



HAWAI'I ENERGY: HISTORY OF ANNUAL EM&V-RELATED RESEARCH

Program Year 2009 through Calendar Year 2018

Impact, cost-effectiveness, market, potential, process and related evaluations

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HAWAII PUBLIC UTILITIES COMMISSION

Energy Solutions. Delivered.

Program Year 2017 through Calendar Year 2018 work performed by

Applied Energy Group, Inc.
500 Ygnacio Valley Blvd., Suite 250
Walnut Creek, CA 94596

Project Director &

Potential Study Lead: I. Rohmund

Project Manager &

TRM Update Lead: K. Parmenter

EEPS Research Lead: K. Marrin

Baseline Study Lead: D. Lineweber

With support from

Tetra Tech
6410 Enterprise Lane, Suite 300
Madison, WI 53719

Verification Lead: R. Hasselman

TRM Framework Lead: S. Hanson

in consultation with the Hawaii Public Utilities Commission

PBF Contracts Administrator: D. Won

Senior Staff Oversight: D. Parsons

EE Program Manager: A. Norman

and the Energy Efficiency Manager team

Project Team Lead: T. Pope

PBF EM&V Lead: S. Schiller

EEPS/Baseline/Potential Lead: C. Dickerson

EEPS Review Support: J. Fox

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- Evergreen Economics, EM&V Contractor, PY2009-PY2013
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INTRODUCTION

This report provides a summary-level description of all Evaluation, Measurement and Verification (EM&V) research completed in each program year (PY) from the inception of Hawai'i Energy in PY2009 through PY2017. It also includes additional EM&V research activities completed through calendar year (CY) 2018. Each of the past Annual EM&V Reports¹ was carefully reviewed to identify both ongoing and unique research efforts. Related reports including, but not limited to, the most recent potential and market characterization studies and customer research and satisfaction studies were also reviewed. The outcome of the review, synthesis, and analysis documented in this report includes the following:

- Tables that summarize each research activity for each PY by sector (e.g. Residential, Business).
- A brief description of each research activity for each PY identified in the summary tables. This will allow the reader to not only see when a given research activity was executed (in what PYs) but also easily review the associated description for each PY.

¹ Reports referenced within this document are available at www.hawaienergy.com/about/information-reports

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EM&V RESEARCH ACTIVITY BY PROGRAM YEAR

The table on the following page provides a summary of the EM&V research activities completed for each PY. Appendix A provides a high-level definition of each research activity presented in the table. The subsequent sections include a brief description of all EM&V-related research for each PY, including a table that illustrates whether the research was completed for the residential sector, business sector, or both.

Table 2-1 EM&V Research Activities - Residential and Business

			All PYs	PY2009	PY2010	PY2011	PY2012	PY2013	PY2014	PY2015	PY2016	PY2017
Impact	TRM Review	Technical Reference Manual (TRM) Review		✓	✓	✓	✓					✓
		TRM Recommendations Review				✓	✓		✓	✓	✓	✓
		Major TRM Update					✓ ²					✓
		TRM Framework										✓
	Verification	Database Review	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Application of TRM Values	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Application and Invoice Review			✓	✓	✓		✓	✓	✓	✓
		Engineering Desk Review	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		On-Site Verification		✓	✓	✓	✓		✓	✓		✓
		Upstream Lighting Review	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Peer Comparison Billing Data Review						✓	✓	✓	✓	✓
		Market Transformation Verification					✓	✓	✓	✓		✓
		Customer Satisfaction Verification										✓
		Total Resource Benefits (TRB) Calculations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Verification of Award Claim, Island Equity Calculations		✓	✓	✓			✓	✓	✓	✓
	Other	Net-to-Gross (NTG) Assessment				✓						✓
		Integrated Building Design and Construction Standards Verification						✓				
		Small Business Direct Install Lighting (SDBIL) Verification						✓				
		Peer Group Comparison Control Group Analysis				✓						
		Solar Water Heating Billing Analysis			✓							
		Condominium Sub-metering Analysis					✓	✓				
		Energy Efficiency Portfolio Standard (EEPS) Review Research						✓				✓
		Peer Program Incremental Savings Approach										✓
		NTG and Baseline Approach										✓
		LED Lifetime Savings										✓
Process		Participant Surveys		✓	✓	✓	✓	✓				
		Non-participant Surveys		✓								
		Trade Ally Interviews		✓	✓		✓					
		Focus Group Data Collection			✓							
Market Assessment		Market Assessment Evaluation		✓	✓							
		Baseline Study						✓				✓
		Potential Study		✓	✓			✓				✓
		Food Service Sector Market Assessment					✓					
		Upstream Lighting Program Analysis				✓	✓	✓				
Other Studies		Non-Energy Benefits Literature Review				✓						
		Economic Impact Analysis			✓							
		Energy Efficiency Study		✓	✓							

² The EM&V Contractor conducted a major TRM review in PY2012, which led to considerable TRM updates.

Table 2-1 *EM&V Research Activities - Residential and Business*

		All PYs	PY2009	PY2010	PY2011	PY2012	PY2013	PY2014	PY2015	PY2016	PY2017
Other Studies	New Initiatives and Pilot Program Analysis			✓							
	Hours of Use Inputs for Key C&I Programs									✓	
	Potential Overlap Between Key C&I Programs									✓	
	Comprehensive Longitudinal Effects (CLE) Study									✓	
	History of Hawaii Building Energy Codes							✓			
	Hawai'i Energy Awareness Study								✓		
	Historic Participation Analysis								✓		
	History of Annual EM&V-Related Research		✓	✓						✓	✓

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EM&V RESEARCH BY PROGRAM YEAR & SECTOR

The subsections below provide a brief description of each EM&V research activity for each program year.

3.1 PY2009 EM&V Research

Table 3-1 presents the residential and business research activities completed by the EM&V Contractor in PY2009.³

Table 3-1 EM&V Research Activities – PY2009

			PY2009	
			Residential	Business
Impact	TRM Review	TRM Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review		✓
		Engineering Desk Review		✓
		On-Site Verification	✓	✓
		Upstream Lighting Review	✓	
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
Process		Participant Surveys	✓	✓
		Non-participant Surveys	✓	✓
		Trade Ally Interviews	✓	✓
Market Assessment		Market Assessment Evaluation	✓	✓
		Potential Study	✓	✓
Other Studies		Energy Efficiency Study	✓	✓
		History of Annual EM&V-Related Research	✓	✓

3.1.1 TRM Review

TRM Review

The EM&V Contractor reviewed the TRM and compared the savings values against other sources such as those in other jurisdictions and research documentation from KEMA (the EM&V contractor that evaluated the HECO utilities' prior energy efficiency programs), the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the National Renewable Energy Laboratory (NREL), and other organizations. The EM&V Contractor examined not only the derived deemed savings values, but also assumptions regarding operating conditions and baseline equipment, and the reasonableness of the supporting documentation (e.g., effective useful life (EUL) and system loss factor (SLF)) when compared to available sources and findings from other utility programs.

The EM&V Contractor did not make any recommendations for changes for Program Year 2009 but recommended changes for Program Year 2010.

³ PY2009 EM&V research activities compiled using information from:
 Program Year 2009 EM&V Verification Report. "Evaluation of the Hawai'i Energy Conservation and Efficiency Programs. Program Year 2009." Volume 1 of 2: Main Report. Prepared by Evergreen Economics. Prepared for Hawaii Public Utilities Commission. March 31, 2011.
https://hawaiienergy.com/images/resources/EMV_ProgramYear2009_VerificationReport.pdf.

3.1.2 Verification

Database Review

The EM&V Contractor confirmed that the claimed savings and measure installation counts in the PY2009 Hawai'i Energy Annual Report matched the total savings and measure counts in the PY2009 program-tracking database.

Application of TRM Values

The EM&V Contractor confirmed that the per-unit savings values for each measure in the program-tracking database mirror the approved (deemed) values in the PY2009 TRM.

Application and Invoice Review

The EM&V Contractor reviewed business project files associated with claimed measures to verify measure counts and program eligibility. The EM&V Contractor checked data in the program-tracking database against participants' rebate applications, purchase invoices and post-inspection forms.

Engineering Desk Reviews

The EM&V Contractor conducted technical engineering desk reviews based on electronic project files such as vendor records and equipment invoices. The engineering desk reviews verified the accuracy of original calculations and determined if the customer's actual operation was consistent with program assumptions. Additionally, the review ensured consistency, accuracy, and whether the measure or project met program requirements. Key pieces of information such as invoices, equipment specifications, descriptions from customers, project applications, and any calculations were reviewed to ensure that the savings were accurate and consistent with program-tracking data.

On-Site Verification

The EM&V Contractor conducted on-site verification visits for a sample of residential and non-residential facilities to confirm that the measures were installed, that they qualified for the Program, and were operational. During the on-site visits, the EM&V Contractor recorded the quantity of installed equipment verified by inspection and equipment specifications. These two pieces of information were used to ensure that the installed equipment was consistent with the information presented in the application and the program-tracking database and met Program requirements.

Upstream Lighting Review

For the upstream lighting measures in REEM, the EM&V Contractor conducted site visits and invoice audits to verify that CFLs sold through the upstream REEM program component were Program-qualifying, and to collect pricing information on bulbs. The research focused on participating manufacturers, distributors and retailers.

- Lighting retailer site visits. The EM&V Contractor visited 14 retail stores across Oahu, Maui, and Hawaii for a sample of participating lighting retailers to verify that the stores met the requirements of the Memorandum of Understanding (MOU).
- CFL retailer invoice audit. The EM&V Contractor reviewed a sample of invoices from lighting retailers to ensure that the information in the database matched the invoices and to verify that the stores met the requirements of the Program participation agreement. Store name, stock-keeping unit (SKU) number, and number of packages from the program-tracking database were compared to the information on the invoices. The EM&V Contractor then compared the SKU numbers with a list of ENERGY STAR certified CFLs, as reported on the ENERGY STAR website.

Total Resource Benefits Calculations

A separate verification was conducted for the net Total Resource Benefit (TRB) presented in the PY2009 Annual Report. Using verified net savings (kW and kWh) and approved measure effective useful lives (EULs) given in the TRM, the EM&V Contractor replicated the TRB calculations described in the PY2009 Annual Report.

Verification of Award Claim, Island Equity Calculations

The Hawaii Public Utilities Commission (HPUC) sets performance goals and incentives for Hawai'i Energy to achieve. Verified savings were used to evaluate how well the Program is meeting its goals to distribute benefits across islands in a manner deemed equitable by the HPUC.

3.1.3 Process

Participant Surveys

The EM&V Contractor completed participant surveys for both residential and non-residential customers to verify that the customer received a rebate for a program measure, had installed the measure, and that the measure was still operable. The surveys also included batteries on process evaluation (e.g., customer satisfaction and program awareness) and market assessment (e.g., energy efficiency equipment saturation and energy efficiency awareness, behaviors, and attitudes).

Non-participant Surveys

The EM&V Contractor completed general population surveys using random digit dialing (including cell phones) for all residential type customers (e.g., renters, owners, individually metered, master-metered, military, and civilian). The residential survey included the following survey batteries:

- Home and household characteristics for demographics and market potential
- General energy efficiency awareness, attitudes, behaviors, and awareness of other Hawai'i Energy programs/campaigns
- CFL awareness, purchases, satisfaction, saturation, storage, and installations

Additionally, the EM&V Contractor completed non-residential, non-participant surveys to provide a snapshot of market conditions. The business survey included the following survey batteries:

- Account characteristics
- Participation in Hawai'i Energy and earlier programs
- Barriers to participation
- General and energy saving investment activity in last two years
- Plans for future investment
- Detailed invest in shell, cooling, motors and drives, lighting, air compressors, commercial cooking, pools, clothes washers, controls, process and other measures
- Investment criteria

Trade Ally Interviews

The EM&V Contractor completed in-depth interviews with participating and non-participating contractors across a variety of industries including lighting, HVAC, and solar water heating. The in-depth interviews provided data that supported the impact evaluation, process evaluation, and market assessment.

Feedback from the in-depth interviews provided insight into how the programs had been perceived by retailers. Additionally, the interviews revealed how utility customers think about investment in efficient equipment and how trade allies can be engaged to expand the market.

3.1.4 Market Assessment

Market Assessment Evaluation

The EM&V Contractor completed the following research activities to support the market assessment evaluation:

- General population surveys
- Non-residential non-participant surveys
- Contractor interviews
- Lighting and appliance retailer interviews
- Comprehensive review of energy efficiency potential studies and other secondary research

Potential Study

The EM&V Contractor compared program savings both by sector and by end-use to the achievable savings potential estimated by various studies conducted in Hawaii in the past several years, including:

- A 2004 study by Global Energy Partners (GEP) that estimated maximum achievable potential by 2019 by sector and end-use (the EM&V Contractor scaled these results to actual 2009 usage for comparison purposes)
- A 2010 study by Booz Allen Hamilton (BAH) that updated and expanded upon the study listed above, focusing on six sectors that account for 62% of Hawai'i Energy's usage

3.1.5 Other Studies

Energy Efficiency Study

The EM&V Contractor reviewed several studies that were conducted at the national, state, or regional level on initiatives outside of Hawaii to update their understanding of national energy efficiency market conditions, including:

- Energy Star appliance sales figures by state from the U.S. Environmental Protection Agency (EPA)
- National CFL market profiles. Annual D&R International profile of the CFL market, including sales and market share estimates
- Various CFL industry papers and studies. Key papers and studies on CFLs from the International Energy Program Evaluation Conference (IEPEC) and American Council for an Energy Efficient Economy (ACEEE) conferences, as well as recent evaluations conducted in California and the Northwest
- Rankings of state energy efficiency activities. Annual state "scorecards" prepared for ACEEE
- Program evaluation reports posted at calmac.org, energytrust.org, nwalliance.org, and neep.org
- Rebate levels from other regions from the Database of State Incentives for Renewables and Efficiency (DSIRE)

History of Annual EM&V-Related Research

The EM&V Contractor reviewed information regarding HECO utility programs operating in Hawaii prior to PY2009, including:

- 2001-2007 HECO Utilities Evaluations. Impact evaluations conducted every three years that provided independent estimates of program savings.
- 2008 Hawaii Integrated Resource Planning Document. Contains energy savings and energy efficiency equipment saturation estimates.

3.2 PY2010 EM&V Research

Table 3-2 presents the residential and business research activities completed by the EM&V Contractor in PY2010.⁴

Table 3-2 EM&V Research Activities – PY2010

			PY2010	
			Residential	Business
Impact	TRM Review	TRM Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review		✓
		On-Site Verification	✓	✓
		Upstream Lighting Review	✓	
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
	Other	Solar Water Heating Billing Analysis	✓	
Process		Participant Surveys	✓	✓
		Trade Ally Interviews	✓	✓
		Focus Group Data Collection	✓	✓
Market Assessment		Market Assessment Evaluation	✓	✓
		Potential Study	✓	✓
Other Studies		Economic Impact Analysis	✓	✓
		Energy Efficiency Study	✓	✓
		New Initiatives and Pilot Program Analysis	✓	✓
		History of Annual EM&V-Related Research	✓	✓

3.2.1 TRM Review

TRM Review

The EM&V Contractor reviewed the TRM and compared the savings values against other sources such as those in other jurisdictions and research documentation from KEMA (the EM&V contractor that evaluated the HECO utilities' prior energy efficiency programs), the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the National Renewable Energy Laboratory (NREL), and other organizations. The EM&V Contractor examined not only the derived deemed savings values, but also assumptions regarding operating conditions and baseline equipment, and the reasonableness of the

⁴ PY2010 EM&V research activities compiled using information from: Program Year 2010 EM&V Evaluation Report. "Evaluation of the Hawai'i Energy Conservation and Efficiency Programs". Program Year 2010. Volume 1 of 2: Main Report. Prepared by Evergreen Economics. Prepared for Hawaii Public Utilities Commission. April 18, 2012. https://hawaiienergy.com/images/resources/EMV_ProgramYear2010_EvaluationReport.pdf.

supporting documentation (e.g., effective useful life and system loss factor) when compared to available sources and findings from other utility programs.

Additionally, the EM&V Contractor offered recommendations for a small number of TRM values and suggested conducting further research for a few TRM values to improve accuracy and reliability.

3.2.2 Verification

Database Review

The EM&V Contractor confirmed the claimed savings and measure installation counts in the PY2010 Hawai'i Energy Annual Report matched the total savings and measure counts in the PY2010 program-tracking database.

Application of TRM Values

The EM&V Contractor confirmed that the per-unit savings values for each measure in the program-tracking database mirror the approved (deemed) values in the PY2010 TRM.

Application and Invoice Review

The EM&V Contractor reviewed invoices and related community-based organizations (CBO) paperwork for the Residential Low-Income (RLI) Program to verify that CFLs, showerheads, and smart strips were distributed appropriately to low-income customers. Because the documentation was incomplete, the EM&V Contractor developed recommendations for RLI CFL tracking for PY2011.

Engineering Desk Reviews

The EM&V Contractor conducted technical engineering desk reviews for large, custom, and non-residential military facility projects based on electronic project files such as vendor records and equipment invoices. The engineering desk reviews verified the accuracy of original calculations and determined if the customer's actual operation was consistent with program assumptions. Additionally, the review ensured consistency, accuracy, and whether the measure or project met program requirements. Key pieces of information such as invoices, equipment specifications, descriptions from customers, project applications, and any calculations were reviewed to ensure that the savings were accurate and consistent with program-tracking data.

On-Site Verification

The EM&V Contractor conducted on-site verification of participating business and residences to verify that the measures were installed, that they qualified for the Program, and were operational. During the on-site visits, the EM&V Contractor recorded the quantity of installed equipment verified by inspection and equipment nameplate information. These two pieces of information were used to ensure the installed equipment was consistent with the information presented in the application, and was Program qualifying. Additionally, the EM&V Contractor collected operational characteristics such as temperature set points, operating schedules, typical loading characteristics, baseline system equipment and baseline system operational details. This information was used to verify the accuracy of any original calculations and to determine if customer's actual operation was consistent with Program assumptions.

Upstream Lighting Review

For the upstream lighting measures in REEM, the EM&V Contractor conducted site visits and invoice audits to verify that CFLs sold through the upstream REEM program component were Program qualifying, and to collect pricing information on bulbs. This research focused on participating manufacturers, distributors and retailers.

- Lighting retailer site visits. The EM&V Contractor visited five retail stores in early 2011 to confirm that the Program-qualifying CFLs were being sold by participating retailers
- CFL retailer invoice audit. The EM&V Contractor reviewed a sample of invoices from lighting retailers to ensure that the information in the program-tracking database matched the invoices and to verify that the stores met the requirements of the Program participation agreement. Store name, stock-keeping unit (SKU) number, and number of packages from the program-tracking database were compared to the information on the invoices. They then compared the SKU numbers with a list of ENERGY STAR certified CFLs, as reported on the ENERGY STAR website.

Total Resource Benefits Calculations

A separate verification was conducted for the net TRB presented in the PY2010 Annual Report. Using verified net savings (kW and kWh) and approved measure EULs given in the TRM, the TRB calculations described in the PY2010 Annual Report were replicated.

Verification of Award Claim, Island Equity Calculations

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. Verified savings were used to evaluate how well the Program is meeting its goals to distribute benefits across islands in a manner deemed equitable by the HPUC.

Solar Water Heating Billing Analysis

The Solar Water Heating (SWH) billing analysis focused on the installation of residential SWH systems for PY2009 and PY2010. The final model used PY2010 as a control group to determine the savings realized by PY2009 participants. The EM&V Contractor developed a fixed effects billing regression model using monthly panel data to estimate changes in household electricity consumption between the baseline (pre-measure installation) and post-measure installation periods.

3.2.3 Process

Participant Surveys

The EM&V Contractor conducted surveys with residential and business Program participants to verify that customers received the rebate for a program measure, installed the measure, and that the measure was still operable. The survey also included questions related to process evaluation (e.g., customer satisfaction and program awareness) and market assessment (e.g., energy efficiency equipment saturation, energy efficiency awareness, behaviors, and attitudes).

Additionally, the EM&V Contractor conducted surveys to collect data on customer experiences with the Program including both residential and business Program participants, each of whom received Program rebates. The purpose of the surveys was to understand customer perspectives on key Program attributes. The surveys examined a variety of topics, including:

- Initial Program awareness
- Rebate satisfaction
- Motivation for reducing energy usage
- Reasons for installing SWH
- Effects of rebates on purchase cost
- Importance of rebate

- Knowledge of rebate
- Rebate impact on timing of purchases
- Influence of rebate on purchase of specific technologies

The EM&V Contractor compared year-over-year results to identify any differences. When possible, comparative results were visually displayed for both PY2009 and PY2010.

Trade Ally Interviews

The EM&V Contractor conducted in-depth interviews with trade allies across a variety of industries. The interviews included HVAC, SWH, and electric/lighting contractors along with representatives from manufacturers, distributors, builders, developers, and businesses involved in the industries. The objective of the in-depth interviews was to assess market perspectives on a set of specific research areas that included:

- Standard process evaluation issues (e.g., feedback on programs, satisfaction and suggestions for improvement)
- Changes in incentive levels
- Financing issues
- Bonus and stimulus offers
- Barriers to participation
- Outreach to targeted communities
- Prospects for new technologies and program ideas
- Feedback on new program offerings (e.g., awareness, participation, barriers, potential for savings and suggestions for improvement)
- Extent of spillover effects
- Program awareness
- Perception of program effectiveness
- Potential recommendations for program design improvements

The EM&V Contractor reviewed and summarized comments from the in-depth interviews. The assessment included a summary of trends found in the responses, with a review of how contractors perceive Hawai'i Energy and their preferences for changes to Program offerings and design in the future. Findings from in-depth interviews informed all aspects of the evaluation. Interviews with trade allies, contractors, and businesses provided insight into how the programs have been perceived and aided the assessment of the market, as they revealed how various stakeholders view incentives offered through each of the programs and think about investment in efficient equipment, as well as how trade allies can be engaged to expand the market.

Focus Group Data Collection

The EM&V Contractor conducted two 90-minute focus group sessions that were structured as a seminar style discussion with conversations lead by a moderator. The sessions were flexible to adapt to the dynamics presented by the group-setting format. This allowed for unanticipated topics of discussion, while retaining a focus on the following session objectives:

- **Contractor Background.** Obtain an overview of how these businesses operate, assess how familiar these contractors are with energy efficient lighting options, and assess the relative frequency with which energy efficiency is recommended to customers.
- **Hawai'i Energy Lighting Program Component.** Describe program component options to these contractors, solicit their feedback on specific elements of the program, assess current awareness levels and reasons for non-participation, identify what works well for their business model and what does not work as well.
- **Program Design Options.** Build upon what does, and does not, work with the current program design, and explore alternative program designs.

The EM&V Contractor reviewed and summarized comments from the focus group. The assessment included a summary of trends found in the responses, with a review of how contractors perceive Hawai'i Energy and their preferences for changes to Program offerings and design in the future. Findings from the focus groups informed all aspects of the evaluation. Focus group discussions helped the EM&V Contractor better understand the limited involvement of contractors in the direct install lighting program component and identify program design changes that may encourage future participation.

3.2.4 Market Assessment

Market Assessment Evaluation

The EM&V Contractor reviewed internal data and documentation and obtained feedback from Hawai'i Energy staff, Program participants, and other stakeholders. In particular, the EM&V Contractor completed the following research activities to support the market assessment evaluation:

- Participant phone surveys
- In-depth interviews with program staff and market actors
- Contractor focus groups
- Comprehensive review of energy efficiency potential studies and other secondary research
- Development of program theory and logic models
- Review of last year's general population and non-participant business customer surveys
- Geographic information system (GIS) analysis of program participation

Potential Study

The EM&V Contractor compared program savings both by sector and by end-use to the achievable savings potential estimated by various studies conducted in Hawaii in the past several years. The EM&V Contractor added the savings for PY2009 to those for the current year and estimated the cumulative percentage of first year savings to the potential that existed in PY2009 to better demonstrate the cumulative effect of two years of savings. This approach provides a rough measure of market penetration useful for indicating whether the Program allocated its resources effectively or whether it needed to shift its focus or assign more support for some markets and/or measures.

3.2.5 Other Studies

Economic Impact Analysis

Spending related to Program implementation, participation, and the reduction in spending due to reduced energy costs were used as inputs to a model that shows how these changes in spending affect the local

economy. Using data from Hawai'i Energy's Program tracking system, economic impacts were estimated for PY2010 for each county that had active Program participants. The EM&V Contractor measured the economic impacts using an input-output modeling framework and the Impact Analysis for Planning (IMPLAN) modeling software. This analysis measures Program impacts that accrue to each county as well as secondary spending impacts that spill over to other islands. Measured impacts include changes in output, wages, business income, employment, and indirect business taxes.

Energy Efficiency Study

The EM&V Contractor reviewed several studies that were conducted at the national, state, or regional level on initiatives outside of Hawaii to update their understanding of national energy efficiency market conditions, including the following:

- National CFL market profiles. Annual D&R International profile of the CFL market, including sales and market share estimates.
- Various CFL industry papers and studies. Key papers and studies on CFLs from the International Energy Program Evaluation Conference (IEPEC) and ACEEE conferences, as well as recent evaluations conducted in California and the Northwest.
- Rankings of state energy efficiency activities. Annual state "scorecards" prepared for ACEEE.
- Program evaluation reports. Reports on programs across the nation.
- Database of State Incentives for Renewables and Efficiency (DSIRE). Program descriptions, implementation plans and evaluation results for programs and pilots similar to those pilots fielded by Hawai'i Energy in the current program year.
- Individual utility websites. For information on similar programs and initiatives.

New Initiatives and Pilot Program Analysis

The EM&V Contractor analyzed Hawai'i Energy's new initiatives and pilot programs by focusing on two initiatives that were most like traditional pilot programs: Central Plant Optimization and Condo Sub-metering. To evaluate these two initiatives the EM&V Contractor did the following:

- Reviewed similar pilots and programs elsewhere
- Prepared a generic pilot/new initiative Program Theory Logic Model (PTLM) as well as several program-specific models
- Reviewed initiative participation
- Conducted interviews with Program staff
- Conducted interviews with pilot participants

History of Annual EM&V-Related Research

The EM&V Contractor reviewed information regarding HECO utility programs operating in Hawaii prior to PY2009, including:

- 2001-2007 HECO Utilities Evaluations. Impact evaluations conducted every three years that provided independent estimates of program savings.
- 2008 Hawaii Integrated Resource Planning Document. Contains energy savings and energy efficiency equipment saturation estimates.

3.3 PY2011 EM&V Research

Table 3-3 presents the residential and business research activities completed by the EM&V Contractor in PY2011.⁵

Table 3-3 EM&V Research Activities – PY2011

			PY2011	
			Residential	Business
Impact	TRM Review	TRM Review	✓	✓
		TRM Recommendations Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review		✓
		On-Site Verification		✓
		Upstream Lighting Review	✓	
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
	Other	Net-to-Gross Assessment	✓	✓
		Peer Group Comparison Control Group Analysis	✓	
Process		Participant Surveys	✓	✓
Market Assessment		Upstream Lighting Program Analysis	✓	
Other Studies		Non-Energy Benefits Literature Review	✓	✓

3.3.1 TRM Review

TRM Review

The EM&V Contractor conducted an independent review of the TRM. This review aided in developing an in-depth understanding of how the measure savings values were derived and in assessing the reasonableness of these values. The PY2011 TRM values were compared to a wide variety of industry sources such as program evaluations and market studies from across the nation. The EM&V Contractor provided recommendations and suggested conducting further research for a few PY2011 TRM values to improve accuracy and reliability. Recommendations included integrating the recommended changes from the prior TRM review conducted in PY2010, and increasing the EUL for business LEDs.

TRM Recommendation Review

Several recommendations were provided as part of the PY2010 evaluation in the initial review of the PY2011 TRM. The EM&V Contractor reviewed the PY2011 TRM to verify whether these recommendations were updated in the latest version of the TRM. There appeared to be a few recommendations made during the PY2010 evaluation that had not yet been incorporated in the TRM document. The EM&V Contractor noted that most of these recommendations pertain to measure eligibility or quantities, and not the algorithms.

⁵ PY2011 EM&V research activities compiled using information from: Program Year 2011 EM&V Evaluation Report. "Evaluation of the Hawai'i Energy Conservation and Efficiency Programs". Program Year 2011. Volume 1 of 2: Main Report. Prepared by Evergreen Economics. Prepared for Hawaii Public Utilities Commission. June 20, 2013. https://hawaiienergy.com/images/resources/EMV_ProgramYear2011_EvaluationReport.pdf.

3.3.2 Verification

Database Review

The EM&V Contractor confirmed the claimed savings and measure installation counts in the PY2011 Hawai'i Energy Annual Report matches the total savings and measure counts in the PY2011 program-tracking database.

Application of TRM Values

The EM&V Contractor confirmed that the per-unit savings values for each measure in the program-tracking database mirror the approved (deemed) values in the PY2011 TRM.

Application and Invoice Review

The EM&V Contractor conducted additional verification for CFLs distributed through the Residential Hard-to-Reach (RHTR) program and advanced power strips (APS) distributed through BEEM, REEM and RHTR programs. For PY2011, the verification included a thorough review of program documentation and verification of the number of measures claimed versus those listed in the hard copy documentation.

The CFL and APS verification for PY2011 was conducted in three parts:

- Checking compliance with the documentation requirements set forth by the Contract Manager in a memorandum dated October 5, 2011
- Verifying quantities of equipment between tracking spreadsheets, final program data, and the Annual Report
- Reviewing a sample of distribution logs from giveaway and exchange events, and comparing related quantities to the tracking spreadsheets

To check compliance with the documentation requirements, the EM&V Contractor reviewed the tracking spreadsheets and distribution logs for information such as receipts for equipment purchases, number and description of units given to third parties, number and description of units distributed to end users, and dates and nature of distribution events. After the review of documentation, they compared the quantities shown in the CFL and APS tracking spreadsheets to the quantities reflected in the Annual Report and the final Program data. Finally, the EM&V Contractor reviewed the sample of distribution logs from community events and compared the quantities logged on paper to the quantities reflected in the tracking spreadsheets.

Engineering Desk Reviews

The EM&V Contractor conducted technical engineering desk reviews for a sample of measures installed in business locations for CBEEM and large (> 100,000 kWh claimed savings) business projects from BEEM. The engineering desk reviews verified the accuracy of original calculations and determined if the customer's actual operation was consistent with program assumptions. Additionally, the review ensured consistency, accuracy, and whether the measure or project met program requirements. Key pieces of information such as invoices, equipment specifications, descriptions from customers, project applications, and any calculations were reviewed to ensure that the savings were accurate and consistent with program tracking data.

On-Site Verification

The EM&V Contractor conducted on-site verification for measures installed in business locations for CBEEM and large BEEM projects to verify that the measures were installed, that they qualified for the Program, and were operational.

The business on-site surveys also supported the engineering analyses performed on all custom measures. During the on-site visits, the quantity of installed equipment was verified by inspection, and equipment nameplate information was recorded. These two pieces of information were used to ensure the installed equipment was consistent with the information presented in the application, and was Program qualifying. Additionally, operational characteristics such as temperature set points, operating schedules, typical loading characteristics, baseline system equipment and baseline system operational details were collected. This information was used to verify the accuracy of any original calculations and to determine if customer's actual operation was consistent with Program assumptions.

Upstream Lighting Review

For the upstream lighting measures in REEM, the EM&V Contractor reviewed a sample of invoices to ensure that measure descriptions, savings, and quantities claimed matched the program-tracking database and the Annual Report. Additionally, they confirmed that the products are Program qualifying (e.g., matching the unique retail product number with the ENERGY STAR website).

Total Resource Benefits Calculations

A separate verification was conducted for the net TRB presented in the PY2011 Annual Report. Using verified net savings (kW and kWh) and approved measure EULs given in the TRM, the EM&V Contractor replicated the TRB calculations described in the PY2011 Annual Report.

Verification of Award Claim, Island Equity Calculations

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. Verified savings were also used to evaluate how well the Program is meeting its goals to distribute benefits across islands in a manner deemed equitable by the HPUC.

Net-to-Gross (NTG) Assessment

The NTG assessment was intended to help frame on-going discussions related to attribution (or NTG measurement) for demand-side management programs in Hawaii. Research activities included the following:

- An examination of secondary research and survey data from the first two years of Program evaluation
- Recommendations for revisions to NTG ratios as needed for the next program cycle

As part of PY2011 evaluation tasks, the EM&V Contractor developed a NTG Assessment Memo which provides an overview of why NTG is relevant, highlights how the regulatory treatment of NTG can impact the success of energy efficiency goals, and provides both near and long-term recommendations.

Peer Group Comparison Control Group Analysis

The EM&V Contractor conducted a review of the 2011 Peer Group Comparison (PGC) Program. The research methods consisted of two complementary analysis activities:

- A phone survey of 300 PGC participants and a control group (n=300) that solicited information on how the Home Energy Reports (HER) influenced energy usage

- A billing regression on a sample of participants and a control group to develop an independent estimate of energy savings

3.3.3 Process

Participant Surveys

The EM&V Contractor conducted surveys with residential and business Program participants to understand overall customer satisfaction as well as verify measure installation. They then compared this feedback to that received over the past two evaluation cycles to identify trends that warranted additional study. The surveys included questions to verify that the customer had received a rebate for a Program measure, installed the measure, and that the measure was still operable. Additionally, the customers provided insight into trends in Program-participant perspectives over time.

3.3.4 Market Assessment

Upstream Lighting Program Analysis

The EM&V Contractor conducted an annual analysis of the Upstream Lighting Program, offered as a component of the REEM program. This analysis provided insight into how the program adapted to the changing residential lighting market as LEDs gain market acceptance and make up an increasing share of rebated bulbs sold in Hawaii. The EM&V Contractor reviewed sales records for qualifying lighting measures (CFLs and LEDs) at participating retailers for the past three program years (PY2009-PY2011) to determine the number of qualifying measures sold through the program each year by lamp type and store type, as well as the relative distribution of rebate dollars.

3.3.5 Other Studies

Non-Energy Benefits Literature Review

The EM&V Contractor conducted a review of literature on non-energy benefits of energy efficiency programs. To narrow the focus of the review, the EM&V Contractor selected non-energy benefits based on the following criteria:

- Benefit is commonly found in the literature. The non-energy benefits selected were those that are most commonly considered in other jurisdictions and therefore most commonly addressed in the literature. This typically enabled them to find benefit estimates for both the residential and non-residential sectors, as well as for a range of different program types.
- Study included primary data collection. Studies that involved only a review of existing literature without conducting any additional primary data collection on non-energy benefits are not included in this review. These literature reviews tend to cite existing studies without conducting any analysis on the quality of studies being reviewed. In this manner, sub-standard studies can get cited repeatedly and eventually obtain an appearance of legitimacy that is not merited.
- Applicability to Hawaii. The non-energy benefits needed to be relevant for Hawaii to be included in the review. As a result, benefits relating to heating (e.g., reduced fire hazards) and similar impacts associated with cold weather were excluded from the final review.
- Estimates based on credible analysis methods. The review focused on studies that used the more commonly accepted approaches, as discussed below. However, while these approaches have seen widespread use, it is not necessarily true that researchers used them appropriately to produce credible estimates. The EM&V Contractor excluded those studies in which the analysis did not appear credible.

Based on the above criteria, the review focused on a subset of non-energy benefits that were among the most common studied in the literature and are applicable to Hawaii, including:

- Greenhouse gas (GHG) emissions reductions
- Improved occupant comfort
- Improved health and safety
- Reduced operation and maintenance costs
- Increased productivity

3.4 PY2012 EM&V Research

Table 3-4 presents the residential and business research activities completed by the EM&V Contractor in PY2012.⁶

Table 3-4 EM&V Research Activities – PY2012

			PY2012	
			Residential	Business
Impact	TRM Review	Major TRM Review	✓	✓
		TRM Recommendations Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	
		Engineering Desk Review		✓
		On-Site Verification		✓
		Upstream Lighting Review	✓	
		Market Transformation Verification	✓	✓
		Total Resource Benefits Calculations	✓	✓
	Other	Condominium Sub-metering Analysis	✓	
Process		Participant Surveys	✓	✓
		Trade Ally Interviews		✓
Market Assessment		Food Service Sector Market Assessment		✓
		Upstream Lighting Program Analysis	✓	

3.4.1 TRM Review

TRM Review

The EM&V Contractor conducted an independent review of the TRM. This review aided in developing an in-depth understanding of how the measure savings values were derived and in assessing the reasonableness of these values. The PY2012 TRM values were compared to a wide variety of industry sources such as program evaluations and market studies from across the nation. The EM&V Contractor provided recommendations and suggested conducting further research for a few PY2012 TRM values to improve accuracy and reliability. Recommendations included integrating the recommended changes from the prior TRM review conducted in PY2011, updating parameters to include Hawaii specific data, and adjusting savings for faucet aerators to be consistent with the literature.

⁶ PY2012 EM&V research activities compiled using information from:
 Program Year 2012 EM&V Evaluation Report. "Evaluation of the Hawai'i Energy Conservation and Efficiency Programs". Program Year 2012. Volume 1 of 2: Main Report. Prepared by Evergreen Economics. Prepared for Hawaii Public Utilities Commission. June 26, 2014.
https://hawaiienergy.com/images/resources/EMV_ProgramYear2012_EvaluationReport.pdf

TRM Recommendation Review

Several recommendations were provided as part of the PY2011 evaluation in the initial review of the PY2012 TRM. The EM&V Contractor reviewed the PY2012 TRM to verify whether these recommendations were updated in the latest version of the TRM. There appeared to be several recommendations made during the PY2011 evaluation that had not yet been incorporated in the TRM document. It should be noted that most of these recommendations pertain to measure eligibility or quantities, and not the algorithms. The EM&V Contractor developed a recommendation checklist to help clarify, expedite, and track any recommended changes to new measures and past recommendations that had not been implemented in the TRM.

3.4.2 Verification

Database Review

The EM&V Contractor confirmed that the claimed savings in the PY2012 Hawai'i Energy Annual Report matches the total savings in the PY2012 program-tracking database.

Application of TRM Values

The EM&V Contractor reviewed the savings calculations confirmed that the per-unit savings values for each measure in the program-tracking database mirror the approved (deemed) values in the PY2012 TRM.

Application and Invoice Review

The EM&V Contractor conducted additional verification for refrigerator trade-ins and advanced power strips (APS) distributed through the Residential Hard-to-Reach (RHTR) program. For PY2012, this RHTR verification included a thorough review of program documentation and verification of the number of measures claimed versus those listed in the hard copy documentation.

Engineering Desk Reviews

The EM&V Contractor conducted technical engineering desk reviews for a sample of measures installed in business locations for CBEEM and large (> 100,000 kWh claimed savings) business projects from BEEM. The engineering desk reviews verified the accuracy of original calculations and determined if the customer's actual operation was consistent with program assumptions. Additionally, the review ensured consistency, accuracy, and whether the measure or project met program requirements. Key pieces of information such as invoices, equipment specifications, descriptions from customers, project applications, and any calculations were reviewed to ensure that the savings were accurate and consistent with program-tracking data.

On-Site Verification

The EM&V Contractor conducted on-site verification for small and medium business projects completed through the BEEM, BESM and CBEEM) programs. They also conducted a sample of on-site surveys of measures installed in business locations for CBEEM and large (> 100,000 kWh claimed savings) BEEM projects. On-site verification confirmed that measures were installed, qualified for the Program, and were operational.

The on-site verification for business Programs also supported the engineering analyses performed on all custom measures. During the on-site visits, the quantity of installed equipment was verified by inspection, and equipment nameplate information was recorded. These two pieces of information were used to ensure the installed equipment was consistent with the information presented in the application, and to determine if it was Program qualifying. Additionally, the EM&V Contractor collected operational

characteristics such as temperature set points, operating schedules, typical loading characteristics, baseline system equipment and baseline system operational details. This information was used to verify the accuracy of any original calculations, and to determine if a customer's actual operation was consistent with Program assumptions.

Upstream Lighting Review

The EM&V Contractor conducted a separate verification of the CFLs and LEDs rebated through the upstream portion of the REEM Program. The CFL and LED verification for PY2012 was conducted in three parts:

- Checked compliance with participation requirements set forth by the Memorandum of Understanding (MOU) that all retailers are required to sign to participate in the program
- Verified quantities of equipment between invoice/rebate documentation, final program data, and the Hawai'i Energy PY2012 Annual Report
- Reviewed sample of CFL and LED model numbers to ensure that the rebated measures are program qualifying (e.g., matching the unique retail product numbers with the ENERGY STAR website)

Market Transformation Verification

The EM&V Contractor reviewed the Transformational Program Portfolio by completing the following four research activities:

- Reviewed existing literature on market transformation and gathered information about peer programs run by other organizations
- Conducted a review of the Transformational Program Portfolio, including a series of in-depth interviews with key program staff to better understand program objectives
- Completed an in-depth study of four specific Transformational Programs selected by the EM&V Contractor and approved by Hawai'i Energy
- Developed rough estimates of saving magnitudes for the programs

Total Resource Benefits Calculations

A separate verification was conducted for the net TRB presented in the PY2012 Annual Report. Using verified net savings (kW and kWh) and approved measure EULs given in the TRM, the TRB calculations described in the PY2012 Annual Report were replicated.

Condominium Sub-Metering Analysis

In PY2010, Hawai'i Energy began a Condominium Sub-Metering Pilot Program to offer rebates for the installation of sub-meters at previously master metered multifamily buildings. The EM&V Contractor conducted a billing analysis of the Condominium Sub-metering program. The research objectives included the following:

- Estimate savings associated with sub-metering projects completed in PY2011 and PY2012
- Determine whether an update to the TRM for this measure is necessary

The research methods consisted of two complementary analysis activities:

- A fixed effects billing regression on a sample of sub-metering projects to develop an independent estimate of energy savings

- A review of sub-metering savings found in other jurisdictions across the US and Canada

For purposes of the PY2012 cycle, condominium sub-metering was treated as a custom measure rather than a deemed savings measure. The billing analysis was used to verify savings (resulting in savings of 22.7 percent) rather than the TRM value of 10 percent.

3.4.3 Process

Participant Surveys

The EM&V Contractor conducted telephone surveys with residential and business Program participants to understand overall customer satisfaction as well as verify measure installation. Survey results were compared to that received over the past three evaluation cycles to identify related trends. In both residential and business participant surveys, respondents rated on a scale from 1 to 5 their overall satisfaction with the Program, where 1 is not at all satisfied and 5 is extremely satisfied. Measure verification questions confirmed that the participants received rebates for program measures, installed the measures, and that the measures were still operable.

Trade Ally Interviews

The EM&V Contractor conducted eight in-depth interviews with participating SBDIL contractors from six different companies, including those who work on projects in the food service sector, with the purpose of gaining insight into program operation and processes. Of these eight interviews, four were with owners (one was the lighting corporation owner, and three were owners/contractors), two lighting and electrical contractors (non-owners/employees), one rebate specialist and one sales rep (office employee).

3.4.4 Market Assessment

Food Service Sector Market Assessment

The EM&V Contractor conducted research on Hawaii's food service sector (including restaurants, retail food stores and groceries) to assess the potential for increasing energy efficiency efforts in this market, leveraging the baseline data collected (as part of the 2013 Baseline Study) and addressing recommendations made in the PY2011 evaluation report. The research activities included the following:

- In-depth interviews with program staff, trade allies in Hawaii and administrators of other successful food service programs outside of Hawaii
- Analysis of baseline energy savings data from the 2013 Baseline Study and the State of Hawaii Energy Efficiency Potential Study published in 2014 to identify potential for energy savings among Hawaii's food service businesses
- Review of the literature on food service energy efficiency programs

Upstream Lighting Program Analysis

The EM&V Contractor conducted an annual analysis of the Upstream Lighting Program, offered as a component of the REEM program. This analysis provided insight into how the program is adapting to the changing residential lighting market as LEDs gain market acceptance and make up an increasing share of rebated bulbs sold in Hawaii. The EM&V Contractor reviewed sales records for qualifying lighting measures (CFLs and LEDs) at participating retailers for the past four program years (PY2009-PY2012) to determine the number of qualifying measures sold through the program each year by lamp type and store type, as well as the relative distribution of rebate dollars.

3.5 PY2013 EM&V Research

Table 3-5 presents the residential and business research activities completed by the EM&V Contractor in PY2013.⁷

Table 3-5 EM&V Research Activities – PY2013

			PY2013	
			Residential	Business
Impact	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Engineering Desk Review		✓
		Upstream Lighting Review	✓	
		Peer Comparison Billing Data Review	✓	
		Market Transformation Verification	✓	✓
		Total Resource Benefits Calculations	✓	✓
	Other	Condominium Sub-metering Analysis	✓	
		Integrated Building Design and Construction Standards Verification		✓
		Small Business Direct Install Lighting (SDBIL) Verification		✓
		EEPS Review Research	✓	✓
Process		Participant Surveys	✓	✓
Market Assessment	Baseline Study		✓	✓
	Potential Study		✓	✓
	Upstream Lighting Program Analysis		✓	

3.5.1 Verification

Database Review

The EM&V Contractor confirmed that the total savings and measure installation counts in the PY2013 program-tracking database matched the claimed savings in the PY2013 Hawai'i Energy Annual Report.

Application of TRM Values

The EM&V Contractor confirmed that the per-unit savings values for each measure in the program-tracking database mirror the approved (deemed) values in the PY2013 TRM.

Engineering Desk Reviews

The EM&V Contractor conducted technical engineering desk reviews for a sample of measures installed in business locations for CBEEM and large business projects (from BEEM, BESM, and BHTR). The engineering desk reviews verified the accuracy of original calculations and determined if the customer's actual operation was consistent with program assumptions. Additionally, the review ensured consistency, accuracy, and whether the measure or project met program requirements. Key pieces of information such as invoices, equipment specifications, descriptions from customers, project applications, and any calculations were reviewed to ensure that the savings were accurate and consistent with engineering fundamentals.

⁷ PY2013 EM&V research activities compiled using information from: Program Year 2013 EM&V Verification Report. "Verification of Hawai'i Energy Program Year 2013 Programs". Memorandum. Prepared by Evergreen Economics. Prepared for Chris Ann Dickerson and Jim Flanagan. December 19, 2014. https://hawaiienergy.com/files/resources/PY13_HawaiiEnergyVerificationReport.pdf.

Upstream Lighting Review

The EM&V Contractor conducted a separate verification of the CFLs and LEDs rebated through the upstream portion of the REEM Program. The CFL and LED verification for PY2013 was conducted in three parts:

- Checked compliance with the participation requirements set forth by the MOU that all retailers are required to sign to participate in the program
- Verified quantities of equipment between invoice/rebate documentation, final program data, and the Hawai'i Energy PY2013 Annual Report
- Reviewed sample of CFL and LED model numbers to ensure that the rebated measures are program qualifying (e.g., matching the unique retail product numbers with the ENERGY STAR website).

Peer Comparison Billing Data Review

The EM&V Contractor conducted an independent calculation to verify savings claimed for the REEM Peer Group Comparison. The EM&V Contractor reviewed the entire Peer group comparison customer list for PY2013 and each participating household's electricity billing data for a full year before they began participating in the program to verify the savings found in the final program-tracking database, using the formula provided in the PY2013 TRM.

Market Transformation Verification

The EM&V Contractor reviewed market transformation program activities. The activities were grouped into the categories of Behavior Modification, Professional Development, and Technical Knowledge and Training. This research included a review of the activities in each category and online research to verify that each of the market transformation activities occurred as described in the Annual Report and during the PY2013 cycle.

Total Resource Benefits Calculations

A separate verification was conducted for the net TRB presented in the Annual Report. Using verified net savings (kW and kWh) and approved measure EULs given in the TRM, the TRB calculations described in the PY2013 Annual Report were replicated.

Condominium Sub-Metering Analysis

In PY2010, Hawai'i Energy began a Condominium Sub-Metering Pilot Program to offer rebates for the installation of sub-meters at previously master metered multifamily buildings. In addition to the verification activities, which determined the verified savings for Condominium sub-metering, the EM&V Contractor also conducted a billing analysis of 11 condominium sub-metering projects. The objective of this analysis was to estimate average kWh savings for PY2013 sub-metering projects and compare the savings estimate to the previously approved value in the TRM to inform prospective (i.e., PY2014 and forward) assessments of the savings associated with this measure.

Integrated Building Design and Construction Standards Verification

The EM&V Contractor conducted documentation review of all seven Integrated Building Design and Construction Standards projects rebated by RESM in PY2013. Due to the small number of RESM projects, 100% of the rebated projects were reviewed. The design projects were verified by comparing quantities and savings in the project documentation to the values recorded in the final tracking data. The documentation included a project summary, combined submittal workbook, results of any home energy

modeling and/or testing performed (e.g. air leakage reports, HERS ratings), certificates of occupancy, floor plans, and incentive applications.

Small Business Direct Install Lighting (SBDIL) Verification

The EM&V Contractor reviewed a sample of SBDIL inspection reports for projects rebated by BESM or BHTR in PY2013, including 21 BESM and 12 BHTR projects. For each SBDIL project in the sample, the EM&V Contractor compared the types and quantities of each measure in the program-tracking database to the types and quantities of SBDIL measures installed, per the inspection reports. The EM&V Contractor identified any discrepancies during and determined a verified measure quantity.

3.5.2 Process

Participants Surveys

The EM&V Contractor conducted telephone surveys with residential and business Program participants to understand overall customer satisfaction as well as verify measure installation. They then compared this feedback to that received over the past four evaluation cycles to identify related trends. In both residential and business participant surveys, respondents rated on a scale from 1 to 5 their overall satisfaction with the Program, where 1 is not at all satisfied and 5 is extremely satisfied. Measure verification questions confirmed that the participants received rebates for program measures, installed the measures, and that the measure were still operable.

3.5.3 Market Assessment

Baseline Study

This study presents the results of research conducted on behalf of the HPUC to assess key characteristics of buildings, appliances and equipment that use electricity in the Hawaiian Electric Companies' service territories providing a "baseline" from which to assess changes in the buildings, equipment, appliance, and use patterns over time. Study results informed the planning of future energy efficiency programs and supported a statewide energy efficiency potential study via the HPUC. The baseline data was used to enhance or update PBFA-funded energy efficiency programs and for planning other energy-related programs and policies in the state. These baseline data served as a reference point to monitor the effectiveness of program efforts or track progress toward energy efficiency and related goals. Finally, these baseline data were used by the Hawaiian Electric Companies for electricity load planning.

Potential Study

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

- Developed a thorough and independent assessment of the energy efficiency resources available to the State through the actions of entities that contributed savings toward EEPs goals using allowable measures and activities per the EEPs Framework
- Developed technical and economic potential estimates for 2013–2030 for benchmarking and future analyses by island
 - Annual kWh savings and peak savings (net and gross)
 - Reporting tables that convey the potential that was captured from 2009 through present, in addition to savings available in 2013 and beyond

- Provided guidance and insight regarding attainment of the EEPS goals based on the energy savings opportunities identified in the potential study and relative to the EEPS base year of 2008
- Provided estimates of available energy efficiency potential that can be used as a resource and included in IRP filings by the Hawaii electric utilities [Hawaiian Electric Company (HECO), Hawaii Electric Light Company (HELCO), Maui Electric Company (MECO) and Kauai Island Utility Cooperative (KIUC)]

Upstream Lighting Program Analysis

The EM&V Contractor conducted an annual analysis of the Upstream Lighting Program, offered as a component of the REEM program. This analysis provided insight into how the program is adapting to the changing residential lighting market as LEDs gain market acceptance and make up an increasing share of rebated bulbs sold in Hawaii. The EM&V Contractor reviewed sales records for qualifying lighting measures (CFLs and LEDs) at participating retailers for the past five program years (PY2009-PY2013) to determine the number of qualifying measures sold through the program each year by lamp type and store type, as well as the relative distribution of rebate dollars.

3.6 PY2014 EM&V Research

Table 3-6 presents the residential and business research activities completed by the EM&V Contractor in PY2014.⁸

Table 3-6 EM&V Research Activities – PY2014

			PY2014	
			Residential	Business
Impact	TRM Review	TRM Recommendations Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review		✓
		On-Site Verification		✓
		Upstream Lighting Review	✓	
		Peer Comparison Billing Data Review	✓	
		Market Transformation Verification	✓	✓
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
		Other Studies	History of Hawaii Building Energy Codes	✓

3.6.1 TRM Review

TRM Recommendations Review

The Hawai'i Energy Program implementation team reviewed the PY2012 TRM and recommended 44 updates to be included in the PY2014 TRM. The EM&V Contractor reviewed the PY2014 TRM to identify whether the 44 recommendations were integrated within the PY2014 TRM. This review recognized that of the 44 recommendations, 24 were fully integrated in the PY2014 TRM, 15 were not addressed, 1 was partially updated, and 4 require updates in future TRM versions.

⁸ PY2014 EM&V research activities compiled using information from: Program Year 2014 EM&V Verification Report. "Verification of Hawai'i Energy Program Year 2014 Programs". Memorandum. Prepared by Opinion Dynamics. Prepared for Chris Ann Dickerson and Jim Flanagan. March 16, 2016. https://hawaiienergy.com/files/resources/PY14_HawaiiEnergyVerificationReport.pdf

3.6.2 Verification

Database Review

For all programs except for CBEEM, the EM&V Contractor verified that the information in the program-tracking database was correct and free of errors. This process began with cleaning the program-tracking database, which consisted of removing negative quantities, checking duplicates, removing measures with no savings (e.g., payment tracking, etc.), and confirming that the tracked savings in the database matched the claimed savings in the PY2014 Hawai'i Energy Annual Report.

Application of TRM Values

The EM&V Contractor performed a database and TRM review for all residential and non-CBEEM business sector programs (BEEM, BHTR, and BESM). For each measure in the program-tracking database, they confirmed that the per-unit savings (kW and kWh), Net-To-Gross Ratios (NTGR), and EUL values mirrored the stipulated values documented in the PY2014 TRM. This consisted of three areas:

- Savings Estimates (kW, kWh). The EM&V Contractor referred to the PY2014 TRM for the correct savings estimates for all non-custom measures. Additionally, they checked for any possible duplicates within the program-tracking database.
- Net-to-Gross. The EM&V Contractor compared program-tracking database NTGR values to those stipulated in the PY2014 TRM.
- Effective Useful Life. The PY2014 TRM includes EULs for all measures. The EM&V Contractor compared these values to values used in the program-tracking database.

Application and Invoice Review

For REEM, BEEM, and BHTR Programs, the EM&V Contractor reviewed a sample of applications and invoices to confirm the accuracy of the quantities listed in the program-tracking database. This review included 99 REEM measures (49 solar water heaters; 50 refrigerator/freezers), 89 BEEM measures (44 HVAC; 45 Lighting), and 45 BHTR applications.

Engineering Desk Review

The EM&V Contractor completed desk reviews for a sample of 40 custom projects representing a high proportion of CBEEM savings. They developed a stratified random sample of projects based on net-tracked energy savings to ensure that the largest projects from the database were included in the sample. The desk reviews consisted of reviewing all project documentation including applications, specification sheets, test reports, rebate checks, program savings calculations, post-inspection pictures and invoices as available. A reviewed of the project documentation was completed to ensure consistency with the program-tracking database for all measure-specific variables and to identify parameters for onsite verification (e.g., measure counts, efficiencies, horsepower, capacities, etc.).

Desk reviews included the following:

- Project Documentation Review. Identify the types of installed measures, quantity of installed measures, and other measure specific characteristics (i.e. wattage, installed location, horse power, etc.).
- Claimed Savings Calculations. Calculate claimed savings using information found in project documentation. This step helps identify variables that require on site verification to provide more accurate savings estimates in ex post impacts.
- Project Magnitude Define project size to estimate time needed to perform site visit.

- Sampling Strategy. Determine whether sampling within the sample is required to gather adequate data that does not compromise or skew the verification results. If sampling was required, engineers developed an appropriate sampling strategy prior to the site visit. Thirteen sites required sampling designs.

On-Site Verification

The EM&V Contractor conducted 40 site visits for the CBEEM Program for measures representing a high proportion of CBEEM savings to verify that measures remained in place and are operating, verify the appropriateness of Hawai'i Energy's savings calculations, and gather specific savings parameters needed to calculate ex post savings. In addition to verifying measures are in place and operating, six sites required short-term metering. The EM&V Contractor generated Measurement and Verification (M&V) plans for these six sites as described below:

- Measure description
- Summary of claimed savings calculations
- Ex post savings methodology
 - Determine what data to use as baseline and how it will be used
 - Determine what data is needed to record while on site and how it will be used
 - Identify algorithms for ex post savings calculations
- Specific activities to perform while on site (i.e. record nameplate information, interview building operator, discuss hours of operation and plant shutdowns, etc.)
- Detailed description of monitoring equipment and its purpose

The EM&V Contractor independently calculated savings based on data gathered onsite and site-specific information. Each site received a verification rate that was the comparison of the program-tracking savings value to the value calculated by the EM&V Contractor. After completing verification of all sites, the EM&V Contractor provided draft verification rates for each site and met to discuss them.

Following the site visits, the EM&V Contractor calculated ex post savings for each project based on data gathered onsite and applied any applicable adjustments to measure-specific variables. For the six sites that received short-term metering, the metering data was used to adjust equipment assumptions for run-time and other operating characteristics.

Upstream Lighting Review

The EM&V Contractor reviewed REEM upstream lighting measures for 50 records. The verification included the following steps:

- Checked compliance with the participation requirements set forth by the MOU documents submitted by each of the manufacturers
- Verified quantities of equipment between invoice/rebate documentation, final program data, and Hawai'i Energy PY2014 Hawai'i Energy Annual Report

Peer Comparison Billing Data Review

The EM&V Contractor conducted an independent calculation, based on billing data, to verify savings claimed for the REEM Peer Group Comparison. For the Peer Group Comparison, the data provided by Hawai'i Energy was used to identify participating customers (i.e., which households received program

home energy reports) in PY2014. The EM&V Contractor chose to use PY2014 usage as its base year (instead of PY2013) and not to apply the algorithm from the TRM. Instead the EM&V Contractor followed the fundamental principal for calculation of this type of program that has a random control trial design and use the energy use of the year under construction (PY2014).

Market Transformation Verification

The EM&V Contractor validated the achievements of the nine Transformational Programs to ensure they matched Hawai'i Energy's performance indicators. Hawai'i Energy provided documents used to verify that each of the nine Transformational Programs targeted for evaluation occurred during the PY2014 cycle. The verification included the following tasks:

- Data Gathering. Submission of two data requests for Transformational Programs, two meetings with Hawai'i Energy, and multiple email communications to assure understanding of the data.
- Document Review. Review of event or workshop attendance spreadsheets/signup sheets, presentation slides, and logic models.
- Activity Information Review. Review of detailed information, specifically:
 - Participation Counts. For the Behavior Modification, Professional Development, Clean Energy Ally, and Technical Know How Programs, the EM&V Contractor determined program participation counts. This included social media engagements, participation in the Professional Development internship program, and several buildings or sites evaluated within the Energy Systems Integration Pilot's Benchmarking activities.
 - Study Review. For the Energy Systems Integration Pilots on Codes & Standards, Demand Response, Smart Grid, and Electric Vehicle, the EM&V Contractor reviewed and counted the number of studies conducted and any other actions/activities performed that aligned with these pilots.

Total Resource Benefits Calculations

The EM&V Contractor used verified savings (kWh and KW) to estimate TRB for residential and business Programs. They then compared the verified TRB value to the claimed TRB value presented in the Hawai'i Energy PY2014 Annual Report.

Verification of Aware Claim, Island Equity Calculations

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. The EM&V Contractor reviewed the established goals, claimed results and award, and separately calculated a verified award based on PY2014 verification results. In addition, a verification of the distribution of incentives across Honolulu County, Hawaii County, and Maui County (i.e., Island Equity calculations) was completed.

3.6.3 Other Studies

History of Hawaii Building Energy Codes

The EM&V Contractor performed an assessment of the history of Hawaii building energy codes and potential implications for energy savings stemming from future code enforcement and adoption activities.

3.7 PY2015 EM&V Research

Table 3-7 presents the residential and business research activities completed by the EM&V Contractor in PY2015.⁹

Table 3-7 EM&V Research Activities – PY2015

			PY2015	
			Residential	Business
Impact	TRM Review	TRM Recommendations Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review		✓
		On-Site Verification		✓
		Upstream Lighting Review	✓	
		Peer Comparison Billing Data Review	✓	
		Market Transformation Verification	✓	✓
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
		Other Studies	Hawai'i Energy Awareness Study	✓
Historic Participation Analysis	✓		✓	

3.7.1 TRM Review

TRM Recommendations Review

The Hawai'i Energy Program implementation team recommended 22 updates to the PY2014 Hawai'i Energy TRM. The EM&V Contractor reviewed each of the 22 recommendations to assess the merit of each recommendation and indicated whether they agree with and accept the recommendations or if additional supporting documentation is required. This review included a comparison between the recommended values and similar measures or values used in other jurisdictions. When assessing the merit of the recommended changes, the following steps were performed:

- Reviewed each recommended change to assess, at a high level, whether the change is warranted (e.g., if a recommendation is to remove a measure and the EM&V Contractor agreed, they performed no additional research).
- For all recommended additions or changes to existing measures, the EM&V Contractor reviewed:
 - Publicly available TRMs used throughout North America as a comparison to the recommended change. While individual measure inputs and savings will vary by jurisdiction depending on many factors, leveraging other TRMs allows for a useful comparison to determine the reasonableness of the recommended changes. The TRMs used for these purposes included: the Illinois TRM, Indiana TRM, Pennsylvania TRM, and the California Database for Energy Efficient Resources (DEER), among others.
 - Previous Hawai'i Energy evaluation reports and memorandums and previous versions of the Hawai'i Energy TRMs for additional context around existing TRM methodologies.

⁹ PY2015 EM&V research activities compiled using information from: Program Year 2015 Verification Report. "Verification of Hawai'i Energy Program Year 2015 Programs". Memorandum. Prepared by Opinion Dynamics. Prepared for Jim Flanagan, Steve Grover, and Jenny Fraser. November 28, 2016. https://hawaiienergy.com/files/resources/PY15_HawaiiEnergyVerificationMemo.pdf

- Other relevant secondary sources to assess the reasonableness of the recommendations such as ASHRAE Fundamentals for heating and cooling degree day requirements for Hawaii.

3.7.2 Verification

Database Review

For all programs except CBEEM and CESH, the EM&V Contractor performed a database review. This process began with cleaning the program-tracking database, which consisted of removing negative quantities, checking duplicates, removing measures with no savings (e.g., payment tracking, etc.), and confirming through discussions with PBFA that the tracked savings in the database matched claimed savings for PY2015.

Application of TRM Values

The EM&V Contractor performed a database and TRM review for residential and non-CBEEM business sector programs (BEEM, BHTR and BESM). For each measure type in the program-tracking database, they confirmed that the per-unit savings (kW and kWh), NTGR, and EUL values mirrored the stipulated values documented in the TRM. This consisted of three areas:

- Savings Estimates. The EM&V Contractor referred to the PY2015 TRM for the correct savings estimates for all non-CESH and non-CBEEM measures. Additionally, they checked for any possible duplicates within the program-tracking database.
- Net-To-Gross. The EM&V Contractor applied the program specific NTG values found in the PY2015 TRM.
- Effective Useful Life. The EM&V Contractor applied the measure specific EUL values found in the PY2015 TRM.

Application and Invoice Review

For REEM, BEEM, and BHTR, the EM&V Contractor performed an additional step of reviewing a sample of applications and invoices to confirm the accuracy of the quantities listed in the program-tracking database. The EM&V Contractor limited this step to these three programs as they contributed more than 96% of the non-CBEEM tracked savings in the PY2015 portfolio.

Engineering Desk Review

The EM&V Contractor performed detailed desk reviews for a sample of 25 CBEEM projects. Desk reviews included a complete review of the provided documentation (e.g., incentive applications, equipment invoices, and any other related project information included in the project database) to help outline the methodology behind calculating project energy savings and ensure site visits focused on the parameters needed to execute energy savings calculations.

Desk reviews included the following:

- Project Documentation Review. Identify the types of installed measures, quantity of installed measures, and other measure specific characteristics (i.e. wattage, installed location, horsepower, etc.).
- Claimed Savings Calculations. Calculate claimed savings using information found in project documentation. This step helps identify variables that require on site verification to provide more accurate savings estimates in ex post impacts.
- Project Magnitude. Define project size to estimate time needed to perform site visit.

- Sampling Strategy. Determine whether sampling within the sample is required to gather adequate data that does not compromise or skew the verification results. For example, a site with more than 1,000 lighting fixtures would require site-specific sampling. If sampling is required, engineers developed an appropriate sampling strategy prior to the site visit.

On-Site Verification

The EM&V Contractor facilitated on-site verification for a sample of 25 CBEEM projects. Data collection activities for these 25 sites ranged from simple in-place and operation verification (n=22) to short-term metering (n=3).

Upstream Lighting Review

For the upstream lighting measures in REEM, the verification included the following steps:

- Checked compliance with the participation requirements set forth by the MOU documents submitted by each of the ten manufacturers
- Verified quantities of equipment between invoice/rebate documentation, final program data, and Hawai'i Energy PY2015 Hawai'i Energy Annual Report

Peer Comparison Billing Data Review

For the Peer Comparison component of REEM, the EM&V Contractor verified savings by leveraging program participation and customer billing data consistent with the TRM savings algorithm. This effort required additional data requests (beyond the typical program-tracking database data requests) for the list of all residential customers within the Peer Comparison program by treatment cohort (i.e., which year they were added to the program and their associated monthly electric usage for PY2015). This data allowed us to perform a calculation based on the TRM savings algorithm to estimate the savings from the Peer Comparison component of REEM.

Market Transformation Verification

The EM&V Contractor verified achievements resulting from the nine market transformation programs offered by Hawai'i Energy. These programs seek to determine and overcome market barriers that prevent residential and business customers from becoming energy-efficient in terms of energy savings actions or the equipment they use. Market transformation Programs include Behavior Modification, Professional Development, and Technical Knowledge and Training Programs. The EM&V Contractor verified that each of the nine market transformation programs occurred in the PY2015 cycle. Specifically, the EM&V Contractor verified accomplishments through the following tasks:

- Submission of a data request for the market transformation programs, two meetings with the PBFA, and email communications to confirm our understanding of the data
- Review of event, presentation, or workshop attendance spreadsheets/signup sheets, presentation slides, and reports
- Review of detailed information, specifically:
 - For the Behavior Modification, Professional Development, and Technical Knowledge and Training programs, the EM&V Contractor determined program participation counts
 - For the Hawai'i Energy Ally program, the EM&V Contractor determined the number of Clean Energy Allies, while for the Benchmarking pilot the number of buildings or sites evaluated was determined

- For the Codes & Standards, Shift for Savings Plan (Demand Response), Smart Grid, and Electric Vehicle Support pilots, the EM&V Contractor reviewed and counted the number of studies conducted and any other actions performed that aligned with these pilots

Total Resource Benefits Calculations

The EM&V Contractor used program-level net verified savings (kWh and kW) to calculate the TRB for Residential and Business Programs. The verified program-level TRB values were then compared to the claimed values presented in the PY2015 Annual Report.

Verification of Award Claim, Island Equity Calculations

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. The EM&V Contractor reviewed the established goals, claimed results and award, and separately calculated a verified award based on our PY2015 verification results. They found several errors in the claimed savings and award calculations and corrected these errors as part of the verification effort. In addition, the EM&V Contractor verified the distribution of incentives across Honolulu County, Hawaii County, and Maui County (i.e., Island Equity calculations).

3.7.3 Other Studies

Hawai'i Energy Awareness Study

The primary objective of this research was to measure changes in Hawai'i Energy awareness since the inception of Hawai'i Energy in 2009. In addition, The EM&V Contractor measured changes in awareness and knowledge related to actions that customers can take to save energy in their homes or businesses since the launch of Hawai'i Energy. The ability to compare and contrast current findings to past survey results is highly dependent upon comparable survey designs across studies (and the specific questions asked). In order to enable valid comparisons, the following research was performed:

- Incorporated survey questions from prior Hawaii surveys (both residential and business) that measure changes in awareness
- Incorporated survey questions, to the extent feasible and applicable, from similar survey efforts in other jurisdictions for the purposes of benchmarking
- Included demographic/firmographic questions

The findings are based upon two customer surveys—one residential and one business—which, together, capture data from over 1,700 Hawaii residential and business customers in the target counties of Honolulu, Hawaii, and Maui. The residential survey effort included telephone fielding, and a parallel web survey. Business survey efforts included telephone fielding.

Historic Participation Analysis

To understand program participation patterns, energy savings achievements, and changes in customer energy purchases since the inception of Hawai'i Energy, the EM&V Contractor conducted a historic participation analysis in both the residential and business sectors. The analysis synthesized data from various sources of historical information, including:

- PY2009-PY2014 Hawai'i Energy program-tracking databases
- PY2009-PY2014 Hawaiian Electric Company (HECO) customer billing data
- U.S. Census Bureau data

- Energy consumption data from the U.S. Energy Information Administration (EIA)

3.8 PY2016 EM&V Research

Table 3-8 presents the residential and business research activities completed by the EM&V Contractor in PY2016.¹⁰

Table 3-8 EM&V Research Activities – PY2016

			PY2016	
			Residential	Business
Impact	TRM Review	TRM Recommendations Review	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review		✓
		Upstream Lighting Review	✓	
		Peer Comparison Billing Data Review	✓	
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
Other Studies	Hours of Use Inputs for Key C&I Programs			✓
	Potential Overlap Between Key C&I Programs			✓
	Comprehensive Longitudinal Effects (CLE) Study		✓	✓
	History of Annual EM&V-Related Research		✓	✓

3.8.1 TRM Review

TRM Recommendations Review

The Hawai'i Energy Program implementation team recommended 25 updates to the PY2016 Hawai'i Energy TRM. The EM&V Contractor reviewed each of the 25 recommendations to assess the merit of each recommendation and indicate whether they accept the recommendations or if additional supporting documentation is required. When assessing the merit of the recommended changes, the EM&V Contractor performed the following steps:

- Reviewed each recommended change to assess, at a high level, whether the change is warranted (e.g., if a recommendation is to remove a measure and the EM&V Contractor agreed, they perform no additional research).
- For all recommended additions or changes to existing measures, the EM&V Contractor reviewed:
 - Publicly available TRMs used throughout North America as a comparison to the recommended change. While individual measure inputs and savings vary by jurisdiction depending on many factors, leveraging other TRMs allows for a useful comparison to determine the reasonableness of the recommended changes. The TRMs used for these purposes included: the Illinois TRM, Indiana TRM, Pennsylvania TRM, and the California Database for Energy Efficient Resources (DEER), among others.
 - Previous Hawai'i Energy evaluation reports and memorandums and previous versions of the Hawai'i Energy TRMs for additional context around existing TRM methodologies.

¹⁰ PY2016 EM&V research activities compiled using information from: Program Year 2016 Evaluation Report. "Evaluation of the Hawai'i Energy Conservation and Efficiency Programs PY2016 Program Results." Prepared by Opinion Dynamics. Prepared for Hawaii Public Utilities Commission. March 13, 2018. https://hawaiienergy.com/files/about/information-and-reports/PY2016_Hawaii_Energy_Annual_Evaluation_Report.pdf.

- Other relevant secondary sources to assess the reasonableness of the recommendations such as ASHRAE Fundamentals for heating and cooling degree day requirements for Hawaii.

3.8.2 Verification

Database Review

The EM&V Contractor conducted a thorough review of all records in the Hawai'i Energy program tracking database to check for duplicates, verify incented measures meet program requirements (e.g., minimum efficiencies), and identify any parameters that are outside of expected ranges (e.g., efficiencies, horsepower, etc.). Additionally, the accuracy and appropriateness of savings and incentive calculations were verified (i.e., check per-unit savings across similar measure types and multiply by quantities to ensure they match total project savings). The EM&V Contractor performed this task for all records in the Hawai'i Energy program-tracking database, however the review was limited to information contained within the database.

Application of TRM

The EM&V Contractor conducted a thorough review of all measure-specific savings calculations for REEM and BEEM Programs included in the program-tracking database to verify that the database incorporates the stipulated values from the Hawaii TRM correctly. Together, these programs accounted for more than 90% of the non-custom claimed energy savings for PY2016. This included verifying deemed savings values (kW and kWh), NTG values, and other parameters (wattages, hours of use, horsepower, etc.) as applicable. This review consisted of two elements:

- Savings Estimates: The EM&V Contractor referred to the Hawaii TRM for the correct savings estimates and use of appropriate savings algorithms and assumptions.
- Net-To-Gross: In 2013, evaluators revised, and stakeholders vetted Hawai'i Energy's NTG estimates in the TRM. These estimates were applied for PY2016.

The EM&V Contractor did not review the application of TRM values for the BHTR, RHTR, and RESM programs, which accounted for less than 10% of the claimed non-custom program energy savings in PY2016.

Application and Invoice Review

The EM&V Contractor reviewed a sample of project applications (i.e. desk reviews) for REEM and BEEM including all associated documentation and invoices to ensure verification of measures or programs.

Engineering Desk Review

The EM&V Contractor conducted 25 desk reviews of CBEEM projects. The desk reviews consisted of a rigorous review of project files and attempt to recreate the claimed savings for each project. The EM&V Contractor did not perform any site visit verification of the projects.

Upstream Lighting Review

For the upstream lighting measures in REEM, the verification included a review of a sample of program MOUs with participating retailers, invoices and distribution data, as well as verification that program qualifying models appear on the ENERGY STAR website.

Peer Comparison Billing Data Review

For the Peer Comparison component of REEM, the EM&V Contractor verified savings by leveraging program participation and customer billing data consistent with the TRM savings algorithm. This effort

required additional data requests (beyond the typical program-tracking database data requests) for the list of all residential customers within the Peer Comparison program by treatment cohort (i.e., which year they were added to the program and their associated monthly electric usage for PY2016). This data allowed the EM&V Contractor to perform calculations based on TRM savings algorithms to estimate the savings from the Peer Comparison component of REEM.

Total Resource Benefits Calculations

The EM&V Contractor used program-level net verified savings (kWh and kW) to calculate the TRB for Residential and Business Programs. The verified program-level TRB values were then compared to the claimed values presented in the PY2015 Annual Report.

Verification of Award Claim, Island Equity Calculations

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. The EM&V Contractor reviewed the established goals, claimed results and award, and separately calculated a verified award based on the PY2016 verification results. In PY2015, the EM&V Contractor found several errors¹¹ in the claimed savings and award calculations and corrected these errors as part of our verification effort. The EM&V Contractor again checked for these types of discrepancies in PY2016. In addition, the EM&V Contractor verified the distribution of incentives across Honolulu County, Hawaii County, and Maui County (i.e., Island Equity calculations).

3.8.3 Other Studies

Hours of Use Inputs for Key C&I Programs

The EM&V Contractor validated contractor-based hours of use inputs for the SBDIL and Custom Lighting Program. Direct Entry of Facility Operating Hours (for establishing incentive amounts) by Participating Contractors. This investigation begins with a conversation/meeting with Hawai'i Energy toward the goal of understanding how each program operates and the controls/checks that are in place to ensure that contractors are entering accurate operating hours estimates. Questions centered around:

- The checks and balances currently in place by Hawai'i Energy
- The extent to which relevant issues have arisen historically
- Requesting data (as available) to allow the EM&V Contractor to compare entered hours estimates (for the population of projects) to TRM default values—allowing us to understand the extent to which default (TRM) values were being used as well as the range of hours estimates included in the database (including outliers). Key evaluation metrics include:
 - The percentage of time set at TRM default levels
 - The percentage of time set above and below default levels
 - The percentage of projects under vs. over \$3,000 (as under \$3,000 does not trigger a Hawai'i Energy review)

Potential Overlap Between Key C&I Programs

The EM&V Contractor investigated the potential overlap—and double counting of savings—for measures and associated incentives across C&I Prescriptive, SBDIL, and Midstream efforts. This investigation begins

¹¹ The most substantial errors involved 1) the Island Equity calculation; and 2) the Peer comparison savings calculation. Based on our feedback, Hawai'i Energy has indicated that they will make corrections going forward.

with a conversation/meeting with Hawai'i Energy toward the goal of understanding how each program operates and what measures (if any) overlap with one another. Questions centered around:

- Potential for overlap and mechanisms that are in place to prevent the double counting (or double paying) of incentives
- Information that is collected at relevant steps in the delivery process (e.g., from distributors, contractors, or customers) and how it might (or might not) inform the degree to which such overlap is occurring

Comprehensive Longitudinal Effects (CLE) Study

The goal of the comprehensive longitudinal effects (CLE) study was to quantify and describe the opportunities that remain for the Hawai'i Energy programs to achieve long-term energy savings. Toward this goal, the study focuses on the savings realized through Hawai'i Energy programs to date as well as the potential for those programs to claim additional energy savings through 2030. To understand cumulative program (i.e., inception-to-date) accomplishments overall, by sector and end use, the EM&V Contractor first compared cumulative Hawai'i Energy (Public Benefit Fund Administrator or PBFA) savings generated by Program Year (PY) 2009 through PY2015 program interventions to economic potential savings estimates in order to understand cumulative program (i.e., inception-to-date) accomplishments, both overall and by sector and end use.¹² To understand future savings opportunities, the EM&V Contractor estimated the savings potential available to be captured by program interventions (Available Economic Potential) and the remaining savings potential after current and anticipated program interventions (Remaining Economic Potential), for Hawai'i Energy overall and by end use.

History of Annual EM&V-Related Research

The EM&V Contractor provided a summary-level description of all research completed in each PY (from the inception of Hawai'i Energy in PY2009 through PY2016). As part of this task, they carefully reviewed each of the past seven Annual EM&V Reports to identify both consistent and unique research efforts. The EM&V Contractor also reviewed related reports including, but not limited to, the most recent potential and market characterization studies (both included in 2013) and customer research and satisfaction studies. The outcome of the review, synthesis, and analysis is documented in this report and includes:

- Catalogue of research activities, identifying both the timing (when) and the extent of repetitiveness (how often) a given research activity has been executed.
- Tables that summarize each research activity by sector (e.g. Residential, Business).
- A brief description of each research activity for each PY identified in the summary tables. This will allow the reader to not only see when a given research activity was executed (in what PYs) but also easily review the associated description for each PY.

¹² To accurately compare program savings to potential savings, all savings are at the meter and do not include line losses. The EM&V Contractor used Customer Tracked Savings for PY2009 through PY2012. For PY2013 through PY2015, the EM&V Contractor used Net Tracked Savings from which savings associated with line losses were removed. Estimates of economic potential were derived from the 2014 Potential Study (*State of Hawaii Energy Efficiency Potential Study Final*. Applied Energy Group (dba EnerNOC Utility Solutions Consulting). January 15, 2014).

3.9 PY2017 EM&V Research

Table 3-9 presents the residential and business research activities completed by the EM&V Contractor for PY2017 and inclusive of work done in CY2018.

Table 3-9 EM&V Research Activities – PY2017 through CY2018

			PY2017 – CY2018	
			Residential	Business
Impact	TRM Review	TRM Review	✓	✓
		TRM Recommendations Review	✓	✓
		Major TRM Update	✓	✓
		TRM Framework	✓	✓
	Verification	Database Review	✓	✓
		Application of TRM Values	✓	✓
		Application and Invoice Review	✓	✓
		Engineering Desk Review	✓	✓
		On-Site Verification		✓
		Upstream Lighting Review	✓	
		Peer Comparison Review	✓	
		Market Transformation Verification	✓	✓
		Customer Satisfaction Verification	✓	✓
		Total Resource Benefits Calculations	✓	✓
		Verification of Award Claim, Island Equity Calculations	✓	✓
	Other	Peer Program Incremental Savings Approach	✓	
		NTG and Baseline Approach	✓	✓
		LED Lifetime Savings	✓	✓
		NTG Assessment	✓	✓
		EEPS Review Research	✓	✓
Market Assessment	Baseline Study (Planning)		✓	✓
	Potential Study (Update)		✓	✓

3.9.1 TRM Review and Update

PY2017 and PY2018 TRM Review

The purpose of the PY2017 and PY2018 Hawai'i Energy TRM update was for the EM&V Contractor to review TRM changes proposed by Hawai'i Energy. The EM&V Contractor reviewed a series of proposed updates for the PY2017 TRM, and through discussions with Hawai'i Energy, the EEM and the HPUC, worked with Hawai'i Energy to incorporate some of the updates into the PY2017 TRM and others into the PY2018 TRM. The PY2017 TRM updates included mostly editorial and formatting updates, as well as minor corrections and clarifications to select measures. The PY2018 TRM updates included more substantive updates, including change in methods and assumptions for several measures, and updates to parameter inputs for other measures.

This work involved the development of several memoranda, to communicate to Hawai'i Energy and others the exact recommendations for updates.^{13,14,15} Hawai'i Energy then used these memoranda to update the applicable version of the Hawaii TRM, and the EM&V Contractor approved or suggested additional

¹³ Recommended Updates for PY2017 TRM, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steven Schiller, Energy Efficiency Manager, April 11, 2018.

¹⁴ Updates for the PY2018 Hawaii TRM, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steven Schiller, Energy Efficiency Manager, May 2, 2018.

¹⁵ Review of Proposed Updates to PY2017-PY2018 for the PY2018 TRM, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steven Schiller, Energy Efficiency Manager, May 21, 2018.

modifications based on a final review of the TRM(s). This task resulted in final versions of the PY2017 and PY2018 Hawai'i Energy TRM documents.

PY2019 Major TRM Update

The EM&V Contractor carried out a comprehensive review of the PY2018 TRM and developed an updated version of the TRM for PY2019.¹⁶ The purpose of the TRM review and update process was to address the following:

- Align baselines with current market conditions and changes to building codes and appliance standards
- Benchmark algorithms against industry best practices
- Incorporate newer, more applicable data to estimate values for key parameters
- Modify or add measures to reflect program design changes since the last major review
- Ensure that prior year recommendations were incorporated into the TRM

The review and update process had five main steps:

- Prioritization of measures and general information for review and update
- Review of high priority measures and information by comparing with best practices
- Hawaii-specific analysis of key parameters, including system loss factors¹⁷ and avoided energy and capacity costs¹⁸
- Update of TRM measure entries and general information
- Delivery of PY2019 TRM

The prioritization process identified 20 priority measures (7 residential and 13 business measures) and a variety of additional, cross-cutting metrics, factors, and general information items for review and update.¹⁹ The EM&V Contractor used the methods listed below to review and update the priority items:

- Documentation review
- Program tracking system review and analysis
- Benchmarking
- Measure characterization
- Simulation modeling
- Load shape analysis

¹⁶ State of Hawaii EM&V: Summary of PY19 TRM Update, Memorandum, Prepared by Kelly Parmenter, AEG, Prepared for the EEM, HPUC, and Hawai'i Energy Teams, January 7, 2019.

¹⁷ Recommendations for PY19 System Loss Factors (SLF) for Hawai'i Energy Programs Goals and Reporting, Memorandum, Prepared by Steve Schiller, EEM team, Prepared for Ashley Norman and Dave Parsons, HPUC, January 4, 2019.

¹⁸ Recommendations for Updates to Avoided Costs for the Hawai'i Energy Programs, Memorandum, Prepared by Steve Schiller, Energy Efficiency Manager, and Kelly Parmenter, Applied Energy Group, Prepared for Dave Parsons and Ashley Norman, Hawaii Public Utilities Commission, January 16, 2019.

¹⁹ State of Hawaii EM&V: PY2019 TRM Updates Prioritization Memo (DRAFT), Memorandum, Prepared by Michael Daukoru, Applied Energy Group, Prepared for EEM Team, September 18, 2018.

3.9.2 TRM Framework

The EM&V Contractor initiated the development of a Hawai'i Energy TRM Framework document. The purpose of developing the TRM Framework was to have a mechanism for formally documenting the roles, responsibilities, and processes needed to guide the ongoing development, maintenance, and application of the TRM.

The following key activities were completed to help inform development of the TRM Framework:

- In-depth interviews with key entities involved with the Hawai'i Energy programs, as well as other stakeholders
- Benchmarking of TRM Framework-type documents from other areas of the country

The resulting TRM Framework describes the common understanding all involved parties and stakeholders share regarding the process and assumptions Hawai'i Energy and the EM&V Contractor use in measuring impacts and determining the success of the Hawai'i Energy programs. The Framework was finalized in April of 2019.²⁰

3.9.3 Verification

The EM&V Contractor conducted an independent verification of Hawai'i Energy's performance relative to the PY17 Annual Plan performance targets. The targets span a range of performance indicators, including energy and demand savings, financial benefits to Hawaii, targets for customer equity and market transformation, and customer satisfaction. Successfully meeting the performance targets leads to a performance incentive award for Hawai'i Energy.

The EM&V Contractor utilized several methods to arrive at verified savings and performance results. The subsections below summarize the methods.

Database Review

The EM&V Contractor received an initial set of project details from Hawai'i Energy in July 2018. This initial database was reviewed across all programs to assess the close-to-final aggregate savings and inform the verification plan and was used to inform the options for verification methods and their applicability for each program. A final database was provided to the EM&V Contractor in late October 2017. Projects and savings tracked in this database are what the EM&V Contractor used to assess final claimed savings and what will be used by Hawai'i Energy in their PY17 Annual Report.

Application of TRM

For measures that utilized the PY17 Hawai'i Energy TRM (the TRM) to establish savings, the EM&V Contractor developed a spreadsheet that incorporated the TRM savings values and algorithms to develop independent savings calculations, verifying the initial and final databases' claimed savings in comparison to the TRM's savings. The spreadsheet tool was designed to be readily updateable to align with TRM changes from one year to the next and then used in subsequent program years. The approach was applied to a census of the measures for each program that utilized TRM savings, with CBEEM and CREEM being the exception. For Small Business Direct Install Lighting (SBDIL) measures, the final database included data that allowed for verification of custom savings, with the EM&V Contractor utilizing this data for the purpose of verifying SBDIL measures.

²⁰ Hawai'i Energy Technical Reference Manual Framework, Version 1.0, April 2019.

Engineering Desk Review, including Application and Invoice Review

For the CBEEM and CREEM programs, engineering desk reviews were used to verify installations and savings for a sample of projects. While a typical verification method, these desk reviews were a key activity in verifying the Hawai'i Energy savings, as the tracking database did not record the underlying data used to calculate savings. For measures recorded in the BEEM and REEM programs, projects were sampled for engineering desk reviews to verify whether the tracking data accurately reflected the supporting documentation. Desk reviews for the Peer Comparison Group program (Peer program) included an analysis of program documentation, comparing the results to those recorded in the tracking databases. Market transformation initiatives and customer satisfaction performance also used a desk review method to analyze information based on the available documentation provided by Hawai'i Energy for the purpose of verifying performance relative to PY17 goals.

Across these programs, the EM&V Contractor received a variety of documentation from Hawai'i Energy to support the desk review verification process. The nature of the documentation spanned project-specific calculators, invoices, applications, and equipment specification sheets. In the case of the Peer program desk reviews, verification included documentation of individual program participants and their tenure in the program, as well as when Home Energy Reports were mailed. For market transformation initiatives, the EM&V Contractor received training and event sign-in sheets and other material related to the specific initiatives. For customer satisfaction results, the survey outcomes and methods were shared with the EM&V Contractor.

On-Site Verification

The EM&V Contractor conducted site verification for a total of 31 PY17 participants—20 of these site visits were completed for CBEEM and 11 were completed for BEEM. For CBEEM, the results were used to inform desk reviews and adjustments that affected extrapolating CBEEM verified results to the program population. For BEEM, the site visits were used to make adjustments only to the projects that were visited, with qualitative results informing considerations and recommendations for the program. The site visits verified installation and documentation accuracy, with CBEEM site visits also verifying key parameters used in the calculation of custom savings.

Upstream Lighting Review

The Upstream initiative has provided retailers with incentives as a means of buying-down the purchase cost of high efficiency equipment often sold through retail channels. Upstream savings were dominated by LED lamp purchases, though also included home appliances and electronics. For the Upstream initiative, past verifications have found no variance from projects recorded in the program tracking data. While the EM&V Contractor did complete a tracking system review of the Upstream measures, no additional verification methods were employed for this program.

Peer Comparison Review

Desk reviews for the Peer program involved analysis of program documentation and comparison of the results to those recorded in the tracking databases. The documentation reviewed during the verification included data on individual program participants, their tenure in the program, the island on which a given participant was located, and a record of which accounts received HERs throughout the year as well as when they were mailed.

Savings for the Peer program are described in the PY2017 TRM and are based on annual savings for a single participating home. Savings of 59 kWh and 0.0197 kW are based on past studies investigating the percent energy savings from program participants, adjusted to the 2015 average annual electricity

consumption of HECO residential customers. The savings are treated with a one-year measure life and a NTG value of 1.0. Hawai'i Energy's practice is to divide the annual savings described in the TRM into a per-month savings rate, with each month being credited with a 1/12 pro rata proportion of the annual rate.

The EM&V Contractor was able to verify that Hawai'i Energy correctly applied the savings rate to the number of participants from each island in the tracking database and Hawai'i Energy correctly adjusted savings for island-level system loss factors. However, through the verification process, the EM&V Contractor learned that the participation counts in Hawai'i Energy's tracking system were based on planning estimates for PY2017 and did not reflect actual participation levels. As such, the verification analysis differs from the program claimed savings and island location in that the verified results are based on actual participation documentation.

Market Transformation Verification

Hawai'i Energy provided the EM&V Contractor with documentation used to verify the market transformation activities. These included numbers of participant-hours, number of participants attending, and other metrics identified under the Market Transformation targets for PY2017. Specifically, the EM&V Contractor assessed accomplishments by engaging in the following tasks:

- Review of event, presentation, or workshop attendance spreadsheets/sign-up sheets and event flyers (if available),
- Review of event invoices documenting the date and number of participants in attendance
- Review of data on social media activity and associated metrics

To verify the performance of social media followers and subscribers, the EM&V Contractor reviewed Hawai'i Energy's Facebook, Twitter, and Instagram publicly available pages. For each of these social media platforms, the number of subscribers is indicated on the landing page. The EM&V Contractor summed the total across the three social media platforms to verify the total number of subscribers. In addition to verifying the subscriber/follower metric, the EM&V Contractor received monthly activity logs for Facebook and Instagram, as well as a description of an online campaign using all three social media platforms. While the results do not directly tie to the annual performance metric, the data indicates Hawai'i Energy actively utilized the three platforms to engage with subscribers.

In addition to reviewing Hawai'i Energy documentation, the EM&V Contractor issued its own survey of PY2017 professional training attendees. The participant survey, which was administered as a web survey via an embedded email link, served two primary purposes: (1) it provided a secondary mechanism by which to verify participation in trainings, and (2) elicited qualitative information about Hawai'i Energy's professional development offerings. In total, 408 unique customers participating in 11 different professional development events were recruited via email to complete the survey. Survey recruits were identified using event sign-in sheets provided by Hawai'i Energy; participants' email addresses were then harvested from these documents, if email addresses were recorded. Email harvesting was limited to email addresses that were typed (i.e., not handwritten). In total, 91 respondents, approximately 22% of participants recruited, completed the survey.

Customer Satisfaction Verification

Hawai'i Energy has an annual target of achieving an overall satisfaction score of 8.5 or greater (out of a possible 10) on customer satisfaction. The EM&V Contractor reviewed documentation from Hawai'i Energy that described their customer satisfaction feedback system, with output results from their customer experience management tool, Medallia. According to program documentation and subsequent discussions with Hawai'i Energy staff, Medallia sent 3,158 surveys to customers in PY2017, of which 27 percent responded

to the survey. The EM&V Contractor verified that Medallia compiled an overall satisfaction rating of 9.2 out of 10 on average by compiling satisfaction scores across all categories queried, satisfying the target performance metric. In addition to verifying Hawai'i Energy's customer satisfaction results, the EM&V Contractor reviewed the current process by which Hawai'i Energy measures customer satisfaction and offered recommendations on potential adjustments to the process.

Total Resource Benefit Calculations

Using the results from the tracking system verification, desk review verification, and site visit verification, the EM&V Contractor developed program and portfolio realization rates,²¹ along with their associated TRBs. To calculate the TRBs, the EM&V Contractor utilized the deemed factors presented in the PY2017 TRM and applied those criteria to each program, sector, and the Hawai'i Energy portfolio for purposes of verifying TRB performance achievement relative to the PY2017 goals.

Island Equity Calculations

To verify Hawai'i Energy's PY2017 results for meeting its island equity goals, the EM&V Contractor reviewed documentation provided by Hawai'i Energy and confirmed incentive payments using the tracking database and a monthly report from June 2017 that included the full program year-to-date spending. Performance goals were framed as incentive spending that was associated with each island across the resource acquisition and market transformation programs. For purposes of tracking spending for Maui county, the islands of Maui, Lanai, and Molokai were combined to reflect the totality of Maui county. Additionally, the EM&V Contractor received a document that described previously agreed-to arrangements for how program costs were allocated across the counties.

Verification of Award Claim

The HPUC sets performance goals and incentives for Hawai'i Energy to achieve. The EM&V Contractor reviewed the established goals, claimed results and award, and separately calculated a verified award based on the PY2017 verification results.

3.9.4 Market Assessment

Baseline Study (Planning)

During CY2018, the EM&V Contractor began planning for the 2019 Baseline Study. The work consisted of developing the baseline study research design and preparing for fielding the surveys. The customer surveys, data analysis, and final reporting will be carried out during 2019. The baseline study and other types of primary market research will support future TRM updates, EEPS implementation, EEPS EM&V, and program planning for the Hawai'i Energy program portfolio.

Potential Study (Update)

During CY2018, the EM&V Contractor completed a partial update to the 2014 Potential Study as part of the EEPS Review Research (see Section 3.9.5).²² It is referred to as "Phase I." Phase II will be a comprehensive update of the potential study and will be conducted during 2019. It will rely on results from the 2019 Baseline Study (see subsection above).

The objectives for Phase I were to estimate the historical savings from state and federal codes and standards, to align with the previous and current programmatic achievements of Hawai'i Energy and KIUC

²¹ The Realization Rate is the ratio of verified savings to claimed savings.

²² Applied Energy Group (dba EnerNOC Utility Solutions Consulting). State of Hawaii Energy Efficiency Potential Study. Prepared for the Hawaii Public Utilities Commission. 2014.

and historical PV installations, and to offer preliminary insights into the potential for future savings. Because the comprehensive update will be performed in 2019, only a limited set of changes were made to the 2014 Study during CY2018. The Phase I update used a simplified approach based on extrapolating data from the island of Oahu and estimated historical savings from codes and standards.

The preliminary forecast shows that, under business-as-usual (BAU) assumptions, the EEPS program appears to be on track to meet interim goals through 2020, but not between 2020 and 2030. However, preliminary results of the economic potential indicate that the available, untapped, economic energy efficiency resource in Hawaii exceeds the EEPS goal of a cumulative 4,300 GWh in 2030.²³ These preliminary findings suggest that the EEPS goal is achievable, but requires strategic adaptation to current programs and initiatives, possible increases in energy efficiency program budgets, and continued innovation in program design.

3.9.5 Other Studies

Peer Program Incremental Savings Approach

Energy savings from Hawai'i Energy's Peer program have been evaluated using a static deemed savings approach since 2011. Through discussions between Hawai'i Energy, the EEM, the EM&V Contractor, and other stakeholders in Fall 2017, the decision was made to investigate an updated empirical savings approach rather than continue to rely on the original deemed savings value in future program years. The program has reached virtually all of Hawaii's residential population, so no comparison/control group is available for this analysis. Rather, the group of stakeholders collectively agreed to a selective stoppage of treatment approach, whereby home energy reports would no longer be sent to a stratified random sample of current program participants starting July 1, 2018, and the resulting decay rate of savings would be used to estimate the savings from continuing treatment for program participants. This work consisted of a literature review of home energy reports program evaluations that have empirically measured persistence/decay rates of savings, as well as a research design for selective stoppage of treatment to a stratified random sample of 22,500 households in Hawaii that have previously received Peer reports. The literature review and associated memorandum summarized the methods and findings of pre-existing studies, providing context and a recommended approach for the future evaluation of Hawai'i Energy's Peer program consistent with best evaluation practice for similar program designs.²⁴ The research design for selective stoppage of treatment for a sample of program participants beginning in PY2018 used a randomized control trial (RCT) design and stratified random sampling by cohort. It included power analysis to identify the minimum sample size at which the presence of a decay rate signal should be detected with statistical confidence. The memorandum accompanying the sample design also described how the savings decay rate is to be used in calculating program savings.²⁵

NTG and Baseline Approach

The purpose of this study was to develop a white paper and associated framework for how Hawaii can best select and apply baseline energy usage measurement methods, as well as the related measurement of net program savings relative to that baseline.²⁶ The white paper and associated framework provide guidance for measuring, applying, and periodically updating baseline energy usage and NTG ratios as

²³ As specified in HRS § 269-96, the statewide EEPS goal is 4,300 gigawatt-hours ("GWh") of electricity savings by 2030.

²⁴ Literature Review of Decay Rates from Home Energy Report Programs, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steve Schiller, Energy Efficiency Manager, June 15, 2018.

²⁵ Hawaii Peer Comparison Program Stoppage of Treatment Study Sample Selection, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steve Schiller, Contract Manager, June 18, 2018.

²⁶ Hawaii Baseline and Net-to-Gross Framework, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steve Schiller, Contract Manager, June 27, 2018.

important metrics for characterizing forward movement in Hawaii's energy efficiency markets. The study featured a literature review to define and characterize common practices for baseline determination across jurisdictions in the U.S., including consideration of regulatory context, program goals, program intervention strategy, and other considerations. The literature review also focused on defining and describing terms and common practices associated with NTG measurement, as well as the policy context in terms of why NTG is measured, how NTG adjustment factors are typically applied, and its purpose in energy efficiency program evaluation and planning. Based on findings and characterizations from the literature review, the memorandum and framework were then used to provide recommendations for how Hawaii can best select, apply, and periodically update baseline measurement methods and NTG methods going forward, taking account of the interrelationship between these factors.

LED Lifetime Savings

The EM&V Contractor conducted research and developed a memorandum on the EUL of LEDs and how this informs lifetime energy savings calculations for LEDs in a selection of TRMs and other high-level guidance documents in the U.S.²⁷ The EM&V Contractor reviewed six TRMs from a variety of regions across the U.S. as a convenience sample, selected to represent disparate geographic array of U.S. states. The EM&V Contractor also reviewed and summarized guidance on LED EUL from the U.S. Department of Energy's (DOE's) Uniform Methods Project. The review covered adoption of the EISA 2012-2014 and 2020 standards as the baseline conditions for general service LEDs in residential settings. The review and characterization also covered specialty LED lamp types and screw-in LEDs in commercial applications. The purpose of the research and memorandum was to help inform Hawaii's treatment of lifetime savings calculations for screw-in LEDs.

NTG Assessment

As part of the PY2019 TRM update process, the AEG EM&V Team built upon the methodology used previously by the Evergreen Economics EM&V Team to benchmark the NTG ratios of similar programs in the U.S. with the NTG ratios in Hawai'i Energy's PY2018 TRM.²⁸ Evergreen used comparison programs from Wisconsin, California, Massachusetts, and NYSEDA. The comparison programs were similar in terms of target market sector (Residential, C&I, etc.), measures, and delivery. Since the Evergreen research was several years old, the AEG researched the same programs to determine if the NTG ratios from these programs had been updated. AEG found updated NTG data for Wisconsin (2017),²⁹ some California programs (2019),³⁰ and Massachusetts (C&I: 2013, MF: 2018, SF: 2019).³¹ AEG also drew on research conducted by the Opinion Dynamics EM&V Team, identifying similar programs that could be used for NTG

²⁷ Hawaii PUC LED Baseline Memo, Memorandum, Prepared by Jeremy Eddy and Bill Norton, Opinion Dynamics, Prepared for Steve Schiller, Contract Manager, April 9, 2018.

²⁸ Evaluation of the Hawai'i Energy Conservation and Efficiency Programs, Program Year 2011, Evergreen Economics, June 20, 2013, Appendix D: Net-to-Gross Assessment Memo. NTG benchmarking analysis covered four resources: Wisconsin Focus on Energy (2011), CPUC DEER (2006-2007), Massachusetts Energy Efficiency Advisory Council (2010), and NYSEDA (2011-12).

²⁹ Wisconsin Focus on Energy, NTG data, 2017.

³⁰ California Public Utilities Commission, Database for Energy Efficient Resources (DEER), 2020, Ex Ante Database Support Table Export, Support Table Group: cpCostEff, Support Table: NTG2020, file created on 9/20/2018, www.deeresources.com.

³¹ Massachusetts NTG Study, 2013. Massachusetts MF NTG and Impact Study, 2018. Massachusetts Home Energy Assessment LED NTG Study, 2019. Massachusetts Products NTG Study, 2019. Massachusetts Res HVAC NTG & Market Effects Study, 2019. Massachusetts Res New Construction Attribution Assessment, 2019.

comparison research.³² Based on the programs identified in Opinion Dynamics' research, AEG benchmarked the most recent NTG ratios being used by Com Ed (2018)³³ and Ameren Illinois (2017).³⁴

AEG paid special attention to the NTG ratios for two measures because of their important contributions to Hawai'i Energy's programs: Residential LEDs and Solar Water Heaters. For the Residential LED measure, AEG carried out additional benchmarking of baselines and NTG ratios beyond the sources cited above. The current NTG ratio planned for the Residential LED measure (NTG=0.5) was reviewed along with baseline assumptions and verified to be reasonable, so no change was made for PY2019.³⁵ For the Solar Water Heater measure, there were no comparable solar water heater programs to benchmark the Hawaii program against, particularly since the new construction codes and the marketing and promotion of solar water heaters are unique to Hawaii. Therefore, AEG used findings from the PY2017 Verification to develop a Hawaii-specific algorithm for the NTG ratio and presented the recommended algorithm to the EEM, HPUC, and Hawai'i Energy for consideration.

EEPS Review Research

The EM&V Contractor conducted research to support the evaluation of progress toward EEPS goals in the First EEPS Performance Period (2009–2015) and the associated report to Legislature.³⁶ While the majority of the EEPS savings has historically been provided by the Hawai'i Energy portfolio, other entities also contribute to achieving the EEPS goals. Therefore, the research included evaluating savings from two categories of contributors to the EEPS goals: Commission Regulated Entities³⁷ and Non-Regulated Entities.³⁸ The EM&V Contractor's approach to quantifying savings for the two categories of entities is summarized below:

- Commission Regulated entities included Hawai'i Energy and KIUC:
 - For the analysis related to Hawai'i Energy, the EM&V Contractor reviewed publicly available documents and reports including Annual Reports, Annual TRMs, and Annual Verification reports
 - For KIUC, the EM&V Contractor conducted an interview with KIUC representatives to discuss their program savings and reviewed publicly available reports and filings
- Non-Regulated entities included state and federal agencies, Green Energy Market Securitization (GEMS) financing program, and federal, state and local appliance standards:
 - For local, state, and federal agencies and the GEMS program, the EM&V Contractor conducted interviews with representatives of each entity to discuss their program savings and reviewed publicly available reports when appropriate

³² Hawaii Baseline and Net-to-Gross Framework, Memorandum, Prepared by Opinion Dynamics Corporation, Prepared for Steve Schiller, Contract Manager, June 27, 2018.

³³ Com Ed, Final NTG Ratios for 2018.

³⁴ Ameren Illinois PY9 Evaluation Summary, 2017.

³⁵ The median value from five comparison sources was $NTG_{median}=0.48$, which is close to the current $NTG=0.5$.

³⁶ Pursuant to Hawaii Revised Statute (HRS) § 269-96 and the EEPS Framework, there are four "performance periods" during the EEPS implementation timeline (January 1, 2009-December 31, 2030) and five "evaluation reports" are required. The first report was submitted to the Legislature in January 2014 to report on the development and start-up of PBFA programs and the EEPS Framework. The next four evaluation reports (reports two through five) are due to the Legislature following each of the four performance periods.

³⁷ Commission Regulated Entity savings include savings from utility administered and third party administered energy efficiency programs. The bulk of these savings are anticipated to be provided by Hawai'i Energy and Kauai Island Utility Cooperative (KIUC).

³⁸ Non-Regulated Entity savings include savings from legislative mandates, non-profits, other coordinated programs, building codes, and federal, state, and local appliance standards.

- To estimate savings from historical and future codes and standards, the EM&V Contractor completed a partial update to the 2014 Potential Study (see Section 3.9.4)^{39,40}

The results of the research show that Hawai'i Energy has accounted for a significant share of savings toward the EEPS goal since 2009. For example, in PY2017, Hawai'i Energy contributed two-thirds (67%) of first year energy savings. In addition, Hawai'i Energy has been a very cost-effective energy resource in Hawaii. Since 2013, Hawai'i Energy's direct program expenditures have maintained a lifetime energy savings cost of between 1.8 and 3.2 cents/kWh, a small fraction of the avoided cost of energy supply. Including costs borne by program participants, the lifetime cost of saved energy is estimated to be approximately 7-8 cents/kWh.⁴¹ This cost is below the "wholesale" cost of electricity in Hawaii, including recent power purchase agreements for utility-scale solar PV, and compares very favorably to average retail rates, which ranged from 26 to 33 cents/kWh during the same period.⁴²

³⁹ Applied Energy Group (dba EnerNOC Utility Solutions Consulting). State of Hawaii Energy Efficiency Potential Study. Prepared for the Hawaii Public Utilities Commission. 2014.

⁴⁰ A full potential study will be conducted in 2019.

⁴¹ Hoffman, Ian, et al. June 2018. *The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015*. Lawrence Berkeley National Laboratory.

⁴² https://files.hawaii.gov/dbedt/economic/data_reports/energy-trends/Monthly_Energy_Data.xlsx

A

EM&V RESEARCH CATEGORY DEFINITIONS

The evaluation activities for PY2009 through PY2017 consist of dozens of research categories across residential and business sectors. Table A-1 provides a high-level definition for each EM&V research category, however the specific scope and approach for carrying out the work for a given category may vary from year-to-year.

Table A-1 *EM&V Research Category Definitions*

EM&V Research Category	Definition
TRM Review	Review of the TRM content (assumptions and resources) while providing recommendations for improvement
TRM Recommendations Review	Review of recommendation provided as part of a previous TRM review to ensure most current version of the TRM incorporated these changes
Major TRM Update	Comprehensive update of the TRM based on findings during TRM Review
TRM Framework	Creation / update ⁴³ of document that guides the development, maintenance, and application of the TRM
Database Review	Review Hawai'i Energy program-tracking database by checking for duplicates and comparing to claimed savings in Annual Report
Application of TRM Values	Verify that the Hawai'i Energy program-tracking database applied the appropriate per-measure TRM values
Application and Invoice Review	Review of project applications and documentation to ensure consistency with the Hawai'i Energy program-tracking database
Engineering Desk Review	Detailed review of project files used to prepare for site visit verification
On-Site Verification	Site visits to verify measures in-place and operating, measure quantity, and measure type. Data collected on site used to calculate ex post savings
Upstream Lighting Review	Invoice review comparing measure quantity and type to the data in the Hawai'i Energy program-tracking database
Peer Comparison Billing Data Review	Ex post calculations using billing data for Peer Comparison Group
Market Transformation Verification	Validation of achievements for Transformational Programs
Customer Satisfaction Verification	Review of Hawai'i Energy's customer satisfaction feedback system and verification of customer satisfaction performance results

⁴³ The TRM framework was first developed during the PY2017 EM&V research cycle. It may need to be updated during future program years.

EM&V Research Category	Definition
Total Resource Benefits (TRB) Calculations	TRB calculations using verified savings and approved avoided energy and capacity costs, and comparing to claimed values in the Annual Report
Verification of Award Claim, Island Equity Calculations	Award calculations using verified results. Verification of incentive distribution across islands
Net-to-Gross (NTG) Assessment	Assessment intended to frame on-going research related to attribution for demand-side management programs
Peer Group Comparison Control Group Analysis	Analysis using phone surveys and billing data to develop independent energy savings estimates
Solar Water Heating Billing Analysis	Separate analysis targeting solar water heating measures
Condominium Sub-Metering Analysis	Billing analysis to estimate average savings and compare to the TRM value
EEPS Review Research	Analysis to support the report to Legislature on Hawaii's Energy Efficiency Portfolio Standard
Peer Program Incremental Savings Approach	Literature review of behavioral program evaluations that have measured persistence/decay rates of savings, and research design for selective stoppage of treatment study
NTG and Baseline Approach	Literature review of best practices for establishing baselines and NTG ratios to inform net savings approaches for Hawai'i Energy programs
LED Lifetime Savings	Literature review of baseline assumptions and the effective useful life for LEDs to assess how EISA legislation affects lifetime savings calculations
Integrated Building Design and Construction Standards Verification	Documentation review to verify quantities and savings in the project documentation to the values recorded in the program-tracking database
Small Business Direct Install Lighting (SDBIL) Verification	Separate verification for SBDIL measures that required a review of inspection reports to ensure consistency within the program-tracking database
Participant Surveys	Surveys with customers who received rebates through the residential or business programs to gather information for measure verification and customer satisfaction
Non-participant Surveys	Surveys with the general population to gather information related to household characteristics, demographics, market potential, and awareness
Trade Ally Interviews	In-depth interviews with contractors to gain insight into program operation and processes
Focus Group Data Collection	Group sessions with participation from contractors to gather information related to changes in program offerings and design that could encourage future participation
Market Assessment Evaluation	Review of internal data, documentation, and feedback from Hawai'i Energy staff, program participants, and stakeholders to evaluate the market

EM&V Research Category	Definition
Baseline Study	Assessment of key building characteristics, equipment, appliances, and use patterns within Hawai'i Energy service territories used to establish a baseline for future planning, program effectiveness, and energy efficiency progress toward achieving related goals
Potential Study	Comparison of program savings by sector and end-use to the achievable savings potential estimated by various studies conducted in Hawaii
Food Service Sector Market Assessment	Food service research used to assess the potential for increasing energy efficiency efforts in the market
Upstream Lighting Program Analysis	Annual analysis to provide insight into how the program adapted to the changing residential lighting market by reviewing sales records for qualifying measures sold through the program each year
Non-Energy Benefits Literature Review	Review of literature on non-energy benefits of energy efficiency programs
Economic Impact Analysis	Analysis used to measure program impacts including changes in output, wages, business income, employment, and indirect business taxes
Energy Efficiency Study	Review of studies to understand national energy efficiency market conditions
Hours of Use Inputs for Key C&I Programs	Validation of contractor-based hours of use inputs for SBDIL and Custom Lighting Programs
Potential Overlap Between Key C&I Programs	Investigation of potential overlap for measures associated with C&I Prescriptive, SBDIL, and Midstream efforts
New Initiatives and Pilot Program Analysis	Analysis of new initiative and pilot programs using program staff and pilot participant survey data, initiative participation, and additional research
Comprehensive Longitudinal Effects (CLE) Study	A study that quantifies and describes opportunities that remain for Hawai'i Energy programs to achieve long-term energy savings
History of Hawaii Building Energy Codes	Assessment of past and present Hawaii building energy codes
Hawai'i Energy Awareness Study	Study that measures awareness and knowledge related to actions that customers take to save energy since the inception of Hawai'i Energy in 2009
Historic Participation Analysis	Assessment of past program accomplishments in Program participation and savings impacts
History of Annual EM&V-Related Research	Assessment of past EM&V related research

Applied Energy Group, Inc.
500 Ygnacio Valley Road, Suite 250
Walnut Creek, CA 94596

P: 510.982.3525

