

Memorandum

PY2016 Verification Report - Final

To: Steven Schiller, Energy Efficiency Manager (EEM)

From: Opinion Dynamics

Date: January 18, 2018

Re: Verification of Hawaii Energy Program Year 2016 Programs

1. Introduction and Background

Opinion Dynamics has been engaged by the State of Hawaii Public Utilities Commission (PUC) to conduct a comprehensive multi-year evaluation of the Hawaii Energy Conservation and Efficiency Program (Hawaii Energy¹). Every program year (PY) since the inception of Hawaii Energy in 2009, the PUC has commissioned an effort to verify program energy (kWh) and demand (kW) savings as claimed and published in the Hawaii Energy Annual Report.²

The purpose of this memorandum is to document the results of a multi-step verification process, completed by Opinion Dynamics, to verify that Hawaii Energy properly tracked and reported key program outcomes for PY2016, which ran from July 1, 2016 through June 30, 2017. 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 Manual³ (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, indicates that Opinion Dynamics estimated overall portfolio savings for the given program year at the exact level claimed by the program. A verification rate of 100% essentially means that, overall⁴, Hawaii Energy is properly tracking (through the program database) and reporting program outcomes and applying the correct savings values and associated program adjustments as stipulated in the TRM.

The verification effort (and the overall verification rate) is an important indicator of the accuracy of Hawaii Energy’s tracking effort in terms of properly tracking measure installations (and incentives paid) and applying

¹ Hawaii Energy is a ratepayer-funded conservation and efficiency program administered by Leidos Engineering, LLC under contract with the Hawaii Public Utilities Commission as the Public Benefits Fee Administrator (PBFA) serving the islands of Hawaii, Lanai, Maui, Molokai, and Oahu. On July 1, 2009, Hawaii Energy took over management of the demand side management programs from Hawaiian Electric Company (HECO) and its subsidiaries, Maui Electric Company (MECO) and Hawaii Electric Light Company (HELCO), referred to as the HECO utilities. Program Year 2016 ran between July 1, 2016 and June 30, 2017.

² PY2016 Hawaii Energy Annual Report. Leidos Engineering, LLC, Hawaii Energy.

³ 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.

⁴ We use the term “overall” because it is possible that verification efforts could increase the savings for some measures and decrease savings for other measures, thus increases in savings in one area could be offset by decreases in another—resulting in an overall 100% verification rate. Historically, adjustments to claimed savings (either up or down) have tended to be relatively small.

pre-agreed upon savings values and associated adjustments. **It is important to note, however, that this verification process does 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.

In addition to verified savings (kWh and kW), we calculated the Total Resource Benefits⁵ (TRB) achieved and the extent to which Hawaii Energy funds were equitably distributed across Islands (i.e., Island Equity). Ultimately, all three of these important outcomes (i.e., program savings, TRB, Island Equity) as well as the extent to which other related program goals were met⁶ become the key inputs to determining the performance award earned by the Hawaii Energy Public Benefits Fund Administrator (PBFA)—Leidos Engineering, LLC. Verification of the performance award earned by Leidos is an important outcome of this verification process.

As previously stated, 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 with the database are referred to “tracked” savings. We provide detailed definitions of the various savings terms referenced in this report in Table 1-1.

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.⁷ Table 1-1 provides definitions of these terms.

⁵ TRB accounts for utility avoided costs per reduced kWh and kW at the individual measure level over the lifetime of each measure. Utility avoided costs, the associated discount rate, and the lifetime (EUL) of each measure come from the Hawaii TRM.

⁶ An additional factor in the overall performance award is the verification that Hawaii Energy executed all contractually agreed upon Market Transformation and Customer Satisfaction activities. In PY2016, verification of these activities was not part of the verification scope, and a 100% verification rate was applied to the claimed values from the Hawaii Energy Annual Report for all Market Transformation activities.

⁷ Claimed savings are those savings reported, in aggregate fashion, within the Hawaii Energy Annual Report.

Table 1-1. 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).

The remainder of this memorandum is organized as follows:

- Section 2 Summary of Findings: Provides a summary of program year 2016 claimed, tracked, and verified savings and the associated performance award.
- Section 3 Verification Methods and Results: Presents an overview of verification methods and results by sector and program.
- Section 4 Business Sector Detailed Verification Method and Results: Provides additional verification details further breaking down program results by measure.
- Section 5 Residential Sector Detailed Verification Method and Results: Provides additional verification details further breaking down program results by measure.

This memo also contains additional detail on verification activities in several appendixes, including:

- Appendix A: Business Sector Detailed Verification Savings Adjustments
- Appendix B: Business Sector Total Resource Benefits
- Appendix C: Residential Sector Detailed Verification Savings Adjustments
- Appendix D: Residential Sector Total Resource Benefits
- Appendix E: Differences Between PY2015 and PY2016 Hawaii TRM

■ Appendix F: Glossary of Terms

2. Summary of Findings

Table 2-1 and Table 2-2 present the overall savings results of our verification efforts. The results of the TRB verification, and island equity calculation are shown in Table 2-3. Notably, Table 2-1 includes first-year net tracked and verified savings. As described above, we do not provide first-year net claimed savings as we found net tracked savings to be identical to claimed savings for PY2016 and we therefore maintain the tracked savings term throughout to allow for a more granular comparison of savings at the measure level. Table 2-2 includes lifecycle tracked and verified net energy savings. Overall, Opinion Dynamics verified that the PBFA reached 99.8% of first-year energy savings claimed in the PY2016 Hawaii Energy Annual Report. We verified 98.7% of the Business sector first-year energy savings and 101.4% of the Residential sector first-year energy savings. The slight reduction in verified business savings is mainly driven by the verified CBEEM Program savings⁸, while the slight increase in verified residential savings is due to the verified Peer Comparison Program results⁹. Table 2-1 shows the verified first-year net energy and demand savings by sector, compared to the PBFA’s tracked savings.

Table 2-1. PY2016 Tracked and Verified First-Year Net Energy and Demand Savings by Sector

Sector	Tracked First-Year Net Savings		Verified First-Year Net Savings		Verified Savings as % of Tracked Savings		Verified Savings as % of Total Verified Savings	
	MWh	MW	MWh	MW	MWh	MW	MWh	MW
Business	85,272	10.5	84,146	10.2	98.7%	97.1%	59.9%	47.1%
Residential	55,544	8.1	56,334	11.5	101.4%	142.6%	40.1%	52.9%
Portfolio	140,816	18.6	140,480	21.7	99.8%	116.9%	100.0%	100.0%

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

Table 2-2 shows the verified lifecycle net energy savings by sector, compared to the PBFA’s tracked savings.

⁸ The verification resulted in a verification rate of 95.9% for the CBEEM Program which brought down the verified savings for the overall business sector. This reduction was primarily driven by one large project, that upon review of the utility bills and discussions with the site contact through Hawaii Energy, is not achieving the planned energy savings due to inefficiencies in the plant design. We describe this in more detail in Appendix A.

⁹ The verification resulted in a verification rate of 105.9% for the Peer Comparison Program which drove up the overall REEM Program verification rate to 101.5%, and the overall residential sector verification rate to 101.4%. This discrepancy is due to differences in methodology between Hawaii Energy and Opinion Dynamics in how we allocate deemed savings per participant and how the number of participants are identified. Opinion Dynamics allocates savings based on the specific day that a participant enters and leaves the program, whereas Hawaii Energy allocates savings based on the month that a participant enters and leaves the program. Because the Peer Comparison Program accounts for approximately 27% of the claimed residential sector energy savings, this difference in Peer savings methodology was enough to drive the overall residential verification rate to 101.4%.

Table 2-2. PY2016 Tracked and Verified Lifetime Net Energy Savings by Sector

Sector	Tracked Lifecycle Net Savings (MWh)	Verified Lifecycle Net Savings (MWh)	Verified Savings as % of Tracked Savings	Verified Savings as % of Total Verified Savings
Business	1,188,857	1,149,984	96.7%	67.4%
Residential	569,845	557,456	97.8%	32.6%
Portfolio	1,758,702	1,707,440	97.1%	100.0%

About 60% of overall portfolio level verified first-year net energy savings is achieved through Business Programs. The business programs also garner higher lifecycle net savings than the residential programs because measures installed in these programs, on average, remain in place and operating for a longer period of time (i.e., they have a higher Effective Useful Life or EUL). The overall savings weighted EUL across all measures within each sector is 13.7 years for the business sector and 9.9 for the residential sector. As described above, our verification effort was limited to ensuring Hawaii Energy applied the correct EUL as stipulated in the TRM, but did not include review of the EULs themselves for accuracy¹⁰.

The PUC sets performance goals and incentives for Hawaii Energy each program year and this verification effort includes an assessment (check) of the performance award claimed by Hawaii Energy in their Annual Report. Table 2-3 illustrates the various performance indicators used to determine the total performance award payable to Hawaii Energy. For Energy, Demand, and Total Resource Benefit (TRB), the PUC establishes “minimum” and “target” values contractually with Hawaii Energy¹¹. The minimum threshold must be met to earn an award and the maximum award is paid if the target threshold is achieved. For example, the first-year energy reduction minimum threshold is 103,146,054 kWh and the target is 137,528,072. The maximum award available is \$145,073 according to the PY2016 Hawaii Energy Annual Report. Notably, for this performance indicator, Hawaii Energy claimed savings of 140,816,393 exceeding the target value and, as such, claimed the entire \$145,073 award. If Hawaii Energy had not met the target, the award amount would have been prorated based on the percentage of savings between the minimum and target value that was achieved. The final four columns of the Table 2-3 illustrate the award results as verified by Opinion Dynamics. With respect to the first-year energy reduction performance indicator, we verified 140,480,148 kWh of first-year energy savings which also exceeds the target threshold of 137,528,072. Thus, we confirmed that Hawaii Energy should be awarded the entire energy reduction incentive payment of \$145,073. We verified the Peak Demand Reduction and Utility Cost Avoidance (TRB) performance awards in a similar manner.

We did not perform verification of Market Transformation and Customer Satisfaction Award activities in PY2016 (for budgetary reasons) and thus the Hawaii Energy claimed results are assumed to be correct. Based on this, we approved the \$154,744 incentive award payment.

Finally, we determined that Hawaii Energy met the Island Equity minimum thresholds which are set at 80% of target values. For Island Equity, the available award is paid in its entirety if the minimum thresholds are met for each Island. Since we verified that minimum thresholds were met, the entire incentive award payment of \$96,715 is approved.

Overall, we calculated the overall performance award to be \$924,584 which is slightly higher (about \$9,000) than claimed by Hawaii Energy. This is because we found a significant error in Hawaii Energy’s tracking database with respect to demand (kW) savings for the Peer Comparison program, resulting in an increase of

¹⁰ EULs come from the Hawaii TRM and were originally sourced from the Database for Energy Efficiency Resources (DEER).

¹¹ We presume the minimum and target values (and associated performance award amounts) are spelled out contractually between the PUC and Leidos Engineering, LLC, but we have not seen that contract to date.

about \$13,000 in the Peak Demand Reduction performance indicator award amount. Additionally, we found TRB results to be lower than claimed by Hawaii Energy, resulting in about a \$4,000 reduction in the Utility Cost Avoidance Performance Indicator award amount.

Table 2-3.PY2016 Claimed and Verified Performance Award

Performance Indicator	Minimum	Target	Claimed			Verified				
			Results	% of Target	Award	Results	% of Target	Award ^b	% of Total Award	
Energy, Demand, and Cost Avoidance										
First Year Energy Reduction	kWh	103,146,054	137,528,072	140,816,393	102.4%	\$ 145,073	140,480,148	102.1%	\$ 145,073	16%
Peak Demand Reduction	kW	15,303	20,404	18,578	91.1%	\$ 132,090	21,711	106.4%	\$ 145,073	16%
Utility Cost Avoidance	TRB ^a	\$ 233,770,797	\$ 311,694,396	\$ 312,887,982	100.4%	\$ 386,860	\$308,567,880	99.0%	\$ 382,980	41%
Market Transformation and Customer Satisfaction Award ^c										
All activities	n/a	n/a	n/a	n/a	n/a	\$ 154,744	n/a	n/a	\$ 154,744	17%
Island Equity ^d										
Honolulu County	Incentives	59.2%	74.0%	71.7%	96.9%	\$ 96,715	71.7%	96.8%	\$ 96,715	10%
Hawaii County	Incentives	10.4%	13.0%	14.6%	112.3%		14.6%	112.3%		
Maui County	Incentives	10.4%	13.0%	13.7%	105.4%		13.7%	105.7%		
Total Performance Award						\$ 915,482			\$924,584	100%

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

^a Total Resource Benefits (TRB) are the monetized avoided utility costs from the lifecycle net energy and demand savings. Through discussions with Hawaii Energy, we determined that their claimed TRB calculations contained a minor error. Our verification corrected this error, and accounted for other verified changes to savings and effective useful life at the individual measure level. These combined changes result in the verified TRB results in this table.

^b For the energy, demand, and utility cost avoidance verified award, we used the target award breakout from Table 4 of the PY2016 Hawaii Energy Annual Report, and multiplied by the verified % of target (capping at 100%).

^c The PY2016 Verification did not include verifying any Market Transformation activities. The total claimed and verified award listed here was taken from Table 4 of the PY2016 Hawaii Energy Annual Report.

^d To obtain an award, the PBFA must distribute incentives at no less than 80% of the targeted PBFA funding for Hawaii and Maui counties. Honolulu County covers the island of Oahu. Maui County includes the island of Maui and neighboring islands of Molokai and Lanai. We calculate the Minimum as 80% of the Target. We apply the Target from Table 13 of the PY2016 Hawaii Energy Annual Report. We calculate the Claimed % of Target as described on page 34 of the PY2016 Annual Report (i.e., % incentive spend / % PBF target).

3. Verification Methods and Results

The PY2016 Hawaii Energy portfolio claimed energy savings for six programs aimed at attaining direct energy savings, with three targeting the business¹² sector and three targeting the residential sector (Business Programs and Residential Programs, respectively). Table 3-1 presents a description of each of these programs by sector.

Table 3-1. PY2016 Hawaii Energy Program Summary – Business and Residential

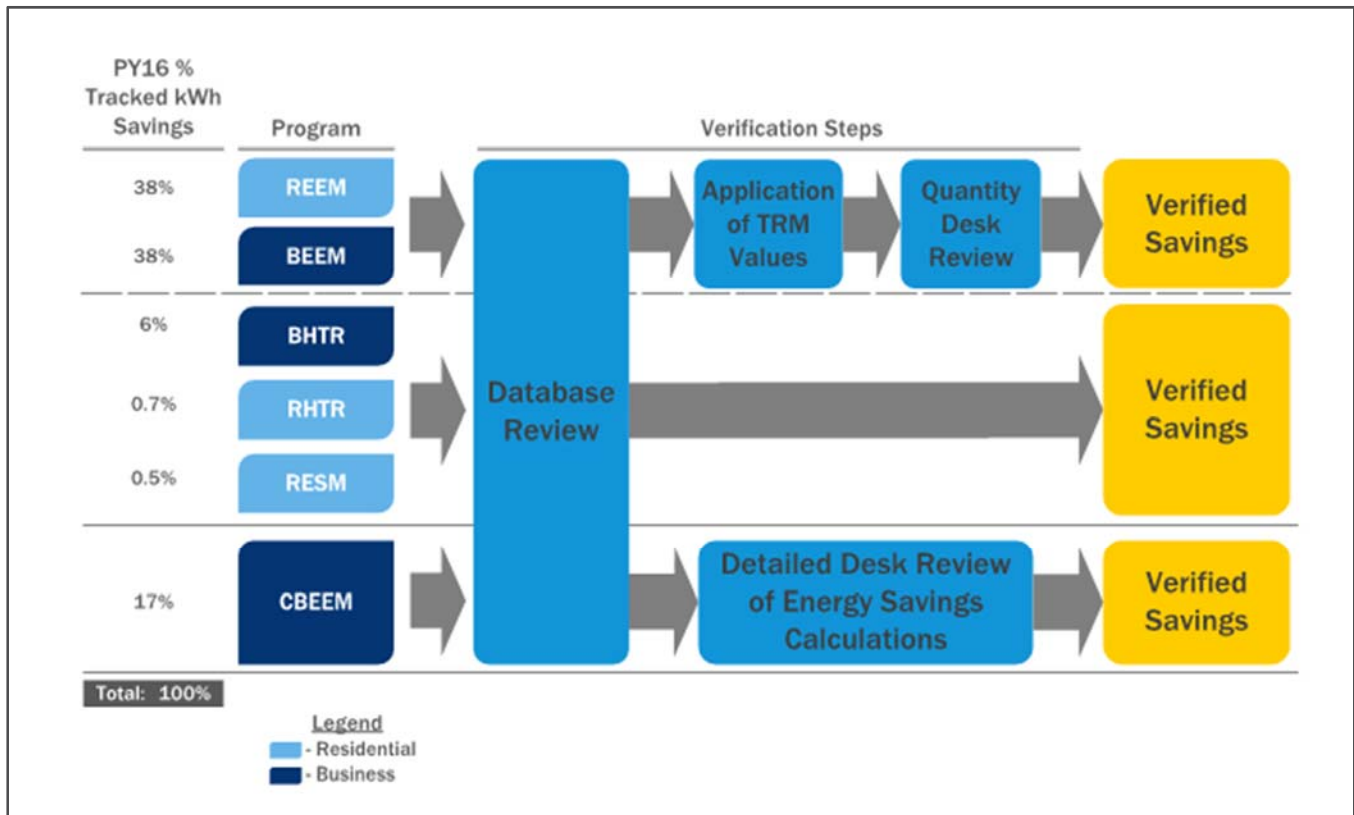
Sector	Program	Program Description ^a
Business	Business Energy Efficiency Measures (BEEM)	The objective of this program is to acquire electric energy and demand savings through customer installations of standard, known, energy efficiency technologies by applying prescriptive incentives in a streamlined 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.

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

¹² The term “business” includes all non-residential customer categories (commercial, industrial and agricultural).

Using the programs outlined in Table 3-1, Opinion Dynamics deployed several methods to verify Hawaii Energy PY2016 savings. Figure 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) in the subsections that follow.

Figure 1. PY2016 Verification Methods



3.1 Database Review

For all programs, we conducted a manual review of all (nearly 80,000) equipment records in the Hawaii Energy program tracking database¹³ 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. This level of review occurred for all records where details on efficiencies, horsepower, etc. were available in the database by looking at minimums, maximums, averages, etc. across the available parameters to identify outliers (e.g., finding a horsepower of 10,000 that was meant to be 10). We perform this task by looking at the per-unit savings across individual measures to ensure they are consistent (where applicable)¹⁴ by end-use.

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

¹⁴ Not all measures or programs contain per-unit savings. For example, CBEEM is based on customized calculations and per-unit savings are not able to be calculated from the program tracking database.

Additionally, we verified the accuracy and appropriateness of savings and incentive calculations (i.e., check per-unit savings across similar measure types and multiply by quantities to ensure they match total project savings). This review focused solely on information contained within the database as subsequent verification steps cover the appropriateness and accuracy of quantities and deemed savings assumptions.

Through this review, we made the following minor adjustments:

- Removed canceled rebates for 76 measures¹⁵
- Corrected the capacity for one measure that was larger than other capacities of the same measure type¹⁶

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 sections that follow. The database review verification step yields a clean database from which we drew program specific samples of projects (as applicable) to support additional verification steps.

3.2 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).¹⁷ Because of this, 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 TRM¹⁸ were accurately applied to the measures in the program tracking database. As described in Section 2, 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 assessing the validity of all assumptions within the TRM. As part of this review, we documented all discrepancies observed between tracked savings assumptions and verified savings assumptions in Appendix A and Appendix C. In addition, we identified inconsistencies between the PY2015 and PY2016 TRM and documented these inconsistencies in Appendix E.

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

¹⁵ The tracking database correctly excluded savings for these measures, but we also removed them from our verification analysis.

¹⁶ We identified one BEEM heat pump water measure where the tracked quantity of 94 tons appeared to be significantly larger than the other capacities for the same measure type. We investigated this by taking another step of looking up the product specification sheet and corrected the capacity to 73 tons based on the available documentation. Opinion Dynamics accounted for this discrepancy during the review of the correct application of TRM values.

¹⁷ 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.

¹⁸ We used the Hawaii Energy PY2016 TRM v16. All references to the TRM in this memo refer to the Hawaii TRM unless otherwise stated.

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 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.

We document these adjustments in detail at the measure level for Business (Appendix A) and Residential (Appendix C) programs.

3.3 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.). These reviews consisted of looking at a sample of projects at the measure level to ensure the tracked quantities in the program tracking database matched quantities on invoices for the measures in the sample. Section 3.2 describes the additional step of verifying the correct application of per unit deemed savings values.
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. 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.

We provide a high-level overview of the desk review process in Table 3-2. We provide additional details regarding our approach (sample sizes, precision, results, etc.) by program in Section 4 and Section 5. 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. Detailed project-level results of the CBEEM desk reviews are provided in Appendix A.

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. See 4.1 and 5.1 for additional details on methods and reasons behind sample sizes.

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.

3.4 Verification Results

Table 3-3 shows the PY2016 verified first-year net energy savings by program, accounting for the verification steps shown in Figure 1 above. The table compares the verified savings to the PBFA’s tracked savings.

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

Sector	Program	Net Tracked (kWh) [A]	Verification Steps ^a			Verified Savings (kWh) ^b [E]	Verification Rate [F]
			Application of TRM Values (kWh) [B]	% of Tracked [C]	Desk Reviews [D]		
					$C = B / A$		$E = B * D$
Business	BEEM	53,269,643	53,263,469	100.0%	99.7%	53,097,776	99.7%
	CBEEM	23,438,710	N/A	N/A	95.9%	22,484,239	95.9%
	BHTR	8,564,037	N/A	N/A	N/A	8,564,037	100.0%
	Business Total	85,272,390	N/A	N/A	N/A	84,146,052	98.7%
Residential	REEM	53,767,121	54,557,215	101.5%	100.0%	54,557,215	101.5%
	RHTR	1,023,996	N/A	N/A	N/A	1,023,996	100.0%
	RESM	752,885	N/A	N/A	N/A	752,885	100.0%
	Residential Total	55,544,003	N/A	N/A	N/A	56,334,096	101.4%
Portfolio Overall		140,816,393	N/A	N/A	N/A	140,480,148	99.8%

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

^a The database review resulted in only one minor adjustment to one record in REEM so we accounted for that adjustment during the Application of TRM Values step which was the first step that resulted in any adjustments to tracked savings.

^b For CBEEM, the Verified Savings are the Net Tracked Savings [A] multiplied by the population-level verification rate from the desk reviews [D] because CBEEM projects do not apply deemed TRM assumptions and therefore do not have any adjustments in [B].

Table 3-4 summarizes net tracked and verified first-year energy savings and includes the percent of total savings by program to provide the relative contribution to savings for each program. The table illustrates that Opinion Dynamics verified 98.7% of the Business sector energy savings and 101.4% of the Residential sector energy savings.

Table 3-4. PY2016 Tracked and Verified First-Year Net Energy Savings (kWh) by Sector and Program

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.

Table 3-5 shows the PY2016 verified lifecycle net energy savings by sector and program; accounting for the verification steps described in this section above. We calculate lifecycle savings by multiplying first-year savings by the effective useful life (EUL) of each measure¹⁹. Business programs account for 67.4% of the total

¹⁹ EULs come from the Hawaii TRM and were originally sourced from the Database for Energy Efficiency Resources (DEER).

verified lifecycle savings while residential programs account for 32.6%. The contribution of business programs to overall savings is higher on a lifecycle basis (67.4%) than first-year basis (59.9%) because measures installed through business program, on average, remain in place and operating for a longer period of time (13.7 years for the business sector and 9.9 for the residential sector).

It is also notable that the lifecycle verification rate for the BEEM program (96.6%) is slightly lower than the first-year verification rate (99.7%). The lower first-year verification rate is mainly attributed to differences between tracked and verified effective useful life (EUL) across 16 measures.²⁰

Table 3-5. PY2016 Tracked and Verified Lifecycle Net Energy Savings (MWh) by Sector and Program

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%	6.9%
	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.

4. Business Sector Detailed Verification Method and Results

In PY2016, verified business sector savings accounted for 60% of all Hawaii Energy first-year portfolio energy savings, with 98.7% of tracked first-year net savings being verified.

4.1 Methods

As described in Section 3, Opinion Dynamics performed a database review for all measures within the program-tracking database. Additionally, we reviewed the application of TRM values for the BEEM program, and performed quantity desk reviews for BEEM and detailed desk reviews for the CBEEM program as shown in Table 4-1.

²⁰ Tracked lifecycle savings applied PY2015 TRM EULs for 9 measures, incorrect EULs due to program tracking database configuration errors for 5 measures, and PY2014 TRM EULs for 2 measures, whereas Opinion Dynamics used the PY2016 TRM for all measures.

Table 4-1. Summary Business Verification Methods

Program	Tracked Net kWh Savings	% Contribution to Business	Database Review	Application of TRM Values	Desk Reviews
BEEM	53,269,643	62%	✓	✓	Quantity Desk Review
CBEEM	23,438,710	27%	✓	N/A	Detailed Desk Review
BHTR	8,564,037	10%	✓	None	None
Total	85,272,390	100%			

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

Table 4-2 provides an overview of the methods, sampling and analysis conducted for business sector program verification.

Table 4-2. PY2016 Business Sector Verification Method, Sample and Analysis Overview by Program

Program	Percent of Tracked PY2016 Savings	Method	Sample	Analysis
BEEM	62%	Database and Application of TRM Values	All measures included	Performed high-level database review and confirmed the correct application of TRM values for the population of BEEM projects. See Section 3.1 and Section 3.2 for additional information.
		Quantity Desk Review	50 projects	Reviewed project documentation to confirm the program tracking database correctly tracks quantities for the sample of projects.
CBEEM	27%	Database and Detailed Desk Review	25 projects (22% of overall tracked CBEEM energy savings)	Performed detailed desk review for all projects in sample.
BHTR	10%	Database Review	All measures included	Performed high-level database review. See Section 3.1 for additional information.
		Desk Review	None	Expected savings was relatively small and not cost effective to evaluate in this step.

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

Below we document our desk review sampling methodology and results for the BEEM and CBEEM programs.

4.1.1 BEEM Quantity Desk Reviews

Table 4-3 shows the tracked savings for BEEM broken down by end-use. Additionally, the table displays our sampling strategy where we grouped the three end-uses that accounted for more than 90% of the BEEM savings into one sample for performing the quantity desk reviews.

Table 4-3. PY2016 BEEM Savings by End Use

End Use	Tracked kWh	% Contribution to BEEM	Notes
Midstream	30,715,796	58%	Sampled n=50 out of N=595 projects for quantity desk reviews.
HVAC	9,115,219	17%	
Lighting	8,815,453	17%	
Other	4,623,175	9%	Apply 100% quantity verification rate.
Total	53,269,643	100%	

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

For BEEM projects, we performed desk reviews on a random sample of the projects²¹ to verify the measure quantities and measure type. This consisted of reviewing all available project documentation on the individual projects (e.g., invoices, applications, specification sheets) to determine whether the quantity and measure type in the project documentation matched the quantity and measure type specified in the program tracking database. We tracked this information in Excel format at the project level, allowing us to verify all applicable parameters consistently across the projects. Because these are prescriptive projects with deemed savings per the TRM, the desk reviews focused on verifying the application of the correct quantity and measure type. The review of the correct per-unit savings per the TRM is covered in the Application of TRM Values described in Section 3.2.

Our requirement across all our sampling efforts is to achieve $\pm 10\%$ precision at the 90% confidence level. Effectively, like all subsequent confidence and precision estimates provided in this memorandum, this means that we are 90% confident that the population parameter we are estimating (e.g., the overall BEEM program verification rate) falls within $\pm 10\%$ of the sample-based verification rate we provide. It is important to note, however, that statements we make about confidence and precision around verification rates for key programs should not be construed as global statements about the accuracy of the associated net savings tracked by Hawaii Energy. To be more pointed, our precision estimates speak to the reliability of our sampling approach and how close our estimates are likely to be to the overall population value. To many readers, sampling and precision estimates infer a certain reliability around overall net tracked savings. However, as we have previously noted, extending confidence and precision estimates to overall savings reliability rests on the assumption that TRM stipulated values have been regularly updated and accurately reflect current market conditions. Because the Opinion Dynamics team—since our involvement as the Hawaii Energy EM&V contractor—has not had an opportunity to thoroughly review all pertinent TRM values, we cannot make any informed statements about the reliability/accuracy of overall net tracked program savings.

Due to the high verification rates, low relative precision, and low error ratio observed during the PY2014 and PY2015 verification efforts for BEEM, we combined the three largest BEEM end-uses by savings (HVAC, lighting, midstream) into one sample for PY2016²². This results in 595 unique projects across these end-uses. If we assume the largest error ratio from the previous two years (i.e., 0.06 for HVAC in PY2015), our sample

²¹ One project represents one rebate ID.

²² These three largest end-uses account for more than 90% of the tracked PY2016 BEEM energy savings. Since verification rates across all end-uses have been high historically (i.e., at or very near 100%), there is little need to try to gain additional precision through stratified sampling, which would isolate each end-use and apportion sample points to each. In short, stratification would complicate the overall analysis process while providing very little additional benefit.

size would be minimal (i.e., less than 5) to achieve relative precision $\pm 10\%$ at the 90% confidence level. To ensure we meet this requirement, we conducted a simple random sample of 50 projects across the three BEEM largest end-uses.

To determine the verification rate for the sampled quantities, we developed an overall “verified quantity” from our sample after performing the quantity desk review and then divided our verified quantity by the quantity of the sample in the database²³. This resulted in an overall verification rate from our sample. We applied this quantity verification rate to the population from which we sampled. For the remaining BEEM end-uses not included in the sample (<10% of overall BEEM savings) we applied a quantity verification rate of 100%.²⁴

The results of our BEEM quantity desk reviews are included in Table 4-4. Overall, we achieved a desk review verification rate of 99.66% with relative precision of $\pm 0.3\%$ at the 90% confidence level.²⁵

Table 4-4. BEEM Desk Review Summary

Measures	PY2016 Sample Size	PY2016 Desk Review Verification Rate	Notes
Midstream Lighting	35	99.65%	Minor discrepancy with three measures
Non-Midstream Lighting	10	100.00%	No discrepancies
HVAC	5	100.00%	No discrepancies
Total	50	99.66%	

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

4.1.2 CBEEM Detailed Desk Reviews

The Custom Business Energy Efficiency Measures (CBEEM) program has historically accounted for approximately a quarter of overall portfolio energy savings (see Table 4-5). In PY2016, large increases in savings within the BEEM program and decreases within the CBEEM program contributed to a drop in the overall contribution to the portfolio for CBEEM (i.e., from 26% of overall savings in PY2015 to 17% of overall savings in PY2016). In PY2014 and PY2015, we performed desk reviews and on-site measurement and verification to verify savings. For PY2016, our verification consisted of detailed desk reviews and we achieved a CBEEM program-level verification rate of 95.9% for energy with relative precision of $\pm 6.4\%$ at the 90% confidence level. We provide additional sampling and detailed results below.

Table 4-5. CBEEM Savings 2014-2016 and Sample Size

Program Year	Tracked MWh	% Contribution to Overall Portfolio	Desk Reviews	Site Visit M&V	Sample Size	Relative Precision ^a	Error Ratio
2014	25,621	22%	✓	✓	n=40	3%	0.23
2015	31,310	26%	✓	✓	n=25	10%	0.28

²³ For example, if the tracked quantity in the sample is 100, but through our desk review, we determine the quantity should have been 98 (i.e., verified quantity), the verification rate would be = 98/100 or 98%.

²⁴ We applied a quantity verification rate of 100% to these measures, but we still reviewed all measures in terms of the correct application of TRM values as described in Section 3.2.

²⁵ We used the Levy and Lemeshow, Ratio Method Using Simple Random Sample. 2008. Page 195.

Program Year	Tracked MWh	% Contribution to Overall Portfolio	Desk Reviews	Site Visit M&V	Sample Size	Relative Precision ^a	Error Ratio
2016	23,439	17%	✓		n=25	6%	0.21

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

^a Relative precision at the 90% confidence level

Given the change in CBEEM savings contributions to the overall portfolio between PY2015 and PY2016, the results of the PY2014 and PY2015 CBEEM verifications (see Table 4-5), and based on discussions with the Energy Efficiency Manager (EEM), we performed detailed desk reviews on a stratified random sample by energy savings for 25 projects. Consistent with previous years, we attempted to achieve precision $\pm 10\%$ at the 90% confidence level for this program. We outline our sampling strategy in Table 4-6. Similar to previous years, we elected to stratify the sample for CBEEM projects because there is a substantial range in the savings achieved across projects. As illustrated in Table 4-6, 221 projects (Strata 1) produced savings at or below 50,000 kWh and 32 projects (Strata 3) produced savings between 200,000 and 700,000 kWh, with one project alone (Strata 4) producing savings of over 1 million kWh. In this situation, stratification provides a much higher overall precision level than one would realize using a simple random sample. Most importantly, stratification has historically produced a precision estimate for this program that is below our stated $\pm 10\%$ target.

Table 4-6. PY2016 CBEEM Sampling Strategy

Savings Strata	Strata Range (kWh)	PY2016 Projects (N)	Sample size (n)	Population Tracked Savings (kWh)	Sample Tracked Savings (kWh)	Sample Tracked % of Total CBEEM
1	<50,001	221	7	3,651,318	121,176	1%
2	50,001 - 200,000	82	6	7,524,251	625,426	3%
3	200,000 - 700,000	32	11	11,112,906	3,208,398	14%
Certainty	1,150,235	1	1	1,150,235	1,150,235	5%
Total	N/A	336	25	23,438,710	5,105,235	22%

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

We performed detailed desk reviews on a stratified random sample of 25 projects for PY2016. Detailed desk reviews included reviewing all installed measures, quantity of installed measures, and other measure specific characteristics (e.g., wattage, installed location, horsepower, etc.) and generating a verified estimate of savings using the information made available to us in the project documentation and other sources as necessary (e.g., HECO billing data, websites for hours of operation, specification sheets from manufacturer websites, etc.). For large complex projects that included multiple measures (e.g., chillers, motors, scheduling adjustments, lighting, etc.) we performed whole facility consumption analyses²⁶ using at least 12-months of pre-and post HECO billing data and accounting for weather normalization. We performed all the work in Excel

²⁶ IPMVP Option C.

format, with individual tabs for each project to document the program tracking assumptions and any adjustments that we made for the verified savings.

To determine the overall verification rate for CBEEM, we used the stratified ratio estimator combined method²⁷. The stratified combined ratio estimator method is used when some or all of the sample strata are too small to produce a stable estimate of the ratio, but when combined, can produce a good estimate. However, it is still beneficial to use stratification because it helps with sample precision. We provide our results below, with additional, more detailed results and explanations for differences in verification rates at the individual CBEEM project level in Appendix A.

4.2 Results

The Business sector has an overall verification rate of 98.7%, primarily caused by a reduction in verified savings for the CBEEM Program, which had a verification rate of 95.9%. This reduction was primarily driven by one large project, that upon review of the utility bills and discussions with the site contact through Hawaii Energy, is not achieving the planned energy savings due to inefficiencies in the plant design. With a likely shift from lighting-based projects to non-lighting-based and custom projects in the future, it will be important to apply the appropriate implementation and evaluation resources to these types of projects to prevent similar discrepancies from occurring. We describe this and other CBEEM discrepancies in more detail in Appendix A.

Table 4-7 shows the overall verification results by program and measure for the business sector. Similar to other jurisdictions in which Opinion Dynamics is familiar, per measure category verification rates can vary significantly. For Hawaii Energy, the range was primarily due to Opinion Dynamics’ adjustments during the quantity desk review and application of TRM values. Measures with 99.7% verification rates are explained by the quantity desk review adjustments while verification rates beyond the 99.7% are related to the application of TRM value adjustments. While the range of differences within measure categories varied in some instances, at a portfolio level these differences largely cancelled each other out or were too small in relation to the overall savings to make a significant impact. However, we still document all discrepancies found during the verification. Specific reasons for differences between PY2016 tracked and verified per-measure savings are discussed in Appendix A.

Table 4-7. PY2016 Business Sector Verification Results by Program and Measure

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (kWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
Custom Business Energy Efficiency Measures	All Measures	23,438,710	22,484,239	95.9%	26.72%	260,888,345	22.69%
Business Energy Efficiency Measures	LED--A19	20,201,961	20,140,627	99.7%	23.94%	302,109,409	26.27%
	LED--Linear Type	5,684,973	5,665,614	99.7%	6.73%	84,984,210	7.39%
	LED--PAR30	5,567,578	5,548,473	99.7%	6.59%	83,227,095	7.24%
	LED--PAR20	3,782,629	3,769,764	99.7%	4.48%	56,546,454	4.92%

²⁷ Levy and Lemeshow Stratified Ratio Estimators, Combined Method. 2008. Page 215.

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (kWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
	Custom - Advanced Energy Management Controls	2,935,313	2,925,318	99.7%	3.48%	23,402,542	2.04%
	LED-MR16	2,368,197	2,360,133	99.7%	2.80%	35,401,990	3.08%
	HVAC-Chiller-Centrifugal	1,970,212	1,963,503	99.7%	2.33%	39,270,064	3.41%
	HVAC-P/S-Packaged (P)-Air Cooled	1,322,367	1,317,864	99.7%	1.57%	19,767,959	1.72%
	Water Cooler Timer	993,219	993,219	100.0%	1.18%	4,966,095	0.43%
	Booster Pumps	944,726	944,726	100.0%	1.12%	14,170,894	1.23%
	ECM Refrigeration	863,069	863,069	100.0%	1.03%	12,946,035	1.13%
	HVAC-Chiller-Air Cooled	608,130	606,059	99.7%	0.72%	12,121,173	1.05%
	LED-PAR38	582,795	580,786	99.7%	0.69%	8,711,795	0.76%
	HVAC-VRF-Split (S)-Air Cooled	566,638	564,708	99.7%	0.67%	8,470,627	0.74%
	LED Exit Sign	550,853	548,996	99.7%	0.65%	8,234,941	0.72%
	HVAC-VFD-Pump - Chilled Water Pump	545,721	543,863	99.7%	0.65%	8,157,943	0.71%
	Submetering	508,337	508,337	100.0%	0.60%	4,066,699	0.35%
	HVAC-VFD-Pump - Condenser Water Pump	483,890	482,243	99.7%	0.57%	7,233,639	0.63%
	Anti-Sweat Heater Controls	449,698	449,698	100.0%	0.53%	5,396,382	0.47%
	ECM Fan Coil	264,993	264,993	100.0%	0.31%	3,974,889	0.35%
	Window Film	224,092	224,092	100.0%	0.27%	2,240,924	0.19%
	HVAC-VFD	179,857	179,241	99.7%	0.21%	2,688,620	0.23%
	HVAC-Chiller-Positive Displacement	172,715	172,127	99.7%	0.20%	3,442,547	0.30%
	HVAC-Heat Pump-Split (S)-Air Cooled	126,123	125,693	99.7%	0.15%	1,885,396	0.16%
	LED-Troffer	124,970	124,545	99.7%	0.15%	1,868,170	0.16%
	LED-Corn Cob	121,500	121,086	99.7%	0.14%	1,816,297	0.16%
	Heat Pump Water Heater	113,424	96,937	85.5%	0.12%	969,367	0.08%
	Delamping without Reflectors (4' Lamp)	110,626	110,250	99.7%	0.13%	1,543,494	0.13%
	4' 32w T8 - LW 4' T8	109,695	109,322	99.7%	0.13%	1,530,507	0.13%

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (kWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
	HVAC-P/S-Split (S)-Air Cooled	97,629	97,297	99.7%	0.12%	1,459,454	0.13%
	Solar Water Heating	88,380	88,380	100.0%	0.11%	1,767,605	0.15%
	Delamping with Reflectors (4' Lamp)	85,176	85,258	100.1%	0.10%	1,193,608	0.10%
	LED-U-bend	78,744	78,476	99.7%	0.09%	1,177,138	0.10%
	HVAC-VRF-Packaged (P)-Air Cooled	68,481	68,248	99.7%	0.08%	1,023,721	0.09%
	Sensors	52,269	52,121	99.7%	0.06%	416,972	0.04%
	Refrigerator - Trade In	52,018	52,018	100.0%	0.06%	728,247	0.06%
	4' T12 - LW 4' T8	45,914	45,757	99.7%	0.05%	640,605	0.06%
	LED Refrigerated Case Lighting-4' retrofit kit	22,730	22,653	99.7%	0.03%	113,263	0.01%
	HVAC-P/S-Split (S)-Water/Evaporatively Cooled	22,095	22,019	99.7%	0.03%	330,291	0.03%
	Custom - Submetering	22,016	22,016	100.0%	0.03%	176,130	0.02%
	Delamping without Reflectors (8' Lamp)	18,729	18,665	99.7%	0.02%	261,313	0.02%
	Transformer (Three-Phase)-Tier 1-75-kVA	17,179	17,179	100.0%	0.02%	257,689	0.02%
	HVAC-Heat Pump-Packaged (P)-Air Cooled	16,046	15,992	99.7%	0.02%	239,877	0.02%
	Pool Pump VFD	11,236	11,236	100.0%	0.01%	112,360	0.01%
	VRF Outdoor - Small	10,900	10,900	100.0%	0.01%	98,100	0.01%
	Transformer (Three-Phase)-Tier 1-45-kVA	9,508	9,508	100.0%	0.01%	142,617	0.01%
	Transformer (Three-Phase)-Tier 1-112.5-kVA	9,199	9,199	100.0%	0.01%	137,980	0.01%
	VFD Pool Pump	8,884	8,884	100.0%	0.01%	88,844	0.01%
	VRF Outdoor - Large	6,873	6,873	100.0%	0.01%	61,859	0.01%
	Transformer (Three-Phase)-Tier 1-30-kVA	6,869	6,869	100.0%	0.01%	103,030	0.01%
	LED-Energy Star approved hard wired recessed can retro kit-nondimmable	5,567	8,140	146.2%	0.01%	122,097	0.01%
	LED Refrigerated Case Lighting-5' retrofit kit	4,995	4,978	99.7%	0.01%	24,891	0.00%

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (kWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
	CFL (>26W)	4,391	4,376	99.7%	0.01%	13,127	0.00%
	LED Refrigerated Case Lighting-6' retrofit kit	4,300	4,285	99.7%	0.01%	21,427	0.00%
	Bounty - Refrigerator	4,289	4,289	100.0%	0.01%	60,053	0.01%
	Cool Roof	3,168	3,168	100.0%	0.00%	47,517	0.00%
	Heat Pump (ESTAR)	2,741	2,741	100.0%	0.00%	27,415	0.00%
	Refrigerator - Trade In (Commercial)	2,034	2,034	100.0%	0.00%	28,472	0.00%
	Transformer (Three-Phase)-Tier 1-150-kVA	1,917	1,917	100.0%	0.00%	28,756	0.00%
	Delamping with Reflectors (2' Lamp)	1,737	1,731	99.7%	0.00%	24,236	0.00%
	Window AC	1,321	1,321	100.0%	0.00%	11,886	0.00%
	CFL (<16W)	827	825	99.7%	0.00%	2,474	0.00%
	Ceiling Fan	759	759	100.0%	0.00%	3,794	0.00%
	Reach-In Freezer-Solid Door-15<V<30 (1 Door)	724	724	100.0%	0.00%	8,692	0.00%
	Transformer (Three-Phase)-Tier 1-15-kVA	690	690	100.0%	0.00%	10,355	0.00%
	Whole House Fan	304	264	86.8%	0.00%	5,286	0.00%
	Transformer (Single-Phase)-Tier 1-15-kVA	260	260	100.0%	0.00%	3,899	0.00%
	Solar Attic Fan	258	258	100.0%	0.00%	5,167	0.00%
	Delamping without Reflectors (2' Lamp)	92	92	99.7%	0.00%	1,290	0.00%
	Refrigerator	88	88	100.0%	0.00%	1,226	0.00%
	Subtotal	53,269,643	53,097,776	99.7%	63.10%	772,128,916	67.14%
Business Hard to Reach ^a	All Measures	8,564,037	8,564,037	100.0%	10.18%	116,966,844	10.17%
All Business - Total		85,272,390	84,146,052	98.7%	100.00%	1,149,984,105	100.00%

a. We did not perform any verification activities for the Business Hard to Reach program due to the relative contribution to the portfolio. We therefore “passed through” the tracked savings for this program.

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

5. Residential Sector Detailed Verification Method and Results

In PY2016, verified residential sector savings accounted for 40% of all Hawaii Energy first-year portfolio energy savings, with 101.4% of tracked first-year net savings being verified.

5.1 Methods

The REEM program accounted for more approximately 97% of the PY2016 tracked residential energy savings. Therefore, we focused the residential verification efforts on this program when developing a verification and sampling approach. Specifically, our verification approach prioritized the top five energy-saving measures within the REEM program: upstream lighting, peer comparison, solar hot water heating, refrigerator trade-in and variable refrigerant flow measures. Together, these five measure types accounted for nearly 95% of the total REEM PY2016 tracked energy savings. We describe our verification methods in more detail below.

Table 5-1. PY2016 Residential Sector Tracked Net Savings Summary

Program	Measures	Tracked First-Year Net Savings GWh	Percent of First-Year Net Savings
REEM	Upstream Lighting	31.80	57.25%
	Peer Comparison	14.98	26.98%
	Solar Hot Water (SHW)	2.28	4.10%
	Refrigerator Trade In	1.79	3.21%
	Variable Refrigerant Flow	2.12	3.81%
	All other REEM Measures	0.80	1.44%
RTHR		1.02	1.84%
RESM		0.75	1.36%
Total		55.54	100.00%

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

As described in Section 3, Opinion Dynamics performed a database review for all measures within the program-tracking database. Additionally, we reviewed the application of TRM values for the REEM program, and performed quantity desk reviews for several of the major end-uses within the REEM program as shown within Table 5-2 and Table 5-3.

Table 5-2. Summary Residential Verification Methods

Program	Tracked Net kWh Savings	% Contribution to Residential	Database Review	Application of TRM Values	Desk Reviews
REEM	53,767,121	97%	✓	✓	Quantity Desk Review
RHTR	1,023,996	2%	✓	None	None
RESM	752,885	1%	✓	None	None
Total	55,544,003	100%			

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

Table 5-3 provides an overview of the methods, sampling and analysis conducted for residential sector programs.

Table 5-3. PY2016 Residential Sector Verification Method, Sample and Analysis Overview by Program

Program	End Use	Percent of Tracked PY2016 Savings	Method	Sample	Analysis
REEM	All	96.8%	Database and Application of TRM Values	All measures included	Performed high-level database review and confirmed the correct application of TRM values for the population of REEM projects. See Section 3.1 and Section 3.2 for additional information.
	Upstream	57.3%	Quantity Desk Review	50 projects	Reviewed project documentation to confirm the program tracking database correctly tracks quantities for the sample of projects.
	Peer Comparison	27.0%	Participant data review	All PY2016 participants	Reviewed PY2016 household participant counts and applied TRM stipulated savings values
	Solar Hot Water, Refrigerators, VRF	11.2%	Quantity Desk Review	50 projects	Reviewed project documentation to confirm the program tracking database correctly tracks quantities for the sample of projects.
RHTR	All	1.8%	Database Review	All measures included	Performed high-level database review. See Section 3.1 for additional information.
			Quantity Desk Review	None	Expected savings was relatively small and not cost effective to evaluate in this step.
RESM	All	1.4%	Database Review	All measures included	Performed high-level database review. See Section 3.1 for additional information.
			Quantity Desk Review	None	Expected savings was relatively small and not cost effective to evaluate in this step.

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

Below we document our end-use-specific sampling methodology, approach, and results for the REEM program.

5.1.1 Upstream Quantity Desk Reviews

For the upstream lighting measures in REEM, our verification included a review of a random sample of program participant agreements with participating retailers, invoices and distribution data. Our requirement is to achieve $\pm 10\%$ precision at the 90% confidence level. For PY2014 and PY2015, there were 996 and 1,465 total upstream projects, respectively and we randomly sampled 50 projects²⁸ each year, and verified 100% of the quantity and invoice data with the tracking database. There are 1,267 unique upstream projects in the PY2016 database. We historically have not found any errors, leading to precision of $\pm 0\%$ at the 90%

²⁸ One project represents one rebate ID. Per Hawaii Energy, a rebate for the Upstream Program is generated on a weekly or monthly cadence as each participating retailer submits its sales data broken down by store location, product SKU, purchase timeframe, and invoice.

confidence level. Therefore, we continued with a random sample of 50 projects for PY2016. Similar to previous years, our PY2016 review of invoices and distribution data did not find any errors in the tracking database, resulting in a 100% verification rate of the quantities contained within the measure tracking database for the Upstream Program, resulting in precision of ±0% at the 90% confidence level.

The residential upstream lighting program distributed approximately 1.66 million bulbs in PY2016, down from 1.82 million bulbs in PY2015. In PY2016, 83% of these bulbs were LED, compared with only 49% LED in PY2015. The PY2016 breakdown of bulbs by Island is in Table 5-4.

Table 5-4. PY2016 REEM Upstream Lighting Measures by County

County	CFLs (N)	LEDs (N)	Total Bulbs (N)	% of Total Bulbs	Sample Size (n)
Honolulu (Oahu)	195,817	871,341	1,067,158	64%	18
Hawaii Island	52,010	263,118	315,128	19%	17
Maui ^a	40,666	239,358	280,024	17%	15
Total	288,493	1,373,817	1,662,310	100%	50

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

^a Maui includes 750 records sold on the island of Molokai, which is part of Maui County, but is listed separately in the program tracking data as Molokai.

In total, we reviewed the associated project documentation for 50 projects, accounting for 675 equipment IDs, and found no discrepancies, resulting in a 100% verification rate.

5.1.2 Peer Comparison: Confirmation of Participation and Savings

Originally funded through the American Recovery and Reinvestment Act of 2009 (ARRA), the Peer Comparison program began in 2011 with an initial 15,000 pilot customers on the Island of Oahu. Hawaii Energy subsequently increased the number of recipients in PY2012 to include about 62,000 customers in Hawaii and Maui counties and has continued to expand the program in each subsequent program year. Just over 265,000 households participated in the Home Energy Report (i.e., Peer Comparison) program during PY2016.

Table 5-5 summarizes the number of households who were participating at the start of PY2016, those who were added during PY2016, those who ended participation during PY2016 (due to moving or opting out of the program), as well as the number participating as of the end of PY2016. As illustrated in Table 5-5, 244,833 households were participating at the beginning of PY2016 and 20,360 were added (for a total of 265,193 participants during the year) but 30,139 opted out or moved. As a result, 235,054 households were participating at the end of PY2016

Table 5-5. PY2016 Peer Comparison Program Participants by County

County	Participants: Start of PY2016 (N)	Participants: Added During PY2016 (N)	Participants: Attrition During PY2016 (N)	Participants: End of PY2016 (N)
Honolulu (Oahu) ^a	164,179	15,729	21,254	158,654
Hawaii Island	44,590	2,139	4,810	41,919
Maui ^b	36,064	2,492	4,075	34,481
Total	244,833	20,360	30,139	235,054

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

^a Honolulu County covers the island of Oahu and several minor outlying islands.

^b Maui County covers the island of Maui and the neighboring islands of Molokai and Lanai.

We conducted an independent calculation to verify the savings claimed for the Peer Comparison Program participants using the methodology stipulated in the PY2016 TRM. The most important aspect of the TRM is the fact that it deems (or stipulates) the annual net energy savings (kWh) of a Peer Comparison household at 59.03 kWh per year, for one year²⁹.

Table 5-6 illustrates the steps involved in applying the PY2016 TRM calculation. In Step 1, we establish the number of households that participated in the program at some point during PY2016.³⁰ Then, we calculated the average (mean) number of days throughout PY2016 that households participated. As illustrated in Table 5-6, the mean number of days participated across all three counties was approximately 340 days—meaning most households participated for the entire program year. As illustrated in Step 2, we use the mean days of participation by island to adjust the savings downward from what it would have been had all households participated for the entire year or 365 days. For example, for Hawaii County the resulting savings illustrated in Step 2 is effectively 93% (340/365) of what the savings would have been if all 46,729 Hawaii County households participated for the entire year. Finally, we apply the county-specific system loss factors to arrive at net verified kWh savings (Step 3). Then, we arrive at net kW savings by dividing, as stipulated in the PY2016 TRM, net verified kWh savings by 3,000.

Overall, this method resulted in a 105.9% energy verification rate and a 309.4% demand verification rate. The differences are due to differences in methodology. For example, we apply the TRM-stipulated savings based on the specific day that a customer enters and/or leaves the program while Hawaii Energy applies the savings on a monthly basis. Additionally, the large discrepancy on demand savings is due to an error in Hawaii Energy’s tracked savings calculations.

Table 5-6. Summary of PY2016 Verified Peer Comparison Savings

County	Step 1: Participant Count PY2016 [A]	Mean Days of Participation [B]	Annual kWh Savings [C]	Step 2: Verified kWh Savings [D] = A * B * C / 365	System Loss Factor (SLF) [E]	Step 3: Net kWh Savings (with SLF) [F] = D * (1+E)	Net kW Savings [G] = F / 3,000
Honolulu	179,908	332	59.03	9,668,612	0.1117	10,748,596	3,583
Hawaii	46,729	340		2,572,786	0.09	2,804,337	935
Maui	38,556	338		2,104,749	0.0996	2,314,382	771
Total	265,193			14,346,147		15,867,314	5,289

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

²⁹ The 59.03 kWh is derived from applying a 0.89% savings rate to an assumed average annual billed energy consumption for a Peer comparison household of 6,633 kWh (i.e., 6,633 * 0.0089 = 59.03 kWh). The 6,633 kWh per year is deemed per the TRM.

³⁰ The count, by island, is taken from the previous table by adding the number of participants at the start of PY2016 and the number of participants added during PY2016. For Hawaii County, for example, this equates to adding 44,590 participants at the start of the PY and 2,139 participants added during the PY for a total of 46,729 household who participated during PY2016—either the entire year or part of the year.

5.1.3 Other REEM Measure Quantity Desk Reviews

For other REEM measures (outside of the Upstream and Peer programs), we performed quantity desk reviews on a random sample of projects³¹ to verify the measure quantities and measure type at the equipment level³². This consisted of reviewing all available project documentation on the individual projects (e.g., invoices, applications, specification sheets) to determine whether the quantity and measure type in the project documentation matches the quantity and measure type specified in the program tracking database. We tracked this information in Excel format at the equipment level, ensuring all applicable parameters were verified consistently. Because these are prescriptive projects with deemed savings per the TRM, the desk reviews only include a review of the correct quantity and measure type. The review of the correct per-unit savings per the TRM is covered in the Application of TRM Values described in Section 3.2.

Our requirement is to achieve $\pm 10\%$ precision at the 90% confidence level. Due to the high verification rates, low relative precision, and low error ratio observed during the PY2014 and PY2015 verification efforts for REEM, we combined the three largest REEM end-uses by savings (solar hot water, refrigerator trade-in, variable refrigerant flow (VRF)) into one sample for PY2016³³, resulting in 4,921 unique projects across these end-uses. To develop the required sample size to achieve the desired level of confidence and precision, we assumed the largest realized error ratio from our analysis of other REEM measures over the previous two years (i.e., 0.29 error ratio for VRF in PY2015), as shown in Table 5-7.

Table 5-7. PY2014 and PY2015 Sampling Results for "Other" REEM End-Uses

End Use	Sample Size (n)		Verification Rate		Relative Precision ^a		Error Ratio	
	PY2014	PY2015	PY2014	PY2015	PY2014	PY2015	PY2014	PY2015
Solar Hot Water	49	40	100%	100%	$\pm 0\%$	$\pm 0\%$	0.00	0.00
Refrigerators/Freezers	50	40	100%	100%	$\pm 0\%$	$\pm 0\%$	0.00	0.00
Variable Refrigerant Flow (VRF)	N/A	40	N/A	99.2%	N/A	$\pm 2\%$	N/A	0.29

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

^a Relative precision at 90% confidence level.

Applying this error ratio to the 2016 sample frame yields a minimum sample size of 25 projects to achieve relative precision $\pm 10\%$ at the 90% confidence level. To ensure we meet the required precision and confidence, we selected a simple random sample of 50 projects across the four largest end-uses. This ensured we meet our required $\pm 10\%$ precision at the 90% confidence level. For the remaining end-uses not sampled (<2% of overall REEM savings) we applied a quantity verification rate of 100%³⁴.

³¹ One project represents one rebate ID.

³² One project/rebate can include multiple equipment IDs.

³³ REEM Upstream and REEM Peer account for approximately 87% of the total tracked REEM savings. The "other" REEM end-uses (i.e., non-Upstream and non-Peer) account for the remaining 13% of the overall REEM savings. The four largest end-uses within the "other" REEM category account for approximately 11% of the overall REEM savings, meaning our review (including the separate Upstream review and Peer analysis) covered more than 98% of overall REEM savings.

³⁴ While we applied a quantity verification rate of 100% to these measures, we corrected errors found in application of TRM values and deemed assumptions through the review in Section 3.2.

To determine the verification rate for the sampled quantities, we developed an overall “verified quantity” from our sample after performing the quantity desk review and then divided our verified quantity by the quantity of the sample in the database. This resulted in an overall verification rate from our sample. We applied this quantity verification rate to the population from which we sampled. For the remaining REEM end-uses not included in the sample (<2% of overall REEM savings) we applied a quantity verification rate of 100%.³⁵

The results of our REEM desk reviews are included in Table 5-8. Overall, we achieved a desk review verification rate of 100.00% with relative precision of ±0.00% at the 90% confidence level. Sample sizes within each measure category were determined randomly through the selection of 50 projects.

Table 5-8. REEM Desk Review Summary

Measures	PY2016 Sample Size	PY2016 Desk Review Verification Rate	Notes
Refrigerator Trade-In	19	100.00%	No discrepancies
Solar Hot Water	12	100.00%	No discrepancies
VRF	19	100.00%	No discrepancies
Total	50	100.00%	

5.2 Results

The residential sector has a verification rate of 101.4%, primarily caused by an increase in verified savings for the Peer Comparison program. This discrepancy is due to differences in methodology between Hawaii Energy and Opinion Dynamics in how we allocate deemed savings per participant. Opinion Dynamics allocates savings based on the specific day that a participant enters and leaves the program, whereas Hawaii Energy allocates savings based on the month that a participant enters and leaves the program. Because the Peer Comparison Program accounts for approximately 27% of the claimed residential sector energy savings, this difference in Peer savings methodology was enough to drive the overall residential verification rate to 101.4%.

Table 5-9 shows the overall verification results by program and measure for the residential sector. Similar to other jurisdictions in which Opinion Dynamics is familiar, per measure category verification rates vary by measure type. For Hawaii Energy, the range of measure-specific verification rates was primarily due to application of savings based on previous versions of the TRM instead of those from the PY2016 TRM. Specific reasons for differences between PY2016 verified and tracked savings per measure are discussed in Appendix C.

Table 5-9. PY2016 Residential Sector Verification Results by Program and Measure

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (MWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
	Residential LED	26,994,296	26,994,296	100.0%	47.9%	404,914	72.64%
	Peer Comparison	14,984,156	15,867,314	105.9%	28.2%	15,867	2.85%

³⁵ We applied a quantity verification rate of 100% to these measures, but we still reviewed all measures in terms of the correct application of TRM values as described in Section 3.2.

Table 5-9. PY2016 Residential Sector Verification Results by Program and Measure

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Verified Lifecycle Net Savings (MWh)	Verified Lifecycle Net Savings as % of Total Sector Savings
Residential Energy Efficiency Measures	CFL	4,285,473	4,209,847	98.2%	7.5%	25,259	4.53%
	Solar Hot Water Heater	2,278,316	2,278,316	100.0%	4.0%	45,566	8.17%
	Refrigerator - Trade In	1,605,354	1,605,354	100.0%	2.8%	22,475	4.03%
	VRF Outdoor - Small	1,361,328	1,361,328	100.0%	2.4%	12,252	2.20%
	VRF Outdoor - Large	754,729	754,729	100.0%	1.3%	6,793	1.22%
	TV	481,758	481,758	100.0%	0.9%	2,891	0.52%
	Basic Energy Kit – Online - LED	200,240	200,240	100.0%	0.4%	3,004	0.54%
	Bounty - Refrigerator	153,614	153,614	100.0%	0.3%	2,151	0.39%
	Heat Pump (ESTAR)	152,325	152,325	100.0%	0.3%	1,523	0.27%
	Whole House Fan	132,524	115,096	86.8%	0.2%	2,302	0.41%
	VFD Pool Pump	89,927	89,927	100.0%	0.2%	899	0.16%
	Advanced Energy Kit - Online-Smart strip	62,103	62,103	100.0%	0.1%	311	0.06%
	Window AC	62,059	62,059	100.0%	0.1%	559	0.10%
	Sound bar	39,625	39,625	100.0%	0.1%	277	0.05%
	Low Flow Showerhead	35,305	35,294	100.0%	0.1%	176	0.03%
	Solar Attic Fan	27,511	27,511	100.0%	0.0%	550	0.10%
	Bounty - Freezer	25,609	25,609	100.0%	0.0%	359	0.06%
	Kitchen Aerator	16,406	16,406	100.0%	0.0%	82	0.01%
	Bathroom Aerator	16,406	16,406	100.0%	0.0%	82	0.01%
	Ceiling Fan	7,230	7,230	100.0%	0.0%	36	0.01%
Refrigerator	828	828	100.0%	0.0%	12	0.00%	
	Verified Subtotal	53,767,121	54,557,215	101.5%	96.8%	548,339	98.4%
Residential Hard to Reach ^a	All Measures	1,023,996	1,023,996	100.0%	1.82%	6,170	1.11%
Residential Energy Services and Maintenance ^a	All Measures	752,885	752,885	100.0%	1.34%	2,946	0.53%
All Residential - Total		55,544,003	56,334,096	101.4%	100.0%	557,456	100.0%

a. We did not perform any verification activities for the Residential Hard to Reach and Residential Energy Services and Maintenance programs due to their relative contribution to the portfolio. We therefore “passed through” the tracked savings for these programs.

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

Appendix A. Business Sector Detailed Verification Savings Adjustments

This appendix provides detailed results from the verification of business sector savings along with reasons for any differences identified between tracked and verified values. Table 5-10 shows Hawaii Energy’s tracked net savings for all business programs, the verified savings, the percent difference between tracked and verified, and the reasons for the differences in savings. We discuss any significant differences between tracked and verified values (e.g., incorrect deemed value applied, database error) in the final “Reasons for Differences” column of Table 5-10. Minor differences (i.e., within 1%) are simply denoted as “N/A” as they are due to rounding or the quantity review adjustment step described in Section 4.1. Table 5-10 is sorted to show savings as a percent of total sector savings from high to low within each program. This order facilitates an understanding of the contribution of the measure level verified savings to the overall sector verified savings. It is notable that the verification rate for measures that contribute a small amount to overall verified savings, whether the rate be very high or very low, has little impact on overall program and sector level verified savings.

Table 5-10. PY2016 Verified Participation and Savings by Program and Measure Business Programs

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Reasons for Differences
Custom Business Energy Efficiency Measures	All Measures	23,438,710	22,484,239	95.9%	26.72%	See Table 5-11.
Business Energy Efficiency Measures	LED–A19	20,201,961	20,140,627	99.7%	23.94%	N/A
	LED–Linear Type	5,684,973	5,665,614	99.7%	6.73%	N/A
	LED–PAR30	5,567,578	5,548,473	99.7%	6.59%	N/A
	LED–PAR20	3,782,629	3,769,764	99.7%	4.48%	N/A
	Custom - Advanced Energy Management Controls	2,935,313	2,925,318	99.7%	3.48%	N/A
	LED–MR16	2,368,197	2,360,133	99.7%	2.80%	N/A
	HVAC-Chiller-Centrifugal	1,970,212	1,963,503	99.7%	2.33%	N/A
	HVAC-P/S-Packaged (P)-Air Cooled	1,322,367	1,317,864	99.7%	1.57%	N/A
	Water Cooler Timer	993,219	993,219	100.0%	1.18%	N/A
	Booster Pumps	944,726	944,726	100.0%	1.12%	N/A

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Reasons for Differences
	ECM Refrigeration	863,069	863,069	100.0%	1.03%	N/A
	HVAC-Chiller-Air Cooled	608,130	606,059	99.7%	0.72%	N/A
	LED-PAR38	582,795	580,786	99.7%	0.69%	N/A
	HVAC-VRF-Split (S)-Air Cooled	566,638	564,708	99.7%	0.67%	N/A
	LED Exit Sign	550,853	548,996	99.7%	0.65%	N/A
	HVAC-VFD-Pump - Chilled Water Pump	545,721	543,863	99.7%	0.65%	N/A
	Submetering	508,337	508,337	100.0%	0.60%	N/A
	HVAC-VFD-Pump - Condenser Water Pump	483,890	482,243	99.7%	0.57%	N/A
	Anti-Sweat Heater Controls	449,698	449,698	100.0%	0.53%	N/A
	ECM Fan Coil	264,993	264,993	100.0%	0.31%	N/A
	Window Film	224,092	224,092	100.0%	0.27%	N/A
	HVAC-VFD	179,857	179,241	99.7%	0.21%	N/A
	HVAC-Chiller-Positive Displacement	172,715	172,127	99.7%	0.20%	N/A
	HVAC-Heat Pump-Split (S)-Air Cooled	126,123	125,693	99.7%	0.15%	N/A
	LED-Troffer	124,970	124,545	99.7%	0.15%	N/A
	LED-Corn Cob	121,500	121,086	99.7%	0.14%	N/A
	Heat Pump Water Heater	113,424	96,937	85.5%	0.12%	Tracked savings assumed a quantity of 94 tons for one heat pump water heater measure while verified savings assumed a quantity of 73 tons based on the product specification.
	Delamping without Reflectors (4' Lamp)	110,626	110,250	99.7%	0.13%	N/A
	4' 32w T8 - LW 4' T8	109,695	109,322	99.7%	0.13%	N/A
	HVAC-P/S-Split (S)-Air Cooled	97,629	97,297	99.7%	0.12%	N/A

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Reasons for Differences
	Solar Water Heating	88,380	88,380	100.0%	0.11%	N/A
	Delamping with Reflectors (4' Lamp)	85,176	85,258	100.1%	0.10%	Tracked savings excluded interactive effects while verified savings included interactive effect factors of 1.019 for energy and 1.053 for demand per the TRM.
	LED--U-bend	78,744	78,476	99.7%	0.09%	N/A
	HVAC-VRF-Packaged (P)-Air Cooled	68,481	68,248	99.7%	0.08%	N/A
	Sensors	52,269	52,121	99.7%	0.06%	N/A
	Refrigerator - Trade In	52,018	52,018	100.0%	0.06%	N/A
	4' T12 - LW 4' T8	45,914	45,757	99.7%	0.05%	N/A
	LED Refrigerated Case Lighting-4' retrofit kit	22,730	22,653	99.7%	0.03%	N/A
	HVAC-P/S-Split (S)-Water/Evaporatively Cooled	22,095	22,019	99.7%	0.03%	N/A
	Custom - Submetering	22,016	22,016	100.0%	0.03%	N/A
	Delamping without Reflectors (8' Lamp)	18,729	18,665	99.7%	0.02%	N/A
	Transformer (Three-Phase)-Tier 1-75-kVA	17,179	17,179	100.0%	0.02%	N/A
	HVAC-Heat Pump-Packaged (P)-Air Cooled	16,046	15,992	99.7%	0.02%	N/A
	Pool Pump VFD	11,236	11,236	100.0%	0.01%	N/A
	VRF Outdoor - Small	10,900	10,900	100.0%	0.01%	N/A
	Transformer (Three-Phase)-Tier 1-45-kVA	9,508	9,508	100.0%	0.01%	N/A

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Reasons for Differences
	Transformer (Three-Phase)-Tier 1-112.5-kVA	9,199	9,199	100.0%	0.01%	N/A
	VFD Pool Pump	8,884	8,884	100.0%	0.01%	N/A
	VRF Outdoor - Large	6,873	6,873	100.0%	0.01%	N/A
	Transformer (Three-Phase)-Tier 1-30-kVA	6,869	6,869	100.0%	0.01%	N/A
	LED--Energy Star approved hard wired recessed can retro kit--nondimmable	5,567	8,140	146.2%	0.01%	Tracked savings applied savings per the PY2015 TRM based on building type while verified savings applied savings per the PY2016 TRM based on building type.
	LED Refrigerated Case Lighting-5' retrofit kit	4,995	4,978	99.7%	0.01%	N/A
	CFL (>26W)	4,391	4,376	99.7%	0.01%	N/A
	LED Refrigerated Case Lighting-6' retrofit kit	4,300	4,285	99.7%	0.01%	N/A
	Bounty - Refrigerator	4,289	4,289	100.0%	0.01%	N/A
	Cool Roof	3,168	3,168	100.0%	0.00%	N/A
	Heat Pump (ESTAR)	2,741	2,741	100.0%	0.00%	N/A
	Refrigerator - Trade In (Commercial)	2,034	2,034	100.0%	0.00%	N/A
	Transformer (Three-Phase)-Tier 1-150-kVA	1,917	1,917	100.0%	0.00%	N/A
	Delamping with Reflectors (2' Lamp)	1,737	1,731	99.7%	0.00%	N/A
	Window AC	1,321	1,321	100.0%	0.00%	N/A
	CFL (<16W)	827	825	99.7%	0.00%	N/A
	Ceiling Fan	759	759	100.0%	0.00%	N/A
	Reach-In Freezer-Solid Door-15<V<30 (1 Door)	724	724	100.0%	0.00%	N/A
	Transformer (Three-Phase)-Tier 1-15-kVA	690	690	100.0%	0.00%	N/A

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Savings (kWh)	Verified % of Tracked First-Year Net Savings	Verified Savings as % of Total Sector Savings	Reasons for Differences
	Whole House Fan	304	264	86.8%	0.00%	Tracked savings applied savings per the PY2015 TRM (365 kWh/fan and 0.5 kW/fan) while verified applied savings per the PY2016 TRM (317 kWh/fan and 0.1 kW/fan).
	Transformer (Single-Phase)-Tier 1-15-kVA	260	260	100.0%	0.00%	N/A
	Solar Attic Fan	258	258	100.0%	0.00%	N/A
	Delamping without Reflectors (2' Lamp)	92	92	99.7%	0.00%	N/A
	Refrigerator	88	88	100.0%	0.00%	N/A
	Subtotal		53,269,643	53,097,776	99.7%	63.1%
Business Hard to Reach ^a	All Measures	8,564,037	8,564,037	100.0%	10.2%	N/A
All Business - Total		85,272,390	84,146,052	98.7%	100.0%	N/A

a. We did not perform any verification activities for the Business Hard to Reach program due to the relative contribution to the portfolio. We therefore “passed through” the tracked savings for this program.

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

Table 5-11 displays the results of the CBEEM detailed desk reviews by project including reasons for differences at the individual project level.

Table 5-11. PY2016 CBEEM Detailed Desk Review Verification Results by Project

Rebate ID	Measure Group	Tracked Savings		Verified Savings		Verification Rate ^a		Reasons for Differences
		kW	kWh	kW	kWh	kW	kWh	
a0h1300000P0pLWAAZ	Lighting	15.86	93,716	14.31	84,344	90%	90%	<ul style="list-style-type: none"> Tracked database savings are slightly larger than savings in project files which is most likely due to rounding. Verified savings changed efficient wattage assumptions to reflect spec sheet.
a0h1300000P0prTAAR	Lighting	5.42	130,239	5.33	129,897	98%	100%	<ul style="list-style-type: none"> Tracked savings assumed 12W for the Cree CR6 12-Watt LEDs, whereas verified used the wattage specified in the data sheets of 12.5W. This change was not significant enough to show up in the rounded verification rates. Tracked database kW savings are slightly larger than kW savings in project files which is most likely due to rounding. This caused a slight adjustment in the kW verification rate.
a0h1300000QyerEAAR	Lighting	65.24	272,034	65.21	272,034	100%	100%	N/A
a0h1300000QySsYAAV	Lighting	22.10	133,921	21.70	131,096	98%	98%	<ul style="list-style-type: none"> Tracked database savings are slightly larger than savings in project files which is most likely due to rounding.
a0h1300000TukoCAAR	Lighting	1.58	9,349	1.60	9,349	101%	100%	<ul style="list-style-type: none"> Tracked database savings are slightly smaller than savings in project files which is most likely due to rounding.
a0h1300000TutgeAAB	Lighting	13.35	116,920	13.35	116,920	100%	100%	N/A
a0h1300000TuulIAAZ	Lighting	88.46	219,078	86.00	212,766	97%	97%	<ul style="list-style-type: none"> Verified savings changed efficient wattage assumptions to reflect spec sheet.
a0h1300000Tuv4UAAR	Lighting	3.92	25,868	1.25	8,268	32%	32%	<ul style="list-style-type: none"> Verified savings reduced baseline wattages to 90W for 2 of the 3 measures per the provided spec sheets.
a0h1300000TuvyCAAR	Lighting	0.25	1,536	0.18	1,280	73%	83%	<ul style="list-style-type: none"> Verified savings updated baseline system wattage to reflect 4-lamp wattage.

Rebate ID	Measure Group	Tracked Savings		Verified Savings		Verification Rate ^a		Reasons for Differences
		kW	kWh	kW	kWh	kW	kWh	
a0h1300000Tuxd2AAB	Lighting	0.57	2,617	0.56	2,589	100%	99%	<ul style="list-style-type: none"> • Verified savings changed efficient wattage assumptions to reflect spec sheet. • Tracked database savings are slightly larger than savings in project files which is most likely due to rounding.
a0h1300000Tv0mBAAR	Lighting	83.38	510,106	83.38	510,106	100%	100%	N/A
a0h1300000Tv3bDAAR	Lighting	6.67	50,619	6.67	50,619	100%	100%	N/A
a0h1300000Tv3M3AAJ	Lighting	11.51	100,010	11.52	100,010	100%	100%	N/A
a0h1300000Tv3VUAAZ	Lighting	30.52	262,068	31.36	269,672	103%	103%	<ul style="list-style-type: none"> • Verified savings changed efficient wattage assumptions to reflect spec sheet.
a0h1300000Tv5ELAAZ	Lighting	0.81	5,653	0.81	5,653	100%	100%	N/A
a0h1300000UxUAtAAN	Lighting	5.52	38,652	8.06	56,474	146%	146%	<ul style="list-style-type: none"> • Tracked savings multiplied the number of LED modules (2) by the total system wattage for the efficient LED - GE ABV102V57s. The total system wattage already accounts for the 2 modules (total of 190W for 2 module system). Each individual module is 95W. Because tracked savings multiplied the total system wattage of a 2-module system by the number of modules (2) the total tracked system wattage is double the verified system wattage (380W vs. 190W). • Tracked savings applies 190W for the Lumateq LB100s, whereas spec sheets indicate 100W, which was used for verified savings.
a0h1300000TusFCAAZ	Lighting	41.86	369,737	41.91	370,418	100%	100%	N/A
a0h1300000POpqfAAB	Non-Lighting	3.92	37,501	3.93	37,501	100%	100%	N/A
a0h1300000POqMHAAZ	Non-Lighting	34.69	260,138	34.69	260,138	100%	100%	N/A
a0h1300000POqstAAB	Non-Lighting	12.51	289,382	12.28	289,382	98%	100%	<ul style="list-style-type: none"> • Tracked database savings are slightly larger than savings in project files which is most likely due to rounding.
a0h1300000PSR3YAAX	Non-Lighting	27.93	244,505	27.48	239,095	98%	98%	<ul style="list-style-type: none"> • Verified savings updated the analysis to include actual billing data for the first 12 months following project completion. This caused a slight decrease in verification rates.

Rebate ID	Measure Group	Tracked Savings		Verified Savings		Verification Rate ^a		Reasons for Differences
		kW	kWh	kW	kWh	kW	kWh	
a0h1300000TonnEAAR	Non-Lighting	25.10	220,029	23.86	209,677	95%	95%	<ul style="list-style-type: none"> • Verified savings updated the analysis to include actual billing data for the first 12 months following project completion. This caused a slight decrease in verification rates.
a0h1300000TulkyAAB	Non-Lighting	35.19	308,284	30.86	269,825	88%	88%	<ul style="list-style-type: none"> • Verified savings updated the analysis to include actual billing data for the first 12 months following project completion. This caused a slight decrease in verification rates.
a0h1300000TuvxJAAR	Non-Lighting	70.57	253,038	65.61	239,485	93%	95%	<ul style="list-style-type: none"> • Verified savings used actual capacities of equipment installed from this project rather than averages from TRM which brought savings slightly down compared with tracked savings.
a0h1300000QybydAAB	Non-Lighting	137.10	1,150,235	19.25	584,223.7	14%	51%	<ul style="list-style-type: none"> • Tracked savings relied on 12 days of post project completion metered data. Since that time, the building engineer indicated that the project is operating much less efficiently due to undersized cooling towers. • Verified savings performed a weather-normalized billing analysis using HECO utility bills resulting in the large decrease in energy savings. Additionally, tracked demand savings used a peak period of 12-2 pm, but it should have been 5-9 pm, which further reduces demand savings. This project and our review was limited to the scope of this project, and therefore did not include investigation of the undersized cooling towers mentioned by the building engineer.

a. For several projects, the tracked savings values (kW and/or kWh) in the database differed slightly (<2%) from the calculated savings values in the project-specific calculations provided by Hawaii Energy. We suspect these differences were due to rounding of individual input parameters. When performing the verified savings calculations, we leveraged the project-specific input data and updated as applicable. Given these slight rounding differences, there are some cases where the kW verification rate is slightly different from the kWh verification rate at an individual project level.

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

Appendix B. Business Sector Total Resource Benefits

This appendix provides detailed results from the verification and calculation of verified net TRB for the business sector. Table 5-13 shows Opinion Dynamics' independent estimate of savings for business programs and measures, ordered by tracked first-year net savings (high to low) within programs.

We calculated TRB estimates using the Excel algorithms in Equation 1 and parameters in Table 5-12. These algorithms are based on the California Standard Practice Manual.

Equation 1. TRB Calculation Excel Algorithms

$$\text{TRB} = \text{kWh TRB} + \text{kW TRB}$$

$$\text{kWh TRB} = [\text{First-Year of Avoided Cost} + \text{NPV}(\text{Discount Rate, Avoided Supply Costs, EUL-1})] * \text{Verified First-Year Net kWh Savings} * \text{Line Losses}$$

$$\text{kW TRB} = [\text{First-Year of Avoided Cost} + \text{NPV}(\text{Discount Rate, Avoided Supply Costs, EUL-1})] * \text{Verified First-Year Net kW Savings} * \text{Line Losses}$$

Table 5-12. TRB Parameters and Sources

Variable	Value	Source
Discount Rate	6%	PBFA and PY2016 TRM.
Avoided Costs	Varies	PBFA and PY2016 TRM.
EUL (effective useful life)	Varies by measure	PY2016 TRM
First-Year Net Savings	Verification of Savings	Opinion Dynamics
Line Losses	N/A	Not included in this analysis as the scalar is embedded in net savings per the PY2016 TRM.

Table 5-13. PY2016 Business Sector Verified Participation, Savings and TRB by Program and Measure

Program	Measure	Tracked First-Year Net Energy Savings (kWh) (A)	Tracked First-Year Net Savings (kW) (B)	kWh Verified Ratio (C)	kW Verified Ratio (D)	Verified First-Year Net Savings (kWh) (E = A * C)	Verified First-Year Net Savings (kW) (F=B * D)	EUL - in Program-Tracking Database (G)	Verified EUL from TRM (H)	Verified Net TRB (I)
Custom Business Energy Efficiency Measures	All Measures	23,438,710	3,500	0.96	0.94	22,484,239	3,293	11.6	11.6	\$49,296,655
Business Energy Efficiency Measures	LED--A19	20,201,961	1,590	1.00	0.95	20,140,627	1,504	15.0	15.0	\$49,262,256
	LED--Linear Type	5,684,973	552	1.00	1.00	5,665,614	550	15.0	15.0	\$14,528,971
	LED--PAR30	5,567,578	517	1.00	1.00	5,548,473	518	15.0	15.0	\$14,121,724
	LED--PAR20	3,782,629	310	1.00	1.00	3,769,764	309	15.0	15.0	\$9,363,940
	Custom - Advanced Energy Management Controls	2,935,313	391	1.00	1.00	2,925,318	390	15.0	8.0	\$4,514,020
	LED--MR16	2,368,197	185	1.00	1.00	2,360,133	184	15.0	15.0	\$5,814,882
	HVAC-Chiller-Centrifugal	1,970,212	319	1.00	1.00	1,963,503	318	20.0	20.0	\$7,011,991
	HVAC-P/S-Packaged (P)-Air Cooled	1,322,367	273	1.00	1.00	1,317,864	272	15.0	15.0	\$4,141,011
	Water Cooler Timer	993,219	88	1.00	1.00	993,219	88	8.0	5.0	\$841,431
	Booster Pumps	944,726	90	1.00	1.00	944,726	90	15.0	15.0	\$2,413,078
	ECM Refrigeration	863,069	93	1.00	1.00	863,069	93	15.0	15.0	\$2,261,127
	HVAC-Chiller-Air Cooled	608,130	81	1.00	1.00	606,059	81	20.0	20.0	\$2,055,524
	LED--PAR38	582,795	53	1.00	1.00	580,786	53	15.0	15.0	\$1,470,334
	HVAC-VRF-Split (S)-Air Cooled	566,638	63	1.00	1.00	564,708	63	15.0	15.0	\$1,489,667
	LED Exit Sign	550,853	65	1.00	1.00	548,996	65	15.0	15.0	\$1,468,200
HVAC-VFD-Pump - Chilled Water Pump	545,721	148	1.00	1.00	543,863	148	15.0	15.0	\$1,896,994	

Program	Measure	Tracked First-Year Net Energy Savings (kWh) (A)	Tracked First-Year Net Savings (kW) (B)	kWh Verified Ratio (C)	kW Verified Ratio (D)	Verified First-Year Net Savings (kWh) (E = A * C)	Verified First-Year Net Savings (kW) (F=B * D)	EUL - in Program-Tracking Database (G)	Verified EUL from TRM (H)	Verified Net TRB (I)
	Submetering	508,337	55	1.00	1.00	508,337	55	8.0	8.0	\$751,615
	HVAC-VFD-Pump - Condenser Water Pump	483,890	131	1.00	1.00	482,243	131	15.0	15.0	\$1,682,062
	Anti-Sweat Heater Controls	449,698	47	1.00	1.00	449,698	47	12.0	12.0	\$950,154
	ECM Fan Coil	264,993	30	1.00	1.00	264,993	30	15.0	15.0	\$703,647
	Window Film	224,092	56	1.00	1.00	224,092	56	10.0	10.0	\$515,026
	HVAC-VFD	179,857	64	1.00	1.00	179,241	64	15.0	15.0	\$704,760
	HVAC-Chiller-Positive Displacement	172,715	31	1.00	1.00	172,127	31	20.0	20.0	\$635,132
	HVAC-Heat Pump-Split (S)-Air Cooled	126,123	17	1.00	1.00	125,693	17	15.0	15.0	\$346,689
	LED--Troffer	124,970	18	1.00	1.00	124,545	18	15.0	15.0	\$352,121
	LED--Corn Cob	121,500	9	1.00	1.00	121,086	9	15.0	15.0	\$294,622
	Heat Pump Water Heater	113,424	4	0.85	0.85	96,937	3	10.0	10.0	\$151,988
	Delamping without Reflectors (4' Lamp)	110,626	17	1.00	1.00	110,250	17	14.0	14.0	\$297,153
	4' 32w T8 - LW 4' T8	109,695	34	1.00	1.00	109,322	34	14.0	14.0	\$375,892
	HVAC-P/S-Split (S)-Air Cooled	97,629	14	1.00	1.00	97,297	14	15.0	15.0	\$275,775
	Solar Water Heating	88,380	26	1.00	1.00	88,380	26	20.0	20.0	\$390,219
	Delamping with Reflectors (4' Lamp)	85,176	7	1.00	1.01	85,258	7	14.0	14.0	\$201,145
	LED--U-bend	78,744	11	1.00	1.00	78,476	11	15.0	15.0	\$218,339
	HVAC-VRF-Packaged (P)-Air Cooled	68,481	16	1.00	1.00	68,248	16	15.0	15.0	\$222,097

Program	Measure	Tracked First-Year Net Energy Savings (kWh) (A)	Tracked First-Year Net Savings (kW) (B)	kWh Verified Ratio (C)	kW Verified Ratio (D)	Verified First-Year Net Savings (kWh) (E = A * C)	Verified First-Year Net Savings (kW) (F=B * D)	EUL - in Program-Tracking Database (G)	Verified EUL from TRM (H)	Verified Net TRB (I)
	Sensors	52,269	5	1.00	1.03	52,121	5	8.0	8.0	\$76,413
	Refrigerator - Trade In	52,018	2	1.00	1.00	52,018	2	14.0	14.0	\$111,359
	4' T12 - LW 4' T8	45,914	5	1.00	1.00	45,757	5	14.0	14.0	\$112,624
	LED Refrigerated Case Lighting-4' retrofit kit	22,730	4	1.00	1.00	22,653	4	5.0	5.0	\$20,348
	HVAC-P/S-Split (S)-Water/Evaporatively Cooled	22,095	3	1.00	1.00	22,019	3	15.0	15.0	\$58,767
	Custom - Submetering	22,016	3	1.00	1.00	22,016	3	8.0	8.0	\$34,210
	Delamping without Reflectors (8' Lamp)	18,729	3	1.00	1.00	18,665	3	14.0	14.0	\$49,510
	Transformer (Three-Phase)-Tier 1-75-kVA	17,179	2	1.00	1.00	17,179	2	32.0	15.0	\$45,773
	HVAC-Heat Pump-Packaged (P)-Air Cooled	16,046	4	1.00	1.00	15,992	4	15.0	15.0	\$52,306
	Pool Pump VFD	11,236	1	1.00	1.00	11,236	1	15.0	10.0	\$19,520
	VRF Outdoor - Small	10,900	3	1.00	1.00	10,900	3	15.0	9.0	\$23,432
	Transformer (Three-Phase)-Tier 1-45-kVA	9,508	1	1.00	1.00	9,508	1	32.0	15.0	\$25,313
	Transformer (Three-Phase)-Tier 1-112.5-kVA	9,199	1	1.00	1.00	9,199	1	32.0	15.0	\$24,352
	VFD Pool Pump	8,884	1	1.00	1.00	8,884	1	13.8	10.0	\$15,317
	VRF Outdoor - Large	6,873	2	1.00	1.00	6,873	2	15.0	9.0	\$14,769
	Transformer (Three-Phase)-Tier 1-30-kVA	6,869	1	1.00	1.00	6,869	1	32.0	15.0	\$18,301

Program	Measure	Tracked First-Year Net Energy Savings (kWh) (A)	Tracked First-Year Net Savings (kW) (B)	kWh Verified Ratio (C)	kW Verified Ratio (D)	Verified First-Year Net Savings (kWh) (E = A * C)	Verified First-Year Net Savings (kW) (F=B * D)	EUL - in Program-Tracking Database (G)	Verified EUL from TRM (H)	Verified Net TRB (I)
	LED--Energy Star approved hard wired recessed can retro kit--nondimmable	5,567	1	1.46	1.50	8,140	1	15.0	15.0	\$23,601
	LED Refrigerated Case Lighting-5' retrofit kit	4,995	1	1.00	1.00	4,978	1	5.0	5.0	\$4,472
	CFL (>26W)	4,391	0.5	1.00	1.00	4,376	0.5	3.0	3.0	\$2,116
	LED Refrigerated Case Lighting-6' retrofit kit	4,300	1	1.00	1.00	4,285	1	5.0	5.0	\$3,850
	Bounty - Refrigerator	4,289	0.2	1.00	1.00	4,289	0.2	14.0	14.0	\$9,146
	Cool Roof	3,168	1	1.00	0.50	3,168	1	10.0	15.0	\$9,851
	Heat Pump (ESTAR)	2,741	0.4	1.00	1.00	2,741	0.4	10.0	10.0	\$5,171
	Refrigerator - Trade In (Commercial)	2,034	0.1	1.00	5.18	2,034	0.4	14.0	14.0	\$6,065
	Transformer (Three-Phase)-Tier 1-150-kVA	1,917	0.2	1.00	1.00	1,917	0.2	32.0	15.0	\$5,100
	Delamping with Reflectors (2' Lamp)	1,737	0.3	1.00	1.00	1,731	0.3	14.0	14.0	\$4,866
	Window AC	1,321	0.4	1.00	1.00	1,321	0.4	12.0	9.0	\$2,832
	CFL (<16W)	827	0.2	1.00	1.00	825	0.2	3.0	3.0	\$399
	Ceiling Fan	759	0.1	1.00	1.00	759	0.1	5.0	5.0	\$695
	Reach-In Freezer-Solid Door-15<V<30 (1 Door)	724	0.1	1.00	1.00	724	0.1	12.0	12.0	\$1,556
	Transformer (Three-Phase)-Tier 1-15-kVA	690	0.1	1.00	1.00	690	0.1	32.0	15.0	\$1,857
	Whole House Fan	304	0.4	0.87	0.20	264	0.1	20.0	20.0	\$1,197
	Transformer (Single-Phase)-Tier 1-15-kVA	260	0.03	1.00	1.00	260	0.03	32.0	15.0	\$706

Program	Measure	Tracked First-Year Net Energy Savings (kWh) (A)	Tracked First-Year Net Savings (kW) (B)	kWh Verified Ratio (C)	kW Verified Ratio (D)	Verified First-Year Net Savings (kWh) (E = A * C)	Verified First-Year Net Savings (kW) (F=B * D)	EUL - in Program-Tracking Database (G)	Verified EUL from TRM (H)	Verified Net TRB (I)
	Solar Attic Fan	258	-	1.00	N/A	258	-	5.0	20.0	\$661
	Delamping without Reflectors (2' Lamp)	92	0.02	1.00	1.00	92	0.02	14.0	14.0	\$259
	Refrigerator	88	0.01	1.00	1.00	88	0.01	14.0	14.0	\$239
	Subtotal	53,269,643	5,452	1.00	0.98	53,097,776	5,357	15.0	14.5	\$132,510,537
Business Hard to Reach ^a	All Measures	8,564,037	1,573.4	1.00	1.00	8,564,037	1,573	13.7	13.7	\$22,175,191
Business Total		85,272,390	10,525	0.99	0.97	84,146,052	10,223	13.9	13.7	\$203,982,383

a. We did not perform any verification activities for the Business Hard to Reach program due to the relative contribution to the portfolio. We therefore “passed through” the tracked savings for this program.

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

Appendix C. Residential Sector Detailed Verification Savings Adjustments

This appendix provides detailed results from the verification of residential sector savings along with reasons for any differences identified between tracked and verified values. Table 5-14 shows Hawaii Energy’s tracked net savings for all residential programs, the verified savings, the verified savings as a percent of tracked savings and the reasons for the differences in savings. We discuss any significant differences between tracked and verified values (e.g., incorrect deemed value applied, database error) in the final “Reasons for Differences” column of Table 5-14. Table 5-14 is sorted to show savings as a percent of total sector savings from high to low within each program. This order facilitates an understanding of the contribution of the measure level verified savings to the overall sector verified savings.

Table 5-14. PY2016 Residential Sector Verified Savings by Program and Measure

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Energy Savings (kWh)	Verified Savings as % of Tracked Savings	Verified Program Savings as % of Total Verified Residential Savings	Reasons for differences between Tracked and Verified Values
Residential Energy Efficiency Measures	Residential LED	26,994,296	26,994,296	100.0%	47.9%	N/A
	Peer Comparison	14,984,156	15,867,314	105.9%	28.2%	Tracked savings use slightly different methodology for applying savings to participants.
	CFL	4,285,473	4,209,847	98.2%	7.5%	Tracked savings applied savings per the PY2015 TRM (17 kWh/lamp) while verified savings applied savings per the PY2016 TRM (16.7 kWh/lamp)
	Solar Hot Water Heater	2,278,316	2,278,316	100.0%	4.0%	N/A
	Refrigerator - Trade In	1,605,354	1,605,354	100.0%	2.8%	N/A
	VRF Outdoor - Small	1,361,328	1,361,328	100.0%	2.4%	N/A
	VRF Outdoor - Large	754,729	754,729	100.0%	1.3%	N/A
	TV	481,758	481,758	100.0%	0.9%	N/A
	Basic Energy Kit - Online - LED	200,240	200,240	100.0%	0.4%	N/A
	Bounty - Refrigerator	153,614	153,614	100.0%	0.3%	N/A
	Heat Pump (ESTAR)	152,325	152,325	100.0%	0.3%	N/A

Program	Measure	Tracked First-Year Net Energy Savings (kWh)	Verified First-Year Net Energy Savings (kWh)	Verified Savings as % of Tracked Savings	Verified Program Savings as % of Total Verified Residential Savings	Reasons for differences between Tracked and Verified Values
	Whole House Fan	132,524	115,096	86.8%	0.2%	Tracked savings applied savings per the PY2015 TRM (365 kWh/fan and 0.5 kW/fan) while verified savings applied savings per the PY2016 TRM (317 kWh/fan and 0.1 kW/fan)
	VFD Pool Pump	89,927	89,927	100.0%	0.2%	N/A
	Advanced Energy Kit - Online-Smart strip	62,103	62,103	100.0%	0.1%	N/A
	Window AC	62,059	62,059	100.0%	0.1%	N/A
	Sound bar	39,625	39,625	100.0%	0.1%	N/A
	Low Flow Showerhead	35,305	35,294	100.0%	0.1%	N/A
	Solar Attic Fan	27,511	27,511	100.0%	0.05%	N/A
	Bounty - Freezer	25,609	25,609	100.0%	0.05%	N/A
	Kitchen Aerator	16,406	16,406	100.0%	0.03%	N/A
	Bathroom Aerator	16,406	16,406	100.0%	0.03%	N/A
	Ceiling Fan	7,230	7,230	100.0%	0.01%	N/A
	Refrigerator	828	828	100.0%	0.001%	N/A
	Subtotal	53,767,121	54,557,215	101.5%	96.8%	N/A
Residential Hard to Reach ^a	All Measures	1,023,996	1,023,996	100.0%	1.8%	N/A
Residential Energy Services and Maintenance ^a	All Measures	752,885	752,885	100.0%	1.3%	N/A
All Residential - Total		55,544,003	56,334,096	101.4%	100.0%	N/A

a. We did not perform any verification activities for the Residential Hard to Reach and Residential Energy Services and Maintenance programs due to their relative contribution to the portfolio. We therefore “passed through” the tracked savings for these programs.

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

Appendix D. Residential Sector Total Resource Benefits

This appendix provides detailed results from the verification and calculation of verified net TRB for the residential sector. Table 5-16 shows Opinion Dynamics' independent estimate of savings for residential programs and measures, ordered by tracked first-year net savings (high to low) within programs.

We calculated TRB estimates using the Excel algorithms in Equation 2 and parameters in Table 5-15. These algorithms are based on the California Standard Practice Manual.

Equation 2. TRB Calculation Excel Algorithms

$$\text{TRB} = \text{kWh TRB} + \text{kW TRB}$$

$$\text{kWh TRB} = [\text{First-Year of Avoided Cost} + \text{NPV}(\text{Discount Rate, Avoided Supply Costs, EUL-1})] \\ * \text{Verified First-Year Net kWh Savings} * \text{Line Losses}$$

$$\text{kW TRB} = [\text{First-Year of Avoided Cost} + \text{NPV}(\text{Discount Rate, Avoided Supply Costs, EUL-1})] \\ * \text{Verified First-Year Net kW Savings} * \text{Line Losses}$$

Table 5-15. TRB Parameters and Sources

Variable	Value	Source
Discount Rate	6%	PBFA and PY2016 TRM.
Avoided Costs	Varies	PBFA and PY2016 TRM.
EUL (effective useful life)	Varies by measure	PY2016 TRM
First-Year Net Savings	Verification of Savings	Opinion Dynamics
Line Losses	N/A	Not included in this analysis as the scalar is embedded in net savings per the PY2016 TRM.

Table 5-16. PY2016 Residential Sector Verified Participation and Savings by Program and Measure

Program	Measure	Tracked First-Year Net kWh Savings (A)	Tracked First-Year Net kW Savings (B)	kWh Verification Ratio (C)	kW Verification Ratio (D)	Verified First-Year kWh Savings (E = A * C)	Verified First-Year kW Savings (F=B * D)	EUL - Useful Life in Program Tracking DB (G)	Verified EUL - Useful Life from TRM (H)	Verified Net TRB (I)
Residential Energy Efficiency Measures	Residential LED	26,994,296	3,839	1.00	1.00	26,994,296	3,839	15.0	15.0	\$75,682,863
	Peer Comparison	14,984,156	1,710	1.06	3.09	15,867,314	5,289	1.0	1.0	\$2,631,277
	CFL	4,285,473	605	0.98	1.00	4,209,847	605	6.0	6.0	\$4,782,276
	Solar Hot Water Heater	2,278,316	509	1.00	1.00	2,278,316	509	20.0	20.0	\$9,013,026
	Refrigerator - Trade In	1,605,354	66	1.00	1.00	1,605,354	66	14.0	14.0	\$3,436,734
	VRF Outdoor - Small	1,361,328	374	1.00	1.00	1,361,328	374	15.0	9.0	\$2,926,442
	VRF Outdoor - Large	754,729	207	1.00	1.00	754,729	207	15.0	9.0	\$1,621,738
	TV	481,758	58	1.00	1.00	481,758	58	6.0	6.0	\$531,311
	Basic Energy Kit - Online - LED	200,240	28	1.00	1.00	200,240	28	15.0	15.0	\$561,406
	Bounty - Refrigerator	153,614	6	1.00	1.00	153,614	6	14.0	14.0	\$327,523
	Heat Pump (ESTAR)	152,325	19	1.00	1.00	152,325	19	10.0	10.0	\$287,347
	Whole House Fan	132,524	182	0.87	0.20	115,096	36	20.0	20.0	\$521,319
	VFD Pool Pump	89,927	1	1.00	1.00	89,927	1	10.0	10.0	\$134,499
	Advanced Energy Kit - Online Smart strip	62,103	7	1.00	1.00	62,103	7	5.0	5.0	\$53,745
	Window AC	62,059	17	1.00	1.00	62,059	17	12.0	9.0	\$133,085
	Sound bar	39,625	2	1.00	1.00	39,625	2	7.0	7.0	\$45,949
	Low Flow Showerhead	35,305	-	1.00	N/A	35,294	-	5.0	5.0	\$27,654
	Solar Attic Fan	27,511	-	1.00	N/A	27,511	-	5.0	20.0	\$70,419
	Bounty - Freezer	25,609	1	1.00	1.00	25,609	1	14.0	14.0	\$54,601

Program	Measure	Tracked First-Year Net kWh Savings (A)	Tracked First-Year Net kW Savings (B)	kWh Verification Ratio (C)	kW Verification Ratio (D)	Verified First-Year kWh Savings (E = A * C)	Verified First-Year kW Savings (F=B * D)	EUL - Useful Life in Program Tracking DB (G)	Verified EUL - Useful Life from TRM (H)	Verified Net TRB (I)
	Kitchen Aerator	16,406	-	1.00	N/A	16,406	-	5.0	5.0	\$12,854
	Bathroom Aerator	16,406	-	1.00	N/A	16,406	-	5.0	5.0	\$12,854
	Ceiling Fan	7,230	1	1.00	1.00	7,230	1	5.0	5.0	\$6,620
	Refrigerator	828	0.1	1.00	1.00	828	0.1	14.0	14.0	\$2,259
	Subtotal	53,767,121	7,633	1.01	1.45	54,557,215	11,068	10.4	10.1	\$102,877,801
Residential Hard to Reach ^a	All Measures	1,023,996	343	1.00	1.00	1,023,996	343	6.0	6.0	\$1,211,909
Residential Energy Services and Maintenance ^a	All Measures	752,885	78	1.00	1.00	752,885	78	3.9	3.9	\$495,788
Residential Total		55,544,003	8,054	1.01	1.43	56,334,096	11,488	10.3	9.9	\$104,585,498

a. We did not perform any verification activities for the Residential Hard to Reach and Residential Energy Services and Maintenance programs due to their relative contribution to the portfolio. We therefore “passed through” the tracked savings for these programs.

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

Appendix E. Differences Between PY2015 and PY2016 Hawaii TRM

Throughout the PY2016 verification process, Opinion Dynamics documented any differences that we found between the PY2015 and PY2016 TRMs. There are two main categories of issues found:

1. Differences between deemed savings assumptions or EULs at the measure level (Table 5-17)
2. Missing sections in the PY2016 TRM that previously appeared in the PY2015 TRM (Table 5-18)

We summarize these differences in the two tables below.

Table 5-17. Differences in Deemed Savings Assumptions or EULs

PY2016 TRM Section Number	PY2016 TRM Section Name	PY2016 Page	Description of Difference or Issue	Notes and Recommendations for Hawaii Energy
Section 3	Common Tables (Table 3.1)	6	There are two issues with Table 3.1: 1. Table 3.1, and the assumed hours for linear fluorescent lighting and CFLs did not exist in the PY2015 TRM. 2. The LED hours of use in Table 3.1 are inconsistent with the values in Table 4.6.5.d of the PY2016 TRM for seven of the building types. We believe this is due to a transcription error as it appears they are off by one row between the two tables.	Opinion Dynamics used Table 4.6.5.d (consistent with tracked calculations) for the PY2016 verification as we believe the values in it are correct and consistent with the PY2015 TRM. We recommend updating Table 3.1 to align with all other tables in the PY2016 TRM as applicable. Additionally, provide clarification on the use of the hours for linear fluorescent lighting and CFLs and sources.
Section 4.6.5	Non-Linear LED Lamps	90	The PY2015 TRM provided deemed savings for dimmable and non-dimmable LED lamps while the PY2016 TRM developed a blended value applicable to both types of LEDs. The PY2015 TRM also provided two sets of deemed values for PAR20 bulbs (8 degrees and 25 degrees) while PY2016 TRM provides a combined value for all PAR20 LEDs.	This proposed change by Hawaii Energy was reviewed by Opinion Dynamics and we provided a memo summarizing our recommendation to move forward with this change on June 26, 2017.
Section 4.7.2	Transformer	124	Measure life in PY2016 TRM is 15 years instead of 32 years per the PY2015 TRM.	Tracked savings applied the PY2015 EUL while verified savings applied the PY2016 EUL. Provide reasoning and source behind difference between TRM versions.

PY2016 TRM Section Number	PY2016 TRM Section Name	PY2016 Page	Description of Difference or Issue	Notes and Recommendations for Hawaii Energy
Section 5.3.1	Window AC & VRF AC	177	Measure life in PY2016 TRM is 9 years instead of 15 years per the PY2015 TRM. Deemed values are specified as savings/ton, but they are savings/unit and already account for system capacity.	Tracked savings applied the PY2015 EUL of 15 to VRF measures and an EUL of 12 to window AC measures while verified savings applied PY2016 EUL throughout. Apply deemed savings per unit installed. Clarify in measure descriptions that savings are per unit and not per ton to avoid confusion.
Section 5.3.6	Whole House Fan	190	Energy and demand savings changed between the PY2015 and PY2016 TRM. Energy savings went from 365 kWh/year to 317 kWh/year while demand savings went from 0.50 kW to 0.10 kW per fan.	These changes are in addition to the change in operating hours that Opinion Dynamics reviewed and accepted pending further documentation as part of our review of proposed PY2016 TRM changes summarized in our memo on June 7, 2016. We recommend providing clarification and supporting documentation as to what caused this additional change.
Section 5.4.1	Residential Compact Fluorescent Lamp	194	In Table 5.4.1.d, the deemed kWh savings has duplicate names, but varying deemed kWh values.	The second value (25 kWh) should be labeled as military.
Section 5.8.2	Peer Group Comparison	222	The PY2015 TRM methodology relies on actual billed energy usage of participants for determining savings. PY2016 TRM methodology includes an average deemed billed energy consumption per customer per year assumption that is not well sourced. The PY2015 TRM assumes an EUL of 1 year, while the PY2016 TRM assumes an EUL of 15 years.	Opinion Dynamics relied on the PY2016 methodology for the PY2016 verification. We also leveraged the PY2015 EUL of 1 year rather than 15 years as 15 years is unreasonable for this type of program.

The second category of issues pertain to missing sections in the PY2016 TRM that appeared in the PY2015 TRM.

Table 5-18. Missing Sections in PY2016 TRM

PY2015 Section Number	PY2015 Section Name	PY2015 Page	Notes
2	Gross Customer to Net Program Savings	6	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.

PY2015 Section Number	PY2015 Section Name	PY2015 Page	Notes
3	Interactive Effects	7	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.
4	Persistence	8	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.
5	Glossary	9	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.
6	Load Shapes and Demand Coincidence factors	10	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.
7	Total Resource Benefits	11	Per discussions with Hawaii Energy, it appears that this section was inadvertently left out of the PY2016 TRM.
8	Effective Useful Life	12	PY2016 includes EUL at measure level. EUL Discrepancies found at the measure level are summarized in the Table 5-17.
10.6.1	Home Energy Savings Kits	64	This measure and the associated deemed savings is missing from the PY2016 TRM. We recommend providing this measure in the next version of the TRM and updating the methodology to transparently document all supporting equations and assumptions for the various measures contained within the kit.

Appendix F. Glossary of Terms

Table 5-19. Glossary of Terms Used in this Memo

Term	Abbreviation	Definition
Claimed	N/A	Information drawn from the PY2016 Hawaii Energy Annual Report. Usually refers to energy savings or achieved performance indicators.
Deemed	N/A	Energy or demand savings for a measure that the PUC and PBFA agree to prior to the beginning of a program year, typically contained within the Hawaii TRM.
Effective Useful Life	EUL	The point in time when half of the measures installed in the first-year of a program are still in place and operating. The EUL is a mathematical artifact that allows for easier calculation of benefits from an energy efficiency program.
Technical Resource Manual	TRM	<i>Herein referring to the TRM used in Hawaii.</i> A document that provides the algorithms and background information for each non-custom measure included in the Hawaii Energy portfolio. Typically updated annually by the PBFA, this document is the source of deemed per-unit savings, EUL, and NTGR values.
Net-To-Gross-Ratio	NTGR	A value that accounts for the energy savings attributable to program actions. Typically, between zero and one, a NTGR can go over one if the program causes savings to occur outside of the program, but because of the program.
Program-tracking Database	N/A	The database maintained by the PBFA and used to track Hawaii Energy program activity and participant information.
Public Benefits Fee Administrator	PBFA	The third-party consultant hired by the Hawaii Public Utilities Commission to implement the Hawaii Energy suite of programs.
Total Resource Benefits	TRB	Utility avoided costs from the lifecycle energy and demand savings.
Tracked	N/A	Information calculated directly from the revised “frozen” PY2016 program-tracking database as received on October 13, 2017 or from supporting project documentation.
Verified	N/A	Program verification occurs through activities undertaken by Opinion Dynamics to assure that planned program activities occurred and that measures are in place and operating, and therefore able to save energy as expected.
Verification Rate	N/A	The verification rate derives from post-verification savings values divided by savings values in the program-tracking database.