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Evaluation of the Hawaii Energy Conservation and Efficiency Programs – PY2016 Program Results

Prepared for the State of Hawaii Public Utilities Commission

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Opinion Dynamics

Table of Contents

List of Appendices

All Appendices can be found in PY2016 Hawaii Energy Annual Evaluation Report_Final_Appendices.pdf

Opinion Dynamics

Table of Tables

Table of Figures

1. Executive Summary

The purpose of this report is to present the results of evaluation, measurement and verification (EM&V) activities addressing the Hawaii Energy Conservation and Efficiency Programs (Hawaii Energy or Program[1]) during calendar year 2017, which includes predominantly evaluation activities for program year 2016 which runs from July 1, 2016 through June 30, 2017 (PY2016).

In addition to providing the results of efforts to verify program energy and demand savings impacts, this report provides key findings from a number of other research activities, including, but not limited to[2]: 1) a longitudinal analysis of program accomplishments to date and assessment of future energy savings opportunities; 2) investigations of several program operational and oversight issues related to energy savings claims and rebate/incentive payment processes; and 3) a review of multiple updates—proposed by Hawaii Energy—to the PY2017 Technical Reference Manual (TRM) completed in early March 2018, but included for completeness in this report.

Verification of Program Impacts

As in prior years, Opinion Dynamics deployed considerable EM&V resources to the verification of energy (kWh) savings, demand (kW) savings, and total resource benefit (TRB) claims of Hawaii Energy. The PY2016 Hawaii Energy portfolio claimed energy savings for six programs aimed at attaining direct energy savings, with three targeting the business[3] sector and three targeting the residential sector (Business Programs and Residential Programs, respectively). Table ES-1 presents a description of each of these programs by sector.

[1] The Program is administered by Leidos Engineering, LLC (Leidos), under contract to the Hawaii Public Utilities Commission since 2009, at which time Hawaii Energy took over management of the state's demand side management programs from Hawaii Electric Company (HECO) and its subsidiaries, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO). The Program is funded by ratepayers in the HECO Companies' service territories via a Public Benefits Fee (PBF) that is intended to promote the development of programs and services that increase energy efficiency, reduce electricity consumption and demand, and ultimately decrease Hawaii's dependence on imported fossil fuels. The program provides a suite of offering for both residential customers (Residential Programs) and business customers (Business Programs). In its role with Hawaii Energy, Leidos serves as the state's Public Benefits Fee Administrator (PBFA).

[2] The EM&V team also completed a report cataloging the various EM&V activities that have taken place since program inception (PY2009 through PY2016). The report [Hawaii Energy: History of Annual EM&V-Related Research (PY2009-2016)] can be found in Appendix E.

[3] The term "business" includes all non-residential customer categories (commercial, industrial and agricultural).

Table ES-1 PY2016 Hawaii Energy Program Summary – Business and Residential

Sector	Program	Program Description[a]
Business	Business Energy Efficiency Measures (BEEM)	The objective of this program is to acquire electric energy and demand savings through customer installations of standard, known, energy efficiency technologies by applying prescriptive incentives in a streamlined application process. The BEEM program consisted of several offerings in PY2016. Channels included Midstream (high-efficiency lighting), Trade Ally-Provided (high-efficiency lighting, HVAC, motors, water heating, water pumping, envelope improvements and others), and Traditional Retail (high efficiency equipment and appliances).
	Customized Business Energy Efficiency Measures (CBEEM)	The objective of this program is to provide a custom application and approval process for participants to receive incentives for installing non-standard energy efficiency technologies. The commercial and industrial custom incentives enable customers to invest in energy efficiency opportunities related to manufacturing process and other technology measures that may require calculations of energy savings on a case-by-case basis for specific, unique applications.
	Business Hard to Reach (BHTR)	The objective of this program is to help targeted geographic areas and sectors that have been traditionally underserved, such as retail, restaurants other small businesses and commercially metered multifamily. Additionally, this program conducted more aggressive outreach to lighting and electrical contractors with training, promotional materials and frequent communications on program updates.
Residential	Residential Energy Efficiency Measures (REEM)	This program represents the largest program within Hawaii Energy's residential portfolio, both in terms of incentives distributed and energy savings achieved. The REEM program consisted of several offerings in PY2016 including Program Communication, Upstream lighting, Traditional Retail, Online Retail, and Trade Ally-Provided.
	Residential Hard to Reach (RHTR)	This program seeks to secure various projects among Hawaii residents that have traditionally been underserved. Specifically, it addresses financial and landlord/tenant barriers to installing energy-saving technologies through direct installation.
	Residential Energy Services and Maintenance (RESM)	This program aims to provide customers with incentives for services and maintenance to their homes' biggest energy consuming equipment.

a. Program summaries adapted from the PY2016 Hawaii Energy Annual Report.

Opinion Dynamics deployed several methods to verify Hawaii Energy PY2016 savings claims, including:

- **Database Review**. For all programs, we conducted a manual review of all (nearly 80,000) equipment records in the Hawaii Energy program tracking database[4] to assess completeness of data, check for duplicates, assess records with zero and negative quantities for accuracy, and identify any parameters that are outside of expected ranges. The database review produced a clean dataset from which we drew program specific samples of projects (as applicable) to support addition verification steps.

- **Application of TRM Values**. Together, the REEM and BEEM programs account for approximately 90% of PY2016 portfolio-level first-year net tracked savings (after excluding savings from the CBEEM

[4] We used the revised "frozen" database provided to Opinion Dynamics on October 13, 2017.

program).[5] As such, we focused the review of the correct application of TRM values on REEM and BEEM specifically. For both programs, we reviewed the population of records within the database to ensure that the deemed savings assumptions from the Hawaii TRM[6] were accurately applied to the measures in the program tracking database. The goal is to assess the extent to which Hawaii Energy correctly applies TRM gross savings values and related adjustments, but the review did not extend to 1) assessing the validity of all assumptions within the TRM, or 2) field work to verify installations or correct project data for verification of savings.

- **Desk Reviews.** For REEM, BEEM, and CBEEM, we developed samples and reviewed project documentation (e.g., invoices, specification sheets, Hawaii Energy calculations, etc.) and other data as necessary to verify the accuracy and appropriateness of tracked calculations. We performed two types of desk reviews:

  1. **Quantity Desk Reviews:** For REEM and BEEM, the desk reviews consisted of verifying the accuracy of the measure quantities in the tracking database based on project documentation (e.g., invoices, post-inspection forms, etc.).

  2. **Detailed Desk Reviews:** For CBEEM, the desk reviews included a review of project documentation (e.g., invoices, program savings calculations, specification sheets, inspection forms, etc.) supplied by Hawaii Energy to confirm accuracy and appropriateness of savings assumptions and methodologies and to calculate verified savings.

Table ES-2 presents the PY2016 energy and demand savings targets (from the Hawaii Energy PY2016 Annual Plan[7]), tracked values (from the PY2016 program-tracking database), and verified performance. As illustrated in the table, the overall kWh and kW verification rates are 99.8% and 116.9%, respectively. The KW verification rate of 116.9% stems from a calculation error made by Hawaii Energy for the PEER Comparison Program that resulted in an understatement of demand savings, which was corrected by the EM&V team. Table ES-2 also provides the TRB target, claimed value, and verified performance. The overall TRB verification rate is 98.6%.

[5] CBEEM does not rely on the TRM for savings, but relies on custom calculations at the individual project level. We therefore do not include CBEEM when performing the review of the correct application of TRM values.

[6] We used the Hawaii Energy PY2016 TRM v16. All references to the TRM in this memo refer to the Hawaii TRM unless otherwise stated.

[7] Leidos Engineering, LLC, Hawaii Energy Program Year 2016 Annual Plan (Honolulu, HI: Hawaii Public Utilities Commission, June 10, 2015). https://hawaiienergy.com/images/resources/AnnualPlans_ProgramYear2016.pdf. Updated filing: March, 2017.

Table ES-2. Hawaii Energy First-Year Net Demand Savings (kW), Electricity Savings (kWh), Lifecycle TRB and Budget: PY2016

	Residential	Business	Total
Target[a] kW	7,882	12,522	20,404
Tracked[b] kW	8,054	10,525	18,578
Verified kW	11,488	10,223	21,711
kW Verification Rate[c]	***142.6%***	***97.1%***	***116.9%***
Target[a] kWh	57,591,442	79,936,630	137,528,072
Tracked[b] kWh	55,544,003	85,272,390	140,816,393
Verified kWh	56,334,096	84,146,052	140,480,148
kWh Verification Rate[c]	***101.4%***	***98.7%***	***99.8%***
Target[a] TRB	$103,301,708	$208,392,688	$311,694,396
Claimed[d] TRB	$105,826,684	$207,061,298	$312,887,982
Verified TRB	$104,585,498	$203,982,382	$308,567,880
TRB Verification Rate[c]	***98.8%***	***98.5%***	***98.6%***
Budget[e]	$10,484,288	$16,371,091	$30,473,928

[a] Target amounts sourced from Hawaii Energy PY2016 Annual Report or Annual Plan.
[b] Program-level net savings from the final program-tracking database provided to us for this analysis.
[c] kW and kWh Verification Rates = Verified ÷ Tracked. TRB Verification Rate = Verified ÷ Claimed
[d] Claimed TRB values sourced from Hawaii Energy, Annual Report PY2016, p. 42. Table 17
[e] Budget amounts sourced from Hawaii Energy PY2016 Annual Report (p. 39. Table 16) Plan. Total budget includes transformational services and initiatives, tax on non-incentives and performance awards totaling $3,618,549

Table ES-3 provides PY2016 first-year net tracked and net verified energy savings by sector and program. While the table provides the actual savings values and corresponding verification rates (business programs verification rate of 98.7% and residential rate of 101.4%), Figure ES-1 provides a visual display of how these savings split across sectors, programs, and end uses.

Table ES-3. Hawaii Energy First-Year Net Tracked and Net Verified Energy Savings (kWh) by Sector and Program: PY2016

Sector	Program	First-Year Net Savings (kWh)		Verified Savings as % of Tracked Savings	Verified Savings as % of Total Verified Savings
		Tracked	Verified		
Business	BEEM	53,269,643	53,097,776	99.7%	37.8%
	CBEEM	23,438,710	22,484,239	95.9%	16.0%
	BHTR	8,564,037	8,564,037	100.0%	6.1%
	Business Total	**85,272,390**	**84,146,052**	**98.7%**	**59.9%**
Residential	REEM	53,767,121	54,557,215	101.5%	38.8%
	RHTR	1,023,996	1,023,996	100.0%	0.7%
	RESM	752,885	752,885	100.0%	0.5%
	Residential Total	**55,544,003**	**56,334,096**	**101.4%**	**40.1%**
Portfolio Overall		**140,816,393**	**140,480,148**	**99.8%**	**100.0%**

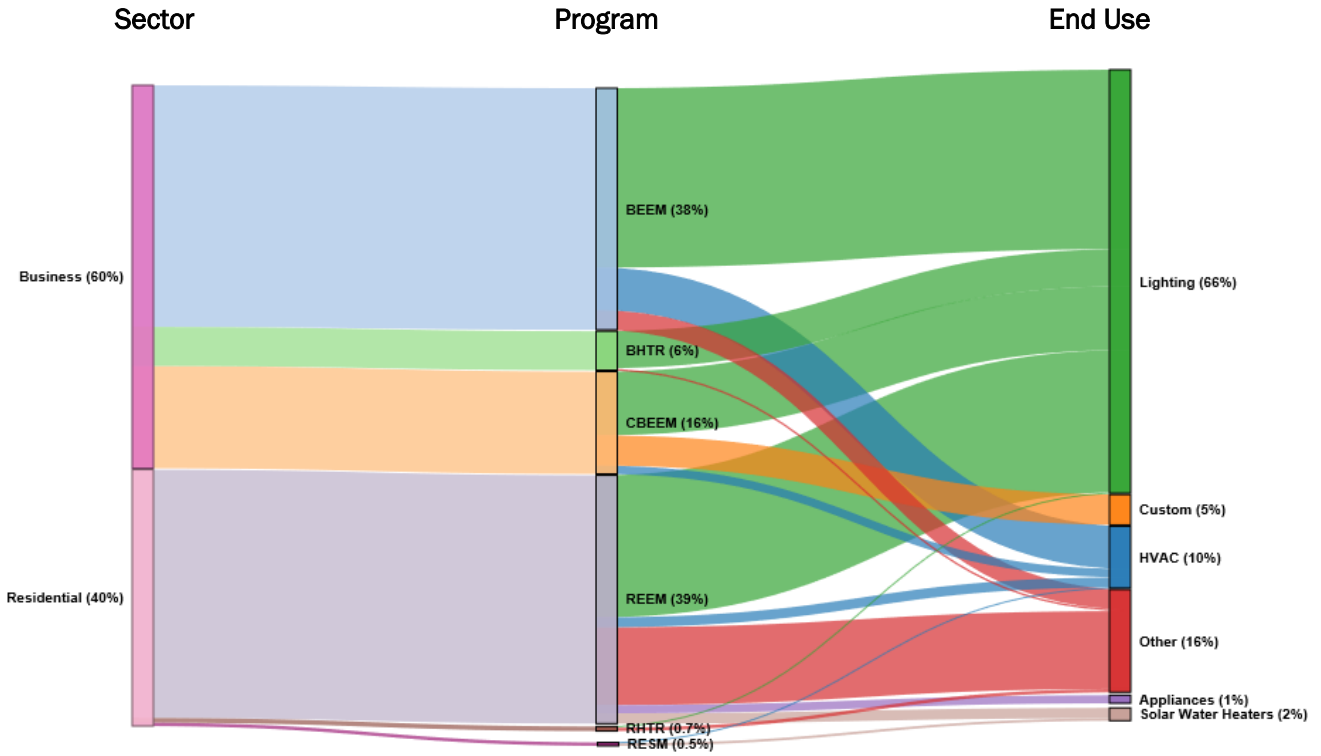
Note: Values are rounded for reporting purposes and may not sum to the totals shown in the table above.

Reading the graphic from left to right, Figure ES-1 disaggregates PY2016 savings for each sector (business and residential) by program, and program savings by end use. Conversely, reading the graphic from right to left, Figure ES-1 aggregates PY2016 savings attributable to each end use to the program level, and then program savings to the sector level.

As illustrated in Figure ES-1, the business sector accounts for approximately 60% of overall portfolio first-year net verified kWh savings, with the residential sector accounting for the remaining 40%. Further, three programs account for the vast majority (93%) of first-year net verified savings at the portfolio level, with the Residential Energy Efficiency Measures (REEM), Business Energy Efficiency Measures (BEEM), and the Custom Business Energy Efficiency Measures (CBEEM) programs accounting for 39%, 38% and 16% of PY2016 kWh savings, respectively.

Figure ES-1 also illustrates that the lighting end use is the most significant contributor to overall savings, representing 66% of overall PY2016 portfolio first-year net verified savings. While the majority of lighting savings come from the BEEM and REEM programs, CBEEM and BHTR make notable contributions to savings from lighting measures. From an overall portfolio perspective, the figure also illustrates that HVAC measures contribute 10% of first-year net verified energy savings.

Figure ES-1. Percent of Hawaii Energy First-Year Net Verified Savings by Sector, Program, and End Use: PY2016



Note: **Total First-Year Net Verified MWh savings: 140,480.** CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach; REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance; Percentages may not sum to 100 due to rounding.

Longitudinal Effects, Program Oversight, and TRM Changes

In addition to the savings verification process, Opinion Dynamics completed several other research activities for the PY2016 program period, including: 1) a longitudinal analysis of program accomplishments to date and assessment of future energy savings opportunities; 2) investigations of several program operational and oversight issues related to energy savings claims and rebate/incentive payment processes; and 3) a review of multiple updates—proposed by Hawaii Energy—to the PY2017 Technical Reference Manual (TRM). We summarize each of these studies in this subsection.

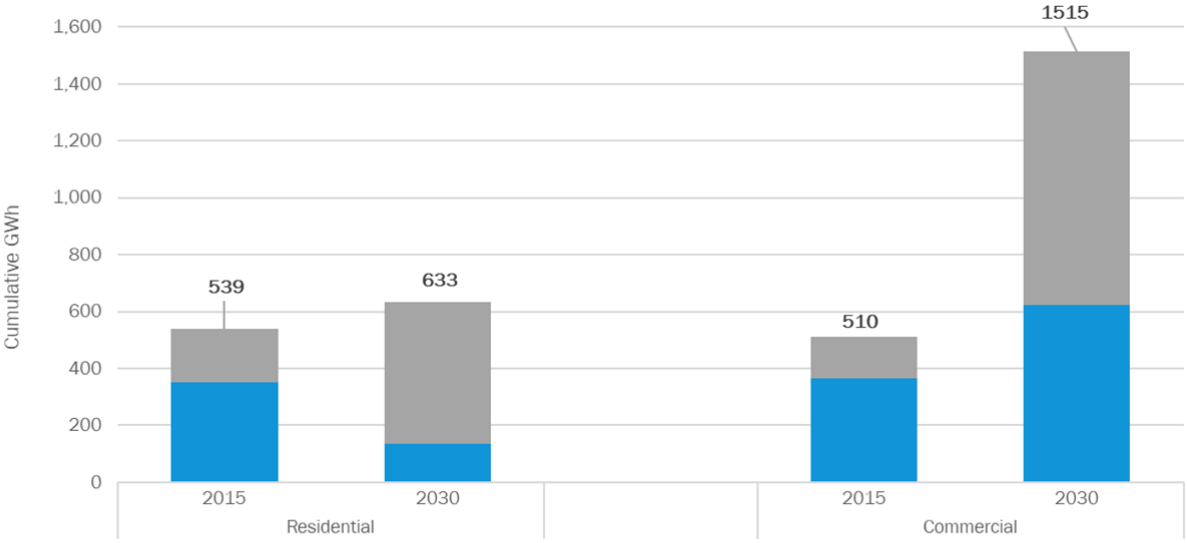
Longitudinal Effects. The Comprehensive Longitudinal Effects (CLE) Study focused on the savings realized through Hawaii Energy programs to date as well as the potential for those programs—based on current program designs and savings assumptions—to claim additional energy savings through 2030. The study was designed to leverage readily available secondary data, including the 2012 baseline and potential studies and cumulative net tracked energy savings reported by Hawaii Energy since program inception. Notably, the potential and baseline studies are now almost 6-years old and important markets (e.g., residential and commercial lighting—specifically the proliferation of LEDs) have changed more rapidly than expected. Furthermore, program accomplishments for each PY are based on numerous TRM inputs that have not been

updated in many years. Despite these limitations, CLE provides important insights into past program accomplishments and future opportunities.

Based on net tracked savings from inception through PY2015, Hawaii Energy program installations and market interventions, on a cumulative basis, have reduced Hawaii's energy consumption by over 718 GWh, roughly split evenly between the residential (352 GWh) and commercial (366 GWh) sectors. Lighting is the dominant source of savings, comprising 71% and 55% of total cumulative savings in the residential and commercial sectors, respectively. However, future potential is more heavily reliant on the commercial sector and on non-lighting end uses. Broadly speaking, to capture the remaining economic potential available to Hawaii Energy through 2030 (Remaining Available Economic Potential)—at the portfolio level—Hawaii Energy will need to 1) capture a higher proportion of savings from the commercial sector and 2) adapt program strategies to account for a lower proportion of savings from the lighting end use, especially in the residential sector.

As illustrated in Figure ES-2, by 2030 the commercial sector will offer almost two and a half times the available economic potential as the residential sector (1,515 GWh vs 633 GWh). This is illustrated by the significant increase in the Total Available Potential between 2015 and 2030. If Hawaii Energy continues to operate programs at "business as usual" levels with respect to non-lighting end uses, commercial sector programs will capture 41% of the available economic potential by 2030 and will leave 892 GWh uncaptured, a savings opportunity that exceeds the estimated total economic potential from the residential sector through 2030 (633 GWh).

Figure ES-2. Cumulative Available Economic Potential and PBFA Estimates, by Sector, 2015 and 2030



Remaining Available Economic Potential	187	498		143	892
Cumulative PBFA Estimates	352	135		366	623
Total Available Economic Potential	**539**	**633**		**510**	**1,515**
Captured Percentage	**65%**	**21%**		**72%**	**41%**

In the residential sector, the transition away from lighting is stark. By 2030, residential lighting—which in PY2015 accounted for almost three-quarters of Hawaii Energy's cumulative residential sector savings—will be entirely realized by a combination of expected market driven savings, codes & standards savings, and prior (PY2009 through PY2015) program accomplishments. Our analysis indicates that this heavy reliance on lighting needs to taper off quickly due to the convergence of energy efficient lighting saturation levels reaching very high levels and significant changes within the LED market.

In the commercial sector, Hawaii Energy will need to rely on multiple end uses to capture the economic potential available by 2030. Due to similar market forces that are impacting the residential lighting market, our analysis indicates that the program's heavy reliance on lighting in the commercial sector also needs to taper off somewhat by 2020, particularly with respect to screw-in LEDs. Moving forward, the commercial lighting end use will still play an important role in the commercial sector, but due to growth in available potential (especially when compared to business as usual projections of program savings), water heating, refrigeration, cooling, and ventilation will all need to become more prominent contributors to commercial savings.

Program Oversight. The EM&V team investigated and reported on two issues related to program oversight and rebate/incentive payment processes. First, in the business sector, we sought to understand and document the safeguards that Hawaii Energy has in place to prevent customers from receiving a rebate/incentive for the same (identical) lighting measure from multiple business programs. The review focused on the data gathered by relevant parties (e.g., lighting distributors, contractors, Hawaii Energy, etc.) at key steps in the program delivery process. The overriding goal of the investigation was to determine whether adequate safeguards are in place to eliminate the potential for a rebate/incentive to be paid—and for energy and demand savings to be claimed—by more than one business program. We found that Hawaii Energy has a well thought out and executed set of manual procedures to enable due diligence review of data to ensure that double counting of savings and double paying does not take place. Notably, Hawaii Energy indicates that they do consistently perform checks (as part of all application/invoice reviews) to ensure compliance. The EM&V team, however, recommends that the Hawaii Public Utilities Commission (PUC) require Hawaii Energy to establish a clear set of written procedures and workflows that must be followed when approving incentives for all business programs.

In addition to the above issue, the EM&V team investigated the practice of allowing trade allies to determine lighting operation hours as part of the Small Business Direct Install Lighting (SBDIL) Program. The inquiry was prompted over a concern that this practice creates an opportunity for trade allies to overstate operating hours—potentially resulting in inflated savings estimates and higher incentive payments. The EM&V team found that the site specific custom hours entered (by trade allies) for SBDIL result in overall program savings that are approximately 19% lower than what the savings would be if TRM stipulated values were used. Additionally, we found that Hawaii Energy staff review submitted lighting operating hours for all SBDIL projects. Furthermore, projects resulting in incentive payments of $3,000 or greater are required to have an on-site inspection by Hawaii Energy staff—which includes a review of all entered operating hours for all space types. Our analysis found that about 50% of all SBDIL projects were inspected in PY2016. These inspected projects accounted for approximately 75% of SBDIL incentive payments and 73% of SBDIL energy savings. Overall, our findings suggest that trade allies are likely entering hours estimates correctly—providing a more accurate representation of savings than using the TRM hours of use. Additional confidence in the accuracy of trade ally entered hours stems from a very high level of inspection.

TRM Review. Hawaii Energy maintains a Technical Reference Manual (TRM) for the Hawaii Energy Conservation and Efficiency Program (Hawaii Energy). The TRM provides methods, formulas and default assumptions for estimating energy and peak demand impacts from energy efficient measures and projects offered by Hawaii Energy. In addition, the TRM includes default net-to-gross (NTG), system loss factors (SLF)

and effective useful life (EUL) assumptions for the programs and measures offered by Hawaii Energy. Our TRM review found multiple differences between the PY2015 and PY2016 TRMs. These include differences between deemed savings assumptions or effective useful life (EUL) assumptions at the measure level and missing sections in the PY2016 TRM that previously appeared in the PY2015 TRM. Some of these differences were substantial and indicate some potential issues with document updating, control and approval processes. Hawaii Energy proposed 25 updates based on the PY2016 version of the Hawaii TRM. These updates (if incorporated) would be included in a new PY2017 TRM.[8] Opinion Dynamics reviewed the 25 proposed updates and collapsed the updates by measure, resulting in 16 unique measure updates. Additionally, Hawaii Energy postponed two proposed updates, leaving a total of 14 unique measures receiving updates for the PY2017 TRM. These updates spanned from relatively minor residential measures such as faucet aerators and showerheads to commercial measures such as chillers and retro-commissioning. Of the 14 proposed updates, we recommend accepting the proposed change to six, and revising the proposed change for eight. With the exception of residential LEDs and CFLs, the impact of the adjustments to individual measures have a minor impact on overall portfolio energy savings—a change to chillers and conversation AC calculations impact just 3.56% of portfolio savings and all other measures combined impact 1.25% of portfolio savings.

A more complete assessment of updates to the residential LED measure—which currently represents 22.56% of overall portfolio savings—is the subject of ongoing discussions between the EEM Team, Hawaii Energy, and Opinion Dynamics. Decisions and recommendations from that process are likely to be finalized in the spring of 2018.

Key Findings and Implications

The PY2016 EM&V activities provide a number of important insights—or takeaways—impacting both program direction and future areas of research.

Finding: Hawaii Energy claimed overall PY2016 portfolio energy savings of 140,816,393 kWh and the EM&V verified savings of 140,480,148 kWh—an overall verification rate of 99.8%. This verification rate is an important indicator of the accuracy of Hawaii Energy's efforts to track measure installations (and incentives paid) and apply deemed savings values and associated adjustments. The 99.8% verification rate indicates that Hawaii Energy is carefully and accurately tracking program outcomes. However, the verification process did not involve primary research to verify measure installation and appropriate operation, or an assessment of the validity of measure level gross savings values or the adjustments to them (e.g., net-to-gross ratios, system loss factors, etc.) as stipulated in the PY2016 TRM. Notably, NTGRs stipulated in the PY2016 TRM were last updated in PY2012, making use of secondary data in so doing. Additionally, TRM specified gross savings values and the estimated useful life (EUL) for key measures have been updated sporadically over time and may no longer be appropriate for current market conditions.

Implication: TRM gross savings values and other adjustments have not been holistically reviewed for a number of years. Gross savings values, NTGRs, system loss factors[9], and effective useful measure lives should be systematically reviewed and adjusted. Some adjustments (e.g., gross saving values, effective useful lives) may be able to rely on

[8] PY2017 runs from July 1, 2017 through June 30, 2018

[9] We understand that HECO has recently provided Hawaii Energy with updated system loss factors.

secondary information, but others (e.g., NTGRs, system loss factors) will require Hawaii-based primary research.

Finding: Based on program claimed savings through PY2015, Hawaii Energy program installations and market interventions from PY2009 through PY2015, on a cumulative basis, have reduced Hawaii's energy consumption by over 718 GWh, roughly split evenly between the residential (352 GWh) and commercial (366 GWh) sectors. The 718 GWh represents about 68% of the economic potential available (1,049 GWh) in 2015—as estimated by the 2012 potential study. The 2012 potential study indicates that, by 2030, the commercial sector will account for almost two and a half times the available economic potential from the residential sector (1,515 GWh vs 633 GWh).

Implication: Broadly speaking, to capture the remaining economic potential available to Hawaii Energy through 2030 (Remaining Available Economic Potential) as documented in the 2012 potential study—at the portfolio level—Hawaii Energy will need to capture a higher proportion of savings from the commercial sector.

Finding: Lighting has dominated Hawaii Energy's residential portfolio, comprising 71% of total cumulative savings in the residential sector. The displacement of CFLs by LEDs, combined with the Energy Independence and Security Act (EISA) regulations scheduled to take effect in 2020, suggest that the effective market baseline for screw-based residential lighting will be LEDs, suggesting that residential lighting will no longer provide a cost-effective source of energy savings.

Implication: Hawaii Energy will need to reduce the dependency on residential lighting measures (i.e., LEDs) as a major source of energy savings over the next two program years. Improvements in residential water heating efficiency represent the greatest remaining available potential for residential program savings through 2030. Hawaii Energy should carefully assess residential water heating efficiency options and expand overall activity for this important end use.

Finding: Lighting comprises 55% of cumulative energy savings in the commercial sector. Due to similar market forces that are impacting the residential lighting market, the market for screw-in bulbs appears to be transforming toward LEDs more rapidly than expected.

Implication: Lighting will continue to play an important role in the commercial sector. However, the commercial program's heavy reliance on lighting will need to taper off somewhat by 2020, particularly with respect to screw-in LEDs. Due to growth in available potential, water heating, refrigeration, cooling, and ventilation will all need to become more prominent contributors to commercial savings.

Implication: The Midstream Lighting Program is a significant contributor to overall savings in the commercial sector. Since LEDs make up the majority of Midstream savings, research is needed to better understand the commercial LED market and inform an associated net-to-gross ratio (i.e., an estimate of the extent to which LED savings in the commercial sector would not take place in the absence of the Midstream Program).

Finding: The CLE Study was based upon three primary sources of information: 2012 baseline and potential studies, and net tracked energy savings from program inception. Notably, the potential and baseline studies are now almost 6-years old and important markets (e.g., residential and commercial lighting—specifically the proliferation of LEDs) have changed more rapidly than expected. And, as discussed above under the "Savings Verification Process", program accomplishments (verified net kWh savings) for each PY are based on numerous TRM inputs that have not been updated in many years.

Implication: To inform future program planning, consideration should be given to the need for updated baseline and potential studies. Such studies will not only inform program savings estimates and key TRM inputs but also, and perhaps more importantly, assist program planners in identifying future savings opportunities. Given the rapid deployment of lighting technologies, particularly LEDs, it would appear to be particularly valuable to ensure any baseline or potential study explore niche opportunities to promote lighting (and other) technologies. Technologies within the residences of residential low-income and hard to reach customers, for example, may be quite different than other households. Similarly, within the commercial sector, there may be opportunities to serve small businesses and other entities that have—traditionally—been less likely to participate in programs and, therefore, have higher needs for energy efficiency improvements. Given the vintage of the last baseline study, the significant changes in key end-use markets since that time, the widespread deployment of renewable energy, and the unique characteristics of the customer base, we strongly recommend a rigorous, primary data driven approach should the Commission decide to move forward with a potential study.

Finding: Many business lighting measures meet the eligibility requirements of multiple business programs and, therefore, the potential exists for customers to receive an incentive from more than one Hawaii Energy program for the same exact measure and, associated with this, that more than one program could claim savings for that measure. Thus, overlap could lead to both the double-payment of an incentive and the double-counting of savings. Our investigation found no evidence of overlap. Additionally, we found that Hawaii Energy appears to have a well thought out and executed set of manual procedures to enable due diligence review of data to ensure that double counting of savings and double paying does not take place.

Implication: Carefully and consistently validating/checking Prescriptive Program, CBEEM, and SBDIL application information for overlap with the Midstream Program (to determine the source/seller of lighting equipment) is essential. Hawaii Energy notes that they do carefully and consistently perform these checks. However, the EM&V team recommends that the PUC require Hawaii Energy to establish a clear set of written procedures and workflows that must be followed when approving all business program incentives (including the Prescriptive Program, CBEEM, and SBDIL).

Finding: Allowing trade allies to determine lighting operation hours as part of the Small Business Direct Install Lighting (SBDIL) Program creates an opportunity for trade allies to overstate those hours—potentially resulting in inflated savings estimates and higher incentive payments. The EM&V team found that the site specific custom hours entered (by trade allies) for SBDIL result in overall program savings that are approximately 19% lower than what the savings would be if TRM stipulated values were used. Notably, Hawaii Energy staff review the submitted lighting operating hours for all SBDIL projects. Furthermore, projects resulting in incentive payments of $3,000 or greater are required to have an on-site inspection by Hawaii Energy staff—which includes a review of all entered operating hours for all space types. Our analysis found that about 50% of all SBDIL projects were inspected in PY2016. These inspected projects accounted for approximately 75% of SBDIL incentive payments and 73% of SBDIL energy savings.

Implication: The findings suggest that trade allies are likely entering hours estimates correctly—providing a more accurate representation of savings than using the TRM hours of use. Additional confidence in the accuracy of trade ally entered hours stems from a very high level of inspection.

Finding: The TRM review found multiple differences between the PY2015 and PY2016 TRMs. These include differences between deemed savings assumptions or effective useful life (EUL) assumptions at the measure

level and missing sections in the PY2016 TRM that previously appeared in the PY2015 TRM. Some of these differences were substantial.

> *Implication:* Differences between the PY2015 and PY2016 TRMs indicate some potential issues with document updating, control and approval processes—suggesting a need for a TRM guidance document that specifies document control procedures as well as the cadence for updates to the TRM, stakeholders that should be included in a review and update process, and the overall timeline and process that should be followed.

Finding: Hawaii Energy proposed 25 updates based on the PY2016 version of the Hawaii TRM. These updates (if incorporated) would be included in a new PY2017 TRM.[10] Opinion Dynamics reviewed the 25 proposed updates and collapsed the updates by measure, resulting in 16 unique measure updates. Additionally, Hawaii Energy postponed two proposed updates, leaving a total of 14 unique measures receiving updates for the PY2017 TRM. These updates spanned from relatively minor residential measures such as faucet aerators and showerheads to commercial measures such as chillers and retro-commissioning. Of the 14 proposed updates, we recommend accepting the proposed change to six, and revising the proposed change for eight.

> *Implication:* With the exception of residential LEDs and CFLs, the impact of the adjustments to individual measures have a minor impact on overall portfolio energy savings—a change to chillers and conversation AC calculations pertain to just 3.56% of portfolio savings and all other measures combined pertain to 1.25% of portfolio savings.

Finding: The residential LED and CFL measures currently account for 22.56% of overall portfolio savings. At this point, all parties (Hawaii Energy, EEM, Opinion Dynamics) agree that changes are needed to LED and CFL savings calculations (gross, NTG, etc.).

> *Implication:* A more complete assessment of the residential LED measure is the subject of ongoing discussions between the EEM Team, Hawaii Energy, and Opinion Dynamics. Decisions and recommendations from that process are likely to be finalized in the spring of 2018.

There are a number of additional issues that warrant future consideration. We list them below.

> *Importance of Underserved Segments:* Underserved segments will continue to be an important component of future program offerings and may warrant particular attention in future baseline and potential studies. Hawaii Energy current serves both residential and commercial underserved segments with a variety of initiatives. Maintaining, and possibly expanding, these initiatives will ensure the underserved populations realize the energy efficiency benefits associated with PBFA participation.
>
> *Future cost of Energy Efficiency:* As highlighted in this report, lighting has been the dominant source of energy savings over the first eight years of Hawaii Energy (PY2009-PY2016). This heavy focus on efficient lighting, and particular emphasis on screw-based CFLs and LEDs, has driven the cost-effectiveness of the Hawaii Energy portfolio. As Hawaii Energy begins to move away from important lighting markets (e.g., LEDs), it will be important to recognize that future energy savings (that will be more focused on non-lighting end-uses) will likely come at a higher cost per lifecycle kWh saved.
>
> *Baseline and Net-to-Gross Framework:* Currently, there is no established framework for the cadence and methods to be use when researching baseline and net-to-gross issues. Consideration should be

[10] PY2017 runs from July 1, 2017 through June 30, 2018

given to the establishment of a framework that can be applied across various program designs and delivery models.

Market Transformation Goals: Market transformation refers to meaningful changes in the structure or functioning of energy efficiency markets that are substantial and long lasting[11]. As a general rule, if market transformation has occurred, then the barriers to adoption of energy efficient equipment have been reduced to the point where a given program no longer needs to intervene to increase adoption[12]. While Hawaii Energy has a number of market transformation initiatives, no formal guidance document[13] exists regarding how transformation will be measured and how any resulting credit will be tracked and reported.

100% Renewables Goal: Consideration may need to be given to other possible contributors to the 100% renewables goal established by the PUC. Transmission and distribution systems can be strained in key locations and times of the day. Distributed energy resources and various technologies, in addition to energy efficiency improvements, may need to be considered when determining how to address such issues—toward the goal of meeting the 100% renewables goal.

[11] In California, D Decision (D.)09-09-047 defines market transformation as "long-lasting, sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate in that specific market."

[12] PY2013-2014 California Statewide Residential and Nonresidential Spillover Study. Prepared by Opinion Dynamics and Itron for the California Public Utilities Commission Energy Division. December 2017. Page 13.

[13] It is important to note, however, that the Hawaii Energy Annual Plan outlines market transformation initiatives, with associated metrics to be tracked and reported on.

2. Introduction and Background

The purpose of this report is to present the results of evaluation, measurement and verification (EM&V) activities addressing the Hawaii Energy Conservation and Efficiency Programs (Hawaii Energy or Program[14]) for program year 2016 (PY2016), covering Program activity from July 1, 2016 through June 30, 2017, the eighth year of operation. EM&V-related research activities for PY2016 were determined in consultation with the Hawaii Public Utilities Commission contract manager.

In addition to providing the results of efforts to verify program energy and demand savings impacts, this report provides key findings from a number of other research activities, including, but not limited to[15]: 1) a longitudinal analysis of program accomplishments to date and assessment of future energy savings opportunities; 2) investigations of several program operational and oversight issues related to energy savings claims and rebate/incentive payment processes; and 3) a review of multiple updates—proposed by Hawaii Energy—to the PY2017 Technical Reference Manual (TRM).

In addition to this report (Evaluation of Hawaii Energy Conservation and Efficiency Programs - PY2016 Program Results), we provide an associated appendix[16], consisting of the following reports/memorandums addressing PY2016 activities:

- **PY2016 Verification Report.** This report outlines the process used (and results of) EM&V efforts to verify program year 2016 Energy Conservation and Efficiency Program (Hawaii Energy) claimed savings.
- **Comprehensive Longitudinal Effects Study**. This report describes the opportunities that remain for Hawaii Energy to achieve long-term energy savings by documenting the cumulative energy savings realized through Hawaii Energy programs to date (through PY2015) as well as the potential for those programs to claim additional energy savings through 2030.
- **Overlap of Incented/Rebated Business Program Measures**. This report assesses the safeguards that are in place to eliminate the potential for rebates/incentives to be paid—and for energy and demand savings to be claimed—for the same (identical) measure by more than one business sector program.
- **SBDIL Custom Hours Investigation Results.** This report assesses the practice of allowing Small Business Direct Install Lighting (SBDIL) Program trade allies (e.g., local contractors) to enter lighting operating hours for businesses participating in the SBDIL program—ultimately comparing the resulting

[14] The Program is administered by Leidos Engineering, LLC (Leidos), under contract to the Hawaii Public Utilities Commission since 2009, at which time Hawaii Energy took over management of the state's demand side management programs from Hawaii Electric Company (HECO) and its subsidiaries, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO). The Program is funded by ratepayers in the HECO Companies' service territories via a Public Benefits Fee (PBF) that is intended to promote the development of programs and services that increase energy efficiency, reduce electricity consumption and demand, and ultimately decrease Hawaii's dependence on imported fossil fuels. The program provides a suite of offering for both residential customers (Residential Programs) and business customers (Business Programs). In its role with Hawaii Energy, Leidos serves as the state's Public Benefits Fee Administrator (PBFA).

[15] The EM&V team also completed a report cataloging the various EM&V activities that have taken place since program inception (PY2009 through PY2016)

[16] Evaluation of the Hawaii Energy Conservation and Efficiency Programs - PY2016 Appendices

energy savings to what savings would have been had PY2016 TRM operating hours values, by business type, been used.

- **Hawaii Energy: History of Annual EM&V-Related Research (PY2009-2016).** This report provides a summary-level description of all Evaluation, Measurement, and Verification (EM&V) research completed in each program year from the inception of Hawaii Energy in PY2009 through PY2015, including approved PY2016 plans. The document is intended to serve as a future reference guide to identifying the contents of past EM&V reports.

- **Hawaii Energy First-Year and Lifecycle Net Savings (PY2009-PY2016).** Two tables[17] that document first-year and lifecycle net savings from the inception of Hawaii Energy in PY2009 through PY2016.

- **Review of Proposed Updates to PY2017 TRM.** Hawaii Energy proposed 25 updates based on the PY2016 version of the Hawaii TRM. This report provides the results of Opinion Dynamic's review of the proposed changes. The purpose of the review was to assess the reasonableness of each recommendation and/or provide support to improve the recommendation.

2.1 Background

Leidos Engineering, LLC (Leidos) has administered the Program under contract to the Hawaii Public Utilities Commission since 2009, at which time Hawaii Energy took over management of the state's energy efficiency programs from Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO). Within HECO service territory, the Program is ratepayer funded via a Public Benefits Fee collected to fund efforts to promote the development of programs and services that increase energy efficiency, reduce electricity consumption and demand, and ultimately decrease Hawaii's dependence on imported fossil fuels.

The Program provides a suite of offerings for both residential customers (Residential Programs) and business customers (Business Programs), including activities aimed at garnering immediate energy savings (Energy Efficiency Programs), as well as some targeting market transformation for possible future savings (Transformational Programs.)

In its role with Hawaii Energy, Leidos serves as the state's Public Benefits Fee Administrator (PBFA) and program implementation contractor.[18] Hawaii Energy used the following subcontractors to implement the PY2016 Program:

- **Blue Planet Foundation**. Provided residential energy efficiency education, including school workshops, as well as social media and messaging campaigns and work on energy conservation codes advocacy and outreach.

[17] These tables were not part of a formal PY2016 EM&V activity. They were, however, included in the Executive Summary of past Annual EM&V reports. We have moved the tables to the appendix to preserve historical information (including PY2016 results) while reducing the length and increasing the readability of this year's Executive Summary.

[18] For more detail on the Public Benefits Fee Administrator role, the related contract between Hawaii Public Utilities Commission and Leidos may be downloaded from the Hawaii Energy site at http://www.hawaiienergy.com/information-reports. This report and prior EM&V reports can also be found there.

- **Honeywell**. Provided customer service and administrative functions for the residential and business incentive programs.
- **Selling Energy**. Provided sales training and support to Clean Energy Allies involved in energy efficiency sales and services.
- **Vivian Ward Affairs (Energy Unplugged) and Helen N. Wai**. Provided energy efficiency education particularly in hard-to-reach communities.
- **Oracle**. Provided peer group comparison Home Energy Reports.
- **First Fuel**. Provided software for personalized data analytics for commercial buildings to improve customer engagement.
- **Kanu Hawaii**. Provided transformational social media messaging, advanced power strip distribution and 60-day Energy Challenge implementation support.
- **SunHedge**. Developed sales training for small business direct install lighting (SBDIL) program contractors to better engage customers.
- **Kupu**. Provided interns through Rewarding Internships for the Sustainable Employment (RISE) program.
- **National Energy Education Development (NEED) Project**. Provided training for teachers to deliver energy efficiency curriculum in schools.
- **Association of Energy Engineers, University of Hawaii Outreach College and University of Hawai'i Maui College – Sustainable Living Institute of Maui (SLIM)**. Provided technical training for energy professionals, building operators and engineers.
- **Vermont Energy Efficiency Corporation (VEIC)**. Provided support with program design and innovation and review of core business program; and the development of strategic energy management (SEM) pilot project framework.

Hawaii Energy also has an implementation and oversight organization, the Technical Advisory Group (consisting of the Hawaii Public Utilities Commission, and the Public Benefits Fee Administrator contract managers, fiscal agent and contract evaluator, and local energy stakeholders), to provide expertise and technical guidance. Hawaii Energy has also assumed a supporting role in the Hawaii Clean Energy Initiative (HCEI),[19] a collaborative effort between the State of Hawaii and the U.S. Department of Energy (DOE) focusing on transforming the energy sector of Hawaii to a clean energy economy based on 70% clean sources by 2030.

[19] More information on HCEI can be found on its website. http://www.hawaiicleanenergyinitiative.org/

Hawaii Energy is also participating in the Integrated Resource Planning (IRP) Framework[20] and Energy Efficiency Portfolio Standards (EEPS)[21] open dockets.

2.2 Energy Efficiency Program Overview

Hawaii Energy implemented three Residential and three Business Programs in PY2016. As outlined in the PY2016 Hawaii Energy Annual Report, the residential and business sector budgets were $10,484,288 and $16,371,091, respectively. Additionally, Hawaii Energy allocated $3,618,549 for transformational services and initiatives, tax on non-incentives and performance awards for Leidos (the Hawaii Energy Program Public Benefits Fee Administrator)[22]. Table 2-1 presents a description of each of these programs by sector.

[20] A summary of the IRP since its inception in 1992 is available at the Hawaiian Electric Company (HECO) website at http://www.heco.com/portal/site/heco/menuiterm.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=b71bf2b154da9010VgnVCM10000053011bacRCRD&vgnextfmt=defau. Information about the current IRP process and Advisory Group meeting can be found on line. https://www.google.com/folder/d/OBxvCvKr8bi94Z1Y3cnA1MkxURzg/edit?pli=1

[21] More information on the EEPS can be found on the DSIRE website. http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=HI15R

[22] Budget amounts sourced from Hawaii Energy PY2016 Annual Report (p. 39. Table 16).

Table 2-1. PY2016 Hawaii Energy Program Summary – Business and Residential

Sector	Program	Program Description[a]
Business	Business Energy Efficiency Measures (BEEM)	The objective of this program is to acquire electric energy and demand savings through customer installations of standard, known, energy efficiency technologies by applying prescriptive incentives in a streamlined application process. The BEEM program consisted of several offerings in PY2016. Channels included Midstream (high-efficiency lighting), Trade Ally-Provided (high-efficiency lighting, HVAC, motors, water heating, water pumping, envelope improvements and others), and Traditional Retail (high efficiency equipment and appliances).
	Customized Business Energy Efficiency Measures (CBEEM)	The objective of this program is to provide a custom application and approval process for participants to receive incentives for installing non-standard energy efficiency technologies. The commercial and industrial custom incentives enable customers to invest in energy efficiency opportunities related to manufacturing process and other technology measures that may require calculations of energy savings on a case-by-case basis for specific, unique applications.
	Business Hard to Reach (BHTR)	The objective of this program is to help targeted geographic areas and sectors that have been traditionally underserved, such as retail, restaurants other small businesses and commercially metered multifamily. Additionally, this program conducted more aggressive outreach to lighting and electrical contractors with training, promotional materials and frequent communications on program updates.
Residential	Residential Energy Efficiency Measures (REEM)	This program represents the largest program within Hawaii Energy's residential portfolio, both in terms of incentives distributed and energy savings achieved. The REEM program consisted of several offerings in PY2016 including Program Communication, Upstream, Traditional Retail, Online Retail, and Trade Ally-Provided.
	Residential Hard to Reach (RHTR)	This program seeks to secure various projects among Hawaii residents that have traditionally been underserved. Specifically, it addresses financial and landlord/tenant barriers to installing energy-saving technologies through direct installation.
	Residential Energy Services and Maintenance (RESM)	This program aims to provide customers with incentives for services and maintenance to their homes' biggest energy consuming equipment.

b. Program summaries adapted from the PY2016 Hawaii Energy Annual Report.

Table 2-2 provides a summary, by program and measure/service, of the PY2016 Residential and Business Program offerings.

Table 2-2. Hawaii Energy Residential and Business Programs: PY2016

Sector	Measures/Services
Residential Programs	
REEM	**Residential Energy Efficiency Measures**
	High Efficiency Water Heating
	High Efficiency Lighting
	High Efficiency Air Conditioning
	High Efficiency Appliances
	Energy Efficiency Equipment Kits
	Energy Awareness, Measurement and Control Systems
RHTR	**Residential Hard-to-Reach**
	Direct Installation – Residential Energy Kits
	Energy Efficiency Equipment Grants
RESM	**Residential Energy Services and Maintenance**
	Residential System Tune-ups
	Residential Design and Audits
Business Programs	
BEEM	**Business Energy Efficiency Measures**
	High Efficiency Water Heating
	High Efficiency Lighting
	High Efficiency HVAC
	High Efficiency Water Pumping
	High Efficiency Motors
	Commercial Industrial Processes
	Building Envelope Improvements
	High Efficiency Appliances
	ENERGY STAR® Business Equipment
	Direct Install – Residential Energy Kits
	Energy Awareness, Measurement and Control Systems
CBEEM	**Custom Business Energy Efficiency Measures**
	Customized Project Measures
BHTR	**Business Hard-to-Reach**
	Business Direct Installation
	Energy Efficiency Equipment Grants
	Restaurant Targeted Participation Programs

Source: Hawaii Energy PY2016 Annual Plan

2.3 Transformational Programs Overview

In addition to the six energy efficiency programs described in Section 2.2, Hawaii Energy pursued a number of Transformational Programs (or market transformation programs) in PY2016. These efforts focus on behavior modification, professional development, and training that may lead to energy efficiency and conservation

within the next five years. Hawaii Energy does not quantify or record energy savings attributable to these activities in the program-tracking database and, for PY2016, the EM&V team did not verify these efforts.

Hawaii Energy implemented the following Transformational Programs in PY2016:

- **Behavior Modification.** Aimed to reach the mass market as well as hard-to-reach residents in underserved communities in Hawaii, Honolulu and Maui counties to build on the foundation of energy literacy established through various programs.
- **Professional Development.** Designed to educate professionals who are either new to the working world, new to energy efficiency or both.
- **Technical Knowledge and Training.** Focused on engineers, facility managers, architects, building operators, energy managers and similar trade professionals who have experience in infrastructure and energy, but need to enhance their technical skills in implementing energy efficiency upgrades or practices in facilities, offering Building Operator Certifications, sponsoring water efficiency and conservation education, and other additional trainings.
- **Decision-making support** for large energy users in developing comprehensive energy management strategies to incorporate into business practices and encourage ongoing improvements in energy efficiency.
- **Benchmarking** the energy use of facilities and business sectors in order to identify energy-saving opportunities and provide technical assistance and incentives to save energy.
- **Clean Energy Collaboration/Demand Response (DR) Pilots.** Aimed to incorporate DR capacity acquisition activities to provide Hawaiian Electric Company's (HECO) customers greater access to controllable loads.
- **Educator training and grants.** Worked with teachers to create a community of educators who are "energy champions" incorporating energy lessons into their curriculum and engaging students in conservation messages and behaviors.
- **Codes and Standards Support.** Aimed to increase support of codes and standards to help the State reach its Energy Efficiency Portfolio Standard (EEPS) goals faster. Included advocacy for code adoption at the state level and development of tools and educational outreach materials for the design and construction community.
- **Energy Industry Workforce Development and Vocational Training.** Worked with KUPU Hawaii fellows to draw highly qualified recent graduates into the energy industry while providing cost -effective support to key initiatives in the Program.

3. Verification Methods and Results

As previously stated, the PY2016 Hawaii Energy portfolio claimed energy savings for six programs aimed at attaining direct energy savings, with three targeting the business sector and three targeting the residential sector (Business Programs and Residential Programs, respectively). Opinion Dynamics deployed multiple methods to verify Hawaii Energy PY2016 savings. Specifically, we verify that incented projects/measures are appropriately "tracked" (in the program database) and that estimated savings values and related adjustments—as stipulated in the applicable Technical Reference Manual[23] (TRM)—have been properly applied. The goal of this verification effort is to provide an overall portfolio level verification rate, which represents Opinion Dynamics' estimate of the percentage of the energy (kWh) and demand (kW) savings claimed by Hawaii Energy that Opinion Dynamics verified. A verification rate of 100%, for example, would indicate that Opinion Dynamics estimated overall portfolio savings at the exact level claimed by the program. A detailed description of all verification activities and results can be found in Appendix A[24].

Verification rates are an important indicator of the accuracy of Hawaii Energy's tracking effort in terms of properly tracking measure installations (and incentives paid) and applying pre-agreed upon savings values and associated adjustments. **It is important to note, however, that this verification process did not involve a review or scrutiny of measure level gross savings values or the adjustments to them (e.g., net-to-gross ratios, system loss factors, etc.) as stipulated in the TRM. In short, the goal is to assess the extent to which TRM gross savings values and related adjustments (that produce net savings) are being applied properly, but does not extend to assessing their validity.** For example, an important adjustment to gross savings is a net-to-gross ratio (NTGR). The NTGR is an estimate of the percentage of savings claimed by Hawaii Energy that is determined to be induced/caused by the program (i.e., the savings would not have occurred naturally, in absence of the program). Over the course of time, program NTGRs can be expected to change as overall market conditions and associated program activity change—the result of which can be substantial changes in program "net" savings. This verification effort did not involve research to determine the appropriateness of TRM specified NTGRs. As such, the NTGRs stipulated in the PY2016 TRM were last updated in PY2012. Additionally, TRM specified gross savings values for key measures have been updated sporadically over time and may no longer be appropriate for current market conditions. Finally, the TRM stipulates the estimated useful life (EUL) for each measure and this information is used to compute measure savings over the life of the equipment. Similar to NTGR's and gross measure level savings values, research was not completed as part of this verification effort to assess the credibility of TRM-stipulated EULs.

Hawaii Energy publishes an annual report which highlights program accomplishments with a focus on first-year and lifecycle net energy savings. For the purposes of this memorandum, these accomplishments are considered "claimed" because they were not—prior to publication—"verified" (checked) by a third party independent Evaluation, Measurement and Verification (EM&V) contractor. It is important to note that these "claimed" savings are based upon the program tracking database maintained by Hawaii Energy. Savings contained within the database are referred to as "tracked" savings. We provide detailed definitions of the various savings terms referenced in this report in Table 3-1.

[23] Hawaii Energy Efficiency Program Technical Reference Manual (TRM) PY2016. The TRM documents the gross savings values and assumptions that should be applied to various measures incented through the Hawaii Energy programs as well as adjustments to those savings such as net-to-gross-ratios and system loss factors.

[24] Appendix A: PY2016 Verification Report

For consistency, all energy and demand savings values presented in this memorandum (e.g., claimed, tracked, and verified) are at the "net" level, as net savings are the values tracked and claimed by Hawaii Energy. Additionally, we found claimed savings and tracked savings to be identical in PY2016 and, therefore, we focus on tracked savings throughout this memorandum because it allows for more granular comparisons at the individual measure level.[25] Table 3-1 provides definitions of these terms.

Table 3-1. Definitions of Savings Terms

Term	Definition
Claimed	Hawaii Energy annual net[a] program savings or accomplishments (kWh, kW, benefits, awards) as reported in the Hawaii Energy Annual Report.
Tracked	Annual net program savings (kWh and kW) and avoided costs (total resource benefits (TRB)) that result from the Opinion Dynamics' independent summation of savings contained in Hawaii Energy's program tracking database. In theory, "Claimed Savings" and "Tracked Savings" should be equal, as claimed savings are based on Hawaii Energy's efforts to sum results as tracked in the program database. Historically, however, Opinion Dynamics has found some relatively minor discrepancies[b] between Claimed and Tracked savings.
Verified	Program net savings (kWh and kW), TRB calculations, and award amounts resulting from various steps—described more fully in this memorandum—taken by Opinion Dynamics to ensure that the program tracking system accurately reflects program activities and that stipulated Technical Reference Manual (TRM) values and related adjustments have been properly applied. Verified savings differ from tracked savings in that tracked savings are simply the result of Opinion Dynamics independently summing savings as tracked in the program database. Verified savings goes multiple steps further and adjusts savings in instances where the tracking database (i.e., Tracked Savings) does not properly reflect actual program activity or uses incorrect savings values and related adjustments as stipulated in the TRM.

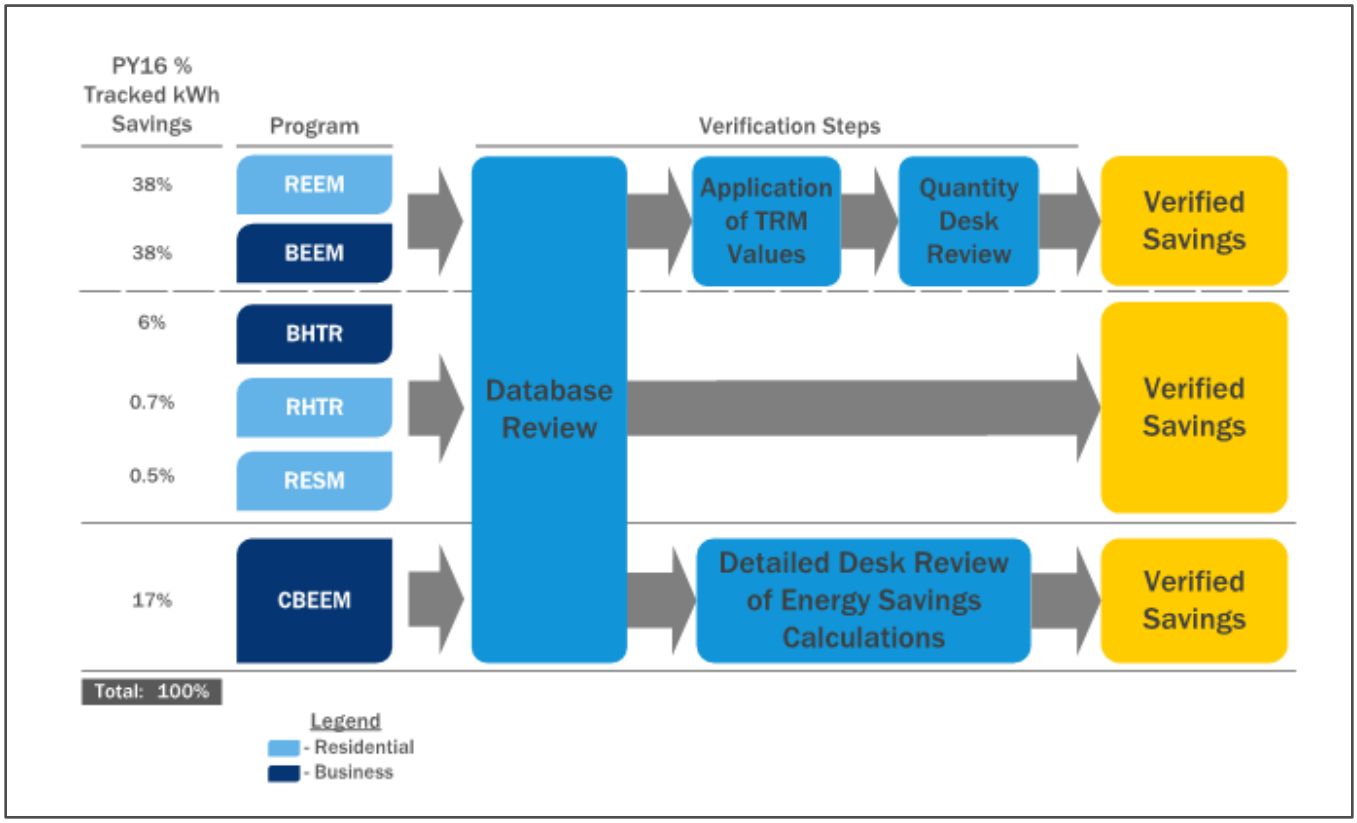
a. Net savings refers to the gross savings adjusted for net-to-gross ratios and system loss factors per the TRM.
b. In PY2014 and PY2015, for example, the EM&V team found slight (less than 1%) differences between Claimed Savings and Tracked Savings due to minor corrections or changes that occurred between delivery of the "frozen" program tracking database to Opinion Dynamics (typically in August) and publication of the Hawaii Energy Annual Report (typically in October).

3.1 Verification Methods

Figure 3-1 provides a visual representation of the verification steps applied to each program. We provide detailed descriptions of each verification step (e.g., database review, application of TRM values, quantity desk reviews, detailed desk reviews) in the subsections that follow.

[25] Claimed savings are those savings reported, in aggregate fashion, within the Hawaii Energy Annual Report.

Figure 3-1. PY2016 Verification Methods



■ Database Review

For all programs, we conducted a manual review of all (nearly 80,000) equipment records in the Hawaii Energy program tracking database[26] to assess completeness of data, check for duplicates, assess records with zero and negative quantities for accuracy, and identify any parameters that are outside of expected ranges. The database review verification step is intended to provide a high-level screen of all records, and serves to identify clear and discernable data entry errors (i.e., values outside of expected ranges), but was not intended to verify the accuracy of every individual parameter (e.g., whether a per-unit deemed savings is correctly applied from the Hawaii TRM or whether a quantity is consistent with the project invoice and application). A detailed review of the accuracy of individual parameters occurs in subsequent verification steps for select programs and a sample of measures and is described in the subsections that follow. The database review verification step produced a clean database from which we drew program specific samples of projects (as applicable) to support additional verification steps.

[26] We used the revised "frozen" database provided to Opinion Dynamics on October 13, 2017.

Application of TRM Values

- Together, the REEM and BEEM programs account for approximately 90% of PY2016 portfolio-level first-year net tracked savings (after excluding savings from the CBEEM program).[27] As such, we focused the review of the correct application of TRM values on REEM and BEEM specifically, to be cost-efficient. For both programs, we reviewed the population of records within the database to ensure that the deemed savings assumptions from the Hawaii TRM[28] were accurately applied to the measures in the program tracking database. The goal of this activity is to assess the extent to which Hawaii Energy correctly applies TRM gross savings values and related adjustments, but the review did not extend to 1) assessing the validity of all assumptions within the TRM, or 2) field work to verify installations or correct project data for verification of savings.

For the REEM and BEEM programs, we conducted a review of the population of measures within the program tracking database (more than 40,000 equipment records). This included reviewing all measure-specific savings calculations and inputs included in the program tracking database to confirm that the database correctly incorporates and applies the stipulated values from the Hawaii TRM. This review consisted of two elements:

- **Savings Estimates:** Opinion Dynamics applied the deemed measure-level savings estimates and associated savings algorithms and assumptions from the PY2016 Hawaii TRM.
- **Net-To-Gross:** In 2012, evaluators revised, and stakeholders vetted Hawaii Energy's NTG estimates, by program. For PY2016, we applied these 2012 estimates as stipulated in the current TRM.

This step resulted in adjustments to measure-specific assumptions for some measures. These adjustments included:

- Correcting for an error in the tracked Peer Comparison demand (kW) savings calculation.
- Updating deemed savings assumptions to be consistent with the PY2016 Hawaii TRM when tracked values used an earlier version of the TRM.
- Correctly applying interactive effects and hours of use assumptions to all measures as applicable.

Desk Reviews

For REEM, BEEM, and CBEEM, we developed samples and reviewed project documentation (e.g., invoices, specification sheets, Hawaii Energy calculations, etc.) and other data as necessary to verify the accuracy and appropriateness of tracked calculations. We performed two types of desk reviews:

Quantity Desk Reviews: For REEM and BEEM, the desk reviews consisted of verifying the accuracy of the measure quantities in the tracking database based on project documentation (e.g., invoices, post-inspection forms, etc.). These reviews consisted of looking at a sample of projects at the measure level

[27] CBEEM does not rely on the TRM for savings, but relies on custom calculations at the individual project level. We therefore do not include CBEEM when performing the review of the correct application of TRM values.

[28] We used the Hawaii Energy PY2016 TRM v16. All references to the TRM in this memo refer to the Hawaii TRM unless otherwise stated.

to ensure the tracked quantities in the program tracking database matched quantities on invoices for the measures in the sample.

Detailed Desk Reviews: For CBEEM, the desk reviews included a review of project documentation (e.g., invoices, program savings calculations, specification sheets, inspection forms, etc.) supplied by Hawaii Energy to confirm accuracy and appropriateness of savings assumptions and methodologies and to calculate verified savings. Additionally, we performed facility-level electric consumption analyses for some CBEEM projects for comparison to the claimed/tracked savings methodologies using monthly utility bill energy consumption.

The quantity desk reviews resulted in a slight adjustment to the BEEM program (verification rate of 99.7%), but resulted in a 100% verification for the REEM program. The detailed desk reviews for CBEEM resulted in a verification rate of 95.9% for energy savings and 94.1% for demand savings. The verification rate for CBEEM was mainly driven by adjustments to one large chiller project and minor adjustments to several other lighting and HVAC projects.

We performed simple random samples for the REEM and BEEM samples (quantity desk reviews) and a stratified random sample by energy savings for the CBEEM sample (detailed desk review). We chose simple random samples for the REEM and BEEM programs based on the results of the past two years of verification for these programs. For CBEEM, we chose a stratified random sample due to the mix of project types, sizes, and relative contribution to overall CBEEM savings.

Table 3-2. Desk Review Method Summary

Program	End Use	Desk Review Method
REEM	Upstream	**Quantity and Participant Agreement review:** Reviewed a simple random sample (n=50 out of population of N=1,267) of invoices and distribution data to confirm quantities and associated participant agreements with participating retailers.
	Peer Comparison	**Participant data review:** Leveraged participation data for the population of PY2016 Peer Comparison program households and applied the TRM stipulated deemed kWh and KW savings value per household.
	Solar Hot Water, Refrigerators, VRF	**Quantity review:** Reviewed invoices, applications, and other secondary documentation to confirm database quantities for a simple random sample of projects (n=50 out of population of N=4,921) for the end-uses with the largest savings.
BEEM	Midstream, Lighting, HVAC	**Quantity review:** Reviewed invoices, applications, and other secondary documentation to confirm database quantities for a simple random sample of projects (n=50 out of population of N=595) for the end-uses with the largest savings.
CBEEM	All	**Detailed desk review:** Reviewed all project-specific documentation and savings calculations for a stratified random sample of projects by energy savings (n=25 out of population of N=336) and revised calculations as necessary at the individual project level.

3.2 Verification Results

The EM&V team verified first-year net energy and demand savings by sector, program, and end use. Additionally, by applying TRM stipulated effective useful lives (EUL), the team verified lifecycle net energy and demand savings by sector, program, and end use.

First-Year Verified Savings Results

Table 3-3 below shows the PY2016 verified first-year net energy savings by program; resulting from the application of the verification methods described in Section 3.1. The table compares the verified savings to the PBFA's tracked savings. As illustrated in the Table, the overall portfolio level first-year kWh verification rate is 99.8%. Hawaii Energy claimed (net tracked) first-year savings of 140,816,393 kWh and the EM&V verified savings of 140,480,148 kWh. Further, the table illustrates that Business Programs accounted for first-year verified savings of 84,146,052 kWh while residential programs accounted for 56,334,096 kWh.

Table 3-3. Hawaii Energy First-Year Net Tracked and Net Verified Energy Savings (kWh) by Sector and Program: PY2016

Sector	Program	First-Year Net Savings (kWh)		Verified Savings as % of Tracked Savings	Verified Savings as % of Total Verified Savings
		Tracked	Verified		
Business	BEEM	53,269,643	53,097,776	99.7%	37.8%
	CBEEM	23,438,710	22,484,239	95.9%	16.0%
	BHTR	8,564,037	8,564,037	100.0%	6.1%
	Business Total	**85,272,390**	**84,146,052**	**98.7%**	**59.9%**

Sector	Program	First-Year Net Savings (kWh)		Verified Savings as % of Tracked Savings	Verified Savings as % of Total Verified Savings
		Tracked	Verified		
Residential	REEM	53,767,121	54,557,215	101.5%	38.8%
	RHTR	1,023,996	1,023,996	100.0%	0.7%
	RESM	752,885	752,885	100.0%	0.5%
	Residential Total	**55,544,003**	**56,334,096**	**101.4%**	**40.1%**
Portfolio Overall		**140,816,393**	**140,480,148**	**99.8%**	**100.0%**

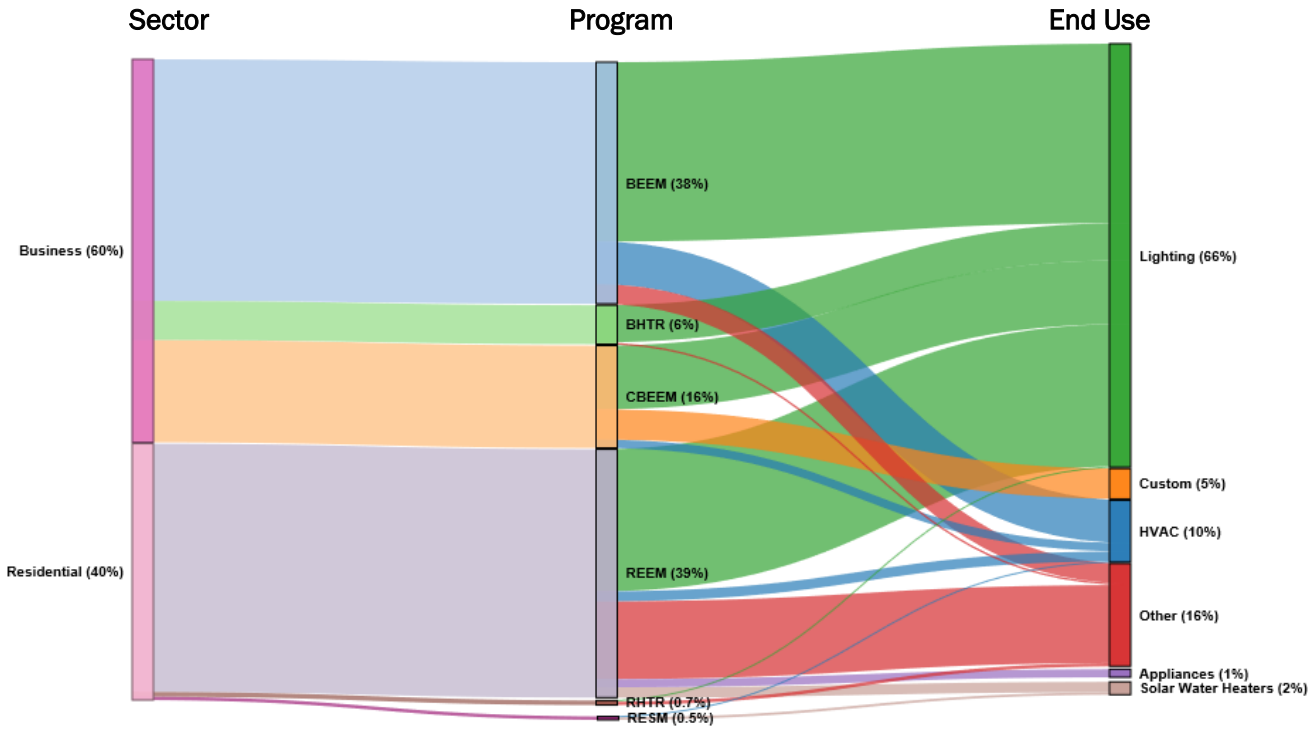
Note: Values are rounded for reporting purposes and may not sum to the totals shown in the table above.

Similar to Table 3-3, Figure 3-2 presents the distribution of total PY2016 first-year net verified kWh savings by sector and program, but then extends the information to include end use. Reading the graphic from left to right, Figure 3-2 disaggregates PY2016 savings for each sector (business and residential) by program, and program savings by end use. Conversely, reading the graphic from right to left, Figure 3-2 aggregates PY2016 savings attributable to each end use to the program level, and then program savings to the sector level.

As illustrated in Figure 3-2, the business sector accounts for approximately 60% of overall portfolio first-year net verified savings, with the residential sector accounting for the remaining 40%. Three programs account for the vast majority of first-year net verified savings (93%) at the portfolio level, with the Residential Energy Efficiency Measures (REEM), Business Energy Efficiency Measures (BEEM), and the Custom Business Energy Efficiency Measures (CBEEM) programs accounting for 39%, 38% and 16% of PY2016 savings, respectively.

Figure 3-2 also illustrates that lighting is the most significant contributor to overall savings, representing 66% of overall PY2016 portfolio first-year net verified savings. While the majority of lighting savings come from the BEEM and REEM programs, CBEEM and BHTR make notable contributions to savings from lighting measures. From an overall portfolio perspective, the figure also illustrates that HVAC measures contribute 10% of first-year net verified energy savings.

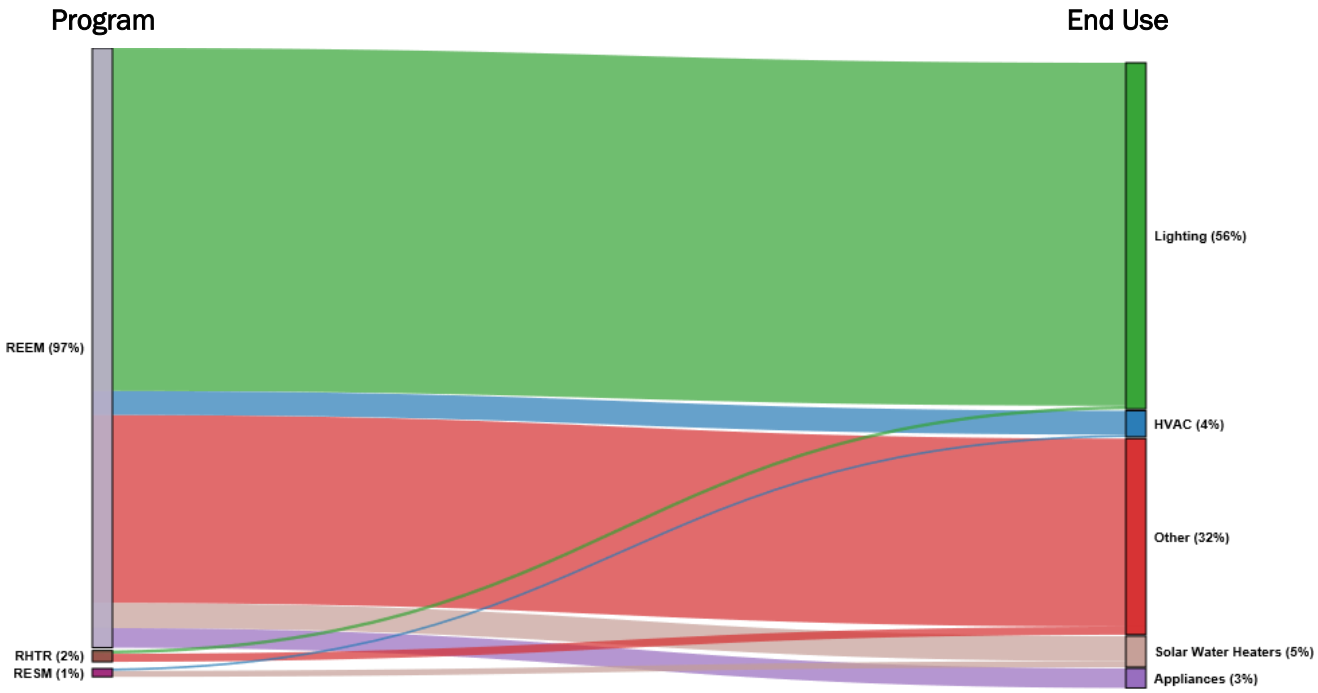
Figure 3-2. Percent of PY2016 First-Year Net Verified Savings by Sector, Program, and End Use



Note: **Total First-Year Net Verified MWh savings: 140,480.** CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach; REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance. Percentages may not sum to 100 due to rounding.

Figure 3-3 presents the distribution of PY2016 first-year net verified energy savings for the residential sector by program and end use. As illustrated in the figure, the REEM program accounts for 97% of residential sector savings. Furthermore, efficient lighting measures account for the vast majority of residential sector savings (56%), with other measures, solar water heaters, HVAC, and appliances accounting for a smaller share of residential savings (32%, 5%, 4% and 3% of first-year net verified energy savings, respectively). In PY2016, the majority of savings in the "other" end use category is from the Peer Comparison program.

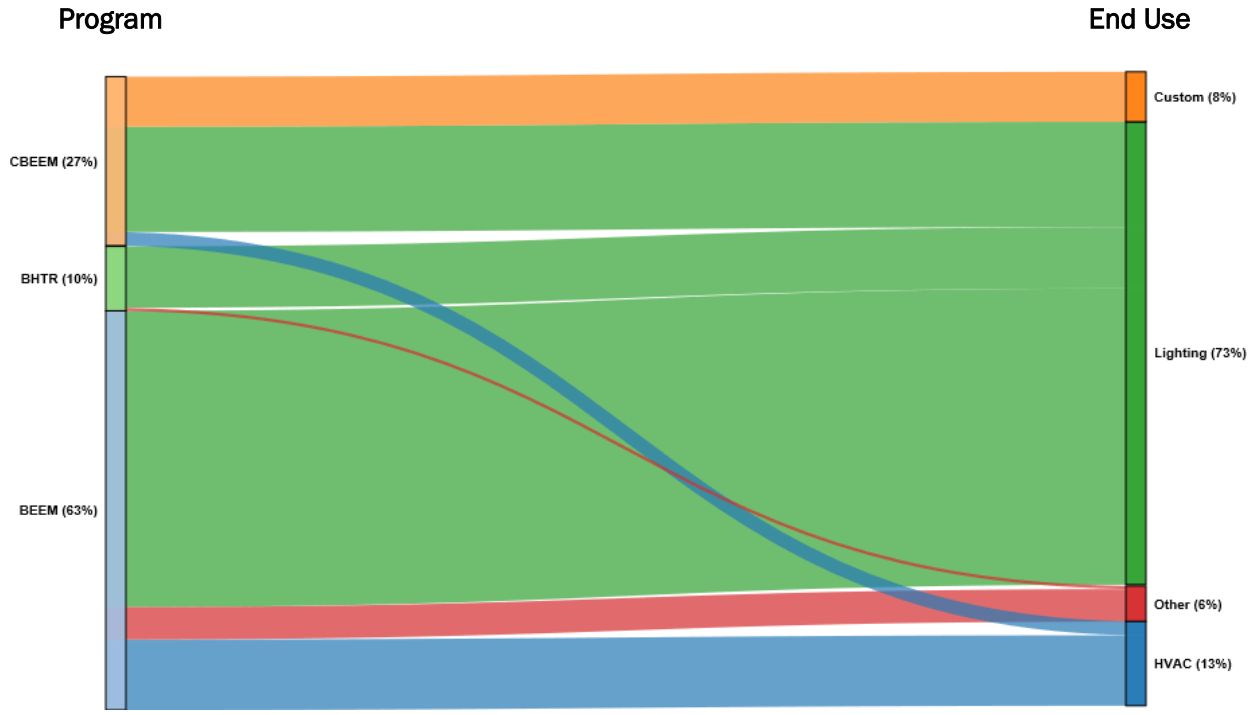
Figure 3-3. Percent of PY2016 First-Year Net Verified Savings by Program and End Use: Residential Sector



Note: **Residential First-Year Net Verified MWh savings: 56,334.** REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance.

Figure 3-4 provides a breakdown of PY2016 first-year net verified energy savings for the business sector by program and end use. As illustrated in the figure, the BEEM (63%) and CBEEM (27%) program account for the vast majority of business sector first-year net verified savings (90%), with almost three-quarters (73%) of business sector first-year net verified savings derived from lighting measures. HVAC measures (13%) also make significant contributions to overall Business Program first-year net verified savings.

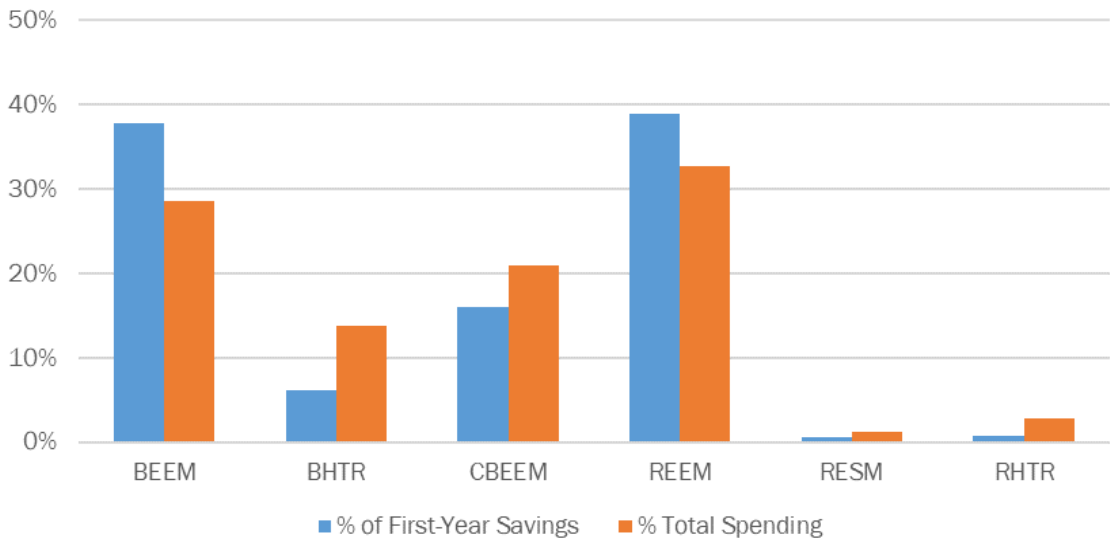
Figure 3-4. Percent of PY2016 First-Year Net Verified Savings by Program and End Use: Business Sector



Note: **Business First-Year Net Verified MWh savings: 84,146.** CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach.

Figure 3-5 presents PY2016 first-year net verified savings and PY2016 total program spending (both incentives, and operations and management costs). Most programs account for a higher share of portfolio spending as compared to their contributions to portfolio savings. The BHTR and RHTR programs represent 6% and 1% of portfolio-wide first-year net verified savings, respectively, but account for 14% and 3% of portfolio-wide spending. The exceptions are the BEEM and the REEM programs, which represent a higher portion of portfolio savings compared to their contribution to portfolio spending. The BEEM and REEM programs represent 38% and 39% of portfolio-wide first-year net verified savings, respectively, while only accounting for 29% and 33% of portfolio-wide spending. These outcomes reflect the cost-effectiveness of lighting measures, such as LEDs that dominate the REEM and BEEM programs, and the nature of the RHTR and BHTR programs, which target traditionally underserved customer segments which face higher barriers to participation and conducts outreach and trainings with lighting and electrical contractors.

Figure 3-5. PY2016 First-Year Net Verified Savings and Spending



Note: CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach; REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance.
"Total Spending" includes both incentives, and operations and management costs.

Lifecycle Verified Savings Results

In addition to verifying first-year net savings, the PY2016 impact evaluation included the verification of PY2016 lifecycle net energy savings by program, sector, and overall. Table 3-4 below presents lifecycle net verified energy savings by sector and program. Hawaii Energy's PY2016 programs produced lifecycle net verified savings of 1,707,440 MWh, 67% of which was realized by the business sector. We calculated lifecycle savings by multiplying first-year net verified savings for each measure by the corresponding effective useful life for the measure, arriving at lifecycle savings by measure. We then summed the resulting measure specific lifecycle savings by program, sector, and overall.

Table 3-4. Hawaii Energy Lifecycle Net Tracked and Net Verified Energy Savings (MWh) by Sector and Program: PY2016

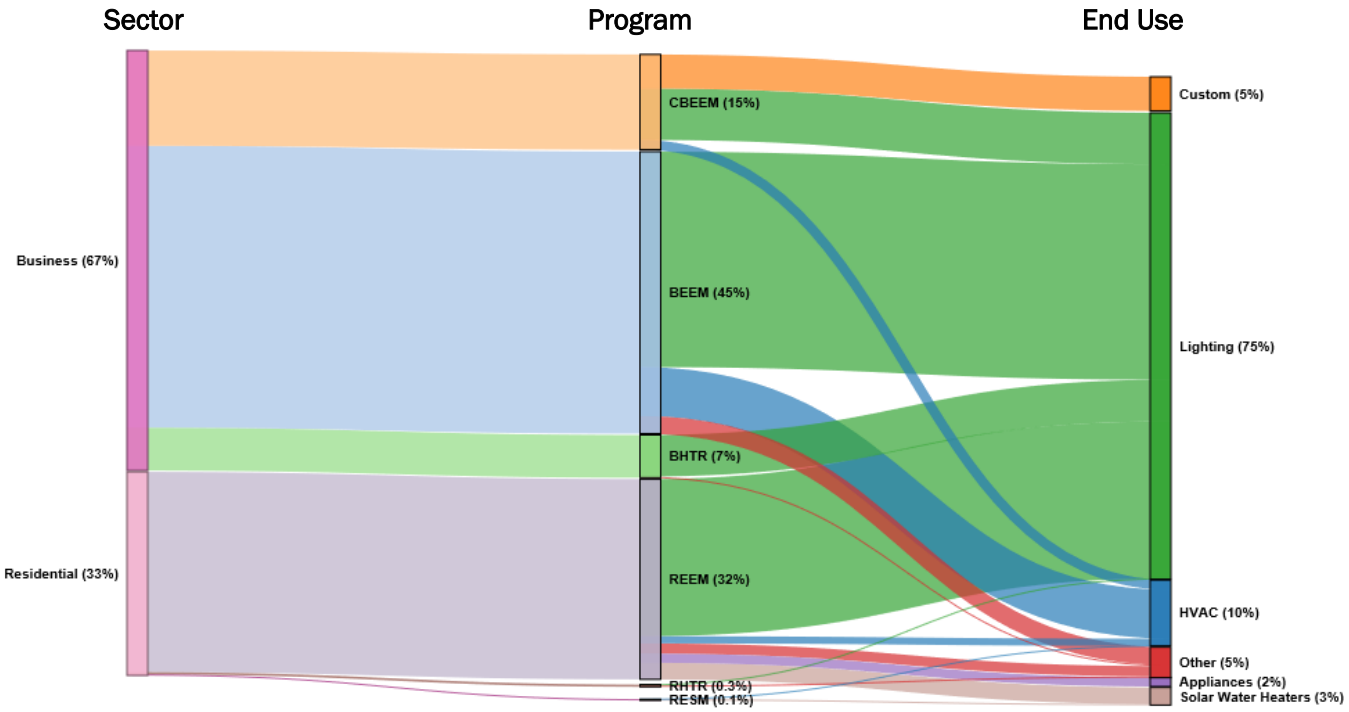
Sector	Program	Lifecycle Net Savings (MWh)		Verified Savings as % of Tracked Savings	Verified Savings as % of Total Verified Savings
		Tracked	Verified		
Business	BEEM	799,090	772,129	96.6%	45.2%
	CBEEM	272,801	260,888	95.6%	15.3%
	BHTR	116,967	116,967	100.0%	6.8%
	Business Total	**1,188,857**	**1,149,984**	**96.7%**	**67.4%**
Residential	REEM	560,728	548,339	97.8%	32.1%
	RHTR	6,170	6,170	100.0%	0.4%
	RESM	2,946	2,946	100.0%	0.2%
	Residential Total	**569,845**	**557,456**	**97.8%**	**32.6%**
Portfolio Overall		**1,758,702**	**1,707,440**	**97.1%**	**100.0%**

Note: Values are rounded for reporting purposes and may not sum to the totals shown in the table above.

Figure 3-6 presents the distribution of PY2016 lifecycle net verified kWh savings by sector, program and end use. Compared to first-year net verified kWh savings, the relative contribution of each sector (residential vs. business) changes somewhat. While the residential sector accounts for 40% of first-year net verified energy savings, it only represents 33% of lifecycle net verified savings. Conversely, the business sector represents 60% of first-year net verified energy savings but 67% of lifecycle net verified savings. This is because Business Program measures, on average, have longer EULs than residential measures (13.7 years for business vs. 9.9 years for residential[29]), extending first-year savings over a greater time horizon. Thus, Business Programs and related end uses represent a higher proportion of overall PY2016 portfolio lifecycle net verified savings compared to their respective share of first-year net verified savings.

[29] EUL = PY2016 Lifecycle net tracked kWh ÷ PY2016 First-Year net tracked kWh

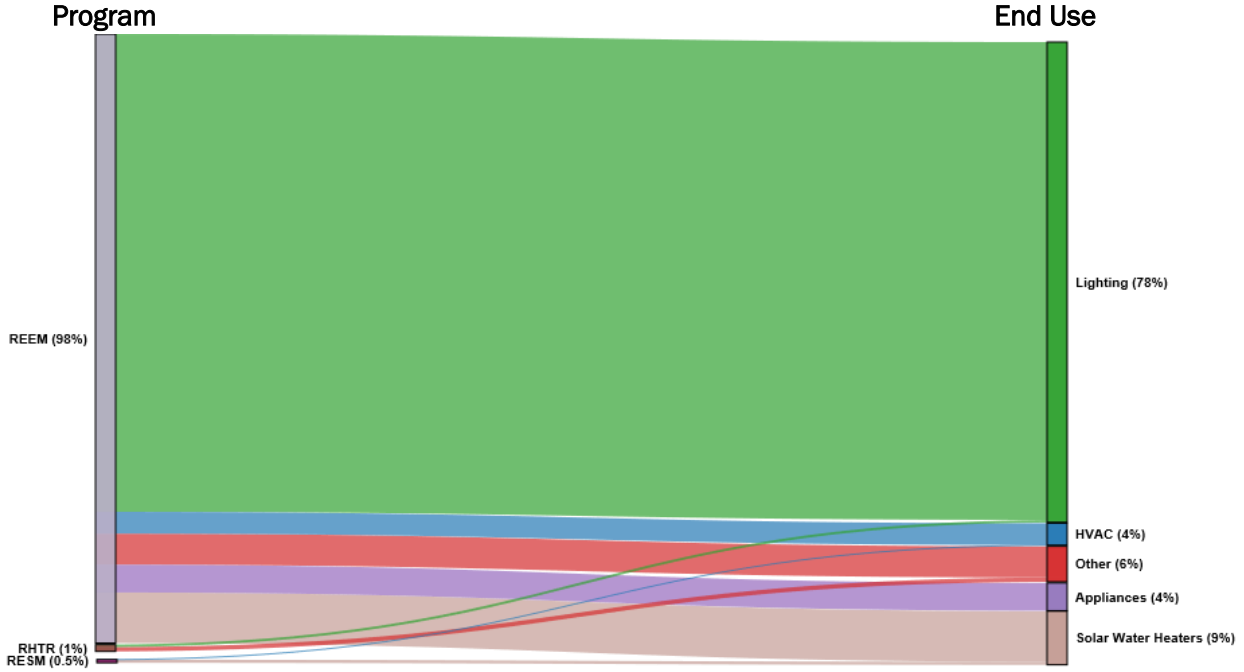
Figure 3-6. Percent PY2016 Lifecycle Net Verified Savings by Sector, Program, and End Use



Note: **Total Lifecycle Net Verified MWh savings: 1,707,440.** CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance. Percentages may not sum to 100 due to rounding.

Figure 3-7 Illustrates that within the residential sector, the relative contribution of individual programs to total lifecycle net verified savings is comparable to their contribution to total first-year net verified savings. For example, REEM accounts for 98% of residential sector lifecycle net verified savings and 97% of first-year net verified savings realized by residential customers.

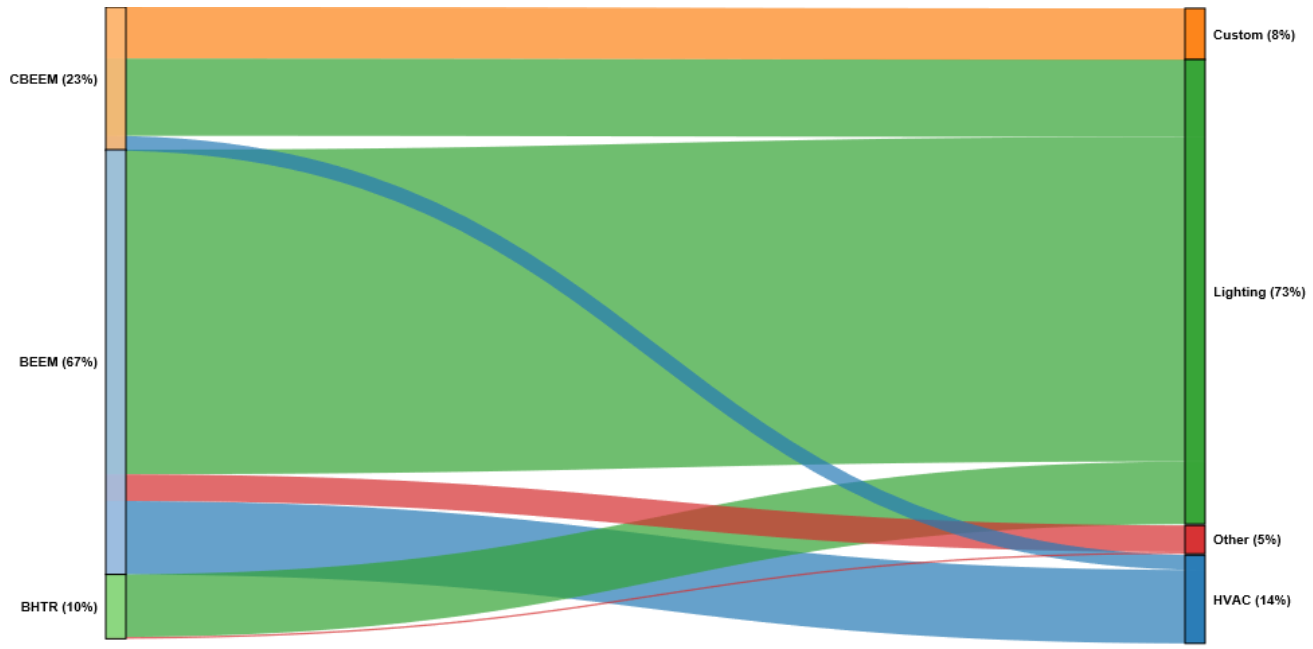
Figure 3-7. Percent of PY2016 Lifecycle Net Verified Savings by Program and End Use: Residential Sector



Note: **Residential Lifecycle Net Verified MWh savings: 557,456.** REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance. Percentages may not sum to 100 due to rounding.

Similar to the residential sector, within the business sector the relative contribution of individual programs to total lifecycle net verified savings is comparable to their contribution to total first-year net verified savings, as shown in Figure 3-8. For example, CBEEM and BEEM together account for 90% of business sector lifecycle net verified savings and 90% of business sector first-year net verified savings. However, compared to first-year net verified savings, the BEEM program contributes more to business sector lifecycle net verified savings while the CBEEM program contributes less. This is due to differences in the effective useful life of measures that contribute to each program (i.e., BEEM measures have higher EULs, on average, than do CBEEM measures).

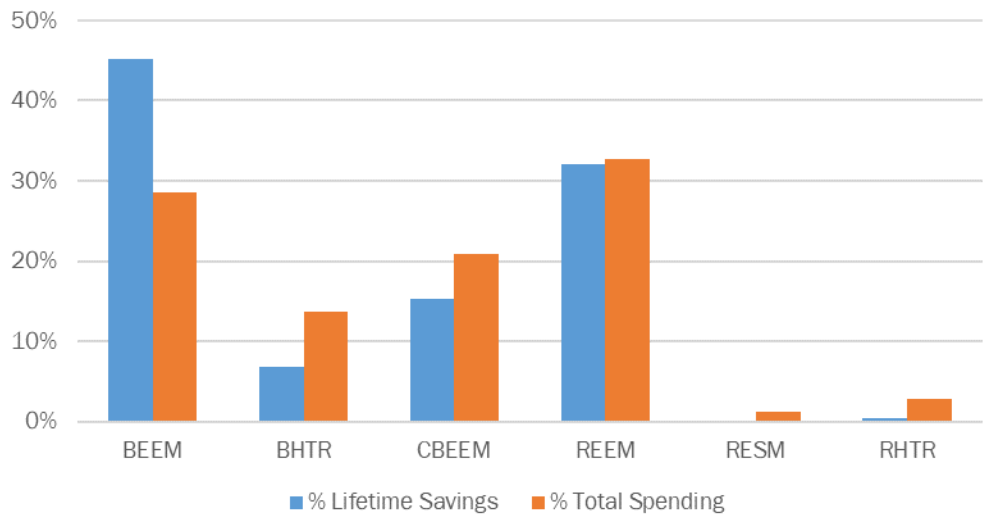
Figure 3-8. Percent of PY2016 Lifecycle Net Verified Savings by Program and End Use: Business Sector



Note: **Business Lifecycle Net Verified MWh savings: 1,149,984.** CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach. Percentages may not sum to 100 due to rounding.

Figure 3-9 provides a summary of PY2016 lifecycle net verified savings and PY2016 total program spending (including both incentives, and operations and management costs). For most programs, total spending outpaces the resulting lifecycle net verified savings (expressed as a percent of total portfolio spending and total portfolio lifecycle savings, respectively). Once exception is the BEEM program, which produced about 45% of overall portfolio verified lifecycle savings by utilizing about 29% of the PY2016 portfolio budget. Overall, Business Programs produce more lifecycle savings and, therefore, the ratio of savings to spending is more favorable for them on a lifecycle (rather than first-year) basis. This is due to the higher average EUL of Business Program measures.

Figure 3-9. PY2016 Lifecycle Net Verified Savings and Spending



Note: CBEEM=Custom Business Energy Efficiency Measures; BEEM=Business Energy Efficiency Measures; BHTR=Business Hard-to-Reach; REEM=Residential Energy Efficiency Measures; RHTR=Residential Hard-to-Reach; RESM=Residential Energy Services and Maintenance
"Total Spending" includes both incentives, and operations and management costs.

Figure 3-10 through Figure 3-12 provide graphical representations of lifecycle net tracked savings from PY2009 through PY2016 by sector and end use. All three graphics illustrate the lifecycle net tracked savings associated with measures installed through Hawaii Energy Program activity from PY2009 through PY2016. For the residential sector, Figure 3-10 clearly illustrates that lighting measures make the most significant contribution to the lifecycle net tracked savings associated with program activity over this period. Notably, appliances and solar water heating play a slightly higher role in the later years as these measures have longer EULs than most lighting measures (particularly CFLs).

Compared to those of the residential sector, business sector lifecycle savings PY2009 to PY2016 (shown in Figure 3-11) are considerably more balanced, with all four end use categories (e.g., lighting, HVAC, custom, and other) making fairly significant contributions to the lifecycle net tracked savings attributable to the eight years of program activity.

Finally, the combined results (Figure 3-12) again point to lighting as the most significant contributor to PY2009 to PY2016 lifecycle net tracked savings. This is not surprising given the fact that lighting is not only the dominant contributor to residential lifecycle net tracked savings attributable across the eight years of program activity but also an important contributor on the business side as well. Finally, it is important to note that the

average effective useful life (EUL) for both Business and Residential Programs has been increasing over time. For example, the average residential end use EUL has increased 46% from 6.8 years in PY2009 to 9.9 years in PY2016. Similarly, the average business measure EUL has increased 19% from 11.5 years in PY2009 to 13.7 years in PY2016.

Figure 3-10. PY2009-2016 Lifecycle Net Tracked Savings by End Use: Residential Sector

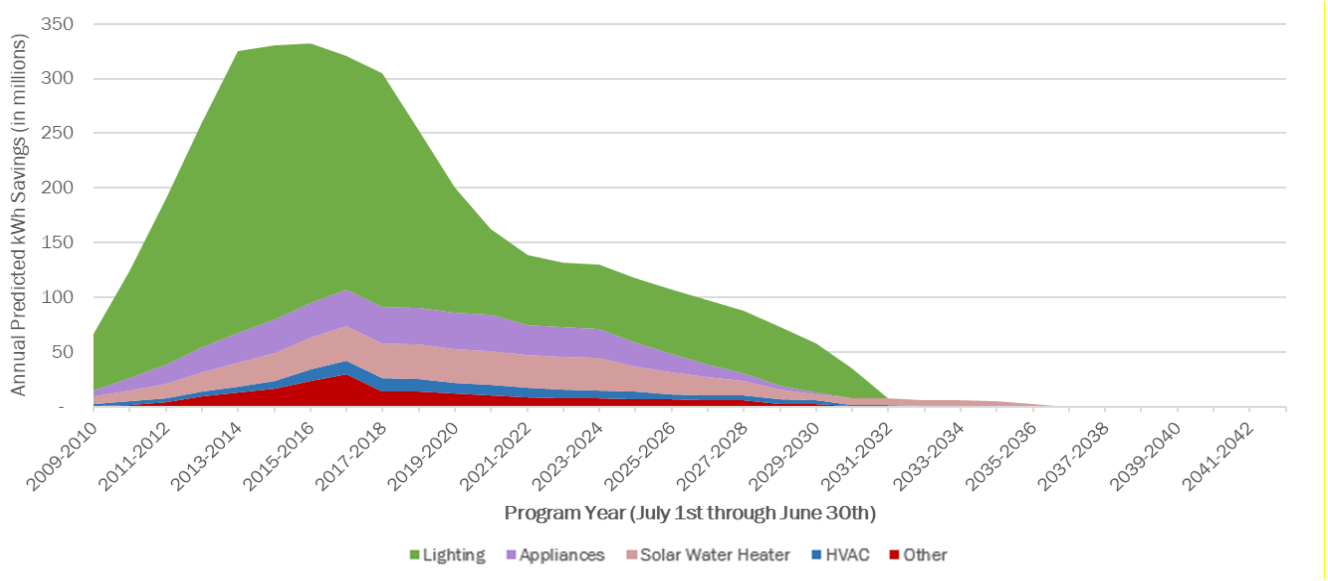


Figure 3-11. PY2009-2016 Lifecycle Net Tracked Savings by End Use: Business Sector

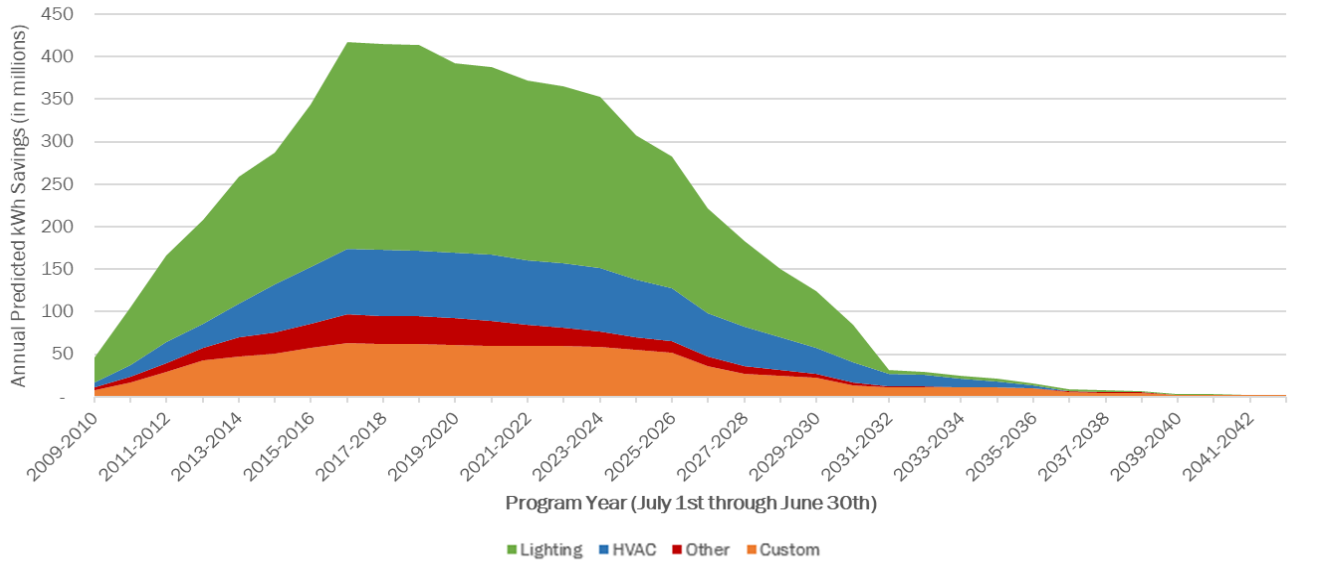


Figure 3-12. PY2009-2016 Lifecycle Net Tracked Savings by End Use: Residential and Business Sectors Combined

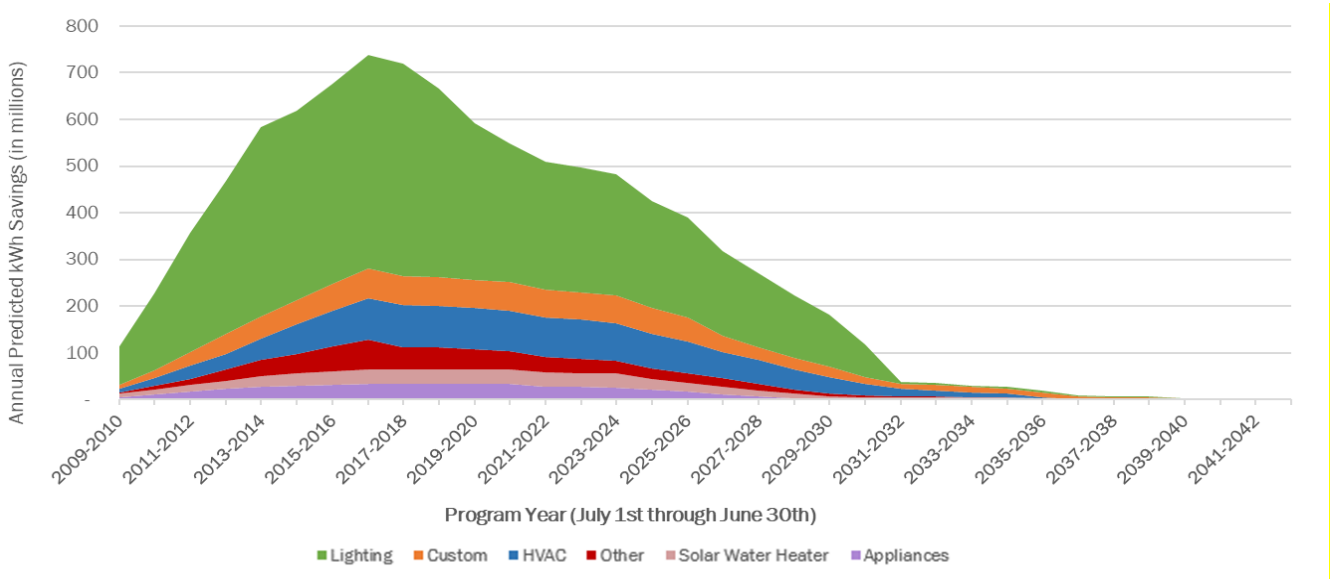
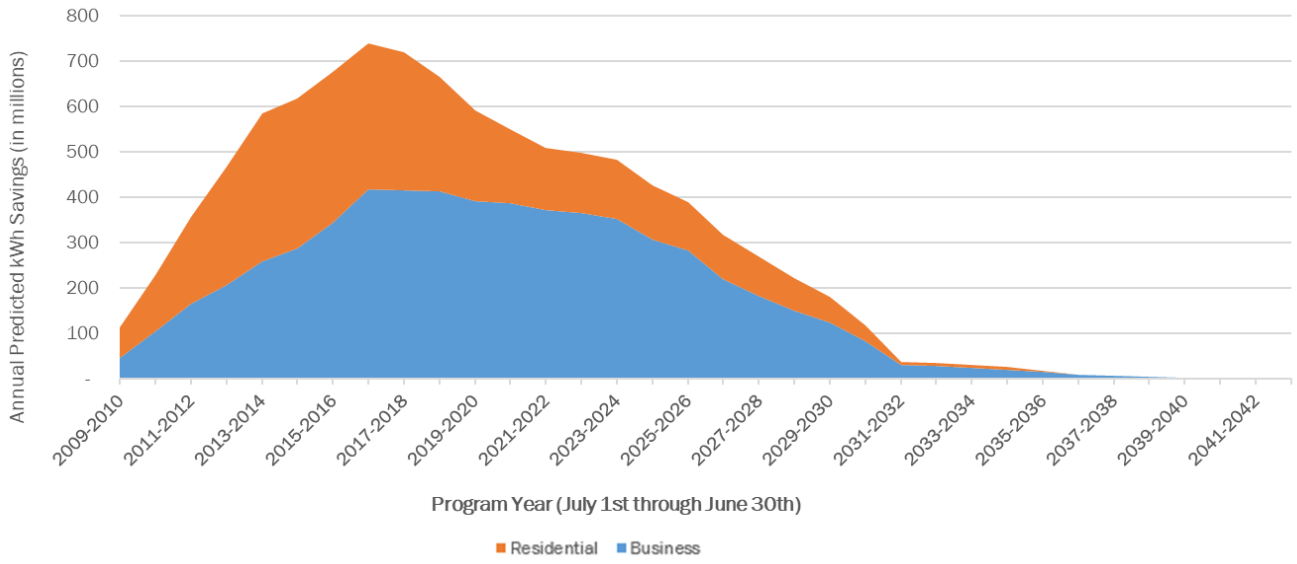


Figure 3-13 compares residential and Business Program lifecycle net tracked savings from PY2009 through PY2016. Both Residential and Business Programs make significant contributions to overall lifecycle net tracked savings, with Residential Programs providing more savings during the early years and Business Programs providing more savings in the later years. As previously discussed, this reflects the fact that Residential Program measures have significantly shorter effective useful lives (e.g., CFLs), on average, than do Business Program measures (e.g., HVAC and custom).

Figure 3-13. PY2009-2016 Lifecycle Net Tracked Savings By Sector



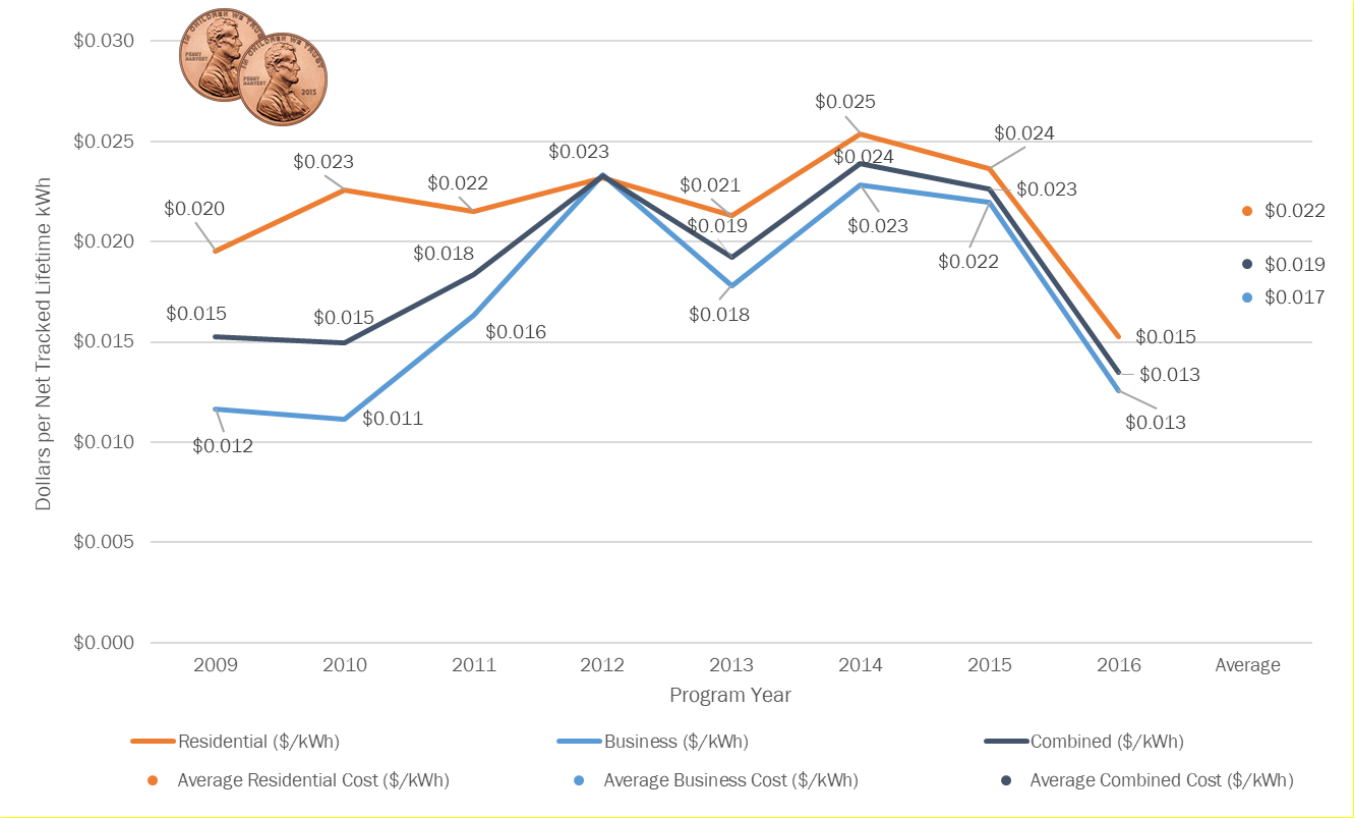
Cost of Lifecycle Net Savings

Figure 3-14 presents the per kWh cost of lifecycle net tracked savings by sector by program year and overall. The figure illustrates that the cost of an acquired kWh of savings from Business Programs over the eight years of program activity has averaged 1.7 cents per kWh while Residential Programs average 2.2 cents. This compares to average retail rates in October 2017 of 29.29 cents per kWh and 26.71 cents per kWh in the residential and commercial sectors, respectively.[30] Within Figure 3-14, there is a notable decline in the cost per kWh from PY2015 to PY2016. This is due to a significant decline in Hawaii Energy spending between PY2015 and PY2016 (from $30,207,679 to $23,677,446) but an increase in first-year net tracked savings (from 123,118,778 kWh to 140,480,148 kWh) over the same time period.

Figure 3-15 presents the per kWh cost of lifecycle net savings for the residential sector by end use. Because we present these costs at the end use level, the cost includes incentives only. Not surprisingly, lighting, appliances, and HVAC have the lowest per lifecycle kWh saved acquisition cost. Figure 3-16 presents the same data for the business sector. These data indicate that lighting, HVAC, and Custom have the lowest per lifecycle net kWh saved acquisition cost.

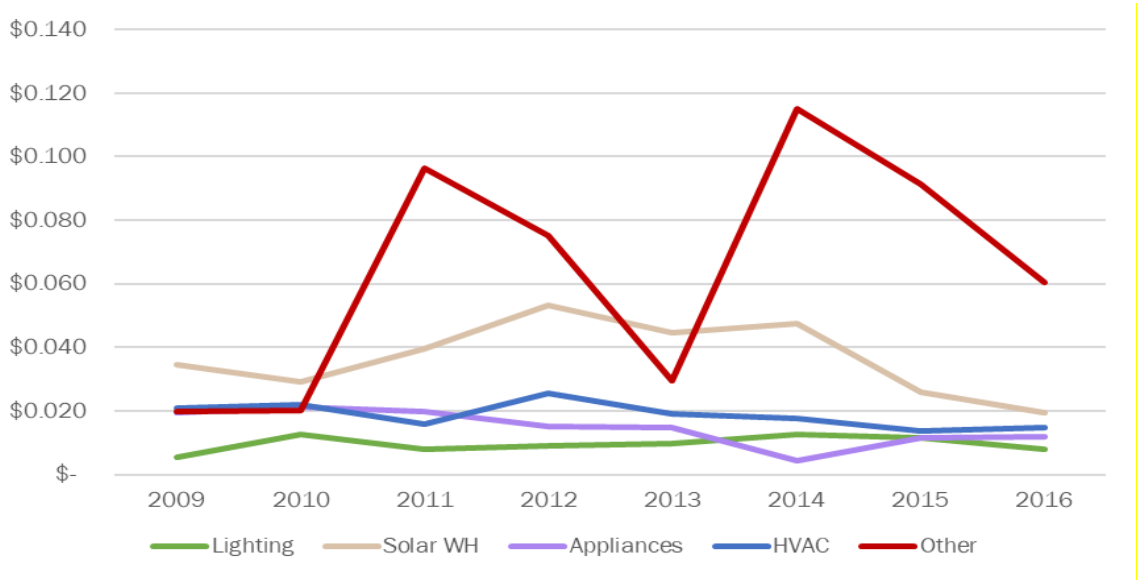
[30] U.S. Energy Information Administration. Electric Power Monthly (December 2017) https://www.eia.gov/electricity/monthly/

Figure 3-14. Hawaii Energy $/Net Tracked Lifecycle kWh Saved by Sector: PY2009-PY2016



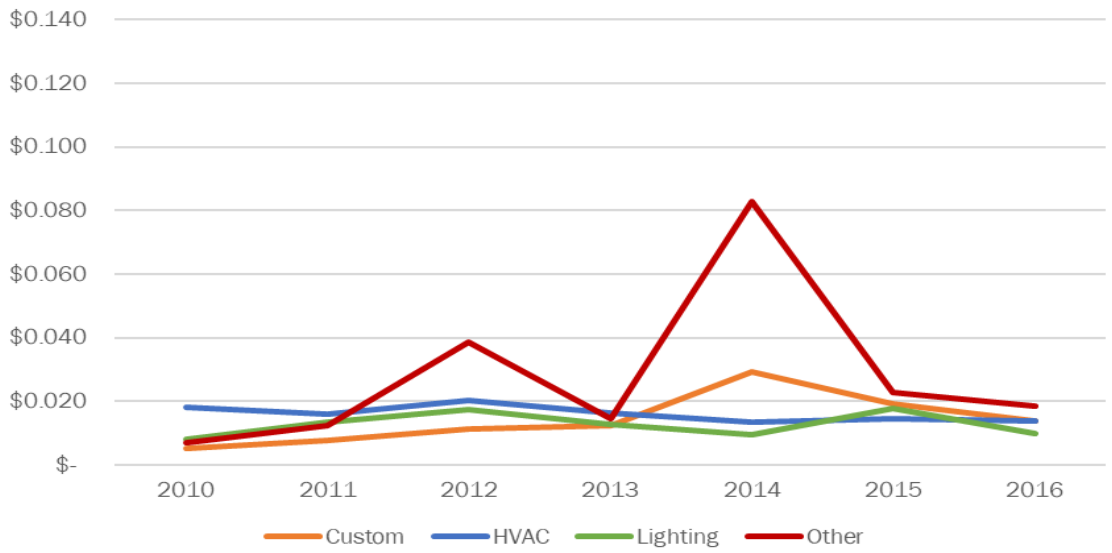
Note: Cost includes both incentives, and management and operations expenses.

Figure 3-15. Hawaii Energy $/Net Tracked Lifecycle kWh Saved by End Use: PY2009-PY2016, Residential Sector



Note: Cost includes incentives only.

Figure 3-16. Hawaii Energy $/Net Tracked Lifecycle kWh Saved by End Use: PY2009-PY2016, Business Sector



Note: Cost includes incentives only

4. Comprehensive Longitudinal Effects (CLE) Study

The goal of the CLE study was to quantify and describe the opportunities that remain for Hawaii Energy to achieve long-term energy savings. Toward this goal, the study focused on the savings realized through Hawaii Energy programs to date (through PY2015) as well as the potential for those programs—based on current program designs and savings assumptions—to claim additional energy savings through 2030. CLE was designed to leverage readily available secondary data, developed through program implementation and research primarily conducted by the previous EM&V team, to paint a picture of the accomplishments of the program to date, and produce a general estimate of the remaining energy efficiency potential. The entire CLE Study can be found in Appendix B[31].

The CLE study was based upon three primary sources of information: the 2012 baseline and potential studies, and cumulative net tracked energy savings reported by Hawaii Energy since program inception. Notably, the potential and baseline studies are now almost 6-years old and important markets (e.g., residential and commercial lighting—specifically the proliferation of LEDs) have changed more rapidly than expected. Furthermore, program accomplishments for each PY are based on numerous TRM inputs that have not been updated in many years. For example, an important adjustment to gross savings is a net-to-gross ratio (NTGR). The NTGR is an estimate of the percentage of savings claimed by Hawaii Energy that is determined to be induced/caused by the program (i.e., the savings would not have occurred naturally, in absence of the program). Over time, program NTGRs typically change as overall market conditions and associated program activity change, yielding changes in program "net" savings. As such, the NTGRs were last updated in PY2012 (and based upon NTGRs in other jurisdictions). Additionally, TRM specified gross savings values for key measures have been updated sporadically over time and may no longer be appropriate for current market conditions. Finally, the TRM stipulates the estimated useful life (EUL) for each measure and this information is used to compute measure savings over the life of the equipment (and important input to determining cumulative program savings). Similar to NTGR's and gross measure level savings values, recent research has not been completed to assess the credibility of TRM-stipulated EULs.

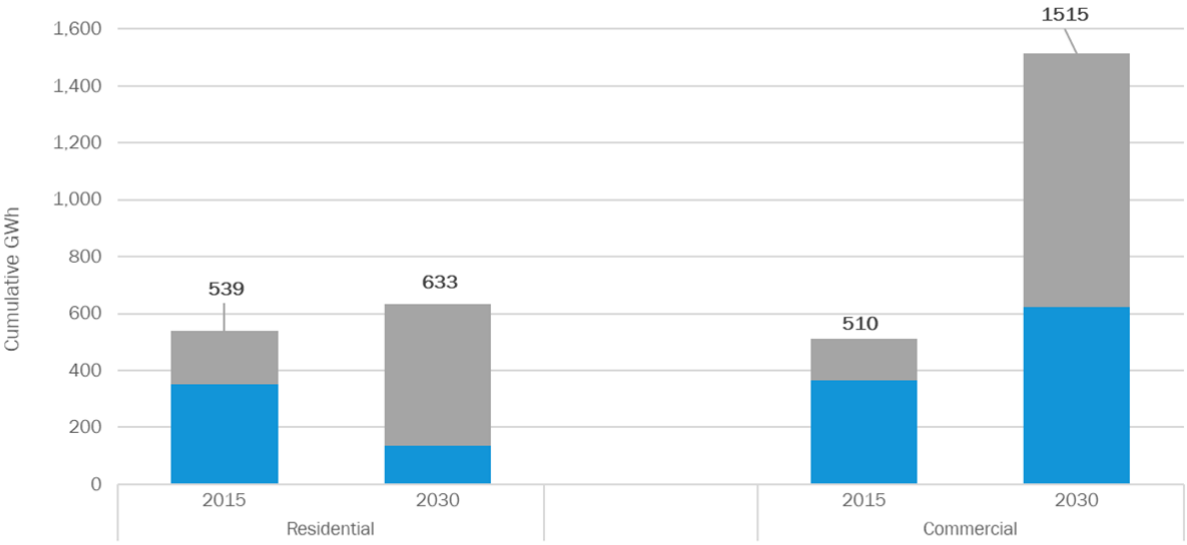
Based on net tracked savings through PY2015, Hawaii Energy program installations and market interventions from PY2009 through PY2015, on a cumulative basis, have reduced Hawaii's energy consumption by over 718 GWh, roughly split evenly between the residential (352 GWh) and commercial (366 GWh) sectors. Lighting is the dominate source of savings, comprising 71% and 55% of total cumulative savings in the residential and commercial sectors, respectively. However, future potential is more heavily reliant on the commercial sector and on non-lighting end uses. **Broadly speaking, to capture the remaining economic potential available to Hawaii Energy through 2030 (Remaining Available Economic Potential)—at the portfolio level—Hawaii Energy will need to 1) capture a higher proportion of savings from the commercial sector and 2) adapt program strategies to account for a lower proportion of savings from the lighting end use, especially in the residential sector.**

As illustrated in Figure 4-1, by 2030 the commercial sector will offer almost two and a half times the available economic potential as the residential sector (1,515 GWh vs 633 GWh). This is illustrated by the significant increase in the Total Available Potential between 2015 and 2030. If Hawaii Energy continues to operate programs at "business as usual" levels with respect to non-lighting end uses, commercial sector programs will capture 41% of the available economic potential by 2030 and will leave 892 GWh uncaptured, a savings

[31] Appendix B: Comprehensive Longitudinal Effects Study.

opportunity that exceeds the estimated total economic potential from the residential sector through 2030 (633 GWh).

Figure 4-1. Cumulative Available Economic Potential and PBFA Estimates, by Sector, 2015 and 2030



Remaining Available Economic Potential	187	498		143	892
Cumulative PBFA Estimates	352	135		366	623
Total Available Economic Potential	**539**	**633**		**510**	**1,515**
Captured Percentage	**65%**	**21%**		**72%**	**41%**

4.1 Residential Sector

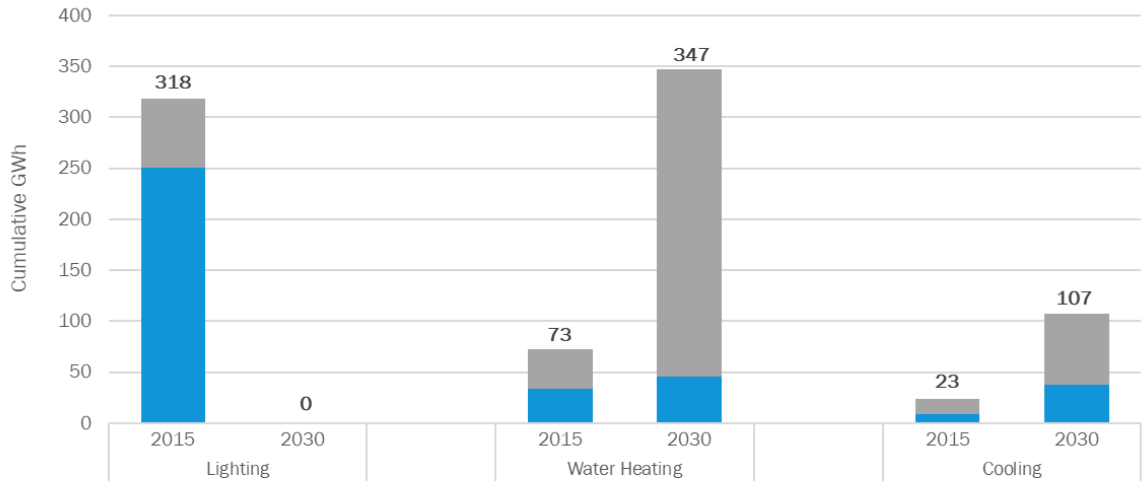
In the residential sector, the transition away from lighting is stark. By 2030, residential lighting—which in 2015 accounted for almost three-quarters of Hawaii Energy's cumulative residential sector savings—will be entirely realized by a combination of expected market driven savings, codes & standards savings, and prior (PY2009 through PY2015) program accomplishments. Our analysis indicates that this heavy reliance on lighting needs to taper off quickly due to the convergence of energy efficient lighting saturation levels reaching very high levels and significant changes within the LED market.

Simultaneously, the potential study suggests that achievable potential associated with residential water heating will grow significantly by 2030, especially when compared to projected program savings realized by "business as usual" levels of program activity (see Figure 4-2). Our review of current program data indicates that "business as usual" program savings from residential water heating will capture just 12% of the 347 GWh of Available Economic Potential forecasted for this end use through 2030. While the opportunity exists for significant savings from residential water heating in the future, acquiring these savings will require a shift in program strategies and expectations. Notably, the cost to achieve a kWh of lifetime savings in the residential sector has averaged approximately $0.01 per kWh since PY2009. This result is largely driven by the fact that most residential savings have been from lighting, which is extremely cost effective. In the future, as the

residential program pivots away from lighting and towards the residential water heating, and potentially other end uses, the cost of acquiring savings will increase perhaps three to four-fold (i.e., from around $0.01 per kWh to $0.03-$0.04 per kWh).

Figure 4-2 shows the residential Available Economic Potential and cumulative PBFA estimates for 2015 and 2030 for three key end uses. These end uses account for 77% of Available Economic Potential in 2015 and 72% of Available Economic Potential in 2030.

Figure 4-2. Cumulative Residential Available Economic Potential and PBFA Estimates, by End Use, 2015 and 2030



	Lighting 2015	Lighting 2030		Water Heating 2015	Water Heating 2030		Cooling 2015	Cooling 2030
Remaining Available Economic Potential	67	0		39	301		15	70
Cumulative PBFA Estimates	251	0		34	46		8	37
Total Available Economic Potential	**318**	**0**		**73**	**347**		**23**	**107**
Captured Percentage	**79%**	**N/A**		**47%**	**13%**		**36%**	**35%**

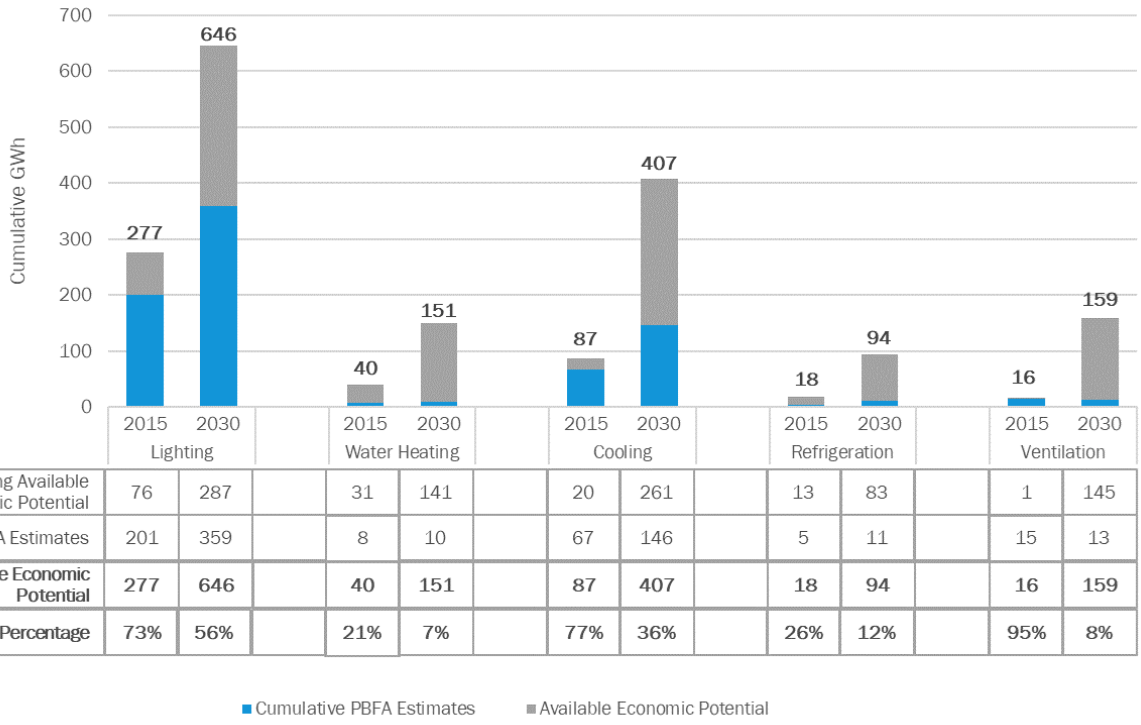
4.2 Commercial Sector

In the commercial sector, Hawaii Energy will need to rely on multiple end uses to capture the economic potential available by 2030. Due to similar market forces that are impacting the residential lighting market, our analysis indicates that the program's heavy reliance on lighting in the commercial sector also needs taper off somewhat by 2020, particularly with respect to screw-in LEDs.

Moving forward, the commercial lighting end use will still play an important role in the commercial sector, but due to growth in available potential (especially when compared to business as usual projections of PBFA savings), water heating, refrigeration, cooling, and ventilation will all need to become more prominent contributors to commercial savings.

Figure 4-3 shows the commercial Available Economic Potential and cumulative PBFA estimates for 2015 and 2030 for three key end uses. These end uses account for 86% of Available Economic Potential in 2015 and 96% of Available Economic Potential in 2030.

Figure 4-3. Cumulative Commercial Available Economic Potential and PBFA Estimates, by End Use, 2015 and 2030



	Lighting		Water Heating		Cooling		Refrigeration		Ventilation	
	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030
Remaining Available Economic Potential	76	287	31	141	20	261	13	83	1	145
Cumulative PBFA Estimates	201	359	8	10	67	146	5	11	15	13
Total Available Economic Potential	**277**	**646**	**40**	**151**	**87**	**407**	**18**	**94**	**16**	**159**
Captured Percentage	**73%**	**56%**	**21%**	**7%**	**77%**	**36%**	**26%**	**12%**	**95%**	**8%**

To capture the maximum amount of available potential through PY2030, the CLE study suggested that Hawaii Energy consider:

- Reducing the dependency on residential lighting measures (i.e., LEDs) as a major source of energy savings. The displacement of CFLs by LEDs, combined with the Energy Independence and Security Act (EISA) regulations, scheduled to take effect in 2020, suggest that the majority of products on retailer shelves by January 1, 2020 will be LEDs.
- Exploring residential water heating options as they represent the greatest remaining available potential for residential program savings through 2030 according to the most recent potential study.
- Continuing to pursue commercial lighting opportunities as they will continue to account for the largest share of Remaining Available Economic Potential through 2030 according to the most recent potential study.
- Increasing commercial cooling and ventilation activities from currently low levels of activity—and consider new measures and technologies and program designs.

- Looking for opportunities to improve the ability to help customers identify and execute custom projects as businesses seek to implement efficiency improvements beyond those most easily identified and implemented.
- Laying the foundation for upstream delivery models through the development of market intelligence of current and expected sales trends.
- Continuing contractor driven efforts for Hard to Reach commercial segments like restaurants and food service.

5. Other Areas of Inquiry

In addition to the savings verification process and completion of the CLE Study, the EM&V team provided a number of other important PY2016 deliverables. These include: 1) investigation of two program operational and oversight issues related to energy savings claims and rebate/incentive payment processes; and 2) a review of multiple updates—proposed by Hawaii Energy—to the PY2017 Technical Reference Manual (TRM). Key findings are provided in this section.

5.1 Overlap of Incented/Rebated Business Program Measures

Hawaii Energy offers a Midstream Program that includes point of purchase discounts to customers and trade allies on lighting measures purchased through participating distributors. Since the program is "midstream", it removes the implementation contractor (in this case, Hawaii Energy) from direct-to-user/customer rebate administration. Because many lighting measures meet the eligibility requirements of multiple business programs, the potential exists for customers to receive an incentive from more than one Hawaii Energy program for the same exact measure and, associated with this, that more than one program could claim savings for that measure. Thus, overlap could lead to both the double-payment of an incentive and the double-counting of savings. To provide insight into this issue, the EM&V team sought to understand the extent to which the same measure is eligible for rebate/incentive under both the Midstream Program and other business programs. Then, we sought to document the safeguards that Hawaii Energy has in place to prevent customers from receiving a rebate/incentive for the same (identical) measure from multiple programs. The detailed report pertaining to these issues can be found in Appendix C[32].

We identified three business programs [Prescriptive Program, Small Business Direct Install Lighting (SBDIL) program[33], Custom Business Energy Efficiency Measures (CBEEM) program] that provide incentives/rebates for lighting measures that are also eligible for Midstream Program incentives.

Mechanisms in Place to Prevent Double Paying/Counting

Our program review focused on the data gathered by relevant parties (e.g. distributors, contractors, and/or end use customers) at key steps in the delivery process and mechanisms that are in place to prevent double

[32] Appendix C: Overlap of Incented/Rebated Business Program Measures

[33] The SBDIL program is included within and primary source of savings within the overall Business Hard to Reach (BHTR) program.

counting of savings and double paying of rebates/incentives. We outline the relevant issues, by business program, below.

> ***Prescriptive Program and CBEEM.*** Both the Prescriptive Program and CBEEM require that all customers submit an invoice that includes the equipment procurement documentation with the application for incentive/rebate. Hawaii Energy staff review all invoices submitted through the both programs to ensure lighting measures were not, in fact, already incented through the Midstream Program.
>
> ***SBDIL.*** Unlike the Prescriptive Program, SBDIL invoices are 1) between the customer (e.g., small business participant) and a participating SBDIL contractor, and 2) Hawaii Energy does not require submission of the contractor's equipment procurement documentation for every project. Rather, per the contractor agreement with Hawaii Energy, contractors are required to submit their proof of purchase (invoice) documentation for lighting projects when they reach $25,000 in total projects completed or every quarter, whichever comes first.

There are no automated checks within the program tracking system for detecting overlap in lighting measures across the Midstream Program and other business sector programs. Thus, identifying cases of overlap relies on manual review of program records and the due diligence of Hawaii Energy staff.

The overriding goal of the investigation was to determine whether adequate safeguards are in place to eliminate the potential for a rebate/incentive to be paid—and for energy and demand savings to be claimed—for the same (identical) measure by more than one program. Our investigation found that both the Midstream Program (all lighting) and other business programs claim significant level of lighting-related savings. And, because of this, it seems reasonable to conclude that carefully and consistently validating/checking Prescriptive Program, CBEEM, and SBDIL application information for overlap with the Midstream Program (to determine the source/seller of lighting equipment) is essential.

At this time, Hawaii Energy appears to have a well thought out and executed set of manual procedures to enable due diligence review of data to ensure that double counting of savings and double paying does not take place. Two facts greatly enhance Hawaii Energy's ability to detect overlap between the Midstream Program and other business programs (including, but not limited to, CBEEM, Prescriptive, and SBDIL). First, participating distributors are required to provide all customer "ship to" names and addresses when requesting reimbursement from Hawaii Energy for discounts provided through the Midstream Program. Second, distributors are required to clearly note on their invoicing (to contractors/customers) that a Midstream Program discount/incentive has been provided[34]. Thus, Hawaii Energy staff can check invoices submitted through other business program applications for a notation indicating that a Midstream Program incentive was provided. In addition, Hawaii Energy staff can check distributor provided "ship to" information as another way of determining if a customer received a Midstream Program incentive.

Hawaii Energy notes that they do consistently perform checks (as part of all application/invoice reviews) to ensure that measures eligible for incentive under the Midstream Program do not receive incentives through other business program offerings. However, the EM&V team's recommendation is that the Hawaii Public Utilities Commission (PUC) require Hawaii Energy to establish a clear set of written procedures and workflows that must be followed when approving all business program incentives (including the Prescriptive Program, CBEEM, and SBDIL). This might be as simple as including a "checkbox" (signed by the Hawaii staff member

[34] This includes any shipments to contractors or customers that ultimately participate in SBDIL.

approving an application) attesting to the fact that cross-checks to other programs were made (including the associated equipment supplier) and the results of any follow-up process that ensued.

5.2 Small Business Direct Install Lighting (SBDIL) Custom Operating Hours Investigation

Hawaii Energy's Small Business Direct Install Lighting (SBDIL) Program covers the cost of lighting retrofits for small businesses and restaurants that have limited time and expertise to research lighting technology options, secure financing, and hire contractors to replace older, less efficient lighting technologies. The offering provides full energy-efficient lighting retrofits to restaurants and small businesses in Hawaii, Honolulu, and Maui counties at limited cost to the customer. Trade allies (e.g., lighting and electrical contractors) recruit customers, perform audits, and execute the associated retrofits.

Trade allies determine each SBDIL project's custom lighting operating hours on a space-by-space basis. For instance, a business with a shop floor and office space will have two different custom hours of use entries to represent each of the space types within that building. Hawaii Energy uses this approach because, executed properly, it allows for a better representation of overall lighting operating hours—and the associated energy use/savings—for a given building. However, allowing trade allies to determine lighting operation hours creates an opportunity for trade allies to overstate those hours—resulting in inflated savings estimates and higher incentive payments. To provide insight into this issue, the EM&V team compared the custom operating hours entered by trade allies to what those operating hours would have been if the program solely relied on values stipulated in the 2016 Hawaii Energy Technical Reference Manual (PY 2016 TRM). The detailed report pertaining to these issues can be found in Appendix D[35].

We sought to directly compare the trade ally entered custom operating hours to what the PY2016 would have suggested (by building type), as seen below in Table 5-1. Notably, the overall average custom hours, across all building types, are about 10 percent lower than what the TRM would suggest (4,002 average custom hours vs. 4,432 TRM hours). However, there are substantial variations within some building types. For instance, Health building type custom hours are on average 60% lower than the TRM hours, while Education and Grocery are more than 10% higher.

Table 5-1 Comparison of PY2016 SBDIL Custom Hours to TRM Hours by Building Type

Building Type	Number of Projects	Claimed kWh Savings	Weighted Average Custom Hours	Weighted Average TRM Hours	Percent Change from TRM
Education	77	200,608	2,987	2,582	16%
Grocery	488	799,711	6,353	5,722	11%
Health	151	176,794	2,508	6,293	-60%
Industrial	216	492,077	2,968	3,963	-25%
Misc. Commercial	429	698,813	2,842	4,235	-33%
Office	597	1,150,540	2,866	2,779	3%
Restaurant	920	2,373,779	4,617	5,221	-12%
Retail	1,089	2,081,050	3,884	4,147	-6%
TOTAL	**3,967**	**7,973,374**	**4,002**	**4,432**	**-10%**

[35] Appendix D: SBDIL Customer Hours Investigation Results

In addition to the direct comparison of hours, the Evaluation Team compared the program level energy savings obtained through application of both the custom and TRM hours methodologies[36], in Table 5-2 below. The discrepancy between the overall custom and TRM hours is more apparent within the comparison of estimated energy savings. Overall, Hawaii Energy's application of custom hours results in a 19% decrease in savings compared to what the savings would be if TRM hours were used.

Table 5-2. Comparison of PY2016 SBDIL Program Level Savings using Custom and TRM Sourced Hours

Building Type	Number of Projects	Program Level kWh Savings [Custom Hours]	Program Level kWh Savings [TRM Hours]	Percent Change from TRM
Education	77	200,608	183,107	10%
Grocery	488	799,711	802,849	0%
Health	151	176,794	448,187	-61%
Industrial	216	492,077	680,521	-28%
Misc. Commercial	429	698,813	1,079,180	-35%
Office	597	1,150,540	1,146,610	0%
Restaurant	920	2,373,779	2,705,699	-12%
Retail	1,089	2,081,050	2,804,548	-26%
TOTAL	**3,967**	**7,973,374**	**9,850,699**	**-19%**

As a precursor to our analysis, a number of meetings were held with Hawaii Energy staff. The purpose of the meetings was to understand the administrative procedures in place to ensure the integrity of the lighting operating hours entered by trade allies. Through this process, we learned that Hawaii Energy staff review the submitted lighting operating hours for all SBDIL projects. Furthermore, projects resulting in incentive payments of $3,000 or greater are required to have an on-site inspection by Hawaii Energy staff—which includes a review of all entered operating hours for all space types[37]. Our analysis found that about 50% of all SBDIL projects were inspected in PY2016. These inspected projects accounted for approximately 75% of SBDIL incentive payments and 73% of SBDIL energy savings[38].

In general, the site specific custom hours entered (by trade allies) for SBDIL result in overall program savings that are approximately 19% lower than what the savings would be if TRM stipulated values were used. This suggests that trade allies are likely to be entering hours estimates correctly—providing a more accurate representation of savings than using the TRM hours of use. We base this determination largely on the significant amount of inspection activity that is currently taking place and Hawaii Energy staff's description of the inspection process. Since we did not complete inspections ourselves, we rely on staff's representations regarding inspection procedures and quality.

Looking forward, the Evaluation Team offered the following considerations:

- **Develop Consistent Building Type Nomenclature:** Space types assigned to each project in the program tracking data are not always consistent with the TRM building types. Additionally, the nomenclature for space types within Hawaii Energy's program tracking data sources is not consistent (e.g., we found

[36] kWh savings for TRM hours are calculated by applying a ratio of custom hours to TRM hours to the tracked energy savings for each building type.

[37] Hawaii Energy is currently in the process of automating this process with a tablet-based field tool to enter inspection data.

[38] Hawaii Energy staff indicated that the number of PY2016 SBDIL projects that required revisions to contractor estimated operating hours following an inspection by Hawaii Energy was minimal.

instances where the same project is labeled as two different space types between the project data and the equipment data). It would be useful for all parties (i.e., the EEM, PUC, and Opinion Dynamics) to assess the importance, cost, and associated effort around updating TRM building types and using the established nomenclature in the Hawaii Energy program tracking system.

- **Update TRM Operating Hours by Building Type**: Associated with the prior point, the operating hours connected to the various TRM building types appear to be out-of-date and, perhaps, not applicable to Hawaii. Building type hours in the PY2016 are based on California, not Hawaii. It would be useful for all parties (i.e., the EEM, PUC, and Opinion Dynamics) to assess the importance, cost, and associated effort around updating the operating hours associated with each TRM building type. This activity would be connected to updating the building type nomenclature (see previous bullet).

- **Continue to implement the custom estimation of operating hours for both SBDIL and CBEEM.** The TRM should be updated to reflect the fact that a custom approach should be used for both programs (including the associated checks and balances required).

5.3 Review of Proposed Updates to PY2017 TRM

Hawaii Energy maintains a Technical Reference Manual (TRM) for the Hawaii Energy Conservation and Efficiency Program (Hawaii Energy). The TRM provides methods, formulas and default assumptions for estimating energy and peak demand impacts from energy efficient measures and projects offered by Hawaii Energy. In addition, the TRM includes default net-to-gross (NTG), system loss factors (SLF) and effective useful life (EUL) assumptions for the programs and measures offered by Hawaii Energy. Since the inception of Hawaii Energy in program year (PY) 2009, Hawaii Energy has proposed updates to the TRM and those updates have been reviewed by the Evaluation Team in place at the time.[39] Regular updates and maintenance of TRMs is necessary for several reasons, including but not limited to:

- Staying current with changes to Hawaii Energy programs (e.g. measures offered, added, and/or removed; changes to program design; target participants; change in market).
- Incorporating findings from more recent studies, reports, primary data collection, or any other creditable source to inform dated variable assumptions and parameters.
- Staying current with changes in federal efficiency standards, local building codes, engineering standards (e.g., ASHRAE), and energy efficiency guidelines (e.g., ENERGY STAR).
- Addressing corrections and/or clarification to inputs or algorithms.

The TRM review found multiple differences between the PY2015 and PY2016 TRMs. These include differences between deemed savings assumptions or effective useful life (EUL) assumptions at the measure level and missing sections in the PY2016 TRM that previously appeared in the PY2015 TRM. Some of these differences were substantial and indicate some potential issues with document updating, control and approval processes. The report detailing this TRM review can be found in Appendix G[40].

[39] Hawaii Energy proposed updates that were reviewed by the Evaluation Team in place at the time for the following years: PY2011, PY2012, PY2014, PY2015, and PY2016. Opinion Dynamics has been the lead evaluator since PY2015.

[40] Appendix G: Review of Proposed Updates to PY2017 TRM.

Hawaii Energy proposed 25 updates based on the PY2016 version of the Hawaii TRM. These updates (if incorporated) would be included in a new PY2017 TRM.[41] Opinion Dynamics reviewed the 25 proposed updates and collapsed the updates by measure, resulting in 16 unique measure updates. Additionally, Hawaii Energy postponed two proposed updates, leaving a total of 14 unique measures receiving updates for the PY2017 TRM. These updates spanned from relatively minor residential measures such as faucet aerators and showerheads to commercial measures such as chillers and retro-commissioning. Of the 14 proposed updates, we recommend accepting the proposed change to six, and revising the proposed change for eight. With the exception of residential LEDs and CFLs, the impact of the adjustments to individual measures have a minor impact on overall portfolio energy savings—a change to chillers and conversation AC calculations impact just 3.56% of portfolio savings and all other measures combined impact 1.25% of portfolio savings.

A more complete assessment of updates to the residential LED measure—which currently represents 22.56% of overall portfolio savings—is the subject of ongoing discussions between the EEM Team, Hawaii Energy, and Opinion Dynamics. Decisions and recommendations from that process are likely to be finalized in the spring of 2018.

6. Key Findings and Implications of PY2016 EM&V Activities

This PY2016 Annual EM&V Report highlights the findings and outcomes of multiple PY2016 EM&V activities. In addition to providing the results of efforts to verify program energy and demand savings, key PY2016 activities included the provision of 1) a longitudinal analysis of program accomplishments to date and assessment of future energy savings opportunities—referred to as the CLE Study; 2) investigations of two program operational and oversight issues related to energy savings claims and rebate/incentive payment processes; and 3) a review of multiple updates—proposed by Hawaii Energy—to the PY2017 Technical Reference Manual (TRM). Together, these activities provide a number of important insights—or takeaways—impacting both program direction and future areas of research. We outline the findings and implications in this final section, attempting to delineate them by major subject area.

Savings Verification Process

Finding: Hawaii Energy claimed overall PY2016 portfolio energy savings of 140,816,393 kWh and the EM&V verified savings of 140,480,148 kWh—an overall verification rate of 99.8%. This verification rate is an important indicator of the accuracy of Hawaii Energy's efforts to track measure installations (and incentives paid) and apply deemed savings values and associated adjustments. The 99.8% verification rate indicates that Hawaii Energy is carefully and accurately tracking program outcomes. However, the verification process did not involve primary research to verify measure installation and appropriate operation, or an assessment of the validity of measure level gross savings values or the adjustments to them (e.g., net-to-gross ratios, system loss factors, etc.) as stipulated in the PY2016 TRM. Notably, NTGRs stipulated in the PY2016 TRM were last updated in PY2012, making use of secondary data in so doing. Additionally, TRM specified gross savings values and the estimated useful life (EUL) for key measures have been updated sporadically over time and may no longer be appropriate for current market conditions.

[41] PY2017 runs from July 1, 2017 through June 30, 2018

Implication: TRM gross savings values and other adjustments have not been holistically reviewed for a number of years. Gross savings values, NTGRs, system loss factors, and effective useful measure lives should be systematically reviewed and adjusted. Some adjustments (e.g., gross saving values, effective useful lives) may be able to rely on secondary information, but others (e.g., NTGRs, system loss factors) will require Hawaii-based primary research.

Comprehensive Longitudinal Effects (CLE) Study

Finding: Based on program claimed savings through PY2015, Hawaii Energy program installations and market interventions from PY2009 through PY2015, on a cumulative basis, have reduced Hawaii's energy consumption by over 718 GWh, roughly split evenly between the residential (352 GWh) and commercial (366 GWh) sectors. The 2012 potential study indicates that, by 2030, the commercial sector will account for almost two and a half times the available economic potential from the residential sector (1,515 GWh vs 633 GWh).

Implication: Broadly speaking, to capture the remaining economic potential available to Hawaii Energy through 2030 (Remaining Available Economic Potential) as documented in the 2012 potential study—at the portfolio level—Hawaii Energy will need to capture a higher proportion of savings from the commercial sector.

Finding: Lighting has dominated Hawaii Energy's residential portfolio, comprising 71% of total cumulative savings in the residential sector. The displacement of CFLs by LEDs, combined with the Energy Independence and Security Act (EISA) regulations scheduled to take effect in 2020, suggest that the effective market baseline for screw-based residential lighting will be LEDs, suggesting that residential lighting will no longer provide a cost-effective source of energy savings.

Implication: Hawaii Energy will need to reduce the dependency on residential lighting measures (i.e., LEDs) as a major source of energy savings over the next two program years. Improvements in residential water heating efficiency represent the greatest remaining available potential for residential program savings through 2030. Hawaii Energy should carefully assess residential water heating efficiency options and expand overall activity for this important end use.

Finding: Lighting comprises 55% of cumulative energy savings in the commercial sector. Due to similar market forces that are impacting the residential lighting market, the market for screw-in bulbs appears to be transforming toward LEDs more rapidly than expected.

Implication: Lighting will continue to play an important role in the commercial sector. However, the commercial program's heavy reliance on lighting will need to taper off somewhat by 2020, particularly with respect to screw-in LEDs. Due to growth in available potential, water heating, refrigeration, cooling, and ventilation will all need to become more prominent contributors to commercial savings.

Implication: The Midstream Lighting Program is a significant contributor to overall savings in the commercial sector. Since LEDs make up the majority of Midstream savings, research is needed to better understand the commercial LED market and inform an associated net-to-gross ratio (i.e., an estimate of the extent to which LED savings in the commercial sector would not take place in the absence of the Midstream Program).

Finding: The CLE Study was based upon three primary sources of information: 2012 baseline and potential studies, and net tracked energy savings from program inception. Notably, the potential and baseline studies are now almost 6-years old and important markets (e.g., residential and commercial lighting—specifically the proliferation of LEDs) have changed more rapidly than expected. And, as discussed above under the "Savings Verification Process", program accomplishments (verified net kWh savings) for each PY are based on numerous TRM inputs that have not been updated in many years.

Implication: To inform future program planning, consideration should be given to the need for updated baseline and potential studies. Such studies will not only inform program savings estimates and key TRM inputs but also, and perhaps more importantly, assist program planners in identifying future savings opportunities. Given the rapid deployment of lighting technologies, particularly LEDs, it would appear to be particularly valuable to ensure any baseline or potential study explore niche opportunities to promote lighting (and other) technologies. Technologies within the residences of residential low-income and hard to reach customers, for example, may be quite different than other households. Similarly, within the commercial sector, there may be opportunities to serve small businesses and other entities that have—traditionally—been less likely to participate in programs and, therefore, have higher needs for energy efficiency improvements. Given the vintage of the last baselines study, the significant changes in key end-use markets since that time, the widespread deployment of renewable energy, and the unique characteristics of the customer based, we strongly recommend a rigorous, primary data driven approach should the commission decide to move forward with a potential study.

Program Operation and Oversight

Finding: Many business lighting measures meet the eligibility requirements of multiple business programs and, therefore, the potential exists for customers to receive an incentive from more than one Hawaii Energy program for the same exact measure and, associated with this, that more than one program could claim savings for that measure. Thus, overlap could lead to both the double-payment of an incentive and the double-counting of savings. Our investigation found no evidence of overlap. Additionally, we found that Hawaii Energy appears to have a well thought out and executed set of manual procedures to enable due diligence review of data to ensure that double counting of savings and double paying does not take place

Implication: Carefully and consistently validating/checking Prescriptive Program, CBEEM, and SBDIL application information for overlap with the Midstream Program (to determine the source/seller of lighting equipment) is essential. Hawaii Energy notes that they do carefully and consistently perform these checks. However, the EM&V team recommends that the PUC require Hawaii Energy to establish a clear set of written procedures and workflows that must be followed when approving all business program incentives (including the Prescriptive Program, CBEEM, and SBDIL).

Finding: Allowing trade allies to determine lighting operation hours as part of the Small Business Direct Install Lighting (SBDIL) Program creates an opportunity for trade allies to overstate those hours—potentially resulting in inflated savings estimates and higher incentive payments. The EM&V team found that the site specific custom hours entered (by trade allies) for SBDIL result in overall program savings that are approximately 19% lower than what the savings would be if TRM stipulated values were used. Notably, Hawaii Energy staff review the submitted lighting operating hours for all SBDIL projects. Furthermore, projects resulting in incentive payments of $3,000 or greater are required to have an on-site inspection by Hawaii Energy staff—which includes a review of all entered operating hours for all space types. Our analysis found that about 50% of all

SBDIL projects were inspected in PY2016. These inspected projects accounted for approximately 75% of SBDIL incentive payments and 73% of SBDIL energy savings.

Implication: The findings suggest that trade allies are likely entering hours estimates correctly—providing a more accurate representation of savings than using the TRM hours of use. Additional confidence in the accuracy of trade ally entered hours stems from a very high level of inspection.

Review of Proposed Updates to PY2017 TRM

Finding: The TRM review found multiple differences between the PY2015 and PY2016 TRMs. These include differences between deemed savings assumptions or effective useful life (EUL) assumptions at the measure level and missing sections in the PY2016 TRM that previously appeared in the PY2015 TRM. Some of these differences were substantial.

Implication: Differences between the PY2015 and PY2016 TRMs indicate some potential issues with document updating, control and approval processes—suggesting a need for a TRM guidance document that specifies document control procedures as well as the cadence for updates to the TRM, stakeholders that should be included in a review and update process, and the overall timeline and process that should be followed.

Finding: Hawaii Energy proposed 25 updates based on the PY2016 version of the Hawaii TRM. These updates (if incorporated) would be included in a new PY2017 TRM.[42] Opinion Dynamics reviewed the 25 proposed updates and collapsed the updates by measure, resulting in 16 unique measure updates. Additionally, Hawaii Energy postponed two proposed updates, leaving a total of 14 unique measures receiving updates for the PY2017 TRM. These updates spanned from relatively minor residential measures such as faucet aerators and showerheads to commercial measures such as chillers and retro-commissioning. Of the 14 proposed updates, we recommend accepting the proposed change to six, and revising the proposed change for eight.

Implication: With the exception of residential LEDs and CFLs, the impact of the adjustments to individual measures have a minor impact on overall portfolio energy savings—a change to chillers and conversation AC calculations pertain to just 3.56% of portfolio savings and all other measures combined pertain to 1.25% of portfolio savings.

Finding: The residential LED and CFL measures currently account for 22.56% of overall portfolio savings. At this point, all parties (Hawaii Energy, EEM, Opinion Dynamic) agree that changes are needed to LED and CFL savings calculations (gross, NTG, etc.).

Implication: A more complete assessment of the residential LED measure is the subject of ongoing discussions between the EEM Team, Hawaii Energy, and Opinion Dynamics. Decisions and recommendations from that process are likely to be finalized in the spring of 2018ith the savings.

[42] PY2017 runs from July 1, 2017 through June 30, 2018

Additional Considerations

There are a number of additional issues that warrant future consideration. We list them below.

Importance of Underserved Segments: Underserved segments will continue to be an important component of future program offerings and may warrant particular attention in future baseline and potential studies. Hawaii Energy current serves both residential and commercial underserved segments with a variety of initiatives. Maintaining, and possibly expanding, these initiatives will ensure the underserved populations realize the energy efficiency benefits associated with PBFA participation.

Future cost of Energy Efficiency: As highlighted in this report, lighting has been the dominant source of energy savings over the first eight years of Hawaii Energy (PY2009-PY2016). This heavy focus on efficient lighting, and particular emphasis on screw-based CFLs and LEDs, has driven the cost-effectiveness of the Hawaii Energy portfolio. As Hawaii Energy begins to move away from important lighting markets (e.g., LEDs), it will be important to recognize that future energy savings (that will be more focused on non-lighting end-uses) will likely come at a higher cost per lifecycle kWh saved.

Baseline and Net-to-Gross Framework: Currently, there is no established framework for the cadence and methods to be use when researching baseline and net-to-gross issues. Consideration should be given to the establishment of a framework that can be applied across various program designs and delivery models.

Market Transformation Goals: Market transformation refers to meaningful changes in the structure or functioning of energy efficiency markets that are substantial and long lasting[43]. As a general rule, if market transformation has occurred, then the barriers to adoption of energy efficient equipment have been reduced to the point where a given program no longer needs to intervene to increase adoption[44]. While Hawaii Energy has a number of market transformation initiatives, no formal guidance document exists regarding how transformation will be measured and how any resulting credit will be tracked and reported.

100% Renewables Goal: Consideration may need to be given to other possible contributors to the 100% renewables goal established by the PUC. Transmission and distribution systems can be strained in key locations and times of the day. Distributed energy resources and various technologies, in addition to energy efficiency improvements, may need to be considered when determining how to address such issues—toward the goal of meeting the 100% renewables goal.

[43] In California, D Decision (D.)09-09-047 defines market transformation as "long-lasting, sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate in that specific market."

[44] PY2013-2014 California Statewide Residential and Nonresidential Spillover Study. Prepared by Opinion Dynamics and Itron for the California Public Utilities Commission Energy Division. December 2017. Page 13.