State of Hawaii Energy Efficiency Potential Study

Final

Project #1448

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EXECUTIVE SUMMARY

The Hawaii Public Utilities Commission (PUC) contracted with EnerNOC to conduct an independent evaluation of energy efficiency (EE) market potential in the State of Hawaii from 2013–2030. This study identifies the potential that can be achieved by contributing entities toward achieving the goals outlined in the state's Energy Efficiency Portfolio Standard (EEPS).

Key Findings

The purpose of the study was to assess whether the State is on track to meet the EEPS goals by 2030. As shown in Figure ES-1, this study concludes it is **highly** likely that the **EEPS** goals can be met through a combination of interventions:

- **Energy-efficiency programs** like those being delivered by Hawai'i Energy [the Public Benefits Fee Administrator (PBFA)][1] and Kauai Island Utility Cooperative (KIUC)
- **Existing appliance standards and building codes** that are already in place or "on the books" for the next five years. Federal, state and local codes and standards taking effect on or after January 1, 2009 count toward EEPS goals. Savings from these existing codes and standards are substantial and reflect the federal Energy Independence and Security Act of 2007 (EISA) lighting standard and several federal appliance standards that were established since the EEPS goal was set in 2008.
- **Economic potential** is the amount of cost-effective potential remaining after appliance standards and building codes are taken into consideration. In addition to savings that can be gained through future EE programs, economic potential also includes savings that result from changes in manufacturing practices as a result of agreements with ENERGY STAR or energy efficiency agencies (most notable for consumer electronics) and savings from early adopters that purchase energy-efficient appliances or equipment **outside** of programs. While these latter two categories, (savings from manufacturing practices and from early adopters) are not directly attributed to energy efficiency programs offered by KIUC or the PBFA, the savings are significant. If a method can be developed to measure the savings from these categories in the future, it might be appropriate to count these savings toward the EEPS goal.

Figure ES-1 shows the year-by-year potential savings from the interventions against the EEPS goal. This study was grounded in 2012 and estimates potential savings for 2013 through 2030. For 2009–2012, program savings estimates developed outside this study were used and are assumed to decay over time. The study estimates that cost-effective cumulative energy efficiency potential in 2030 is 6,210 GWh, or about 144% of current EEPS goals. This indicates that the while the EEPS goals are aggressive, it is likely they can be met cost-effectively.

[1] Hawai'i Energy is a ratepayer-funded efficiency services program implemented by the Public Benefits Fee Administrator under contract to the PUC.

Figure ES-1 Potential Savings Estimates Compared to the EEPS Goal (GWh)

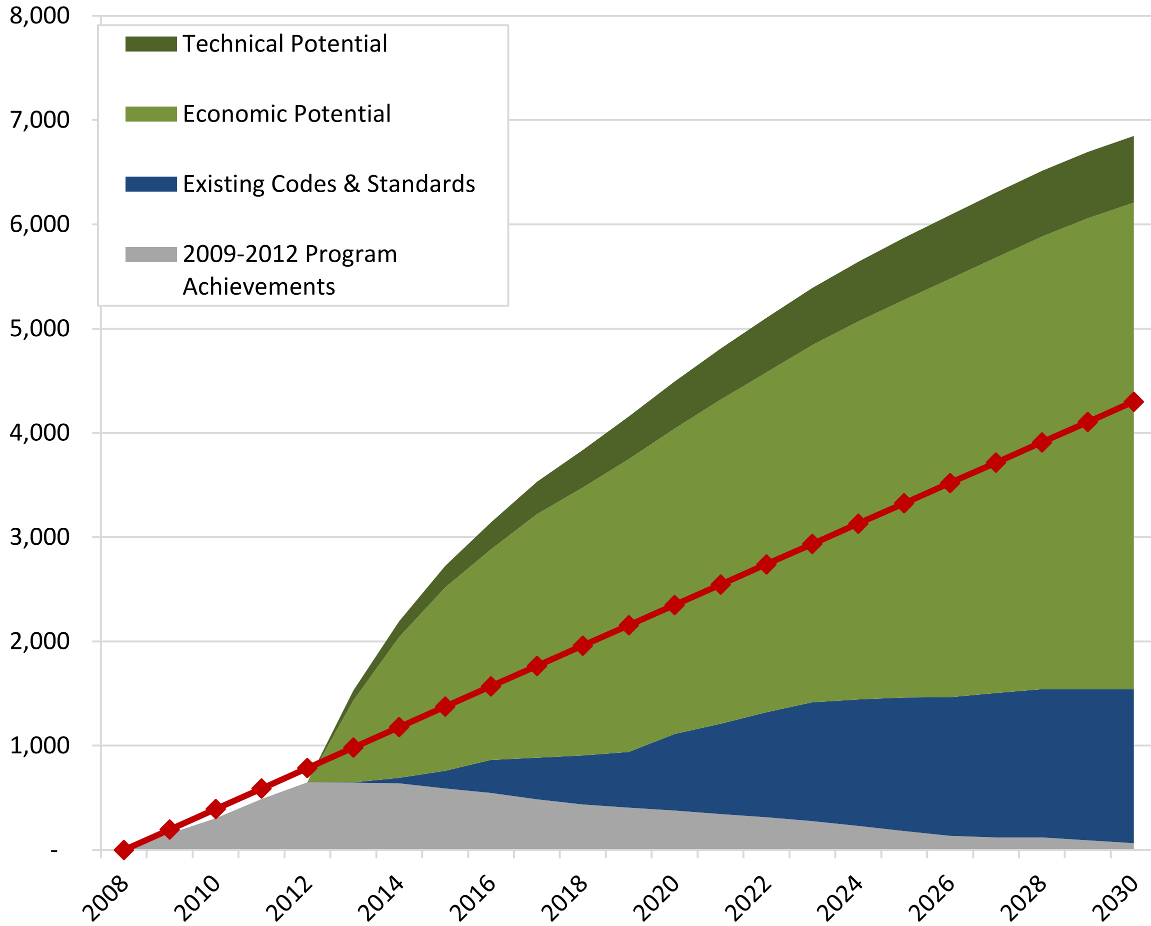


Table ES-1 compares the EEPS goals and the levels of cumulative potential for selected years. The last column shows the marginal contribution of each potential level relative to the next. It also shows the percentage of the 4,300 GWh goal corresponding to each level's marginal contribution.

Table ES-1 Potential Energy Efficiency Savings Relative to EEPS GWh Goal

	2015	2020	2025	2030	Marginal Contribution in 2030
EEPS GWh Goal	1,375	2,350	3,325	4,300	n/a
Cumulative Savings (GWh)					
2009-2012 Program Savings	591	377	182	64	64
Existing Codes & Standards	759	1,110	1,461	1,540	1,476
Economic Potential	2,519	4,042	5,275	6,210	4,670
Technical Potential	2,724	4,493	5,870	6,848	638
Energy Savings (% of EEPS GWh Goal)					
2009-2012 Program Savings	43%	16%	5%	1%	1%
Existing Codes & Standards	55%	47%	44%	36%	34%
Economic Potential	183%	172%	159%	144%	109%
Technical Potential	198%	191%	177%	159%	15%

The remainder of this executive summary provides a high-level overview of the key elements of the study.

Study Objectives

The study objectives address energy efficiency potential and inform the program design process in the following ways:

- Develop a thorough and independent assessment of the energy efficiency resources available to the State through the actions of entities that contribute savings toward EEPS goals using allowable measures and activities per the EEPS Framework.
- Develop technical and economic potential estimates for 2013–2030 for benchmarking and future analyses by island.
    - Annual kWh savings and peak savings (net and gross).
    - Reporting tables that convey the potential that has been captured from 2009 through present, in addition to savings available in 2013 and beyond.
- Provide guidance and insight regarding attainment of the EEPS goals based on the energy savings opportunities identified in the potential study and relative to the EEPS base year of 2008.
- Provide estimates of available energy efficiency potential that can be used as a resource and included in IRP filings by the Hawaii electric utilities [Hawaiian Electric Company (HECO), Hawaii Electric Light Company (HELCO), Maui Electric Company (MECO) and Kauai Island Utility Cooperative (KIUC)].
- Provide a transparent and thoroughly documented energy efficiency potential model for the State of Hawaii. Report the results at the following levels:
    - Statewide
    - Utility service territory (HECO, MECO, HELCO, KIUC)
    - Island (Oahu, Hawaii, Maui, Kauai, Molokai, Lanai)
    - Contributions from entities regulated by PUC, such as the utilities and Hawai'i Energy, and from non-regulated entities such as from programs offered by government agencies or nonprofits that offer energy efficiency programs, and/or from governmental decisions to enact codes & standards. This includes contributions from the military and government buildings.
- Develop an EE potential study that is useful for all stakeholders including the PUC, the Consumer Advocate, Hawai'i Energy, EEPS facilitator, EEPS Technical Working Group, the HECO Companies, and KIUC.

Definition of Energy-Efficiency Savings

In this study, we estimate the potential for savings from contributing entities relative to the January 1, 2009 baseline established with the creation of the EEPS goals. The savings estimates represent the potential that could be achieved from all contributing entities. We present four levels of potential contribution to the EEPS goals. The various levels are described below.

- **Technical potential.** For energy efficiency, technical potential is defined as the theoretical upper limit of energy efficiency potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option. Technical potential also assumes the adoption of every other available measure, where applicable. This level of potential is inclusive of all levels of potential, including economic and savings from existing codes and standards. These subsets of technical potential are described below.
- **Economic potential.** The economic potential is a subset of technical potential and represents the adoption of all **cost-effective** energy efficiency measures. The EEPS statute requires that all cost-effective energy efficiency is pursued. In this analysis, cost-effectiveness is measured from a societal perspective by the total resource cost (TRC) test. As with technical potential, economic potential is a hypothetical case that assumes that all applicable customers will adopt the measure.

- **Existing codes and standards.** This case reflects savings from federal or state codes or standards that have been approved and on the books since 2008, when the EEPS goal was set, and through mid-2013 when the study was performed. These savings from existing codes and standards come from improvements in appliance, equipment, or building efficiency. These standards include the lighting standards from EISA that increased the lumens per Watt requirement of lamps and has resulted in the phasing out of incandescent light bulbs starting in 2012. They also include the consensus agreement reached between the Association of Home Appliance Manufacturers (AHAM) and appliance manufacturers in 2012, which resulted in standards that become effective starting in 2014. They also include Hawaii-specific building codes, such as the requirement that newly constructed single-family homes use solar hot water heaters.
- **2009–2012 Program savings.** These savings are the energy efficiency program savings that were achieved through programs offered by KIUC and the PBFA administrator between 2009 and 2012. These programs have shown increasing savings as investment in the program has grown.

Study Approach

To execute this project, EnerNOC used a bottom-up analysis approach that involved the following steps.

1. Held a meeting with the EEPS Technical Working Group project team to refine the objectives.
2. Performed a market characterization to describe sector-level electricity use for the residential and non-residential (commercial, industrial, military, water/wastewater and street lighting) sectors for the base year, 2012.
3. Developed a baseline projection that does not include the impact from appliance standards since 2008, building codes since 2008, market driven conservation, or impacts from any DSM programs. This was developed using EnerNOC's Load Management Analysis and Planning (LoadMAP™) tool. The projection is therefore labeled LoadMAP baseline projection. The LoadMAP projection is in alignment with the forecasts provided by the HECO Companies and KIUC.
4. Identified and characterized existing appliances and equipment used in residential and commercial buildings, as well as energy efficiency measures. The measures are characterized based on the Hawaii Technical Reference Manual (TRM), EnerNOC's Building Energy Simulation Tool (BEST), and EnerNOC's own measure database.
5. Developed projections for the three levels of savings considered in this study: Existing Codes & Standards, Economic Potential, and Technical Potential.

We used EnerNOC's LoadMAP version 3.0 to develop the baseline projection and the estimates of energy efficiency potential. EnerNOC developed LoadMAP in 2007 and has enhanced it over time, using it for the Electric Power Research Institute (EPRI) National Potential Study and dozens of utility-specific forecasting and potential studies.

Details of the approach as well as the data sources used in the study appear in Chapter 2.

Market Characterization

Total electricity use for the residential, commercial, water/wastewater, military, and outdoor lighting sectors for the state of Hawaii in 2012 was 9,639 GWh.[2] As shown in Figure ES-2, the largest sector is commercial, accounting for 52% of electricity sales, followed by residential, with 32% of sales. The residential and commercial sectors were modeled in LoadMAP while the military, water/wastewater and street lighting sectors were estimated outside of the LoadMAP model.

[2] Energy usage as measured "at-the-meter," i.e., does not include line losses.

Figure ES-2 Statewide Electricity Use by Sector, 2012 (9,639 GWh)

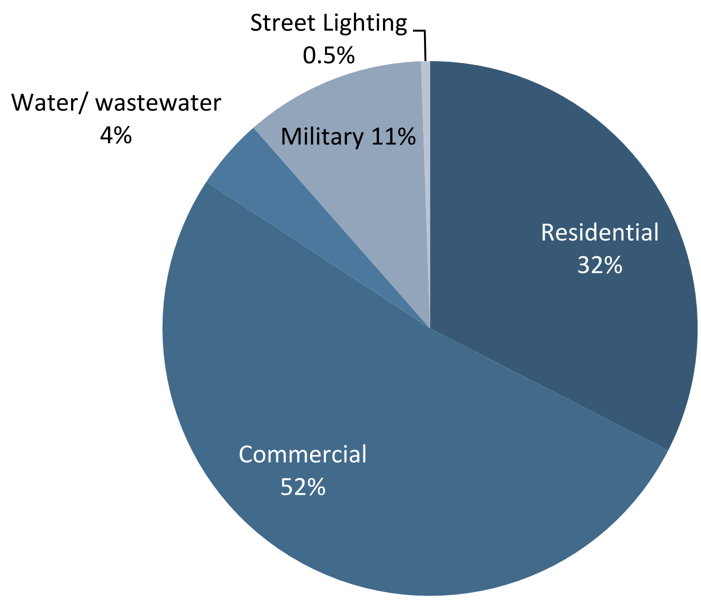


Figure ES-3 presents the shares of residential electricity use statewide by housing type: single family/owner occupied, single family/renter, multifamily/owner occupied, multifamily/renter, master-metered apartments. The majority of the homes are single-family homes, which are also primarily owner occupied. For the purposes of the modeling, we separated the typical residential housing unit energy use within large multi-family master-metered apartments from the commercial building usage. To capture the difference in sales we modeled the cooling, water heating, and pool equipment energy use in the commercial sector because those energy uses typically apply to the entire building. Chapter 3 describes in detail of how the usage was split.

Figure ES-3 Share of Residential Sector Electricity Sales, Statewide by Housing Type, 2012

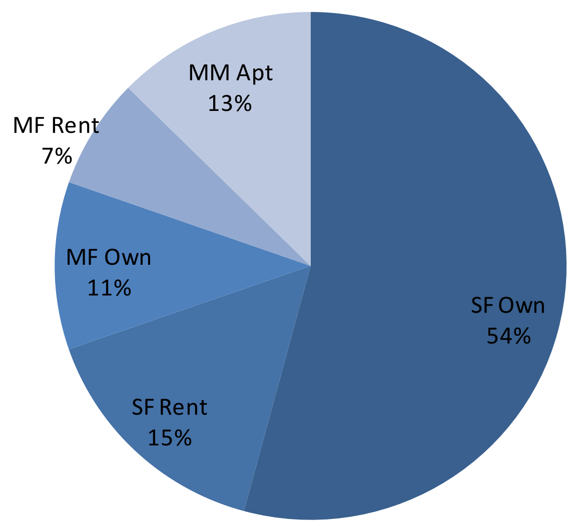


Figure ES-4 shows the breakdown of annual use per household by end use for each segment in the residential sector for the entire state. Appliances represent the largest end use with 36% of usage, followed by water heating with 19%, and lighting (interior and exterior) with 16%.

Figure ES-4 Annual Electricity Use by End Use and Housing Type, Statewide 2012

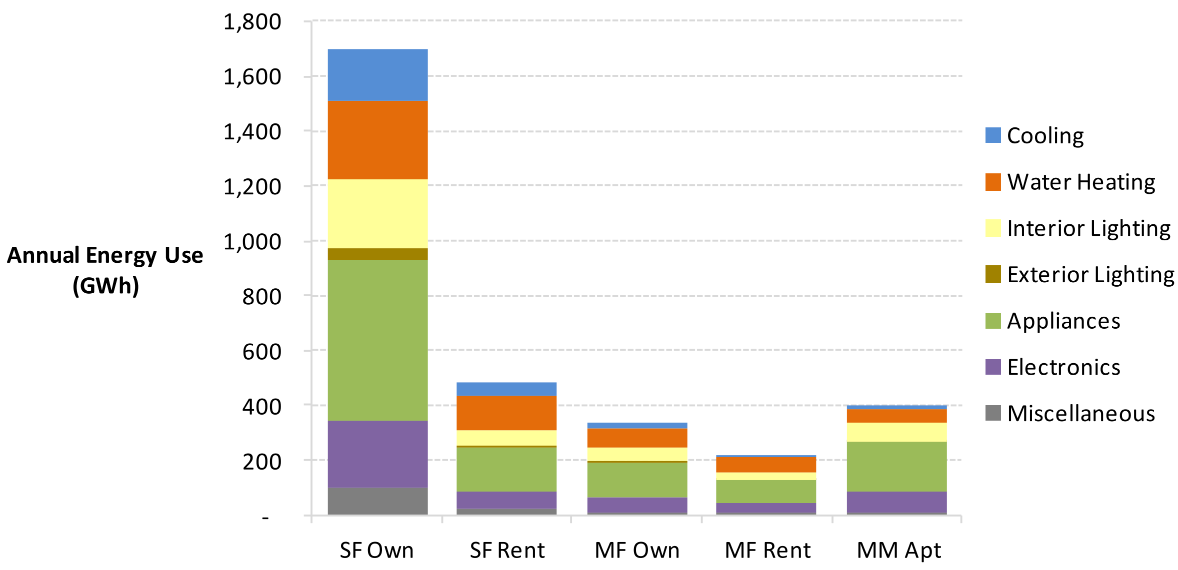


Figure ES-5 shows the percentage of the 2012 commercial energy use, 4,983 GWh, by each of the 11 segments analyzed for the potential study. The retail segment, which also includes services, constitutes 19% of total energy use, with offices making up about 14% of the commercial sector energy use. The largest segment is miscellaneous and contains a variety of building types, not elsewhere identified, including manufacturing facilities.

Figure ES-5 Share of Commercial Sector Electricity Use by Building Type, Statewide, 2012

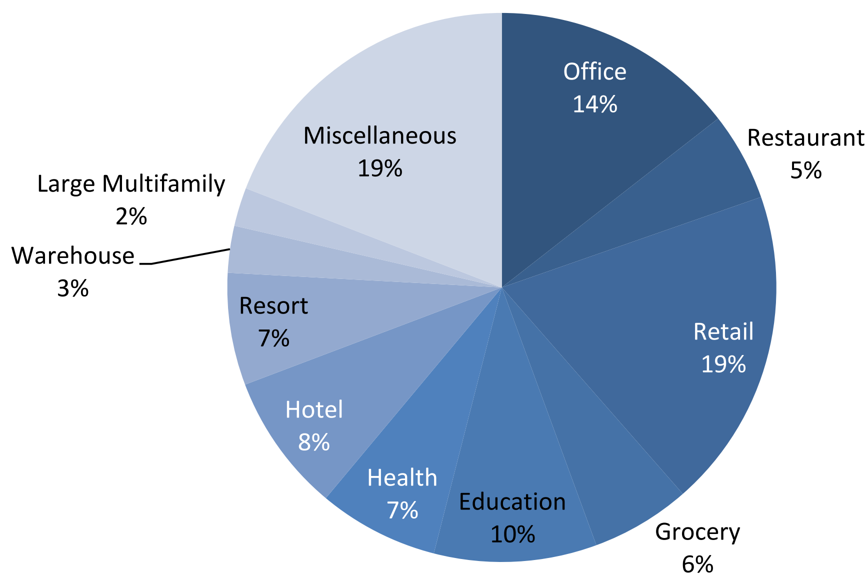


Figure ES-6 shows the breakdown of annual commercial electricity usage by end use for the commercial sector as a whole for the state. Lighting (interior and exterior) is the largest single end use in the commercial sector, accounting for about 34% of total usage. Cooling consumes 29% of energy use. Each of the remaining end uses accounts for 10% or less of total usage.

Figure ES-6 Commercial Electricity Consumption by End Use, Statewide, 2012

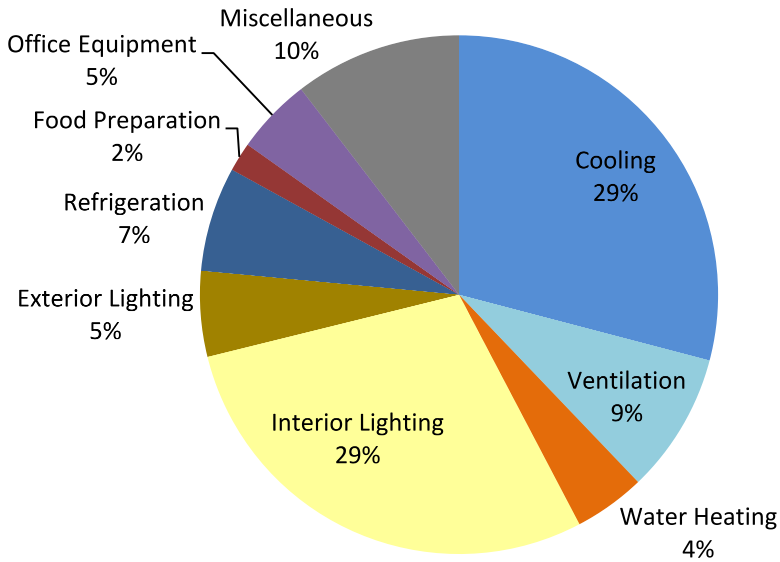
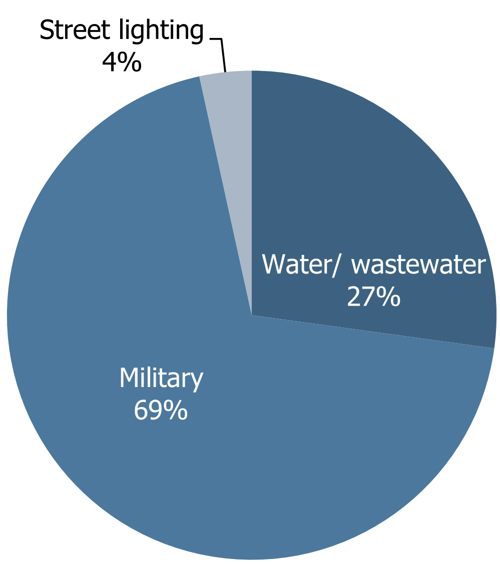


Figure ES-7 shows the distribution of energy use by all other sectors. These three sectors are not modeled in LoadMAP because there was not enough detail to break each sector out by segment, end use, or technology. These segments are characterized by using utility billing data. Energy efficiency potential for each of these sectors is handled separately using information from the Baseline Study[3].

Figure ES-7 Other Sectors Electricity Sales by Sector, Statewide, 2012



[3] *Baseline Energy Appliance Equipment and Building Characteristics Study*. Prepared for the State of Hawaii Public Utilities Commission. Evergreen Economics, Inc., 2013.

LoadMAP Baseline Projection

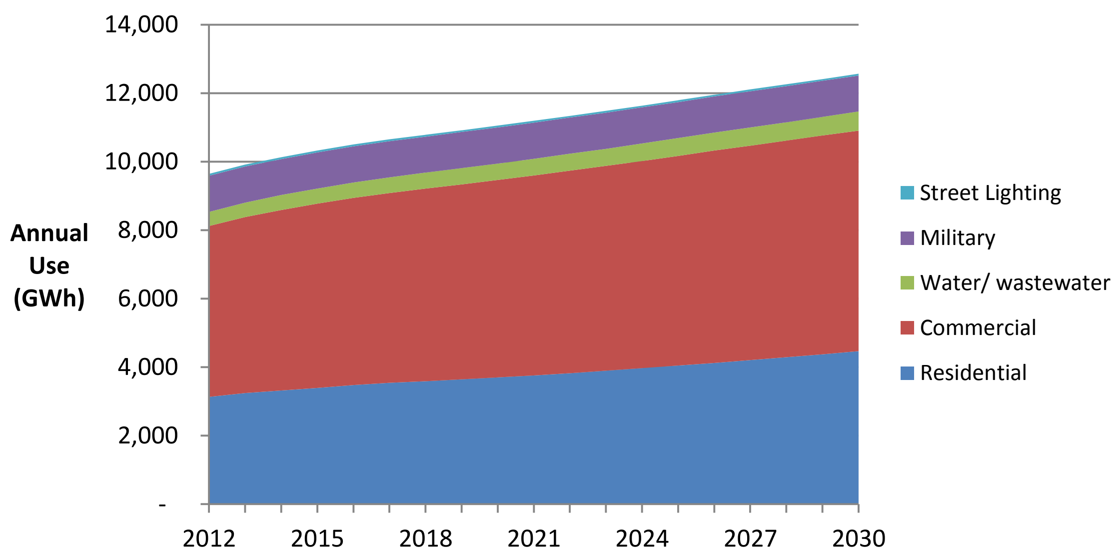
Prior to developing estimates of savings potential, a LoadMAP baseline projection was developed to quantify how electricity is used by end use in the base year and what the consumption is likely to be in the future. The LoadMAP baseline is a fixed-efficiency projection that **does not include** the impact of early adoption, market transformation, naturally occurring conservation, spillover, price effects, existing codes and standards, or future market interventions by contributing entities beyond 2012. The LoadMAP projection serves as the metric against which savings from each type of intervention is measured.

Table ES-2 and Figure ES-8 show the LoadMAP projection for all the sectors statewide. The commercial sector is the largest sector, accounting for over half the energy use in 2030.

Table ES-2 LoadMAP Baseline Projection Summary, Statewide (GWh)

Sector	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Residential	3,136	3,398	3,698	4,047	4,463	42%	2.0%
Commercial	4,983	5,373	5,765	6,123	6,444	29%	1.4%
Water/wastewater	413	446	480	516	553	34%	1.6%
Military	1,054	1,054	1,054	1,054	1,054	0%	0.0%
Street Lighting	52	54	57	59	62	20%	1.0%
Total	**9,639**	**10,324**	**11,054**	**11,800**	**12,577**	**30%**	**1.5%**

Figure ES-8 LoadMAP Baseline Projection Summary, Statewide (GWh)



Characterization of End-Use Technologies and Efficiency Measures

To develop the LoadMAP baseline projection and the four potential cases, the study began with a characterization of the end-use appliances and equipment in the marketplace and those likely to come into the mainstream in the future. These include central air conditioners, heat pump water heaters, and LED lighting in the residential sector. The basic technology building blocks are presented in the market profiles in Chapter 3.

To estimate the savings that are expected to be achieved through existing codes and standards, and energy-efficiency programs, the study identified the list of all relevant EE measures that should be considered for the State of Hawaii. Sources for the measure assumptions were drawn first from the Hawaii TRM, followed by the EnerNOC's measure database. To supplement these sources, we used EnerNOC's building modeling tool BEST and other measure databases from previous studies and program work. The measures are categorized into two types according to the LoadMAP taxonomy: equipment measures and non-equipment measures:

- **Equipment measures,** or efficient energy-consuming pieces of equipment, save energy by providing the same service with a lower energy requirement. An example is the replacement of a standard efficiency refrigerator with an ENERGY STAR model. For equipment measures, many efficiency levels are available for a specific technology that range from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the federal standard EER 13 unit and spans a broad spectrum of efficiency, with the highest efficiency level represented by an EER 21 unit.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve replacement or purchase of major end-use equipment (such as a refrigerator or air conditioner). An example would be a programmable thermostat that is pre-set to run the air conditioner only when people are home. Non-equipment measures fall into one of the following categories:
    - Building shell (windows, insulation, roofing material)
    - Equipment controls (thermostat, occupancy sensors)
    - Equipment maintenance (cleaning filters, changing setpoints)
    - Whole-building design (natural ventilation, passive solar lighting)
    - Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)
    - Displacement measures (ceiling fan to reduce use of central air conditioners)
    - Commissioning and retrocommissioning

Table ES-3 summarizes the number of equipment and non-equipment measures evaluated for each segment.

Table ES-3 Number of Unique Measures Evaluated

	Residential	Commercial	Total Number of Measures
Equipment Measures Evaluated	102	115	**217**
Non-Equipment Measures Evaluated	44	81	**125**
Total Measures Evaluated	**146**	**196**	**342**

Estimates of Energy-Efficiency Savings

Table ES-4 and Figure ES-9 summarize the energy efficiency savings for the different levels of potential relative to the 2008 reference forecast. The 2008 reference forecast is the 2008 Hawaii forecast (developed in 2004) upon which the EEPS goals are based.

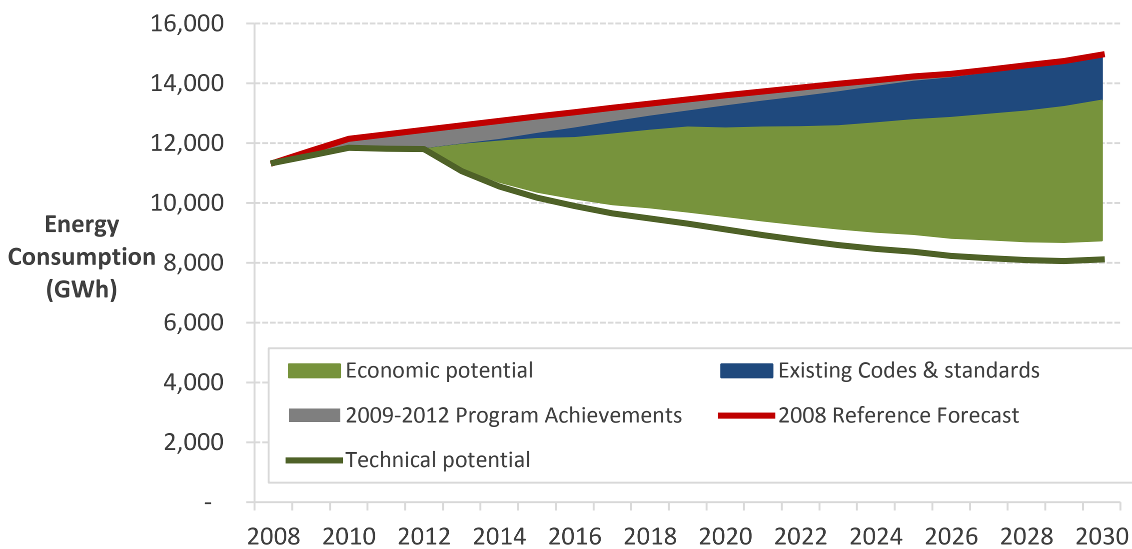
- **Technical potential,** which reflects the adoption of all energy efficiency measures regardless of cost-effectiveness, is a theoretical upper bound on savings. In 2030, energy savings are 6,848 GWh, or 46% of the 2008 reference forecast for that year.
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 6,210 GWh in 2030. This represents 42% of the 2008 reference forecast for 2030 and 92% of the technical potential. Due to the high avoided costs in Hawaii it not surprising that the majority of the technical potential is also economic. Like technical potential, economic potential is an analytical measure of analysis that does not reflect what is expected to be achieved.
- **Existing codes and Standards** which reflects the savings that are achieved by the federal and state appliance standards and building codes, is 1,540 GWh in 2030 statewide. This represents 10% of the 2008 reference forecast in 2030. These savings come from codes and standards enacted between January 1, 2009, and December 31, 2012, which can contribute to meeting EEPS goals.

- **2009–2012 Program Savings** reflect the program achievements from the PBFA and KIUC between 2009 and 2012 that contribute to meeting the annual EEPS goals. Due to the decay rate of these savings, the 2009–2012 program savings only contribute 64 GWh in 2030 or 0.4% of the 2008 reference forecast for 2030.

Table ES-4 Summary of Energy Efficiency Potential, Statewide Relative to 2008 Reference Forecast

	2015	2020	2025	2030	Marginal Contribution in 2030
2008 Reference Forecast	12,898	13,606	14,235	14,963	n/a
Cumulative Savings (GWh)					
2009-2012 Program Savings	591	377	182	64	64
Existing Codes & Standards	759	1,110	1,461	1,540	1,476
Economic Potential	2,519	4,042	5,275	6,210	4,670
Technical Potential	2,724	4,493	5,870	6,848	638
Energy Savings (% of 2008 Reference Forecast)					
2009-2012 Program Savings	5%	3%	1%	0%	0%
Existing Codes & Standards	6%	8%	10%	10%	10%
Economic Potential	20%	30%	37%	42%	31%
Technical Potential	21%	33%	41%	46%	4%

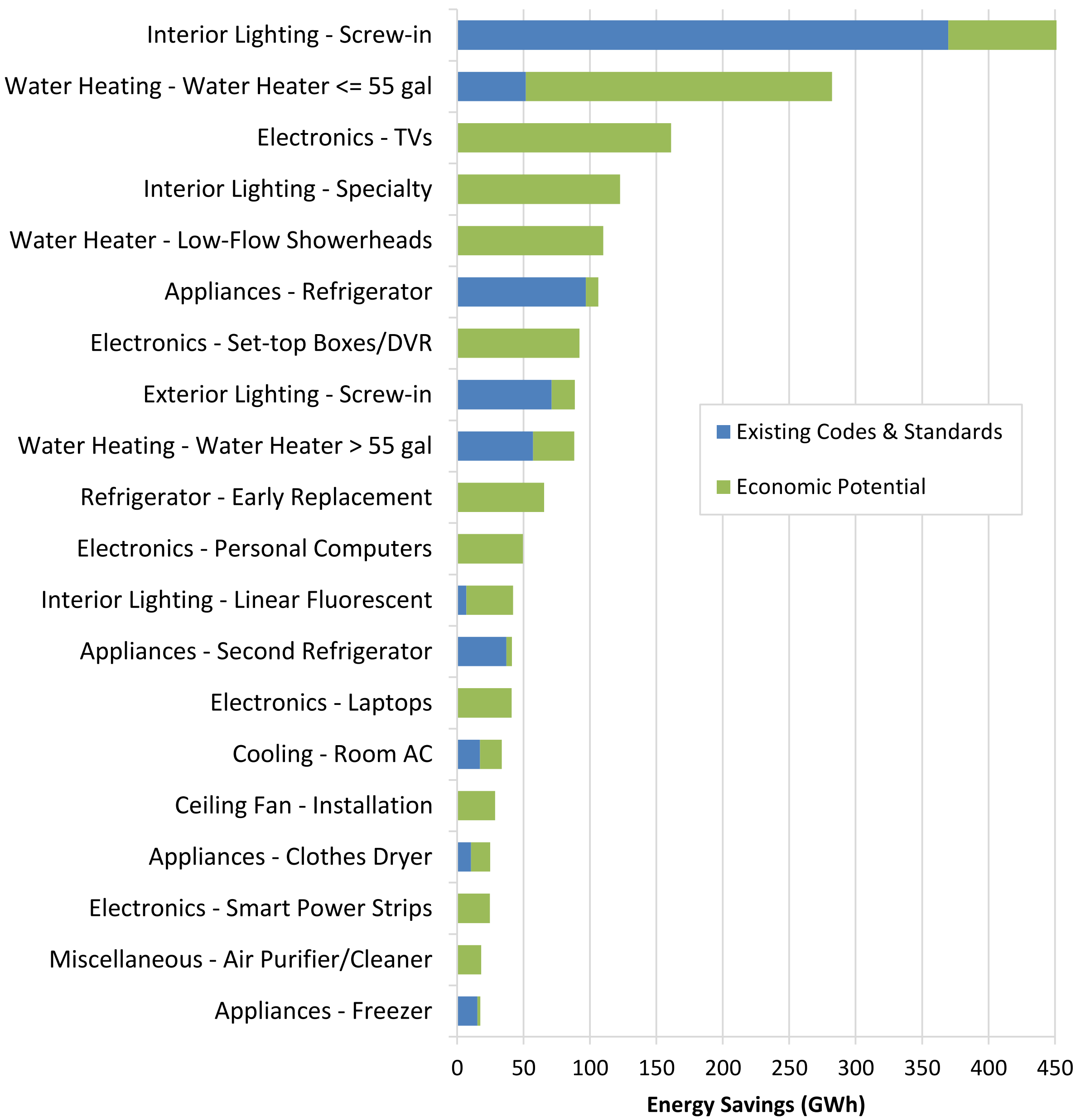
Figure ES-9 Savings Estimates with Respect to 2008 Reference Forecast



Residential Sector Savings. Figure ES-10 focuses on the statewide residential cumulative potential from 2013 to 2030.

- Lighting, where codes and standards savings are primarily due to the EISA standard, while additional economic potential is due to conversion to LED lamps.
- Water heating, including low-flow showerheads, efficient water heaters, and solar water heaters, can be achieved through interventions by contributing entities such as Hawaiʻi Energy or KIUC programs. Solar water heating is required by building code in new single-family construction.
- Electronics, including efficient televisions, computers, and set top boxes, which are primarily driven by manufacturers voluntarily choosing to produce products conforming to ENERGY STAR guidelines. (See Chapter 6 in the body of the report for an explanation of market driven and spillover savings.)

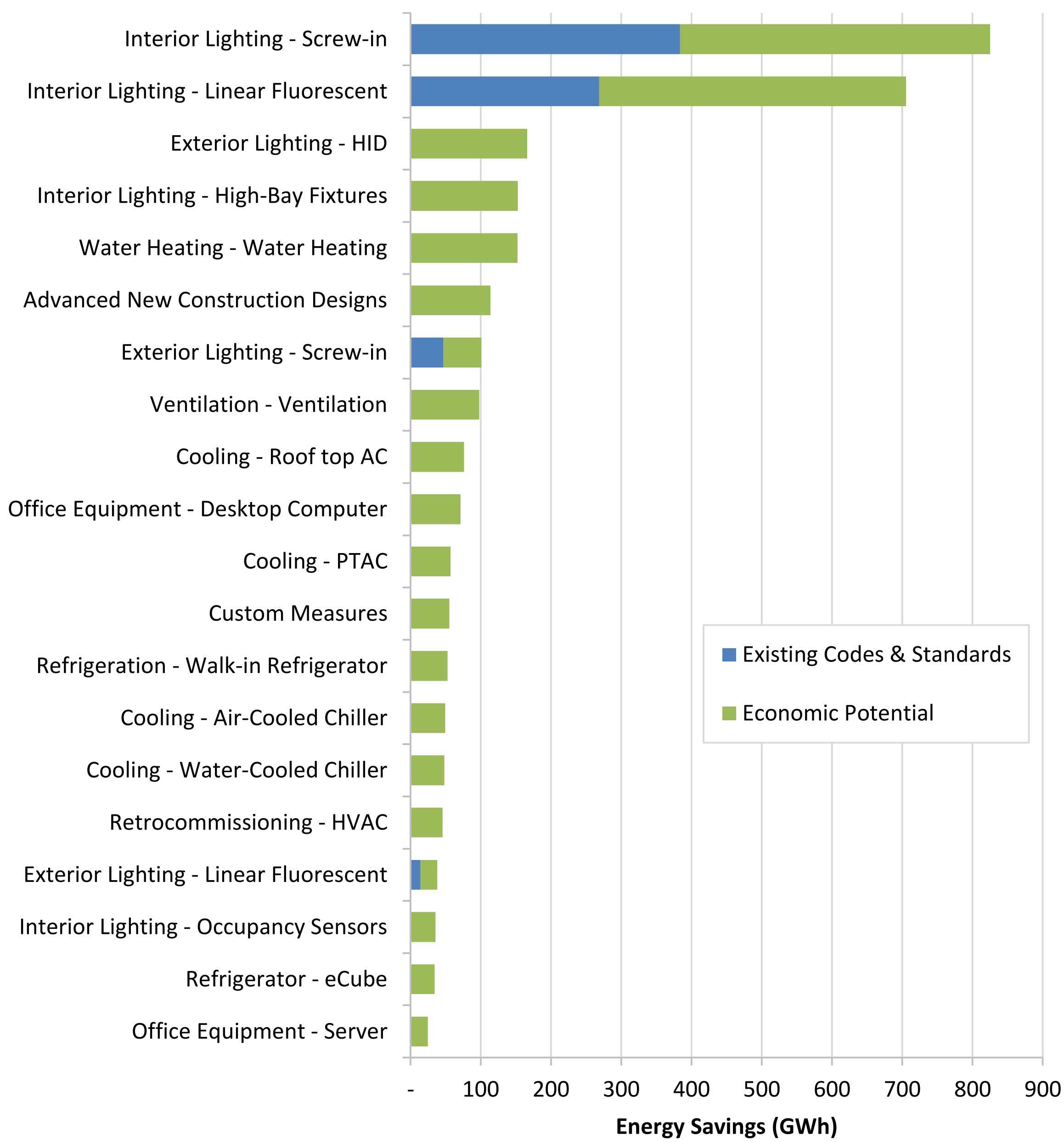
Figure ES-10 Residential Energy Efficiency Potential by Category, Statewide (Cumulative in 2030)



Commercial Sector Savings. As shown in Figure ES-11 the primary sources of commercial sector energy efficiency savings between 2013 and 2030 are as follows:

- Screw-in lighting savings in the Codes & Standards case result from the EISA standard that removes most incandescent lamps by 2014. Economic potential savings results from the adoption of LED interior and exterior screw in lighting.
- Linear fluorescent light bulbs, including the installation of super T8 light bulbs, which are driven by the federal lighting standard and through interventions such as PBFA or utility programs.
- Water heating including the conversion to heat pump water heaters as part of interventions such as PBFA or utility programs.

Figure ES-11 Commercial Energy Efficiency Potential by Category, Statewide



Findings, Conclusions, and Recommendations

The results of this study reveal that significant energy efficiency opportunities exist in the State of Hawaii. Before providing conclusions and recommendations, we provide a high-level overview of electricity use on the islands:

- The commercial sector makes up almost half of the energy use in the state. The primary segments are retail/services and offices. The miscellaneous segment is also large and includes any manufacturing facilities. The primary end uses for the commercial sector are lighting and cooling.
- The residential sector accounts for 32% of the statewide energy use in 2012. The sector is dominated by owner-occupied single family homes, which represent 46% of homes and 54% of residential energy use. The average energy use per home for single-family homes is significantly higher than multi-family homes due to the larger size, the higher saturation of air conditioning, and more appliances and electronics within the single-family homes. Appliances, water heating, and lighting are the largest end uses in the sector.
- The military is the third largest energy sector within the state. The military sector includes energy use from residential housing that is located on military bases because military accounts do not differentiate between housing and other end uses of energy. Due to the sensitive nature of military energy usage details, the military was separately characterized using a case study analysis conducted as part of the Baseline Study. Future energy efficiency potential studies, as well as energy efficiency program design efforts, would benefit from additional detailed study of military energy end use characteristics in cooperation with the Department of Defense.
- In the absence of energy savings from building codes, appliance standards, or PBFA/utility energy efficiency programs, the baseline forecast is expected to grow substantially; at an average of 1.5% per year through 2030. The largest increase will come from the residential sector with a 42% increase in energy use between 2012 and 2030.

By 2030, there is substantial potential for reducing energy use in the state — 6,210 GWh of economic potential. The analysis shows that in 2030 energy efficiency could easily more than offset any anticipated load growth.

- The analysis attempts to breakdown how the potential energy efficiency savings could be achieved. A large portion of the savings will come from the federal appliance standards and state building codes. The analysis considers savings from any appliance standard or building code that was "on the books" since 2008. This includes the EISA lighting standard that phases out incandescent lamps by 2014.
- With extremely high avoided costs in Hawaii, a considerable amount of the technical potential is considered economic (cost-effective). Although there are additional barriers to adopting economic measures, a best-in-class PBFA or utility program can expect to achieve the majority of the potential economic savings. In order to achieve these savings, the current programs need to continue to increase awareness of the value of energy efficiency and accelerate energy savings.
- The majority of the statewide energy efficiency savings potential is found in the commercial sector. However, in the early years almost half of the energy efficiency savings potential comes from the residential sector.
- In the residential sector, the potential savings come from a few key energy efficiency measures. Screw-in lighting savings includes the conversion of interior and exterior lamps to LED lamps. Water heating savings can be achieved, typically through PBFA or utility programs, by installing solar water heating or heat pump water heaters, as well as low flow showerheads and faucet aerators. Electronics, such as televisions, computers, and set top boxes are primarily driven by industry practices that primarily manufacture to ENERGY STAR guidelines.
- In the commercial sector, the majority of potential savings are driven by lighting improvements. Similar to the residential sector, significant savings can be achieved through changing screw-in lamps to LED lamps. Savings from linear fluorescent light bulbs, including the installation of super T8 light bulbs, are driven by the federal lighting standard, as well as PBFA and utility programs. Water heating savings can be achieved through the installation of heat pump water heaters through PBFA or utility programs.

- Although a measure-level analysis is not available for the military and water and wastewater sectors, the savings that can be achieved from these sectors are significant. The military is working to meet a federal mandate to achieve aggressive energy efficiency goals. The state should work closely with the military to maximize the energy savings. For the water and wastewater sector, significant savings can be achieved by working with government agencies and private-sector entities that provide water supply and wastewater services.
- The State EEPS goal of 4,300 GWh was proposed based on approximately 30% savings from the 2008 Reference Forecast. However, given subsequent deviations from the original Reference Forecast due to economic changes, the 4,300 GWh goal has likely become a slightly larger percentage of 2030 sales than it was when originally developed. Based on the baseline sales in 2030 projected by the LoadMAP model of 12,577 GWh, the 4,300 GWh EEPS goal represents 34% of sales in that year. It should be noted that continued adoption of distributed solar photovoltaic (PV) systems throughout Hawaii will have the effect of reducing electric utility sales, thereby continuing to increase the state's energy efficiency potential relative to sales.
- It appears that the state is on track to achieve the EEPS goal by 2030, but it is clear that additional savings could be achieved beyond the savings goal established in statute. Striving to exceed the EEPS goal and capture additional energy savings would result in significant additional discretionary income for Hawaii's households and businesses.

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INTRODUCTION

Background

The Hawaii Public Utilities Commission (PUC) contracted with EnerNOC to conduct an independent evaluation of Energy Efficiency (EE) market potential in the State of Hawaii from 2013-2030. This study identifies the potential that can be achieved by contributing entities towards achieving the goals outlined in the state's Energy Efficiency Portfolio Standard (EEPS).[4]

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- Develop technical and economic potential estimates for 2013–2030 for benchmarking and future analyses by island.
    - Annual kWh savings and peak savings (net and gross).
    - Reporting tables that convey the potential that has been captured from 2009 through present, in addition to savings available in 2013 and beyond.
- Provide guidance and insight regarding attainment of the EEPS goals based on the energy savings opportunities identified in the potential study and relative to the EEPS base year of 2008.
- Provide estimates of available energy efficiency potential that can be used as a resource and included in IRP filings by the Hawaii electric utilities [Hawaiian Electric Company (HECO), Hawaii Electric Light Company (HELCO), Maui Electric Company (MECO), and Kauai Island Utility Cooperative (KIUC)].
- Provide a transparent and thoroughly documented energy efficiency potential model for the State. Report the results at the following levels:
    - Statewide
    - Utility service territory (HECO, HELCO,MECO, KIUC)
    - Island (Oahu, Hawaii, Maui, Kauai, Molokai, Lanai)
    - Contributing entities (from entities regulated by PUC such as utilities and Hawai‘i Energy and from non-regulated entities such as from programs offered by government agencies or nonprofits that offer energy efficiency programs and/or from governmental decisions to enact codes & standards. This includes contributions from the military and government buildings.
- Develop an EE potential study that is useful for all stakeholders including the PUC, the Consumer Advocate, EEPS facilitator, EEPS Technical Working Group, the HECO Companies, KIUC, and the Hawaii Energy program administrator (PBFA).

[4] Hawai‘i's Energy Efficiency Portfolio Standard, established by Act 155, Session Laws of Hawaii 2009, and promulgated as Hawaii Revised Statutes § 269-96, requires statewide electricity use savings of 4,300 GWh by 2030.
[5] The EEPS Framework was approved by the Hawaii Public Utilities Commission in Decision and Order No. 30089, Approving A Framework of Energy Efficiency Portfolio Standards, filed on January 3, 2012, in Docket No. 2010-0037.

Definition of Potential Cases

In this study, we estimate the potential for savings from contributing entities relative to the January 1, 2009 baseline established with the creation of the EEPS goals. The savings estimates represent the potential that could be achieved from all contributing entities. We present four levels of potential contribution to the EEPS goals, as shown in Figure 1-1. The various levels are described below.

- **Technical potential.** For energy efficiency, technical potential is defined as the theoretical upper limit of energy efficiency potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option. In new construction, customers and developers also choose the most efficient equipment option. Examples of measures that make up technical potential for electricity include: solar hot water heating, compact MEF 2.79 clothes washers, and LED lighting.

  Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and assumes air conditioning maintenance is performed in all existing buildings with air conditioning systems. These retrofit measures are phased in over a number of years, which is longer for higher-cost and more complex measures.

  This level of potential is inclusive of all levels of potential, including economic, market driven and spillover, and savings from existing codes and standards. These subsets of technical potential are described below.

- **Economic potential.** The economic potential is a subset of technical potential and represents the adoption of all **cost-effective** energy efficiency measures. The EEPS statute requires that all cost-effective energy efficiency is pursued. In this analysis, cost-effectiveness is measured from a societal perspective by the total resource cost (TRC) test, which compares benefits (as measured by lifetime utility avoided cost, including energy and capacity) to the incremental cost of the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is considered in the economic potential. Customers are then assumed to purchase the most cost-efficient option applicable to them at any decision juncture. The LoadMAP model calculates cost effectiveness in each year of the forecast to account for changes in the mix of technology options and avoided costs.

  Economic potential for Hawaii is substantial and includes potential savings from existing codes and standards, existing program achievements, and anticipated market driven and spillover savings. In order to gain a better understanding of the economic potential, we separately estimated the market driven and spillover savings, as defined below, which do not currently qualify for meeting the EEPS goal.

  The remaining economic potential after removing market driven and spillover, does contribute to the EEPS goal. This portion of economic potential is available to be captured by contributing entities such as EE programs from KIUC and Hawaiʻi Energy, additional federal, state and local codes and standards, and contributions from other entities such as nonprofits and government agencies. As with technical potential, economic potential is a hypothetical case that assumes that all applicable customers adopt all cost effective measures.

- **Market driven and Spillover.** This case reflects savings from two sources, which could contribute to the EEPS savings goal, if there were a way to measure and report the savings. Under the current EEPS framework, the market driven and spillover savings cannot contribute to the EEPS goal because it cannot be captured, measured, and reported by a contributing entity.
  - Savings from early adopters that purchase energy-efficient equipment or take efficiency actions **outside** of programs. Using central air conditioning (CAC) as an example, most customers will purchase the minimum level of efficiency as dictated by standards, However, some customers will purchase more efficient units—a mixture of EER 14, EER 15, EER 16, ductless mini-split systems and EER 21 units. While some customers will only buy the higher efficiency unit using a rebate or incentive available as part of an energy efficiency program, some customers will purchase more efficient options absent an incentive because they prefer the higher efficiency or other features of these options. For example, customers may purchase an LED light bulb instead of a less efficient

CFL because they prefer the quality of the light that comes from an LED to that from a CFL. Customers may also prefer the more efficient option because they consider it to be good for the environment or simply because they consider it to be a good investment. These savings include the spillover effect of customers who learn about more efficient options through a program, but do not participate in the program by taking a rebate. Finally, these savings also are a by-product of a change in stocking practices in stores due to past program participation. In some studies, this category of savings is labeled naturally occurring.

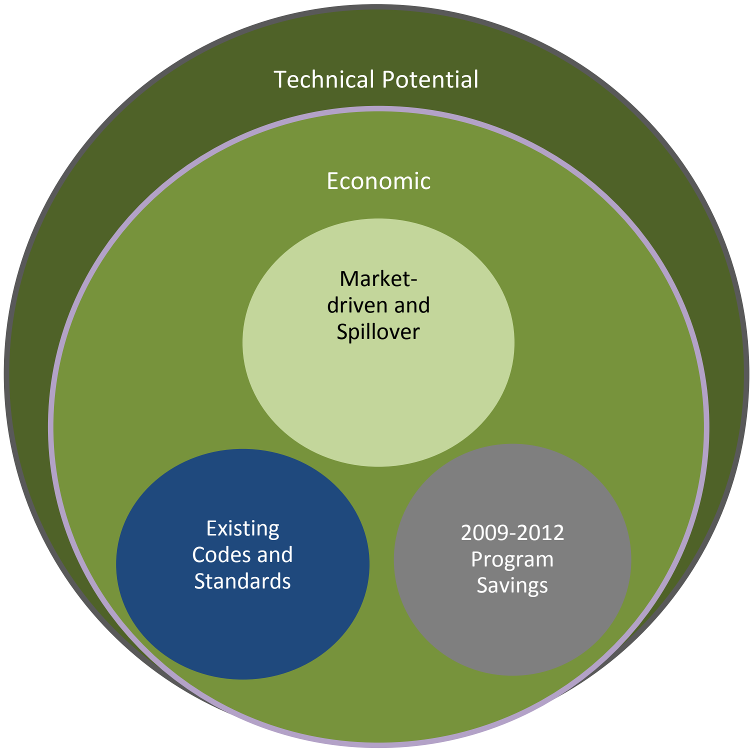
  - Savings that are achieved due to changes in manufacturing practices. This is most notable in the electronics end use where most of the televisions, laptops, and computers now available for purchase are ENERGY STAR qualified. Because ENERGY STAR 5.0 is a voluntary program and not a federal appliance standard, savings associated with ENERGY STAR 5.0 products are considered to be market driven because manufacturers are delivering products to the marketplace that meet ENERGY STAR 5.0 criteria at no additional cost relative to lower efficiency products.

- **Existing codes and standards.** This case reflects savings from federal or state codes or standards that have been approved and on the books since 2008, when the EEPS goal was set, and through mid-2013 when the study was performed. These savings from existing codes and standards come from improvements in appliance, equipment, or building efficiency. These standards include the lighting standards from the Energy Independence and Security Act of 2007 (EISA) that increased the lumens per Watt requirement of lamps and has resulted in the phasing out of incandescent light bulbs starting in 2012. Also included is the consensus agreement reached between AHAM and appliance manufacturers in 2012, which resulted in standards that become effective starting in 2014. In addition, savings in this category come from Hawaii-specific building codes, such as the requirement that newly constructed single-family homes use solar hot water heaters.

  For example, ongoing federal standards for CAC begin at EER 13 in 2009 and increase to EER 14 in 2015. To estimate the savings from standards in the forecast, the LoadMAP model removes appliances that no longer meet the standard from the customer choice set and forces customers to choose from among the standard-compliant appliances thereafter. The LoadMAP model accommodates multiple standards for each technology. For CAC, the minimum efficiency level is EER 13 units through 2014. In 2015, the minimum efficiency level increases to EER 14.

- **2009-2012 Program Savings.** These savings are the energy efficiency program savings that were achieved through programs offered by KIUC and the PBFA between 2009 and 2012. The programs have shown increasing savings as investment in the program has grown, though these savings decay over time based on the lifetime of measures installed through these programs.

Figure 1-1 The Levels of Potential Savings in this Study



Abbreviations and Acronyms

Throughout the report we use several abbreviations and acronyms. Table 1-1 shows the abbreviation or acronym, along with an explanation.

Table 1-1 Explanation of Abbreviations and Acronyms

Acronym	Explanation
ACS	American Community Survey
AEO	Annual Energy Outlook forecast developed annual by the Energy Information Administration of the Department of Energy
AHAM	Association of Home Appliance Manufacturers
B/C Ratio	Benefit to cost ratio
BEST	EnerNOC's Building Energy Simulation Tool
CAC	Central air conditioning
C&I	Commercial and industrial
CBECS	Commercial Building Energy Consumption Survey (prepared by EIA)
COMMEND	EPRI COMMercial END-use planning system
Contributing entity	An entity that implements programs or activities (e.g. enacting codes and standards) designed to produce energy efficiency savings that contribute to the EEPS goal.
CBSA	NEAA Commercial Building Stock Assessment
CFL	Compact fluorescent lamp
DBEDT	Department of Business Econometric Development and Tourism
DEEM	EnerNOC's Database of Energy Efficiency Measures
DEER	State of California Database for Energy-Efficient Resources
DG	Distributed generation
DSM	Demand side management
eCube	The eCube is a refrigeration EE measure that reduces the frequency of refrigeration cycles.
EE	Energy efficiency
EEPS	Energy Efficiency Portfolio Standard, standard set forth by Act 155, Session Laws of Hawaii 2009, and promulgated as Hawaii Revised Statutes § 269-96
EER	Energy Efficiency Ratio for cooling
EF	Energy Factor
EIA	Energy Information Administration
EISA	Energy Efficiency and Security Act of 2007
ENERGY STAR	A government-backed program that helps businesses and individuals protect the environment through energy efficiency by setting higher than minimum efficiency standards in order to earn the ENERGY STAR label.
EPACT	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
EUI	Energy-use index
GWh	Gigawatt hours equal to 1,000,000 kWh
HECO	Hawaiian Energy Company, Inc. (island of Oahu)
HECO Companies	HECO-owned Utilities – HECO, HELCO, MECO
HELCO	Hawaii Electric Light Company (island of Hawaii)
HH	Household
HID	High intensity discharge lamps
HPWH	Heat pump water heater
HRS	Hawaii Revised Statute
HVAC	Heating, ventilation and air conditioning
IRP	Integrated Resource Plan
KIUC	Kauai Island Utility Cooperative (island of Kauai)
LED	Light emitting diode lamp
LoadMAP	EnerNOC's Load Management Analysis and Planning™ tool

Acronym	Explanation
MM	Master metered apartments
MECO	Maui Electric Company (islands of Maui, Lanai and Molokai)
MECS	Manufacturing Energy Consumption Survey (prepared by EIA)
MEF	Modified Energy Factor for clothes washers
NAECA	National Appliance Energy Conservation Act of 1987
NPCC	Northwest Power and Conservation Council
PBF	Public Benefits Fee
PBFA	Public Benefits Fee Administrator, implements Hawaii Energy (ratepayer funded energy efficiency program) under contract in the HECO Companies' service territories under contract to PUC
PTAC	Packaged Terminal Air Conditioner
PUC	Hawaii Public Utilities Commission
PV	Photovoltaic
RAC	Room Air Conditioner
RASS	Residential Appliance Saturation Survey
REEPS	EPRI Residential End-use Energy Planning System
RECS	Residential Energy Consumption Survey (prepared by EIA)
RTU	Roof top unit
Sq. ft.	Square feet
TRM	Technical Reference Manual
TRC	Total resource cost
TWG	EEPS Technical Working Group
UEC	Unit energy consumption

Report Organization

This remainder of this report is presented in five chapters as outlined below.

- Chapter 2 — Analysis Approach and Data Development
- Chapter 3 — Market Characterization and Market Profiles
- Chapter 4 — LoadMAP Baseline Projection
- Chapter 5 — Existing Codes and Standards Projection
- Chapter 6 — Market-Driven and Spillover Projection
- Chapter 7 — Energy Efficiency Potential Relative to the LoadMAP Baseline Projection
- Chapter 8 — Comparison of Savings to EEPS Goals

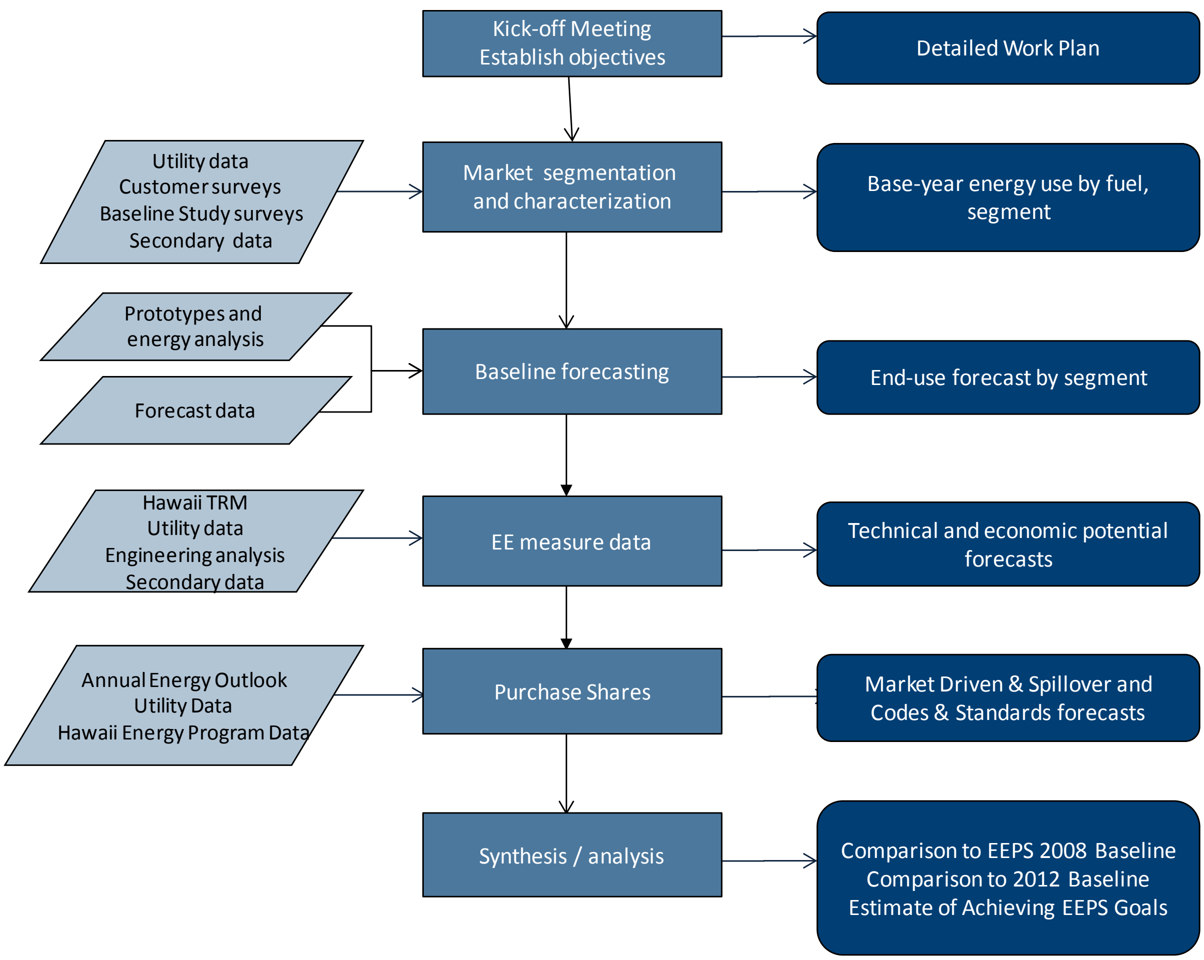
ANALYSIS APPROACH AND DATA DEVELOPMENT

This section describes the analysis approach taken for the study and the data sources used to develop the potential estimates.

Overview of Analysis Approach

To perform the energy efficiency potential analysis, EnerNOC used a bottom-up analysis approach as shown in Figure 2-1.

Figure 2-1 Overview of Analysis Approach



The analysis involved the following steps.

1. Held a meeting with the EEPS Technical Working Group (TWG) project team to refine the objectives.
2. Performed a market characterization to describe sector-level electricity use for the residential and non-residential (commercial, industrial, military, water/wastewater and street lighting) sectors for the base year, 2012. This step drew upon the Residential Appliance Saturation Survey (RASS) conducted by the HECO Companies, and a separate, but similar RASS conducted by KIUC. For Lanai and Molokai, we adjusted the Maui County information to reflect the differences in electricity usage for the smaller islands where data was not available. For the non-residential sectors, the market characterization

relied upon the recently completed Baseline Study for the HECO Companies' service territories.[6] For KIUC, we used the billing analysis provided by their consultant (KEMA) as well as previous studies to characterize the non-residential sectors.

3. Developed a reference projection that does not include the impact from appliance standards or building codes that took effect since 2008, market driven conservation, or impacts from any DSM programs.
4. Identified and characterized existing appliances and equipment used in residential and commercial buildings, as well as energy efficiency measures. The list of EE measures is based on EnerNOC's measure database with additional input from the EEPS TWG. The measures are characterized based on the Hawaii TRM, EnerNOC's Building Energy Simulation Tool (BEST), and EnerNOC's own measure database.
5. Developed projections for the four levels of savings considered in this study: Existing Codes & Standards, Market Driven and Spillover, Economic Potential, and Technical Potential.

The analysis approach for all these steps is described in further detail throughout the remainder of this chapter.

LoadMAP Model

To perform all the analysis encompassed in this study, we used EnerNOC's Load Management Analysis and Planning tool (LoadMAP). EnerNOC first developed LoadMAP in 2007 and has used it for the EPRI National Potential Study[7] and more than two dozen utility- and state-specific forecasting and potential studies. Built in Excel, the LoadMAP framework is both accessible and transparent and has the following key features.

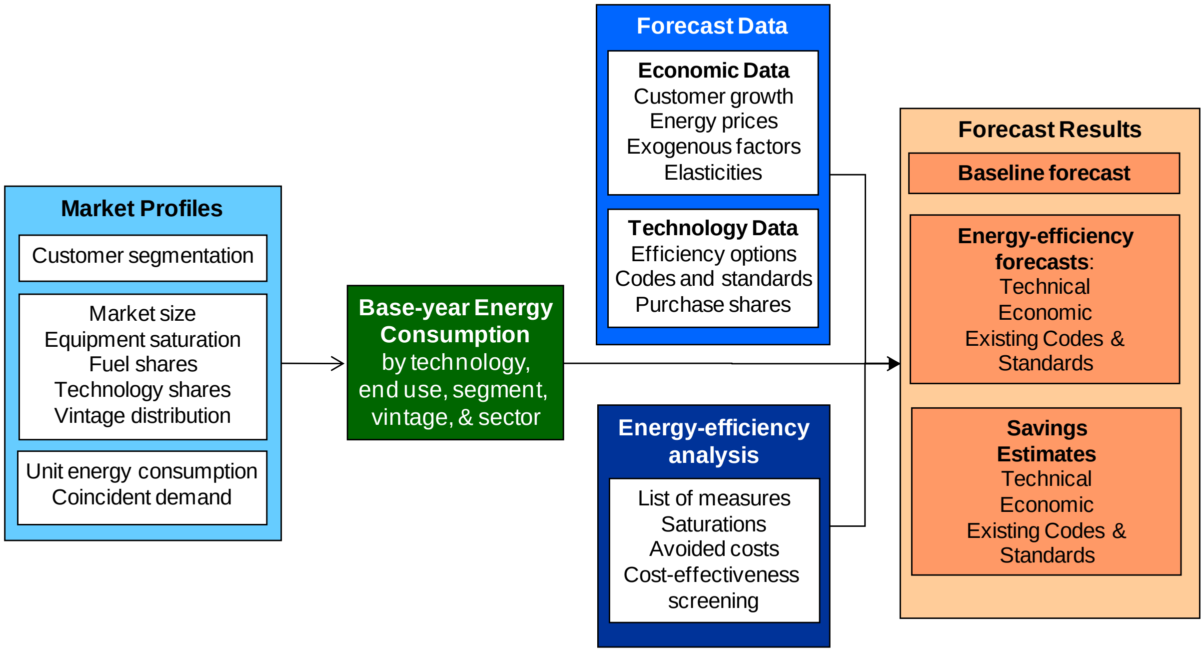
- Develops a bottom-up projection based on energy use by end use of major energy-consuming equipment.
- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions defined by the user.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.
- Uses a simple logic for appliance and equipment decisions. LoadMAP allows the user to drive the appliance and equipment choices year by year directly in the model. This flexible approach allows users to import the results from diffusion models or to input individual assumptions. The framework also facilitates sensitivity analysis.
- Includes appliance and equipment models customized by end use. For example, the logic for lighting is distinct from refrigerators and freezers.
- Can accommodate various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).

Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides projections of baseline energy use by island, sector, segment, end use, and technology for

[6] *Baseline Energy Appliance Equipment and Building Characteristics Study*. Prepared for the State of Hawaii Public Utilities Commission. Evergreen Economics, Inc., 2013.
[7] Electric Power Research Institute. "Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S." January 2009. (EPRI Technical Report #1016987).

existing and new buildings. It also provides projections of total energy use and energy efficiency savings associated with each type of potential.[8]

Figure 2-2 LoadMAP Analysis Framework



Market Characterization

In order to estimate the savings potential from all contributing entities, it is necessary to understand how much energy is used today and what equipment is currently being used. This characterization begins with a segmentation of the state of Hawaii's energy footprint to quantify energy use by island, sector, segment, fuel, end-use application, and the current set of technologies used. We incorporate information from the HECO residential appliance saturation survey (RASS), KIUC RASS survey, the non-residential Baseline Study for HECO Companies, the non-residential billing analysis by KEMA for KIUC, and various secondary data to advise the market characterization.

Segmentation for Modeling Purposes

The market characterization begins with a segmentation of electricity use. The segmentation scheme is shown in Table 2-1. The details of how the market was segmented are provided in Chapter 3.

Following this scheme, the residential sector was segmented for each island as described below, starting with customer segments by building type:

- Single family own
- Single family rent
- Multi-Family own
- Multi-Family rent
- Master metered apartments

In addition to segmentation by housing type, we identified the set of end uses and technologies that are appropriate for Hawaii's residential sector. These are shown in Table 2-2.

[8] The model computes energy and peak-demand forecasts for each type of potential for each end use as an intermediate calculation. Annual-energy and peak-demand savings are calculated as the difference between the value in the reference forecast and the value in the potential forecast (e.g., the technical potential forecast).

For the commercial sector, it is useful to think of the segments based on the unique characteristics of the type of building. This study used the following building types:

- Offices – all types including medical/dental offices and government offices
- Restaurants – fast-food, sit-down, and cafeteria-style restaurants
- Retail – retail and service establishments such as small boutiques, large box retailers, hair salons, and dry cleaners
- Grocery – convenience stores, small markets, and supermarkets
- Education – primary and secondary schools, colleges, universities, and technical colleges
- Health – hospitals and nursing homes
- Hotel (not included for Lanai) – motels, hotels, and small inns
- Resort (not included for Molokai) – large hotels that typically include large grounds that include multiple pools, fountains, retail areas, or golf courses
- Warehouse – storage facilities, refrigerated or unrefrigerated
- Large multifamily (not included for Lanai, Molokai or Kauai) – master-metered apartments where the individual housing units are not metered separately
- Miscellaneous – all remaining building types, such as manufacturing facilities, police stations, parking garages, public assembly, amusement parks, etc.

For Lanai, all lodging is included in the Resorts segment because there are not enough customers to segment into hotels and resorts. The same is true for Molokai, but in this case, the lodging on the island is smaller and thus was included in the hotel segment. Large multi-family buildings are not typically found on Lanai, Molokai or Kauai so we did not include that segment for those islands. Note that time share properties are included in the resort segment. The set of end uses and technologies for the commercial sector appear in Table 2-3.

With the segmentation scheme defined, we then performed a high-level market characterization of electricity sales in the base year to allocate sales to each customer segment on each island. We used various data sources to identify the annual sales in each customer segment, as well as the market size for each segment. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base-year. The details on how the market profiles were developed are included in Chapter 3.

Table 2-1 Overview of Segmentation Scheme for Potentials Modeling

Market Dimension	Segmentation Variable	Dimension Examples
1	Island	Oahu, Hawaii, Maui, Lanai, Molokai and Kauai
2	Sector	Residential, commercial , military*, water/wastewater,* street lighting*
3	Segment	**Residential**: single family own, single family rent, multi-family own, multi-family rent, and master metered apartments
		Commercial: office, restaurant, retail, grocery, health, hotel, resort, warehouse, education, large multi-family, miscellaneous (includes industrial)
		Water/wastewater: as a whole
		Military: as a whole
		Street Lighting: as a whole
4	Vintage	Existing and new construction
5	Fuel	Electricity
6	End uses	Cooling, lighting, water heat, motors, etc. (as appropriate by sector)
7	Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment, motors by application, etc.
8	Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

** Note: Military, water/wastewater, and street lighting are modeled outside the LoadMAP framework because details on end uses and technologies were not available for these sectors.*

Table 2-2 Residential Electric End Uses and Technologies

End Use	Technology
Cooling	Central Air Conditioning (CAC)
Cooling	Split Air Conditioning
Cooling	Room Air Conditioning (RAC)
Cooling	Dehumidifier
Water Heating	Water Heater <= 55 Gal
Water Heating	Water Heater > 55 Gal
Interior Lighting	Screw-in Lamps
Interior Lighting	Linear Fluorescent Lamps
Interior Lighting	Specialty
Exterior Lighting	Screw-in Lamps
Appliances	Clothes Washer
Appliances	Clothes Dryer
Appliances	Dishwasher
Appliances	Refrigerator
Appliances	Freezer
Appliances	Second Refrigerator
Appliances	Stove
Appliances	Microwaves
Electronics	Personal Computers

End Use	Technology
Electronics	Monitor
Electronics	Laptops
Electronics	Printer/Fax/Copier
Electronics	TVs
Electronics	Set-top Boxes/DVR
Electronics	Devices and Gadgets
Miscellaneous	Air purifier/cleaner
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Hot Tub / Spa
Miscellaneous	Miscellaneous heating
Miscellaneous	Vehicle charger
Miscellaneous	Miscellaneous

Table 2-3 Commercial Electric End Uses and Technologies

End Use	Technology
Cooling	Air-cooled chiller
Cooling	Water-Cooled Chiller
Cooling	Roof top AC
Cooling	PTAC
Ventilation	Ventilation
Water Heating	Water Heater
Interior Lighting	Screw-in
Interior Lighting	High-Bay Fixtures
Interior Lighting	Linear Fluorescent
Exterior Lighting	Screw-in
Exterior Lighting	HID
Exterior Lighting	Linear Fluorescent
Refrigeration	Walk-in Refrigerator
Refrigeration	Reach-in Refrigerator
Refrigeration	Glass Door Display
Refrigeration	Open Display Case
Refrigeration	Icemaker
Refrigeration	Vending Machine
Food Preparation	Oven
Food Preparation	Fryer
Food Preparation	Dishwasher
Food Preparation	Hot Food Container
Office Equipment	Desktop Computer
Office Equipment	Laptop
Office Equipment	Server
Office Equipment	Monitor

End Use	Technology
Office Equipment	Printer/Copier/Fax
Office Equipment	POS Terminal
Miscellaneous	Non-HVAC Motors
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Miscellaneous

Market Profiles

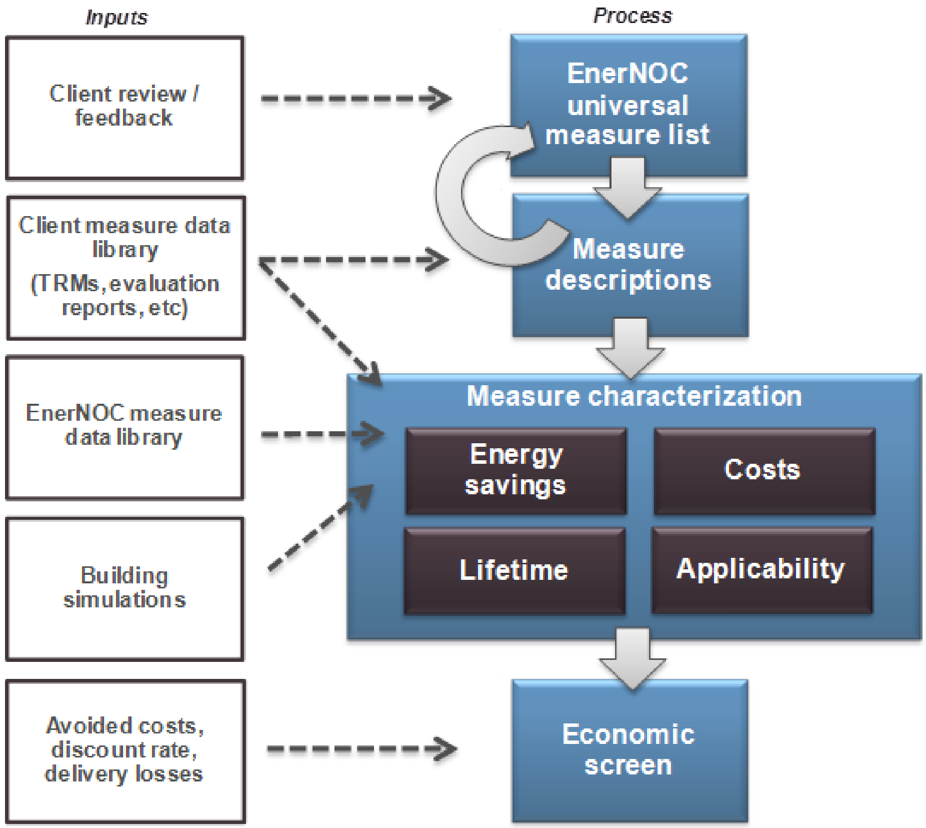
The next step was to develop market profiles for each island, sector, customer segment, end use, and technology. A market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, it is number of households. In the commercial sector, it is floor space measured in square feet.
- **Saturation** defines the fraction of homes or commercial square feet with the various technologies. (e.g., homes with electric water heating).
- **UEC (unit energy consumption) or EUI (energy-use index)** describes the amount of energy consumed in 2012 by a specific technology in buildings that have the technology. UECs are expressed in kWh/household for the residential sector, while EUIs are expressed in kWh/square foot for the commercial sector.
- **Intensity** for the residential sector represents the average energy use for the technology across all homes in 2012. It is computed as the product of the saturation and the UEC and is defined as kWh/household for electricity. For the commercial sector, intensity is computed as the product of the saturation and the EUI, represents the average use for the technology across all floor space in 2012.
- **Usage** is the annual energy use by an end use technology in the segment. It is the product of the market size and intensity and is quantified in GWh. The market assessment results and the market profiles are presented in Chapter 3.

Characterization of End-Use Technologies and Efficiency Measures

To estimate the savings that could be achieved through existing codes and standards, market-driven efficiency and spillover and energy-efficiency programs, the study also identified the list of all relevant end-use technologies currently available as well as those expected to be available in the future. The study also identifies other EE measures that should be considered for the State of Hawaii. Figure 2-3 outlines the framework for development of the end-use technologies and EE measures and also identifying measures screening for cost-effectiveness.

Figure 2-3 Approach for Measure Assessment



Develop End-use Technology and EE Measure List

We compiled a robust list of energy efficiency measures based on EnerNOC's measure database. We then incorporated additional measures from the following sources:

- **Measures in the PBFA's and KIUC's current programs**. We cross referenced the current program measures with the measures from our own databases and recent studies to enable the broadest set of applicable measures.
- **Measures in the PBFA Technical Reference Manual (TRM)**. We reviewed the TRM and incorporated information from this manual into the measure development.
- **Measure lists from previous potential studies**. We also reviewed the measure lists from the previous HECO and KIUC potential studies.
- **New and emerging technologies**. EnerNOC is constantly monitoring the feasibility of technologies just entering the marketplace, such as cutting-edge LED lighting, advanced control systems, heat pump water heaters, and advanced air conditioning technologies. We believe that having our pulse on new specific technologies is well-suited to a twenty-year study. We do not assume any new uses of energy that might arise in the study timeframe.

This universal list of energy efficiency measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption. If considered today, some of these measures would not pass the economic screens initially, but may pass in future years as a result of lower projected equipment costs or higher avoided costs. After receiving feedback from the EEPS TWG, we finalized the measure list.

The selected measures are categorized into two types according to the LoadMAP taxonomy: equipment measures and non-equipment measures.

- **Equipment measures** are efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an

ENERGY STAR refrigerator that replaces a standard efficiency refrigerator. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the current federal standard EER 13 unit and spans a broad spectrum up to a maximum efficiency of an EER 21 unit.

- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve replacement or purchase of major end-use equipment (such as a refrigerator or air conditioner). An example would be a programmable thermostat that is pre-set to run cooling systems only when people are home. Non-equipment measures can apply to more than one end use. For instance, a home energy management system will affect the energy use of both space cooling and lighting. Non-equipment measures typically fall into one of the following categories:
  - Building shell (windows, insulation, roofing material)
  - Equipment controls (thermostat, energy management system)
  - Equipment maintenance (air conditioning and heat pump maintenance, changing setpoints)
  - Whole-building design (building orientation, passive solar lighting)
  - Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)
  - Displacement measures (ceiling fan to reduce use of central air conditioners)
  - Commissioning and Retrocommissioning

Characterize End-use Technologies and EE Measures

The next step was to characterize the measures and equipment options in terms of their energy savings, costs, and other attributes needed to perform the economic screen. For the identified technologies and measures we assembled the following information which is included in Appendix A.

- **A brief technical description** of what the measure/options does, its performance, the building types and areas where it is typically installed, its market and technical applicability, and maintenance best practices.
- **Measure/option energy savings** include energy and peak demand savings (kWh, kW) attributable to the measure/option.
- **Lifetime of the measure/option**
- **Costs** associated with each measure/option (these are local costs, not national averages)
- **Applicability** is a parameter that identifies the fraction of each market segment to which the measure/option is relevant.

We developed the measure/option characteristics using the following sources of information:

- The PBFA Technical Reference Manual (TRM)
- PBFA and KIUC measure data from recent program years
- Previous potential studies
- EnerNOC's internal Building Energy Simulation Tool (BEST) which is best suited to developing savings estimates for weather sensitive end uses for EE measures
- EnerNOC's internal measure database (DEEM) for non weather-sensitive EE measures. DEEM is updated on an ongoing basis from the research we do for potential assessments, our implementation work, and other secondary data sources such as the DOE, AEO, DEER, etc.

Prior to using BEST to develop savings estimates, we developed a set of Hawaii-specific prototypes to use in the measure analysis. We started with the prototypes from the Pacific region and updated the key parameters using information from the baseline customer surveys. The prototypes were used together with local weather data, to perform simulations to develop savings for each customer segment.

Representative Measure Data Inputs

Table 2-4 displays the various efficiency levels available as equipment measures, as well as the corresponding useful life, energy usage, and cost estimates. The columns labeled On Market and Off Market reflect equipment availability due to existing codes and standards or the entry of new products to the market.

Table 2-4 Example Equipment Measures for Electric Water Heating –Single Family Home, Existing

Efficiency Level	Useful Life	Equipment Cost	Energy Usage (kWh/yr)	On Market	Off Market
EF 0.9	14	$461	2,478	2012	2014
EF 0.95	14	$553	2,348	2012	n/a
EF 2.3 (Heat Pump)	10	$4,461	970	2012	n/a
Solar	15	$7,061	344	2012	n/a

Table 2-5 lists some of the non-equipment measures applicable to water heating in an existing single-family home. All measures are evaluated for cost-effectiveness based on the lifetime benefits relative to the cost of the measure. The total savings and costs are calculated for each year of the study and depend on the base year saturation of the measure, the applicability[9] of the measure, and the savings as a percentage of the relevant energy end uses.

Table 2-5 Example Non-Equipment Measures – Single Family Home, Existing

End Use	Measure	Saturation in 2012[10]	Applicability	Lifetime (yrs)	Measure Installed Cost	Energy Savings (%)
Water Heating	Faucet Aerators	15%	100%	12	$726	22%
Water Heating	Low-Flow Showerheads	15%	100%	5	$383	40%
Water Heating	Pipe Insulation	0%	100%	15	$5,724	5%
Water Heating	Timer	10%	55%	20	$831	4%

[9] The applicability factors take into account whether the measure is applicable to a particular building type and whether it is feasible to install the measure. For instance, attic fans are not applicable to homes where there is insufficient space in the attic or there is no attic at all.

[10] Note that saturation levels reflected for the base year change over time as more measures are adopted.

Table 2-6 Purchase Shares for Residential Interior Screw-in Lighting and Water Heaters (<= 55 gallons)

Technology/Efficiency level		Case	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025		2030
Interior Screw-in Lighting		**LoadMAP Baseline**															
E1	Incandescent		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%
E2	Infrared Halogen		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E3	Infrared Halogen (2020)		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E4	CFL		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E5	LED		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E6	LED (2020)		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
		Codes & Standards															
E1	Incandescent		100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E2	Infrared Halogen		0%	100%	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%		0%
E3	Infrared Halogen (2020)		0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%		100%
E4	CFL		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E5	LED		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E6	LED (2020)		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
		Market Driven															
E1	Incandescent		45%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E2	Infrared Halogen		0%	39%	37%	35%	33%	31%	29%	0%	0%	0%	0%	0%	0%		0%
E3	Infrared Halogen (2020)		0%	0%	0%	0%	0%	0%	0%	48%	47%	45%	43%	41%	40%		31%
E4	CFL		48%	53%	53%	53%	53%	53%	53%	32%	32%	32%	32%	32%	32%		32%
E5	LED		7%	9%	10%	12%	14%	16%	18%	0%	0%	0%	0%	0%	0%		0%
E6	LED (2020)		0%	0%	0%	0%	0%	0%	0%	20%	21%	23%	25%	26%	28%		36%
Water Heater <= 55 gal		**LoadMAP Baseline**															
E1	EF 0.9		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%
E2	EF 0.95		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E3	EF 2.3 (HP)		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E4	Solar		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
		Codes & Standards															
E1	EF 0.9		100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E2	EF 0.95		0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%
E3	EF 2.3 (HP)		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E4	Solar		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
		Market Driven															
E1	EF 0.9		76%	76%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
E2	EF 0.95		24%	24%	92%	92%	91%	91%	91%	91%	91%	91%	91%	91%	91%		91%
E3	EF 2.3 (HP)		0%	0%	8%	8%	9%	9%	9%	9%	9%	9%	9%	9%	9%		9%
E4	Solar		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%

Technical Potential

As described above, technical potential is a theoretical construct that assumes the highest efficiency measures that are technically feasible to install are adopted by customers, regardless of cost or customer preferences. Thus, determining the technical potential is relatively straightforward: LoadMAP selects the most efficient equipment options for each technology at the time of equipment replacement. In addition, it installs all relevant non-equipment measures for each technology to calculate savings. In the two cases described above, all consumers would purchase LED lighting or solar water heating under the technical potential case.

Economic Potential

Economic potential results from the purchase of the most efficient cost-effective option available for a given equipment or non-equipment measure as determined in the cost-effectiveness screening process described above. As with technical potential, economic potential is a phased-in approach. Economic potential is still a theoretical upper-boundary of savings potential as it represents only measures that are economic, but does not yet consider customer acceptance and other factors.

Screening Measures for Cost-Effectiveness

Only measures that are cost-effective are included in economic potential. Therefore, for each individual measure, LoadMAP performs an economic screen. This study uses the TRC test that compares the lifetime energy benefits (and peak demand for electricity) of each applicable measure with its incremental installed cost, including material and labor. There is no program administration cost considered in this analysis, and therefore, no specific program delivery methods or mechanisms are assumed. The lifetime benefits are calculated by multiplying the annual energy and demand savings for each measure by all appropriate avoided costs for each year, and discounting the dollar savings to the present value equivalent. The analysis uses each measure's values for savings, costs, and lifetimes that were developed as part of the measure characterization process described above.

The LoadMAP model performs this screening dynamically, taking into account changing savings and cost data over time. Thus, some measures pass the economic screen for some — but not all — of the years in the forecast. It is important to note the following about the economic screen:

- The economic evaluation of every measure in the screen is conducted relative to a baseline condition. For instance, in order to determine the kilowatt-hour (kWh) savings potential of a measure, kWh consumption with the measure applied must be compared to the kWh consumption of a baseline condition.
- The economic screening was conducted only for measures that are applicable to each building type and vintage; thus if a measure is deemed to be irrelevant to a particular building type and vintage, it is excluded from the respective economic screen.

If the measure passes the screen (has a B/C ratio greater than or equal to 1), the measure is included in economic potential. Otherwise, it is screened out for that year. If multiple equipment measures have B/C ratios greater than or equal to 1.0, the most efficient technology is selected by the economic screen. Table 2-7 shows the results of the economic screen for selected measures, indicating how the economic unit for a given technology may vary over time. For example, as the price of LEDs decreases, they are the economical unit for single family homes. For exterior lighting, due to longer hours of operation, LEDs are cost-effective.

Table 2-7 Economic Screen Results for Selected Single Family Equipment Measures

Technology	2013	2014	2015	2016	2017	2018
Water heating <55 gallons	EF 0.95	EF 0.95	Solar	Solar	Solar	Solar
Interior Screw-in Lighting	LED	LED	LED	LED	LED	LED
Refrigerator	ENERGY STAR	AHAM (2014)	AHAM (2014)	AHAM (2014)	AHAM (2014)	AHAM (2014)

Table 2-8 summarizes the number of equipment and non-equipment measures evaluated for each segment within each sector.

Table 2-8 Number of Measures Evaluated

	Residential	Commercial	Total Number of Measures
Equipment Measures Evaluated	102	115	**217**
Non-Equipment Measures Evaluated	44	81	**125**
Total Measures Evaluated	**146**	**196**	**342**

Data Development

This section details the data sources used in this study, followed by a discussion of how these sources were applied. In general, data were adapted to local conditions, for example, by using local sources for measure data and local weather for building simulations.

Data Sources

The data sources are organized into the following categories:

- PBFA Technical Reference Manual
- HECO and KIUC utility data
- Hawaii Energy program data
- State of Hawaii 2013 Baseline Study data
- EnerNOC's databases and analysis tools
- Other secondary data and reports

HECO and KIUC Utility Data

Our highest priority data sources for this study were those that were specific to the state of Hawaii.

- Utility 2012 billing data — customers, usage, revenue
- Number of customers and electricity sales by sector (residential, commercial, military, water/wastewater, and outdoor lighting)
- Peak demand by rate sector
- Usage data for commercial and large customers by building type
- 2013 RASS survey, a residential saturation survey
- Energy and peak demand forecasts, at the sector level
- Forecasts of customer growth, persons per household, income, and business employment
- Price forecast
- Avoided costs forecast (peak capacity and energy)
- Discount rate
- Escalation rate
- Line loss factors

Program Implementer Data (Hawaii Energy and KIUC)

- Description of existing energy efficiency programs and results from these programs
- PBFA TRM to characterize the energy efficiency measures

State of Hawaii 2013 Baseline Study Data

- Large business onsite data
- Small and Medium business onsite data
- Small/Medium business mail survey
- Residential onsite data
- Case studies for military and water/wastewater sectors

EnerNOC Databases, Analysis Tools, and Reports

EnerNOC maintains several databases and modeling tools that we use for forecasting and potential studies.

- **EnerNOC Energy Market Profiles**: For more than 10 years, EnerNOC staff have maintained profiles of end-use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel (electricity and natural gas), customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys (RECS, CBECS and MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.
- **Building Energy Simulation Tool (BEST)**. EnerNOC's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **EnerNOC's EnergyShape™:** This database of load shapes includes the following: Residential — electric load shapes for 10 regions, 3 housing types, 13 end uses; Commercial — electric load shapes for 9 regions, 54 building types, 10 end uses; Industrial — electric load shapes, whole facility only, 19 2-digit SIC codes, as well as various 3-digit and 4-digit SIC codes
- **EnerNOC's Database of Energy Efficiency Measures (DEEM):** EnerNOC maintains an extensive database of measure data for our studies. Our database draws upon reliable sources including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog Cost data.
- **Recent studies**. EnerNOC has conducted numerous studies of energy efficiency potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, which include Ameren Illinois, Ameren Missouri, Seattle City Light, Tennessee Valley Authority, Indianapolis Power & Light, Avista Utilities, the State of New Mexico, and Los Angeles Department of Water and Power. In addition, we used the information about impacts of building codes and appliance standards from a recent report for the Institute for Energy Efficiency.[11]

Other Secondary Data and Reports

Finally, a variety of secondary data sources and reports were used for this study. The main sources are identified below.

- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2013 AEO.
- **American Community Survey:** The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. http://www.census.gov/acs/www/
- **Weather data:** Weather from NOAA's National Climatic Data Center for the airport on each island was used as the basis for each island's building simulation.

[11] "Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 – 2025)." Global Energy Partners, LLC for the Institute for Electric Efficiency, May 2011. http://www.edisonfoundation.net/iee/reports/IEE_CodesandStandardsAssessment_2010-2025_UPDATE.pdf

- **Residential Energy Consumption Survey (RECS).** http://www.eia.gov/consumption/residential/data/2009/
- **Electric Power Research Institute – Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.**, also known as the EPRI National Potential Study (2009). In 2009, EPRI hired EnerNOC to conduct an assessment of the national potential for energy efficiency, with estimates derived for the four DOE regions.
- **EPRI End-Use Models (REEPS and COMMEND)**. These models provide the elasticities we apply to electricity prices, household income, home size and heating and cooling.
- **Database for Energy Efficient Resources (DEER).** The California Energy Commission and California Public Utilities Commission (CPUC) sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross check the measure savings we developed using BEST and DEEM.
- **Northwest Power and Conservation Council Sixth Plan workbooks.** To develop its Power Plan, the Council maintains workbooks with detailed information about measures.
- **Other relevant regional sources.** These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy.

Data Application

We now discuss how the data sources described above were used for each step of the study.

Data Application for Market Characterization

To construct the high-level market characterization of electricity use and households/floor space for the residential, commercial, military, water/wastewater, and street lighting sectors, we applied the following data sources:

- HECO Companies and KIUC RASS surveys to allocate residential customers by housing type. This was compared to the American Community Survey (ACS) to make adjustments.
- HECO Companies and KIUC billing data, customer surveys from the Baseline Study, and billing analysis for Kauai, to estimate sales and square footage by building type for the commercial sector.
- HECO Companies and KIUC billing data and Baseline Study case studies to estimate energy use for the military and water/wastewater sectors.

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-9. To develop the market profiles for each segment, we used the following approach for each island:

1. Developed control totals for each segment. These include market size, segment-level annual electricity use, and annual intensity.
2. Used the HECO Companies RASS survey, KIUC RASS Survey, Baseline Study, and the KIUC billing analysis to provide information about market size for customer segments, appliance and equipment saturations, appliance and equipment characteristics, building characteristics, and energy-efficiency actions already taken.
3. Incorporated secondary data sources to supplement and corroborate the data from items 1 and 2 above.
4. Compared and cross-checked with regional data obtained as part of the Energy Market Profiles Database and other recent EnerNOC studies.
5. Ensured calibration to control totals for annual electricity sales in each sector and segment.
6. Worked with staff from each utility to vet the data against their knowledge and experience.

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-9.

Table 2-9 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings and C&I floor space	Utility billing data, HECO Companies RASS, KIUC RASS, Baseline Study, KIUC Billing analysis
Annual intensity	Residential: Annual energy use (kWh/household) C&I: Annual energy use (kWh/ sq ft)	HECO Companies RASS, KIUC RASS, Baseline Study, KIUC Billing Analysis, Energy Market Profiles, previous studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology; Percentage of C&I floor space with equipment/technology	HECO Companies RASS, KIUC RASS, Baseline Study, KIUC Billing Analysis, and other secondary data
UEC/EUI for each end-use technology	UEC: Annual electricity use for a technology in dwellings that have the technology EUI: Annual electricity use per square foot for a technology in floor space that has the technology	HECO Companies RASS, KIUC RASS, Baseline Study, PBFA TRM, prototype simulations, engineering analysis
Appliance/equipment vintage distribution	Age distribution for each technology	HECO Companies RASS, KIUC RASS, Baseline Study, and secondary data (DEEM, EIA, EPRI, DEER, etc.)
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	PBFA TRM, prototype simulations, engineering analysis, appliance/equipment standards, secondary data (DEEM, EIA, EPRI, DEER, etc.)
Peak factors	Share of technology energy use that occurs during the peak hour	EnerNOC's EnergyShape database

Data Application for Baseline Projection

Table 2-10 summarizes the LoadMAP model inputs requirements for the baseline projection. These inputs are required for each segment within each sector, as well as for new construction and existing dwellings/buildings.

Table 2-10 Data Needs for the LoadMAP Baseline Projection

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	Data provided by HECO Companies and KIUC
Equipment purchase shares for baseline projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO AEO 2013 regional forecast assumptions[12] Appliance/efficiency standards analysis Hawaii Energy program results KIUC program results
Electricity prices	Forecast of average energy and capacity avoided costs and retail prices	HECO Companies KIUC AEO 2013
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models AEO 2013

Data Application for Existing Codes and Standards Projection

For the Existing Codes and Standards projection, we implemented assumptions based on future equipment standards and building codes that are known as of September 2013. Any codes and standards that take effect on or after January 1, 2009 count toward EEPS goals. These standards are shown in Table 2-11 and Table 2-12. The tables show what the base standard equipment is for each technology in each year. A Change in color reflects a change in standard and, in the case of lighting and clothes washers, a second standard comes into play during the forecast period.

In addition, we took into account all Hawaii-specific building codes, such as the requirement for solar water heating in single-family new construction. Codes and standards already "on the books" are shown as part of the Existing Codes and Standards estimates in this study. Additional codes and standards could be enacted in the future and those savings would also count toward EEPS goals, but this study makes no attempt to model future standards cases.

Data Application for Market-driven Efficiency and Spillover Projection

For the Market Driven & Spillover projection, we developed initial baseline purchase shares based on the Energy Information Agency's Annual Energy Outlook report (2013). These purchase shares reflect naturally occurring energy efficiency where customers are purchasing more efficient technology outside of an energy efficiency program. These shares were then adjusted to reflect Hawaii Energy's past program efforts to incorporate market transformation that has already occurred in the state of Hawaii. For example, for compact fluorescent lighting, we matched the baseline purchase shares to the existing market saturation to reflect the assumption that for sockets already converted to CFLs, consumers will continue to purchase CFLs.

[12] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2013), which utilizes the National Energy Modeling System (NEMS) to produce a self-consistent supply and demand economic model.

Table 2-11 Existing Residential Electric Equipment Standards Applicable to State of Hawaii

Today's Efficiency or Standard Assumption
1st Standard (relative to today's standard)
2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="4">Cooling</td><td>Central AC</td><td colspan="3">EER 13</td><td colspan="11">EER 14</td></tr>
<tr><td>Room AC</td><td colspan="2">EER 9.8</td><td colspan="12">EER 11.0</td></tr>
<tr><td>Evaporative Central AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Evaporative Room AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="3">EER 13.0/HSPF 7.7</td><td colspan="11">EER 14.0/HSPF 8.0</td></tr>
<tr><td>Space Heating</td><td>Electric Resistance</td><td colspan="14">Electric Resistance</td></tr>
<tr><td rowspan="2">Water Heating</td><td>Water Heater (<=55 gallons)</td><td colspan="3">EF 0.90
(New Construction: Solar)</td><td colspan="11">EF 0.95
(New construction: Solar)</td></tr>
<tr><td>Water Heater (>55 gallons)</td><td colspan="3">EF 0.90</td><td colspan="11">Heat Pump Water Heater</td></tr>
<tr><td rowspan="2">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td rowspan="5">Appliances</td><td>Refrigerator/2nd Refrigerator</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Freezer</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Dishwasher</td><td>Conventional (355kWh/yr)</td><td colspan="13">14% more efficient (307 kWh/yr)</td></tr>
<tr><td>Clothes Washer</td><td colspan="3">Conventional (MEF 1.26 for top loader)</td><td colspan="3">MEF 1.72 for top loader</td><td colspan="8">MEF 2.0 for top loader</td></tr>
<tr><td>Clothes Dryer</td><td colspan="3">Conventional (EF 3.01)</td><td colspan="11">5% more efficient (EF 3.17)</td></tr>
</table>

Table 2-12 Existing Commercial Electric Equipment Standards Applicable to State of Hawaii

Today's Efficiency or Standard Assumption
1st Standard (relative to today's standard)
2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Cooling</td><td>Chillers</td><td colspan="14">2007 ASHRAE 90.1</td></tr>
<tr><td>Roof Top Units</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Packaged Terminal AC/HP</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="14">EER 11.0/COP 3.3</td></tr>
<tr><td>Ventilation</td><td>Ventilation</td><td colspan="14">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td rowspan="3">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td>High Intensity Discharge</td><td colspan="14">88 lumens/watt</td></tr>
<tr><td>Water Heating</td><td>Water Heater</td><td colspan="14">EF 0.97</td></tr>
<tr><td rowspan="5">Refrigeration</td><td>Walk-in Refrigerator/Freezer</td><td colspan="14">EISA 2007 Standard</td></tr>
<tr><td>Reach-in Refrigerator</td><td colspan="14">EPACT 2005 Standard</td></tr>
<tr><td>Glass Door Display</td><td colspan="14">42% more efficient</td></tr>
<tr><td>Open Display Case</td><td colspan="14">18% more efficient</td></tr>
<tr><td>Vending Machines</td><td colspan="14">33% more efficient</td></tr>
<tr><td rowspan="2">Miscellaneous</td><td>Non-HVAC Motors</td><td colspan="3">62.3% Efficiency</td><td colspan="11">70% Efficiency</td></tr>
<tr><td>Commercial Laundry</td><td>MEF 1.26</td><td colspan="13">MEF 1.6</td></tr>
</table>

Energy Efficiency Measure Data Application

Table 2-13 details the data sources used for measure characterization. It describes each input and identifies the key sources used in the analysis.

Table 2-13 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	PBFA TRM BEST DEEM DEER NPCC workbooks Other secondary sources
Peak Demand Impacts	Savings during the peak demand periods are specified for each electric measure. These impacts relate to the energy savings and depend on the extent to which each measure is coincident with the system peak.	PBFA TRM BEST EnergyShape
Costs	Equipment Measures: Includes the full cost of purchasing and installing the equipment on a per-household or per-square-foot basis for the residential and commercial sectors, respectively. Non-equipment measures: Existing buildings – full installed cost. New Construction - the costs may be either the full cost of the measure, or as appropriate, it may be the incremental cost of upgrading from a standard level to a higher efficiency level.	PBFA TRM DEEM DEER NPCC workbooks RS Means Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	PBFA TRM DEEM DEER NPCC workbooks Other secondary sources
Applicability	Estimate of the percentage of either dwellings in the residential sector or square feet/employment in the C&I sector where the measure is applicable and where it is technically feasible to implement.	DEEM DEER Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	EnerNOC appliance standards and building codes analysis

Data Application for Cost-effectiveness Screening

To perform the cost-effectiveness screening, the following information was needed:

- Avoided cost of energy and capacity provided by each utility so that each island uses its own avoided costs. For the HECO Companies, these are based on the IRP 2013 Stuck in the Middle 100%-110% filing. KIUC provided their forecast of estimated avoided costs from 2012.
- Line losses of 5.3% provided by HECO Companies; line losses of 4.49%, provided by KIUC
- Discount rate of 8.06% provided by HECO Companies; discount rate of 4.98%, provided by KIUC

MARKET CHARACTERIZATION AND MARKET PROFILES

In this section, we describe how customers in the State of Hawaii use electricity in the base year of the study, 2012. It begins with a high level summary of energy use by sector and then delves into each sector in detail.

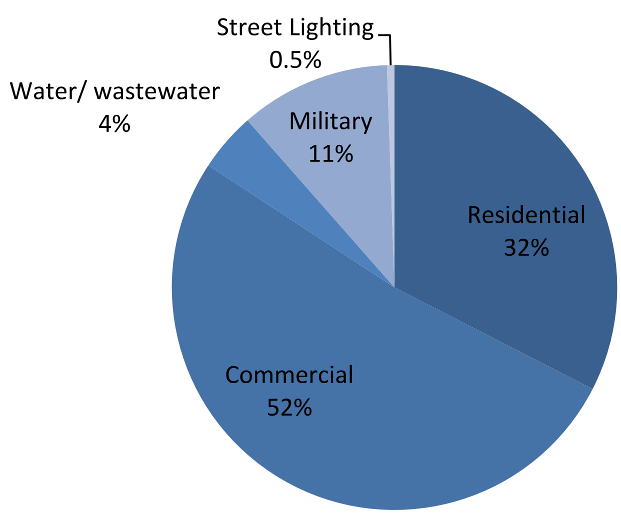
Energy Use Summary

Total electricity use for the residential, commercial, water/wastewater, military, and outdoor lighting sectors for the state of Hawaii in 2012 was 9,639 GWh.[13] As shown in Table 3-1 and Figure 3-1, the largest sector is commercial, accounting for 52% of electricity use, followed by residential, with 32% of sales. The residential and commercial sectors were modeled in LoadMAP while the military, water/wastewater and street lighting sectors were estimated outside of the LoadMAP model.

Table 3-1 Energy Sales by Sector, 2012

Sector	2012 Electricity Sales (GWh)
Residential	3,136
Commercial	4,983
Water/wastewater	413
Military	1,054
Street Lighting	52
Total	**9,639**

Figure 3-1 Electricity Sales by Sector, 2012 (9,639 GWh)



[13] Energy usage as measured "at-the-meter," i.e., does not include line losses.

Residential Sector

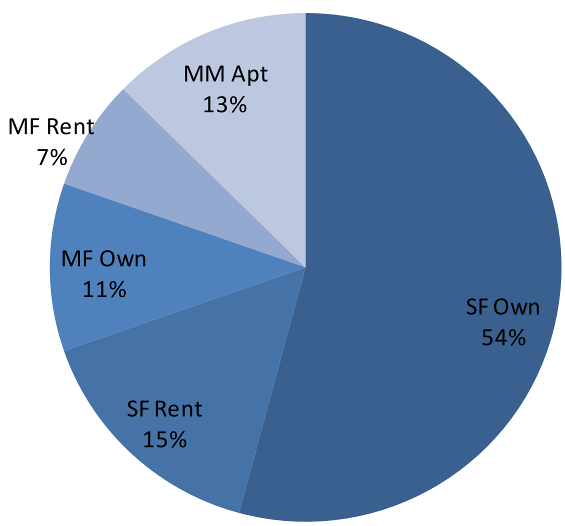
This section characterizes the residential market at a high level, and then provides a profile of how customers in each segment use electricity by end use. Total residential electricity use in 2012 was 3,136 GWh. Customers were allocated to the housing type segments as shown in Table 3-2 and Figure 3-2. The housing type and division between owners versus renters were determined through the RASS survey and using ACS.

The single-family owners segment consumed 54% of total residential sector electricity in 2012 as a result of having the largest number of customers and the highest intensity.

Table 3-2 Residential Sector Allocation by Segments, 2012

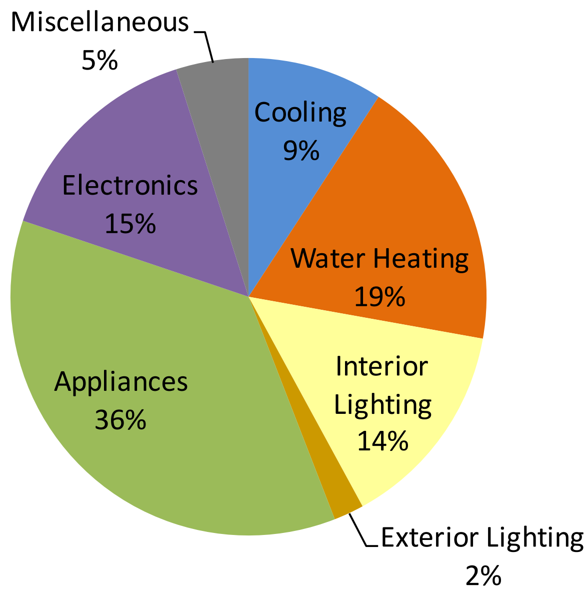
Segment	Number of Customers	Electricity Sales (GWh)	% of Total Usage	Avg. Use/ Customer (kWh)	Demand (MW)
SF Own	231,927	1,700	54%	7,331	672
SF Rent	70,140	486	15%	6,924	352
MF Own	65,951	334	11%	5,058	107
MF Rent	51,633	220	7%	4,259	77
MM Apt	86,063	397	13%	4,614	51
Total	**505,714**	**3,136**	**100%**	**6,202**	**1,208**

Figure 3-2 Residential Electricity Use by Customer Segment, 2012



Due to Hawaii's relatively mild climate, space conditioning accounts for only 9% of annual use. Appliances represent 36% of usage, water heating 19%, and interior lighting 14%. Electronics, which includes personal computers, TVs, set top boxes, home audio, etc., represents 15% of use, while the miscellaneous end use, which encompasses such devices as air purifiers, pool pumps, hot tubs, and other "plug" loads (hair dryers, power tools, coffee makers, etc.), consumes about 5%.

Figure 3-3 Residential Electricity Use by End Use, 2012



Master Meter Apartment Segmentation

The energy use from large multi-family buildings, including master-metered apartments is captured in the commercial sector billing data. For LoadMAP, we needed to separate the typical residential housing unit energy use from the commercial building usage. We split the total billed energy usage into the commercial and residential sectors. In the commercial sector, we modeled cooling, water heating and pool equipment electricity usage for the entire building. In the residential sector, we modeled the energy use from the housing units — lighting, appliances and miscellaneous electricity usage. To estimate the electricity usage for master-metered apartments, we began with the “Condos” data from the commercial Baseline Study sample design. We calculated the average energy use per building by dividing the annual energy usage by the number of accounts for each building type. We assumed that there is one building per account. Table 3-3 through Table 3-5 walks through the calculation for Oahu.

Table 3-3 Large Multifamily Electricity Consumption by Building Size, Oahu

Building Size	Number of Accounts	Electricity Use (MWh)	Avg. Use/Building (kWh/year)
Small	3,778	32,766	8,673
Medium	569	200,901	353,077
Large	51	111,887	2,193,863
Total	**4,398**	**345,554**	**78,571**

To estimate the number of units per buildings, we divided the average energy usage per building by the household intensity for “Multifamily Rent” from the RASS survey, 4,280 kWh. For medium and large buildings, we increased the intensity by 10% to account for the additional energy usage in the common areas. We then multiplied the number of units per building by the number of accounts to calculate the total number of master-metered apartments in the service territory. As shown in Table 3-5, we estimate that there are a total of 74,092 master-metered apartments in Oahu.

Table 3-4 Number of Master-Metered Apartments, Oahu

Building Size	Avg. Use/Building (kWh/year)	MF Rent Intensity (kWh/unit)	No. of Units per Building	Total No. of Units
Small	8,673	4,280	2	7,655
Medium	353,077	4,708	75	42,672
Large	2,193,863	4,708	466	23,765
Total	**78,571**			**74,092**

Finally, from the residential market profile for the Multifamily Rent segment, we estimated that approximately 68% of the Multifamily Rent intensity (2,910 kWh per household) is due to energy usage for lighting, appliances, and miscellaneous use. We applied this portion of the intensity to the total number of units to calculate the consumption for the residential sector for master-metered apartments. The remainder of the energy usage for Large Multifamily buildings is allocated to the commercial sector. The results for the master-metered apartments are shown in Table 3-5.

Table 3-5 Residential and Commercial Consumption for Master Metered Apartments, Oahu

Segment	Total No. of Units	MF Rent Intensity (kWh/unit)	Annual Energy Usage for Residential Sector (MWh)	Annual Energy Usage for Commercial Sector (MWh)
MM Apartments	74,092	2,910	215,641	129,913

We then applied this methodology to each of the islands, where applicable. We assigned the residential portion to the residential LoadMAP model and the commercial energy use to the commercial model.

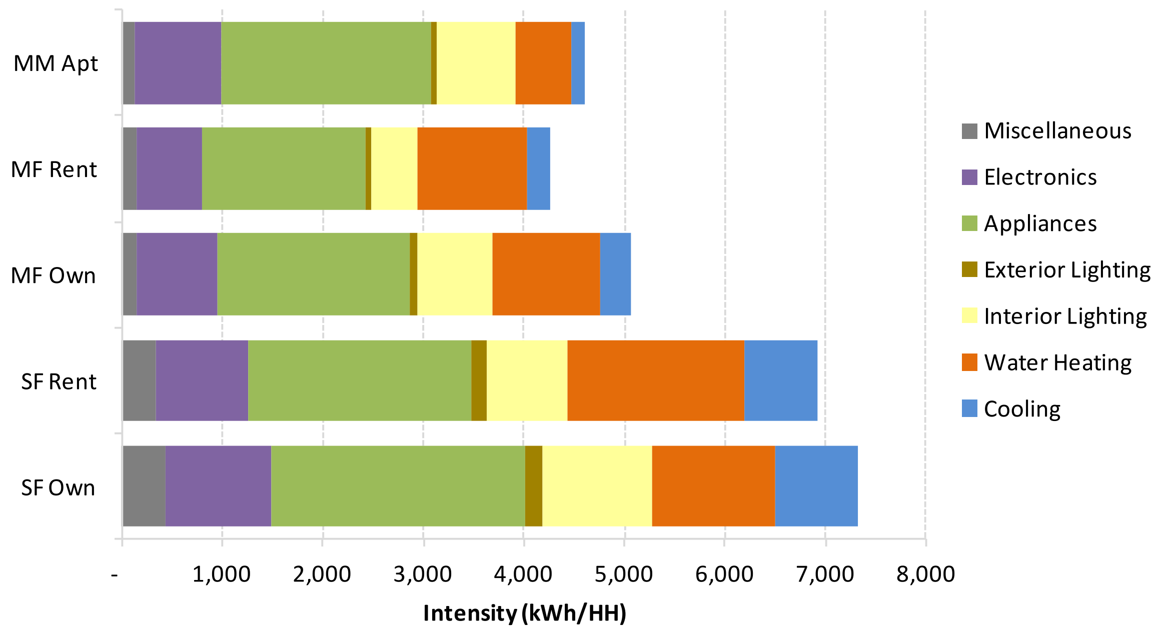
Statewide Electric Residential Profile

Table 3-6 presents the average existing home market profile for all residential segments across all islands. The existing-home profile represents all the housing stock in 2012. Market profiles for each of the residential segments on each island appear in Appendix A. Figure 3-4 presents the end-use breakout in terms of intensity, kWh/household-year, by segment.

Table 3-6 Average Residential Sector Market Profile

End Use	Technology	Saturation	UEC (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Central AC	5%	1,455.0	89.4	45.2
Cooling	Split AC	10%	1,242.8	165.2	83.6
Cooling	Room AC	25%	1,035.6	272.6	137.9
Cooling	Dehumidifier	5%	554.9	25.8	13.0
Water Heating	Water Heater <= 55 gal	43%	2,186.1	931.2	470.9
Water Heating	Water Heater > 55 gal	7%	2,330.3	177.6	89.8
Interior Lighting	Screw-in	100%	572.2	572.2	289.4
Interior Lighting	Linear Fluorescent	100%	114.7	114.7	58.0
Interior Lighting	Specialty	100%	143.1	143.1	72.3
Exterior Lighting	Screw-in	100%	123.4	123.4	62.4
Appliances	Refrigerator	100%	716.8	716.8	362.5
Appliances	Second Refrigerator	30%	814.5	246.3	124.5
Appliances	Freezer	24%	574.0	137.1	69.3
Appliances	Clothes Washer	84%	93.2	78.8	39.8
Appliances	Clothes Dryer	65%	639.8	418.5	211.7
Appliances	Dishwasher	33%	394.5	130.0	65.8
Appliances	Stove	83%	389.0	322.5	163.1
Appliances	Microwave	89%	121.1	107.4	54.3
Electronics	Personal Computers	62%	191.7	119.4	60.4
Electronics	Monitor	62%	38.2	23.8	12.0
Electronics	Laptops	104%	82.6	85.5	43.3
Electronics	Printer/Fax/Copier	75%	38.2	28.7	14.5
Electronics	TVs	213%	207.3	441.5	223.3
Electronics	Set-top Boxes/DVR	74%	131.7	97.6	49.4
Electronics	Devices and Gadgets	100%	94.9	94.5	47.8
Miscellaneous	Air Purifier/Cleaner	5%	1,092.4	55.8	28.2
Miscellaneous	Pool Pump	3%	1,082.1	37.0	18.7
Miscellaneous	Pool Heater	0%	1,244.8	2.5	1.3
Miscellaneous	Hot Tub/Spa	4%	850.0	32.4	16.4
Miscellaneous	Misc Heating	4%	343.5	16.5	8.4
Miscellaneous	Vehicle Charger	1%	2,729.0	30.5	15.4
Miscellaneous	Miscellaneous	100%	125.2	125.2	63.3
	Total			**5,963**	**3,016**

Figure 3-4 Residential Intensity by End Use and Segment, Statewide (kWh/household, 2012)



Commercial Sector

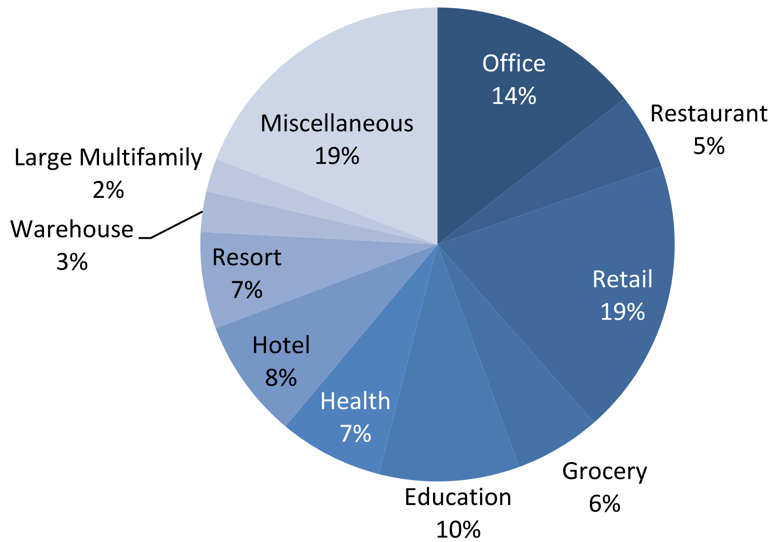
Total electricity use in the commercial sector in 2012 was 4,983 GWh throughout the state. The results of the Baseline Study and information from utility billing data analysis were used to allocate energy usage to building types and develop estimates of energy intensity (annual kWh/sq. ft.). Using the electricity use and intensity estimates, we infer floor space, which is the unit of analysis for the commercial sector in LoadMAP. Table 3-7 shows the commercial sector values to which all energy usage is calibrated in the base year of the study.

Figure 3-5 shows the relative energy use of each segment as a percentage of commercial sector electricity sales.

Table 3-7 Commercial Electricity Use by End Use and Segment (2012)

Segment	Electricity Use (GWh)	Intensity (kWh/SqFt)	Floor Space (1,000 SqFt)
Office	720	18.7	38,423
Restaurant	259	36.4	7,130
Retail	941	15.1	62,334
Grocery	292	69.8	4,187
Education	477	10.2	46,621
Health	353	27.5	12,840
Hotel	407	16.6	24,466
Resort	329	27.2	14,448
Warehouse	137	7.0	19,620
Large Multifamily	113	5.9	19,221
Miscellaneous	953	30.1	31,651
Total	**4,983**	**17.7**	**280,941**

Figure 3-5 Share of Commercial Sector Electricity Use by Building Type, 2012



Statewide Commercial Profile

Table 3-8 presents the average market profile for the commercial sector as a whole for all islands, representing a composite of all the building types. Market profiles for each segment on each island appear in Appendix A.

Figure 3-6 shows the breakdown of annual commercial electricity usage by end use for the commercial sector as a whole. Interior lighting is the largest single end use in the commercial sector, accounting for about 29% of total usage. The cooling end use consumes slightly less, but also about 29% of energy use. Each of the remaining end uses accounts for 10% or less of total usage.

Figure 3-6 Commercial Electricity Consumption by End Use, Statewide, 2012

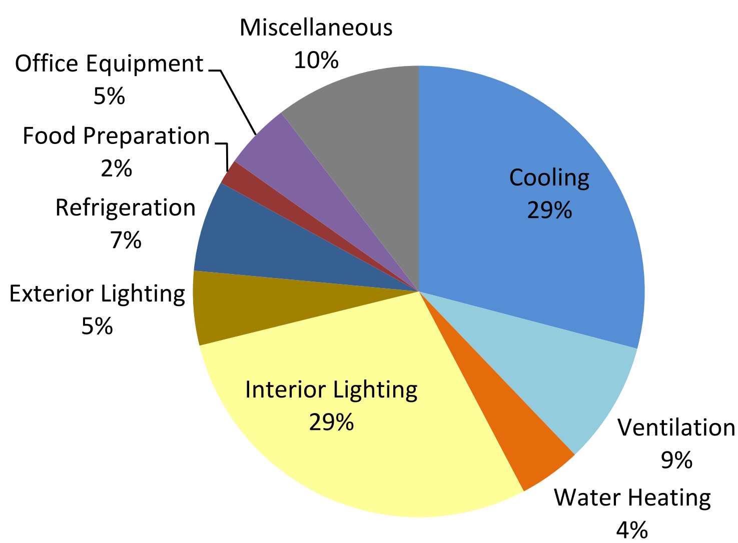
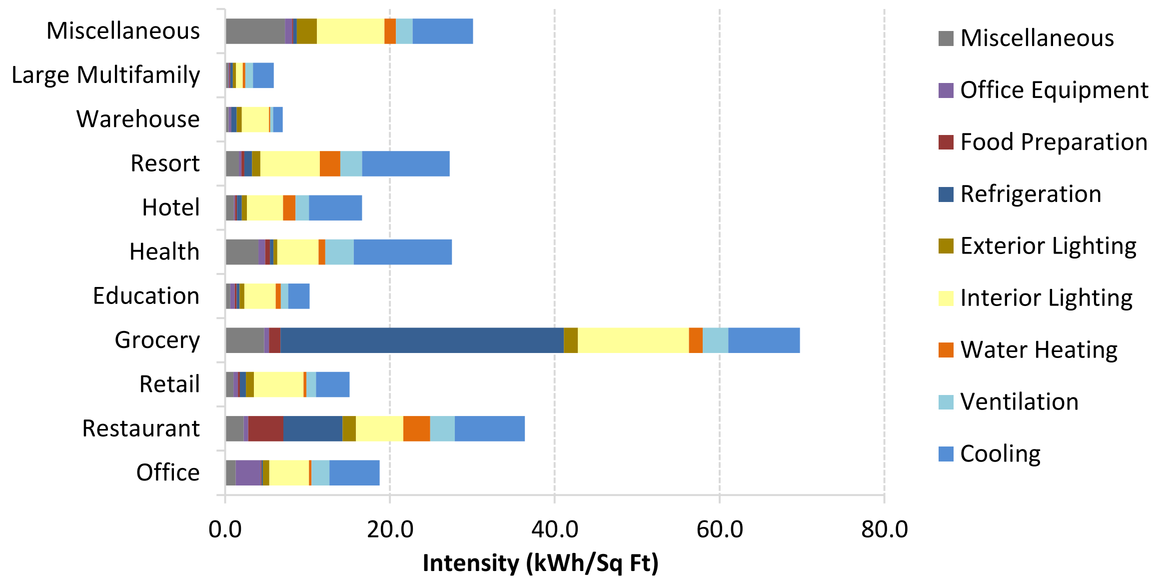


Table 3-8 Total Commercial Segment Market Profile, Statewide, 2012

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Sq	Usage (GWh)
Cooling	Air-Cooled Chiller	5.3%	7.91	0.41	116.0
Cooling	Water-Cooled Chiller	4.5%	8.88	0.40	112.9
Cooling	Roof top AC	39.6%	8.77	3.42	959.5
Cooling	PTAC	12.2%	7.90	0.95	267.2
Ventilation	Ventilation	100.0%	1.58	1.56	437.6
Water Heating	Water Heating	45.5%	1.78	0.80	224.7
Interior Lighting	Screw-in	100.0%	1.44	1.42	398.1
Interior Lighting	High-Bay Fixtures	100.0%	0.50	0.49	137.5
Interior Lighting	Linear Fluorescent	100.0%	3.24	3.20	900.0
Exterior Lighting	Screw-in	100.0%	0.20	0.20	56.1
Exterior Lighting	HID	100.0%	0.58	0.57	159.9
Exterior Lighting	Linear Fluorescent	100.0%	0.17	0.17	48.4
Refrigeration	Walk-in Refrigerator	17.0%	3.44	0.59	164.5
Refrigeration	Reach-in Refrigerator	11.4%	0.18	0.02	5.7
Refrigeration	Glass Door Display	13.2%	1.37	0.18	50.0
Refrigeration	Open Display Case	14.9%	1.06	0.16	43.8
Refrigeration	Icemaker	28.7%	0.51	0.14	40.4
Refrigeration	Vending Machine	22.5%	0.30	0.07	18.7
Food Preparation	Oven	34.2%	0.33	0.11	31.1
Food Preparation	Fryer	16.4%	0.42	0.07	19.0
Food Preparation	Dishwasher	24.0%	0.53	0.13	35.6
Food Preparation	Hot Food Container	16.5%	0.09	0.01	4.1
Office Equipment	Desktop Computer	85.9%	0.38	0.33	91.4
Office Equipment	Laptop	74.4%	0.08	0.06	15.7
Office Equipment	Server	74.9%	0.34	0.25	71.3
Office Equipment	Monitor	85.9%	0.11	0.09	25.2
Office Equipment	Printer/Copier/Fax	55.5%	0.13	0.07	19.5
Office Equipment	POS Terminal	58.5%	0.07	0.04	11.4
Misc	Non-HVAC Motors	17.4%	1.97	0.33	92.7
Misc	Pool Pump	21.3%	0.02	0.00	1.0
Misc	Pool Heater	21.3%	0.03	0.01	1.9
Misc	Misc	100.0%	1.52	1.50	421.8
Total				**17.7**	**4,983.0**

Figure 3-7 shows the electricity intensity by end use and building type in terms of kWh per square foot of building floor space. The grocery segment is the most energy intensive as a result of high refrigeration loads. Restaurants are second as a result of high refrigeration and electric food preparation loads. The miscellaneous sector has a high intensity due to the inclusion of manufacturing facilities in the segment.

Figure 3-7 Commercial Electricity Intensity by End Use and Segment, Statewide (2012)



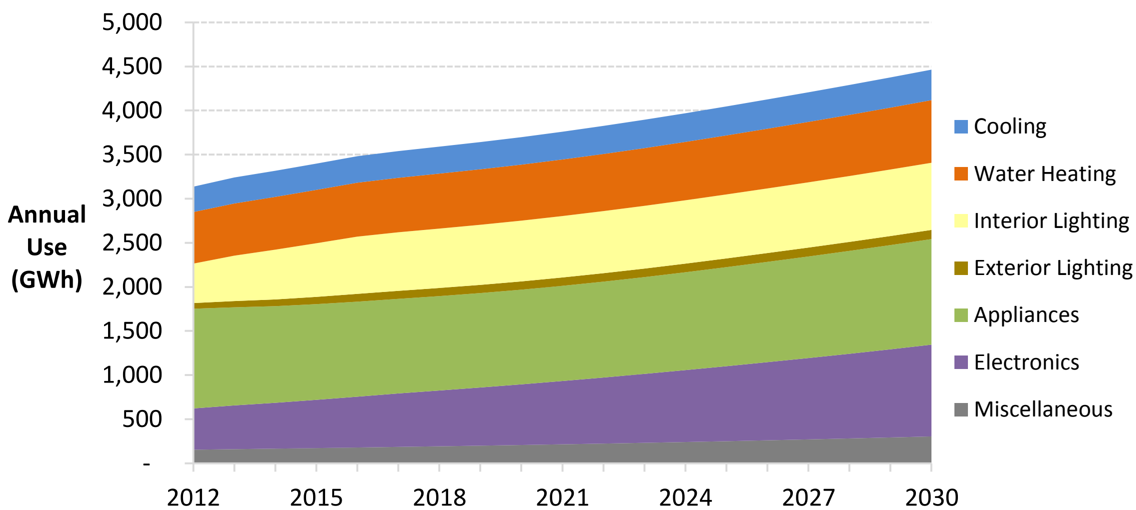
LOADMAP BASELINE PROJECTION

Once the base year is characterized, the next step is to project how energy will be used in the future. The LoadMAP baseline projection was developed to quantify how electricity is used by end use and what the consumption is likely to be in the future. The baseline projection is a fixed efficiency baseline that does **not** include the impact of market drivers and spillover, price effects, existing codes and standards, or future market interventions by contributing entities beyond 2012.[14] A fixed-efficiency baseline projection estimates energy consumption if the technology efficiency purchases made today will continue at the same level throughout the forecast period, as described earlier in Table 2-6.

Residential Sector

Figure 4-1 and Table 4-1 present the LoadMAP baseline projection at the end-use level for the residential sector as a whole for the entire state of Hawaii. Overall, residential use increases significantly, from 3,136 GWh in 2012 to 4,463 GWh in 2030, a 42% increase. Note that this does not take into account any efficiency that might be achieved through existing codes and standards or market drivers and spillover.

Figure 4-1 Residential LoadMAP Baseline Projection by End Use, Statewide



[14] This baseline projection is in alignment with the Underlying Economic Forecast from the HECO Companies' IRP forecast and KIUC's non-DSM sales forecast.

Table 4-1 Residential LoadMAP Baseline Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	288	298	312	329	346	20%	1.0%
Water Heating	585	605	635	669	710	21%	1.1%
Interior Lighting	447	608	689	726	761	70%	3.0%
Exterior Lighting	64	82	94	99	104	62%	2.7%
Appliances	1,131	1,085	1,073	1,123	1,197	6%	0.3%
Electronics	468	547	688	850	1,041	122%	4.4%
Miscellaneous	154	172	207	250	304	98%	3.8%
Total	**3,136**	**3,398**	**3,698**	**4,047**	**4,463**	**42.3%**	**2.0%**

Commercial Sector

Figure 4-2 and Table 4-2 present the LoadMAP baseline projection at the end-use level for the commercial sector as a whole for the entire state of Hawaii. All end uses show growth over the forecast period, from 4,983 GWh in 2012 to 6,444 GWh in 2030, a 29% increase. Note that this does not take into account any efficiency that might have been achieved through existing codes and standards or market drivers and spillover.

Figure 4-2 Commercial LoadMAP Baseline Electricity Projection by End Use

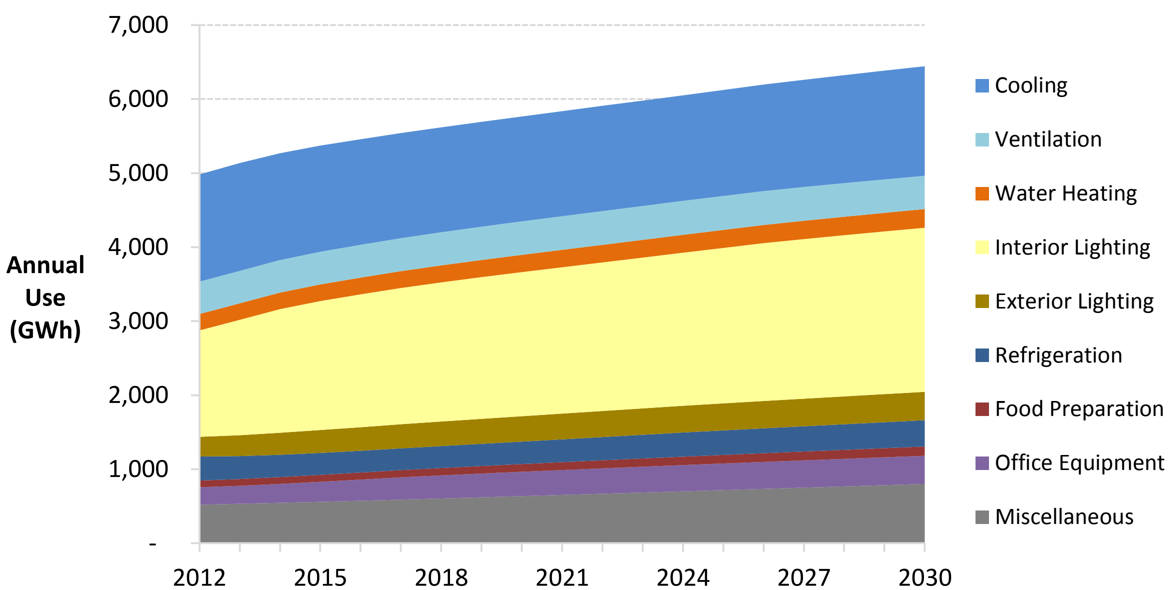


Table 4-2 Commercial LoadMAP Baseline Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	1,449	1,435	1,417	1,432	1,480	2.1%	0.1%
Ventilation	437	441	452	459	449	2.8%	0.2%
Water Heating	222	225	234	243	253	13.9%	0.7%
Interior Lighting	1,437	1,742	1,946	2,100	2,217	54.3%	2.4%
Exterior Lighting	266	310	343	365	383	44.1%	2.0%
Refrigeration	325	297	304	332	356	9.5%	0.5%
Food Preparation	90	94	104	116	125	38.8%	1.8%
Office Equipment	237	270	329	360	380	60.3%	2.6%
Miscellaneous	520	560	637	718	802	54.2%	2.4%
Total	**4,983**	**5,373**	**5,765**	**6,123**	**6,444**	**29.3%**	**1.4%**

Other Sectors

Figure 4-3 and Table 4-3 present the LoadMAP baseline projection at the end-use level for the other sectors as a whole. The growth in each of the sectors was a conservative estimate. For the water/wastewater sector, it is assumed that the sector will increase at 20% for the Board of Water and Sewer (applicable for most of the state) and 1% for the remainder of the sector for the next three years, based on the results of the Baseline Study case study. For the rest of the study period, growth is assumed to be 1% per year. This translates into growth of 34% between 2012 and 2030. For the military sector, the forecast is dependent on the funding from the federal government. Because sales to the military sector have varied over the past few years and the Department of Defense is currently experiencing budget constraints, we assumed 0% growth per year for the baseline forecast. For the street lighting sector, we assumed 1% growth per year in the baseline.

Figure 4-3 Other Sectors LoadMAP Baseline Electricity Forecast by Sector, Statewide

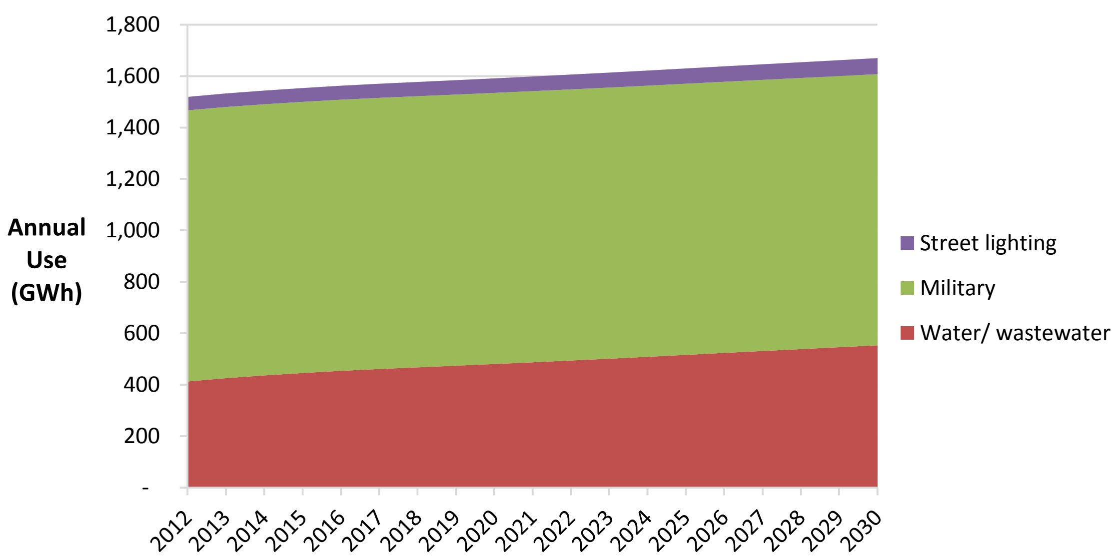


Table 4-3 Other Sectors Electricity Consumption by Sector, Statewide (GWh)

Sector	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Water/ wastewater	413	446	480	516	553	34%	1.6%
Military	1,054	1,054	1,054	1,054	1,054	0%	0.0%
Street Lighting	52	54	57	59	62	20%	1.0%
Total	**1,519**	**1,553**	**1,591**	**1,630**	**1,670**	**10%**	**0.5%**

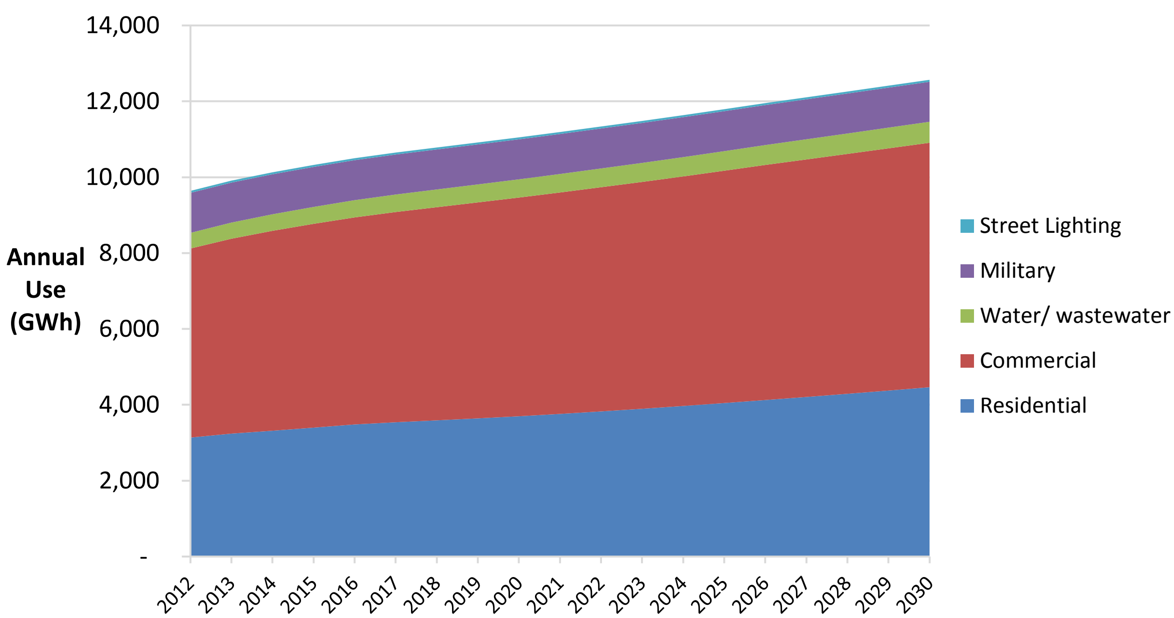
Summary of LoadMAP Baseline Projection

Table 4-4 and Figure 4-4 show the LoadMAP baseline projection for all the sectors statewide combined together. The Commercial sector is the largest sector, accounting for over half the energy use in 2030.

Table 4-4 LoadMAP Baseline Projection Summary, Statewide (GWh)

Sector	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Residential	3,136	3,398	3,698	4,047	4,463	42%	2.0%
Commercial	4,983	5,373	5,765	6,123	6,444	29%	1.4%
Water/wastewater	413	446	480	516	553	34%	1.6%
Military	1,054	1,054	1,054	1,054	1,054	0%	0.0%
Street Lighting	52	54	57	59	62	20%	1.0%
Total	**9,639**	**10,324**	**11,054**	**11,800**	**12,577**	**30%**	**1.5%**

Figure 4-4 LoadMAP Baseline Projection Summary, Statewide (GWh)



EXISTING CODES AND STANDARDS PROJECTION

The next step in the analysis was to develop a projection that reflects customer purchases of the minimum standard efficiency option per the appliance and equipment standards shown in Chapter 2, Table 2-11, and Table 2-12. This chapter shows the existing codes and standards projections for the residential and commercial sectors. Any codes and standards that take effect on or after January 1, 2009 count toward EEPS goals. This includes Hawaii-specific building codes, such as the requirement for solar water heating in single-family new construction. Codes and standards already "on the books" are included. This analysis makes no assumptions regarding future codes and standards, although any such additional codes and standards could be enacted in the future by contributing entities (local, state or federal government agencies) and those savings would count toward EEPS goals.

Residential Sector

Figure 5-1 and Table 5-1 present the Existing Codes and Standards projection at the end-use level for the residential sector as a whole for the entire state of Hawaii. Once building codes and appliance standards are taken into consideration, residential use increases moderately, from 3,136 GWh in 2012 to 3,702 GWh in 2030, an 18% increase. The white area between the LoadMAP baseline and the stacked color bands represents the savings that are achieved by existing codes and standards. This Existing Codes and Standards projection compares to the LoadMAP baseline projection as follows:

- Overall in 2030, the existing codes and standards projection is lower than the LoadMAP baseline projection by 762 GWh, or 17%.
- The biggest difference between the existing codes and standards and LoadMAP baseline projection is in lighting as a result of the EISA lighting standard.
- The water heating end use is dampened due to the State of Hawaii code that requires solar hot water heating for all new single-family construction.

Figure 5-1 Residential Existing Codes and Standards Projection by End Use, Statewide

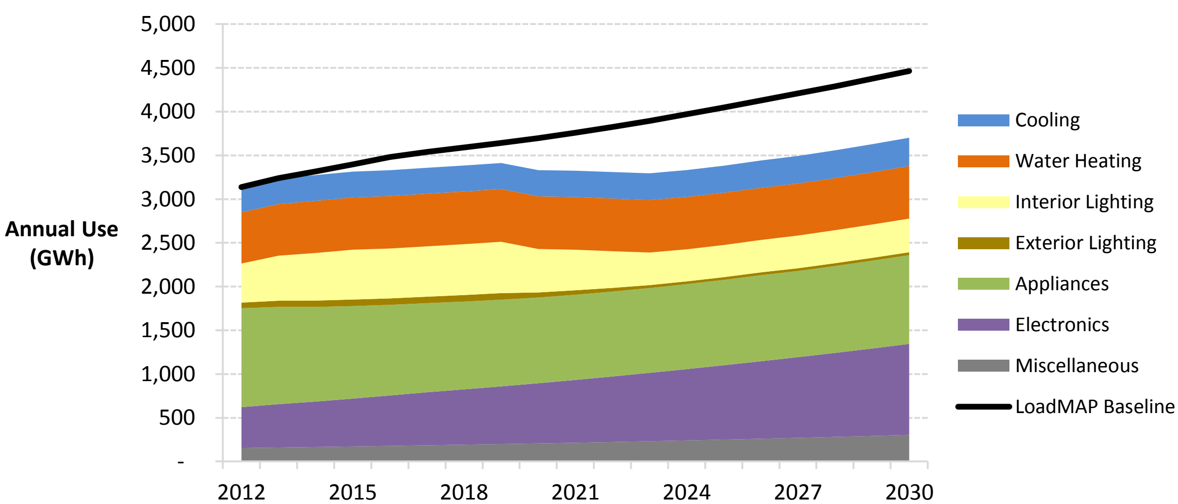


Table 5-1 Residential Existing Codes and Standards Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'303)	Avg. Growth Rate ('12-'30)
Cooling	288	295	299	310	323	12%	0.7%
Water Heating	585	598	602	597	601	3%	0.2%
Interior Lighting	447	570	497	367	385	-14%	-0.8%
Exterior Lighting	64	75	58	31	33	-49%	-3.7%
Appliances	1,131	1,058	980	976	1,015	-10%	-0.6%
Electronics	468	547	688	850	1,041	122%	4.4%
Miscellaneous	154	172	207	250	304	98%	3.8%
Total Existing Codes & Standards	**3,136**	**3,314**	**3,331**	**3,382**	**3,702**	**18.0%**	**0.9%**
LoadMAP Baseline	3,136	3,398	3,698	4,047	4,463	42.3%	2.0%
Savings (% of LoadMAP Baseline)	0%	-2%	-10%	-16%	-17%	n/a	n/a

Commercial Sector

Figure 5-2 and present the Existing Codes and Standards forecast at the end-use level for the commercial sector as a whole for the entire state of Hawaii. The white area below the LoadMAP Baseline represents the savings that are achieved through existing codes and standards. Once existing building codes and appliance standards are taken into consideration, commercial use increases modestly, from 4,983 GWh in 2012 to 5,730 GWh in 2030, a 15% increase.

- Overall, in 2030, the existing codes and standards projection is lower than the LoadMAP baseline projection by 714 GWh, or 11%.
- The biggest difference between the existing codes and standards and LoadMAP baseline projection is in lighting as a result of the EISA lighting standard.

Figure 5-2 Commercial Existing Codes and Standards Projection by End Use, Statewide

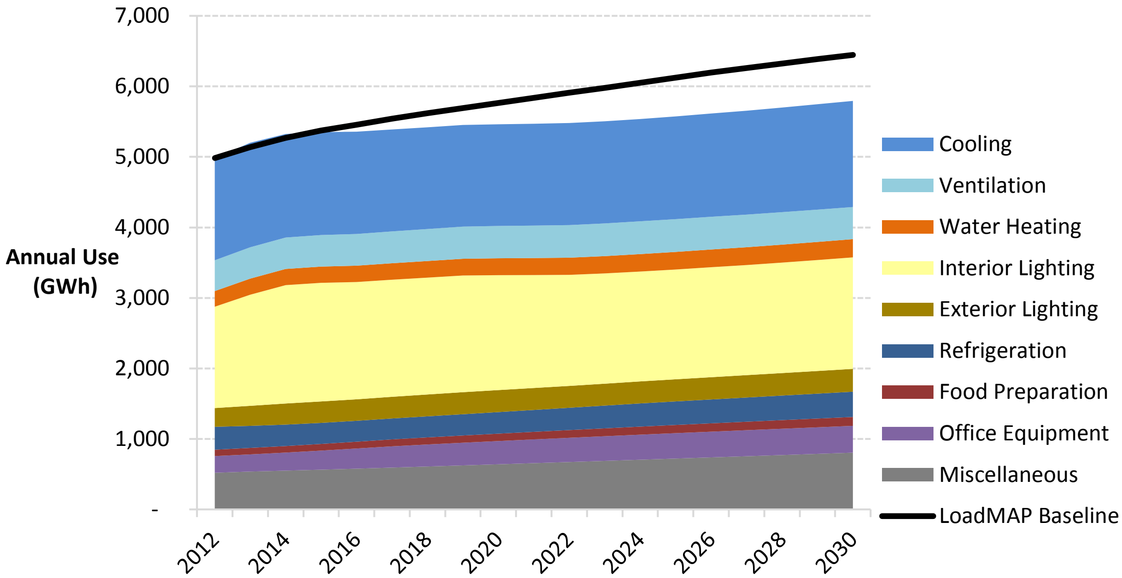


Table 5-2 Commercial Existing Codes and Standards Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	1,449	1,435	1,417	1,432	1,480	2.1%	0.1%
Ventilation	437	441	452	459	449	2.8%	0.2%
Water Heating	222	225	234	243	253	13.9%	0.7%
Interior Lighting	1,437	1,665	1,613	1,540	1,565	8.9%	0.5%
Exterior Lighting	266	301	310	311	321	21.0%	1.1%
Refrigeration	325	297	304	332	356	9.5%	0.5%
Food Preparation	90	94	104	116	125	38.8%	1.8%
Office Equipment	237	270	329	360	380	60.3%	2.6%
Miscellaneous	520	560	637	718	801	54.1%	2.4%
Total	**4,983**	**5,288**	**5,398**	**5,510**	**5,730**	**15.0%**	**0.8%**
LoadMAP Baseline	4,983	5,373	5,765	6,123	6,444	29.3%	1.4%
Savings (% of LoadMAP Baseline)	0.0%	-1.6%	-6.4%	-10.0%	-11.1%	n/a	n/a

MARKET DRIVEN AND SPILLOVER

The third projection is an estimate of market driven and spillover efficiency. As described in Chapter 1, the market driven and spillover projection includes savings from early adopters of energy-efficient appliances or equipment outside of programs and savings achieved due to changes in manufacturing practices, such as with electronics.

Residential Sector

Figure 6-1 and Table 6-1 present the Market Driven and Spillover projection at the end-use level for the residential sector as a whole for the entire state of Hawaii. Overall, residential use remains flat, barely changing from 3,136 GWh in 2012 to 3,143 GWh in 2030, a 0.2% increase. Note that the white area between the Existing Codes and Standards line and the colored bands represents the additional savings that could be achieved through Market Driven and Spillover. The white area between the black LoadMAP Baseline and the grey Existing Codes and Standards line represents the savings from the LoadMAP baseline that can be attributed to Existing Codes and Standards, as discussed in Chapter 5. The Market Driven and Spillover projection compares to the LoadMAP Baseline Projection and to the Existing Codes and Standards projection as follows.

- Overall, in 2030, the market driven and spillover projection is lower than the Existing Codes and Standards projection by 559 GWh, or 15%.
- The biggest difference between the market driven and spillover projections and the LoadMAP baseline is in electronics where customers are purchasing ENERGY STAR electronics because the manufacturers provide more efficient electronics for no additional cost.
- There are also significant savings in lighting due to customers adopting more efficient technologies, such as LED lamps without participating in energy efficiency programs.

Figure 6-1 Residential Market Driven & Spillover Projection by End Use, Statewide

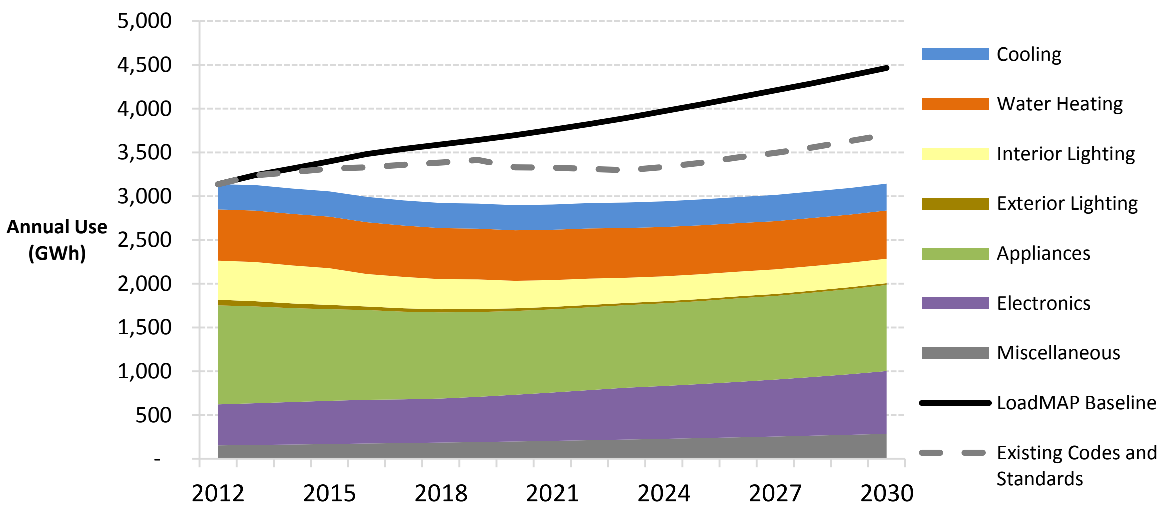


Table 6-1 Residential Market Driven & Spillover Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'303)	Avg. Growth Rate ('12-'30)
Cooling	288	289	287	296	307	7%	0.4%
Water Heating	585	588	577	558	551	-6%	-0.3%
Interior Lighting	447	420	314	284	280	-37%	-2.6%
Exterior Lighting	64	49	30	23	21	-68%	-6.2%
Appliances	1,131	1,046	957	948	983	-13%	-0.8%
Electronics	468	494	533	617	717	53%	2.4%
Miscellaneous	154	169	198	237	285	86%	3.4%
Total	**3,136**	**3,054**	**2,897**	**2,963**	**3,143**	**0.2%**	**0.0%**
LoadMAP Baseline	3,136	3,398	3,698	4,047	4,463	42.3%	2.0%
Savings (% of LoadMAP Baseline)	0%	-10%	-22%	-27%	-30%	n/a	n/a
Existing Codes and Standards	3,136	3,314	3,331	3,382	3,702	18.0%	0.9%
Savings (% of Existing C&S Baseline)	0%	-8%	-13%	-12%	-15%	n/a	n/a

Table 6-2 shows the end-use forecast at the technology level after Existing Codes and Standards and Market Driven and Spillover are taken into consideration. Specific observations include:

- The primary reason for the modest initial growth in the LoadMAP Baseline Projection is the phase-in beginning in 2012 of the federal lighting standards. Appliances energy use also decreases, due to mandated efficiency gains, particularly in refrigeration appliances.
- Cooling increases as higher saturation of air conditioning in new construction and general population growth goes against the effects of appliance standards.
- Water heating decreases as a result of higher solar water heating saturations in new construction.
- Growth in electricity use in electronics is substantial and reflects an increase in the saturation of electronics and the trend toward higher-powered computers, and additional devices such as electronic gaming. This increase is somewhat tempered by higher efficiency televisions.
- Growth in miscellaneous use is also substantial. This use includes various plug loads not elsewhere classified (e.g., hair dryers, power tools, coffee makers, etc.). This end use has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

Table 6-2 Residential Market Driven and Spillover Projection by End Use and Technology (GWh)

End Use	Technology	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	Central AC	45	47	49	54	60	32.4%	1.6%
	Split AC	84	86	88	91	94	12.3%	0.6%
	Room AC	145	142	136	135	137	-5.7%	-0.3%
	Dehumidifier	14	14	14	15	16	16.1%	0.8%
Water Heating	Water Heater <= 55 gal	495	499	498	499	507	2.4%	0.1%
	Water Heater > 55 gal	90	89	78	59	44	-51.2%	-4.0%
Interior Lighting	Screw-in	308	256	157	119	108	-65.0%	-5.8%
	Linear Fluorescent	62	63	65	68	71	15.0%	0.8%
	Specialty	77	100	93	97	101	30.7%	1.5%
Exterior Lighting	Screw-in	64	49	30	23	21	-67.5%	-6.2%
Appliances	Refrigerator	365	328	273	248	247	-32.4%	-2.2%
	Second Refrigerator	129	109	94	93	97	-25.3%	-1.6%
	Freezer	67	67	68	73	79	17.0%	0.9%
	Clothes Washer	42	36	29	26	25	-41.9%	-3.0%
	Clothes Dryer	229	210	189	187	195	-15.0%	-0.9%
	Dishwasher	75	63	55	55	58	-22.6%	-1.4%
	Stove	167	175	188	202	216	29.9%	1.5%
	Microwave	55	57	60	63	66	19.5%	1.0%
Electronics	Personal Computers	64	70	80	91	97	52.5%	2.3%
	Monitor	13	14	17	19	21	64.4%	2.8%
	Laptops	45	49	58	71	87	94.4%	3.7%
	Printer/Fax/Copier	16	17	20	24	29	89.8%	3.6%
	TVs	231	230	232	251	280	21.2%	1.1%
	Set-top Boxes/DVR	52	57	54	64	78	48.2%	2.2%
	Devices and Gadgets	48	57	74	97	126	160.9%	5.3%
Miscellaneous	Air Purifier/Cleaner	28	29	30	31	33	16.2%	0.8%
	Pool Pump	19	19	21	22	24	30.8%	1.5%
	Pool Heater	1	1	1	2	2	32.1%	1.5%
	Hot Tub/Spa	16	17	19	21	24	44.5%	2.0%
	Misc Heating	8	9	9	10	10	23.0%	1.2%
	Vehicle Charger	15	16	18	20	22	39.9%	1.9%
	Miscellaneous	65	77	100	131	171	161.2%	5.3%
Total		**3,136**	**3,054**	**2,897**	**2,963**	**3,143**	**0.2%**	**-0.4%**

Commercial Sector

Figure 6-2 and Table 6-3 present the Market Driven and Spillover projection at the end-use level for the commercial sector as a whole for the entire state of Hawaii. Note that the white area between the Existing Codes and Standards line and the colored bands represents the additional savings that could be achieved through Market Driven and Spillover. The white area between the black LoadMAP Baseline and the grey Existing Codes and Standards line represents the savings from the LoadMAP baseline that can be attributed to Existing Codes and Standards. Overall, commercial use decreases modestly, from 4,983 GWh in 2012 to 4,696 GWh in 2030, a 5.8% decrease. This decrease is driven by the assumed purchase shares. As described in Chapter 1, the market driven and spillover projection include savings from two areas: savings from early adopters of energy-efficient appliances or equipment outside of programs and savings achieved due to changes in manufacturing practices, such as with electronics.

Figure 6-2 Commercial Market Driven & Spillover Projection by End Use, Statewide

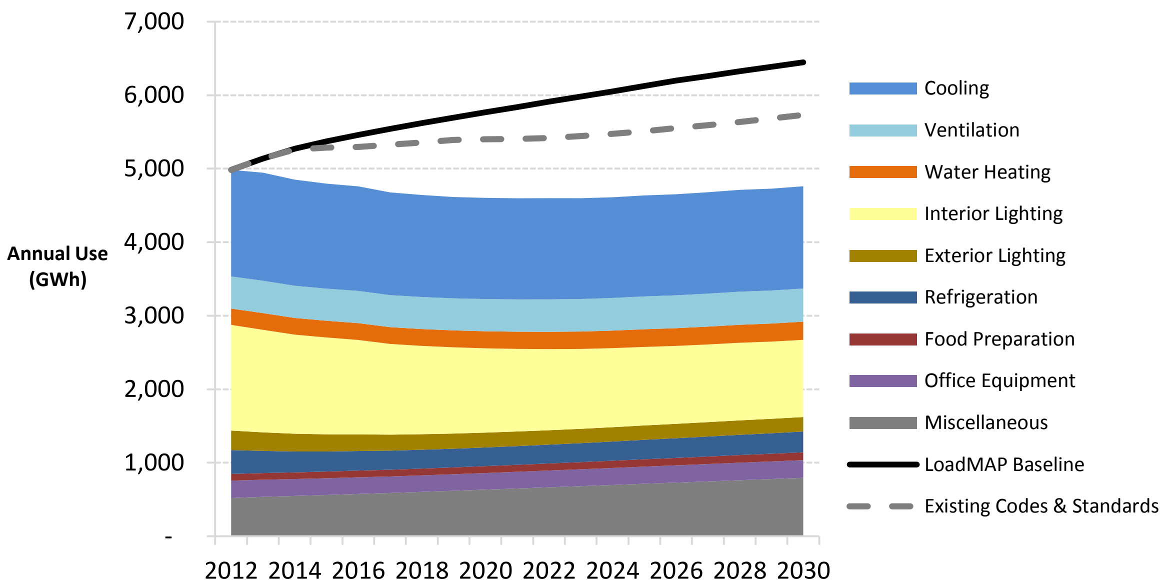


Table 6-3 Commercial Market Driven & Spillover Projection by End Use, Statewide (GWh)

End Use	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	1,449	1,403	1,351	1,349	1,366	-5.7%	-0.3%
Ventilation	437	431	432	440	444	1.7%	0.1%
Water Heating	222	221	226	234	241	8.6%	0.5%
Interior Lighting	1,437	1,300	1,130	1,051	1,033	-28.1%	-1.8%
Exterior Lighting	266	232	200	193	195	-26.7%	-1.7%
Refrigeration	325	271	252	263	280	-13.8%	-0.8%
Food Preparation	90	90	93	99	106	17.1%	0.9%
Office Equipment	237	227	225	232	240	1.3%	0.1%
Miscellaneous	520	557	630	710	791	52.1%	2.3%
Total	**4,983**	**4,732**	**4,538**	**4,571**	**4,696**	**-5.8%**	**-0.3%**
LoadMAP Baseline	4,983	5,373	5,765	6,123	6,444	29.3%	1.4%
% Savings from LoadMAP Baseline	0.0%	-11.9%	-21.3%	-25.3%	-27.1%	n/a	n/a
Existing Codes & Standards	4,983	5,288	5,398	5,510	5,730	15.0%	0.8%
% Savings from Existing Codes & Standards Baseline	0.0%	-10.5%	-15.9%	-17.0%	-18.0%	n/a	n/a

Table 6-4 shows the end-use forecast at the technology level after Existing Codes and Standards and market driven and spillover are taken into consideration. Specific observations include:

- The primary reason for the modest decrease in the LoadMAP Baseline Projection is the phase-in beginning in 2012 of the federal lighting standards. The standard causes a decline in interior lighting use by 59% and exterior lighting use by 61% over the forecast period.
- Refrigeration energy use also decreases, due to mandated efficiency gains.
- Growth in office equipment reflects an increase in the saturation of computers and servers. This increase is somewhat tempered by higher efficiency servers.
- Growth in miscellaneous use is also substantial. This use includes various plug loads not elsewhere classified (e.g., non-HVAC motors, lab equipment, heating, etc.). This end use has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

Table 6-4 Commercial Market Driven and Spillover Projection by End Use and Technology, Statewide (GWh)

End Use	Technology	2012	2015	2020	2025	2030	% Change ('12-'30)	Avg. Growth Rate ('12-'30)
Cooling	Air-Cooled Chiller	117	117	119	123	126	8.2%	0.4%
	Water-Cooled Chiller	108	99	94	90	88	-18.9%	-1.2%
	Roof top AC	963	921	867	852	861	-10.5%	-0.6%
	PTAC	262	266	272	284	291	11.2%	0.6%
Ventilation	Ventilation	437	431	432	440	444	1.7%	0.1%
Water Heating	Water Heating	222	221	226	234	241	8.6%	0.5%
Interior Lighting	Screw-in	391	291	225	186	161	-58.7%	-4.9%
	High-Bay Fixtures	139	136	126	125	130	-6.5%	-0.4%
	Linear Fluorescent	908	873	779	740	742	-18.2%	-1.1%
Exterior Lighting	Screw-in	56	39	29	24	22	-61.0%	-5.2%
	HID	160	145	129	129	133	-17.2%	-1.1%
	Linear Fluorescent	49	47	42	40	40	-18.3%	-1.1%
Refrigeration	Walk-in Refrigerator	166	121	94	92	95	-42.5%	-3.1%
	Reach-in Refrigerator	6	4	3	4	4	-27.0%	-1.7%
	Glass Door Display	50	49	53	58	63	25.9%	1.3%
	Open Display Case	44	43	47	51	55	24.7%	1.2%
	Icemaker	41	39	41	44	47	16.2%	0.8%
	Vending Machine	19	16	14	14	15	-17.8%	-1.1%
Food Preparation	Oven	31	31	33	35	37	19.5%	1.0%
	Fryer	19	20	22	23	25	29.6%	1.4%
	Dishwasher	36	35	35	36	39	9.1%	0.5%
	Hot Food Container	4	4	4	4	5	8.9%	0.5%
Office Equipment	Desktop Computer	92	90	88	91	93	1.0%	0.1%
	Laptop	16	16	16	17	17	8.8%	0.5%
	Server	72	66	64	64	66	-7.8%	-0.5%
	Monitor	25	26	27	29	30	17.5%	0.9%
	Printer/Copier/Fax	20	20	20	21	22	13.0%	0.7%
	POS Terminal	11	10	10	10	11	-5.2%	-0.3%
Miscellaneous	Non-HVAC Motors	93	96	102	108	114	23.4%	1.2%
	Pool Pump	1	1	1	1	1	21.2%	1.1%
	Pool Heater	2	2	2	2	2	17.6%	0.9%
	Miscellaneous	425	459	526	599	673	58.6%	2.6%
Total		**4,983**	**4,732**	**4,538**	**4,571**	**4,696**	**-5.8%**	**-0.3%**

ENERGY EFFICIENCY POTENTIAL RELATIVE TO LOADMAP BASELINE PROJECTION

Following the development of the LoadMAP baseline projection, the projection of savings from existing and/or known codes and standards, and the market-driven efficiency and spillover projection, the next step is to develop estimates of additional savings that could be achieved through interventions by contributing entities. In this step, the study estimates technical and economic potential, as is typical in potential studies.

This chapter presents the results for technical and economic potential, as well as the results from the previous projections, relative to the LoadMAP baseline projection. First, the overall results are presented, followed by results for each sector.

Overall Potential

Table 7-1 and Figure 7-1 summarize the savings potential for all measures derived from the projections developed for this study and compared to the LoadMAP baseline projection.

- **Technical potential,** which reflects the adoption of all energy efficiency measures regardless of cost-effectiveness, is a theoretical upper bound on savings. In 2030, technical potential savings, which include all the other levels as well, are 6,848 GWh. This is 54% of the LoadMAP baseline projection.
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 6,210 GWh in 2030. This is 49% of the LoadMAP baseline projection. Due to the high avoided costs in Hawaii it is reasonable that the majority of the technical potential is also economic.
- **Market-driven and spillover** across all sectors statewide is 3,133 GWh in 2030. This is 25% of the LoadMAP baseline projection.
- **Existing Codes and standards,** which reflects the savings that are achieved by the existing federal and state appliance standards and building codes, is 1,540 GWh in 2030 statewide. This is 12% of the LoadMAP baseline projection
- **2009–2012 Program Savings** includes the savings that were achieved in the first phase between 2009 and 2012. Each year the annual EEPS goals were met. The savings from these years have a decay factor applied to them. At the end of the EEPS forecast period, the annual savings represent 1% of the LoadMAP baseline projection.

Figure 7-2 illustrates the projected energy use for each case.

Table 7-1 Summary of Energy Efficiency Potential, Statewide Relative to the LoadMAP Baseline

	2015	2020	2025	2030	Marginal Contribution in 2030
LoadMAP Baseline Projection (GWh)	10,324	11,054	11,800	12,577	n/a
Cumulative Savings (GWh)					
2009-2012 Program Achievements	591	377	182	64	64
Existing Codes & Standards	759	1,110	1,461	1,540	1,476
Market Driven & Spillover	1,575	2,404	2,818	3,133	1,592
Economic Potential	2,519	4,042	5,275	6,210	3,077
Technical Potential	2,724	4,493	5,870	6,848	638
Energy Savings (% of LoadMAP Baseline Projection)					
2009-2012 Program Achievements	6%	3%	2%	1%	1%
Existing Codes & Standards	7%	10%	12%	12%	12%
Market Driven & Spillover	15%	22%	24%	25%	13%
Economic Potential	24%	37%	45%	49%	24%
Technical Potential	26%	41%	50%	54%	5%

Figure 7-1 Summary of Achievable Potential Energy Savings, Statewide

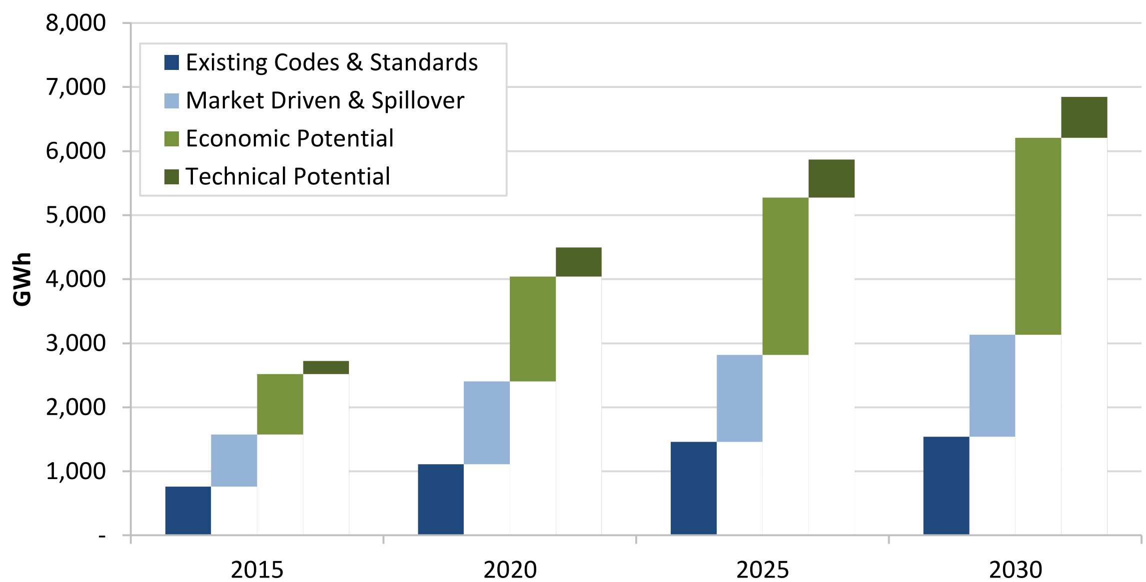
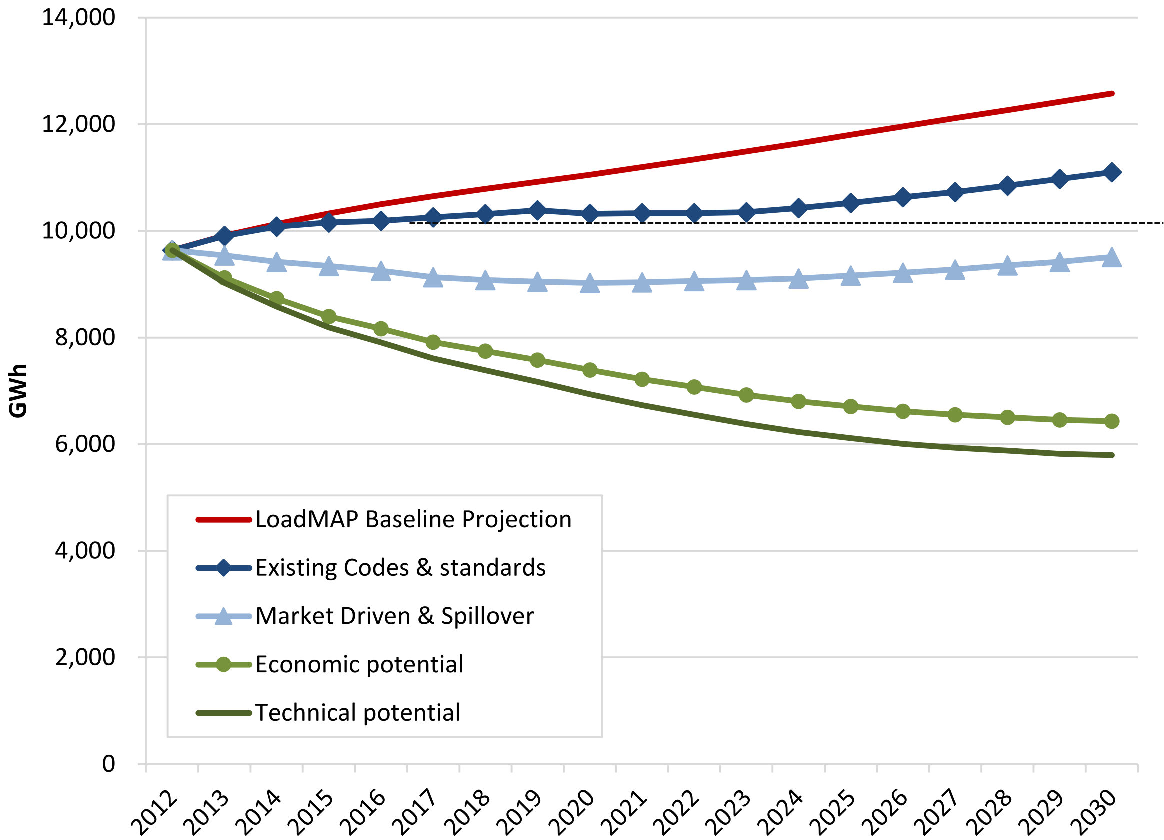


Figure 7-2 Summary of Projections, Statewide



Residential Sector

Table 7-2 presents estimates for the various types of potential for the residential sector starting in 2013. Figure 7-3 depicts the cumulative potential energy savings estimates graphically[15].

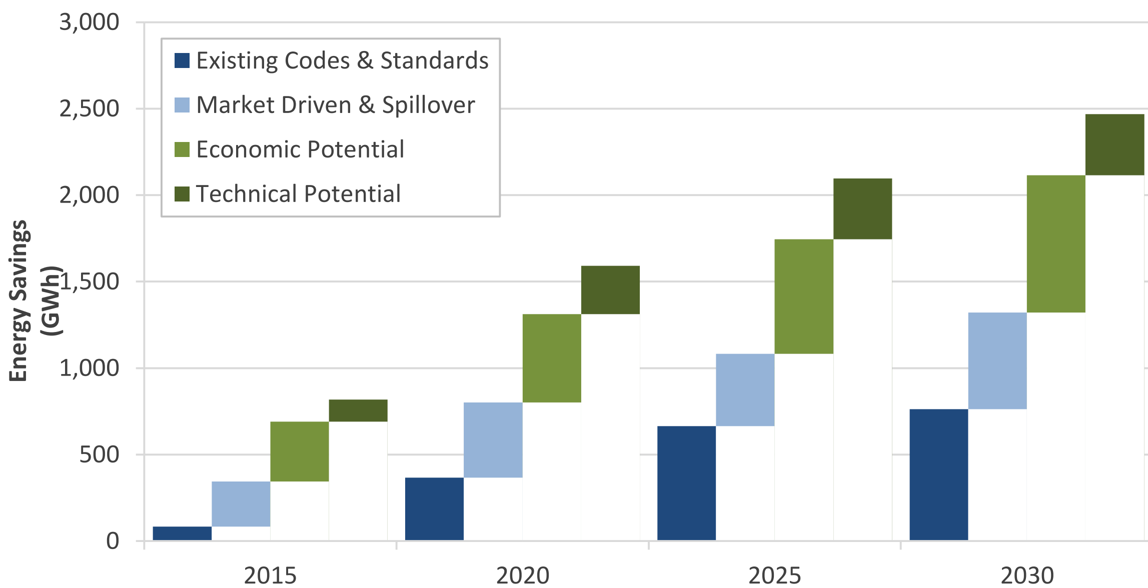
- **Technical potential** which reflects the adoption of all energy efficiency measures regardless of cost is a theoretical upper bound on savings. Technical potential in the residential sector is substantial, because measures such as LED lamps and solar water heaters could cut energy use dramatically. The technical potential is 2,469 GWh in 2030, or 55% of the baseline energy projection.
- **Economic potential** which reflects the savings when all cost-effective measures are taken is 2,115 GWh, or 47% of the baseline energy forecast in 2030. Economic potential is a large percentage of technical potential due to the high avoided energy and capacity costs.
- **Market Driven and Spillover** is 1,321 GWh in 2030. This level of potential is equivalent to 30% of the residential LoadMAP baseline projection for that year.
- **Existing Codes and Standards** which reflects savings from existing codes and standards is significant at 762 GWh, or 17% of the LoadMAP baseline projection.

[15] In Figure 7-3 the savings represent the cumulative savings. Therefore “2015” represents the cumulative savings from 2013, 2014 and 2015. LoadMAP includes savings for the entire year (January 1 through December 31).

Table 7-2 Energy Efficiency Potential for the Residential Sector Relative to the LoadMAP Baseline

	2015	2020	2025	2030	Marginal Contribution in 2030
LoadMAP Baseline (GWh)	3,398	3,698	4,047	4,463	
Cumulative Savings (GWh)					
Existing Codes & Standards	84	367	665	762	762
Market Driven & Spillover	344	801	1,084	1,321	559
Economic Potential	690	1,312	1,745	2,115	794
Technical Potential	818	1,591	2,096	2,469	355
Energy Savings (% of LoadMAP Baseline)					
Existing Codes & Standards	2.5%	9.9%	16.4%	17.1%	17.1%
Market Driven & Spillover	10.1%	21.7%	26.8%	29.6%	12.5%
Economic Potential	20.3%	35.5%	43.1%	47.4%	17.8%
Technical Potential	24.1%	43.0%	51.8%	55.3%	7.9%

Figure 7-3 Residential Energy Efficiency Savings by Potential Case



Residential Potential by End Use, Technology, and Measure Type

Table 7-3 identifies the top 20 residential measures in 2030 by savings type. These top 20 measures account for 90% of the total savings. The top measure is screw-in lamps, which account for 22% of savings in 2030. Most of the savings are due to the EISA standard that calls for the removal of all incandescent screw-in lamps by 2014 and moves consumers to higher-efficiency lamps, and to still higher efficiency units in 2020 as the second tier of the standard takes effect. But further savings come from economic potential that moves consumers to still more efficient CFLs or LEDs in the near term. For water heating, the largest potential for savings would come from a program that incentivizes customers to install solar water heating. For electronics, there are no federal or state standards, but manufacturing practices now include manufacturing to the ENERGY STAR standard. Because the majority of televisions are now ENERGY STAR qualified and do not cost anything additional, the savings are driven by the market.

Table 7-3 Residential Top Measures by Savings Type in 2030, (GWh)

Measure	Existing Codes & Standards Savings	Market Driven & Spillover Savings	Economic Potential Savings	Total Savings (GWh)	% of Total
Interior Lighting - Screw-in	369.8	61.9	28.3	460.0	22.2%
Water Heating - Water Heater <= 55 gal	51.8	41.0	189.4	282.2	13.6%
Electronics - TVs	-	143.3	17.7	161.0	7.8%
Interior Lighting - Specialty	-	40.6	82.0	122.6	5.9%
Appliances - Refrigerator	96.9	8.9	0.4	106.2	5.1%
Electronics - Set-top Boxes/DVR	-	70.6	21.5	92.1	4.4%
Exterior Lighting - Screw-in	71.2	11.9	5.5	88.6	4.3%
Water Heating - Water Heater > 55 gal	57.1	9.4	21.5	88.0	4.2%
Water Heater - Low-Flow Showerheads	-	-	67.2	67.2	3.2%
Refrigerator - Early Replacement	-	-	65.5	65.5	3.2%
Electronics - Personal Computers	-	46.9	2.7	49.6	2.4%
Interior Lighting - Linear Fluorescent	6.9	2.6	32.7	42.2	2.0%
Appliances - Second Refrigerator	37.1	3.6	0.5	41.1	2.0%
Electronics - Laptops	-	40.8	0.2	41.0	2.0%
Cooling - Room AC	17.1	8.1	8.4	33.6	1.6%
Ceiling Fan - Installation	-	-	27.9	27.9	1.3%
Appliances - Clothes Dryer	10.5	11.4	2.9	24.8	1.2%
Electronics - Smart Power Strips	-	-	24.6	24.6	1.2%
Miscellaneous - Air Purifier/Cleaner	-	8.2	9.9	18.0	0.9%
Appliances - Freezer	15.3	1.4	0.7	17.4	0.8%
Total	**733.8**	**510.6**	**609.4**	**1,853.8**	**89.5%**

Figure 7-4 shows the amount of savings in the residential sector by type of savings. Table 7-4 provides estimates of savings for each end use and type of potential.

Figure 7-4 Residential Energy Efficiency Savings by Case

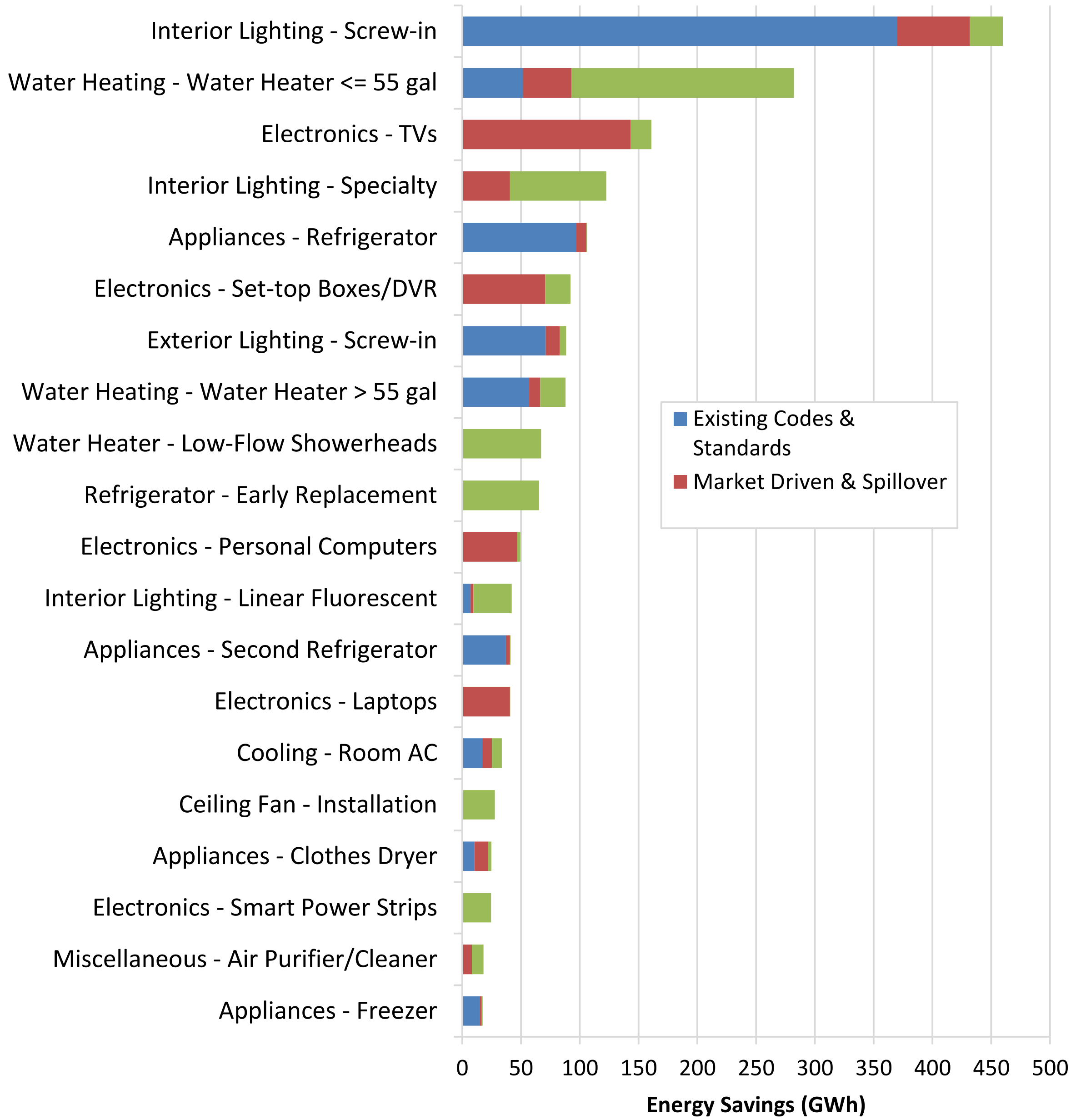


Table 7-4 Residential Cumulative Savings by End Use and Potential Type (GWh)

End Use	Case	2015	2020	2025	2030
Cooling	Existing Codes and Standards	3	12	19	22
	Market Driven and Spillover	9	24	33	39
	Economic Potential	28	73	115	146
	Technical Potential	35	92	140	168
Water Heating	Existing Codes and Standards	7	33	72	109
	Market Driven and Spillover	17	58	111	159
	Economic Potential	66	210	378	505
	Technical Potential	129	346	535	648
Interior Lighting	Existing Codes and Standards	39	192	358	377
	Market Driven and Spillover	189	375	441	482
	Economic Potential	352	517	568	637
	Technical Potential	357	519	565	637
Exterior Lighting	Existing Codes and Standards	7	36	68	71
	Market Driven and Spillover	33	64	76	83
	Economic Potential	54	77	82	92
	Technical Potential	54	77	83	93
Appliances	Existing Codes and Standards	27	93	148	183
	Market Driven and Spillover	39	116	176	215
	Economic Potential	66	175	255	301
	Technical Potential	114	291	423	486
Electronics	Existing Codes and Standards	-	-	-	-
	Market Driven and Spillover	53	155	233	323
	Economic Potential	115	240	312	390
	Technical Potential	120	244	315	392
Miscellaneous	Existing Codes and Standards	-	-	-	-
	Market Driven and Spillover	3	9	13	19
	Economic Potential	9	22	34	44
	Technical Potential	9	22	34	44
Total	**Existing Codes and Standards**	**84**	**367**	**665**	**762**
	Market Driven and Spillover	**344**	**801**	**1,084**	**1,321**
	Economic Potential	**690**	**1,312**	**1,745**	**2,115**
	Technical Potential	**818**	**1,591**	**2,096**	**2,469**

Commercial Sector Potential

Table 7-5 presents estimates for each type of potential for the commercial sector. The LoadMAP baseline projection for the commercial sector grows steadily during the forecast period as the state emerges from the economic downturn. As a result, opportunities for energy-efficiency savings are significant for the commercial sector.

- **Technical potential** which reflects the adoption of all energy efficiency measures regardless of cost is a theoretical upper bound on savings. Technical potential in the commercial sector is substantial, because measures such as LED lamps, Super T-8s, and heat pump and solar water heaters could cut energy use dramatically. The technical potential is 3,474 GWh in 2030, or 54% of the baseline energy forecast.

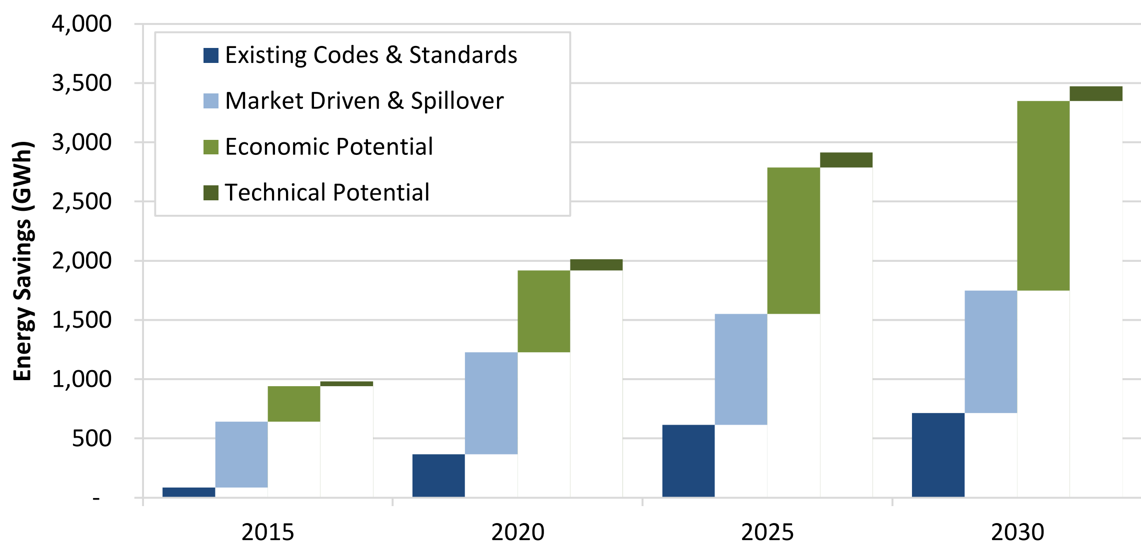
- **Economic potential** which reflects the savings when all cost-effective measures are taken is 3,347 GWh, or 52% of the baseline energy forecast in 2030. Economic potential is a large percentage of technical potential due to the high avoided energy and capacity costs.
- **Market Driven and spillover** is 1,748 GWh in 2030. This level of potential is equivalent to 27% of the commercial LoadMAP baseline projection for that year.
- **Existing Codes and Standards** is 714 GWh in 2030, which is 11% of the commercial LoadMAP baseline projection for that year.

Table 7-5 and Figure 7-5 present the savings associated with each level of potential.

Table 7-5 Cumulative Energy Efficiency Potential for the Commercial Sector Relative to LoadMAP Baseline

	2015	2020	2025	2030	Marginal Contribution in 2030
LoadMAP Baseline (GWh)	5,373	5,765	6,123	6,444	n/a
Cumulative Savings (GWh)					
Existing Codes & Standards	85	367	613	714	714
Market Driven & Spillover	641	1,227	1,552	1,748	1,034
Economic Potential	942	1,917	2,788	3,347	1,599
Technical Potential	982	2,013	2,915	3,474	127
Savings (% of LoadMAP Baseline)					
Existing Codes & Standards	1.6%	6.4%	10.0%	11.1%	11.1%
Market Driven & Spillover	11.9%	21.3%	25.3%	27.1%	16.0%
Economic Potential	17.5%	33.3%	45.5%	51.9%	24.8%
Technical Potential	18.3%	34.9%	47.6%	53.9%	2.0%

Figure 7-5 Commercial Energy Efficiency Savings by Case



Commercial Potential by End Use, Technology, and Measure Type

Table 7-6 identifies the top 20 commercial measures in 2030 by savings type. These top 20 measures account for almost 90% of the total economic commercial savings in 2030. The top measures are lighting measures with most of the savings arising through the federal lighting standard. The top measure is screw-in lamps, which account for 25% of savings in 2030. Linear fluorescent savings are through the installation of Super T8 lamps in the near term and the installation of the next generation of LED lamps which will be available starting in 2020. For the water heating savings, this includes the installation of EF 2.4 water heaters.

Table 7-6 Commercial Top Measures by Savings Type in 2030 (GWh)

Measure	Existing Codes & Standards Savings	Market Driven & Spillover Savings	Economic Potential Savings	Total Savings (GWh)	% of Total
Interior Lighting - Screw-in	383.7	404.6	36.9	825.2	24.7%
Interior Lighting - Linear Fluorescent	268.7	64.3	372.5	705.5	21.1%
Exterior Lighting - HID	-	75.1	91.1	166.2	5.0%
Interior Lighting - High-Bay Fixtures	-	62.5	90.5	153.0	4.6%
Water Heating - Water Heating	-	11.6	140.7	152.3	4.6%
Advanced New Construction Designs	-	-	113.8	113.8	3.4%
Exterior Lighting - Screw-in	46.8	48.2	5.8	100.8	3.0%
Ventilation - Ventilation	-	4.9	92.9	97.8	2.9%
Cooling - Roof top AC	-	38.7	37.3	76.0	2.3%
Office Equipment - Desktop Computer	-	66.6	4.6	71.2	2.1%
Cooling - PTAC	-	17.4	39.6	57.0	1.7%
Custom Measures	-	-	55.1	55.1	1.6%
Refrigeration - Walk-in Refrigerator	-	37.7	15.1	52.8	1.6%
Cooling - Air-Cooled Chiller	-	15.6	33.7	49.3	1.5%
Cooling - Water-Cooled Chiller	-	41.8	6.2	48.0	1.4%
Retrocommissioning - HVAC	-	-	45.8	45.8	1.4%
Exterior Lighting - Linear Fluorescent	14.5	3.5	20.0	37.9	1.1%
Interior Lighting - Occupancy Sensors	-	-	35.7	35.7	1.1%
Refrigerator- eCube	-	-	34.2	34.2	1.0%
Office Equipment - Server	-	22.3	2.5	24.8	0.7%
Total	**713.7**	**914.8**	**1,274.0**	**2,902.5**	**86.7%**

Figure 7-6 shows the amount of savings in the commercial sector by type of savings. Table 7-7 provides estimates of savings for each end use and type of potential.

Figure 7-6 Commercial Energy Efficiency Savings by Potential Case

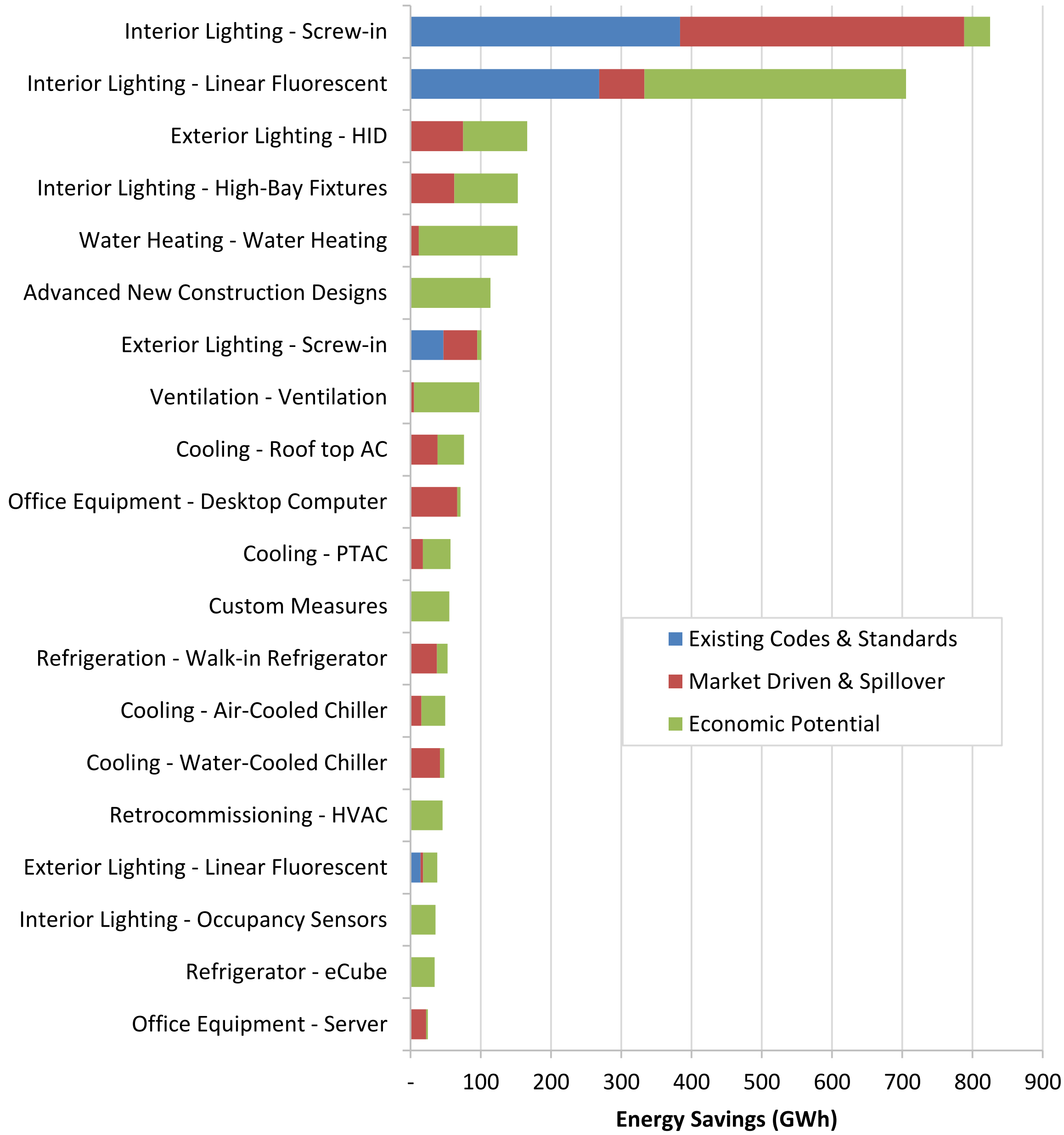


Table 7-7 Commercial Cumulative Savings by End Use and Potential Type (GWh)

End Use	Case	2015	2020	2025	2030
Cooling	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	32	66	83	114
	Economic Potential	79	229	399	515
	Technical Potential	103	285	466	593
Ventilation	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	10	20	18	5
	Economic Potential	16	66	122	163
	Technical Potential	22	79	139	181
Water Heating	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	4	8	9	12
	Economic Potential	38	90	132	161
	Technical Potential	38	90	132	161
Interior Lighting	Existing Codes & Standards	77	334	559	652
	Market Driven & Spillover	442	817	1,049	1,184
	Economic Potential	570	1,073	1,530	1,803
	Technical Potential	572	1,081	1,537	1,808
Exterior Lighting	Existing Codes & Standards	8	33	54	61
	Market Driven & Spillover	78	143	172	188
	Economic Potential	121	204	271	315
	Technical Potential	123	213	281	323
Refrigeration	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	26	52	69	76
	Economic Potential	42	95	144	170
	Technical Potential	47	105	161	188
Food Preparation	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	4	11	17	20
	Economic Potential	6	16	24	27
	Technical Potential	6	16	24	27
Office Equipment	Existing Codes & Standards	-	-	-	-
	Market Driven & Spillover	43	104	127	140
	Economic Potential	66	132	157	171
	Technical Potential	66	132	157	171
Miscellaneous	Existing Codes & Standards	0	0	1	1
	Market Driven & Spillover	3	7	8	11
	Economic Potential	4	12	17	22
	Technical Potential	4	12	17	22
Total	**Existing Codes & Standards**	**85**	**367**	**613**	**714**
	Market Driven & Spillover	**641**	**1,227**	**1,552**	**1,748**
	Economic Potential	**942**	**1,917**	**2,788**	**3,347**
	Technical Potential	**982**	**2,013**	**2,915**	**3,474**

Other Sector Potential

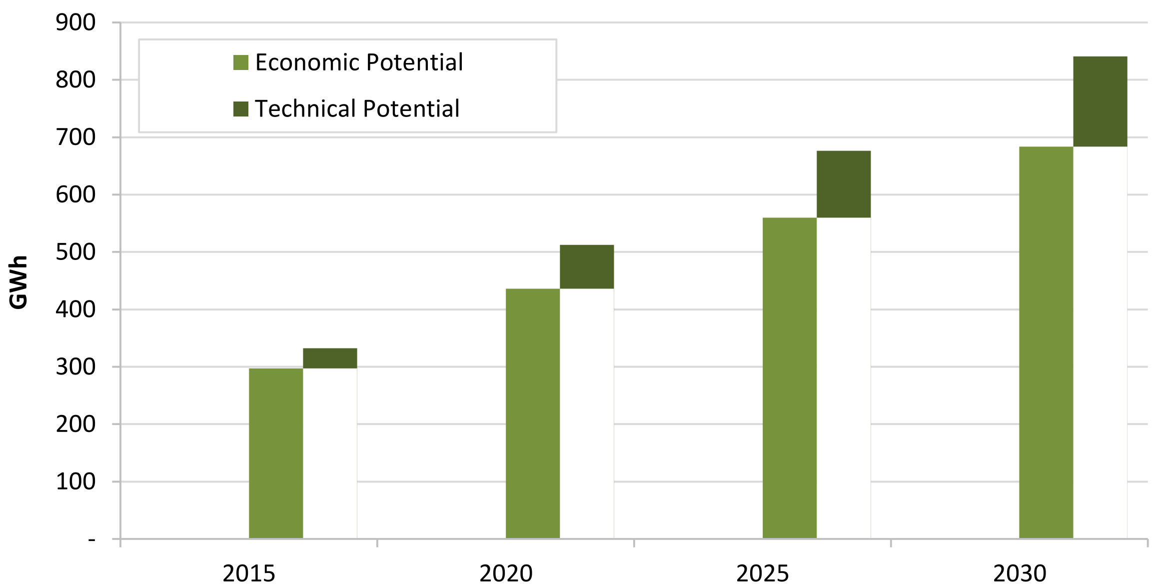
Table 7-8 presents estimates for the three types of potential for the other sectors — water/wastewater, military, and street lighting. Figure 7-7 depicts the potential energy savings estimates graphically.

- **Technical potential** which reflects the adoption of all energy efficiency measures regardless of cost is a theoretical upper bound on savings. Technical potential includes the government mandate for the military sector to reduce energy use by 2.5% per year. In 2030, cumulative technical potential is 841 GWh, 50% of technical potential.
- **Economic potential** which reflects the savings when all cost-effective measures are taken is 684 GWh, or 44% of the baseline energy forecast in 2030. Economic potential is a large percentage of technical potential due to the high avoided energy and capacity costs.

Table 7-8 Energy Efficiency Potential for the Other Sectors

	2015	2020	2025	2030	Marginal Contribution in 2030
LoadMAP Baseline Projection (GWh)	1,553	1,591	1,630	1,670	n/a
Cumulative Savings (GWh)					
Economic Potential	297	436	560	684	684
Technical Potential	333	513	676	841	157
Energy Savings (% of LoadMAP Baseline Projection)					
Economic Potential	19.1%	27.4%	34.3%	40.9%	40.9%
Technical Potential	21.4%	32.2%	41.5%	50.4%	9.4%

Figure 7-7 Other Sector Energy Efficiency Savings by Potential Case



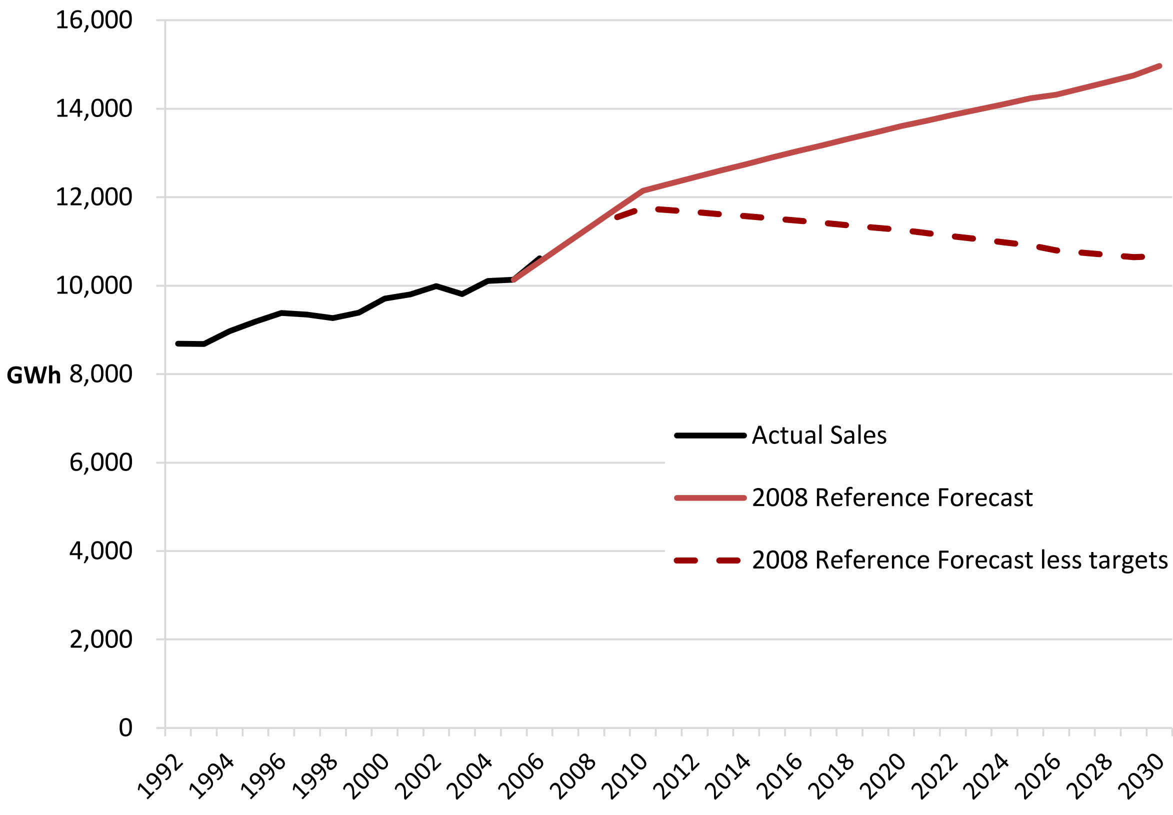
COMPARISON OF SAVINGS TO EEPS GOALS

In this final chapter, we bring the pieces of the analysis together with the EEPS goals starting in 2009 and show how they align. This section shows the LoadMAP baseline projection from the study compared with the Hawaii utility forecast from 2012 and the 2008 Reference Forecast. It also describes the development of savings estimates from PBFA and KIUC EE programs already achieved from 2009 through 2012 and summarizes the savings from the potential cases. Finally, it presents conclusions and recommendations.

Background

This study for the State of Hawaii has a unique objective as compared with typical studies. The State has set an EEPS goal that must be met and is measured in terms of absolute GWh savings by 2030. The goals were set using the forecast of electricity use included in the HECO Companies' 2008 IRP (based on 2004 electricity forecasts) and adjusted upwards to estimate the additional demand anticipated from KIUC. This forecast is referred to as the 2008 Reference Forecast and it is shown in Figure 8-1. The absolute GWh target of 4,300 GWh was proposed based on approximately 30% savings from the 2008 Reference Forecast. [16] It was anticipated that the forecasts of available potential would likely evolve over time.

Figure 8-1 2008 Reference Forecast and EEPS Goals

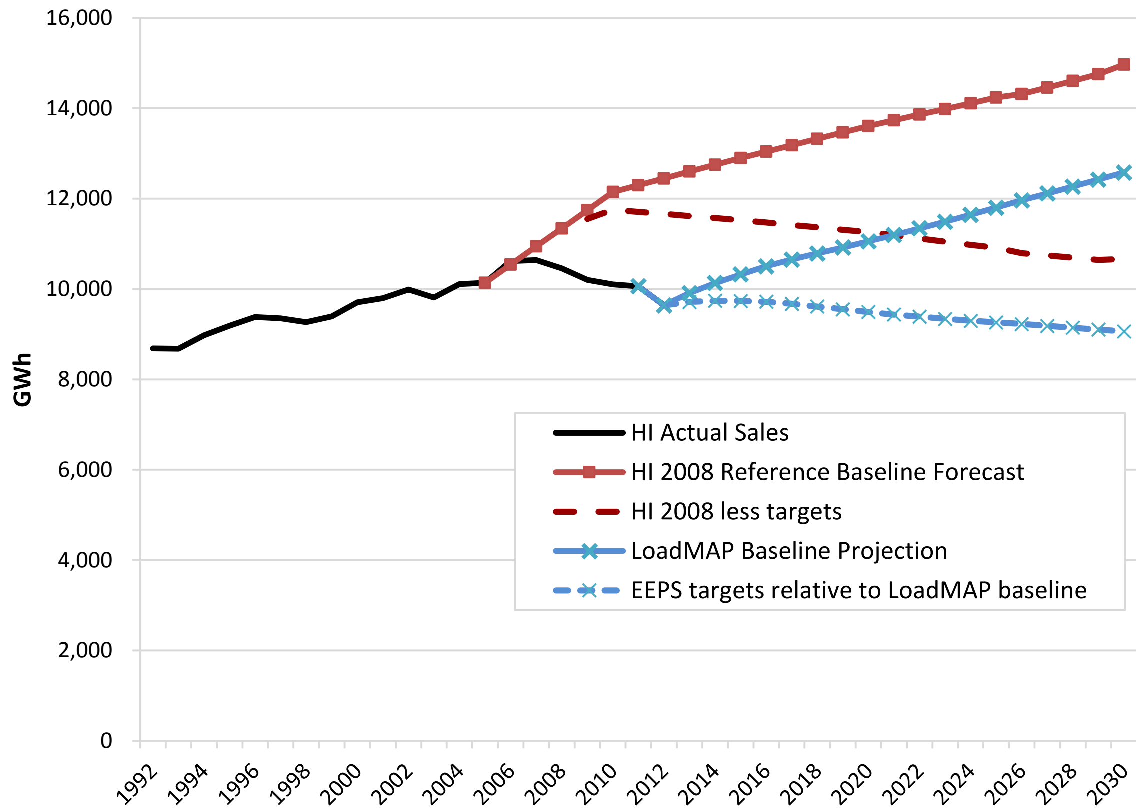


[16] Note: Hawaii's EEPS goal is specified as an absolute 4,300 GWh of electricity savings, so the goal remains constant regardless of changes in electricity sales.

One question of interest is whether the 4,300 GWh goal has become a larger percentage of 2030 sales than it was when originally developed based on the 2008 forecast. The Reference Forecast was developed before the Great Recession and much has changed between 2008 and the time of this study. In addition, energy efficiency programs operated by the PBFA and KIUC have captured savings in the timeframe 2009 to the present, and there have been installations of demand-side distributed generation, in particular solar-photovoltaics. All of these influences caused sales to decline between 2007 and 2012 and the statewide forecast of electricity sales has been revised. Figure 8-2 shows actual sales through 2012, the 2008 reference forecast, the EEPS target relative to the 2008 reference forecast, and the 2012 LoadMAP baseline projection. Please note that the 2012 LoadMAP baseline projection shown in the figure has been adjusted to remove the effects of customer-sited generation.[17] This provides an apples-to-apples comparison to the original 2008 Reference Forecast which did not anticipate a significant contribution from distributed energy resources.

This chart clearly shows the challenge faced by this study: It was necessary to develop an analysis framework that allowed the project team to navigate through history, establish a LoadMAP baseline projection as the metric against which savings are measured, and report savings in a way that has meaning with respect to the EEPS goals.

Figure 8-2 2008 Hawaii Reference Forecast, 2012 Electricity Forecasts and EEPS Goals



Developing the LoadMAP Baseline Projection

The project team had a decision to make: ground the study in 2009 and recreate history or start the analysis is 2012 and then append information for the historical period 2009 through 2012. In order to take advantage of the recent RASS and the Baseline Study that were conducted this year, the study was based in 2012, the most recent year for which sales data are available from each of the utilities. The advantage is that the primary market research provides the best information for understanding how customers use

[17] The adjustment for the baseline projection includes adding an estimate for distributed generation and solar PV to the utility sales forecast in order to create a demand forecast. This distinction will be important going forward as the utility sales will decrease with the increased incidence of distributed generation and solar PV.

energy today. Using this information we created a LoadMAP baseline projection that began in 2013 and continued through 2030. This LoadMAP baseline represents a frozen-efficiency projection that **does not** include any of the following **after 2012**:

- Appliance and equipment standards and building codes that are on the books, but do not come online until after 2012. The most notable of these is the EISA lighting standard.
- Naturally occurring conservation (including price effects)
- Energy-efficiency (EE) programs
- Distributed generation

To develop the LoadMAP baseline projection for each island and sector, we incorporated the following forecast drivers:

- Current economic growth forecasts (i.e. household growth, customer growth, employment growth, income growth)
- Retail electricity price forecasts
- Trends in appliance/equipment saturations
- Replacement and new-appliance purchases held fixed at the minimum efficiency level from 2013 through 2030
- Characterization of end-use technologies available in the marketplace in 2012 and those expected to be available in the future as described above

In the LoadMAP tool, we begin with market profiles for 2012 developed in the previous step, and then set the forecast in motion through 2030. Each year, equipment stock turnover is tracked and accounted for as old units are retired and new units or measures are installed. The outcome of this step is the LoadMAP baseline projection for each island, sector, segment, vintage, end use, technology, and efficiency level. Detailed results for the LoadMAP baseline projection are presented in Chapter 4.

Estimates of Energy-Efficiency Savings

As described in Chapter 1, several levels of savings were developed as part of this effort: Savings from 2009–2012 programs were developed offline. The other levels were developed in LoadMAP as a projection of expected electricity use. Savings were calculated as the difference between the projections. This is described in more detail below.

2009–2012 Program Savings

Energy savings achieved by the PBFA and KIUC are reported as gross generation savings (i.e., avoided gross utility generation, including avoided power station use and transmission and distribution losses). All estimates include solar water heating savings attributable to PBFA incentive programs. A decay factor is applied to the savings based on the average measure lifetime.

Existing Codes and Standards Projection

The Existing Codes and Standards projection reflects customer purchases of the minimum standard efficiency option per the appliance and equipment standards shown in Table 2-11, and Table 2-12. Any codes and standards that take effect on or after January 1, 2009 count toward EEPS goals. This includes Hawaii-specific building codes, such as the requirement for solar water heating in single-family new construction. Codes and standards already “on the books” are included.

This projection is implemented by assuming different purchase shares for equipment replacement. Table 2-6 shows the purchase shares for the LoadMAP baseline projection and the Existing Codes and Standards projection for the set of equipment options for two technologies: residential screw-in lighting and water heaters that are 55 gallons or less in size.

- **Residential screw-in lighting.** For the LoadMAP baseline projection, incandescent lamps are the baseline efficiency level throughout the study period. In the Codes & Standards projection, the EISA standard comes into effect in 2014 and a second EISA standard increases the minimum efficiency again in 2020; purchases shift in those years to the EISA-compliant lamps.

- **Residential water heaters.** For the LoadMAP baseline projection, EF 0.9 water heaters are the baseline efficiency level throughout the study period. In the Codes & Standards case, EF 0.95 water heaters become the minimum efficiency level in 2015 per the federal standard. Note that for water heaters larger than 55 gallons, heat pump water heaters become the standard. Also, in new construction, solar water heating is the minimum standard per Hawaii building codes.

Detailed results of the Codes & Standards projection are presented in Chapter 5.

Market Driven Efficiency and Spillover Projection

The Market-driven Efficiency and Spillover projection accounts for market-driven efficiency and spillover in addition to existing codes and standards. As described in Chapter 1, this projection includes savings from early adopters of energy efficient appliances or equipment outside of programs and savings achieved due to changes in manufacturing practices, such as with the electronics.

As with the Codes & Standards projection, the Market-driven projection is implemented through different purchase shares for equipment replacement as shown in Table 2-6. These purchase shares were developed using information from the 2012 Annual Energy Outlook, adjusted with information about Hawaii purchase patterns gleaned from program data:

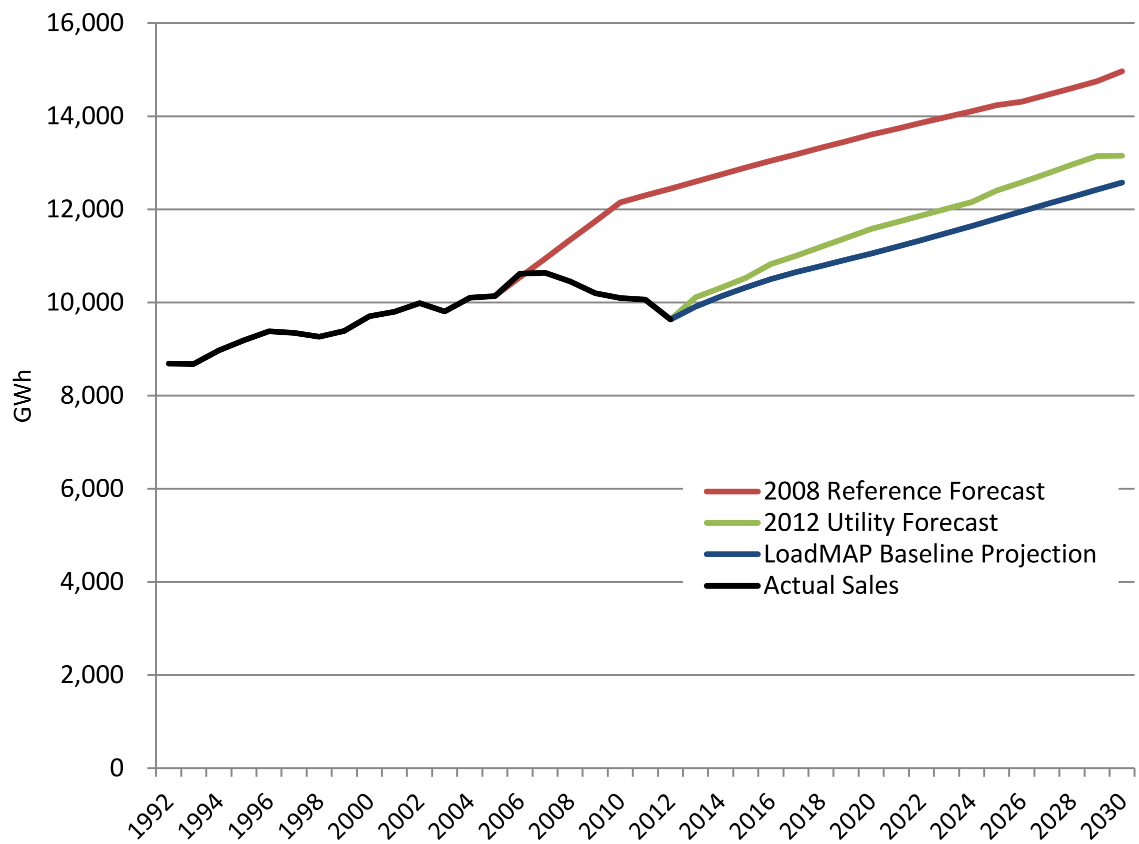
- **Residential screw-in lighting**. In the Market-driven projection, consumers are purchasing CFL lamps in substantial quantities throughout the study period. Consumers also increasingly purchase LED lamps, particularly after the 2020 EISA lamp standard goes into effect.
- **Residential water heaters**. In the Market-driven projection, a small fraction of consumers purchase heat pump water heaters.

Detailed results of the Market-driven projection are presented in Chapter 6.

Comparison of Baselines and Forecasts

Figure 8-3 shows the LoadMAP baseline projection compared to the 2012 utility forecast and the 2008 reference forecast used to develop the EEPS goals. Although we attempted to use the same assumptions as the utilities, we know that the forecasts will never line up exactly because different forecast methodologies were used: the LoadMAP baseline was developed using an end use model, while the utilities used an econometric model. As shown in Figure 8-3, the LoadMAP baseline does not vary significantly from the 2012 utility forecast. Using the LoadMAP baseline as the starting point, we then develop projections for four cases: existing codes and standards, market driven and spillover, economic and technical potential.

Figure 8-3 LoadMAP Baseline Projection Compared with Hawaii Load Forecasts



Summary of All Sources of Savings

As shown in Figure 8-4 and Table 8-1, this study concludes it is very likely that the goals can be met through a combination of interventions:

- **Energy-efficiency programs** like those being delivered by the PBFA, KIUC, or other interventions, which help to realize the economic potential
- **Appliance standards and building codes** that are already in place or “on the books” for the next five years. Savings from existing codes and standards are substantial and reflect the EISA lighting standard and several federal appliance standards that were established since the EEPS goal was set in 2008. Federal, state and local codes and standards taking effect on or after January 1, 2009 count toward EEPS goals.

Figure 8-4 Potential Savings Estimates Compared to the EEPS Goal

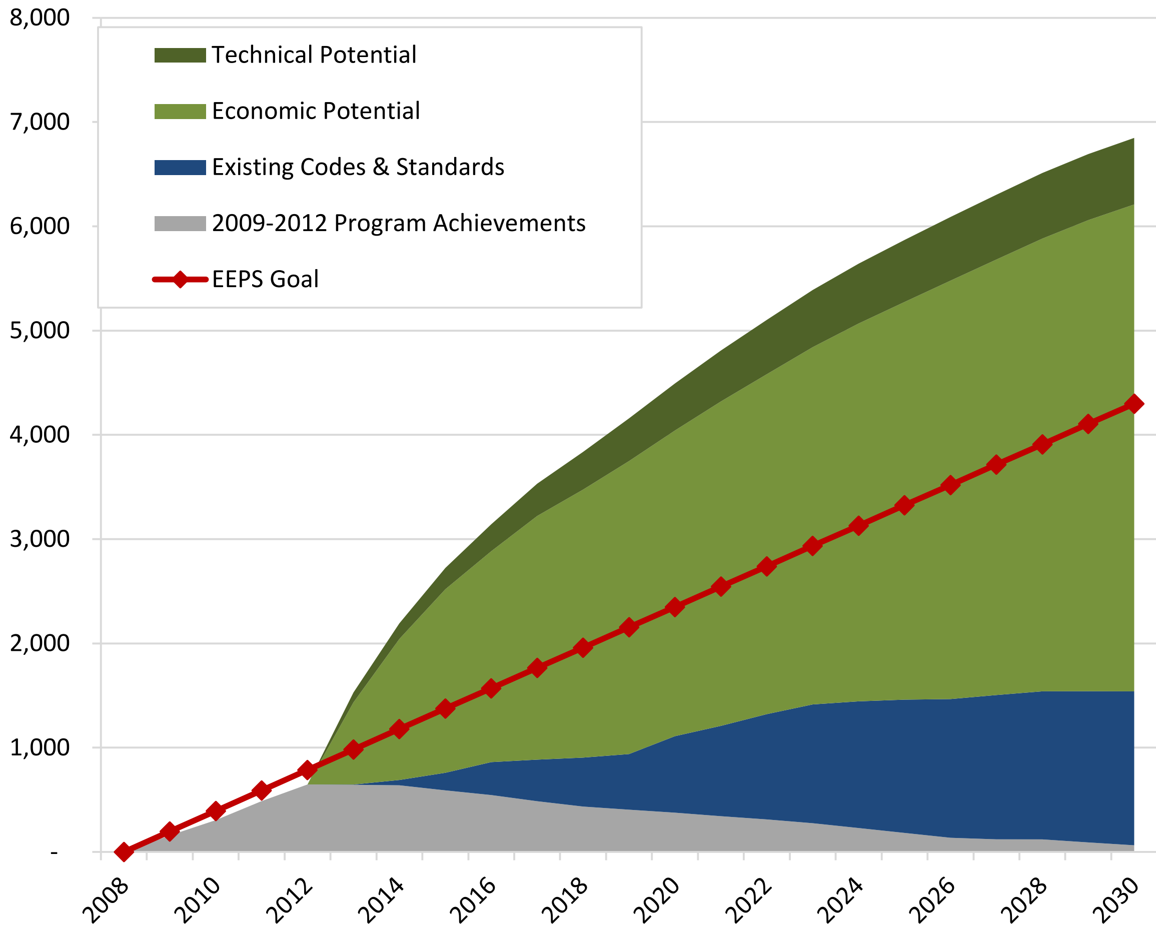


Table 8-1 Summary of Energy Efficiency Potential, Statewide Relative to EEPS GWh Goal

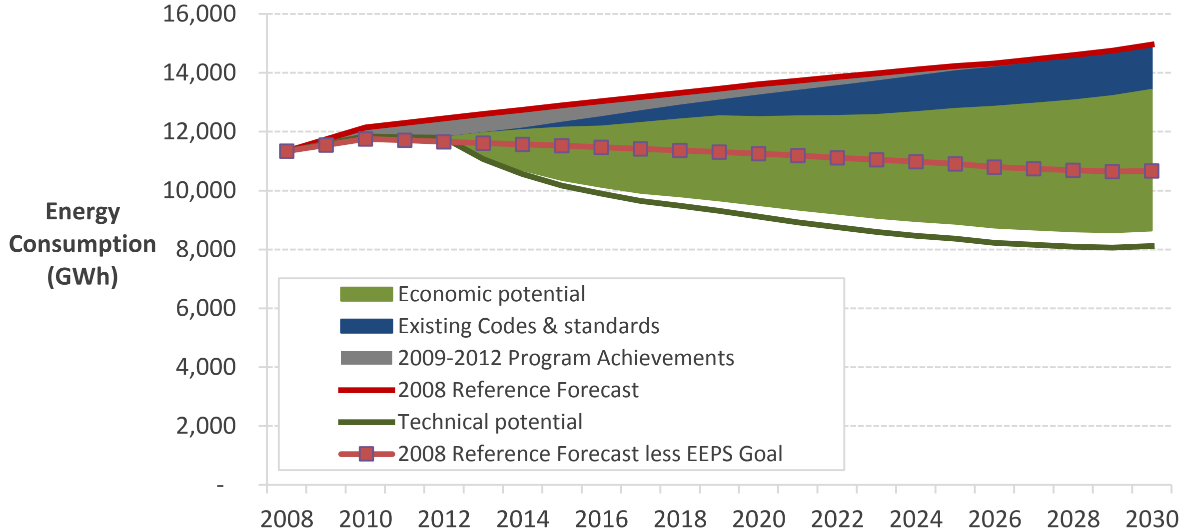
	2015	2020	2025	2030	Marginal Contribution in 2030
EEPS GWh Goal (GWh)	1,375	2,350	3,325	4,300	n/a
Cumulative Savings (GWh)					
2009-2012 Program Achievements	591	377	182	64	64
Existing Codes & Standards	759	1,110	1,460	1,540	1,476
Market Driven & Spillover	1,575	2,404	2,818	3,133	1,592
Economic Potential	2,519	4,042	5,275	6,210	3,077
Technical Potential	2,724	4,493	5,870	6,848	638
Energy Savings (% of EEPS GWh Goal)					
2009-2012 Program Achievements	43%	16%	5%	1%	1%
Existing Codes & Standards	55%	47%	44%	36%	34%
Market Driven & Spillover	115%	102%	85%	73%	37%
Economic Potential	183%	172%	159%	144%	72%
Technical Potential	198%	191%	177%	159%	15%

Table 8-2 and Figure 8-5 present the savings relative to the 2008 Reference Forecast. The economic potential in 2030 is 42% of the 2008 Reference Forecast.

Table 8-2 Energy Efficiency Savings Relative to 2008 Reference Forecast

	2015	2020	2025	2030	Marginal Contribution in 2030
2008 Reference Forecast	12,898	13,606	14,235	14,963	n/a
Energy Savings (% of 2008 Reference Forecast)					
2009-2012 Program Savings	5%	3%	1%	0%	0%
Existing Codes & Standards	6%	8%	10%	10%	10%
Market Driven & Spillover	12%	18%	20%	21%	11%
Economic Potential	20%	30%	37%	42%	21%
Technical Potential	21%	33%	41%	46%	4%

Figure 8-5 Savings Estimates with Respect to 2008 Reference Forecast



Findings and Conclusions

The results of this study reveal that significant energy efficiency opportunities exist in the State of Hawaii. Before providing conclusions and recommendations, we provide a high-level overview of electricity use on the islands:

- The commercial sector makes up almost half of the energy use in the state. The primary segments are retail/services and offices. The miscellaneous segment is also large, but it includes any manufacturing facilities. The primary end uses for the commercial sector are lighting and cooling.
- The residential sector accounts for 32% of the statewide energy use in 2012. The sector is dominated by owner-occupied single family homes, which represent 46% of homes and 54% of residential energy use. The average energy use per home for single-family homes is significantly higher than multi-family homes due to the larger size, the higher saturation of air conditioning, and more appliances and electronics within the single-family homes. For the overall sector, appliances, water heating, and lighting are the largest end uses.
- The military is the third largest energy sector within the state. The military sector includes energy use from residential housing that is located on military bases because military accounts do not differentiate between housing and other end uses of energy. Due to the sensitive nature of military energy usage details, the military was separately characterized using a case study analysis conducted as part of the Baseline Study. Future energy efficiency potential studies, as well as energy efficiency program design efforts, would benefit from additional detailed study of military energy end use characteristics in cooperation with the Department of Defense.
- In the absence of energy savings from building codes, appliance standards, PBFA/utility energy efficiency programs, or market-driven efficiency and spillover, the baseline forecast is expected to grow substantially; at an average of 1.5% per year through 2030. The largest increase will come from the residential sector with a 42% increase in energy use between 2012 and 2030.

By 2030, there is substantial potential for reducing energy use in the state – 6,210 GWh of economic potential. The analysis shows that in 2030 energy efficiency could easily more than offset any anticipated load growth.

- The analysis attempts to breakdown how the potential energy efficiency savings could be achieved. A large portion of the savings will come from the federal appliance standards and state building codes that have already been enacted. The analysis considers savings from any appliance standard or building code that was “on the books” since 2008. This includes the EISA lighting standard that phases out incandescent lamps by 2014.

- With extremely high avoided costs in Hawaii, a considerable amount of the technical potential is considered economic (cost-effective). Although there are additional barriers to adopting economic measures, a best-in-class PBFA or utility program can expect to achieve the majority of the potential economic savings. In order to achieve these savings, the current programs need to continue to increase awareness of the value of energy efficiency and accelerate energy savings.
- The market driven and spillover category contributes about 50% of the overall economic potential. These savings are the result of changes in manufacturing practices, such as with consumer electronics, where manufacturers voluntarily choose to manufacture to ENERGY STAR standards. This also includes savings from early adopters that purchase energy-efficient appliances or equipment outside of PBFA or utility programs. A small, unquantifiable portion of these savings can be attributed to program spillover. However, in the absence of a contributing entity to claim, measure, and report these savings, they would not be counted towards the EEPS goal.
- The majority of the statewide energy efficiency savings potential is found in the commercial sector. However, in the first five years, almost half of the energy efficiency savings potential comes from the residential sector.
- In the residential sector, the potential savings come from a few key energy efficiency measures. Screw-in lighting savings includes the conversion of interior and exterior lamps to LED lamps. Water heating savings can be achieved, typically through PBFA or utility programs, by installing solar water heating or more efficient water heating equipment, as well as low flow showerheads and faucet aerators. Electronics, such as televisions, computers and set top boxes are primarily driven by the manufacturing practices that primarily manufacture to ENERGY STAR guidelines.
- In the commercial sector, the majority of potential savings are driven by lighting improvements. Similar to the residential sector, significant savings can be achieved through changing screw-in lamps to LED lamps. Savings from linear fluorescent light bulbs, including the installation of super T8 light bulbs are also driven by the federal lighting standard, as well as PBFA and utility programs. Water heating savings can be achieved through the installation of heat pump water heaters through PBFA or utility programs.
- Although a measure-level analysis is not available for the military and water and wastewater sectors, the savings that can be achieved from these sectors are significant. The military is working to meet a federal mandate to achieve aggressive energy efficiency goals. The state has many avenues to work with the military to maximize achievement the energy savings. For the water and wastewater sector, significant savings can be achieved by working with government agencies (such as municipal water supply agencies, found on several islands) as well as private-sector entities that provide water supply and wastewater services throughout Hawaii.
- The State EEPS goal of 4,300 GWh was proposed based on approximately 30% savings from the 2008 Reference Forecast. However, given subsequent deviations from the original Reference Forecast due to economic and market changes, the 4,300 GWh goal has become a slightly larger percentage of 2030 sales than it was when originally developed. Based on the baseline electricity consumption in 2030 projected by the LoadMAP model of 12,577 GWh, the 4,300 GWh EEPS goal represents 34% of sales in that year.
- Although it appears that the state is on track to achieve the EEPS goal by 2030, it is clear that additional savings could be achieved beyond the savings goal established in statute. Striving to exceed the EEPS goal and capture additional energy savings would result in significant additional discretionary income for households and businesses.

About EnerNOC

EnerNOC's Utility Solutions Consulting team is part of EnerNOC's Utility Solutions, which provides a comprehensive suite of demand-side management (DSM) services to utilities and grid operators worldwide. Hundreds of utilities have leveraged our technology, our people, and our proven processes to make their energy efficiency (EE) and demand response (DR) initiatives a success. Utilities trust EnerNOC to work with them at every stage of the DSM program lifecycle – assessing market potential, designing effective programs, implementing those programs, and measuring program results.

EnerNOC's Utility Solutions deliver value to our utility clients through two separate practice areas – Implementation and Consulting.

- Our Implementation team leverages EnerNOC's deep "behind-the-meter expertise" and world-class technology platform to help utilities create and manage DR and EE programs that deliver reliable and cost-effective energy savings. We focus exclusively on the commercial and industrial (C&I) customer segments, with a track record of successful partnerships that spans more than a decade. Through a focus on high quality, measurable savings, EnerNOC has successfully delivered hundreds of thousands of MWh of energy efficiency for our utility clients, and we have thousands of MW of demand response capacity under management.
- The Consulting team provides expertise and analysis to support a broad range of utility DSM activities, including: potential assessments; end-use forecasts; integrated resource planning; EE, DR, and smart grid pilot and program design and administration; load research; technology assessments and demonstrations; evaluation, measurement and verification; and regulatory support.

The team has decades of combined experience in the utility DSM industry. The staff is comprised of professional electrical, mechanical, chemical, civil, industrial, and environmental engineers as well as economists, business planners, project managers, market researchers, load research professionals, and statisticians. Utilities view EnerNOC's experts as trusted advisors, and we work together collaboratively to make any DSM initiative a success.

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