32%	4,392	2,134	-51%
2022	174	121	-30%	4,566	2,255	-51%
2023	171	120	-30%	4,737	2,375	-50%
2024	176	120	-32%	4,913	2,495	-49%

Source: PG model release February 2014

G.9.3.2 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 G-23 shows the technical, economic, and cumulative market potential savings as a percent of the CEC industrial forecast. Technical and economic potentials are above 7 percent of the CEC industrial consumption forecast in 2012 and remains there in 2024. Cumulative market potential rises from about 2 percent in 2012 up to 7 percent by 2024.

Figure G-23. California Industrial Savings Potential as a Percent of CEC Industrial Forecast (Technical, Economic, and Cumulative Market Potential)

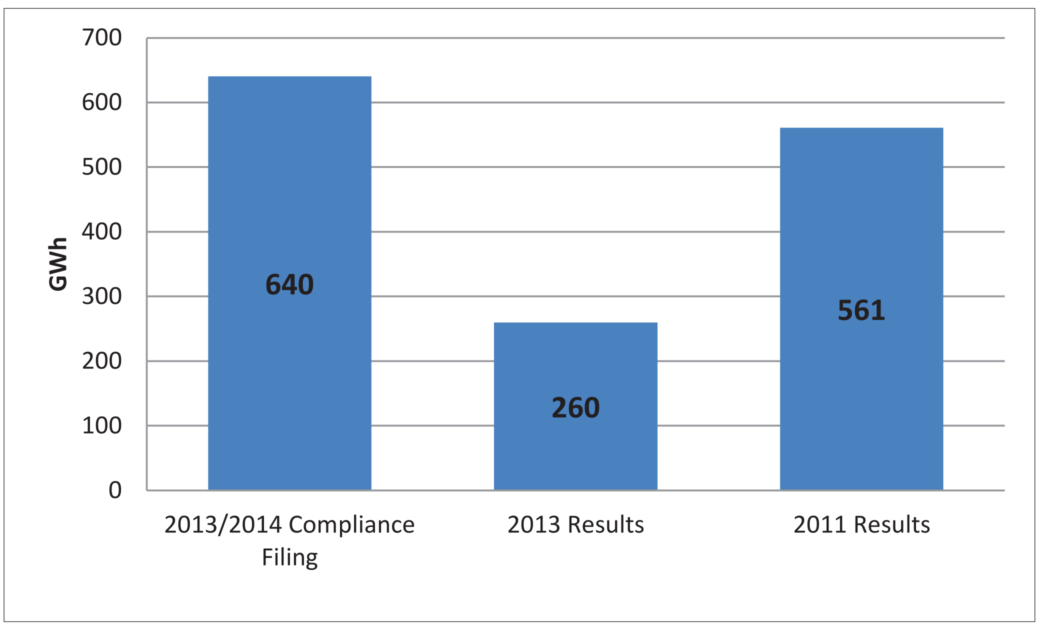


Source: PG model release February 2014

G.9.3.3 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 industrial numbers in the compliance filings were compared to the 2013 potential study as well as the 2011 Potential Study, as shown in Figure G-24. The 2013 study is less than both the compliance filing and 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, Navigant notes that this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, Navigant notes those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, Navigant uses a supply curve approach and relies on a more robust dataset that draws more information from sources that are specific to the Industrial sector. Finally, this reduction reflects derates to account for standard practices and increased regulatory burdens present in California.

Figure G-24. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Electric)



Source: PG model release February 2014

Navigant further investigated the IOU filing data in order to understand the differences between the estimates. Table G-16 shows each IOUs potential assumptions (ex-ante), 2013 and 2014 program budgets, forecasted sales (GWh), and Navigant's analysis results. 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, Navigant notes that this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario. Each table's $/kWh values provides a further comparison of how each IOU's program budgets relate to expected savings, and these vary significantly. Navigant notes that the compliance filing budgets do not separate dollars by electric and gas savings. However, to aid this specific comparative metrics analysis Navigant has assigned all dollars to electric savings.

Table G-16. 2013-2014 Industrial Sector IOU Filings, Electric

IOU	Navigant Model Savings (GWh)	Filing Ex-Ante Electric Savings (GWh)	Filing Program Budget (Million $)	Filing $/kWh	2013-2014 Consumption Forecast (GWh)
All	260	640	$152	$0.24	35,640
PG&E	123	195	$69	$0.35	17,398
SCE	124	429	$77	$0.18	16,687
SDG&E	13	17	$6.2	$0.37	1,556

Source: PG model release February 2014, IOU Compliance Filings and CEC QFER Forecast.

G.9.3.4 *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, Navigant further verified the potential model results for this sector by comparing its analysis to other recent studies completed by KEMA.[108] 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. Navigant compared the distribution of 2013 end use market potential to similar estimates provided in the KEMA reports. As shown in Table G-17, the end use potential generally aligned between studies.

Table G-17. Share of Electric Potential in each End Use Category

KEMA		Navigant	
Electric End-use	Percent of Electric Potential (%)	Percent of Electric Potential (%)	Electric End-use
HVAC	17%	18%	HVAC, process heat, process refrigeration
Lighting	7%	5%	Lighting
Motors, compressed air, pumps, fans	75%	77%	Machine Drives
Other	1%	N/A	N/A
Total	100%	100%	Total

Source: PG model release February 2014 and KEMA Industrial Sector Market Characterizations.

G.9.4 California Industrial Natural Gas Potential

The Industrial sector contributes the majority of the natural gas potential estimated for the California AIMS sectors.

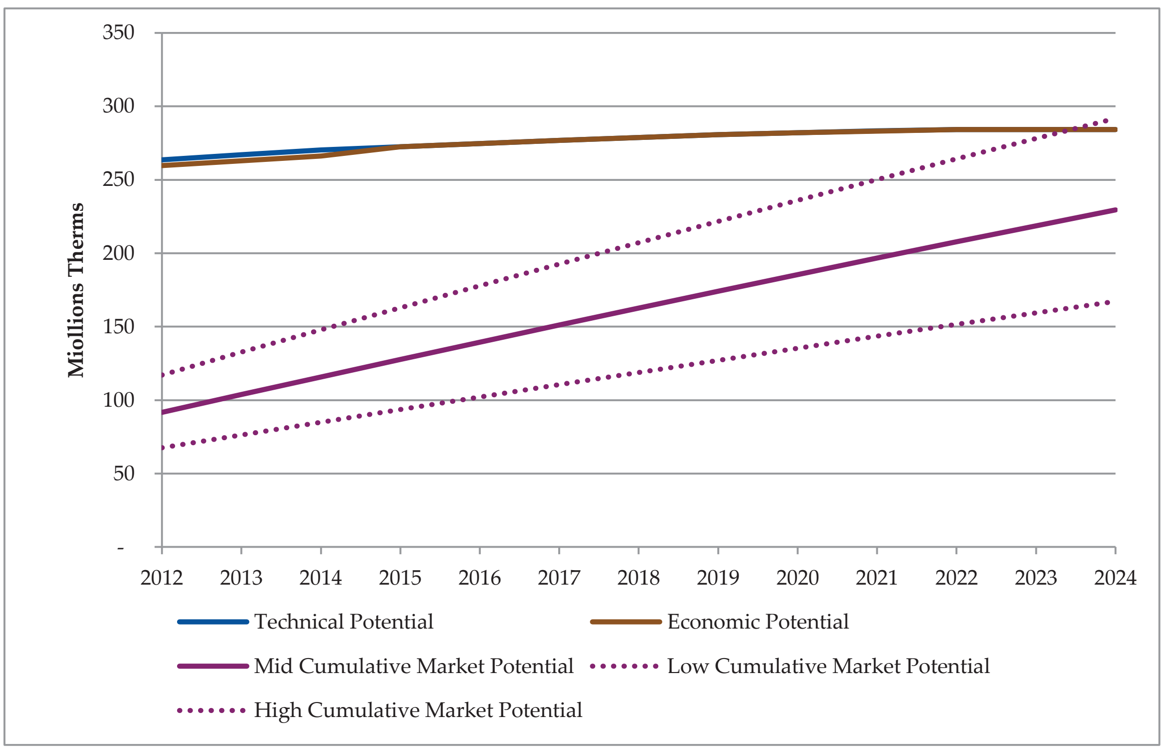
As shown in Figure G-25, the industrial technical and economic energy savings potential remains fairly constant from 2012 through 2024. Navigant's technical and economic potential results are generally the same value because Navigant's analysis used supply curves for the industrial sector that rely on 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 260 and 285 million therms from 2012 through 2024. The technical and

[108] 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;

economic energy savings potential are informed by IOU retail rate forecasts for each sector ($/therm) and energy sales forecasts for each sector (therms by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year. The Navigant team estimates that savings potential for certain end uses within certain industrial segments will maintain incremental savings levels 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 and future equipment emerging technologies that sustain savings achievements. The cumulative market potential lags the technical and economic potentials and increases from around 92 million therms in 2012 to around 230 million therms in 2024 for the Mid EE Penetration market potential scenario. Consistent with the discussion on electric energy and demand, cumulative gas energy 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 G-25. California Industrial Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2012-2024 (Million Therms)

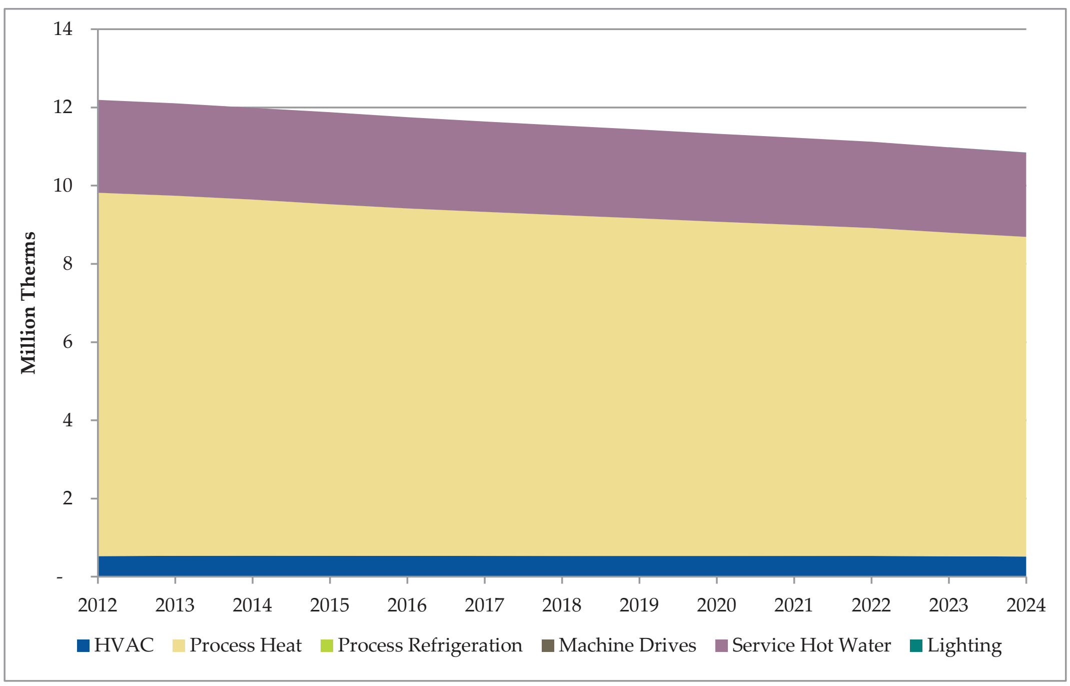


Source: PG model release February 2014

The Navigant team's analysis approach used for gas potential mirrors the approach used for estimating electric potential. Specifically, Navigant identified continually improving and saturating gas measures within certain end-uses and certain subsectors. 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 G-26 presents the incremental market potential gas savings by end-use through 2024. For many industrial subsectors, this savings recurrence represents the introduction of emerging technologies in future years, ongoing and continuous implementation of O&M best practices, long term and large capital strategic improvements, and process improvements that are typically implemented as a part of production changes and equipment retooling. These continuous improvement 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 are estimated to saturated and not maintain incremental savings levels over the analysis period. For example, a significant portion of process heat end-use measures within the Petroleum subsector are estimated to saturate during the 2012 to 2024 timeframe. As a result, the incremental gas savings potential decreases steadily from approximately 12 million therms in 2012 to 11 million therms in 2024.

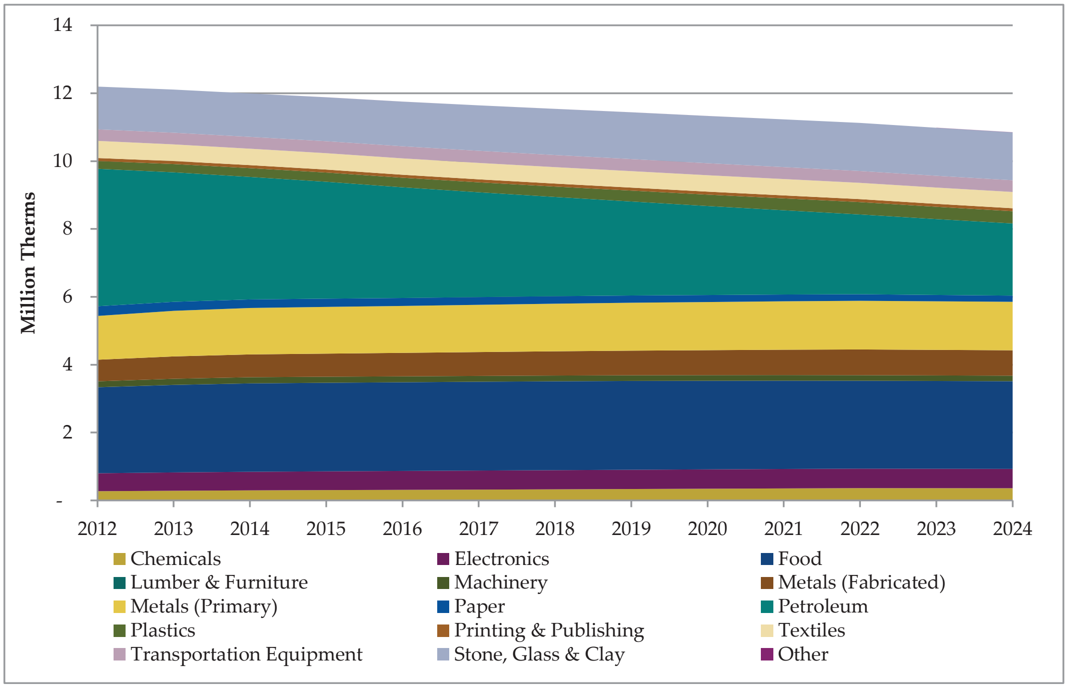
Figure G-26. California Industrial Gross Incremental Market Gas Savings Potential by End Use for 2012-2024



Source: PG model release February 2014

Figure G-27 presents the incremental market energy savings potential in the industrial sector by subsector. This view by subsector shows how the continuous improvement and saturation of potential within certain industrial segments affects the overall industrial market potential. Notably, the Petroleum subsector is estimated to saturate.

Figure G-27. California Industrial Gross Incremental Market Energy Savings Potential by Subsector for 2012-2024 (Million Therms)



Source: PG model release February 2014

G.9.5 California Industrial 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 industrial 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 industrial, 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 industrial sector
- Incremental annual forecast potential for 2013/14 compared to the IOU Industrial Compliance Filings
- 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

G.9.5.1 Comparison between 2011 and 2013 Potential Studies

Table G-18 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The potential energy savings estimates calculated by both studies vary due to the change in analyses approaches used between studies. The 2013 effort that relied on supply curves developed an expanded scope and relied on a more robust dataset. 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 G-18. Changes in California Industrial Incremental and Cumulative Market Energy Potential from the Previous Forecast (Million Therms)

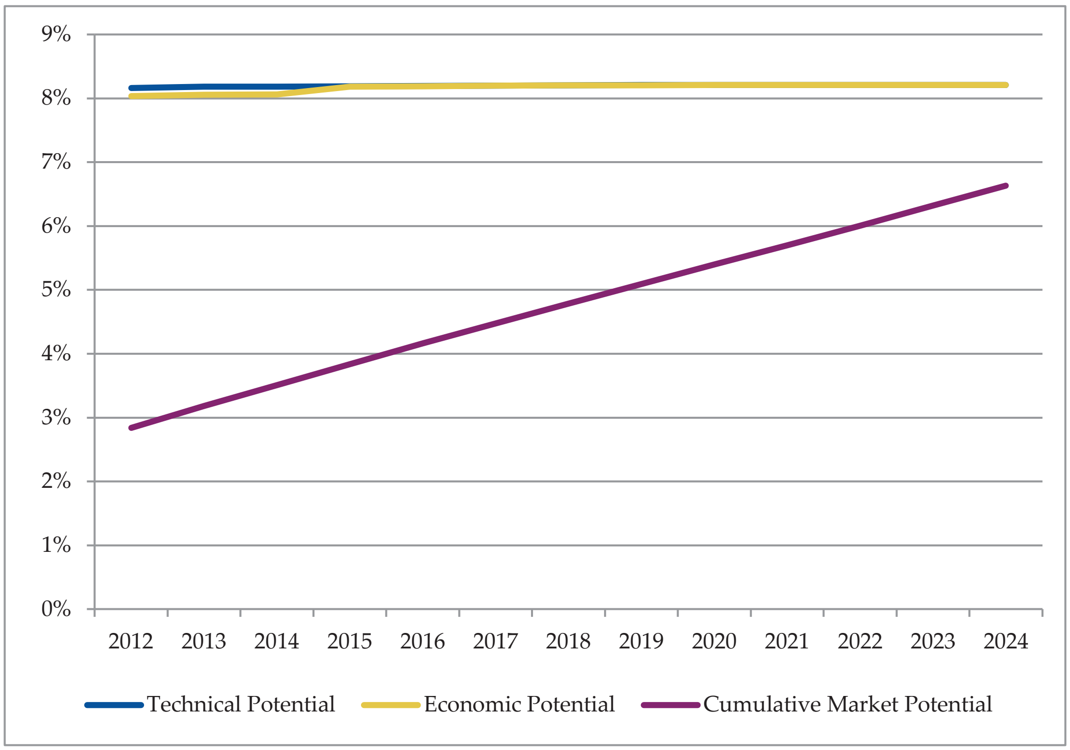
	Incremental Market Potential			Cumulative Market Potential		
Year	2011 Study	2013 Study	Percent Change	2011 Study	2013 Study	Percent Change
2012	21	12	-42%	178	92	-49%
2013	19	12	-36%	197	104	-47%
2014	16	12	-25%	213	116	-46%
2015	13	12	-9%	226	128	-44%
2016	11	12	7%	237	139	-41%
2017	9	12	29%	246	151	-39%
2018	8	12	44%	254	163	-36%
2019	6	11	91%	260	174	-33%
2020	6	11	89%	266	185	-30%
2021	5	11	125%	271	197	-28%
2022	5	11	122%	276	208	-25%
2023	5	11	120%	281	219	-22%
2024	5	11	117%	286	230	-20%

Source: PG model release February 2014

G.9.5.2 *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 G-28 shows the technical, economic, and active cumulative market potential savings as a percent of the CEC industrial forecast. Technical and economic potentials are about 8 percent of the CEC industrial consumption forecast in 2012 and remains there in 2024. Active cumulative market potential rises from about 3 percent in 2012 up to 7 percent by 2024.

Figure G-28. California Industrial Savings Potential as a Percent of CEC Industrial Forecast (Technical, Economic, and Active Cumulative Market Potential)

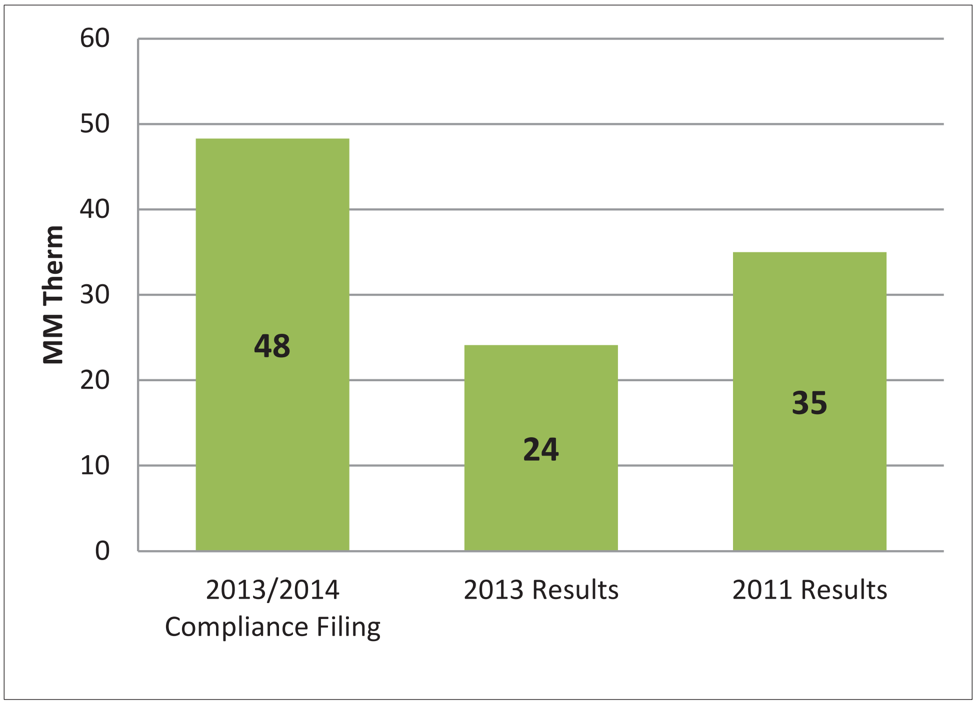


Source: PG model release February 2014

G.9.5.3 *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 industrial numbers in the compliance filings were compared to the 2013 potential study as well as the 2011 Potential Study, as shown in Figure G-29. The 2013 study is less than both the compliance filings and 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, Navigant notes that this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, Navigant notes those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, Navigant uses a supply curve approach and relies on a more robust dataset that draws more information from sources that are specific to the Industrial sector. Finally, this reduction reflects derates to account for standard practices and increased regulatory burdens present in California.

Figure G-29. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Gas)



Source: PG model release February 2014

Navigant further investigated the IOU filing data in order to understand the differences between the estimates. Table G-19 shows each IOUs potential assumptions (ex-ante), forecasted sales, and Navigant's analysis results. 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, Navigant notes that this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario. Finally, Navigant's estimate reflects derates to account for standard practices and increased regulatory burdens present in California.

Table G-19. 2013-2014 Industrial Sector Savings Comparison, Gas

IOU	Navigant Model Savings (MM Therm)	Filing Ex-Ante Gas Savings (MM Therm)	2013-2014 Consumption Forecast (MM Therm)	Navigant Percent Savings (%)	Filing Percent Savings (%)
All	24	48	6,567	0.37%	0.73%
PG&E	11	22	3,140	0.36%	0.70%
SDG&E	0.3	0.4	56.4	0.58%	0.71%
SCG	13	26	3,371	0.37%	0.77%

Source: PG model release February 2014, IOU Compliance Filings and CEC QFER Forecast.

G.9.5.4 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, Navigant further verified the potential model results for this sector by comparing its analysis to other recent studies completed by KEMA.[109] 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. Navigant compared the distribution of 2013 end use market potential to similar estimates provided in the KEMA reports. As shown in Table G-20, the end use potential generally aligned between studies though the KEMA reports showed slightly less HVAC potential while the Navigant study indicated slightly less service hot water (boiler) potential.

Table G-20. Share of Gas Potential in each End Use Category

KEMA		Navigant	
Gas End-use	Percent of Gas Potential (%)	Percent of Gas Potential (%)	Gas End-use
HVAC	2%	4%	HVAC
Process (varies)	59%	76%	Process Heat
Boilers	39%	20%	Service Hot Water
Total	100%	100%	Total

Source: PG model release February 2014 and KEMA Industrial Sector Market Characterizations.

[109] Ibid, KEMA reports on CALMAC.org

Appendix H Approach to Agricultural Sector Analysis

This appendix provides a detailed explanation of the steps used to determine energy efficiency potential in the agricultural sector.

Similar to the industrial sector, the Navigant team applied energy efficiency supply curves as a top-down approach to calculating agricultural sector energy efficiency potential. Supply curves present an attractive option for calculating energy efficiency potential in the agricultural sector because energy efficiency databases, such as the Database for Energy Efficiency Resources (DEER), contain few agricultural-specific measures. In addition, supply curves generally require fewer model inputs than the measure-based, bottom-up approaches used in the residential and commercial sectors.

Rather than indicating the energy efficiency potential of a specific measure (e.g. a high-bay LED lighting fixture), EE supply curves indicate efficiency potential at sub-sector and end-use levels of analysis. EE supply curves typically relay two key pieces of information: 1) the *amount* of energy efficiency potential available for a particular end use or system and 2) the *cost* at which the energy efficiency potential can be achieved.

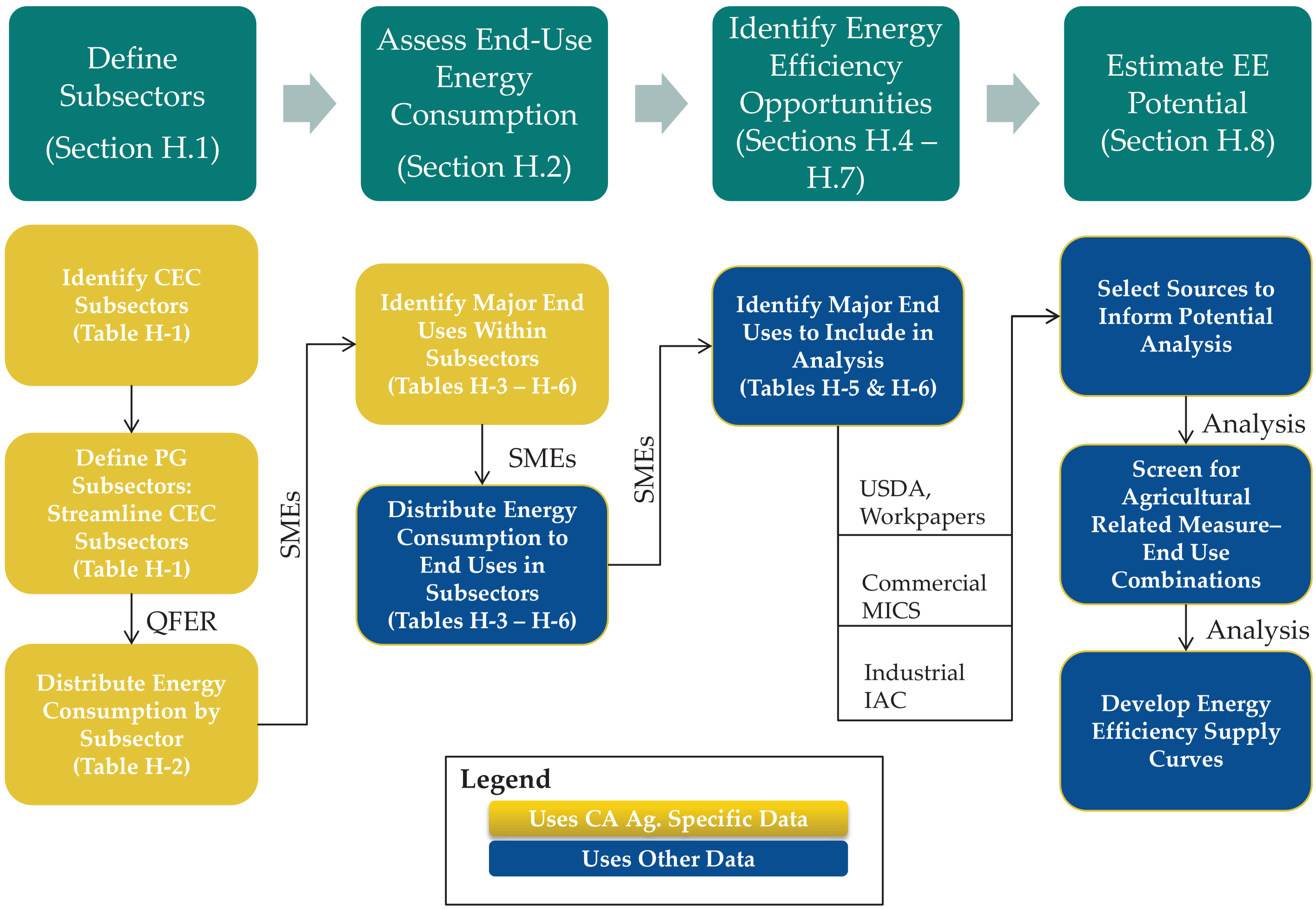
The Navigant team's approach to developing the supply curves for the agricultural sector follow the methods developed for the industrial sector. That approach included four main steps:

1. Define a framework for conducting the analysis at the market subsector level
2. Estimate current energy consumption in each subsector
3. Identify energy efficiency opportunities in each subsector using existing data
4. Estimate energy efficiency potential for each subsector using the supply curve approach

Figure H-1 provides a guide to navigating the remainder of this appendix. It includes the following features:

- Detailed analysis that contributed to each of the four main steps outlined in the previous paragraph (in each yellow or blue box)
- Indications of the content in each of the tables in this section (in the yellow and blue boxes)
- Key data sources that informed each detailed step in the analysis (captured along the connector lines) and whether this data was specific to California's agricultural sector (yellow) or specific to another region
- A map for the rest of the section (section numbers included in the top row of boxes)

Figure H-1. Overview of the Navigant Team's Approach to Calculating Agricultural Sector Potential



Source: Navigant team Analysis, 2013

H.1 *Define Subsectors and Assess Current Energy Consumption*

The agricultural sector accounts for four percent of electricity consumption and one percent of natural gas consumption across all four IOU service territories.[110] The agricultural sector refers to energy consumption from activities related to growing, harvesting, and storing of crops, as well as raising and tending of livestock. To develop the subsector categorization, the Navigant team used the CEC's definition of agricultural subsectors as a starting point.[111] The team then identified corresponding NAICS codes for these identifiers. For the purposes of this potential study, the Navigant team summarized agricultural NAICS codes by combining similar activities and expanding certain NAICS codes, where appropriate. In doing so, the Navigant team identified seven subsectors within this sector: dairies, irrigated agriculture, greenhouses and nurseries, vineyards and wineries, confined animal feeding operations (CAFOs), refrigerated warehouse, and post-harvest processing. Table H-1 shows a mapping from the CEC agricultural subsector identifiers to the Navigant team's identifiers.

Table H-1. Agricultural Mapping from CEC Subsectors to Navigant Subsectors

CEC Subsector Identifier	Corresponding CEC NAICS Code(s)	Navigant Subsector Identifier
Dairy Cattle and Milk Production	112120	Dairies
Field Crops; Fruit, Tree and Vine Crops	1111, 1119, 1112, 1113	Irrigated Agriculture
Greenhouse, Nursery, and Floriculture Production	1114	Greenhouses & Nurseries
Wineries (Wine-Making Vineyards)	111332	Vineyards & Wineries
Animal Production except Dairy Cattle/Milk Production	112	CAFOs
Refrigerated Warehousing and Storage	493120	Refrigerated Warehouses
Postharvest Crop Activities (including Cotton Ginning)	115114, 115111	Post-Harvest Processing

Source: CEC's Energy Demand Forecast Methods Report, NAICS Association, naics.com

[110] 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/.
[111] 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.

The Navigant team used Quarterly Fuel and Energy Report (QFER) data provided by CEC to generate a subsector view of IOU service territory agricultural consumption; QFER data is reported by NAICS code. Table H-2 shows the percent distribution of electric and gas consumption by subsector across the four IOU service territories.

Table H-2. Agricultural Sector IOU Territory Electric and Gas Consumption by Subsector, 2011

Navigant Subsector Identifier	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
Electric Consumption (MWh) – 2011 IOU Combined							
Total, MWh	806,403	1,821,397	203,811	555,910	231,815	698,383	929,908
Subsector %	15%	35%	4%	11%	4%	13%	18%
Gas Consumption (Therms) – 2011 IOU Combined							
Total, Therms	2,162,078	19,927,154	36,372,394	20,073,977	10,421,149	2,230,356	33,482,867
Subsector %	2%	16%	29%	16%	8%	2%	27%

Source: CEC data request

H.2 Assess Existing Energy Consumption

H.2.1 Distribute Energy Consumption by End Uses by Subsectors

To further disaggregate subsector consumption into various end uses, the Navigant team used secondary research to identify segment-appropriate end uses. For the purpose of this potential study, Navigant considered the end-use categories that are common and well-defined among the various subsectors.

Referring to sources identified in Navigant's *2011 California Agricultural Market Characterization Literature Review*,[112] the Navigant team identified seven major energy consumption end uses:

- **HVAC** – any energy-consuming technologies in the agricultural sector used for heating, cooling, or ventilating a space for the comfort of the inhabitant. Inhabitants here can include people, animals, or plants.
- **Lighting** – any energy-consuming technologies in the agricultural sector used for lighting an indoor or outdoor space.
- **Motors** – only pumping motors used for pumping water used in irrigation or other agricultural applications.
- **Refrigeration** – energy-consuming technologies used for refrigerating or freezing agricultural goods.
- **Water Heating and Cooling** – energy consuming technologies in the agricultural sector used for heating or cooling water.

[112] See the full list of Agricultural Resources and Subject Matter Experts at the end of this appendix.

- **Process –** energy-consuming technologies specific to the agricultural subsector for processing goods. This includes motors used for conveyance of harvested crops, milking pumps, or other motors not associated with pumping water or HVAC applications.
- **Miscellaneous –** any other energy-consuming technologies in the agricultural sector not covered in the above end uses.

In order to properly distribute each subsector's consumption across all end uses, the Navigant team conducted a number of subject matter expert (SME) interviews.[113] These interviews addressed characteristics of both agricultural end uses, as well as agricultural measures. Using the information gathered through these interviews, the Navigant team identified the distribution of energy consumption across these end uses for each subsector. Table H-3 and Table H-4 illustrate the findings from the SME interviews, showing each agricultural subsector's energy consumption distribution across major end uses, for electricity and natural gas, respectively.

Table H-3. Electric Consumption Distribution across Major End Uses – by Agricultural Subsector

End Use	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
HVAC	8%	0%	54%	5%	78%	0%	4%
Lighting	10%	0%	17%	19%	8%	11%	5%
Motors	1%	95%	7%	8%	3%	4%	2%
Refrigeration	41%	0%	6%	40%	4%	83%	27%
Water Heating and Cooling	6%	0%	5%	9%	3%	3%	0%
Process	22%	0%	8%	17%	3%	0%	61%
Miscellaneous	12%	5%	3%	2%	3%	0%	1%
Subsector Total %	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Subject matter expert interviews

[113] See the full list of Subject Matter Experts in Section H.7.

Table H-4. Gas Consumption Distribution across Major End Uses – by Agricultural Subsector

End Use	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
HVAC	10%	50%	99%	40%	10%	50%	1%
Lighting	0%	0%	0%	0%	0%	0%	0%
Motors	0%	0%	0%	0%	0%	0%	0%
Refrigeration	0%	0%	0%	0%	0%	0%	0%
Water Heating and Cooling	90%	0%	0%	50%	90%	0%	0%
Process	0%	0%	0%	5%	0%	0%	99%
Miscellaneous	0%	50%	1%	5%	0%	50%	0%
Subsector Total %	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Subject matter expert interviews

References for each market subsector varied slightly. The sources referenced for each subsector are as follows:

- **Dairies** – All distribution percentages come from an SCE Study on Dairies. *Dairy Farm Energy Efficiency Guide.* Found at http://www.sce.com. These numbers confirmed through SME interviews with UC Davis expert Jim Thompson, and Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT).
- **Irrigated Agriculture** – Percentages provided through SME interviews with UC Davis expert Jim Thompson; Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT); John Weddington, Pump Efficiency Program Mgr. with Fresno State University; Cecil Ellison with Southern California Edison – Tulare; Steve Villegas with Southern California Edison – Ventura.
- **Greenhouses & Nurseries** – Percentages provided through SME interviews with UC Davis expert Jim Thompson; Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT); James Bethke, Farm Advisor with University of California, Agriculture and Natural Resources.
- **Vineyards & Wineries** – Percentages provided through SME interviews with UC Davis expert Jim Thompson, and Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT).
- **CAFOs** – Percentages provided through SME interviews with UC Davis expert Jim Thompson, and Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT).
- **Refrigerated Warehouses** – Percentages provided through SME interviews with UC Davis expert Jim Thompson, and Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT).
- **Post-Harvest Processing** – Percentages provided through SME interviews with UC Davis expert Jim Thompson, and Dave Ryan, Energy Engineer with the National Center for Appropriate Technology (NCAT).

Once the Navigant team determined distribution of energy consumption within each market subsector, the team paired the distribution data from Table H-5 and Table H-6 with the subsector energy consumption data from Table H-2. In doing so, Navigant generated estimates of total agricultural energy usage by subsector and end use. Table H-5 estimates the portion of agricultural sector electricity consumption for each end use in each subsector, and Table H-6 estimates these proportions for natural gas consumption. The consumption values in these two tables aid in providing reasonable bounds on estimated EE potential for a given subsector and end use.

Table H-5. Electricity Consumption by Sub-Sector and End Use

Navigant Subsector Identifier	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
HVAC	64,512	-	110,058	27,795	180,816	-	37,196
Lighting	80,640	-	34,648	105,623	18,545	78,568	46,495
Motors	8,064	1,730,327	14,267	44,473	5,795	26,189	18,598
Refrigeration	330,625	-	12,229	222,364	8,114	576,166	251,075
Water Heating and Cooling	48,384	-	10,191	50,032	5,795	17,460	-
Process	177,409	-	16,305	94,505	5,795	-	567,244
Miscellaneous	96,768	91,070	6,114	11,118	6,954	-	4,650
Total, MWh	**806,403**	**1,821,397**	**203,811**	**555,910**	**231,815**	**698,383**	**929,908**
Subsector %	**15%**	**35%**	**4%**	**11%**	**4%**	**13%**	**18%**

Source: Navigant team analysis, 2013

Table H-6. Gas Consumption by Sub-Sector and End Use

Navigant Subsector Identifier	Dairies	Irrigated Agriculture	Greenhouses & Nurseries	Vineyards & Wineries	CAFOs	Refrigerated Warehouses	Post-Harvest Processing
HVAC	216,313	9,692,386	36,183,559	8,279,589	1,042,115	1,115,178	334,829
Lighting	-	-	-	-	-	-	-
Motors	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-
Water Heating and Cooling	1,946,818	-	-	10,349,487	9,379,034	-	-
Process	-	-	-	1,034,949	-	-	33,148,038
Miscellaneous	-	9,692,386	365,490	1,034,949	-	1,115,178	-
Total, Therms	**2,162,078**	**19,927,154**	**36,372,394**	**20,073,977**	**10,421,149**	**2,230,356**	**33,482,867**
Subsector %	**2%**	**16%**	**29%**	**16%**	**8%**	**2%**	**27%**

Source: Navigant team analysis

Using these tables, the Navigant team identified a number of key end uses for analysis, both electric and natural gas. The Navigant team focused the analysis on selected end uses within each subsector to ensure an efficient and accurate assessment of the major fuel consuming activities within the agricultural 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 energy efficiency potential.

Key electrical end uses include the following:

- **Motors (pumping) –** For purposes of this agricultural study, "motors" includes only water-pumping motors used at sites classified as irrigated agriculture.
- **Refrigeration –** Warehouses with refrigeration and/or freezing capabilities make up the majority of this end-use consumption. Dairies however, do contain a good deal of refrigeration equipment used in immediately cooling milk.[114] Overall, the Navigant team examined refrigeration end uses in dairies, vineyards and wineries, refrigerated warehouse, and post-harvest processing subsectors.
- **Process (conveyance motors) –** Post-harvest processing facilities contain a large number of conveyance motors used to move harvested crops from drying, shelling, and other processing stations around the site. Overall, the Navigant team examined electric process end uses within the dairies and post-harvest processing subsectors.

[114] Southern California Edison, 2012, *Dairy Farm Energy Management Guide.* http://155.13.50.30/NR/rdonlyres/60CC09E0-2EE1-4087-B46F-51527CC0906D/0/CompleteGuide_102005REV.pdf

Key natural gas end uses include:

- **HVAC (e.g., temperature control) –** For purposes of this agricultural study, any technology used to regulate temperature for plant comfort and growth is included in this HVAC category. Overall, the Navigant team examined gas HVAC end uses within the greenhouses and nurseries and vineyards and wineries subsectors.
- **Water Heating and Cooling –** Gas consumption for water heating is a significant end use within the vineyards and wineries and CAFOs subsectors. Therefore, the Navigant team includes those subsectors within its analysis.
- **Process (drying) –** Gas consumption for drying newly harvested crops makes up more than a quarter of all gas use in the agricultural sector. Therefore, the Navigant team includes the post-harvest processing subsector within its analysis of gas process end-use potential.

H.3 Savings Calculations

The Navigant team relied on a number of sources to develop the supply curves for the agricultural sector. These sources varied by subsector to ensure that the best available data to the analysis provided the most appropriate representation of the agricultural subsector and end use under examination. The Navigant team relied on three main data sources:

- Virtual Grower 3, PG&E work papers, and DEER
- The Commercial MICS used by this study's Commercial sector analysis
- The IAC database used by this study's Industrial sector analysis

H.4 Greenhouses and Nurseries

The Navigant team modeled greenhouse measures separately from the remainder of the market subsectors included in the agricultural analysis. Energy usage for greenhouse measures is relatively well documented as compared to other agricultural measures. Furthermore, the USDA has developed an online tool, known as Virtual Grower 3, for modeling greenhouse energy savings. The tool allows for the simulation of varying construction types, air infiltration, heating schedules and heating efficiency. The tool can also simulate greenhouses in a variety of climate zones throughout the U.S., although model runs showed that savings estimates over the baseline are relatively consistent for all climate zones. The model results account for conduction, convection, infiltration and solar heat gain.

Through secondary research and review of Virtual Grower 3, the Navigant team identified five measures that represent the most common energy efficiency technologies for greenhouses and nurseries. These measures include:

1. Infrared film
2. Double polyethylene layers on walls
3. Double polyethylene layers on roofs
4. Heat curtains
5. Efficient boilers

Because it is an established tool, the Navigant team first chose to use outputs from Virtual Grower 3.[115] As part of the modeling process, the team conducted tests with this tool, which resulted in conservative savings when compared to the PG&E work paper. To develop the model greenhouse parameters, the Navigant team used baseline information found in PG&E's greenhouse thermal curtain work paper.[116] This work paper provides details on materials and specifications for a standard greenhouse, as well as the densities of specific measures within PG&E's service territory. The details of these specifications are shown in Table H-7. Ultimately, the Navigant team used Virtual Grower 3 with information from the PG&E work paper to develop gas measures for greenhouse and nursery HVAC and water heating end uses. Specifically, these measures relate to improvements to greenhouse roofs and walls and efficient boiler installations.

Table H-7. Virtual Grower Baseline Inputs, Informed by PG&E's Thermal Curtain Work Paper

Measure Category	Measure Specification	Virtual Grower Input Value
Building Dimensions and Characteristics	Length (feet)	256
	Width (feet)	32
	Side Height (feet)	16
	Roof Height (feet)	24
	Roof Shape (description)	Arc
	Number of Bays (count)	14
Building Materials	Roof (description)	Single Polyethylene
	Walls (description)	Corrugated Polycarbonate
Air Infiltration Characteristics	Small Gaps (prevalence)	Few
	Large Gaps (prevalence)	Few
Heat Curtain	Installed (yes/no)	No
Lighting	Installed (yes/no)	No
Heating Schedule	Heating Type (description)	Constant
	Settings (temperature)	55 F
	Current system efficiency (%)	80%

Source: Navigant team analysis using the PG&E work paper

[115] Virtual Grower 3, USDA Agricultural Research Service, 5/29/2013, http://www.ars.usda.gov/services/software/download.htm?softwareid=108

[116] Pacific Gas & Electric, *Greenhouse Thermal Curtains*, work paper PGECOAGR101, Feb 5, 2008, http://socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf

To capture interactive effects, the Navigant team ran savings scenarios in Virtual Grower 3 that included a combination of all measures. Using this method, the team determined maximum savings, and subsequently weighted individual measure savings accordingly. Table H-8 shows the weighted savings from each measure. As shown, maximum savings from greenhouse and nursery measures accumulated to 69 percent when compared to the baseline.

Table H-8. Greenhouse and Nurseries Incremental Measure Savings

	Baseline	Infrared Film	Double Wall Insulation	Double Roof Insulation	Heat Curtain	Efficient Boiler
Remaining Energy Use (Therms)	103,401	93,890	88,454	64,052	35,801	31,823
Cumulative Savings Compared to Baseline	-	9%	14%	38%	65%	69%

Source: Navigant team analysis using Virtual Grower 3

The Navigant team also relied on DEER data to further develop gas measures for greenhouses and nurseries. Specifically, the Navigant team relied on several DEER measures for greenhouses related to the following building envelope improvements:

- Infrared film applications to bare roofs (glass roofs)
- Infrared film applications to bare walls (glass walls)
- Heat curtain installation

The final measures developed for greenhouses and nurseries drew data from USDA Virtual Grower 3, IOU thermal curtain work papers, DEER data, or combinations of these sources (i.e., averages calculated).

Finally, following the development of the measure list, Navigant developed the supply curves by compiling the energy savings and cost information associated with each measure. The supply curves relate the cost of an energy efficiency recommendation (shown as dollars per unit energy saved) to the energy savings associated with that measure (shown as a percent of the end-use consumption for the subsector). Finally, Navigant assigned three distinct levels, "Low Cost," "Mid Cost," and "High Cost," to the measures that comprise the supply curve to create the final measure inputs used within the potential model.

See the industrial appendix (Appendix G) for further information on the development of measures using the supply curve approach.

H.5 Wineries and Vineyards

The Navigant team determined that HVAC and water heating end uses within the vineyards and wineries subsector are a close analog to similar end uses within the Commercial sector. Operations at facilities within this agricultural subsector are similar to food handling operations within similar commercial buildings that also consume gas energy through HVAC and water heating end uses. For example, HVAC systems located at vineyard facilities or within wineries are similar to climate-controlled warehouses.

The Navigant team reviewed similar measures within the industrial sector and more specifically industrial food processing and manufacturing subsectors. For example, industrial HVAC operations often include freezing of foodstuffs and other large-scale freezer operations that are not typical to this agricultural subsector. Therefore, through its review of secondary sources and subject matter interview findings, the Navigant team determined that the commercial sector offered the agricultural analysis the best available source of comprehensive information in an accessible format to facilitate an efficient and accurate assessment of these end uses identified as significant agricultural energy consumers.

The Navigant team used the following commercial service hot water (SHW) gas measures from the commercial analysis to develop the agricultural analysis for water heating within the vineyard and wineries subsector.

Table H-9. Vineyard and Wineries Hot Water Heating Inputs

Equipment	Efficient Description	Baseline Description
Small gas instantaneous water heaters, less than 2 gallons	High efficiency	40 gallon gas storage water heater, 0.59 EF, 76% recovery efficiency
Large gas instantaneous water heaters	85% thermal efficiency	Large gas storage water heater, 80% thermal efficiency, 0.56%/hr standby loss
Small gas storage water heater	51 gallon, 0.66 EF	51 gallon gas storage water heater, 0.57 EF, 76% recovery efficiency
Large gas storage water heater	86.5% thermal efficiency	Large gas storage water heater, 80% thermal efficiency, 0.56%/hr standby loss
Condensing large gas storage water heater	99% thermal efficiency	Large gas storage water heater, 80% thermal efficiency, 0.56%/hr standby loss
Condensing small gas storage water heater with low NOx burner	51 gallon, 0.77 EF	51 gallon gas storage water heater, 0.57 EF, 76% recovery efficiency

Source: Navigant Commercial Potential Analysis

The Navigant team used the following commercial HVAC gas measures from the commercial analysis to develop the agricultural analysis for HVAC within the vineyard and wineries subsector.

Table H-10. Vineyard and Wineries HVAC Inputs

Equipment	Efficient Description	Baseline Description
Wall insulation	Efficient spray-on wall insulation	R-0 wall insulation, R-13 (code) wall insulation
Attic insulation	Efficient batt attic insulation	R-11 attic insulation or lower, R-30 (code) attic insulation or greater

Source: Navigant Commercial Potential Analysis

Finally, following the development of the measure list, the Navigant team developed the supply curves by compiling the energy savings and cost information associated with each measure. The supply curves relate the cost of an energy efficiency recommendation (shown as dollars per unit energy saved) to the energy savings associated with that measure (shown as a percent of the end-use consumption for the subsector). Finally, the Navigant team assigned three distinct levels, "Low Cost," "Mid Cost," and "High Cost," to the measures that comprise the supply curve to create the final measure inputs used within the potential model.

See the industrial appendix (Appendix G) for further information on the development of measures using the supply curve approach.

H.6 End Use-Subsector Combinations Utilizing the Industrial Analysis

The Navigant team determined that several agricultural end uses within certain subsectors are similar to end uses within the industrial sector. Specifically, equipment, operations, O&M practices, and efficiency options identified in the industrial sector are applicable to the agricultural sector. Therefore, the Navigant team relied on the data developed for the industrial analysis to estimate the energy savings potential for certain portions of the agricultural sector. The industrial data provided the agricultural analysis the best available source of comprehensive information in an accessible format (i.e., IAC database) to facilitate an efficient and accurate assessment of several major fuel-consuming activities.

The subsectors, end uses, and measure types (equipment or O&M) included within the agricultural analysis that rely on the industrial analysis work are shown in Table H-11.

Table H-11. List of IAC Data Queries Used to Generate Agricultural EE Supply Curves

Query ID	Subsector	End Use	Measure Type	Fuel Type
1	Irrigated Agriculture	Motors (pumping)	O&M	Electric
2	Irrigated Agriculture	Motors (pumping)	Equipment	Electric
3	Post-Harvest Processing	Process (motors)	O&M	Electric
4	Post-Harvest Processing	Process (motors)	Equipment	Electric
5	Dairies	Process (motors)	O&M	Electric
6	Dairies	Process (motors)	Equipment	Electric
7	Post-Harvest Processing	Refrigeration	O&M	Electric
8	Post-Harvest Processing	Refrigeration	Equipment	Electric
9	Dairies	Refrigeration	O&M	Electric
10	Dairies	Refrigeration	Equipment	Electric
11	Refrigerated Warehouses	Refrigeration	O&M	Electric
12	Refrigerated Warehouses	Refrigeration	Equipment	Electric
13	Wineries and Vineyards	Refrigeration	O&M	Electric
14	Wineries and Vineyards	Refrigeration	Equipment	Electric
15	Concentrated Animal Feeding Operation	Hot Water Heating	O&M	Gas
16	Concentrated Animal Feeding Operation	Hot Water Heating	Equipment	Gas
17	Post-Harvest Processing	Process (drying)	O&M	Gas
18	Post-Harvest Processing	Process (drying)	Equipment	Gas

Source: Navigant team analysis, 2013

For the data queries identified for the agricultural sector, the Navigant team first reviewed the IAC data developed by DOE for years 2004 to 2012.[117] The IAC data lists measures by Assessment Recommendation Code (ARC) and Navigant screened in those ARCs that appropriately reflect energy efficiency recommendations made within the agricultural sector. For example, several recommendations to improve compressed air systems within industrial facilities apply to process operations within dairy and post-harvest processing facilities. Additionally, electric motor improvement recommendations made at industrial facilities are similar to those made at agricultural facilities and farming sites. These electric motors may drive processes (e.g., conveyor belts) or fluid pumps (e.g., irrigated agriculture water pumps).

Navigant then assigned the ARC recommendations to the applicable subsectors, end uses, measure types (equipment or O&M), and fuel. Table H-12 shows the ARCs included in the agricultural analysis and the

[117] Access the IAC database manual at http://iac.rutgers.edu/manual_database.php.

corresponding measure assignments. Following the development of the recommendation list, Navigant then developed the supply curves by compiling the energy savings and cost information associated with each ARC that is contained within the IAC database. The supply curves relate the cost of an energy efficiency recommendation (shown as dollars per unit energy saved) to the energy savings associated with that recommendation (shown as a percent of the end-use consumption for the given subsector). Finally, Navigant condense each supply curve into three distinct levels: “Low Cost,” “Mid Cost,” and “High Cost” that define the measures used within the potential model.

See the industrial appendix (Appendix G) for a fully detailed explanation of the steps taken by the Navigant team to create the supply curves from the IAC database.

Table H-12. Industrial Assessment Center (IAC) Measure Recommendations with Assigned Subsector and End Use

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector				
				Dairies	Irrigated Agriculture	CAFOs	Refrigerated Warehouse	Post-Harvest Processing
2.4221	INSTALL COMPRESSOR AIR INTAKES IN COOLEST LOCATIONS	Equipment	Electric	Process (motors)				Process (motors)
2.4222	INSTALL ADEQUATE DRYERS ON AIR LINES TO ELIMINATE BLOWDOWN	Equipment	Electric	Process (motors)				Process (motors)
2.4223	INSTALL DIRECT ACTING UNITS IN PLACE OF COMPRESSED AIR PRESSURE SYSTEM IN SAFETY SYSTEM	Equipment	Electric	Process (motors)				Process (motors)
2.4224	UPGRADE CONTROLS ON COMPRESSORS	Equipment	Electric	Process (motors)				Process (motors)
2.4225	INSTALL COMMON HEADER ON COMPRESSORS	Equipment	Electric	Process (motors)				Process (motors)
2.4226	USE / PURCHASE OPTIMUM SIZED COMPRESSOR	Equipment	Electric	Process (motors)				Process (motors)
2.4227	USE COMPRESSOR AIR FILTERS	Equipment	Electric	Process (motors)				Process (motors)
2.4231	REDUCE THE PRESSURE OF COMPRESSED AIR TO THE MINIMUM REQUIRED	O&M	Electric	Process (motors)				Process (motors)
2.4232	ELIMINATE OR REDUCE COMPRESSED AIR USED FOR COOLING, AGITATING LIQUIDS, MOVING PRODUCT, OR DRYING	O&M	Electric	Process (motors)				Process (motors)
2.4233	ELIMINATE PERMANENTLY THE USE OF COMPRESSED AIR	O&M	Electric	Process (motors)				Process (motors)
2.4234	COOL COMPRESSOR AIR INTAKE WITH HEAT EXCHANGER	O&M	Electric	Process (motors)				Process (motors)
2.4235	REMOVE OR CLOSE OFF UNNEEDED COMPRESSED AIR LINES	O&M	Electric	Process (motors)				Process (motors)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector		
2.4236	ELIMINATE LEAKS IN INERT GAS AND COMPRESSED AIR LINES/ VALVES	O&M	Electric	Process (motors)		Process (motors)
2.4237	SUBSTITUTE COMPRESSED AIR COOLING WITH WATER OR AIR COOLING	O&M	Electric	Process (motors)		Process (motors)
2.4238	DO NOT USE COMPRESSED AIR FOR PERSONAL COOLING	O&M	Electric	Process (motors)		Process (motors)
2.4111	UTILIZE ENERGY-EFFICIENT BELTS AND OTHER IMPROVED MECHANISMS	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4112	INSTALL SOFT-START TO ELIMINATE NUISANCE TRIPS	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4113	INSTALL MOTOR VOLTAGE CONTROLLER ON LIGHTLY LOADED MOTORS	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4131	REPLACE OVER-SIZE MOTORS AND PUMPS WITH OPTIMUM SIZE	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4132	SIZE ELECTRIC MOTORS FOR PEAK OPERATING EFFICIENCY	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4133	USE MOST EFFICIENT TYPE OF ELECTRIC MOTORS	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4134	REPLACE ELECTRIC MOTOR WITH FOSSIL FUEL ENGINE	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4141	USE MULTIPLE SPEED MOTORS OR AFD FOR VARIABLE PUMP, BLOWER AND COMPRESSOR LOADS	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4142	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MOTOR-GENERATOR SET	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4143	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE THROTTLING SYSTEM	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4144	USE ADJUSTABLE FREQUENCY DRIVE TO REPLACE MECHANICAL DRIVE	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4145	INSTALL ISOLATION TRANSFORMER ON ADJUSTABLE FREQUENCY DRIVE	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector		
2.4151	DEVELOP A REPAIR/REPLACE POLICY	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4152	USE ONLY CERTIFIED MOTOR REPAIR SHOPS	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4153	AVOID EMERGENCY REWIND OF MOTORS	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4154	AVOID REWINDING MOTORS MORE THAN TWICE	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4155	STANDARDIZE MOTOR INVENTORY	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4156	ESTABLISH A PREVENTATIVE MAINTENANCE PROGRAM	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4157	ESTABLISH A PREDICTIVE MAINTENANCE PROGRAM	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4311	RECOVER MECHANICAL ENERGY	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4312	IMPROVE LUBRICATION PRACTICES	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4313	PROVIDE PROPER MAINTENANCE OF MOTOR DRIVEN EQUIPMENT	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4314	USE SYNTHETIC LUBRICANT	O&M	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4321	UPGRADE OBSOLETE EQUIPMENT	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4322	USE OR REPLACE WITH ENERGY EFFICIENT SUBSTITUTES	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4323	USE OPTIMUM SIZE AND CAPACITY EQUIPMENT	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)
2.4324	REPLACE HYDRAULIC / PNEUMATIC EQUIPMENT WITH ELECTRIC EQUIPMENT	Equipment	Electric	Process (motors)	Motors (pumping)	Process (motors)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector				
2.4325	UPGRADE CONVEYORS	Equipment	Electric	Process (motors)				Process (motors)
2.5121	REDESIGN FLOW TO MINIMIZE MASS TRANSFER LENGTH	O&M	Electric	Process (motors)	Motors (pumping)			Process (motors)
2.5122	REPLACE HIGH RESISTANCE DUCTS, PIPES, AND FITTINGS	Equipment	Electric	Process (motors)	Motors (pumping)			Process (motors)
2.5123	REDUCE FLUID FLOW RATES	O&M	Electric	Process (motors)	Motors (pumping)			Process (motors)
2.5124	USE GRAVITY FEEDS WHEREVER POSSIBLE	Equipment	Electric	Process (motors)	Motors (pumping)			Process (motors)
2.5125	SIZE AIR HANDLING GRILLS/ DUCT/S COILS TO MINIMIZE AIR RESISTANCE	O&M	Electric	Process (motors)	Motors (pumping)			Process (motors)
2.6127	MAINTAIN AIR FILTERS BY CLEANING OR REPLACEMENT	O&M	Electric	Process (motors)				Process (motors)
2.2621	MODIFY REFRIGERATION SYSTEM TO OPERATE AT A LOWER PRESSURE	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2622	REPLACE EXISTING CHILLER WITH HIGH EFFICIENCY MODEL	Equipment	Electric	Refrigeration			Refrigeration	Refrigeration
2.2623	MINIMIZE CONDENSER COOLING WATER TEMPERATURE	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2624	USE COLD WASTE WATER TO COOL CHILLER FEED WATER	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2625	CHILL WATER TO THE HIGHEST TEMPERATURE POSSIBLE	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2626	AVOID FROST FORMATION ON EVAPORATORS	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2627	USE MULTIPLE-EFFECT EVAPORATORS	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2628	UTILIZE A LESS EXPENSIVE COOLING METHOD	O&M	Electric	Refrigeration			Refrigeration	Refrigeration
2.2436	RECOVER HEAT FROM REFRIGERATION CONDENSERS	Equipment	Electric	Refrigeration			Refrigeration	Refrigeration
2.2516	USE ECONOMIC THICKNESS OF INSULATION FOR LOW TEMPERATURES	Equipment	Electric	Refrigeration			Refrigeration	Refrigeration

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector			
2.2523	REDUCE INFILTRATION TO REFRIGERATED AREAS; ISOLATE HOT EQUIPMENT FROM REFRIGERATED AREAS	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2691	SHUT OFF COOLING IF COLD OUTSIDE AIR WILL COOL PROCESS	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2693	USE WASTE HEAT STEAM FOR ABSORPTION REFRIGERATION	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2694	USE HIGHEST TEMPERATURE FOR CHILLING OR COLD STORAGE	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2695	USE CASCADE SYSTEM OF RECIRCULATING DURING COLD WEATHER TO AVOID SUB-COOLING	Equipment	Electric	Refrigeration		Refrigeration	Refrigeration
2.2696	USE EXCESS COLD PROCESS FLUID FOR INDUSTRIAL COOLING NEEDS	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.6212	TURN OFF EQUIPMENT DURING BREAKS, REDUCE OPERATING TIME	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.6216	SHUT OFF COOLING WATER WHEN NOT REQUIRED	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.6222	USE DRYING OVEN (BATCH TYPE) ON ALTERNATE DAYS OR OTHER OPTIMUM SCHEDULE TO RUN EQUIPMENT WITH FULL LOADS	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2711	UTILIZE OUTSIDE AIR INSTEAD OF CONDITIONED AIR FOR DRYING	O&M	Electric	Refrigeration		Refrigeration	Refrigeration
2.2111	INSTALL STEAM TRAP	Equipment	Gas		Hot Water Heating		
2.2113	REPAIR OR REPLACE STEAM TRAPS	Equipment	Gas		Hot Water Heating		
2.2121	INCREASE AMOUNT OF CONDENSATE RETURNED	O&M	Gas		Hot Water Heating		
2.2122	INSTALL / REPAIR INSULATION ON CONDENSATE LINES	O&M	Gas		Hot Water Heating		
2.2123	INSULATE FEEDWATER TANK	Equipment	Gas		Hot Water Heating		
2.2124	INSTALL DE-AERATOR IN PLACE OF CONDENSATE TANK	Equipment	Gas		Hot Water Heating		
2.2127	FLASH CONDENSATE TO PRODUCE LOWER PRESSURE STEAM	O&M	Gas		Hot Water Heating		

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.2128	USE STEAM CONDENSATE FOR HOT WATER SUPPLY (NON-POTABLE)	O&M	Gas	Hot Water Heating
2.2131	INSULATE STEAM / HOT WATER LINES	Equipment	Gas	Hot Water Heating
2.2132	REPAIR FAULTY INSULATION ON STEAM LINES	O&M	Gas	Hot Water Heating
2.2133	REPAIR LEAKS IN LINES AND VALVES	O&M	Gas	Hot Water Heating
2.2134	ELIMINATE LEAKS IN HIGH PRESSURE REDUCING STATIONS	O&M	Gas	Hot Water Heating
2.2135	REPAIR AND ELIMINATE STEAM LEAKS	O&M	Gas	Hot Water Heating
2.2153	CLOSE OFF UNNEEDED STEAM LINES	O&M	Gas	Hot Water Heating
2.2163	USE MINIMUM STEAM OPERATING PRESSURE	O&M	Gas	Hot Water Heating
2.2164	TURN OFF STEAM TRACING DURING MILD WEATHER	O&M	Gas	Hot Water Heating
2.2192	USE HEAT EXCHANGE FLUIDS INSTEAD OF STEAM IN PIPELINE TRACING SYSTEMS	O&M	Gas	Hot Water Heating
2.2412	USE FLUE GAS HEAT TO PREHEAT BOILER FEEDWATER	O&M	Gas	Hot Water Heating
2.2423	INSTALL WASTE HEAT BOILER TO PRODUCE STEAM	Equipment	Gas	Hot Water Heating
2.1211	MOVE BOILER TO MORE EFFICIENT LOCATION	O&M	Gas	Hot Water Heating
2.1212	OPERATE BOILERS ON HIGH FIRE SETTING	O&M	Gas	Hot Water Heating
2.1213	DIRECT WARMEST AIR TO COMBUSTION INTAKE	O&M	Gas	Hot Water Heating

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector	
2.1221	REPLACE OBSOLETE BURNERS WITH MORE EFFICIENT ONES	Equipment	Gas	Hot Water Heating	
2.1222	INSTALL TURBULATORS	Equipment	Gas	Hot Water Heating	
2.1223	INSTALL SMALLER BOILER (INCREASE HIGH FIRE DUTY CYCLE)	Equipment	Gas	Hot Water Heating	
2.1224	REPLACE BOILER	Equipment	Gas	Hot Water Heating	
2.1231	ESTABLISH BURNER MAINTENANCE SCHEDULE FOR BOILERS	O&M	Gas	Hot Water Heating	
2.1232	KEEP BOILER TUBES CLEAN	O&M	Gas	Hot Water Heating	
2.1233	ANALYZE FLUE GAS FOR PROPER AIR/FUEL RATIO	O&M	Gas	Hot Water Heating	
2.1241	REDUCE EXCESSIVE BOILER BLOWDOWN	O&M	Gas	Hot Water Heating	
2.1242	MINIMIZE BOILER BLOWDOWN WITH BETTER FEEDWATER TREATMENT	O&M	Gas	Hot Water Heating	
2.1243	USE HEAT FROM BOILER BLOWDOWN TO PREHEAT BOILER FEED WATER	O&M	Gas	Hot Water Heating	
2.1111	CONTROL PRESSURE ON STEAMER OPERATIONS	O&M	Gas		Process (drying)
2.1112	HEAT OIL TO PROPER TEMPERATURE FOR GOOD ATOMIZATION	O&M	Gas		Process (drying)
2.1113	REDUCE COMBUSTION AIR FLOW TO OPTIMUM	O&M	Gas		Process (drying)
2.1114	LIMIT AND CONTROL SECONDARY COMBUSTION AIR IN FURNACE	O&M	Gas		Process (drying)
2.1115	ELIMINATE COMBUSTIBLE GAS IN FLUE GAS	O&M	Gas		Process (drying)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.1116	IMPROVE COMBUSTION CONTROL CAPABILITY	O&M	Gas	Process (drying)
2.1117	RELOCATE OVEN / FURNACE TO MORE EFFICIENT LOCATION	O&M	Gas	Process (drying)
2.1121	USE INSULATION IN FURNACES TO FACILITATE HEATING / COOLING	O&M	Gas	Process (drying)
2.1122	RE-SIZE CHARGING OPENINGS OR ADD A MOVABLE DOOR ON EQUIPMENT	O&M	Gas	Process (drying)
2.1123	INSTALL AUTOMATIC STACK DAMPER	Equipment	Gas	Process (drying)
2.1124	REPLACE DIRECT FIRED WITH STEAM HEAT	Equipment	Gas	Process (drying)
2.1125	CONVERT TO OXYFUEL BURNERS	Equipment	Gas	Process (drying)
2.1131	REPAIR FAULTY INSULATION IN FURNACES, BOILERS, ETC	O&M	Gas	Process (drying)
2.1132	REPAIR FAULTY LOUVERS AND DAMPERS	O&M	Gas	Process (drying)
2.1133	ADJUST BURNERS FOR EFFICIENT OPERATION	O&M	Gas	Process (drying)
2.1134	ELIMINATE LEAKS IN COMBUSTIBLE GAS LINES	O&M	Gas	Process (drying)
2.1135	REPAIR FURNACES AND OVEN DOORS SO THAT THEY SEAL EFFICIENTLY	O&M	Gas	Process (drying)
2.2221	USE IMMERSION HEATING IN TANKS, MELTING POTS, ETC	Equipment	Gas	Process (drying)
2.2222	CONVERT LIQUID HEATERS FROM UNDERFIRING TO IMMERSION OR SUBMERSION HEATING	Equipment	Gas	Process (drying)
2.2223	ENHANCE SENSITIVITY OF TEMPERATURE CONTROL AND CUTOFF	O&M	Gas	Process (drying)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.2211	USE OPTIMUM TEMPERATURE	O&M	Gas	Process (drying)
2.2212	USE MINIMUM SAFE OVEN VENTILATION	O&M	Gas	Process (drying)
2.2114	SHUT OFF STEAM TRAPS ON SUPER HEATED STEAM LINES WHEN NOT IN USE	O&M	Gas	Process (drying)
2.2125	REPLACE BAROMETRIC CONDENSERS WITH SURFACE CONDENSERS	Equipment	Gas	Process (drying)
2.2126	LOWER OPERATING PRESSURE OF CONDENSER (STEAM)	O&M	Gas	Process (drying)
2.2151	CLEAN STEAM COILS IN PROCESSING TANKS	O&M	Gas	Process (drying)
2.2152	MAINTAIN STEAM JETS USED FOR VACUUM SYSTEM	O&M	Gas	Process (drying)
2.2161	OPTIMIZE OPERATION OF MULTI-STAGE VACUUM STEAM JETS	O&M	Gas	Process (drying)
2.2162	REDUCE EXCESS STEAM BLEEDING	O&M	Gas	Process (drying)
2.2411	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT COMBUSTION AIR	O&M	Gas	Process (drying)
2.2413	USE HOT FLUE GASES TO PREHEAT WASTES FOR INCINERATOR BOILER	O&M	Gas	Process (drying)
2.2422	USE WASTE HEAT FROM HOT FLUE GASES TO GENERATE STEAM	O&M	Gas	Process (drying)
2.2424	USE HEAT IN FLUE GASES TO PREHEAT PRODUCTS OR MATERIALS	O&M	Gas	Process (drying)
2.2425	USE FLUE GASES TO HEAT PROCESS OR SERVICE WATER	O&M	Gas	Process (drying)
2.2427	USE WASTE HEAT FROM HOT FLUE GASES TO PREHEAT INCOMING FLUIDS	O&M	Gas	Process (drying)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.2428	USE FLUE GASES IN RADIANT HEATER FOR SPACE HEATING, OVENS, ETC	O&M	Gas	Process (drying)
2.2431	RECOVER HEAT FROM TRANSFORMERS	O&M	Gas	Process (drying)
2.2432	RECOVER HEAT FROM OVEN EXHAUST / KILNS	O&M	Gas	Process (drying)
2.2433	RECOVER HEAT FROM ENGINE EXHAUSTS	O&M	Gas	Process (drying)
2.2437	RECOVER WASTE HEAT FROM EQUIPMENT	Equipment	Gas	Process (drying)
2.2441	PREHEAT BOILER MAKEUP WATER WITH WASTE PROCESS HEAT	Equipment	Gas	Process (drying)
2.2442	PREHEAT COMBUSTION AIR WITH WASTE HEAT	Equipment	Gas	Process (drying)
2.2443	RE-USE OR RECYCLE HOT OR COLD PROCESS EXHAUST AIR	Equipment	Gas	Process (drying)
2.2444	USE HOT PROCESS FLUIDS TO PREHEAT INCOMING PROCESS FLUIDS	Equipment	Gas	Process (drying)
2.2445	RECOVER HEAT FROM EXHAUSTED STEAM	Equipment	Gas	Process (drying)
2.2446	RECOVER HEAT FROM HOT WASTE WATER	Equipment	Gas	Process (drying)
2.2447	HEAT WATER WITH EXHAUST HEAT	Equipment	Gas	Process (drying)
2.2511	INSULATE BARE EQUIPMENT	Equipment	Gas	Process (drying)
2.2512	INCREASE INSULATION THICKNESS	Equipment	Gas	Process (drying)
2.2513	COVER OPEN TANKS WITH FLOATING INSULATION	Equipment	Gas	Process (drying)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.2514	COVER OPEN TANKS	Equipment	Gas	Process (drying)
2.2515	USE OPTIMUM THICKNESS INSULATION	Equipment	Gas	Process (drying)
2.2524	AVOID COOLING OF PROCESS STREAMS OR MATERIALS THAT MUST SUBSEQUENTLY BE HEATED	O&M	Gas	Process (drying)
2.2525	ELIMINATE COOLING OF PROCESS STREAMS WHICH SUBSEQUENTLY MUST BE HEATED AND VICE VERSA	O&M	Gas	Process (drying)
2.2531	RE-SIZE CHARGING OPENINGS OR ADD MOVABLE COVER OR DOOR	Equipment	Gas	Process (drying)
2.2532	USE ONLY AMOUNT OF AIR NECESSARY TO PREVENT EXPLOSION HAZARD	O&M	Gas	Process (drying)
2.2533	REPLACE AIR CURTAIN DOORS WITH SOLID DOORS	Equipment	Gas	Process (drying)
2.5111	CONVERT FROM INDIRECT TO DIRECT FIRED SYSTEMS	Equipment	Gas	Process (drying)
2.5112	USE CONTINUOUS EQUIPMENT WHICH RETAINS PROCESS HEATING CONVEYORS WITHIN THE HEATED CHAMBER	Equipment	Gas	Process (drying)
2.5113	USE DIRECT FLAME IMPINGEMENT OR INFRARED PROCESSING FOR CHAMBER TYPE HEATING	Equipment	Gas	Process (drying)
2.5114	USE SHAFT TYPE FURNACES FOR PREHEATING INCOMING MATERIAL	Equipment	Gas	Process (drying)
2.5115	REPOSITION OVEN WALLS TO REDUCE HEATED SPACE	Equipment	Gas	Process (drying)
2.5117	CONVERT TO INDIRECT TEMPERATURE CONTROL SYSTEM	Equipment	Gas	Process (drying)
2.6121	REDUCE HOT WATER TEMPERATURE TO THE MINIMUM REQUIRED	O&M	Gas	Process (drying)

ARC Code*	IAC Recommendation Description	Measure Type	Fuel	End Use Designation by Agricultural Subsector
2.6122	ADJUST VENTS TO MINIMIZE ENERGY USE	O&M	Gas	Process (drying)
2.6126	KEEP SOLID FUELS / RAW MATERIALS DRY	O&M	Gas	Process (drying)
2.6214	SHUT OFF PILOTS IN STANDBY EQUIPMENT	O&M	Gas	Process (drying)

*The IAC database organizes recommendations by their Assessment Recommendation Code (ARC).

Source: Navigant team analysis of IAC measures comprising the DOE IAC database (http://iac.rutgers.edu/database).

H.7 Agricultural Resources and Subject Matter Experts

Table H-13. Key Sources Reviewed for the Agricultural Analysis

Publisher/Source	Citation
Alternative Energy Systems Consulting, Inc.	1997 Agricultural Energy Efficiency Incentive Program Impact Study, Study ID 569, Southern California Edison, *Alternative Energy Systems Consulting, Inc. with Ridge & Associates, and KVDR, Inc.*, 1999
Cadmus	Process Evaluation of PG&E's Agricultural and Food Processing Program, PG&E, *The Cadmus Group in collaboration with Nexus Market Research, Research Into Action, and Strategic Energy Group*, 2009
California Department of Food and Agriculture	*California Dairy – Statistics and Trends,* California Department of Food and Agriculture, 2006, 2007, 2009, 2012.
California Energy Commission	California Energy Commission (CEC). Quarterly Fuel and Energy Report (QFER) data. Data transmission from CEC to Navigant. July 2012.
California Public Utilities Commission	Evaluation, Measurement and Verification Report, California Multi Measure Farm Program, 1354-04 and 1360-04, California Public Utilities Commission and EnSave, Inc, *kW Engineering*, 2007
Colorado Department of Agriculture	Interim Report for Colorado Department of Agriculture, *Net Zero Greenhouse Designs for Colorado,*2012
Equipose Consulting	Evaluation of the Center for Irrigation Technology, 2004-2005 Agricultural Pumping Efficiency Program, *Equipose Consulting, Inc. with California AgQuest Consulting, Inc., Ridge & Associates, and Vanward Consulting*, 2006
Equipose Consulting	Southern California Edison Company's Evaluation Measurement & Verification of the 2002 Pump Test and Hydraulic Services Program, SCE, *Equipose Consulting, Inc. in conjunction with Ridge & Associates, Vanward Consulting, and California AgQuest Consulting Inc.*, 2003
Equipose Consulting	Impact Evaluation of PG&E's 1997 Agricultural Programs Energy Efficiency Incentives Program: Pumping and Related End Use (Study ID 335A), Refrigeration End Use (Study IS 335B) and Greenhouse Heat Curtain End Use (Study ID 335C), *Equipoise Consulting with California AgQuest Consulting and Dr. Kirtida Parikh*, 1999
Itron, Inc.	2006-2008 Evaluation Report for the Southern California Industrial and Agricultural Contract Group, CPUC, *Itron, Inc. with ASW Engineering, Energy and Resources Solutions, Energy Metrics, Helios Resources, Jai J Mitchell Analytics, Michael Engineering, PWP Inc., Katin Engineering, SDV/ACCI, and Warren Energy Engineering*, 2009
Navigant Consulting	2011 California Agricultural Market Characterization: Literature Review*, Navigant Consulting, Inc.,* PG&E, 2011.
Pacific Gas & Electric	*Work Paper PGECOAGR101 - Greenhouse Thermal Curtains Revision 2,* PG&E 2010.
Quantec, LLC.	Evaluation of the Certified Agri-Food Energy Efficiency (CAFEE) Program- 1473-04, for Global Energy Partners, *Quantec LLC*, 2006
Southern California Edison	Southern California Edison, 2012, *Dairy Farm Energy Management Guide.* http://155.13.50.30/NR/rdonlyres/60CC09E0-2EE1-4087-B46F-51527CC0906D/0/CompleteGuide_102005REV.pdf
U.S. Department of Energy	Industrial Assessment Centers Database. Accessed at http://iac.rutgers.edu/database.

Publisher/Source	Citation
University of California Cooperative Extension	University of California Cooperative Extension , *Reducing Energy Costs in California Greenhouses,* 2011
USDA	Virtual Grower 3, USDA Agricultural Research Service, 5/29/2013, http://www.ars.usda.gov/services/software/download.htm?softwareid=108
Xenergy, Inc.	1997 Agricultural Energy Efficiency Incentives Program, First Year Load Impact Evaluation Final Report, Study ID 1022, San Diego Gas & Electric, Xenergy, Inc. 1999

Source: Navigant team analysis, 2013

Table H-14. Subject Matter Experts Consulted for Agricultural Sector Analysis

Individual	Organization or Entity	Area of Expertise
Cecil Ellison	Southern California Edison, Tulare	Provided insight into the Irrigated Agriculture subsector for energy use and technology characteristics.
Dave Ryan	Energy Engineer, The National Center for Appropriate Technology (NCAT).	Provided insight into energy use within each of the Agricultural subsectors.
James Bethke	Farm Advisor, University of California, Agriculture and Natural Resources.	Provided insight into the Greenhouse & Nursery subsector for energy use and technology characteristics.
Jim Thompson	UC Davis	Provided insight into energy use within each of the Agricultural subsectors.
John Weddington	Pump Efficiency Program Mgr., Fresno State University	Provided insight into energy use within each of the Agricultural subsectors.
Steve Villegas	Southern California Edison, Ventura	Provided insight into the Irrigated Agriculture subsector for energy use and technology characteristics.

Source: Navigant team analysis, 2013

H.8 Agricultural Sector Measure Derating

The Navigant team relied on the analysis developed for the Industrial sector as it determined that several Agricultural end-uses within certain subsectors are similar to Industrial end-uses. Further, the Navigant team estimates that approaches to energy efficiency, process optimization, and long-term energy efficiency strategies used in the Industrial sector are also similar to those deployed in the Agricultural sector. Finally, the same constraints present in the Industrial sector will also apply to the Agricultural sector. Specifically, these include constraints from ISPs, Code, and other regulations that limit energy efficiency potential.

In consideration of these sector similarities the Navigant team also applied a derating scheme similar to the method discussed for the Industrial sector in Section G.8.4.5. Navigant developed the following derating factors that are based on the average derates developed for the Industrial sector and presented in Table G-14.

Table H-15. Agricultural Measure Derates

Fuel	Equipment Measures	O&M Measures
Electric	39.0%	26.9%
Gas	34.5%	40.0%

H.9 Agricultural Sector Results

This section provides the estimates of potential energy and demand savings at the statewide level for the agricultural sector.

H.9.1 Overview

The potential energy savings in the agricultural sector do not include an assessment of the impact of upcoming codes and standards changes because the diverse nature of end uses in the agricultural sector makes it difficult to predict these impacts with any level of certainty. Additionally, while some equipment deployed throughout the agricultural sector may be subject to federal standards, the majority of equipment 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 as reports reviewed by the Navigant team do not indicate substantial new construction in this sector.

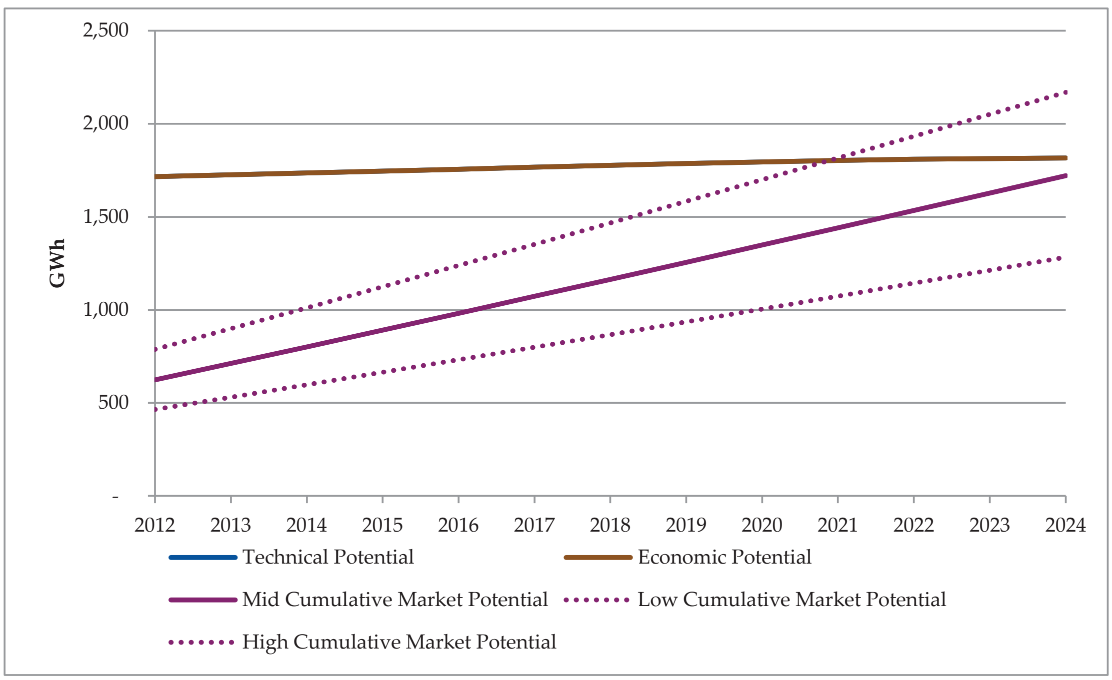
H.9.2 California Agricultural Summary of Results

H.9.2.1 California Agricultural Electric Energy Potential

As shown in Figure H-2, the agricultural technical and economic energy savings potential remains fairly constant from 2012 through 2024. Navigant's technical and economic potential results are generally the same value because Navigant's analysis used supply curves for the agricultural sectors 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 1,700 and 1,800 GWh from 2012 and 2024. The technical and economic energy savings potential are informed by IOU retail rate forecasts ($/kWh) and energy sales forecasts (kWh by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The agricultural cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year. The Navigant team estimates that savings potential for end uses within the segments will maintain incremental saving levels 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 and future equipment emerging technologies that sustain savings achievements. Cumulative market energy savings potential trails economic and technical energy savings potential and increases between around 620 GWh (in 2012) to around 1,700 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 H-2 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 H-2. California Agricultural Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (GWh)

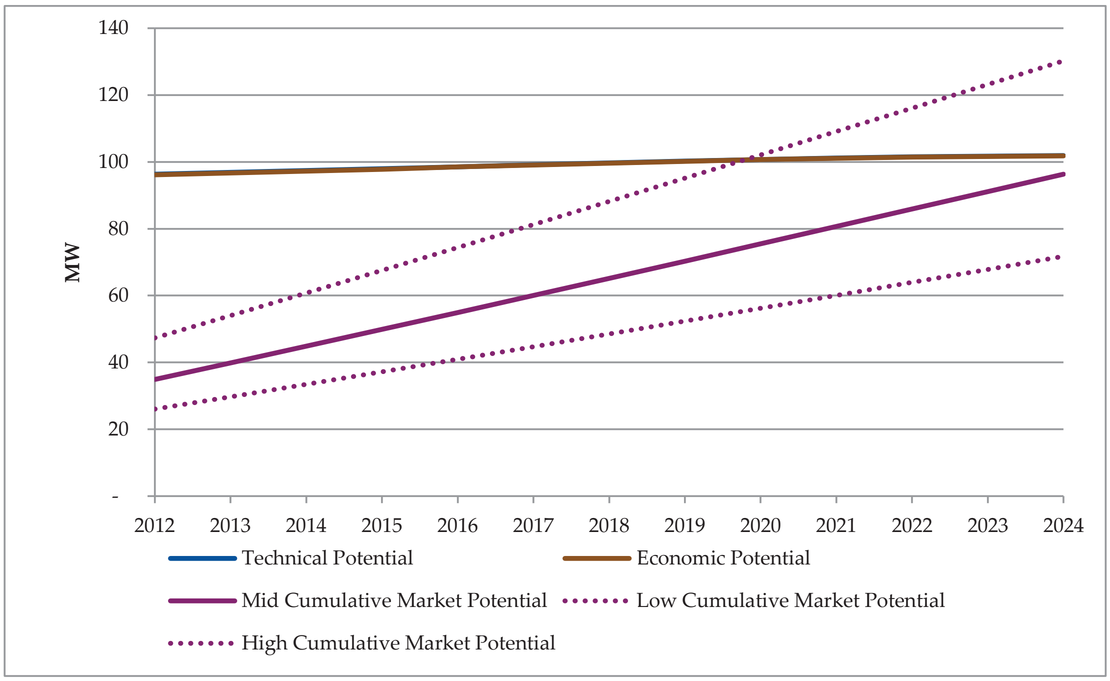


Source: PG model release February 2014

The Navigant team's cumulative market potential reflects recurring savings potential for end uses. 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 agricultural subsectors, this savings recurrence represents the introduction of emerging technologies in future years, ongoing and continuous implementation of O&M best practices, long term and large capital strategic improvements, and process improvements that are typically implemented as a part of production changes and equipment retooling. These continuous improvement 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. Figure H-3 presents the total technical, economic and cumulative market demand savings potential through 2024. Technical and economic demand savings potential stay steady between 95 MW and 105 MW from 2012 through 2024. The cumulative market potential increases from approximately 35 MW in 2012 to 96 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.

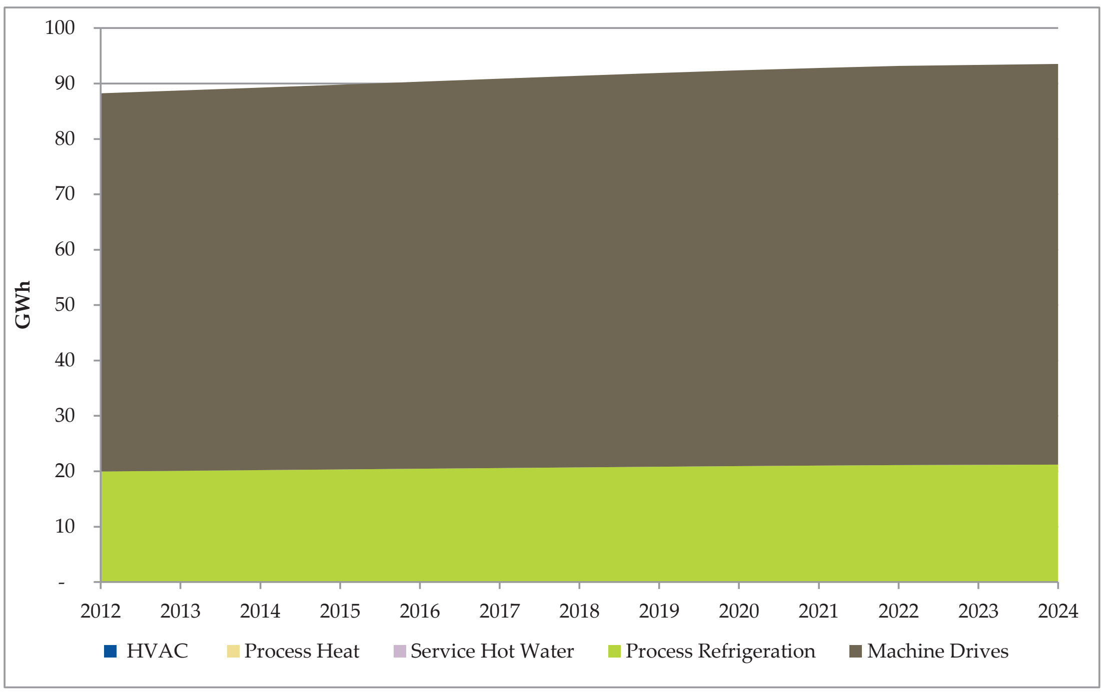
Figure H-3. California Agricultural Gross Technical, Economic, and Active Cumulative Market Demand Savings Potential for 2012-2024 (MW)



Source: PG model release February 2014

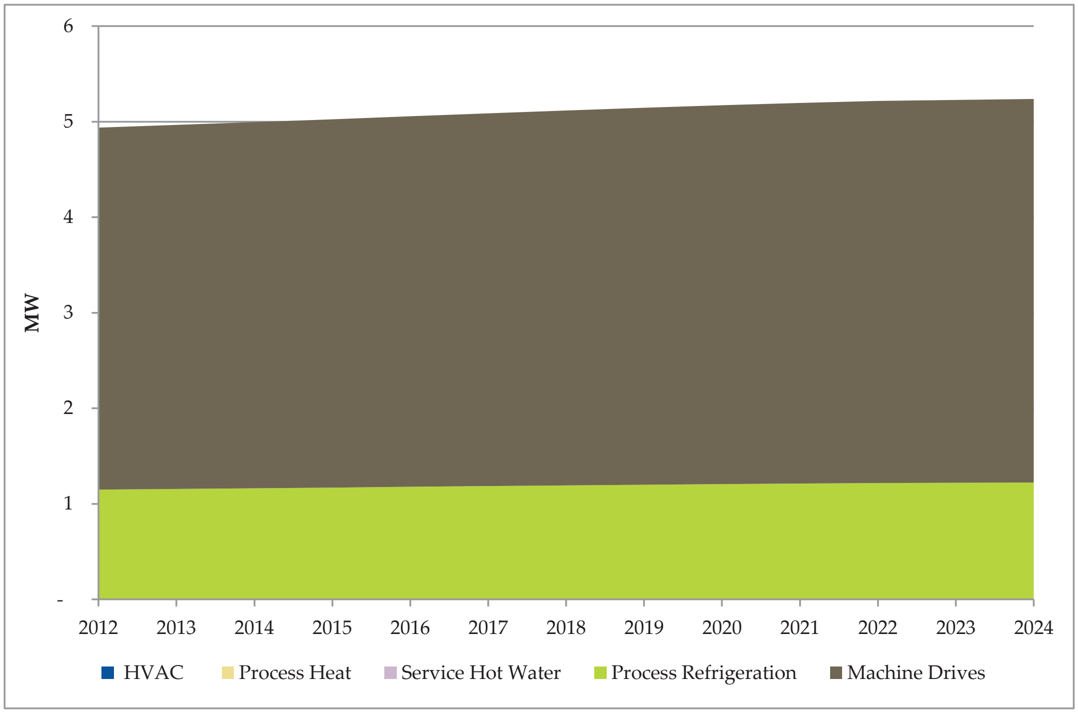
Figure H-4 presents the incremental market energy savings potential in the agricultural sector by end use. The incremental energy savings potential remains fairly constant for those end uses, such as machine drives and process refrigeration, estimated to have savings potential associated with continuous improvement activities. The majority of the savings in the industrial sector 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), Figure H-5 presents the incremental market demand savings potential in the agricultural sector. The demand savings potential follows a similar trend to the energy savings potential, where recurring end uses remain steady. Overall, demand potential increases from 4.9 MW in 2012 to 5.2 MW in 2024.

Figure H-4. California Agricultural Gross Incremental Market Energy Savings Potential for 2012-2024 (GWh)



Source: PG model release February 2014

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



Source: PG model release February 2014

H.9.2.2 California Agricultural 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 agricultural 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 agricultural, 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 agricultural sector
» Incremental annual forecast potential for 2013/14 compared to the IOU Agricultural Compliance Filings

Comparison between 2011 and 2013 Potential Studies

Table H-16 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The potential energy savings estimates calculated by both studies vary due to the change in analyses approaches used between studies. The 2013 effort that relied on supply curves developed an expanded scope and relied on a more robust dataset. 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 H-16. Changes in California Agricultural Incremental and Cumulative Market Energy Potential from the Previous Forecast (GWh)

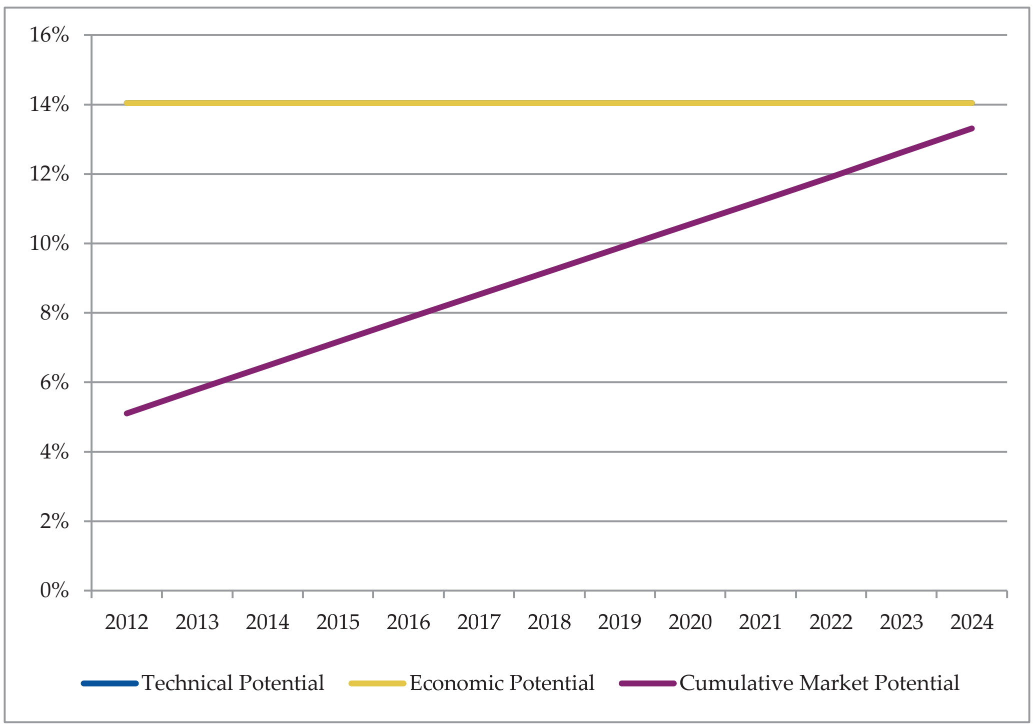
	Incremental Market Potential			Cumulative Market Potential		
Year	2011 Study	2013 Study	Percent Increase or Decrease	2011 Study	2013 Study	Percent Increase or Decrease
2012	91	88	-3%	786	624	-21%
2013	89	89	0%	875	712	-19%
2014	87	89	3%	962	802	-17%
2015	85	90	5%	1,047	891	-15%
2016	86	90	6%	1,132	982	-13%
2017	82	91	10%	1,215	1,073	-12%
2018	80	91	14%	1,295	1,164	-10%
2019	78	92	19%	1,373	1,256	-9%
2020	75	92	23%	1,448	1,348	-7%
2021	73	93	27%	1,521	1,441	-5%
2022	75	93	25%	1,595	1,534	-4%
2023	76	93	23%	1,671	1,628	-3%
2024	81	94	16%	1,752	1,721	-2%

Source: PG model release February 2014

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 H-6 shows the technical, economic, and cumulative market potential savings as a percent of the CEC agricultural forecast. Technical and economic potentials are about 14 percent of the CEC industrial consumption forecast in 2012 and remains there in 2024. Cumulative market potential rises from about 5 percent in 2012 up to 13 percent by 2024.

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

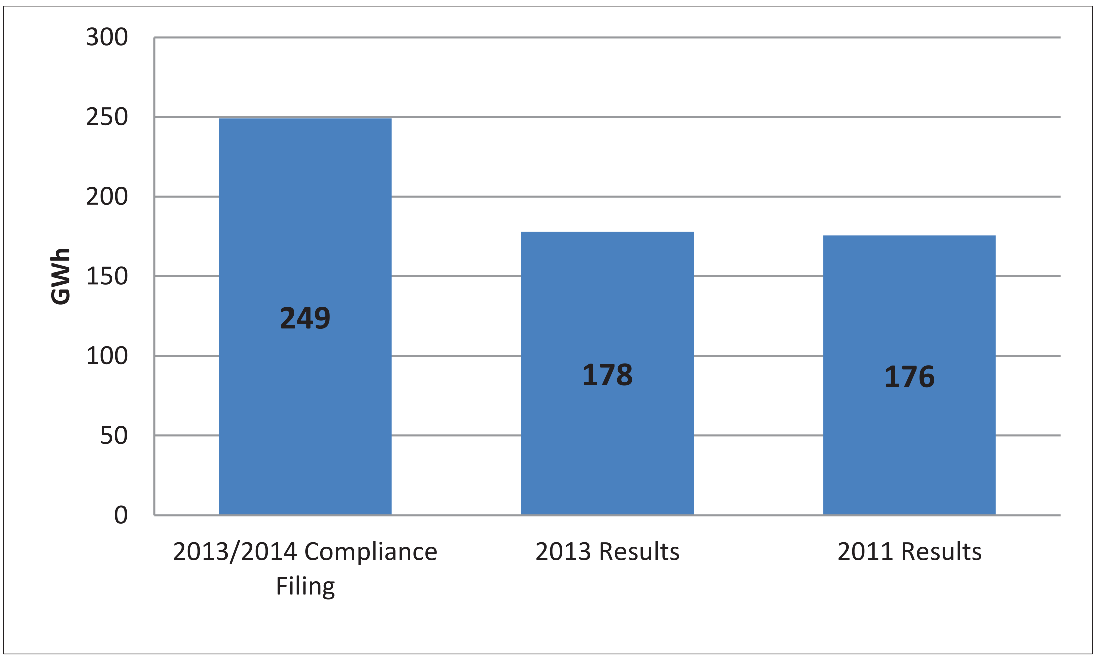


Source: PG model release February 2014

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 agricultural numbers in the compliance filings were compared to the 2013 potential study as well as the 2011 potential Study, as shown in Figure H-7. The 2013 study is slightly greater than the 2011 study and less than the compliance filing. 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, Navigant notes that this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, Navigant notes those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, Navigant uses a supply curve approach and relies on a more robust dataset that draws more information from sources that are specific to the agricultural sector.

Figure H-7. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Electric)



Source: PG model release February 2014

Navigant further investigated the IOU filing data in order to understand the differences between the estimates. Table H-17 shows each IOUs potential assumptions (ex-ante), 2013 and 2014 program budgets, forecasted sales (GWh), and Navigant's analysis results. 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, Navigant notes that this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario. Each table's $/kWh values provides a further comparison of how each IOU's program budgets relate to expected savings, and these vary significantly. Navigant notes that the compliance filing budgets do not separate dollars by electric and gas savings. However, to aid this specific comparative metrics analysis Navigant has assigned all dollars to electric savings.

Table H-17. 2013-2014 Agricultural Sector IOU Filings and Savings Comparison, Electric

IOU	Navigant Model Savings (GWh)	Filing Ex-Ante Electric Savings (GWh)	Filing Program Budget (Million $)	Filing $/kWh	2013-2014 Consumption Forecast (GWh)
All	178	249	$33	$0.13	24,646
PG&E	103	206	$29	$0.14	14,296
SCE	71	35	$1.4	$0.04	9,798
SDG&E	4	8	$2.2	$0.28	553

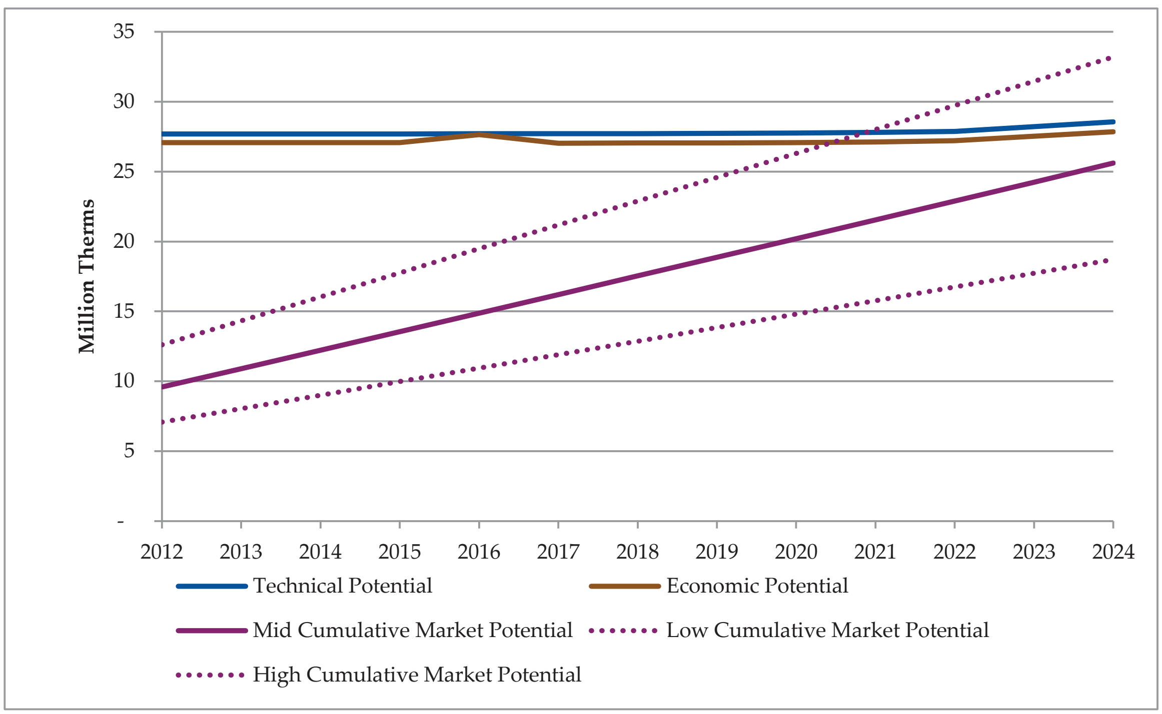
Source: PG model release February 2014, IOU Compliance Filings and CEC QFER Forecast.

H.9.2.3 California Agricultural Natural Gas Potential

As shown in Figure H-8, the agricultural technical and economic energy savings potential remains fairly constant from 2012 through 2024. Navigant's technical and economic potential results are generally the same value because Navigant's analysis used supply curves for the agricultural sector 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 24 and 29 million therms from 2012 through 2024. The technical and economic energy savings potential are informed by IOU retail rate forecasts for each sector ($/therm) and energy sales forecasts for each sector (therm by subsector). Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts.

The agricultural cumulative market energy savings potential increases between 2012 through 2024 due to sustained cumulative addition of the market potential each year. The Navigant team estimates that savings potential for end uses within the segments will maintain incremental savings levels 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 and future equipment emerging technologies that sustain savings achievements. The cumulative market potential lags the technical and economic potentials and increases from around 10 million therms in 2012 to around 26 million therms in 2024 for the Mid EE Penetration market potential scenario. Consistent with the discussion on electric energy and demand, cumulative gas energy 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 H-8. California Agricultural Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2012-2024 (Million Therms)

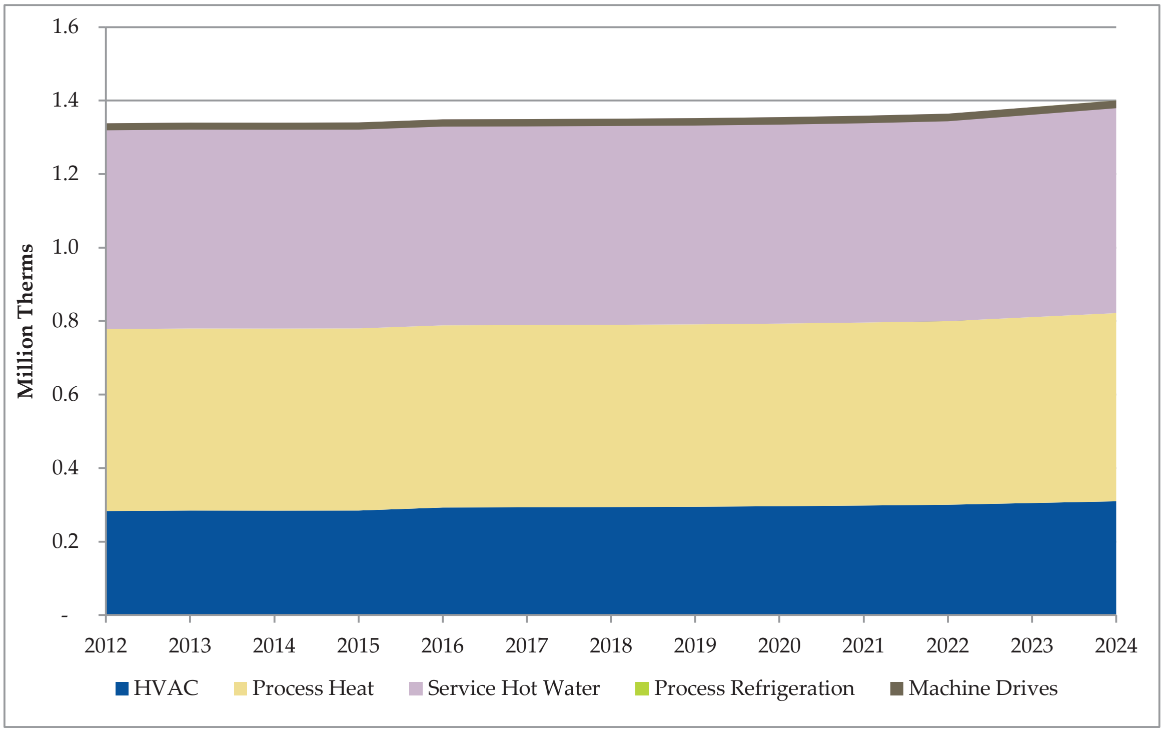


Source: PG model release February 2014

The Navigant team's analysis approach used for gas potential mirrors the approach used for estimating electric potential. Specifically, Navigant estimates that gas measure savings potential will recur during stock turnover events and maintain savings throughout the analysis period.

Figure H-9 presents the incremental market potential gas savings by end use through 2024. The incremental energy savings potential remains fairly constant for those end uses, such as HVAC, service hot water, and process heat, estimated to have recurring savings potential. These continuous improvement 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. As a result, the incremental gas savings potential increases slightly from approximately 1.3 million therms in 2012 to 1.4 million therms in 2024.

Figure H-9. California Agricultural Gross Incremental Market Gas Savings Potential by End Use for 2010-2024 (Million Therms)



Source: PG model release February 2014

H.9.2.4 California Agricultural 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 agricultural 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 agricultural, 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 agricultural sector
- Incremental annual forecast potential for 2013/14 compared to the IOU Agricultural Compliance Filings

Comparison between 2011 and 2013 Potential Studies

Table H-18 presents a comparison of the incremental and cumulative market potentials calculated by the 2011 and the 2013 potential studies. The potential energy savings estimates calculated by both studies vary due to the change in analyses approaches used between studies. The 2013 effort that relied on supply curves developed an expanded scope and relied on a more robust dataset. 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 H-18. Changes in California Agricultural Incremental and Cumulative Market Energy Potential from the Previous Forecast (Million Therms)

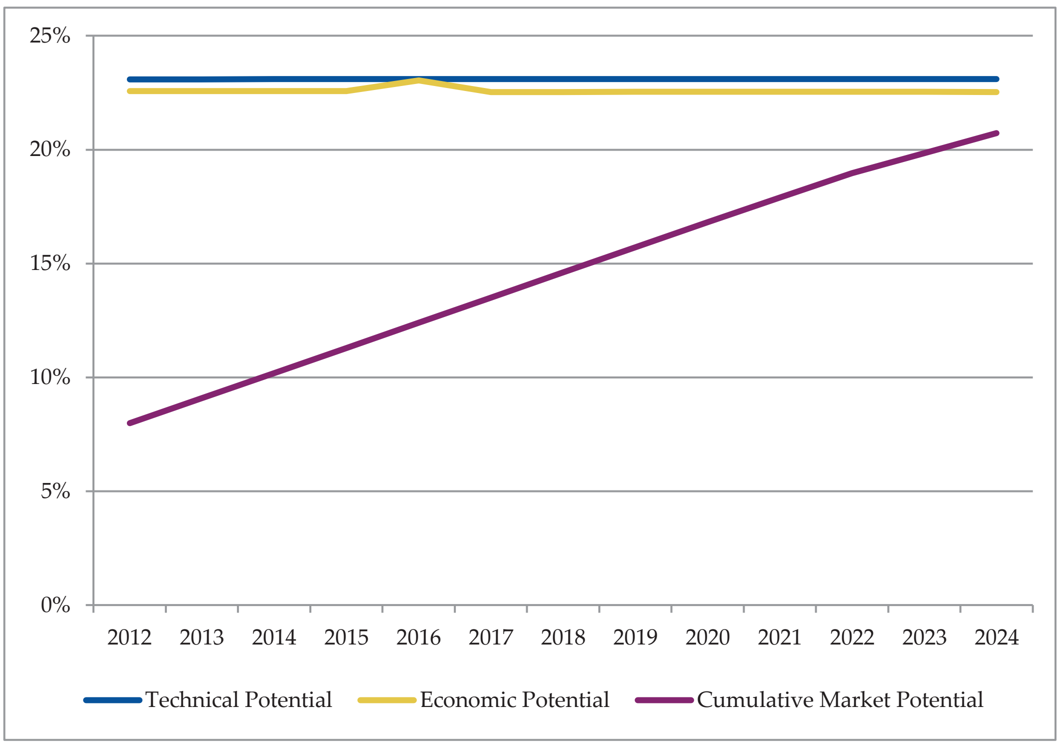
	Incremental Market Potential			Cumulative Market Potential		
Year	2011 Study	2013 Study	Percent Increase or Decrease	2011 Study	2013 Study	Percent Increase or Decrease
2012	0.9	1.3	50%	7.2	9.6	33%
2013	0.7	1.3	91%	7.9	10.9	38%
2014	0.6	1.3	115%	8.5	12.2	44%
2015	0.5	1.3	140%	9.0	13.5	50%
2016	0.5	1.3	169%	9.5	14.9	56%
2017	0.4	1.3	197%	10.0	16.2	62%
2018	0.4	1.3	228%	10.4	17.5	69%
2019	0.4	1.3	257%	10.8	18.9	75%
2020	0.3	1.3	285%	11.1	20.2	82%
2021	0.3	1.3	308%	11.4	21.5	88%
2022	0.3	1.3	301%	11.8	22.9	94%
2023	0.3	1.4	302%	12.1	24.2	100%
2024	0.4	1.4	287%	12.5	25.6	106%

Source: PG model release February 2014

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 H-10 shows the technical, economic, and cumulative market potential savings as a percent of the CEC agricultural forecast. Technical potential and economic potentials are constant at about 23 percent of the CEC agricultural consumption forecast between 2012 and 2024. Cumulative market potential rises from about 8 percent in 2012 up to 21 percent by 2024.

Figure H-10. California Agricultural Savings Potential as a Percent of CEC Agricultural Forecast (Technical, Economic, and Active Cumulative Market Potential)

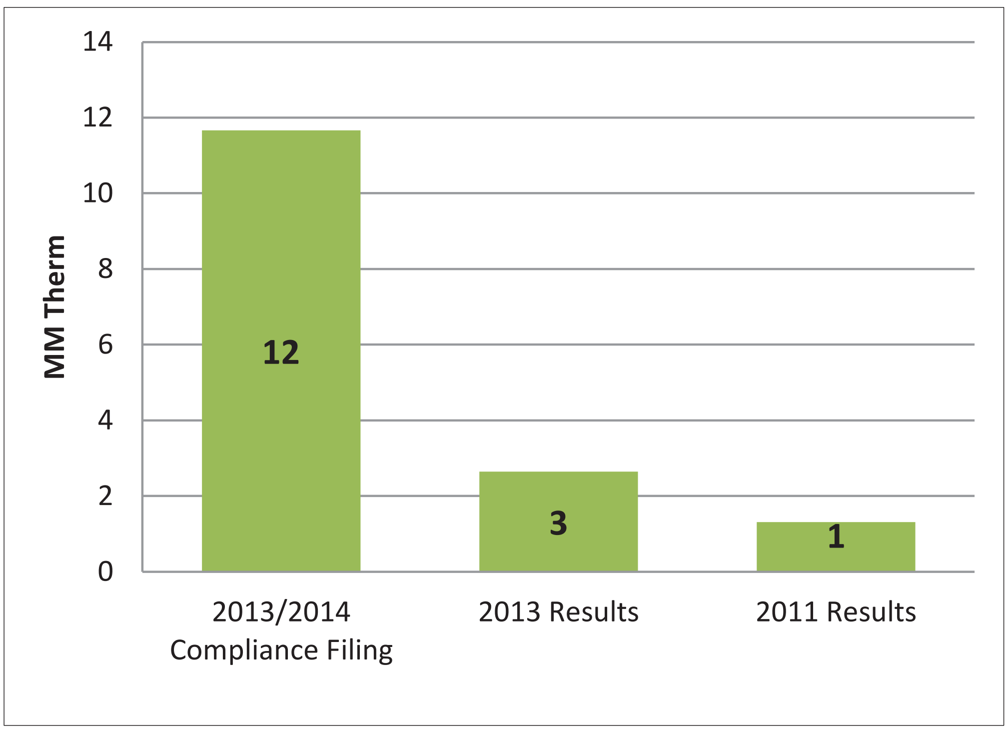


Source: PG model release February 2014

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 agricultural numbers in the compliance filings were compared to the 2013 potential study as well as the 2011 Potential Study, as shown in Figure H-11. The 2013 study is slightly greater than the compliance filing and more 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, Navigant notes that this comparison only reflects two years of IOU program activity where the IOUs may deviate from that typical program year scenario. Additionally, Navigant notes those variations between the 2011 and 2013 potential study efforts reflect changes made to the analysis approaches. Mainly, Navigant uses a supply curve approach and relies on a more robust dataset that draws more information from sources that are specific to the agricultural sector.

Figure H-11. California Comparison of IOU Compliance Filings with Potential Study Results for Program Years 2013 and 2014 (Gas)



Source: PG model release February 2014

Navigant further investigated the IOU filing data in order to understand the differences between the estimates. Table H-19 shows each IOUs potential assumptions (ex-ante), forecasted sales, and Navigant's analysis results. 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, Navigant notes that this comparison only reflects two years of IOU program activity that may deviate from that typical program year scenario.

Table H-19. 2013-2014 Agricultural Sector Savings Comparison, Gas

IOU	Navigant Model Savings (MM Therm)	Filing Ex-Ante Gas Savings (MM Therm)	2013-2014 Consumption Forecast (MM Therm)	Navigant Percent Savings (%)	Filing Percent Savings (%)
All	3	11	240	1.1%	4.7%
PG&E	1	9	71	1.1%	12.7%
SDG&E	0.1	0.2	8	1.1%	2.4%
SCG	2	2	160	1.1%	1.3%

Source: PG model release February 2014, IOU Compliance Filings and CEC QFER Forecast.

Appendix I Approach to Mining Sector Analysis

This appendix details the approach to developing inputs for the Mining sector. All values in the PG study and analytical approaches in the Agricultural, Industrial, Mining, and Street Lighting (AIMS) sectors are based primarily on secondary research.[118] This appendix includes tables detailing specific inputs that define the measures. The reader should refer to the Measure Input Characterization Sheets (MICSs) for more information and specific inputs; the MICS were included with the most recent model release.

I.1 Mining Sector Analysis Strategy

The Mining sector refers to energy consumption from activities related to mineral and metal mining, building construction, and Oil and Gas Extraction. Therefore, the Navigant team identified three subsectors within this sector: “Mining,” “Construction,” and “Oil and Gas Extraction.”

Table I-1 states the portion of mining sector energy consumed by each of the three subsectors, as reported in the CEC Quarterly Fuel and Energy Report (QFER).

Table I-1. Mining Subsectors and Relative Energy Consumption, Statewide

Subsectors	Portion of Sector Consumption		Analyzed in This Study?
	Electricity	Natural Gas	
Oil and Gas Extraction	73%	82%	Yes
Mining	12%	12%	No
Construction	15%	6%	No

Source: Navigant team analysis of source [1]

The Navigant Consulting, Inc. (Navigant) team focused its analysis on the largest energy-consuming subsector, “Oil and Gas Extraction.” The Navigant team did not consider the smaller “Mining” and “Construction” subsectors due to the resource constraints of this potential study.

I.2 Data Collection

The Navigant team then collected publicly available data, using the sources included but not limited to those shown in Table I-2.[119] To supplement this data, the Navigant team reviewed the estimates developed from these secondary sources against QFER data. Additionally, the Navigant team incorporated feedback obtained from Oil and Gas Extraction subject matter experts at Global Energy Partners (GEP), who have implemented energy efficiency (EE) programs in this subsector for California investor-owned utilities (IOUs). Those citations are also included in Table I-2. The Navigant team

118 All research for Mining was collected between October 2012 and January 2013.

119 A complete reference list is provided at the end of this appendix and within the MICS.

reviewed and organized data from each of the various sources in order to complete the analysis of the "Oil and Gas Extraction" subsector and supply the requisite information to the PG model.

Table I-2. Key Sources Used for Oil and Gas Extraction Analysis

Publisher/Source	Citation
California Energy Commission	California Energy Commission (CEC). (July 2012). QFER data. Data transmission from CEC to the Navigant team.
California Department of Conservation	California Department of Conservation. (2010). 2009 Annual Report of the State Oil and Gas Supervisor. Retrieved on December 10, 2012. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf
Global Energy Partners	Navigant team conference meeting with GEP staff via telephone. Global Energy Partners, an EnerNOC Company. http://www.gepllc.com/home.asp. November 30, 2012.
Quantec	Quantec. (2004). Evaluation of the Energy Efficiency Services for Electricity Consumption and Demand Reduction in Oil Production Program. Retrieved on January 16, 2013. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1 &ved=0CDUQFjAA&url=http%3A%2F%2F www.calmac.org%2FstartDownload.asp%3FName%3DQuantec_ Final_Report_072004ES.pdf%26Size%3D65KB&ei=J8z2UN2uDZHS9QS7-YHQAw&usg=AFQjCNEenThkNYXAtP0GPt5WKOzqbVB_BQ&sig2= pAhXlkgI2SWaNQV2xM465w&bvm=bv.41018144,d.eWU
Quantec/SCE	Quantec. (2008). Southern California Edison (SCE) 2004-2005 IDEEA Constituent Program Evaluations. Retrieved on January 16, 2013. http://calmac.org/publications/IDEEA_Constituent_Program_Evaluations_-_Vol_1_FINAL_072808.pdf
Itron/CPUC	Itron. (2010). 2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group. Retrieved on January 16, 2013. http://calmac.org/publications/PG%26E_Fab_06-08_Eval_Final_Report.pdf
CEE	Consortium for Energy Efficiency (CEE). (2012). Motors and Motor Systems. CEE Premium Efficiency Motors List. Retrieved on January 16, 2013. http://www.cee1.org/ind/mot-sys/mtr-ms-main.php3
CEC	CEC. (2003). CEC – EPRI Membership Tailored Collaboration Project: Optimization of Electric Energy Consumption in Marginal California Oilfields. Retrieved on January 16, 2013. http://www.energy.ca.gov/reports/2003-09-12_500-03-062C.PDF
NETL/Peden Energy	National Energy Technology Laboratory (NETL). (2005). Enhanced Recovery Utilizing Variable Frequency Drives and a Distributed Power System Final Report. Retrieved on January 16, 2013. http://www.netl.doe.gov/technologies/oil-gas/publications/EP/15436FinalRpt.pdf
CASE/CEC	Codes and Standards Enhancement (CASE). (2011). CASE Initiative. (2011). Process Boilers. 2013 California Building Energy Efficiency Standards. Retrieved on January 16, 2013. http://www.energy.ca.gov/title24/2013standards/ prerulemaking/documents/current/Reports/Nonresidential/Covered_Processes/ 2013_CASE_Process_Boilers%2010.28.2011.pdf

Source: Navigant team analysis, 2013

I.3 Data Organization

The Navigant team developed the following data sets for the analysis of the Oil and Gas Extraction subsector[120]:

1. Fuel type(s) consumed by the subsector
2. Major end-use divisions within the subsector
3. Efficient measure descriptions and descriptions of the associated baseline equipment
4. The prevalence of emerging technologies in the sector
5. Performance characteristics for each measure:
   a. Baseline and efficient energy consumption (electric [kilowatt-hour] and/or gas [therms])
   b. Baseline and efficient electric demand values (kilowatt [kW])
   c. Baseline and efficient effective and remaining useful lifetimes
6. Economic-specific characteristics for each measure:
   a. Baseline and efficient material and installation costs
7. Market-specific characteristics for each measure:
   a. Baseline and efficient densities (market saturations)
   b. Technology market competition groupings
8. Program-specific characteristics for each measure:
   a. Net-to-gross ratios (NTGRs)
   b. Typical incentive amounts (reported as fractions of installed cost);
9. Replacement scenarios for the defined measures (e.g., retrofit, replace on burnout [ROB], or new construction)

The application and analysis of this data are described in the remainder of this section of the appendix.

I.3.1 Fuel Type Consumed by the Sector

The Oil and Gas Extraction subsector consumes both electricity and natural gas.

[120] As discussed in Section I.1, this report does not include analysis of the Mining and Construction subsectors due to resource constraints.

I.3.2 End Uses within the Oil and Gas Extraction Subsector

Table I-3 describes the major end uses within the Oil and Gas Extraction subsector and states the portion of Mining sector energy consumption that each one represents. The Oil and Gas Extraction subsector includes a wide array of electric and natural gas-consuming equipment. The Navigant team focused on the significant energy-consuming equipment, which accounts for 65 percent of the electric and natural gas consumption within the Mining sector. The remaining sections within this appendix describe how the Navigant team estimated this consumption.

Table I-3. Oil and Gas Extraction Major End Uses and Relative Energy Consumption, Statewide

Major End Use	Description	Portion of Sector Consumption	
		Electricity	Natural Gas
Stripper wells	Electric motor-driven, low-volume- producing wells	5%	0%
Regular wells	Electric motor-driven, regular-volume- producing wells	38%	0%
Injection wells	Electric motor-driven pumps for steam/water injection wells that support production	22%	0%
Boilers	Natural gas process boilers that produce steam for injection wells	0%	65%

Source: Navigant team analysis of the following secondary sources:
Production wells [1], [4], [5], [6], [7], [8]; Injection wells [1], [4], [5], [6]; and Boilers [1], [4], [5], [8]

Table I-4 shows the estimated distribution across the IOUs of energy consumption within the Oil and Gas Extraction subsector. Energy consumption for Oil and Gas Extraction activities is negligible within San Diego Gas and Electric's (SDG&E's) territory relative to the rest of the state. This estimate is based on a review of the *2009 Annual Report of the State Oil and Gas Supervisor* (Conservation report)[121] that reports oil production activity and well inventories by location.

Table I-4. Portion of All IOU Oil and Gas Extraction Energy Consumption by Each IOU

Oil and Gas Extraction	PG&E	SCE	SDG&E	SCG
Electricity	57%	43%	0%	0%
Natural gas	22%	0%	0%	78%

Source: Navigant team analysis of sources [2] and [3]

[121] See the following sources in Section I.9 : [5].

Table I-5 describes the major end uses by the distribution of equipment counts. The Navigant team estimated the equipment counts by major end use individually for each IOU using the Conservation report, CEC's Energy Consumption Data Management System (ECDMS), which tracks sector energy use by IOU, and secondary sources.[122] Generally, stripper and regular production wells are each served by the following equipment:

- One pumping motor: A single injection pump motor serves multiple injection wells and typically injects water.
- One process motor: A single process boiler serves multiple injection wells and typically produces steam for injection.

Table I-5. Portion of Equipment within Each IOU Territory

Major End Use	Unit	Fuel	PG&E	SCE	SDG&E	SCG
All production wells (includes stripper and regular wells)	Well	Electricity	88%	12%	0%	0%
Injection wells	Motor	Electricity	37%	63%	0%	0%
Boilers	Boiler	Natural gas	0.4%	0%	0%	99.6%

Source: Navigant team analysis of the following secondary sources as described in Section I.9:

- *Production wells [2], [4], [5]*
- *Injection wells [2], [4], [5], [6], [9]*
- *Boilers [3], [4], [5], [8]*

The remaining sections of this appendix exclude references to SDG&E.

I.4 Oil and Gas Extraction Measures and Associated Baselines

The Navigant team developed several measures for the Oil and Gas Extraction subsector.

Stripper and Regular Production Wells. The Navigant team identified four potential measures:

- Motor resizing: Existing pump motors are often oversized and can be retrofitted with optimally sized and smaller motors.
- Efficient motor: Existing pump motors are typically inefficient National Electrical Manufacturers Association (NEMA) Design D motors that can be retrofitted with written pole motors or efficient NEMA Design B motors.
- Pump-off controls: Existing wells typically operate with timers; pump-off controls replace timers and operate with an on-demand scheme that only pumps when there is oil present in the well bore.
- Variable frequency drives (VFDs): Existing wells typically do not have VFDs that permit smaller and efficient NEMA Design B motors and modulated pumping operation based on well bore production capacity.

[122] See the following sources in Section I.9 : [2] through [5].

The Navigant team then bundled these four measures into three measures for the potential study by averaging the efficiency impacts of various installation combinations of the four original measures:

- Motor replacement: comprised of motor resizing, efficient motor, and the combination of resizing to an efficient motor
- Motor controls: comprised of pump-off controls, VFDs, and the combination of pump-off controls with VFDs
- Motor replacement and controls: comprised of motor resizing and/or efficient motor paired with pump-off controls and/or VFDs (nine combinations of measures)

Injection Wells. The Navigant team then identified two possible measures for injection wells:

- Efficient motor: Existing injection motors are typically inefficient and can be retrofitted with new and more efficient motors.
- Variable frequency drives: Existing injection motors typically do not have VFDs that permit operation at partial capacity.

The Navigant team then developed three bundled measures for the potential study from these original two:

- Injection pump efficient motor: comprised of efficient motor
- Injection pump VFD: comprised of VFDs
- Injection pump efficient motor and VFD: comprised of the combination of efficient motor and VFDs

Boilers. Finally, the Navigant team identified two measures for boilers, which they used directly as measures in the potential study:

- Efficient boiler replacement: Existing boilers are typically inefficient and can be retrofitted with new and more efficient boilers.
- Controls and improvements: This measure captures the average energy impacts associated with various boiler upgrade strategies that may include parallel positioning, oxygen feedback controls, economizer retrofits, air preheating, piping insulation, and blow-down heat recovery.

Table I-6 shows the resulting measures and their associated baselines. The Navigant team used a similar approach for estimating the other model inputs such as costs for these measures and any associated bundled measures.

Table I-6. Oil and Gas Extraction Measures and Baselines

Major End Use	Measure Description	Baseline Description
Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Standard motor
Stripper wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	Standard motor
Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	Standard motor
Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Standard motor
Regular wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	Standard motor
Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-of controls and/or VFD)	Standard motor
Injection wells	Injection pump efficient motor	Standard motor
Injection wells	Injection pump motor with VFD	Standard motor
Injection wells	Injection pump efficient motor and VFD	Standard motor
Boilers	Efficient steam boiler	Standard boiler
Boilers	Steam boiler controls and improvements	Standard boiler

Source: Navigant team analysis of the following secondary sources: Production wells [4], [6], [10] through [19]; Injection [4], [9], [15], [17], [19], [20] and Boilers [4], [21] through [23]

I.4.1 Emerging Technologies

There are no emerging technologies that are likely to significantly impact the Oil and Gas Extraction subsector during this study's period. To arrive at this conclusion, the Navigant team reviewed the current technologies present in the Oil and Gas Extraction subsector and surveyed secondary sources for research efforts involving new technologies and efficiency improvements.

I.4.2 Measure Characteristics: Performance

The potential analysis relies on estimates for energy consumption (kilowatt-hours [kWh] or therms) and peak demand (kW) for both baseline and efficient measures. Therefore, the Navigant team developed these performance characteristics for the Oil and Gas Extraction measures using secondary sources and IOU consumption data.

I.4.3 Energy Consumption

The Navigant team estimated the energy consumption of both baseline and efficient technologies within the Oil and Gas Extraction subsector and reports consumption as kWh or therms per year per unit. The Navigant team used secondary sources, including evaluation reports from previous EE programs in California, to develop these estimates. The Navigant team reviewed these estimates with staff from

Global Energy Partners, who have implemented similar previous IOU programs targeting the Oil and Gas Extraction industry.[123] Finally, the Navigant team verified its estimates by multiplying the appropriate inventories developed with the Conservation report[124] by the associated per-unit consumption data and comparing the results to the QFER total subsector consumption data.[125]

The Navigant team assumed that per-unit energy consumption was constant across IOUs because the secondary sources used to estimate savings did not differentiate across IOUs. Table I-7 shows the annual consumptions estimated for this analysis.

The Navigant team also examined code-level energy consumption and determined that existing baseline equipment installed within the Oil and Gas Extraction subsector is not currently subjected to any federal or California codes. Therefore, those baseline and code consumption levels are equal. The Navigant team identified some efficient-level measures that are subject to code, but their baseline counterparts are excluded from regulation. For example, stripper and regular well baseline motors are typically NEMA Design D motors that are not covered by any code. However, an efficient motor replacement can be a NEMA Design B motor that is subject to federal standards.[126]

[123] See the following sources in Section I.9 : [4].
[124] See the following sources in section I.9: [5].
[125] See the following sources in Section I.9 :[1].
[126] See the following sources in Section I.9 :[15] and [20].

Table I-7. Baseline and Measure Per-Unit Annual Consumption Estimates (kWh/year or therms/year)

Fuel	Major End Use	Baseline/Measure Description	PG&E	SCE	SCG
Electric	Stripper wells	Baseline standard motor	6,238	6,238	0
Electric	Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	3,797	3,797	0
Electric	Stripper wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	4,316	4,316	0
Electric	Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	2,627	2,627	0
Electric	Regular wells	Baseline standard motor	83,172	83,172	0
Electric	Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	50,622	50,622	0
Electric	Regular wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	57,545	57,545	0
Electric	Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	35,024	35,024	0
Electric	Injection wells	Baseline standard motor	5,074,309	5,074,309	0
Electric	Injection wells	Injection pump efficient motor	5,022,354	5,022,354	0
Electric	Injection wells	Injection pump VFD	3,805,732	3,805,732	0
Electric	Injection wells	Injection pump efficient motor and VFD	3,753,776	3,753,776	0
Natural gas	Boilers	Baseline standard boiler	556,055	0	556,055
Natural gas	Boilers	Efficient steam boiler	494,271	0	494,271
Natural gas	Boilers	Steam boiler controls and improvements	455,568	0	455,568

Source: Navigant team analysis of the following secondary sources: Production wells [1], [4], [5], [6], [7], [11] through [21]; Injection [1], [2], [4], [5], [6], [9], [11], [12], [13], [15], [17], [19], [20]; and Boiler [1], [4], [5], [8], [11], [12], [13], [21], [22], [23]

I.4.4 Peak Demand

The Navigant team also examined electric peak demand for stripper, regular, and injection wells. The Navigant team developed energy consumption estimates for these measures by combining motor operating characteristics obtained from secondary sources. These included motor size in horsepower, duty cycles, motor loads, motor efficiencies, overall system efficiencies, and running hours. As a result, the Navigant team was able to use these same parameters to estimate the peak demand for each technology. The Navigant team estimated peak demand values per unit, as shown in Table I-8.

Similar to baseline and code consumption assumptions previously discussed, the Navigant team estimated that baseline and code peak demand are equivalent. Also, Table I-8 excludes the natural gas measures.

Table I-8. Baseline and Measure Peak Demand Estimates (kW)

Fuel	Major End Use	Baseline/Measure Description	PG&E	SCE	SCG
Electric	Stripper wells	Baseline standard motor	0.71	0.71	0
Electric	Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	0.43	0.43	0
Electric	Stripper wells	Motor controls (blending of retrofit scenarios: pump- off controls and/or VFD)	0.49	0.49	0
Electric	Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	0.30	0.30	0
Electric	Regular wells	Baseline standard motor	9.49	9.49	0
Electric	Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	5.78	5.78	0
Electric	Regular wells	Motor controls (blending of retrofit scenarios: pump- off controls and/or VFD)	6.57	6.57	0
Electric	Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	4.00	4.00	0
Electric	Injection wells	Baseline standard motor	579.26	579.26	0
Electric	Injection wells	Injection pump efficient motor	573.33	573.33	0
Electric	Injection wells	Injection pump VFD	434.44	434.44	0
Electric	Injection wells	Injection pump efficient motor and VFD	428.51	428.51	0

Source: Navigant team analysis of the following secondary sources: Production wells [1], [4], [5], [6], [7], [11] through [21]; Injection [1], [2], [4], [5], [6], [9], [11], [12], [13], [15], [17], [19], [20]

I.5 Effective and Remaining Useful Lifetimes

The Navigant team also accounted for effective useful life (EUL) and remaining useful life (RUL) for the measures under consideration. The Navigant team developed baseline and efficient effective useful lifetimes by averaging values found in several secondary sources. RULs are estimated as half of the EUL for the given technology. This assumes an even mix of equipment ages among existing stocks. Lifetimes are also considered equivalent across the three IOUs, as shown in Table I-9.

Similar to the previous discussions, the Navigant team assumed baseline and code values are equal.

Table I-9. Baseline and Measure Equipment Lifetimes

Major End Use	Baseline/Measure Description	EUL	RUL*
Stripper wells	Baseline standard motor	15	7.5
Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	15	N/A
Stripper wells	Motor controls (blending of retrofit scenarios: pump- off controls and/or VFD)	11.3	N/A
Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	12.8	N/A
Regular wells	Baseline standard motor	15	7.5
Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	15	N/A
Regular wells	Motor controls (blending of retrofit scenarios: pump- off controls and/or VFD)	11.3	N/A
Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	12.8	N/A
Injection wells	Baseline standard motor	15	7.5
Injection wells	Injection pump efficient motor	15	N/A
Injection wells	Injection pump VFD	12.5	N/A
Injection wells	Injection pump efficient motor and VFD	12.5	N/A
Boilers	Baseline standard boiler	18.3	9.2
Boilers	Efficient steam boiler	18.3	N/A
Boilers	Steam boiler controls and improvements	11.7	N/A

*The model only considers baseline/code RULs.

Source: Navigant team analysis of the following secondary sources: Production wells [12], [24]; Injection [12], [24]; and Boiler [21], [23], [24], [25]

I.5.1 Measure Characteristics: Economics

The potential analysis also relies on economic characteristics that further describe measures. The Navigant team reviewed several secondary sources to develop estimates for costs, including costs for material, labor, and operation and maintenance (O&M).

I.5.2 Costs

The Navigant team accounted for material costs, labor installation costs, and O&M benefits (or costs). Material and labor costs are reported as the full costs and the model calculates the incremental costs depending on the assumed installation scenario (i.e., replace on burnout, retrofit, or new construction). O&M benefits reflect the decrease in standard annual O&M requirements as a result of installing the efficient measure. A negative O&M benefit indicates an increase in O&M costs. O&M values reflect the annual benefit or cost per unit. Table I-10 and Table I-11 show the material costs, labor costs, and O&M benefits.

The Navigant team estimated costs by averaging values reported by various secondary sources. The Navigant team also assumed that costs are equivalent across the three IOUs. Similar to the previous discussions, the Navigant team assumed baseline and code values are equal.

For each major end use, the baseline description remains constant across the range of measures. For example, operating a standard motor without controls is paired with each stripper well measure. However, Table I-10 describes the specific baseline installation action in the event an installation is required and the baseline option is selected. This baseline installation action is paired with the appropriate measure. Table I-10 does not specify a retrofit or replace-on-burnout scenario; therefore, the efficient and baseline costs should be reviewed individually.

Table I-10. Baseline and Measure Material and Labor Costs

Major End Use	Measure Description	Baseline *Installation* Description	Efficient Material	Efficient Labor	Baseline Material	Baseline Labor
Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Motor replacement (same size as existing; standard efficiency)	$2,250	$2,667	$2,817	$2,667
Stripper wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	No action	$1,717	$4,646	$0	$0
Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	Motor replacement (same size as existing; standard efficiency)	$3,967	$7,312	$2,817	$2,667
Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Motor replacement (same size as existing; standard efficiency)	$9,000	$2,667	$11,269	$2,667
Regular wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	No action	$3,419	$4,646	$0	$0
Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	Motor replacement (same size as existing; standard efficiency)	$12,419	$7,312	$11,269	$2,667
Injection wells	Injection pump efficient motor	Motor replacement	$132,927	$10,000	$116,723	$10,000
Injection wells	Injection pump VFD	No action	$22,500	$6,600	$0	$0
Injection wells	Injection pump efficient motor and VFD	Motor replacement	$155,427	$16,600	$116,723	$10,000
Boilers	Efficient steam boiler	Boiler replacement	$148,796	$28,415	$103,045	$18,040
Boilers	Steam boiler controls and improvements	No action	$38,852	$20,123	$0	$0

Source: Navigant team analysis of the following secondary sources: Production wells [4], [6], [11], [15], [16], [26], [27]; Injection [6], [15], [26], [27], [28]; and Boiler [21], [22], [25] The O&M benefits reported for the stripper and regular well major end uses reflect the blending of the O&M benefits for the various retrofit scenarios identified by the Navigant team. Specifically, the positive costs shown represent the O&M improvement resulting from installing pump-off controls. Pump-off controls reduce well running time and ensure that pumping only occurs when fluids are present in the well bore. Pump-off controls reduce O&M requirements primarily by preventing the pump from running with a dry well bore where seals are more likely to burn out, fail, and require replacement.

The negative O&M benefits (i.e., additional O&M costs) reported for the steam boiler controls and improvements reflect the additional supervision needed to maintain enhanced boiler features such as oxygen trim control systems, parallel-positioning controllers, combustion air control systems, and other sensing equipment.

Table I-11 shows the O&M benefits for the Oil and Gas Extraction subsector.

Table I-11. Baseline and Measure O&M Benefits

Major End Use	Measure Description	Baseline *Installation* Description	O&M Benefit
Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Motor replacement (same size as existing; standard efficiency)	$0
Stripper wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	No action	$3,350
Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	Motor replacement (same size as existing; standard efficiency)	$3,350
Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	Motor replacement (same size as existing; standard efficiency)	$0
Regular wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	No action	$3,350
Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	Motor replacement (same size as existing; standard efficiency)	$3,350
Injection wells	Injection pump efficient motor	Motor replacement	$0
Injection wells	Injection pump VFD	No action	$0
Injection wells	Injection pump efficient motor and VFD	Motor replacement	$0
Boilers	Efficient steam boiler	Boiler replacement	$0
Boilers	Steam boiler controls and improvements	No action	-$15,000

Source: Navigant team analysis of the following secondary sources: Production wells [16], [18]; Injection [16], [18]; and Boiler [21]

I.6 Measure Characteristics: Market

The Navigant team defined the mix of baseline and efficient technologies found within the Oil and Gas Extraction subsector. A quantified estimate of the current saturation of energy efficiency found within the market supports the analysis's estimation of the energy savings potential that remains.

I.6.1 Technology Densities

After identifying technologies currently present in the market and assigning baseline and efficient designations, the Navigant team developed densities. Densities are based on the units designated in Table I-6 for the respective major end use and quantify the percent of units currently installed that are either baseline units or a specific efficient technology. The Navigant team estimated the distribution of baseline and efficient technologies using various secondary sources, and those sources primarily included evaluation reports of recent energy efficiency programs.[127]

I.6.2 Existing Vintages

The Navigant team developed densities for the existing equipment stocks using various secondary sources including evaluation reports. For a given IOU, major end use, and vintage (e.g., existing), the Navigant team calculated the total baseline and efficient equipment counts currently installed. This subset of equipment composes a competition group. Individual density values are calculated by dividing a specific baseline or efficient measure count by this total competition group count.

I.6.3 New Construction Vintages

In addition to examining the existing equipment stock, the Navigant team also estimated new construction activity within the Oil and Gas Extraction subsector. The Navigant team developed these new construction equipment counts using production and injection well inventories.[128] The Navigant team assumed different growth rates for installations of producing wells, injection wells, and steam boilers and assumed that these are equal across the IOUs. Finally, the Navigant team estimated the distribution of baseline and efficient technologies among new construction installations using net-to-gross values reported by various secondary sources[129] for the respective technologies.

[127] See the following sources in Section I.9 [10] through [13].

[128] See the following sources in Section I.9 : [5].

[129] See the following sources in Section I.9 :[11] through [13].

Table I-12 shows the unit counts and Table I-13 shows the corresponding densities as a percent. For Table I-13, the values within each competition group (distinguished by IOU, major end use, and vintage) sum to 1.00. (Some values within this table are rounded to two decimal places and may not add to 1.00.)

Table I-12. Equipment Counts by Technology and Major End Use for Each IOU

Vintage	Major End Use	Equipment and Technology Description	PG&E	SCE	SCG
Existing	Stripper wells	Standard motor (baseline equipment)	25,120	3,525	0
Existing	Stripper wells	Motor that is optimally sized and/or efficient	729	102	0
Existing	Stripper wells	Motor with pump-off controls and/or VFD	1,399	196	0
Existing	Stripper wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	38	5	0
New	Stripper wells	Standard motor (baseline equipment)	123	17	0
New	Stripper wells	Motor that is optimally sized and/or efficient	107	15	0
New	Stripper wells	Motor with pump-off controls and/or VFD	243	34	0
New	Stripper wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	62	9	0
Existing	Regular wells	Standard motor (baseline equipment)	11,798	1,656	0
Existing	Regular wells	Motor that is optimally sized and/or efficient	2,187	307	0
Existing	Regular wells	Motor with pump-off controls and/or VFD	2,551	358	0
Existing	Regular wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	349	49	0
New	Regular wells	Standard motor (baseline equipment)	76	11	0
New	Regular wells	Motor that is optimally sized and/or efficient	66	9	0
New	Regular wells	Motor with pump-off controls and/or VFD	150	21	0
New	Regular wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	38	5	0
Existing	Injection wells	Standard injection pump motor (baseline equipment)	61	101	0
Existing	Injection wells	Injection pump motor that is efficient	9	15	0
Existing	Injection wells	Injection pump motor with VFD	2	4	0
Existing	Injection wells	Injection pump motor that is efficient and paired with VFD	0	1	0
New	Injection wells	Standard injection pump motor (baseline equipment)	1	2	0
New	Injection wells	Injection pump motor that is efficient	1	1	0
New	Injection wells	Injection pump motor with VFD	1	1	0
New	Injection wells	Injection pump motor that is efficient and paired with VFD	1	1	0
Existing	Boilers	Standard steam boiler (baseline equipment)	1	0	268

Vintage	Major End Use	Equipment and Technology Description	PG&E	SCE	SCG
Existing	Boilers	Steam boiler that is efficient	0	0	67
Existing	Boilers	Steam boiler paired with controls and other system improvements	0	0	67
New	Boilers	Standard steam boiler (baseline equipment)	0	0	14
New	Boilers	Steam boiler that is efficient	0	0	4
New	Boilers	Steam boiler paired with controls and other system improvements	0	0	4

Source: Navigant team analysis of the following secondary sources: Production wells [2], [4], [5], [11] through [15]; Injection wells [2], [4], [5], [6], [9], [11], [12], [13]; and Boilers [3], [4], [5], [8], [11], [12], [13]

Table I-13. Densities by Technology and Major End Use for Each IOU

Vintage	Major End Use	Equipment and Technology Description	PG&E	SCE	SCG
Existing	Stripper wells	Standard motor (baseline equipment)	0.92	0.92	0
Existing	Stripper wells	Motor that is optimally sized and/or efficient	0.03	0.03	0
Existing	Stripper wells	Motor with pump-off controls and/or VFD	0.05	0.05	0
Existing	Stripper wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	0.00	0.00	0
Existing		**All strippers wells**	1.00	1.00	0
New	Stripper wells	Standard motor (baseline equipment)	0.23	0.23	0
New	Stripper wells	Motor that is optimally sized and/or efficient	0.20	0.20	0
New	Stripper wells	Motor with pump-off controls and/or VFD	0.45	0.45	0
New	Stripper wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	0.12	0.12	0
New		**All stripper wells**	1.00	1.00	0
Existing	Regular wells	Standard motor (baseline equipment)	0.70	0.70	0
Existing	Regular wells	Motor that is optimally sized and/or efficient	0.13	0.13	0
Existing	Regular wells	Motor with pump-off controls and/or VFD	0.15	0.15	0
Existing	Regular wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	0.02	0.02	0
Existing		**All regular wells**	1.00	1.00	0
New	Regular wells	Standard motor (baseline equipment)	0.23	0.23	0
New	Regular wells	Motor that is optimally sized and/or efficient	0.20	0.20	0
New	Regular wells	Motor with pump-off controls and/or VFD	0.45	0.45	0
New	Regular wells	Motor that is optimally sized and/or efficiently paired with pump-off controls and/or VFD	0.12	0.12	0
New		**All Regular Wells**	1.00	1.00	0
Existing	Injection wells	Standard injection pump motor (baseline equipment)	0.84	0.84	0
Existing	Injection wells	Injection pump motor that is efficient	0.13	0.13	0
Existing	Injection wells	Injection pump motor with VFD	0.03	0.03	0
Existing	Injection wells	Injection pump motor that is efficient and paired with VFD	0.00	0.00	0
Existing		**All injection wells**	1.00	1.00	0
New	Injection wells	Standard injection pump motor (baseline equipment)	0.40	0.40	0
New	Injection wells	Injection pump motor that is efficient	0.20	0.20	0
New	Injection wells	Injection pump motor with VFD	0.20	0.20	0

Vintage	Major End Use	Equipment and Technology Description	PG&E	SCE	SCG
New	Injection wells	Injection pump motor that is efficient and paired with VFD	0.20	0.20	0
New		**All injection wells**	1.00	1.00	0
Existing	Boilers	Standard steam boiler (baseline equipment)	0.80	0	0.80
Existing	Boilers	Steam boiler that is efficient	0.20	0	0.20
Existing	Boilers	Steam boiler paired with controls and other system improvements	0.20	0	0.20
Existing		**All boilers**	1.00	0	1.00
New	Boilers	Standard steam boiler (baseline equipment)	0	0	0.80
New	Boilers	Steam boiler that is efficient	0	0	0.20
New	Boilers	Steam boiler paired with controls and other system improvements	0	0	0.20
New		**All boilers**	0	0	1.00

Source: Navigant team analysis of the following secondary sources listed in Section I.9:

- *Production wells [2], [4], [5], [11] through [15];*
- *Injection [2], [4], [5], [6], [9], [11], [12], [13];*
- *Boiler [3], [4], [5], [8], [11], [12]. [13]*

I.7 Measure Characteristics: Program

The Navigant team developed measure inputs that describe energy efficiency program characteristics—specifically, NTGRs and incentive levels typically found among Oil and Gas Extraction subsector programs.

I.7.1 Net-to-Gross Ratios

The Navigant team developed net-to-gross ratios for the identified major end-use measures within the Oil and Gas Extraction subsector. The Navigant team estimated these values from various secondary sources including program evaluation reports.[130] Net-to-gross ratios are assumed equivalent across IOUs. Generally, the Navigant team estimated net-to-gross ratios of 0.80 for most energy-efficient installations. However, the Navigant team found information estimating a lower net-to-gross value for pump-off controls at 0.45. The blended measures for stripper and regular wells reflect the inclusion of this lower value within the resulting net-to-gross calculation.

[130] See the following sources in Section I.9 : [10] through [13].

Table I-14. Baseline and Measure Net-to-Gross Ratios

Major End Use	Measure Description	Net-to-Gross
Stripper wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	0.80
Stripper wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	0.74
Stripper wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	0.77
Regular wells	Motor replacement (blending of retrofit scenarios: resizing and/or efficient replacement)	0.80
Regular wells	Motor controls (blending of retrofit scenarios: pump-off controls and/or VFD)	0.74
Regular wells	Motor replacement and controls (blending of retrofit scenarios: resizing and/or efficient replacement paired with pump-off controls and/or VFD)	0.77
Injection wells	Injection pump efficient motor	0.80
Injection wells	Injection pump VFD	0.80
Injection wells	Injection pump efficient motor and VFD	0.80
Boilers	Efficient steam boiler	0.80
Boilers	Steam boiler controls and improvements	0.80

Source: Navigant team analysis of the following secondary sources: Production wells [11], [12], [13]; Injection [11], [12]; and Boiler [11] [12]

I.7.2 Incentive Levels

The Navigant team developed incentive levels for the Oil and Gas Extraction subsector. The Navigant team estimated these values from various secondary sources including program evaluation reports.[131] Historically, programs targeting the Oil and Gas Extraction industry set incentive level limits at 50 percent of the installation cost. Incentive levels represent the typical incentives paid by the IOUs as a fraction of the full installed cost. These are assumed equivalent across IOUs and major end use categories.

[131] See the following sources in Section I.9 : [10] through [13].

Table I-15. Baseline and Measure Incentive Level

Major End Use	Incentive Level
Stripper wells	0.50
Regular wells	0.50
Injection wells	0.50
Boilers	0.50

Source: Navigant team analysis of sources [11] and [12]

I.7.3 Replacement Scenarios

The Navigant team assumes a retrofit scenario for existing electric measures found within the Oil and Gas Extraction subsector. This scenario approach uses the full cost of equipment in benefit cost calculations. Existing gas boiler measures are assumed as ROB. This approach assumes that IOUs and other entities would defer upgrade efforts to the end of the equipment's useful life in order to minimize costs associated with installation and production downtime.

I.8 Measure Derating

After reviewing the measures incorporated into Navigant's model the team vetted them with a subset of stakeholders. These stakeholders commented that some of the measures would not be included in programs as they were considered industry standard practice (ISP) or driven by Code or other regulations (e.g., AB32, air quality management districts, etc.). Additionally, Navigant also used this exercise to further understand business standard practices and approaches to operational improvements. Specifically, a significant portion of improvements are driven by and in response to oil production levels and not equipment efficiency levels. Therefore, the Navigant team, with support from Commission staff, identified measures within the Mining sector for removal or savings reduction. The process also relied on a number of secondary sources to confirm that changes were appropriate and that the potential results reflect program characteristics as well as Mining sector business practices. These secondary sources included:

- 2013/2014 IOU Compliance Filings – Table 3.4 Oil Production Third Party Programs
- 2013/2014 IOU Program Implementation Plans (PIPs) and Addendums for Third Parties

Navigant applied savings reductions at the technology level, and these technology-specific reductions are applied uniformly across the statewide Mining sector. The technology-specific reductions and updated savings are first rolled up to the measure level and then the sector level. Navigant notes that it estimates different mixes of technologies in each IOU territory, and as a result, the aggregated change to potential varies across the IOUs in most instances. Navigant presents the resulting statewide aggregated impact on potential for each fuel type.

Table I-16. Mining Measure Derating Results

Fuel	Factor
Electric (GWh)	70.1%
Demand (MW)	70.1%
Gas (MM Therms)	37.8%

I.9 Mining References

1. California Energy Commission. (July 2012). Quarterly Fuel and Energy Report data. Data transmission from CEC to the Navigant team.
2. California Energy Commission. (2013). ECDMS. Electric Consumption by Entity. Last accessed on January 22, 2013. http://www.ecdms.energy.ca.gov/elecbyutil.aspx.
3. California Energy Commission. (2013). ECDMS. Gas Consumption by Entity. Last accessed on January 22, 2013. http://ecdms.energy.ca.gov/gasbyutil.aspx.
4. Navigant team conference meeting with GEP staff via telephone. Global Energy Partners, an EnerNOC Company. (2012). http://www.gepllc.com/home.asp. Meeting on November 30, 2012.
5. California Department of Conservation. (2010). 2009 Annual Report of the State Oil and Gas Supervisor. Retrieved on December 10, 2012. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf.
6. CEC. (2003). CEC – EPRI Membership Tailored Collaboration Project: Optimization of Electric Energy Consumption in Marginal California Oilfields. Consultant Report. Retrieved January 22, 2013. http://www.energy.ca.gov/reports/2003-09-12_500-03-062C.PDF.
7. Lufkin Oilfield Products Group. (2007). 2008/2009 General Catalog. Retrieved January 22, 2013. http://www.lufkin-arg.com/files/unidades_bombeo_catalogo.pdf.
8. Stanford University. (2011). Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries. Brandt. Stanford University. Retrieved January 22, 2013. https://circabc.europa.eu/d/d/workspace/SpacesStore/db806977-6418-44db-a464-20267139b34d/Brandt_Oil_Sands_GHGs_Final.pdf.
9. Efficiency Vermont. (2005). Technical Reference User Manual. Number 2005-37. Retrieved December 10, 2012. http://www.cee1.org/eval/db_pdf/577.pdf.
10. GEP. (2007). Energy Efficiency for 2009 and Beyond – Big Bold Energy Efficiency Strategy Workshop. Industrial Sector. Retrieved January 22, 2013. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&ved=0CEQQFjAD&url=ftp%3A%2F%2Fftp.cpuc.ca.gov%2FPUC%2Fenergy%2Felectric%2Fenergy%2Befficiency%2Fee%2Bworkshops%2Fglobal%2520energy%2520partners%2520industrial%2520presentation%2520for%2520june%252012%2C%25202007%2520big%2520bold%2520workshop.ppt&ei=1se0UJK0EILC9QSSn4DgDA&usg=AFQjCNGdLAUK5dvQrc6cwrGE2huLQTDsdA&sig2=RLjEMS_I-SL1O7zjaaXPSw.
11. Quantec. (2004). Evaluation of the Energy Efficiency Services for Electricity Consumption and Demand Reduction in Oil Production Program. Retrieved on January 16, 2013. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&sqi=2&ved=0CDAQFjAA&url=http%3A%2F%2Fwww.calmac.org%2FstartDownload.asp%3FName%3DQuantec_Final_

Report_072004.pdf%26Size%3D264KB&ei=0R29UJiGGofo2QXDzIH4Dw&usg=AFQjCNEDLPZTJUEBOWH7UZCaQqChW3283Q&sig2=vZngE_mXLepVgKqEhsKgsw.

12. Quantec. (2008). Southern California Edison 2004-2005 IDEEA Constituent Program Evaluations. Retrieved on January 16, 2013. http://calmac.org/publications/IDEEA_Constituent_Program_Evaluations_-_Vol_1_FINAL_072808.pdf.
13. Itron. (2010). 2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group. Retrieved on January 16, 2013. http://calmac.org/publications/PG%26E_Fab_06-08_Eval_Final_Report.pdf.
14. National Association of State Energy Officials. (2000). Dashboard Guide to Energy Efficiency in the Oil Field. Retrieved on January 16, 2013. http://www.naseo.org/committees/industrial/archive/documents/Dashboard_Guide_to_Energy_Efficiency_in_the_Oil_Field.pdf.
15. CEE. (2012). Motors and Motor Systems. CEE Premium Efficiency Motors List. Retrieved on January 16, 2013. http://www.cee1.org/ind/mot-sys/mtr-ms-main.php3.
16. Marietta College. (2005). Installation of Pump-off Control Technology in Goldsmith-Cummins Deep Unit. Retrieved on January 22, 2013. http://www.marietta.edu/~catalant/Project4Petro2.pdf.
17. NETL. (2005). Enhanced Recovery Utilizing Variable Frequency Drives and a Distributed Power System Final Report. Retrieved on January 16, 2013. http://www.netl.doe.gov/technologies/oil-gas/publications/EP/15436FinalRpt.pdf.
18. Weatherford. (2003). eProduction Solutions. Value of Rod Pump Control. Retrieved January 22, 2013. http://www.ep-solutions.com/PDF/Papers/Value_of_Rod_Pumped_Control.pdf.
19. Schneider Electric. (2011). Case Study. ATFAB. Retrieved January 22, 2013. http://static.schneider-electric.us/docs/Machine%20Control/0100AC1102.pdf.
20. U.S. Department of Energy. (1999). Energy Efficiency Program. Electric Motors. Retrieved January 22, 2013. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/motorsrule.pdf.
21. CASE. (2011). Codes and Standards Enhancement Initiative (CASE). Process Boilers. 2013 California Building Energy Efficiency Standards. Retrieved on January 16, 2013. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Covered_Processes/2013_CASE_Process_Boilers%2010.28.2011.pdf.
22. Northwest Food Processors Association. (2010). Opportunities in Industrial Boiler Efficiency. Alleman. Retrieved January 22, 2013. http://www.nwfpa.org/nwfpa.info/component/content/article/37-boiler/57-opportunities-in-industrial-boiler-efficiency.
23. Gas Networks. (2009). Natural Gas Energy Efficiency Potential in Massachusetts Final Report. Retrieved January 22, 2013. http://www.ct.gov/deep/lib/deep/energy/cep/gds_associates_-_natural_gas_ee_potential_in_ma_-_final_report.pdf.
24. California Public Utilities Commission. (2012). Database for Energy Efficient Resources (DEER). EUL/RUL (Effective/Remaining Useful Life) Values. Retrieved January 22, 2013. http://www.deeresources.com/index.php?option=com_content&view=article&id=65&Itemid=57.
25. U.S. Department of Energy. (2009). Energy Conservation Standards and Test Procedures. Commercial Heating, Air Conditioning, and Water Heating Equipment. Chapter 5. Life-Cycle Cost and Payback Period Analysis. Retrieved on January 22, 2013.

http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ch_5_ashrae_nopr_tsd.pdf.
26. U.S. Department of Energy. (2012). Energy Conservation Standards. Electric Motors. Preliminary Technical Support Document. Retrieved on January 22, 2013. http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0027-0023.
27. Previous Navigant team analysis. (2009 and 2010). Internal research conducted within the Southwest. Incremental cost analysis of variable speed drive installations. Excel file.
28. Grainger. (2012). Motor internet material costs used for data QC and verification. Costs for motors between 40 and 450 HP obtained. Retrieved on December 17, 2012. http://www.grainger.com/Grainger/wwg/start.shtml

I.10 Mining Sector Results

This section provides the estimates of potential energy and demand savings at the statewide level for the mining sector. The mining sector contains three subsectors; oil and gas extraction, mining (mineral, metals, etc.), and construction. The scope of this potential analysis pertains only to oil and gas extraction that accounts for the majority of electric and gas consumption within the mining sector.

I.10.1 Overview

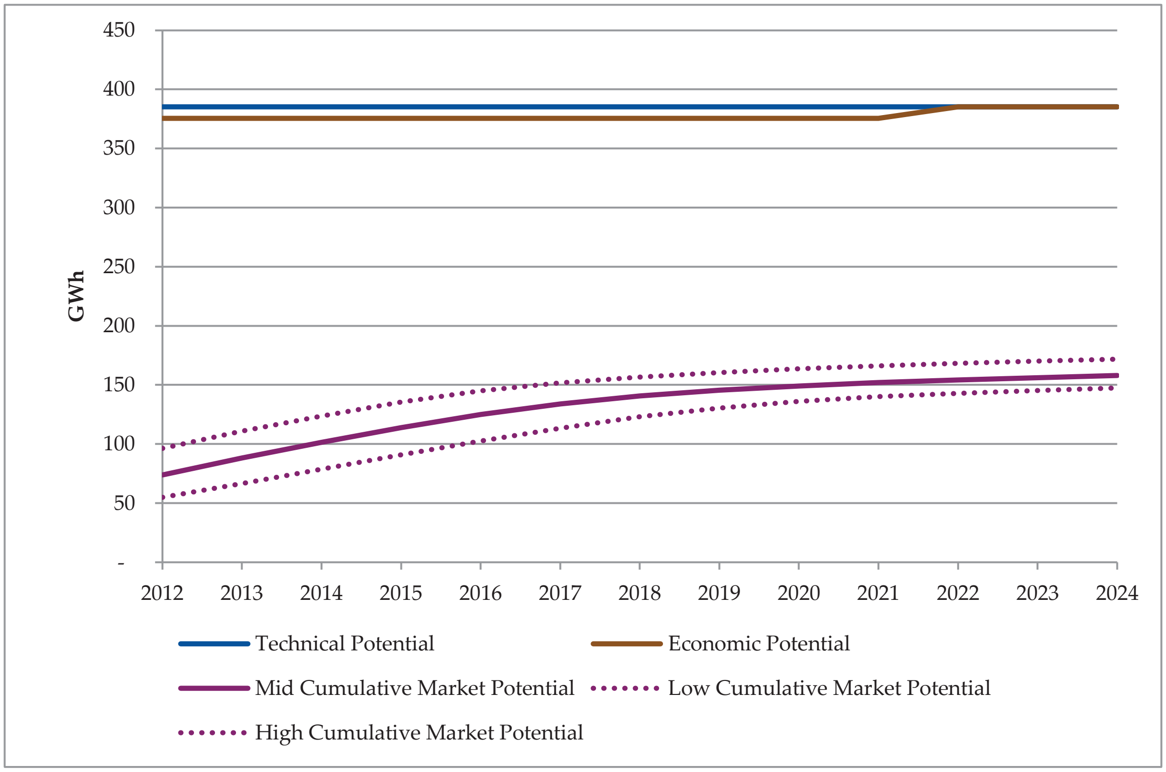
The potential energy savings in the mining sector do not include an assessment of the impact of upcoming codes and standards changes because, while some equipment deployed throughout the mining sector may be subject to Federal standards, the majority of equipment are generally not subject to the same 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 as reports reviewed by Navigant do not indicate substantial new construction in this sector.

I.10.2 California Mining Summary of Results

I.10.2.1 California Mining Electric Energy Potential

As shown in Figure I-1, the mining technical and economic energy savings potential remains fairly constant from 2012 through 2024. Technical and economic energy savings potential in the state of California stay steady between 375 and 385 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. Navigant estimates that the sector's size will remain constant over the period. While new oil wells are expected to come online in the next 10 years, a roughly equal number of existing wells will be shut-in. Therefore, Navigant estimates total energy sales to remain the same through 2024. Finally, cumulative market energy savings potential trails economic and technical energy savings potential and increases from approximately 74 GWh in 2012 to 158 GWh in 2024.

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

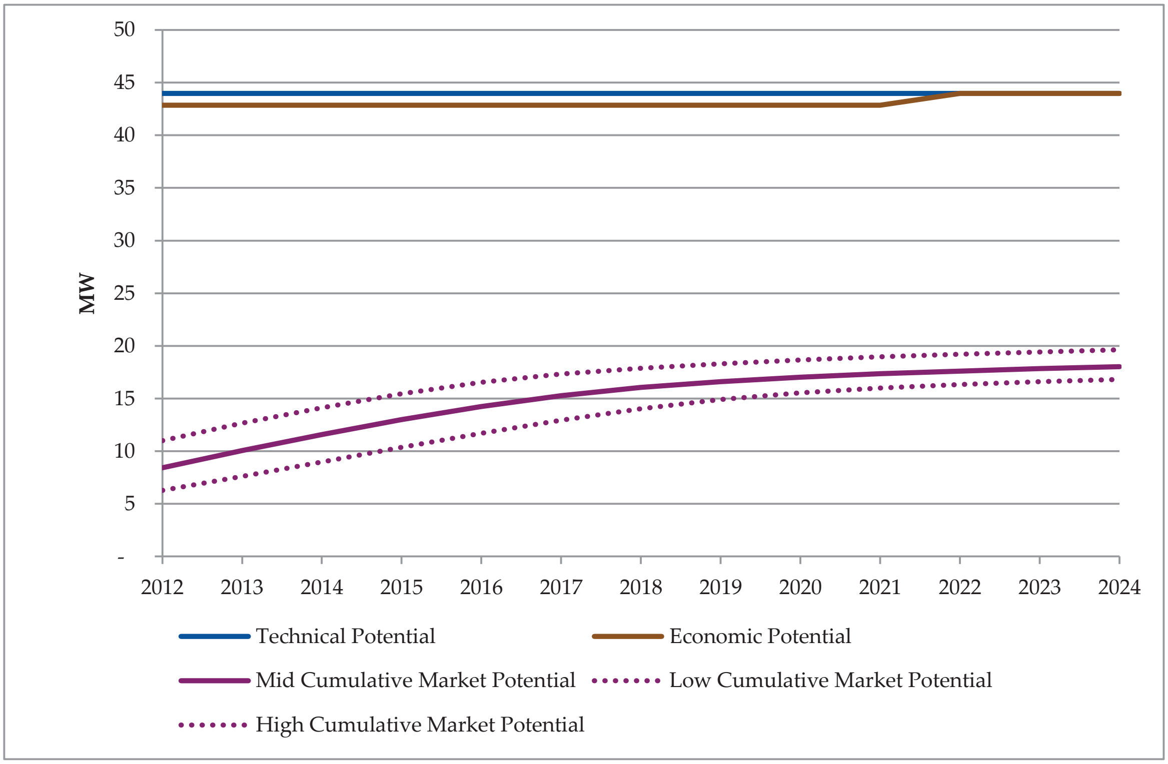


Source: PG model release February 2014

The Navigant team's mining cumulative market potential generally reflects improvements to motors deployed to support oil and gas extraction activities. Typical improvements include changing to efficient motors, resizing to smaller motors, installing VFDs, and installing pump-off controllers. Decreasing incremental market potential reflects the reduction of the current stock of baseline equipment as it is replaced with efficient equipment. Navigant estimates that no emerging technologies will contribute any significant potential to the mining sector.

Figure I-2 presents total technical, economic, and cumulative market demand savings potential through 2024. Technical and economic demand savings potential stay steady between 43 MW and 44 MW from 2012 through 2024. The active cumulative market energy savings potential increases from approximately 8 MW in 2012 to 18 MW in 2024.

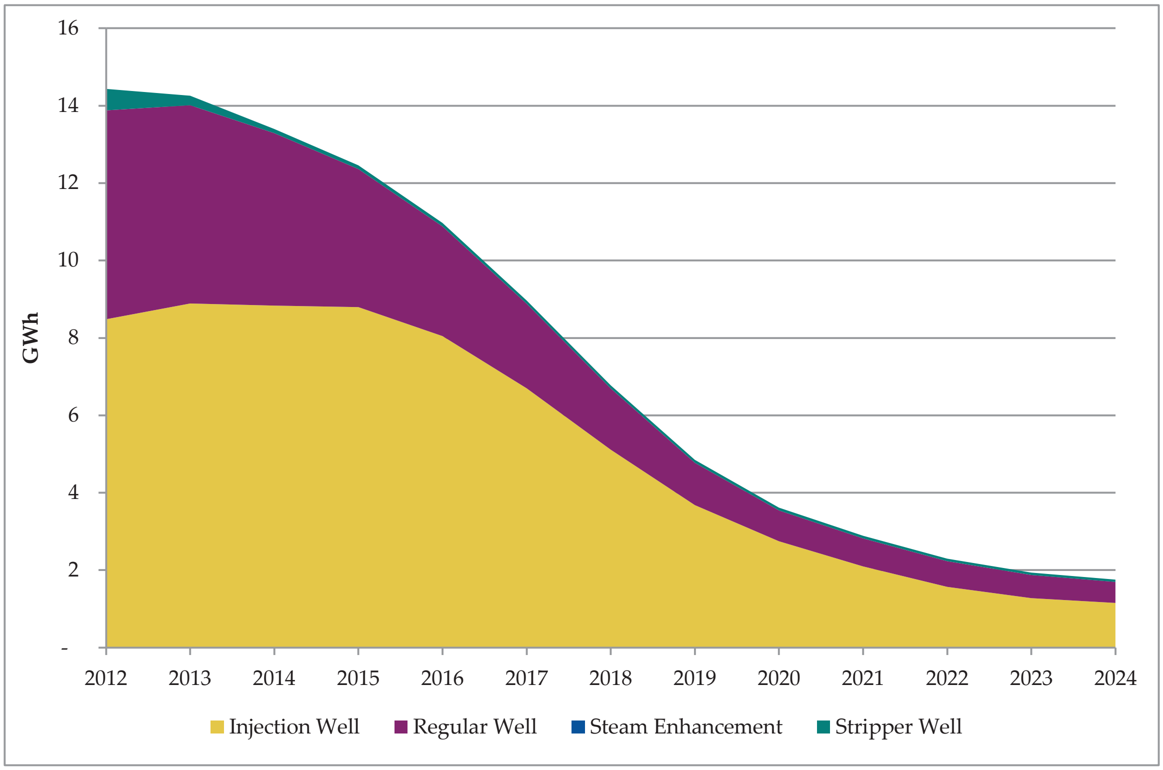
Figure I-2. California Mining Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2012-2024 (MW)



Source: PG model release February 2014

Figure I-3 presents the incremental market energy savings potential in the mining sector by end use. The incremental market potential reduces over the analysis period as baseline stocks convert to the efficient case. Injection well pumps account for the majority of incremental market energy savings potential where either baseline drive motors are replaced or operational efficiency is improved with VFDs.

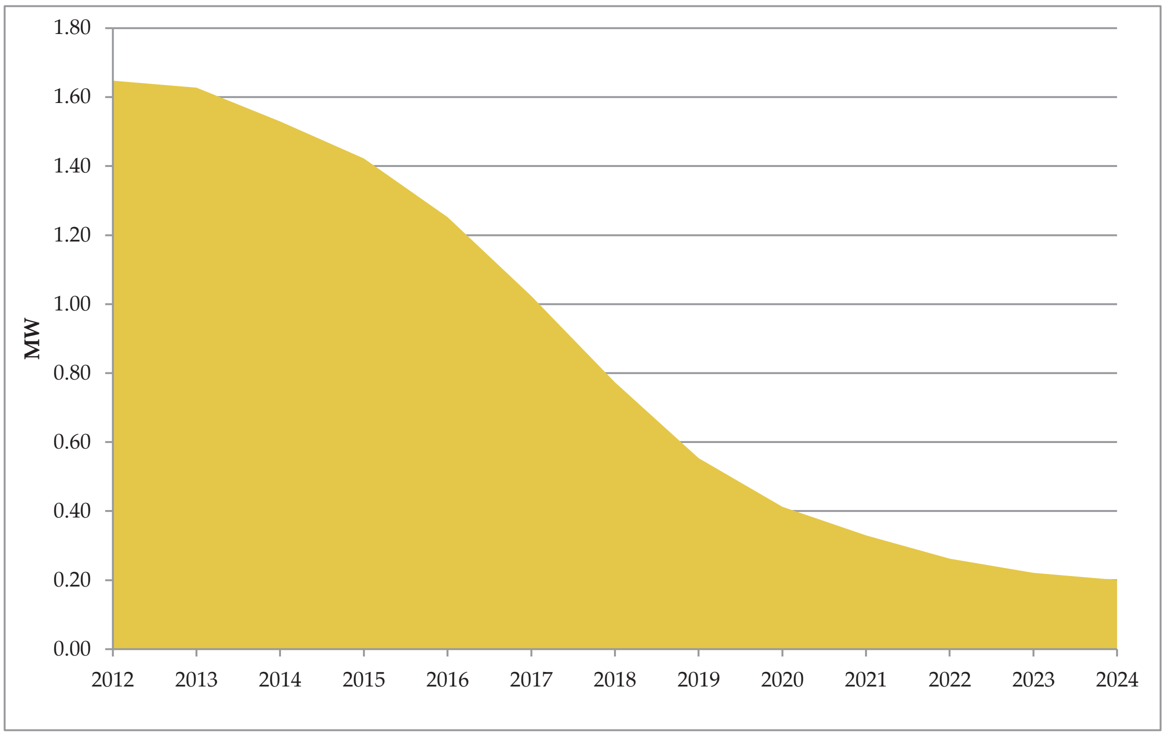
Figure I-3. California Mining Gross Incremental Market Energy Savings Potential for 2012-2024 (GWh)



Source: PG model release February 2014

Figure I-4 presents the incremental market demand savings potential in the mining sector. The incremental market potential starts at approximately 1.65 MW in 2012 and decreases to approximately 0.20 MW in 2024. The incremental demand savings potential follows a similar trend to the incremental energy savings potential. That is, the incremental market potential reduces over the analysis period as baseline stocks convert to the efficient case, and the sector experiences a saturation of energy efficiency in the absence of emerging technologies contributing to potential in future years.

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



Source: PG model release February 2014

I.10.2.2 California Mining Electric Comparative Metrics

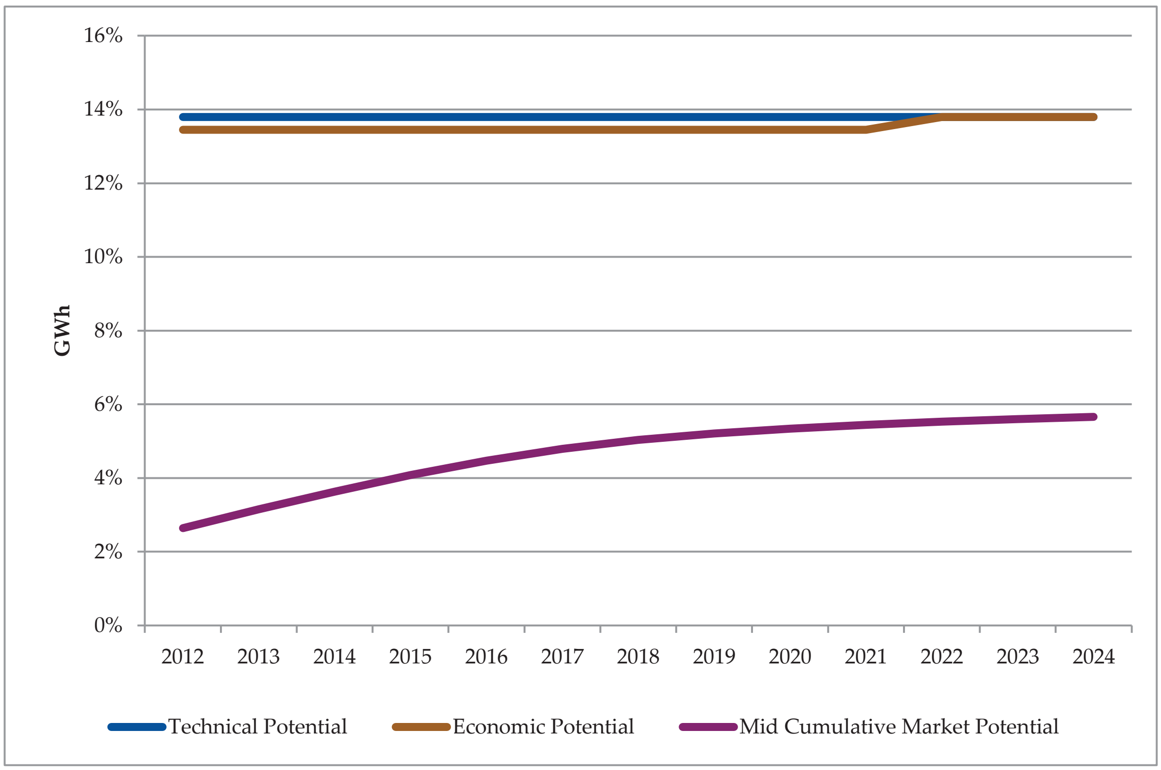
This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 mining analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For mining, comparative metrics are limited because this analysis is the first time that mining is explicitly examined and few other third-party efforts have been conducted in the past. Additionally, the IOU compliance filing data provided to Navigant did not include data specific to the mining sector. The following comparative metrics are provided:

» Cumulative market potential as compared to the total CEC consumption forecast for the mining sector

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 I-5 shows the technical, economic, and active cumulative market potential savings as a percent of the CEC mining forecast. This consumption relates to the electric energy consumed within the oil and gas extraction subsector and excludes mining and construction subsector consumption. Technical and economic potentials are about 13 percent to 14 percent of the CEC mining consumption forecast in 2012 through 2024. Active Cumulative market potential rises from about 3 percent in 2012 up to 6 percent by 2024.

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

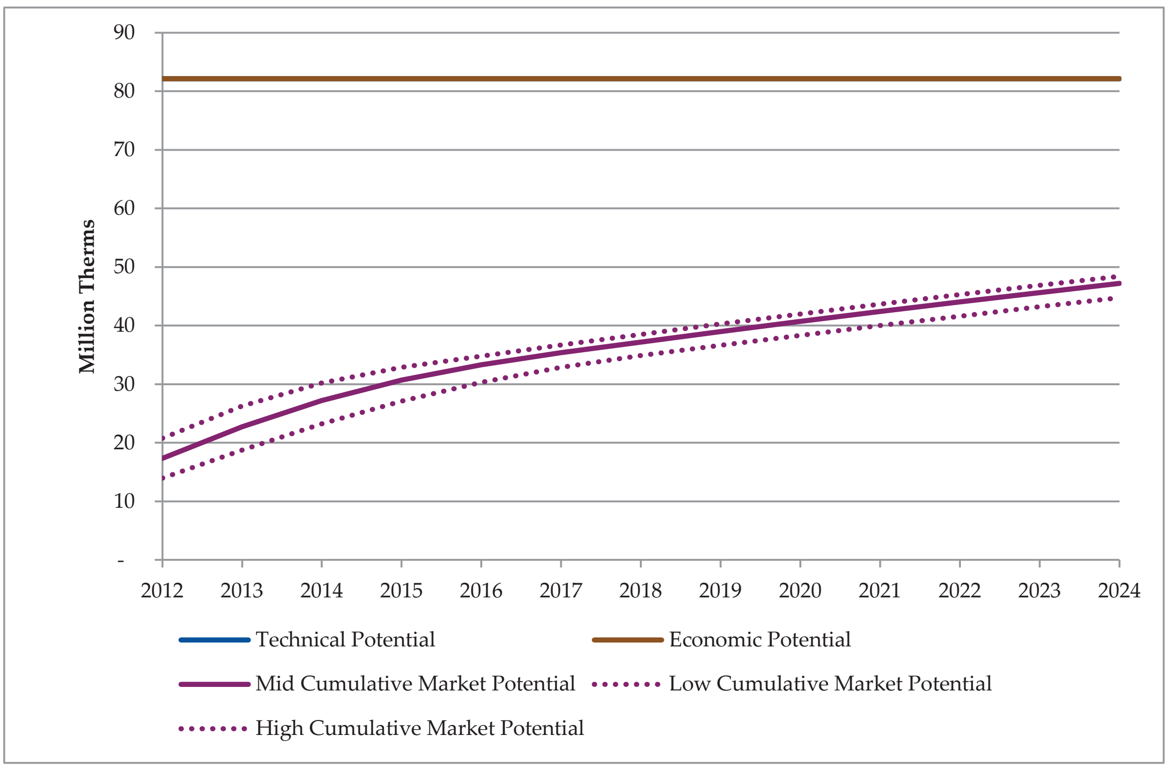


Source: PG model release February 2014

I.10.2.3 California Mining Gas Energy Potential

As shown in Figure I-6, the mining technical and economic energy savings potential remains constant from 2012 through 2024. Technical and economic energy savings potential in the state of California stay steady at 82 million therms from 2012 through 2024. Technical and economic energy savings potential variations during the analysis period reflect variations in those forecasts. Navigant estimates that the sector's size will remain constant over the period. While new oil wells are expected to come online in the next 10 years, a roughly equal number of existing wells will be shut-in. Therefore, Navigant estimates total energy sales to remain the same through 2024. Finally, cumulative market energy savings potential trails economic and technical energy savings potential and from approximately 17 million therms in 2012 to 47 million therms in 2024.

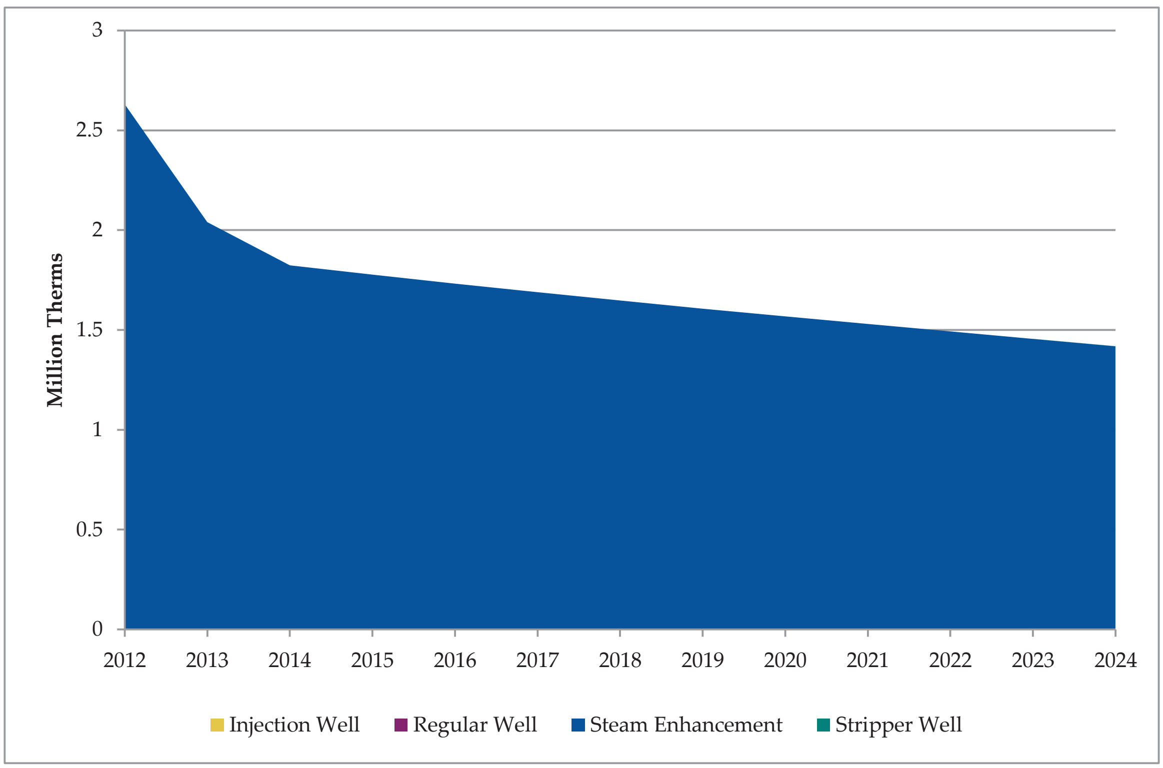
Figure I-6. California Mining Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2012-2024 (Million Therms)



Source: PG model release February 2014

Figure I-7 presents the incremental market energy savings potential in the mining sector by end use. The incremental market potential reduces over the analysis period as baseline stocks convert to the efficient case. Process steam boilers account for all natural gas consumption within the oil and gas extraction subsector of the mining sector. Efficiency is improved by boiler replacements and improvements to existing boiler operations and controls strategies. The incremental gas energy savings potential follows a similar trend to the incremental electric energy savings potential. That is, the incremental market potential reduces over the analysis period as baseline stocks convert to the efficient case, and the sector experiences a saturation of energy efficiency in the absence of emerging technologies contributing to potential in future years.

Figure I-7. California Mining Gross Incremental Market Energy Savings Potential for 2012-2024 (Million Therms)



Source: PG model release February 2014

I.10.2.4 California Mining Gas Comparative Metrics

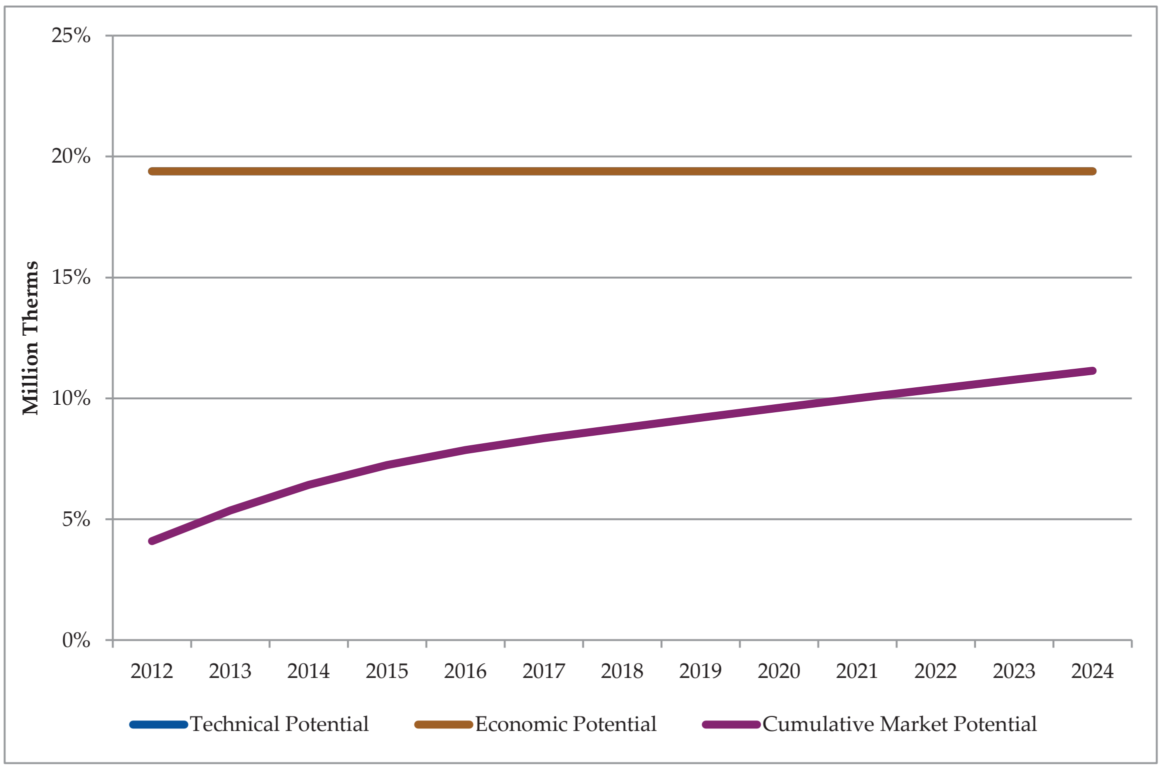
This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 mining analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For mining, comparative metrics are limited because this analysis is the first time that mining is explicitly examined and few other third-party efforts have been conducted in the past. Additionally, the IOU compliance filing data provided to Navigant did not include data specific to the mining sector. The following comparative metrics are provided:

» Cumulative market potential as compared to the total CEC consumption forecast for the mining sector

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 I-8 shows the technical, economic, and cumulative market potential savings as a percent of the CEC mining forecast. This consumption relates to the gas energy consumed within the oil and gas extraction subsector and excludes mining and construction subsector consumption. Technical and economic potentials are about 19 percent of the CEC mining consumption forecast in 2012 through 2024. Active cumulative market potential rises from about 4 percent in 2012 up to 11 percent by 2024.

Figure I-8. California Mining Savings Potential as a Percent of CEC Mining Forecast (Technical, Economic, and Active Cumulative Market Potential)



Source: PG model release February 2014

Appendix J Approach to Street Lighting Sector Analysis

This appendix details the approach to developing inputs for the Street-Lighting sectors. All values in the PG study and Agricultural, Industrial, Mining, and Street Lighting Approach are based primarily on secondary research in addition to some primary data supplied by the investor-owned utilities (IOUs). This appendix includes tables detailing specific inputs that define the measures and the reader should refer to the Measure Input Characterization Sheets for more information and specific inputs.

J.1 Data Collection

The Navigant team started by collecting publicly available data, using the sources included but not limited to those shown in Table J-1. To supplement these sources the Navigant team also asked contacts at each electric IOU to provide an inventory of the Street-Lighting stock in their respective territories. Those citations are also included in Table J-1

Table J-1. Sample of Sources Used for Street Lights

Publisher/Source	Citation
PG&E	PG&E Street Lighting Inventory Data. Email from PG&E Staff to Navigant team, September 19, 2012.
SCE	SCE Street Lighting Inventory Data. Email from SCE Staff to Navigant team, September 7, 2012.
SDG&E	SDG&E Street Lighting Inventory Data. Email from SDG&E Staff to Navigant team, September 19, 2012.
PG&E	PG&E. (2008). Electric Schedule LS-1. PG&E-Owned Street and Highway Lighting. Retrieved January 14, 2013. http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_LS-1.pdf. PG&E (2008). Electric Schedule LS-2. Customer-Owned Street and Highway Lighting. Retrieved January 14, 2013. http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_LS-2.pdf.
SCE	SCE. (2012). Schedule LS-1. Lighting-Street and Highway-Unmetered Service Company-Owned System. Retrieved January 14, 2013. http://www.sce.com/NR/sc3/tm2/pdf/ce36-12.pdf. SCE. (2012). Schedule LS-2. Lighting-Street and Highway Customer-Owned Installation-Unmetered Service. Retrieved January 14, 2013. http://www.sce.com/NR/sc3/tm2/pdf/ce37-12.pdf.
SDG&E	SDG&E. (2012). Schedule LS-1. Lighting-Street and Highway-Utility-Owned Installations. Retrieved January 14, 2013. http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_LS-1.pdf. SDG&E. (2012). Schedule LS-2. Lighting-Street and Highway-Customer-Owned Installations. Retrieved January 14, 2013. http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_LS-2.pdf.
California Lighting Technology Center (CLTC/UC Davis	The State of Street Lighting in California. (2012). Retrieved on September 6, 2012. http://eec.ucdavis.edu/publications/2012_State_of_Street_Lighting_in_CA_Final_Report.pdf.
City of San Diego	Advanced Street Lighting Technologies Assessment Project - City of San Diego. (2010). Retrieved September 6, 2012. http://www.sandiego.gov/environmental-services/energy/pdf/100104assessment.pdf.
U.S. Department of Energy (DOE)	Municipal Solid-State Streetlight Consortium. (2012). Retrieved September 6, 2012. http://www1.eere.energy.gov/buildings/ssl/consortium.html.
American Council for an Energy-Efficient Economy (ACEEE)	New Opportunities in Outdoor Lighting. (2012). Retrieved on September 6, 2012. http://aceee.org/files/pdf/conferences/mt/2011/T1%20-%20Gabe%20Arnold.pdf.
DOE	Street Lighting Consortium. (2012). Adaptive Lighting Controls Panel. September 6, 2012. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/msslc_dallas2012_controls.pdf.
City of Los Angeles	LED Equipment Evaluation, Phase V: 100W HPS Equivalent. (2011). September 6, 2012. http://www.ci.la.ca.us/bsl/LED_evaluation_report_phase_5_100W.pdf.

Source: Navigant team analysis, 2013

The Navigant team reviewed and organized data from each of the various sources in order to complete the analysis of the entire Street-Lighting sector and supply the requisite information to the PG model.

J.2 Data Organization

The Navigant team developed the following data sets for their analysis:

1. Fuel type(s) consumed by the sector
2. Subsector divisions within the sector
3. Efficient measure descriptions and descriptions of the associated baseline equipment
4. The prevalence of emerging technologies in the sector
5. Performance characteristics for each measure:
    a. Baseline and efficient energy consumption (electric [kWh] and/or gas [therms])
    b. Baseline and efficient electric demand values (kilowatt [kW])
    c. Baseline and efficient, effective, and remaining useful lifetimes (RULs)
6. Economic-specific characteristics for each measure including:
    a. Baseline and efficient material and installation costs
7. Market-specific characteristics for each measure including:
    a. Baseline and efficient densities (market saturations)
    b. Technology market competition groupings
8. Program-specific characteristics for each measure including:
    a. Net-to-gross ratios (NTGRs)
    b. Typical incentive amounts (reported as fractions of installed cost)
9. Replacement scenarios for the defined measures (e.g., retrofit, replace on burnout [ROB], or new construction)

The application and analysis of this data are described in the remainder of this section of the appendix.

J.3 Fuel Type Consumed by the Sector

The Street-Lighting sector only consumes electricity. As such, the Street-Lighting analysis excludes Southern California Gas (SCG).

J.4 Subsector Divisions within the Sector

The Navigant team divided the Street-Lighting sector into three main subsectors. Table J-2 describes each of these subsectors and indicates the statewide percent of total electricity (megawatt-hours [MWh]) consumed by each as a percent of the total Street-Lighting sector.

Table J-2. Street-Lighting Subsectors and Relative Electric Energy Consumption

Subsectors	Technology Description	Statewide Electricity Consumption Distribution for Street-Lighting Sector
Streets	Lights used to illuminate roads and highways	86%
Signs	Lights used to illuminate road or highway signs	4%
Traffic Lights	Lights used in red, yellow, and green traffic signals	10%

Source: Navigant team analysis of the following sources in Section J.13: [1] through [10]

The Navigant team estimated the lamp counts by subsector individually for each IOU using the IOU-supplied inventories and secondary sources.

Table J-3 describes the three main subsectors by the distribution of lamp counts in each IOU service territory.

The lamp count distributions differ significantly from the energy consumption distributions due to significant differences in lamp types and consumption, which vary by subsector. While "traffic lights" consume approximately 36 kilowatt-hours (kWh)/lamp/year, lamps in the "Streets" subsector consume 555 kWh/lamp/year on average, and lamps in the "Signs" subsector consume 963 kWh/lamp/year. Even though the Navigant team estimated that "traffic lights" consume only 10 percent of the Street- Lighting sector energy, they account for over half of the portion of lamps for all three IOUs.

San Diego Gas and Electric (SDG&E) has a different lamp count distribution than Pacific Gas and Electric (PG&E) or Southern California Edison (SCE). SDG&E's territory is smaller and more densely populated. The results reflect a denser population that contains more traffic intersections and fewer stretches of open highway.

Table J-3. Portion of Lamps by Subsector for Each IOU

Subsectors	PG&E	SCE	SDG&E	Average Statewide Lamp Consumption (kWh/lamp/year)	Average Statewide Lamp Wattage (watts/lamp)
Streets	36%	36%	23%	555	115
Signs	1%	1%	1%	963	239
Traffic Lights	63%	63%	76%	36	10.3

Note: The operating hours differ for the Streets and Signs subsectors.

Source: Navigant team analysis of the following sources in Section J.13: [1] through [17]

Table J-4 shows the Energy Consumption Data Management System (ECDMS) Street-Lighting Data for 2010, the most recent year of data. Additionally, Table J-4 shows the Navigant team's sector-wide lamp count distribution estimates for each IOU. These estimates align with the California Energy Commission (CEC) data that show SCE and SDG&E as the largest and smallest consumers within the Street-Lighting sector, respectively.

Table J-4. Each IOU's Share of Overall IOU Lamps and Consumption

IOU	Electric Consumption Distribution	Lamp Count Distribution
PG&E	41%	42%
SCE	44%	45%
SDG&E	16%	13%

Source: Navigant team analysis of the following sources in Section J.13: [1] through [17]

J.5 Efficient Measure Descriptions and Associated Baselines

To develop assumptions about the current saturation of efficient and baseline technologies, the Navigant team took a different approach for each of the subsectors:

- The Navigant team reviewed the inventories supplied by the IOUs for the Streets subsector. The Streets subsector includes incandescent, mercury vapor, low-pressure sodium, high- pressure sodium, metal halide, light-emitting diode (LED), and induction lamps. The Navigant team used this information to quantify the distribution of these technologies by lamp count across the Streets subsector. LEDs and induction lamps are considered efficient technologies while the remaining lamp types are considered baseline technologies.

- For the “Signs” subsector, 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 rate of efficient technology saturation within each IOU’s Signs subsector is equivalent to the rate seen within each IOU’s Streets subsector.

- For the “Traffic Lights” subsector, the Navigant team assumed that the use of LEDs is standard practice. As of January 1, 2006, California’s Title 24 (in response to federal standards) requires all traffic signals to have maximum wattages no greater than 11 to 17 watts, depending on the lamp type (i.e., lamp size, color, and signal type).[132] Discussions with IOUs confirmed that all current installations are LEDs.[133]

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[132] See the following source in Section J.12 : [18].
[133] See the following source in Section J.12 :: [19].

The following sections detail the baseline and efficient technology characterizations. Table J-5 shows the portion of lamps by technology and subsector for each IOU.

Table J-5. Portion of Lamps by Technology and Subsector for Each IOU

Subsector	Technology	PG&E	SCE	SDGE
Streets	Incandescent	0%	0%	1%
Streets	Mercury vapor	0%	1%	1%
Streets	Low-pressure sodium	8%	3%	18%
Streets	High-pressure sodium	86%	93%	56%
Streets	Metal halide	1%	1%	0%
Streets	LED	2%	0%	4%
Streets	Induction	2%	1%	20%
Signs	Mercury Vapor	96%	99%	77%
Signs	LED	2%	0%	4%
Signs	Induction	2%	1%	20%
Traffic Lights	LED	100%	100%	100%

Source: Navigant team analysis of IOU-provided lamp inventories and the following secondary sources in Section J.12:

- *Streets: [2] through [4]*
- *Signs: [1] through [17]*
- *Traffic Lights: [1] through [11] and [17] through [19]*

Table J-6 shows the distribution of energy consumption for the same technologies and subsectors as shown in Table J-5. The Navigant team used IOU-supplied inventories and the rate schedules associated with street lamps to estimate "streets" energy consumption per lamp. The majority of IOU street lamps are typically covered by rate schedules LS-1 and LS-2.[134] These rate schedules typically specify the wattage, lumens, operating hours, and monthly kWh charges associated with each lamp type. The Navigant team used secondary sources to estimate "signs" and "traffic lights" energy consumption per lamp.

Table J-6. Portion of Consumption by Technology and Subsector for Each IOU

Subsector	Technology	PG&E	SCE	SDGE
Streets	Incandescent	1%	0%	0%
Streets	Mercury vapor	1%	3%	2%
Streets	Low-pressure sodium	8%	2%	15%
Streets	High-pressure sodium	87%	93%	67%
Streets	Metal halide	1%	1%	0%
Streets	LED	1%	0%	2%
Streets	Induction	1%	0%	14%
Signs	Mercury Vapor	99%	100%	89%
Signs	LED	1%	0%	2%
Signs	Induction	1%	0%	9%
Traffic Lights	LED	100%	100%	100%

Source: Navigant team analysis of IOU-provided lamp inventories, Quarterly Fuel and Energy Report (QFER) data, and the following secondary sources in Section J.12: [1] through [19]

[134] See the following sources in Section J.13 :: [5] through [10].

The Navigant team developed five measures for the Streets subsector, two measures for the Signs subsector, and one measure for the Traffic Lights subsector. Table J-7 shows the measures and associated baselines.

Table J-7. Street-Lighting Measures and Baselines

Subsector	Measure Description	Baseline Description
Streets	Baseline street lights with advanced controls	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)*
Streets	LED street lights	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)*
Streets	LED street lights with advanced controls	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)*
Streets	Induction street lights	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)*
Streets	Induction street lights with advanced controls	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)*
Signs	LED street sign lights	Mercury vapor street sign lights
Signs	Induction street sign lights	Mercury vapor street sign lights
Traffic Lights	Advanced LED traffic lights	LED traffic lights

*HPS = high-pressure sodium; LPS = low-pressure sodium; MH = metal halide; MV = mercury vapor.

Source: Navigant team analysis of IOU-provided lamp inventories, QFER data, and the following secondary sources in Section J.12: [1] through [19]

Streets Subsector. The Navigant team developed the measure characteristics for advanced controls by reviewing several secondary sources. The secondary sources included evaluations of pilot programs that have deployed advanced controls to support municipal Street-Lighting systems. Advanced controls are defined as controls beyond standard photocells, timers, and astronomical timers that generally include activity and motion-sensing, network connections for outage monitoring, and remote controlling. Advanced controls can be deployed on existing light installations (i.e., baseline street lights), or they can be installed along with new LEDs or induction lamps.[135] Advanced controls are only deployed for lights found within the Streets subsector.

The Navigant team defined the baseline for "streets" as the current mix of baseline lamp technologies: high-pressure sodium, low-pressure sodium, metal halide, mercury vapor, and incandescent. The Navigant team represented these baseline lamp types with a single lamp based on a weighted average. Additionally, the five measures shown in Table J-7 are included in a single competition group and compete for the sockets occupied by these baseline lamps.

Signs Subsector. The Navigant team estimated that the majority of baseline sign lights are mercury vapor and that two measures are competing for those sockets: LED and induction lamps.

[135] See the following sources in Section J.13 : [12], [20] through [24].

Traffic Lights Subsector. The Navigant team developed one measure for the "Traffic Lights" subsector and defines the baseline as current and standard LEDs. The measure level, or efficient case, is defined as advanced LEDs that have wattages significantly less than the wattages specified by the current Title 20 requirements.[136]

J.6 Emerging Technologies

The Navigant team considered emerging technologies for some of its measures within the Street-Lighting sector. For the Streets subsector, advanced controls and LEDs are considered emerging technologies. LEDs are also considered emerging technologies for the Signs subsector. Finally, advanced LEDs are considered an emerging technology within the Traffic lights subsector. These are differentiated from the baseline LEDs that will remain constant throughout the analysis time frame. The Navigant team estimated that the advanced LEDs will experience some measure of improvement in efficiency and cost as the technology matures and continues to develop during the course of the analysis period.

J.7 Measure Characteristics: Performance

The potential analysis relies on estimates for energy consumption (kWh) and peak demand (kW) for both baseline and efficient measures. Therefore, the Navigant team developed these performance characteristics for the Street-Lighting measures using IOU-provided data and secondary sources.

J.7.1 Energy Consumption

The Navigant team estimated the energy consumption of both baseline and efficient technologies within the Street-Lighting sector and reports consumption as kWh per year per lamp. The details of the approaches taken for each subsector follow:

» **Sources for energy consumption estimates.** Estimates for the Streets subsector relied on the IOU-provided lamp inventories that are tied to rate schedules (e.g., LS-1 and LS-2) that specify monthly kWh charges.[137] Energy consumption estimates for baseline and efficient technologies within the Signs and Traffic Lights subsectors relied on average values developed from various secondary sources. Secondary sources include program evaluations, technology assessments, and case studies including sources developed by the IOUs.[138]

» **Consistency of energy consumption across IOUs.** Streets subsector energy consumptions vary across IOUs because each IOU inventory reported a different mix of lamp wattages for each technology. The reported consumptions reflect the averages of those mixes. Signs and Traffic Lights subsector energy consumptions are assumed to be equal across the IOUs because secondary sources used to estimate savings did not differentiate across those IOUs.[139] Table J-8 shows the annual consumptions estimated for this analysis.

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[136] See the following source in Section J.12 : [18].

[137] See the following sources in Section J.13 :: [2] through [10].

[138] See the following sources Section J.12 :. Signs: [2] through [10], [13], [14], [15], [16]; Traffic Lights: [17].

[139] See the following sources in Section J.13 :. Signs: [2] through [10], [13], [14], [15], [16]; Traffic Lights: [17].

- **Energy consumption for base and efficient cases.** There are currently no federal or California codes regulating equipment within the Streets and Signs subsectors; therefore, those baseline and code consumption levels are equal. Regulations currently exist for the Traffic lights subsector,[140] but the Navigant team estimated that all baseline equipment has been updated to match the current code.[141] Traffic lights energy consumption for the baseline and efficient case are equal in Table J-8 to reflect the efficient case prior to the saturation of the advanced LED emerging technology in later years.

Finally, Table J-8 shows the resulting energy consumption characteristics of lighting within the Streets subsector that is installed along with advanced controls.

Table J-8. Baseline and Measure Annual Consumption Estimates (kWh/year)

Subsector	Baseline/Measure Description	PG&E	SCE	SDG&E
Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	552	578	553
Streets	Baseline street lights with advanced controls	394	412	394
Streets	Measure: LED street lights	330	195	270
Streets	Measure: LED street lights with advanced controls	236	139	192
Streets	Measure: Induction street lights	257	371	362
Streets	Measure: Induction street lights with advanced controls	183	264	258
Signs	Baseline (mercury vapor street sign lights)	992	992	992
Signs	Measure: LED street sign lights	359	359	359
Signs	Measure: Induction street sign lights	403	403	403
Traffic Lights	Baseline (LED traffic lights)	36	36	36
Traffic Lights	Measure: Advanced LED traffic lights	36	36	36

Source: Navigant team analysis of IOU-provided lamp inventories, QFER data, and the following secondary sources in Section J.12:

- *Streets: [2] through [10]; Streets- advanced controls: [20], [14], [22], [25], [26]*
- *Signs: [2] through [10], [13], [14], [15], [16]*
- *Traffic Lights: [17]*

J.7.2 Peak Demand

The Navigant team assumed that the energy consumption for lamps within the Streets and Signs subsectors occurs during nighttime hours and never during the IOUs' peak demand periods. Although some "streets" and "sign" lighting may operate continuously (e.g., tunnel lighting), the Navigant team considered consumption from these types of lighting installations as negligible relative to the respective subsector.

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140 See the following source in Section J.12 :: [18].
141 See the following source in Section J.12 :: [19].

Traffic lights operate continuously, however, and Table J-9 presents peak demand values per lamp.

Similar to Table J-8, traffic lights demand for the baseline and efficient case is equal in Table J-9. Similar to baseline and code consumption assumptions previously discussed, the Navigant team estimated that baseline and code peak demand are equivalent.

Table J-9. Baseline and Measure Peak Demand Estimates (kW)

Subsector	Baseline/Measure Description	PG&E	SCE	SDG&E
Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	0	0	0
Streets	Baseline street lights with advanced controls	0	0	0
Streets	LED street lights	0	0	0
Streets	LED street lights with advanced controls	0	0	0
Streets	Induction street lights	0	0	0
Streets	Induction street lights with advanced controls	0	0	0
Signs	Baseline (mercury vapor street sign lights)	0	0	0
Signs	LED street sign lights	0	0	0
Signs	Induction street sign lights	0	0	0
Traffic Lights	Baseline (LED traffic lights)	0.004	0.004	0.004
Traffic Lights	Advanced LED traffic lights	0.004	0.004	0.004

Source: Navigant team analysis of the following sources in Section J.13: Traffic Lights: [17]

J.7.3 Effective and Remaining Useful Lifetimes

The Navigant team also accounted for effective useful life (EUL) and RUL for the measures under consideration. The Navigant team developed baseline and efficient effective useful lifetimes by averaging values found in several secondary sources. RULs are estimated as half of the EUL for the given technology. This assumes an even mix of equipment ages among existing stocks. Lifetimes are also considered equivalent across the three IOUs, as shown in Table J-10.

Similar to the previous discussions, the Navigant team assumed baseline and code values are equal.

Table J-10. Baseline and Measure Equipment Lifetimes

Subsector	Baseline/Measure Description	EUL	RUL*
Streets	Baseline (existing HPS, LPS, MH, MV, incandescent street lights (weighted by lamp count))	5.9	2.9
Streets	Baseline street lights with advanced controls	5.9	N/A
Streets	LED streetlights	17.3	N/A
Streets	LED streetlights with advanced controls	17.3	N/A
Streets	Induction streetlights	24.7	N/A
Streets	Induction streetlights with advanced controls	24.7	N/A
Signs	Baseline (mercury vapor street sign lights)	6.2	3.1
Signs	LED street sign lights	17.3	N/A
Signs	Induction street sign lights	24.7	N/A
Traffic Lights	Baseline (LED traffic lights)	11.5	5.8
Traffic Lights	Advanced LED traffic lights	11.5	N/A

*The model only considers baseline/code RULs.

Source: Navigant team analysis of the following sources in Section J.13: [12], [13], [14], [15], [27] through [33].

J.8 Measure Characteristics: Economic

The potential analysis also relies on economic characteristics that further describe measures. The remainder of this section discusses estimates for costs, including costs for material, labor, and operation and maintenance (O&M).

J.8.1 Costs

The Navigant team accounted for material costs, labor costs during installation, and O&M benefits (or costs). Material and labor costs are reported as the full costs and the model calculates the incremental costs depending on the assumed installation scenario (i.e., ROB, retrofit, or new construction). O&M benefits reflect the decrease in standard annual O&M requirements as a result of installing the efficient measure. A negative O&M benefit indicates an increase in O&M costs. O&M values reflect the annual benefit or cost per lamp. Table J-11 and Table J-12 show the material costs, labor costs, and O&M benefits.

The Navigant team estimated costs by averaging values reported by various secondary sources. The Navigant team also assumed that costs are equivalent across the three IOUs. Similar to the previous discussions, the Navigant team assumed baseline and code values are equal.

Table J-11. Baseline and Measure Material and Labor Costs

Subsector	Measure Description	Baseline Description	Efficient Material	Efficient Labor	Baseline Material	Baseline Labor
Streets	Baseline street lights with advanced controls	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)	$441.85	$37.16	$235.42	$32.80
Streets	LED street lights		$680.63	$32.80		
Streets	LED street lights with advanced controls		$887.06	$37.16		
Streets	Induction street lights		$438.33	$32.80		
Streets	Induction street lights with advanced controls		$644.77	$37.16		
Signs	LED street sign lights	Baseline (mercury vapor street sign lights)	$391.06	$32.80	$100.00	$32.80
Signs	Induction street sign lights		$251.85	$32.80		
Traffic Lights	Advanced LED traffic lights	Baseline (LED traffic lights)	$101.50	$47.60	$101.50	$47.60

Source: Navigant team analysis of the following sources in Section J.13:

- *Streets: [12], [22], [26], [31], [33]*
- *Signs: [12], [17], [26], [30], [31], [33], [34], [35]*
- *Traffic Lights: [17], [30], [34], [35]*

The O&M benefits reported for the Streets subsector reflect the benefits associated with advanced controls. The Navigant team estimated that remote monitoring and smart controls will reduce the cost to maintain road and highway lighting systems.

Table J-12. Baseline and Measure O&M Benefits

Subsector	Measure Description	Baseline Description	O&M Benefit
Streets	Baseline street lights with advanced controls	Existing HPS, LPS, MH, MV, incandescents street lights (weighted by lamp count)	$6.00
Streets	LED street lights		$0.00
Streets	LED street lights with advanced controls		$6.00
Streets	Induction street lights		$0.00
Streets	Induction street lights with advanced controls		$6.00
Signs	LED street sign lights	Baseline (mercury vapor street sign lights)	$0.00
Signs	Induction street sign lights		$0.00
Traffic Lights	Advanced LED traffic lights	Baseline (LED traffic lights)	$0.00

Source: Navigant team analysis of the following source in Section J.12: [22].

J.9 Measure Characteristics: Market

The Navigant team defined the mix of baseline and efficient technologies found within the Street-Lighting sector. A quantified estimate of the current saturation of energy efficiency found within the market supports the estimation of the energy savings potential that remains.

J.9.1 Technology Densities

After identifying technologies currently present in the market and assigning baseline and efficient designations, the Navigant team developed densities. Densities are based on the lamp counts within each subsector (and competition group) and quantify the percentage of lamps currently installed that are either baseline lamps or a specific efficient technology. The competition groups are also divided by existing and new construction vintages.

J.9.2 Existing Vintages

The Navigant team developed densities for the existing lamp stocks using the lamp counts from the IOU-provided lamp inventories and secondary sources. For a given IOU, subsector, and vintage (e.g., existing), the Navigant team calculated the total baseline and efficient lamps currently installed. This subset of lamps composes a competition group. Individual density values are calculated by dividing the baseline or efficient measure lamp count by this total competition group lamp count.

J.9.3 New Construction Vintages

In addition to examining the existing lamp stock, the Navigant team also estimated new construction activity within the Street-Lighting sector. The Navigant team used CEC QFER data forecasts of energy consumption in future years,[142] to estimate new construction lamp counts. The Navigant team assumed equal growth rates between the three subsectors and that half of new construction installations will be completed with efficient technologies. Densities for these new construction competition groups are calculated in the same way as the existing vintage.

Table J-13 shows the lamp counts and Table J-14 shows the corresponding densities as a percent of the total lamps in each subsector and vintage. For Table J-14, the values within each competition group (distinguished by IOU, subsector, and vintage) sum to 1.00.

[142] See the following source in Section J.12 : [1].

Table J-13. Lamp Counts by Technology and Subsector for Each IOU

Vintage	Subsector	Baseline/Measure Description	PG&E	SCE	SDG&E
Existing	Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	723,682	772,209	113,304
Existing	Streets	Baseline street lights with advanced controls	0	0	0
Existing	Streets	LED streetlights	15,710	1,213	5,703
Existing	Streets	LED street lights with advanced controls	0	0	0
Existing	Streets	Induction street lights	12,819	5,678	29,037
Existing	Streets	Induction street lights with advanced controls	0	0	0
New	Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	1,396	506	252
New	Streets	Baseline street lights with advanced controls	0	0	0
New	Streets	LED street lights	769	89	41
New	Streets	LED street lights with advanced controls	0	0	0
New	Streets	Induction street lights	627	417	210
New	Streets	Induction street lights with advanced controls	0	0	0
Existing	Signs	Baseline (mercury vapor street sign lights)	19,137	24,048	5,723
Existing	Signs	LED street sign lights	415	38	288
Existing	Signs	Induction street sign lights	339	177	1,467
New	Signs	Baseline (mercury vapor street sign lights)	37	16	13
New	Signs	LED street sign lights	20	3	2
New	Signs	Induction street sign lights	17	13	11
Existing	Traffic Lights	Baseline (LED traffic lights)	1,258,791	1,350,580	481,992
Existing	Traffic Lights	Advanced LED traffic lights	0	0	0
New	Traffic Lights	Baseline (LED traffic lights)	2,336	876	819
New	Traffic Lights	Advanced LED traffic lights	2,336	876	819

Source: Navigant team analysis of IOU-provided lamp inventories, QFER data, and the following secondary sources in Section J.12: [1] through [19], [24]

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Table J-14. Densities by Technology and Subsector for Each IOU

Vintage	Subsector	Baseline/Measure Description	PG&E	SCE	SDG&E
Existing	Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	0.96	0.99	0.77
Existing	Streets	Baseline street lights with advanced controls	0.00	0.00	0.00
Existing	Streets	LED street lights	0.02	0.00	0.04
Existing	Streets	LED street lights with advanced controls	0.00	0.00	0.00
Existing	Streets	Induction street lights	0.02	0.01	0.20
Existing	Streets	Induction street lights with advanced controls	0.00	0.00	0.00
New	Streets	Baseline (existing HPS, LPS, MH, MV, incandescents street lights [weighted by lamp count])	0.50	0.50	0.50
New	Streets	Baseline street lights with advanced controls	0.00	0.00	0.00
New	Streets	LED street lights	0.28	0.09	0.08
New	Streets	LED street lights with advanced controls	0.00	0.00	0.00
New	Streets	Induction street lights	0.22	0.41	0.42
New	Streets	Induction street lights with advanced controls	0.00	0.00	0.00
Existing	Signs	Baseline (mercury vapor street sign lights)	0.96	0.99	0.77
Existing	Signs	LED street sign lights	0.02	0.00	0.04
Existing	Signs	Induction street sign lights	0.02	0.01	0.20
New	Signs	Baseline (mercury vapor street sign lights)	0.50	0.50	0.50
New	Signs	LED street sign lights	0.28	0.09	0.08
New	Signs	Induction street sign lights	0.22	0.41	0.42
Existing	Traffic Lights	Baseline (LED traffic lights)	1.00	1.00	1.00
Existing	Traffic Lights	Advanced LED traffic lights	0.00	0.00	0.00
New	Traffic Lights	Baseline (LED traffic lights)	0.50	0.50	0.50
New	Traffic Lights	Advanced LED traffic lights	0.50	0.50	0.50

Source: Navigant team analysis of IOU-provided lamp inventories, QFER data, and the following secondary sources in Section J.12: [1] through [19], [24]

J.10 Measure Characteristics: Program

The Navigant team developed measure inputs that describe energy efficiency program characteristics (i.e., NTGRs and incentive fractions typically found among Street-Lighting programs).

J.10.1 Net-to-Gross Ratios

The Navigant team developed NTGRs for the Street-Lighting measures. The Navigant team estimated these values from various secondary sources including program evaluation reports. Net-to-gross ratios are assumed equivalent across IOUs and across each subsector.

Table J-15. Baseline and Measure Net-to-Gross Ratios

Subsector	Net-to-Gross
Streets	0.90
Signs	0.90
Traffic Lights	0.90

Source: Navigant team analysis of the following sources in Section J.13: [32], [34], [36]

J.10.2 Incentive Levels

The Navigant team developed incentive levels for the Street-Lighting measures. The Navigant team estimated these values from various secondary sources including program evaluation reports. Incentive levels represent the typical incentives paid by the IOUs as a fraction of the full installed cost. These are assumed to be equivalent across IOUs and across each subsector.

Table J-16. Baseline and Measure Incentive Fraction

Subsector	Incentive Fraction
Streets	0.50
Signs	0.50
Traffic Lights	0.50

Source: Navigant team analysis of the following sources in Section J.13: [14], [37]

J.11 Replacement Scenarios

The Navigant team assumes a retrofit scenario for measures found within the Street-Lighting sector. This scenario assumes that IOUs and other entities would conduct extensive lamp upgrade efforts as soon as possible in order to take advantage of the financial returns.

J.12 Measure Derating

After reviewing the measures and results developed by Navigant the team vetted them with stakeholders. These stakeholders, namely the IOUs, informed the Navigant team that lamps owned by the IOUs are likely not eligible to receive incentive funds through energy efficiency programs. Navigant summarizes the comments received:

- Comment 1: Approval and funding from the General Rate Case would be required before using incentive dollars for IOU-owned lamps. IOUs have historically refrained from using energy efficiency funds established for customers for the IOUs' own facilities.
- Comment 2: IOU-owned lamps are not replaced through customer energy efficiency programs. Instead funds must come from the General Rate Case.

Navigant reviewed IOU-supplied lamp inventories to quantify the distribution of lamps by ownership. Generally, ownership is distinguished by rate schedule where LS-1 includes IOU-owned lamps and LS-2 includes customer-owned lamps. Navigant views ownership distributions in terms of lamps counts and notes that this is approximately the same as comparing total energy consumption (kWh).

Table J-17. Street Lighting Ownership, by Lamp Count

IOU	IOU-Owned	Customer-Owned
Statewide	57.1%	42.9%
PG&E	26.3%	73.7%
SCE	82.4%	17.6%
SDG&E	19.0%	81.0%

Source: Navigant team analysis of the following sources in Section J.13: [2], [3], [4]

As a result, the Navigant team derated the initial potential results to only reflect those street lighting lamps owned by customers. At the statewide level energy efficiency potential is reduced by 57 percent.

J.13 Street-Lighting References

1. California Energy Commission. (2012). Quarterly Fuel and Energy Report (QFER) data. Data transmission from CEC to Navigant team. July 2012.
2. PG&E Street Lighting Inventory Data. Email from PG&E Staff to Navigant team, September 19, 2012.
3. SCE Street Lighting Inventory Data. Email from SCE Staff to Navigant team, September 7, 2012.
4. SDG&E Street Lighting Inventory Data. Email from SDG&E Staff to Navigant team, September 19, 2012.
5. PG&E. (2008). Electric Schedule LS-1. PG&E-Owned Street and Highway Lighting. Retrieved January 14, 2013. http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_LS-1.pdf.
6. PG&E. (2008). Electric Schedule LS-2. Customer-Owned Street and Highway Lighting. Retrieved January 14, 2013. http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_LS-2.pdf.

7. SCE. (2012). Schedule LS-1. Lighting-Street and Highway-Unmetered Service Company-Owned System. Retrieved January 14, 2013. http://www.sce.com/NR/sc3/tm2/pdf/ce36-12.pdf.
8. SCE. (2012). Schedule LS-2. Lighting-Street and Highway Customer-Owned Installation-Unmetered Service. Retrieved January 14, 2013. http://www.sce.com/NR/sc3/tm2/pdf/ce37-12.pdf.
9. SDG&E. (2012). Schedule LS-1. Lighting-Street and Highway-Utility-Owned Installations. Retrieved January 14, 2013. http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_LS-1.pdf.
10. SDG&E. (2012). Schedule LS-2. Lighting-Street and Highway-Customer-Owned Installations. Retrieved January 14, 2013. http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_LS-2.pdf.
11. California Energy Commission. (2013). Energy Consumption Data Management System (ECDMS). Electric Consumption by Entity. Last accessed on January 11, 2013. http://www.ecdms.energy.ca.gov/elecbyutil.aspx
12. City of San Diego. (2010). Advanced Street Lighting Technologies Assessment Project - City of San Diego. Retrieved September 6, 2012. http://www.sandiego.gov/environmental-services/energy/pdf/100104assessment.pdf.
13. Dialight. (2012). StreetSense RS Series LED Roadway Sign Light. Retrieved October 19, 2012. http://www.dialight.com/Assets%5CBrochures_And_Catalogs%5CIllumination%5CMDTSRSSTSX001.pdf.
14. Dialight. (2012). StreetSense RS Series LED Roadway Sign Light. Retrieved October 19, 2012. http://www.tcstraffic.com/product_docs/SS-LEDrdwaySignLight.pdf.
15. Philips. (2003). Highway Sign Lighting and QL Induction Lamps. Case Study. Retrieved October 19, 2012. http://www.greenerfacilities.org/admin/data/case_studies/Highway_Sign_lighting.pdf.
16. California Department of Transportation. (2004). 2004 Energy Conservation Plan Status Report. Retrieved October 19, 2012. http://www.dot.ca.gov/hq/energy/NRGReport04.pdf.
17. PGE. (2001). Statewide LED Traffic Signal Saturation Study, Final. Retrieved September 20, 2012. http://www.calmac.org/publications/LED%20Traffic%20Signals%20-%20Final.pdf.
18. California Code of Regulations. Title 20. Public Utilities and Energy. (November 2012). pages 248 to 249. Retrieved January 8, 2013. http://www.energy.ca.gov/2012publications/CEC-140-2012-002/CEC-140-2012-002.pdf.
19. Telephone discussion between PG&E, SCE, SDG&E (IOUs) and Navigant team. Estimation of LED traffic light saturation. Verbal estimates provided to Navigant team by IOUs. Discussion held on October 18, 2012.
20. California Lighting Technology Center, UC Davis. (2012). The State of Street Lighting in California, 2012. Retrieved on September 6, 2012. http://eec.ucdavis.edu/publications/2012_State_of_Street_Lighting_in_CA_Final_Report.pdf.
21. Street Lighting Consortium. (2012). Retrieved September 6, 2012. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/msslc_dallas2012_controls.pdf.
22. PG&E. (2010). Emerging Technologies Program, LED Street Lighting and Network Controls. Retrieved on October 8, 2012. http://www.etcc-ca.com/images/san_francisco_efficient_street_lighting_report.final.pdf.
23. Pike Research. (2012). Smart Street Lighting Report. Sourced from PikeResearch.com. Retrieved on October 12, 2012.
24. Advanced controls saturation in PG&E territory. Email from PG&E Staff to Navigant, October 16, 2012.

25. FF-Automation Oy. (2008). Autolog Street Light Control and Monitoring System. Retrieved on October 8, 2012. http://www.ff-automation.com/download/Documents/English/AutoLog_Presentations/AutoLog_ControlMan_street_light_control.pdf.
26. Pike Research. (2012). Smart Street Lighting Report. Sourced from PikeResearch.com. Retrieved on October 12, 2012.
27. City of Los Angeles. (2009). LED Equipment Evaluation Pilot Project Phase I. Retrieved September 6, 2012. http://www.ci.la.ca.us/bsl/LED_evaluation_report_phase_1.pdf.
28. City of Los Angeles. (2011). LED Equipment Evaluation Phase V: 100W HPS Equivalent. Retrieved September 6, 2012. http://www.ci.la.ca.us/bsl/LED_evaluation_report_phase_5_rev.pdf
29. Delta. (2010). Field Test Snapshots LED Street Lighting. Retrieved September 6, 2012. http://www.lrc.rpi.edu/programs/DELTA/pdf/FTDelta_LEDStreetLighting.pdf.
30. CEE. (1999). LED Traffic Signal Initiative Description. Retrieved on September 23, 2012. http://www.cee1.org/gov/led/led-init-desc.pdf
31. California Municipal Utilities Association CMUA. (2012). Energy Efficiency in California's Public Power Sector. Retrieved on October 8, 2012. http://www.anaheim.net/utilities/adv_svc_prog/SB1037.pdf.
32. Robert Mowris & Assoc. (2006). M&V Study of Energy Efficiency Programs. Retrieved on October 8, 2012. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CB8QFjAA&url=http%3A%2F%2Fwww.calmac.org%2Fevents%2F8_NCPA_SB5X_M%26V_Study_Mowris.ppt&ei=CO1yUMXmD5DK9gSmzYCgAw&usg=AFQjCNFrqYw9fEp4ov6G31T79ALhcRuk6w&sig2=S3vrnB5KcheiPx2tLTQz6Q.
33. PG&E. (2008). Emerging Technologies Program, LED Street Lighting. Retrieved on October 23, 2012. http://www.etcc-ca.com/images/stories/et_report_for_led_street_lighting_sf.final.011509.pdf.
34. SCE. (2007). VC Project 3 Oxnard Red Traffic Lamp Workpaper. Retrieved on October 8, 2012. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CCoQFjAC&url=http%3A%2F%2Fwww.nwcouncil.org%2Fdropbox%2F6th%2520Plan%2520Industrial%2FIndustrial%2520Conservation%2520Data%2520Catalogue%2FISC%2520Document%2520Catalogue_Public%2520Version-5%2520June%25202009%2FDocuments%2FTier%25202%2FSCE%2520EE%2520Work%2520Papers%2520November%25202007%2520Final%2FNonResidential%2FWPSCNRMI0044.0%2520-%2520VC%2520Project%25203%2520Oxnard%2520Red%2520Traffic%2520Lamp%2520.doc&ei=twJzUPf_POe20AGvu4DIDQ&usg=AFQjCNGNgkptfkRRxxFkdOZVQCWfRv_snQ&sig2=0ViTOjhRnb-rvmUl2zxfrQ.
35. SCE. (2007). VC Project 3 Oxnard Yellow Traffic Lamp Workpaper. Retrieved on October 8, 2012. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CCoQFjAC&url=http%3A%2F%2Fwww.nwcouncil.org%2Fdropbox%2F6th%2520Plan%2520Industrial%2FIndustrial%2520Conservation%2520Data%2520Catalogue%2FISC%2520Document%2520Catalogue_Public%2520Version-5%2520June%25202009%2FDocuments%2FTier%25202%2FSCE%2520EE%2520Work%2520Papers%2520November%25202007%2520Final%2FNonResidential%2FWPSCNRMI0045.0%2520-%2520VC%2520Project%25203%2520Oxnard%2520Yellow%2520Traffic%2520Lamp.doc&ei=Vw

RzUOSdFa2M0QG60IEo&usg=AFQjCNE7SHkWzOAu2AmEefwpvZ_Gbum3Rg&sig2=EqqqDkZwN8oXmy5b9scVhw.
36. PA Electric Company. (2011). Annual Report to the PA PUC. Retrieved on October 8, 2012. https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/ACT129/PENELEC%20Annual%20Report%20PY2Q4.pdf.
37. Bay Area Climate Collaborative BACC. (2012). Bay Area Next Generation Streetlight Initiative. Retrieved on October 8, 2012. http://energy-solution.com/etap/wp-content/uploads/2012/02/03-Rafael-Reyes-BACC.pdf

J.14 Street Lighting Sector Results

This section provides the estimates of potential energy and demand savings at the statewide level for the street lighting sector.

Note to the reader: This section reflects the potential associated street lighting lamps owned both by the customer and the utility. The values presented here should be derated by 57 percent to reflect only the customer-owned lamps that are considered within the goal setting and planning process that excludes IOU-owned lamps.

J.14.1 Overview

The potential energy savings in the street lighting sector do not include an assessment of the impact of upcoming codes and standards changes because, while some equipment deployed throughout the street lighting sector (e.g., traffic lights) may be subject to Federal standards, the majority of equipment are generally not subject to the same codes and standards (e.g., Title 24) that apply to the residential and commercial sectors.

The street lighting sector includes on electric consuming measures. Therefore, this portion of the analysis excludes gas potential.

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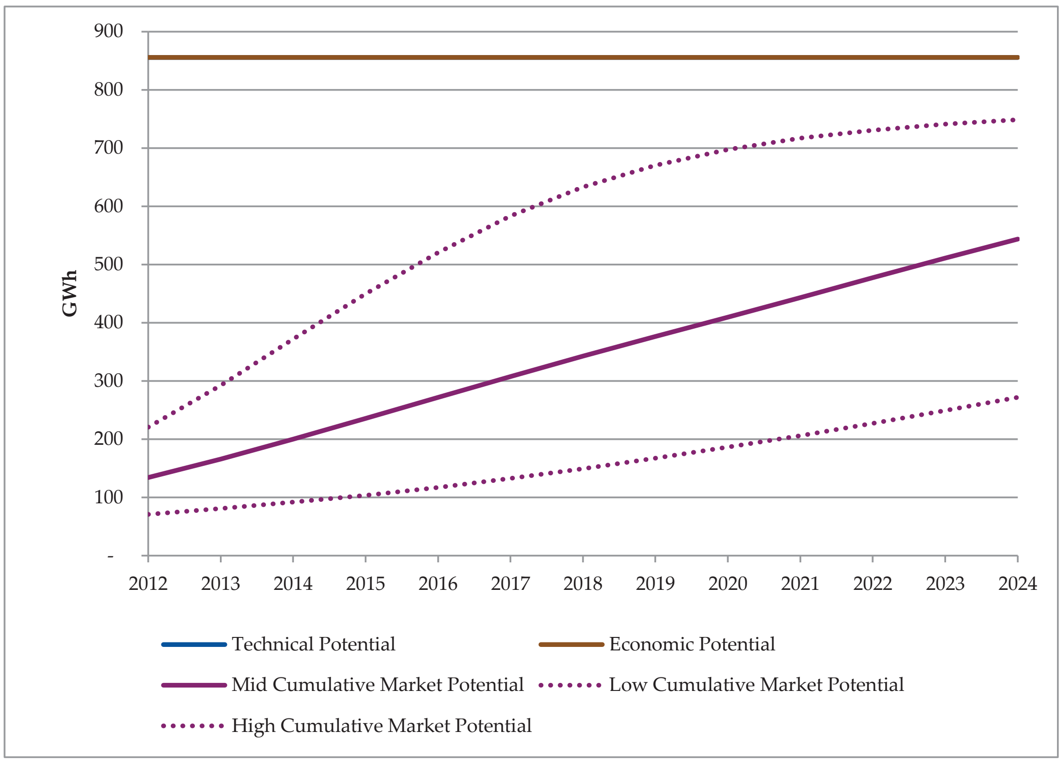
J.14.2 California Street Lighting Summary of Results

J.14.2.1 California Street Lighting Electric Energy Potential

As shown in Figure J-1, the street lighting technical and economic energy savings potential remains constant from 2012 through 2024. Technical and economic energy savings potential in the state of California stay steady at 855 GWh from 2012 through 2024. Cumulative market energy savings potential trails economic and technical energy savings potential and increases from approximately 134 GWh in 2012 to 544 GWh in 2024.

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



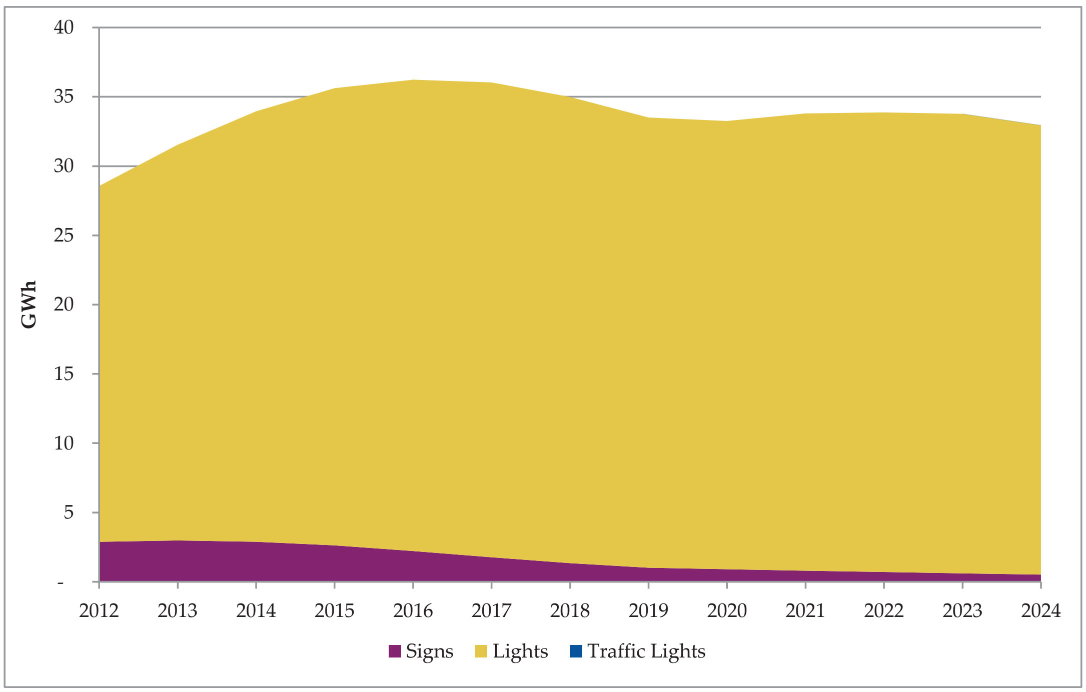
Source: PG model release February 2014

The Navigant team's street lighting cumulative market potential generally pertains to improvements for street lamps (highway and road illumination). Well over 80 percent of current lamps are high-pressure sodium and retrofits to LEDs and induction lamps provide significant potential savings and reductions in O&M costs due to extended lamp EULs. Additionally, emerging technologies for LEDs will further contribute to potential in future years.

Navigant examined the street lighting sector for demand (MW) potential. The Navigant team's analysis concluded that demand potential is negligible for this sector. Lamps within the streets subsector operate during nighttime hours and not during the peak demand period. Some street lamps do operate continuously in tunnels and other areas not exposed to daylight. However, Navigant estimates that the consumption and demand savings potential associated with those lamps are negligible. Additionally, traffic signals operate during the peak demand period. However, after accounting for low wattage LEDs, duty cycles, and coincidence factors Navigant concluded that this consumption and demand savings potential associated with these lamps are also negligible.

Figure J-2 presents the incremental market energy savings potential in the street lighting sector by end use. The incremental market potential remains fairly steady over the analysis period due to the significant presence of baseline street lamps and the significant savings opportunities present for these measures. Additionally, LED emerging technologies provide sustained energy savings potential for the sector, and cumulative market potential reaches 40 percent of consumption by 2024. Savings from traffic lights are negligible because the current stock is completely LED.

Figure J-2. California Street Lighting Gross Incremental Market Energy Savings Potential for 2012-2024 (GWh)



Source: PG model release February 2014

J.14.2.2 California Street Lighting Electric Comparative Metrics

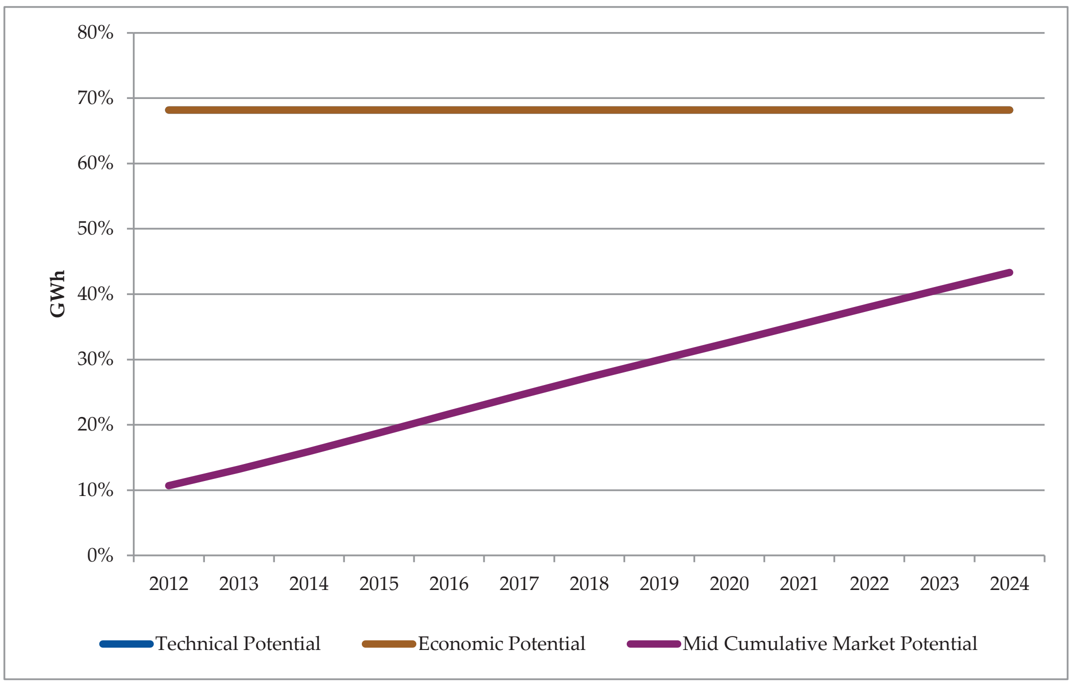
This subsection includes a series of comparative metrics that provide a context from which to assess the reasonableness of the results from the 2013 street lighting analysis. These comparisons also served as a quality control tool during the study and provide a road map for areas of focus for future utility portfolios. For street lighting, comparative metrics are limited because this analysis is the first time that street lighting is explicitly examined and few other third-party efforts have been conducted in the past. Additionally, the IOU compliance filing data provided to Navigant did not include data specific to the street lighting sector. The following comparative metrics are provided:

» Cumulative market potential as compared to the total CEC consumption forecast for the street lighting sector

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 J-3 shows the technical, economic, and cumulative market potential savings as a percent of the CEC street lighting forecast. Technical and economic potentials are about 67 percent to 70 percent of the CEC street lighting consumption forecast in 2012 through 2024. Cumulative market potential rises from about 11 percent in 2012 up to 43 percent by 2024.

Figure J-3. California Street Lighting Savings Potential as a Percent of CEC Street Lighting Forecast (Technical, Economic, and Active Cumulative Market Potential)



Source: PG model release February 2014