TECHNICAL REFERENCE MANUAL (TRM)

Program Year 2018

July 1, 2018 – June 30, 2019

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Hawai'i Energy's mission is to empower island families and businesses to make smart energy choices that reduce energy consumption, save money and pursue a 100% clean energy future.

TABLE OF CONTENTS

General Information

- Changes from PY18 v1.0
- Introduction
- Signatures
- Glossary
- Key Metrics
- Master EUL
- Savings Factors
- EFLH
- Custom

Commercial Measures

Appliance
- Refrigerator

Building Envelope
- Cool Roof
- Window Film

Kitchen
- Combination Oven
- Convection Oven
- Demand-Controlled Ventilation
- Electric Griddle
- Electric Steam Cooker
- Fryer
- Hot Food Holding Cabinet
- Ice Machine
- Low-Flow Spray Nozzle
- Freezer
- Refrigerator

Energy Study Grant
- Design Assistance
- Energy Study

HVAC
- Chiller
- Chiller Worksheet
- AC & Heat Pump
- AC Worksheet
- Variable Frequency Drive Water Pump
- Variable Refrigerant Flow AC
- Energy Management System

Lighting
- General
- Dimmable (Non-linear LED)
- Refrigerated Case Light

Residential Measures

Appliance
- Air Purifier
- Clothes Washer
- Clothes Dryer
- Refrigerator

Electronics
- Television
- Soundbar

HVAC
- Window AC
- VRF Split
- Central AC Retrofit
- Central AC Tune Up
- Ceiling Fan
- Dehumidifier
- Smart Thermostat
- Solar Attic Fan
- Whole House Fan

Lighting
- LED
- Occupancy Sensor

Plug / Process
- Advanced Power Strip

Pump / Motor
- Variable Frequency Drive Pool Pump

Water Heating
- Heat Pump
- Solar Water Heater
- Solar Water Heater Tune Up
- Faucet Aerator
- Low-Flow Showerhead

Other

Occupancy Sensor
Stairwell Bi-Level
Energy Advantage
Plug / Process
Anti-Sweat Heater Control
Vending Miser
Water Cooler Timer
Case Night Cover
Pump / Motor
Variable Frequency Drive Booster Pump
Electronically Commutated Motors
Premium Efficiency Motors
Variable Frequency Drive Pool Pump
Sub-metering
Condominium
Small Business
Water Heating
Solar
Other
Re|Retro-Commissioning
Peer Group Comparison

MAJOR CHANGES FROM PY2018 v1.0

Cover Page	Added cover page for printing/PDF purposes.
C_HVAC_Chiller_WKST	Fixed worksheet formula bug.
C_HVAC_AC_WKST	Streamlined worksheet to only show EER and SEER.
R_Appliance_Air Purifier	Added residential air purifier TRM entry.
R_HVAC_Dehumidifier	Added residential dehumidifier TRM entry.
R_HVAC_Window AC	Added "Window AC without trade-in" savings.
R_HVAC_Window AC	Changed enhanced CEER from 11.2 to 11.4 to match with updated ENERGY STAR value.
R_PlugProcess_Switch Plug	Added residential power switch plug TRM entry,

INTRODUCTION

Technical Resource Manual (TRM)

All energy efficiency and conservation programs need to estimate the average amount of energy and demand that is saved for installations of standard measures. This allows an effective program to promote these standard measures across markets with an incentive amount that is appropriate for the amount of energy and/or demand that is typically saved. Hawai'i Energy maintains these energy saving estimates in the Technical Resource Manual (TRM). The following describes how the TRM was developed and the key assumptions that were used in estimating the energy (kWh) savings and demand (kW) reduction impacts claimed by the Program. Upon the end of each program year, a formal evaluation is conducted by the Program Evaluator whereby recommendations are provided to the Program. Updates and improvements are implemented for the subsequent program year in collaboration with the Contract Manager.

The TRM is intended to be a flexible and living document. New measures may be added as new program designs are implemented. These measures are often not yet characterized, so new information will be gathered through evaluations or research. Savings for current measures may change as the market evolves.

There are four main reasons to update TRM values:

- *New Measure Additions* – As new technologies become cost-effective, they will be characterized and added to the manual. In addition, new program delivery design may result in the need for new measure characterization.
- *Existing Measure Updates* – Updates will be required for a number of reasons; examples include: increase in the federal standard for efficiency of a measure; new information from field tests; altered qualification criteria; decrease in measure cost; or a new evaluation that provides a better value of an assumption for a variable. As programs mature, characterizations need to be updated to meet the changes in the market.
- *Retiring Existing Measures* – When the economics of a measure become such that it is no longer cost-effective or the free-rider rate is so high that it is not worth supporting, the measure shall be retired.
- *Third-Party Measurement and Verification (M&V) Contractor TRM Review* – Annually the M&V contractor will provide a review of the current TRM and make recommendations based on current market research and in-field savings verification of measures.

Overview of the TRM Derivation

In the TRM, each measure includes a description of the typical baseline (average) energy use and the high-efficiency energy use for that type of technology. The energy saved is typically the differential between the two. The energy use of the baseline technology may include some estimation of market status related to various types of older, less efficient equipment.

Data assumptions are based on Hawai'i specific data, when and where available. Where Hawai'i data was not available, data from neighboring regions is used where available and in some cases, engineering judgment is applied. Referenced data sources, in general order of preference, but not necessarily limited to,

- Energy and Peak Demand Impact Evaluation Report of the 2005-2007 Demand Management Programs (KEMA)
- Energy Efficiency Potential Study (HECO IRP-4, HECO 2014 DSM Docket)
- California Commercial Building End-Use Survey (prepared for the California Energy Commission by Itro
- TRM Review/Report (Evergreen Economics, June 2013)
- Third Party Evaluation NTG Recommendation Memo (Evergreen Economics, January 2013)
- The Database for Energy Efficiency Resources (California Public Utilities Commission, 2004 – 2005; updated version 2007-2008)
- ENERGY STAR® Partner Resources
- Field verification of measure performance
- Other energy efficiency program design information (e.g. Efficiency Maine, Focus on Energy, etc.)

The savings estimates for each measure were initially drawn from the KEMA Evaluation Report for 2005 through 2007 since this report was the most recent information available on specific markets. The values in this report were built upon previous evaluation reports and in-field measurements.

Since there were many measures that used "average" field measured data and no mathematical savings derivations, the calculation approach in the TRM attempted to develop these savings calculations based on typical measure characteristics. The primary use of the KEMA report values was to guide market assumptions, especially for the baseline energy use, to more accurately estimate the typical savings.

Customer level savings are based on many variables including: measure life, market sectors, base versus enhanced case, persistence and coincidence factors. Claimed savings were compared against other sources, such as savings values used in other jurisdictions and research documentation from KEMA, the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the National Renewable Energy Laboratory (NREL) and other organizations.

SIGNATURES

Applicable Program Year: PY2018 (July 1, 2018 - June 30, 2019)
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Approvals:

Hawai'i Energy

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Name	Title, Organization	Date

GLOSSARY

System Loss Factor (SLF)	Energy savings at the customer level is equivalent to even greater savings at the point of production, due to energy losses during transmission. Each county in Hawai'i has a different system loss factor due to differences in infrastructure. SLF values are determined by HECO, MECO, and HELCO. System level savings is equal to Customer level savings times (1 + SLF).
Net-to-Gross (NTG)	Also known as freeridership. This is the percent of customers that would have implemented the measure regardless of Hawai'i Energy incentive. Net-to-gross factors are different for each program category, i.e. Business Hard-to-Reach (BHTR) and Residential Energy Efficiency Measures (REEM). NTG factors were deemed by third-party evaluator.
Equipment Useful Life (EUL)	Equipment useful life is commonly defined as the number of years after which 50% of the installed measures are inoperable or removed from service. Except in specific cases, Hawai'i Energy assumes values from the California DEERS database.
Interactive Factors (IF)	When lighting efficiency is improved, the additional cooling load from lighting fixtures is reduced, and therefore demand and energy savings are increased by a deemed factor, depending on business type.
Persistence Factor (PF)	Energy efficiency measures may fail before end of useful life, or be removed by customer. Persistence factor is the liklihood that measures remain installed for the duration of useful life. Range = 0-100%.
Coincidence Factor (CF)	Percent of time savings correspond with utility peak, 5 pm to 9 pm. Range = 0-100%
Total Resource Benefit (TRB)	Total Resource Benefit is the present value of avoided utility costs over the life of the efficiency measures installed through the program. The utilities' total avoided cost of all saved energy and capacity avoided is called the Total Resource Benefit (TRB).
Total Resource Cost (TRC)	Total Resource Cost is the customer's project or incremental cost to purchase and install the energy-efficient equipment or make operational changes above what would have been done anyway.
TRB-TRC Ratio	The societal cost test of the TRB/TRC provides a metric of how much "return on investment" is provided by: (1) Saving energy versus generating it (kWh reductions) and (2) Avoiding the need for increased power plant capacity (Peak kW reductions).
Equivalent Full Load Hours (EFLH)	The number of hours of operation on an annual basis of a piece of equipment

KEY METRICS

Development of Avoided Costs

The primary overall economic benefit to the State of Hawai'i is the avoided cost of the energy that is saved. The total avoided cost of all the energy that is saved is called the Total Resource Benefit (TRB). To estimate the TRB for individual measures or for the total savings for the Program, the cost per MWh supplied and the system capacity cost per kW need to be estimated into the future.

Proxy Avoided Cost

The Program's avoided cost is calculated based on the PY2015 PBFA Contract Renewal Guidelines to use an initial $0.161/kWh avoided cost figure for 2015 and escalate it at 3% per year. The capacity impact was based on the utility revised avoided costs. The capacity avoided cost for the Program takes into account a prorated demand value based on O'ahu demand achievements of 76% in PY13. No capacity savings was used for Maui County for PY16. The following table provides capacity values through year 2033, after which the Program assumes a linear relationship, based on years 2029-2033, to extrapolate the avoided cost for a

Waiver Docket 2013-0056 EEPS (2013-0056) Avoided Capacity Cost

Attachment A: Revised Avoided Costs

EEPS avoided cost with 15% non energy cost benefit added included in Energy price forecast

HECO

P2_100vs110

Year	Energy $/MWH	Capacity $/KY-Yr
2014	192	0
2015	196	0
2016	230	0
2017	233	0
2018	243	0
2019	253	0
2020	260	1,189
2021	273	1,298
2022	295	1,126
2023	297	987
2024	314	872
2025	326	776
2026	328	694
2027	346	624
2028	357	1,342
2029	358	1,403
2030	373	1,269
2031	391	1,151
2032	397	1,046
2033	420	953
	Levelized	Levelized
	273	812
	$/MWH	$/kW-yr

HELCO

H2_100vs110

Year	Energy $/MWH	Capacity $/KY-Yr
2014	225	0
2015	226	0
2016	232	0
2017	241	0
2018	248	0
2019	258	0
2020	271	0
2021	280	0
2022	306	0
2023	319	0
2024	332	0
2025	346	0
2026	359	0
2027	376	0
2028	390	0
2029	407	0
2030	425	0
2031	448	0
2032	465	0
2033	493	0
	Levelized	Levelized
	296	0
	$/MWH	$/kW-yr

MECO

M2_100vs110

Year	Energy $/MWH	Capacity $/KY-Yr
2014	192	0
2015	219	0
2016	220	0
2017	223	0
2018	226	0
2019	232	0
2020	238	0
2021	243	0
2022	267	0
2023	276	0
2024	288	0
2025	295	0
2026	306	0
2027	317	0
2028	329	0
2029	341	4,902
2030	356	5,647
2031	370	5,126
2032	394	4,671
2033	416	4,269
	Levelized	Levelized
	257	1361
	$/MWH	$/kW-yr

Total Resource Benefit (TRB)

The Total Resource Benefit (TRB) is the estimated total net present value (NPV) of the avoided cost for the utility from the reduced lifetime demand (kW) and energy (kWh) from energy efficiency projects and measures. The utility costs were determined based on PY15 guidelines to use an initial $0.161/kWh avoided cost figure and escalate it at 3% per year. Average annual avoided cost for capacity and energy for calendar year 2015 escalated for a 20-year period was the basis for the analysis. The TRB incorporated avoided transmission and distribution costs into the avoided energy and capacity costs. The time value of money is represented by a discount rate of 6%. The discount rate is used to convert all costs and benefits to a "net present value" for comparing alternative costs and benefits in the same years' dollars.

Total Resource Benefit Calculation

Discount Rate	Factored EEPS	Escalation Rate
6%	76%	3%

			Utility Avoided Cost*		NPV for each Year		NPV Cumulative from Final Year	
Year	Period	NPV Multiplier	$/kW/yr	$/kWh/yr	$/kW/yr	$/kWh/yr	$/kW/yr	$/kWh/yr
2018	1	1.00	$ -	$ 0.176	$ -	$ 0.176	$ -	$ 0.176
2019	2	0.94	$ -	$ 0.181	$ -	$ 0.171	$ -	$ 0.347
2020	3	0.89	$ 904	$ 0.187	$ 805	$ 0.166	$ 805	$ 0.513
2021	4	0.84	$ 986	$ 0.192	$ 828	$ 0.161	$ 1,633	$ 0.674
2022	5	0.79	$ 856	$ 0.198	$ 678	$ 0.157	$ 2,311	$ 0.831
2023	6	0.75	$ 750	$ 0.204	$ 560	$ 0.152	$ 2,871	$ 0.983
2024	7	0.70	$ 663	$ 0.210	$ 467	$ 0.148	$ 3,338	$ 1.131
2025	8	0.67	$ 590	$ 0.216	$ 392	$ 0.144	$ 3,730	$ 1.275
2026	9	0.63	$ 527	$ 0.223	$ 331	$ 0.140	$ 4,061	$ 1.415
2027	10	0.59	$ 474	$ 0.230	$ 281	$ 0.136	$ 4,342	$ 1.551
2028	11	0.56	$ 1,020	$ 0.236	$ 570	$ 0.132	$ 4,912	$ 1.683
2029	12	0.53	$ 1,066	$ 0.244	$ 562	$ 0.128	$ 5,474	$ 1.811
2030	13	0.50	$ 964	$ 0.251	$ 479	$ 0.125	$ 5,953	$ 1.936
2031	14	0.47	$ 875	$ 0.258	$ 410	$ 0.121	$ 6,363	$ 2.057
2032	15	0.44	$ 795	$ 0.266	$ 352	$ 0.118	$ 6,715	$ 2.175
2033	16	0.42	$ 724	$ 0.274	$ 302	$ 0.114	$ 7,017	$ 2.289
2034	17	0.39	$ -	$ 0.282	$ -	$ 0.111	$ 7,017	$ 2.400
2035	18	0.37	$ -	$ 0.291	$ -	$ 0.108	$ 7,017	$ 2.508
2036	19	0.35	$ -	$ 0.300	$ -	$ 0.105	$ 7,017	$ 2.613
2037	20	0.33	$ -	$ 0.308	$ -	$ 0.102	$ 7,017	$ 2.715
2038	21	0.31	$ -	$ 0.318	$ -	$ 0.099	$ 7,017	$ 2.814
2039	22	0.29	$ -	$ 0.327	$ -	$ 0.096	$ 7,017	$ 2.910
2040	23	0.28	$ -	$ 0.337	$ -	$ 0.094	$ 7,017	$ 3.004
2041	24	0.26	$ -	$ 0.347	$ -	$ 0.091	$ 7,017	$ 3.095
2042	25	0.25	$ -	$ 0.358	$ -	$ 0.088	$ 7,017	$ 3.183

* EEPS (2013-0156) Avoided Capacity Cost factored by 76% to reflect contribution of kW reductions achieved on Oahu in PY13. $161/MWh Avoided Costs per Guidance Recommendations. This is a conservative estimate based on EEPS 2014 Projections of $192, $225 and $192/MWh for HECO, HELCO and MECO respectively.

Gross-to-Net Calculations

The algorithms shown with each measure calculate gross customer electric savings without counting the effects of line losses from the generator to the customer or free ridership. The formula for converting gross customer-level savings to net generation-level savings are as follows:

Net Program kWh = Gross Customer Level ΔkWh × (1 + SLF) x NTGR
Net Program kW = Gross Customer Level ΔkW × (1 + SLF) x NTGR

Net kWh : kWh energy savings at generation-level, net of free riders and system losses

Net kW : kW savings at generation-level, net of free riders and system losses
Gross Cust. ΔkWh : Gross customer level annual kWh savings for the measure
Gross Cust. ΔkW : Gross customer level connected load kW savings for the measure
SLF : System Loss Factor
NTGR : Net-to-Gross Rate that includes Free Riders and Engineering Verification

Net-to-Gross Rate (NTGR)

The net-to-gross rate used was estimated using the following information from the Evergreen (EM&V) report

Program			Q1 Q2	Q3 Q4	Net-to-Gross
BEEM	Business Energy Efficiency Measures	All BEEM Measures	0.75		0.75
CBEEM	Custom Business Energy Efficiency Measures	All CBEEM Measures	0.75		0.75
BESM	Business Energy Services and Maintenance	All BESM Measures	0.95		0.95
BHTR	Business Hard-to-Reach	All BHTR Measures	0.99		0.99
REEM	Residential Energy Efficiency Measures	Peer Group Comparison - Quarterly Paper Report	1		1
		LED (upstream) [1]	0.65	0.5	0.575
		All other REEM Measures	0.79		0.79
CREEM	Custom Residential Energy Efficiency	All other CREEM Measures	0.65		0.65
RESM	Residential Energy Services and Maintenance	All other RESM Measures	0.92		0.92
RHTR	Residential Hard-to-Reach	All other RHTR Measures	1		1
Effective Program Total Based on PY18 Portfolio Plan					0.84

Notes: 1. Based on HE PY18 Annual Plan, the Net-to-Gross value is an annualized transition from 0.79 to 0.5 over the course of PY18, with an anticipated PY19 NTG of 0.5

System Loss Factor (SLF)

The percentage of energy loss during the transmission and distribution of electricity with respect to the amount generated is known as the System Loss Factor.

The system loss factors were provided by HECO, MECO and HELCO. They do not vary by measure, but by county, and are given in the following table:

County Loss Factors	
Oahu	11.17%
Maui	9.96%
Hawaii	9.00%

EFFECTIVE USEFUL LIFE

Effective Useful Life is the median length of time (in years) that an energy efficiency measure is functional. The measure Effective Useful Life estimated for each measure is shown in the following table:

Residential Measures			
Program	**Measure Type**	**Description**	**DEER Effective Useful Life (years)**
REEM	Water Heating	Solar Water Heating	20
R		Heat Pumps	10
R	Lighting	CFL	9
R		LED	15
R	HVAC	VRF Split	15
R		Window AC w/recycling	9
R		Ceiling Fans	5
R		Dehumidifier	12
R		Solar Attic Fans	20
R		Whole House Fans	20
R	Appliances	Refrigerator (<$600)	14
R		Refrigerator w/Recycling	14
R		Garage Refrigerator/Freezer Bounty	14
R		Clothes Washer (Tier I/II/III)	11
R		Clothes Dryer	14
R		Television	6
R		Set top box	5
R		Electronics Soundbar	7
R		Pool VFD Controller Pumps	10
R		Advanced Power Strip	5
R		Air Purifier	9
R	Control Systems	Room Occupancy Sensors & Timers	8
R		Peer Group Comparison	1
R		Whole House Energy Metering	4
R		Water Cooler Timer	8
CREEM	Custom	Efficiency Project Auction	5
RESM	Design and Audits	Efficiency Inside	15
R	Water Heating	Solar Water Heater Tune Up	5
R	HVAC	Central Air Conditioning Retrofit	15
R	HVAC	Central Air Conditioning Tune-Up	1
RHTR	Hard to Reach Grants	CFL Exchange	6
R		Refrigerator w/Recycling	14
R	Water Heating	Solar Water Heating	20
R	Direct Install	Energy Saving Kits	6
R		Faucet Aerators	5
R		Low Flow Showerheads	5
R		Smart Thermostats	11

Commercial Measures			
Program	**Measure Type**	**Description**	**DEER Effective Useful Life (years)**
BEEM	Water Heating	Solar Water Heating - Electric Resistance	20
B		Solar Water Heating - Heat Pump	20
B		Heat Pump - conversion - Electric Resistance	10
B		Heat Pump Upgrade	10
B		Single Family Solar Water Heating	20
B	Lighting	Ceramic Metal Halide	14
B		CFL	3
B		Delamp w/Reflector (2', 4', 8')	14
B		Delamp	14
B		ENERGY STAR LED Dimmable A19	15
B		ENERGY STAR LED Dimmable w/Controls	15
B		ENERGY STAR LED Non-Dimmable	15
B		ENERGY STAR LED Non-Dimmable A19	15
B		LED Exit Signs	15
B		LED FIXTURE	15
B		LED Refrigerator Case Lighting	16
B		LED STREET AND PARKING LOT FIXTURE	15
B		Sensors	8
B		Stairwell Bi-Level Dimming Fluorescent	14
B		T12 to T8 Standard (2/3/8)	14
B		T12 to T8 Low Wattage	14
B		T8 to T8 Low Wattage	14
B	HVAC	Chillers	20
B		Chiller Plant Efficiency kW/Ton Meter	20
B		Garage Active Ventilation Control	8
B		Package Units	15
B		VFR Split System – New Construction	15
B		VFR Split System – Existing	15
B		VFD – AHU	15
B		VFD – Chilled Water / Condenser Water	15
B	Water Pumping	VFD Dom Water Booster Packages	15
B		VFD Pool Pump	15
B	Motors	Premium Efficiency Motors	15
B		ECM w/ Controller – evap fan motors	15
B		ECM – Fan Coil Fans	15
B	Industrial Process	Kitchen Exhaust Hood Demand Ventilation	15
B		Refrigerated Case Night Covers	5
B	Building Envelope	Window Film	10
B		Cool Roof	15
B	Business Equipment	ENERGY STAR Refrigerator	14
B		Clothes Washer	11
B		Energy Savings Kit	6
B	Control Systems	Energy Management System (EMS)	15

B		Condominium submetering	8
B		Small Business submetering	8
CBEEM	Custom	Custom <= 5 years	5
B		Custom > 5 years	13
B		Efficiency Project Auction	10
B		Re/Retro Commissioning	3
BESM	Design and Audits	Benchmark Metering	1
B		Decision Maker - Real time submeters	1
B		Energy Audit	N/A
B		Energy Study Implementation - 100%	N/A
B		Energy Study Assistance - 50%	N/A
B		Design Assistance - 50%	N/A
B		Water/Wastewater Catalyst	15
BHTR	Direct Install	SBDI	14
B	Grants	Water cooler timer	5
B	Restaurant	SBDI - Kitchen Exhaust Hood Demand Ventilation	15
B		Low flow spray rinse nozzles	5
B		ENERGY STAR Kitchen Equipment	12
B		SBDI - Lighting	14
B	Custom	Customized Retrofit	Customized
B		Anti-Sweat Heater Controls	12
B		Transformer	30

SAVINGS FACTORS

Interactive Factor (IF)

The TRM provides specific savings algorithms for many prescriptive measures. When a customer installs a prescriptive measure, the savings are determined according to these algorithms. In some cases these algorithms include the effects of interactions with other measures or end.

For "custom" measures, Hawaii Energy performs site-specific customized calculations. In this case, Hawaii Energy takes into account interactions between measures (e.g., individual savings from installation of window film and replacement of a chiller are not additive because the first measure reduces the cooling load met by the second measure).

Hawaii Energy will calculate total savings for the package of custom measures being installed, considering interactive effects, either as a single package or in rank order of measures as described below.

If a project includes both prescriptive and custom measures, the prescriptive measures will be calculated in the normal manner. However, the prescriptive measures will be assumed to be installed prior to determining the impacts for the custom measures.

Table 1: Cooling Load Interactive Factors by Building Type

Building Type	IF_energy	IF_demand
Misc. Commercial	1.056	1.075
Cold Storage	1.423	1.22
Education	1.061	1.039
Grocery	1.043	1.114
Health	1.122	1.233
Hotel/Motel	1.115	1.236
Industrial	1.043	1.074
Office	1.068	1.102
Restaurant	1.051	1.073
Retail	1.054	1.085
Warehouse	1.019	1.053
Exterior	1	1

Source: *Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, p.7*

Persistence Factor (PF)

Persistence factors may be used to reduce lifetime measure savings in recognition that initial engineering estimates of annual savings may not persist long term.

This might be because a measure is removed or stops functioning prior to the end of its normal engineering lifetime, because it is not properly maintained, it is overridden, it goes out of calibration (controls only), or for some other reason.

Some of the measure algorithm may contain an entry for persistence factor. The default value if none is indicated is 1.00 (100%). A value lower than 1.00 will result in a downward adjustment of lifetime savings and total resource benefits.

For any measure with a persistence value less than 1.00, the claimed first year savings are reduced, and claimed for each year of the equipment's expected useful life.

Load shapes and Demand Coincidence Factors

Load shapes for different types of equipment or systems were not needed because the savings values estimated in the KEMA 2008 impact evaluation already accounted for these load shapes. The coincidence factors (non-lighting) were developed based on the calculated full load demand reduction and the KEMA values for each building type. The resulting coincidence factors were evaluated for reasonableness depending on the system type and the building type.

EQUIPMENT OPERATING HOURS

Commercial Lighting Hours of Operation & Coincidence Factor (CF)

Coincidence factors represent the fraction of connected load expected to be "on" and using electricity coincident with the system peak period.

The coincidence factors were developed based on the calculated full load demand reduction and the KEMA values for each building type. The resulting coincidence factors were evaluated for reasonableness depending on the system type and the building type.

Table 1. Commercial Lighting: Annual Operating Hours & Coincidence Factors

Building Type	General Lighting Hours	CF
Misc. Commercial	4,325	0.30
Cold Storage	4,160	0.50
Education	2,653	0.20
Grocery	5,824	0.85
Health	6,474	0.65
Hotel/Motel	4,941	0.60
Industrial	4,290	0.50
Office	2,808	0.50
Restaurant	5,278	0.75
Retail	4,210	0.60
Warehouse	4,160	0.45
Exterior	4,380	0.75

Source: Hours from Itron, Inc., KEMA, JJ Hirsh. DEER Database: 2011 Update Documentation Appendices. November 8, 2011. http://www.deeresources.com/files/DEER2011/download/2011_DEER_Documentation_Appendices.pdf
Exterior Coincidence Factor assumes 3/4 of exterior operating hours are coincident with Hawaii Energy peak.

Commercial Chiller Extended Full Load Cooling Hours (EFLH) and Coincident Factor (CF)

Building Type	EFLH[1]	CF[2]
Misc. Commercial	3050	0.7
Cold Storage	3050	0.7
Education	2342	0.74
Grocery	3050	0.7
Health	4709	0.75
Hotel/Motel	1952	0.24
Industrial	3520	0.85
Office	2603	0.7
Restaurant	3050	0.7
Retail	3379	0.76
Warehouse	3050	0.7

Notes: 1. Southern California Edison 13HC030.1 Air-Cooled Packaged Chillers Final Workpaper July 1 2014 and embedded Calculation Template 2015.v4. Available at deeresources.net/workpapers.
Source references SDGE model results. Table 2 values may be averaged or best match to Hawaii Energy tracked building types.

2. Southern California Edison 13HC030.1 Air-Cooled Packaged Chillers Final Workpaper July 1 2014 and embedded Calculation Template 2015.v4. Available at deeresources.net/workpapers.
Source references SDGE summer peak model results, where utility summer peak is 11 am to 6 pm weekdays. Table 2 values may be averaged or best match to Hawaii Energy tracked building types.

Custom Measures

In addition to prescriptive energy conservation measures that are defined within this Technical Reference Manual, there are projects that are handled on a case-by-case basis through our custom incentive program. Custom projects may be complex projects with multiple components, first-of-their-kind projects, or special projects that are unique to a particular customer. A few examples of custom incentive projects from past years include:

- A new packaging machine for a water bottling facility.
- A condominium submetering installation with submetering on electrical consumption as well as chilled water usage at the individual condo level.
- A whole-building retro-commissioning project with "pre" and "post" metering.

In PY17, Hawai'i Energy moved some formerly prescriptive projects to the custom category, mainly for the reason that these projects occur infrequently. These include Transformers, Residential New Construction, and Heat Pump Water Heater-to-Heat Pump Water Heater upgrades. Below is a list and description of a selection of custom measures. Due to the nature of our custom program, this list is not intented to be comprehensive.

3.1 Transformers

In the PY16 TRM, Transformers were treated as a prescriptive measure with pre-defined energy and demand savings based on size and CEE Tier 1 or Tier 2 qualification. Given the low frequency that these projects arise, the Transformer incentive was moved to the custom category in PY17. In addition to the change from prescriptive to custom, the baseline efficiency requirement has changed from a NEMA TP-1 to a CEE Tier1, in accordance with the amended federal standards as of January 1, 2016 (Source: "Distribution Transformers Initiative" 2015 CEE Annual Report, 2015. https://2015annualreport.cee1.org/initiatives/distribution-transformers-initiative/). Qualifying high efficiency transformers must meet CEE Tier 2. The useful life for transformers is 32 years (according to ORNL-6847, Determination Analysis of Energy Conservation Standards for Distribution Transformers). However, Hawai'i Energy limits the measure life of any measure to 25 years maximum to match the period of the TRB calculation.

3.2 Residential New Construction

Hawai'i Energy has moved the Residential New Construction incentive from previous TRM versions to a custom incentive due to the complex and unique nature of these projects. Residential homes vary in size, orientation, construction, and equipment and therefore require a customized approach when estimating energy savings. Residential New Construction projects may include a subset of prescriptive measures, such as Energy Star appliances, which may still be rebated on a prescriptive basis.

3.3 Commercial Heat Pump Water Heater Upgrade

Commercial heat pump water heater projects will be handled on a custom basis. The amount of energy needed to generate sufficient hot water for various business facilities fluctuates due to many contributing factors. Each business type operates differently, thus creating the challenge of defining certain variables witin the savings algorithms to represent all business types. Factors such as occupancy, efficiency, water heater size, hot water demand, temperature settings, and location are examples that require custom inputs to accurately estimate energy savings. Commercial heat pump water heater to heat pump water heaters retrofits are eligible for incentives on the grounds that the current building code allows for installation of standard electric resistance water heaters (SERWH) in this application. Therefore SERWH may be treated as the baseline efficiency for this type of project. Commercial heat pump water heater projects are infrequent and may be evaluated on a case-by-case basis.

3.4 Chillers

As a guideline, Hawai'i Energy has established an upper threshold of 600 tons for prescriptive chiller incentives. Chillers above 600 tons may be treated on a custom basis. Projects that are part of a larger project with a variety of efficiency measures being installed simultaneously, or other unique projects, would be a candidate for custom evaluation, at the discretion of Hawai'i Energy. This threshold was set for the following reasons:

- Larger chiller projects are usually quite complex, and may involve other system changes, such as controls upgrades, pump modifications, VFD upgrades and more. Calculating savings on a prescriptive or even semi-prescriptive basis of tonnage and nameplate efficiency only would be inadequate in most cases for larger chiller projects.
- Hawai'i Energy acknowledges that performing true custom savings calculations is more time, cost, and labor-intensive, due to the additional requirements for pre and post metering. These barriers may actually inhibit the feasibility of a project to move forward, and therefore Hawai'i Energy would limit the number of custom projects per year.
- Hawai'i Energy opted for a cut-off tonnage that aligns with the tonnage break points in IECC code for chiller efficiency, i.e. 300/400/600 tons.

3.5 VFD

As a guideline, Hawai'i Energy has established an upper threshold of 200 horsepower for prescriptive rebates on variable frequency drives. This value was chosen after a literature review. The NEEP VSD Loadshape Project (2014) determined a savings metric for prescriptive energy and demand savings for VSDs on various applications for motors up to 200 hp. In addition, the NREL Chapter 18 VFD Evaluation Protocol (2017) recommended this method for prescriptive evaluation. The NREL Chapter stated that a customized evaluation "is more common for facilities that are applying incentives for a variety of measures in a building." VFD projects that are part of a larger project with a variety of efficiency measures being installed simultaneously would be a candidate for Custom evaluation, at the discretion of Hawai'i Energy.

3.6 Commercial Kitchen Dishwashers

Commercial kitchen dishwashers will be added as a new custom measure in PY18, with the intention to convert this measure to a prescriptive measure in a subsequent year. Energy and demand savings will be calculated on a case-by-base basis using the the Fishnick Dishwasher Life Cycle Cost Calculator.

3.7 Advanced Residential Intelligent Efficiency Services (ARIES)

ARIES is an opt-in deployment of emerging technology and program services designed to provide significant enhancements over historical approaches with improved:

- Savings impact, measurement methods, and understanding of savings sources
- Customer interest, engagement, satisfaction, trust and overall value

- Cost structure and future curve for long term persistence and cost-effectiveness

The source of savings can be considered as coming from the following 4 categories of home energy impact areas, in rough order of estimated impact and cost/complexity:

- "Always On" – We estimate the average "baseline" power draw in homes to be ~250 Watts, whereas many homes have far lower continuous draws of 100W or less. Eliminating 50 Watts of always on would amount to 6% household savings. ARIES will prioritize engaging customers to target this opportunity through gamified feedback.
- "Adjustments & Maintenance" – Changing setting and schedules, or habits associated with devices like electronics and appliances. The savings potential in this category is higher for large electric uses like heat pumps, water and space heaters etc. Depending upon customer context could represent additional 5% savings or more. ARIES will assess customer-specific savings potential and act accordingly with informational interventions.
- "Eliminate" – Many households accumulate energy-using products or equipment over time that they may not need. ARIES will help enhance customers' visibility and awareness of these vestigial device usage and encourage them to consider whether customers have an opportunities to reduce their energy
- "Upgrade" – Akin to conventional program activity, ARIES customers might replace existing devices with new ones that have a different energy impact. Out of program equipment changes can be tracked to better understand savings lifetimes, and in-program actions allow for double-counting adjustments.

The nature and high quality of energy information and customer insights developed by ARIES affords a significant opportunity to advance other opportunities that may serve other energy system stakeholders to support public interest.

COMMERCIAL: Refrigerator

MEASURE DETAILS

Description

ENERGY STAR certified refrigerator as specified below replacing a non-ENERGY STAR refrigerator and turning in the existing refrigerator to be recycled. Also, turn-in only refrigerators rebate available.
The PY15 residential refrigerator measure was duplicated for this commercial refrigerator measure.

Program Criteria

Appliance must comply with Energy Star. Energy Star refrigerators utilize improvements in insulation and compressors.

Unit of Measure

One refrigerator

Baseline Equipment

Baseline energy usage based on 2009 Energy Star Information for the appliances are as follows:

	Demand Baseline (kW)	Energy Baseline (kWh)	Notes
Non ES Qualifying Refrigerator	---	540	19.0 - 21.4 Top Freezer

High Efficiency Equipment

	Demand Baseline (kW)	Energy Baseline (kWh)	Notes
ES Qualifying Refrigerator	---	435	19.0 - 21.4 Top Freezer

ALGORITHMS

$$\Delta E_{.replace} = E_{.base} - E_{.he}$$

$$\Delta E_{.replace\&turn\text{-}in} = E_{.base} - E_{.he} + 717$$

$$\Delta P_{.replace} = (E_{.base} - E_{.he}) / HRS$$

$$\Delta P_{.replace\&turn\text{-}in} = (E_{.base} - E_{.he} + 717) / HRS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$E_{.base}$	Energy usage of the baseline equipment	540	kWh	
$E_{.he}$	Energy usage of the higher efficiency equipment	435	kWh	
ΔE	Energy reduction	Calculated	kWh	
ΔP	Power demand reduction	Calculated	kWh	

CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	100	%	
PF	Persistence factor, % of measures installed and operating	100	%	
HRS	Equivalent full load hours, or hours of lighting for business operation	8760	hrs	
DC	Duty cycle, how often compressor is active	70	%	Hawai'i Energy metered data
Measure Life	Expected duration of energy savings	14	yrs	

SAVINGS

				Reference
		Energy Use		**Reference**
New Non-ENERGY STAR Refrigerator		540.00		Table 4.1.1.f
New ENERGY STAR Refrigerator		- 435.00		Table 4.1.1.f
		105.00	kWh/yr	Table 4.1.1.e

#1 - Purchase of ENERGY STAR Refrigerator	105.00		Table 4.1.1.e
#2 - Removal of old unit from service (off the grid)	+ 717.00		Table 4.1.1.e
#1+#2 = Purchase ES and recycle old unit	822.00	kWh/yr	

	Energy Use	**Ratio**	**Contribution**		
Post-1993 Refrigerator	640	55.4%	354.54		Table 4.1.1.g
Pre-1993 Refrigerator	1131	44.6%	+ 504.46		Table 4.1.1.g
			859.00	kWh/yr	

Energy Savings Opportunities for Program Sponsors

Opportunity	Annual Savings			
	Per Unit		Aggregate U.S. Potential	
	kWh	$	MWh	$ million
1. Increase the number of buyers that purchase ENERGY STAR qualified refrigerators. • 9.3 million units were sold in 2008. • 70 percent were not ENERGY STAR. • 6.5 million potential units per year could be upgraded.	105	11.64	675,928	75
2. Decrease the number of units kept on the grid when new units are purchased. • 8.7 million primary units were replaced in 2008. • 44 percent remained in use, whether they were converted to second units, sold, or given away. • 3.8 million units are candidates for	717	79.53	2,746,062	305

retirement every year.				
3. Decrease the number of second units. • 26 percent of households had a second refrigerator in 2008. • 29.6 million units are candidates for retirement.	859	95.28	25,442,156	2,822
4. Replace pre-1993 units with new ENERGY STAR qualified models. • 19 percent of all units in use in 2008 were manufactured before 1993. • 27.3 million total potential units are candidates for targeted replacement.	730	81	19,946,440	2,212

Sources: See endnote 10.

Energy and Cost Comparison for Upgrading to ENERGY STAR

Purchase Decision	New Non-ENERGY STAR Qualified Refrigerator	New ENERGY STAR Qualified Refrigerator
Annual Consumption	540 kWh	435 kWh
	$60	$48
Annual Savings	–	105 kWh
	–	$12
Average Lifetime	12 years	12 years
Lifetime Savings	–	1,260 kWh
	–	$140
Price Premium	–	$30 - $100
Simple Payback Period	–	3-9 years

Note: Calculations based on shipment-weighted average annual energy consumption of 2008 models. An ENERGY STAR qualified model uses 20 percent less energy than a new non-qualified refrigerator of the same size and configuration.

Source: See endnote 10.

Energy and Cost Comparison for Removing a Second Refrigerator from the Grid

Fate of Unit	Post-1993 Unit		Pre-1993 Unit	
	Remains on the Grid	Removed from the Grid	Remains on the Grid	Removed from the Grid
Annual Consumption	640 kWh	–	1,131 kWh	–
	$71	–	$125	–
Annual Savings	–	640 kWh	–	1,131 kWh
	–	$71	–	$125
Average Lifetime*	6	–	6	–

Lifetime Savings*	–	3,840 kWh	–	6,788 kWh
	–	$426	–	$753
Removal Cost	–	$50 - $100	–	$50 - $100
Simple Payback Period	–	1-2 years	–	<1 year

*Assumes unit has six years of functionality remaining.

Sources: See endnote 10.

Measure Name	Peak Demand Savings	Annual Energy Savings
ES Refrigerator	0.017 kW	105.00 kWh
ES Refrigerator w/ Turn-in	0.140 kW	859.00 kWh
Turn-in Only	0.134 kW	822.00 kWh

COMMERCIAL: Cool Roof

MEASURE DETAILS

Description
This section covers installation of "cool roof" roofing materials in commercial buildings with mechanical cooling. The cool roof is assumed to have a solar absorptance of 0.3(1) compared to a standard roof with solar absorptance of 0.8(2). Energy and demand saving are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. Energy and demand impacts are normalized per thousand square feet of roof space.

Program Criteria
Building must have a means of mechanical cooling and cool roof must meet solar absorptance criteria.

Unit of Measure
Per 1000 square feet of material

Baseline Equipment
Roof with a solar absorptance of 0.80

High Efficiency Equipment
Roof with a solar absorptance of 0.30

ALGORITHMS

ΔE = 250 kWh per 1000-SF
ΔP = CF * (0.0001 / SF)

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction per ft^2	Calculated	kWh	250 kWh per 1000 SF
ΔP	Peak power demand reduction per ft^2	Calculated	kW	0.100 kW per 1000 SF
CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	50	%	
Measure Life	Expected duration of energy savings	15	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Cool Roof	0.05	250

COMMERCIAL: Window Film

MEASURE DETAILS

Description
Window film reduces solar heat gain, reducing load on cooling systems.

Program Criteria
• Film must have a minimum five-year manufacturer's warranty and one-year installer's warranty.

Unit of Measure
one square foot (SF) of window area

Baseline Equipment
No window tinting/film installed.

High Efficiency Equipment
• Shading Coefficient < 0.5
• Solar Heat Gain Coefficient (SHGC) < 0.435
• SC = 0.87*SHGC

ALGORITHMS

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔP	Peak power demand reduction per ft^2	Calculated	kW	
ΔE	Annual energy reduction per ft^2	Calculated	kWh	
PF	Persistance Factor	100	%	
CF	Coincidence factor, percent of time	100	%	
Measure Life	Expected duration of energy savings	10	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Hotel	0.001 kW/sq.ft.	5.60 kWh/sq.ft.
Office	0.001 kW/sq.ft.	4.50 kWh/sq.ft.
Other	0.002 kW/sq.ft.	4.50 kWh/sq.ft.
Average	0.001 kW/sq.ft.	4.87 kWh/sq.ft.

COMMERCIAL: Combination Oven

MEASURE DETAILS

Description

Commercial combination ovens offer the ability to steam food in the oven cavity. These oven are capable of steaming, proofing and reheating various food products in addition to the normal functions of baking and roasting. Foods can be cooked in a variety of ways: in a convection oven dry heat only mode, a steam only mode, and a combination of dry heat and steam modes. Food to be cooked partially in one mode at a certain temperature and then finished in another mode and at a separate temperature by utilizing the programmability of combination ovens. Combination ovens range in size from 6 pan countertop models up to 40 pan stand-alone models.

Program Criteria

Program follows ENERGY STAR guidelines, unless specified otherwise.

Unit of Measure

One oven

Baseline Equipment

See tables below.

High Efficiency Equipment

See tables below.

ALGORITHMS

$$\Delta E_{.annual} = E_{.total,base} - E_{.total,ee}$$

$$E_{.total} = E_{.cook} + E_{.steam} + E_{.preheat}$$

$$E_{.cook} = [(LBS_{.day} * DAYS * ETF_{.cook}) / \eta_{.cook}] + [\%_{.cook} * P_{.cook,idle} * HRS_{.cook,idle} * DAYS]$$

$$E_{.steam} = [(LBS_{.day} * DAYS * ETF_{.steam}) / \eta_{.steam}] + [\%_{.steam} * P_{.steam,idle} * HRS_{.steam,idle} * DAYS]$$

$$E_{.preheat} = \#_{.preheat} * E_{.preheat} * DAYS$$

$$HRS_{.idle} = HRS_{.day} - (LBS_{.day} / CAP_{.cook|steam}) - (\#_{.preheat} * T_{.preheat})$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\eta_{.cook}$	Efficiency of cooking mode	Table	-	
$\eta_{.steam}$	Efficiency of steaming mode	Table	-	
$ETF_{.cook}$	Energy needed to cook 1lb of food	0.0732	kWh/lb	
$ETF_{.steam}$	Energy needed to steam 1lb of food	0.0308	kWh/lb	
$P_{.cook,idle}$	Idle power draw of cooking mode	Table	kWh	
$P_{.steam,idle}$	Idle power draw of steaming mode	Table	kWh	
$HRS_{.cook,idle}$	Idle time in cooking mode	Calculated	hrs	
$HRS_{.steam,idle}$	Idle time in steaming mode	Calculated	hrs	
$E_{.preheat}$	Preheating energy usage	Table	kWh	

$\#_{.preheat}$	Number of preheating cycles	1	-	
$T_{.preheat}$	Duration of preheating	0.25	hrs	
$\%_{.cook}$	Percentage of time in cooking mode	0.5	-	
$\%_{.steam}$	Percentage of time in steaming mode	0.5	-	
$CAP_{.cook}$	Production capacity of cooking mode	Table	lbs/hr	
$CAP_{.steam}$	Production capacity of steaming mode	Table	lbs/hr	
$LBS_{.day}$	Pounds of food to be processed in a day	Table	lbs/day	
$HRS_{.day}$	Hours of equipment operation per day	12	hrs/day	
DAYS	Annual days of equipment operation	365	days	
CF	Coincidence factor, portion of time equipment load corresponds with utility peak load	0.84	-	
Measure Life	Expected duration of energy savings	12	yrs	

ALL	η_cook	η_steam
Base	0.65	0.40
Efficient	0.70	0.50

< 15 Pans	E_cook,idle	E_steam,idle	E_preheat	CAP_cook	CAP_steam	LBS_day
Base	1.50	10.00	3.00	80	100	200
Efficient	1.00	5.00	1.50	100	120	

15 - 28 Pans	E_cook,idle	E_steam,idle	E_preheat	CAP_cook	CAP_steam	LBS_day
Base	3.75	12.50	3.75	100	150	250
Efficient	2.50	6.00	2.00	152	200	

> 28 Pans	E_cook,idle	E_steam,idle	E_preheat	CAP_cook	CAP_steam	LBS_day
Base	5.25	18.00	5.63	275	350	400
Efficient	4.00	9.00	3.00	325	400	

SAVINGS

< 15 Pans		Cooking kWh	Idle kWh	Subtotal	Preheat kWh	Annual Usage
Base	Convection	8220.92	2532.19	10753.11	1095.00	35262.86 kWh
	Steam	5621.00	17793.75	23414.75		
Efficient	Convection	7633.71	1779.38	9413.09	547.50	23658.43 kWh
	Steam	4496.80	9201.04	13697.84		

15 - 28 Pans		Cooking kWh	Idle kWh	Subtotal	Preheat kWh	Annual Usage
Base	Convection	10276.15	6330.47	16606.62	1368.75	48004.23 kWh
	Steam	7026.25	23002.60	30028.85		
Efficient	Convection	9542.14	4610.53	14152.67	730.00	32001.17 kWh
	Steam	5621.00	11497.50	17118.50		

> 28 Pans		Cooking kWh	Idle kWh	Subtotal	Preheat kWh	Annual Usage
Base	Convection	16441.85	9864.33	26306.18	2054.95	74447.59 kWh

Base	Steam	11242.00	34844.46	46086.46	2654.95	74447.39 kWh
Efficient	Convection	15267.43	7679.04	22946.47	1095.00	50691.94 kWh
	Steam	8993.60	17656.88	26650.48		

Equipment Size	Peak Demand Savings	Annual Energy Savings
< 15 Pans	2.226 kW	11,604.43 kWh
15 - 28 Pans	3.069 kW	16,003.06 kWh
> 28 Pans	4.556 kW	23,755.65 kWh

COMMERCIAL: Convection Oven

MEASURE DETAILS

Description

Commercial convection ovens are widely used in the foodservice industry and have a wide variety of uses from baking and roasting to warming and reheating. Convection ovens are also used for nearly all types of food preparation, including foods typically prepared using other types of appliances (e.g., griddles, fryers, etc.). ENERGY STAR commercial ovens are about 20 percent more energy efficient than standard models.

Program Criteria

• Full-size electric convection ovens are defined by the ability to accept a minimum of five (5) standard full-size sheet pans (18 in. x 26 in. x 1 in.). Qualifying ovens must meet Energy Star requirements by having a tested heavy-load (potato) cooking efficiency in accordance with ASTM F1496. Cooking energy efficiency must be greater than or equal to 70 percent (≥70%) and must not exceed the maximum idle energy rate of 1.6 kW (≤1.6kW).

• Half-size electric convection ovens are defined by the ability to accept a minimum of five (5) sheet pans measuring (18 in. x 13 in. x 1 in.). Qualifying ovens must meet Energy Star requirements by having a tested heavy-load (potato) cooking efficiency in accordance with ASTM F1496. Cooking energy efficiency must be greater than or equal to 70 percent (≥70%) and must not exceed the maximum idle energy rate of 1.0 kW (≤1.0kW).

Unit of Measure

One oven

Baseline Equipment

Non-ENERGY STAR

High Efficiency Equipment

ENERGY STAR

ALGORITHMS

$$E_{.conventional} = (PREHEAT_{.rate,bs} * PREHEAT_{.time}) + (IDLE_{.rate,bs} * IDLE_{.time}) + (MASS_{.food} * ASTM_{.energy} / EFF_{.bs})$$

$$E_{.EnergyStar} = (PREHEAT_{.rate,ee} * PREHEAT_{.time}) + (IDLE_{.rate,ee} * IDLE_{.time}) + (MASS_{.food} * ASTM_{.energy} / EFF_{.ee})$$

$$\Delta E = E_{.conventional} - E_{.EnergyStar}$$

$$\Delta P = (\Delta E / HRS) * CF$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔP	Demand savings	Calculated	kW	
ΔE	Annual energy savings	Calculated	kWh/yr	

CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	0.84	-	
HRS	Equivalent full load hours, or hours of lighting for business operation	4380	hrs/yr	12 hrs/day, 365 days/year
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

FULL SIZE OVEN

	DEFAULT	USER ENTRY	
Average daily operation	12	12	hours
Annual days of operation	365	365	days
Food cooked per day	100	100	pounds
Incremental cost	0	0	dollars

	Conventional	ENERGY STAR	
Cooking energy efficiency	0.65	0.7	
Production capacity	70	80	lbs/hr
# of preheats per day	1	1	
Preheat length	15	15	min
Preheat energy rate	6000	4000	W
Idle energy rate	2000	1600	W
ASTM energy to food	73.2		Wh/lb
Equipment lifetime	12		yrs

	Conventional	ENERGY STAR	
Annual operation	4380.00		hrs
Daily preheat energy	1500.00	1000.00	Wh
Daily cooking energy	11261.54	10457.14	Wh
Daily idle time	10.32	10.50	hrs
Daily idle energy	20642.86	16800.00	Wh
Total daily energy	33404.40	28257.14	Wh

	Conventional	ENERGY STAR	
Annual Energy Use per Oven	12192.60	10313.86	kWh

HALF SIZE OVEN

	DEFAULT	USER ENTRY	
Average daily operation	12	12	hours
Annual days of operation	365	365	days
Food cooked per day	100	100	pounds
Incremental cost	0	0	dollars

	Conventional	ENERGY STAR	
Cooking energy efficiency	65%	70%	%
Production capacity	45	50	lbs/hr

Number of preheats per day	1	1	#
Preheat length	15	15	min
Preheat energy rate	4000	3600	W
Idle energy rate	1500	1000	W
ASTM energy to food	73.2		Wh/lb
Equipment lifetime	12		yrs

	Conventional	**ENERGY STAR**	
Annual operation	4380.00		hrs
Daily preheat energy	1000.00	900.00	Wh
Daily cooking energy	11261.54	10457.14	Wh
Daily idle time	9.53	9.75	hrs
Daily idle energy	14291.67	9750.00	Wh
Total daily energy	26553.21	21107.14	Wh

	Conventional	**ENERGY STAR**	
Annual Energy Use per Oven	9691.92	7704.11	kWh

Equipment Size	**Peak Demand Savings**	**Annual Energy Savings**
Full Size	0.360 kW	1878.75 kWh
Half Size	0.381 kW	1987.81 kWh

References

Equipment specifications: - ENERGY STAR specification
- Food Service Technology Center (FSTC) research on available models, 2009

Operating Hours: - FSTC research on average use, 2009

Equipment cost: - EPA research on available models using AutoQuotes, 2010

Equipment lifetime: - FSTC research on available models, 2009

COMMERCIAL: Demand-Controlled Ventilation

MEASURE DETAILS

Description

Kitchen ventilation with DCKV hood exhaust. Demand ventilation uses temperature and/or smoke sensing to adjust ventilation rates. This saves energy comparing with the traditional 100% on/off kitchen ventilation system.

Program Criteria

To qualify for a Hawaii Energy Commercial Kitchen Demand Ventilation Controls Rebate, the following conditions must be met:

1. The control system must be used in conjunction with variable speed fan motor controls.
2. All motors must meet NEMA Premium Efficiency standards and be UL® Approved
3. Temperature and optical sensors must have the ability to sense and ramp up or down the ventilation rate based on the presence of temperature, smoke, or steam from cooking activity
4. Temperature and Infrared cooking sensors must have the ability to measure temperature at the cooking surface to ramp ventilation up or down based on when cooking starts
5. Hawaii Energy Incentive Worksheet must be submitted with rebate application

Unit of Measure

Fan HP

Baseline Equipment

100% on/off kitchen exhaust fan

High Efficiency Equipment

Kitchen ventilation with demand-controlled ventilation according to temperature and/or smoke sensing

ALGORITHMS

$$\text{peak kW savings per HP} = [(0.746 / \eta) - kW_{.in}] * CF$$

$$\text{annual kWh savings per HP} = [0.746 * (HRS / \eta)] - [kW_{.in} * (HRS / \eta)]$$

$$kW_{.in} = kW_{.out} / \eta$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$kW_{.in}$	Input demand of controlled fan per HP	0.38	kW	Table
$kW_{.out}$	Output power of fan per HP	Calculated	kW	
η	Efficiency of fan system	0.90	-	Table
CF	Coincidence factor % of time savings correspond with utility peak, 5pm to 9pm	100	%	
HRS	Operating hours at rated fan speed	5824	hours	16 hrs/day, 7 days/wk, 52 wk/yr

Measure Life	Expected duration of energy savings	15	years	

SAVINGS

% Rated RPM	% Run Time	Op Hours	Output kW/HP	Efficiency	Input kW/HP	kWh/hp/yr
100%	5%	291.2	0.746	0.9	0.829	241.372
90%	20%	1164.8	0.544	0.9	0.604	703.842
80%	25%	1456.0	0.382	0.9	0.424	617.913
70%	25%	1456.0	0.256	0.9	0.284	413.954
60%	15%	873.6	0.161	0.9	0.179	156.409
50%	10%	582.4	0.093	0.9	0.104	60.343
40%	0%	0.0	0.048	0.9	0.053	0.000
30%	0%	0.0	0.020	0.9	0.022	0.000
20%	0%	0.0	0.006	0.9	0.007	0.000
10%	0%	0.0	0.001	0.9	0.001	0.000
				Weight Avg:	0.377	
					Total:	2193.834

Measure Name	Peak Demand Savings	Annual Energy Savings
DCV	0.452 kW/hp	2633.61 kWh/hp

COMMERCIAL: Electric Griddle

MEASURE DETAILS

Description

Energy-efficient commercial electric griddles reduce energy consumption primarily through the application of advanced controls and improved temperature uniformity.

Program Criteria

This measure applies to ENERGY STAR or equivalent electric commercial griddles in retrofit and new construction applications. This appliance is designed for cooking food in oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled.

Unit of Measure

Per linear foot of cooking surface with assumed depth of 2 feet.

Baseline Equipment

Electric griddle that does not meet ENERGY STAR efficiency requirements.

High Efficiency Equipment

Meets ENERGY STAR efficiency requirements. Requirements apply to single and double-sided gridldles.

Performance Parameters	Requirements
Heavy-Load Cooking Energy Efficiency	>= 70%
Idle Energy Rate	<= 320 watts per ft^2

ALGORITHMS

$$\Delta E_{.total} = E_{.base} - E_{.he}$$

$$\Delta E_{.base} \text{ or } \Delta E_{.he} = E_{.cook} + E_{.idle} + E_{.preheat}$$

$$E_{.cook,total} = (LBS_{.food} * E_{.food} / \eta_{.cook}) * DAYS$$

$$E_{.idle,total} = E_{.idle} * [HRS_{.daily} - (LBS_{.food} / CAP) - (MIN_{.preheat} / 60)] * DAYS$$

$$E_{.preheat,total} = E_{.preheat} * DAYS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$HRS_{.daily}$	Daily operating hours	12	hrs	FSTC
$MIN_{.preheat}$	Time to preheat	15	min	FSTC
$E_{.food}$	ASTM defined energy to food	0.139	kWh/lb	FSTC
DAYS	Days of operation per year	365	days	FSTC
$\eta_{.cook}$	Cooking energy efficiency	Table	%	FSTC, ENERGY STAR

$E_{.idle}$	Idle energy rate	Table	kW/ft	FSTC, ENERGY STAR
CAP	Production capacity	Table	lbs/hr	FSTC
$E_{.preheat}$	Daily preheating energy	Table	kWh/ft	FSTC
$LBS_{.food}$	Food cooked per day	Table	lbs/day	FSTC
CF	Coincidence factor	100	%	
PF	Persistance factor	100	%	
Measure Life	Expected duration of energy savings	12	years	ENERGYSTAR

General assumptions used for deriving deemed electric savings are values taken from the Food Service Technology Center (FSTC) work papers. These deemed values assume that the griddles are 3 x 2 feet in size. Parameters in the table are per linear foot, with an assumed depth of 2 feet.

Parameters	Baseline Electric Griddle	Efficient Electric Griddle
Preheat Energy (E_preheat)	1.33	0.67
Idle Energy Rate (E_idle)	0.80	0.64
Cooking Energy Efficiency (η_cook)	65%	70%
Production Capacity (CAP)	11.70	16.33
Lbs of cooked per day, per ft (LBS_food)	33.33	33.33

SAVINGS

Base (kWh/year) per linear foot	
Cook	2602 kWh
Idle	2599 kWh
Preheat	485 kWh
Total Energy Usage	5686 kWh
Power Demand	1.298 kW

Efficient (kWh/year) per linear foot	
Cook	2416 kWh
Idle	2268 kWh
Preheat	245 kWh
Total Energy Usage	4928 kWh
Power Demand	1.125 kW

Measure Name	Peak Demand Savings	Annual Energy Savings
Electric Griddle	0.173 kW	757.88 kWh

COMMERCIAL: Electric Steam Cooker

MEASURE DETAILS

Description

The installation of a qualified ENERGY STAR commercial steam cooker. ENERGY STAR steam cookers save energy during cooling and idle times due to improved cooking efficiency and idle energy rates.

Program Criteria

Meet ENERGY STAR efficiency requirements.

Unit of Measure

Per pan

Baseline Equipment

The Baseline Efficiency case is a conventional electric steam cooker with a cooking energy efficiency of 30%, pan production of 23.3 pounds per hour, and an idle energy rate of 1.2 kW.

High Efficiency Equipment

The High Efficiency case is an ENERGY STAR electric steam cooker with a cooking energy efficiency of 50%, pan production capacity of 16.7 pounds per hour, and an idle energy rate of 0.4 kW.

ALGORITHMS

(See below)

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
HRS_daily	Daily operating hours	12	hrs	FSTC
%_steam	Percentage of time in steam mode	40%	-	FSTC
E_food	ASTM defined energy to food	30.8	Wh/lb	FSTC
DAYS	Annual days of operation	365	days	FSTC
η_cook	Cooking energy efficiency	Table	-	FSTC, ENERGY STAR
E_idle	Idle energy rate	Table	W	FSTC, ENERGY STAR
CAP	Production capacity	Table	lbs/hr	FSTC
LBS_food	Food cooked per day	100	lbs/day	FSTC
CF	Coincidence factor	1	-	
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

Average daily operation	12	hours
Annual days of operation	365	days
Food cooked per day	100	pounds

Number of pans per unit	3

	Conventional	ENERGY STAR	
Type	boiler based	boilerless	
Time in constant steam mode	40%	40%	
Cooking energy efficiency	30%	50%	
Production capacity per pan	23.3	16.7	pounds/hour/pan
Idle energy rate	1,200	400	W
ASTM energy to food	30.8		Wh/pound
Equipment lifetime	12		years

	Conventional	ENERGY STAR	
Annual operation	4380.00		hours
Daily pre-heat energy	1500.00	1500.00	Wh
Daily cooking energy	10266.67	6160.00	Wh
Daily idle time	10.57	10.00	hour
Daily idle energy	37950.01	14750.53	Wh
Total daily energy	49716.68	22410.53	Wh

	Conventional	ENERGY STAR	Savings (3-pan)
Annual Energy Use per Cooker	18146.59	8179.84	9966.75

Measure Name	Peak Demand Savings	Annual Energy Savings
Electric Steam Cooker	0.759 kW/pan	3322.25 kWh/pan

References

Source: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

Equipment specifications:
- ENERGY STAR specification
- Food Service Technology Center (FSTC) research on available models, 2009

Operating Hours: - FSTC research on average use, 2009

Equipment lifetime: - FSTC research on available models, 2009

Notes on Modifications from Original ENERGY STAR Calculator

Cooking energy efficiency for baseline steam cookers is the average efficiency for steam generator and boiler-based cookers. Idle energy rate for baseline steam cookers is the average rate for steam generator and boiler-based cookers.

COMMERCIAL: Fryer

MEASURE DETAILS

Description

This measure applies to ENERGY STAR or its equivalent electric commercial open-deep fat fryers in retrofit and new construction applications. Commercial fryers consist of a reservoir of cooking oil that allows food to be fully submerged without touching the bottom of the vessel. Electric fryers use a heating element immersed in the cooking oil. High efficiency standard and large vat fryers offer shorter cook times and higher production rates through the use of heat exchanger design. Standby losses are reduced in more efficient models through the use of fry pot insulation.

Program Criteria

Meet ENERGY STAR energy efficiency requirements. ENERGY STAR requirements apply to a standard fryer and a large vat fryer. A standard fryer measures 14 to 18 inches wide with a vat capacity from 25 to 60 pounds. A large vat fryer measures 18 inches to 24 inches wide with a vat capacity greater than 50 pounds.

Performance Parameters	Standard Fryer	Large Vat Fryer
Heavy-Load Cooking Energy Efficiency	>= 80%	>= 80%
Idle Energy Rate	<= 1.0 kW	<= 1.1 kW

Unit of Measure

One fryer

Baseline Equipment

See table below.

High Efficiency Equipment

See table below.

ALGORITHMS

$$\Delta E_{.total} = E_{.base} - E_{.he}$$

$$\Delta E_{.base} \text{ or } \Delta E_{.he} = E_{.cook} + E_{.idle} + E_{.preheat}$$

$$E_{.cook,total} = LBS_{.food} * (E_{.food} / \eta_{.cook}) * DAYS$$

$$E_{.idle,total} = E_{.idle} * [HRS_{.daily} - (LBS_{.food} / CAP) - (MIN_{.preheat} / 60)] * DAYS$$

$$E_{.preheat,total} = E_{.preheat} * DAYS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$HRS_{.daily}$	Daily operating hours	12	hrs	FSTC
$MIN_{.preheat}$	Time to preheat	15	min	FSTC

$E_{.food}$	ASTM defined energy to food	0.167	kWh/lb	FSTC
DAYS	Annual days of operation	365	days	FSTC
$\eta_{.cook}$	Cooking energy efficiency	Table	%	FSTC, ENERGY STAR
$E_{.idle}$	Idle energy rate	Table	kW	FSTC, ENERGY STAR
CAP	Production capacity	Table	lbs/hr	FSTC
$E_{.preheat}$	Preheating energy	Table	kWh/day	FSTC
$LBS_{.food}$	Food cooked per day	Table	lbs/day	FSTC
CF	Coincidence factor	100	%	
PF	Persistance factor	100	%	
Measure Life	Expected duration of energy savings	12	yrs	

General assumptions used for deriving deemed electric savings are values taken from the Food Service Technology Center (FSTC) work papers.

Parameters	Baseline Electric Fryer		Efficient Electric Fryer	
	Standard	Large Vat	Standard	Large Vat
Preheat Energy (E_preheat)	2.3	2.5	1.7	2.1
Idle Energy Rate (E_idle)	1.05	1.35	1	1.1
Cooking Energy Efficiency (η_cook)	75%	70%	80%	80%
Production Capacity per ft (CAP)	65	100	70	110
Lbs of food cooked per day, per ft (LBS_food)	150	150	150	150

SAVINGS

Baseline Fryer	Standard	Large Vat
Cook	12191 kWh	13062 kWh
Idle	3619 kWh	5051 kWh
Preheat	840 kWh	913 kWh
Total Base Energy	16649 kWh	19025 kWh
Power Demand	3.801 kW	4.344 kW

Efficient Fryer	Standard	Large Vat
Cook	11429 kWh	11429 kWh
Idle	3507 kWh	4170 kWh
Preheat	621 kWh	767 kWh
Total Base Energy	15556 kWh	16366 kWh
Power Demand	3.552 kW	3.736 kW

Measure Name	Peak Demand Savings	Annual Energy Savings
Standard Electric Fryer	0.250 kW	1093.09 kWh
Large Vat Electric Fryer	0.607 kW	2659.29 kWh

COMMERCIAL: Hot Food Holding Cabinet

MEASURE DETAILS

Description

Commercial insulated hot food holding cabinet models that meet program requirements incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door electric gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. This means that qualified hot food holding cabinets are more efficient at maintaining food temperature while using less energy.

Program Criteria

• Full-size holding cabinets are defined as any holding cabinet with an internal measured volume of greater than or equal to 15 cubic feet (≥15 ft.3). This measure does not include cook-and-hold equipment. All measures must be electric hot food holding cabinets that are fully insulated and have doors. Qualifying cabinets must not exceed the maximum idle energy rate of 20 Watts per cubic foot in accordance with the ASTM Standard test method.

• Half-size holding cabinets are defined as any holding cabinet with an internal measured volume of less than 15 cubic feet (<15 ft.3). This measure does not include cook-and-hold or retherm equipment. All measures must be electric hot food holding cabinets that are fully insulated and have doors. Qualifying cabinets must not exceed the maximum idle energy rate of 20 Watts per cubic foot in accordance with the ASTM Standard test method.

Unit of Measure

Per cabinet

Baseline Equipment

The baseline equipment is assumed to be a standard hot food holding cabinet with an idle energy rate of 40 watts per cubic foot.

High Efficiency Equipment

The efficient equipment is assumed to be an ENERGY STAR qualified hot food holding cabinet with an idle energy rate of 20 watts per cubic foot.

ALGORITHMS

$$\Delta kWh = HRS_{.daily} * DAYS * (kW_{.bs} - kW_{.he})$$

$$\Delta kW = (kW.bs - kW.he) * CF$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$kW_{.bs}$	Baseline equipment demand	See below	kW	
$kW_{.he}$	High efficiency equipment demand	See below	kW	
HRS_daily	Daily hours of operation	15	hrs	
DAYS	Annual days of operation	365	days	

CF	Coincidence factor	100	%	
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

Energy usage calculations are based on 15 hours a day, 365 days per year operation at a typical temperature setting of 150°F. The different sizes for the holding cabinets (half size and full size) have proportional operating energy rates. Operating energy rate for the full size holding cabinets was obtained in accordance with the ASTM Standard.

The energy savings calculations listed in the following tables use Title 20 (California) as the baseline for potential energy savings requiring all hot food holding cabinets sold in California to meet a normalized idle energy rate of 40 Watts/ft^3.

Performance	Full-Size		Half-Size	
	Baseline	High Efficiency	Baseline	High Efficiency
Power Demand	1.000 kW	0.280 kW	0.380 kW	0.050 kW
Annual Energy Use	5475.00 kWh	1533.00 kWh	2080.50 kWh	273.75 kWh
Power Demand Reduction	0.720 kW		0.330 kW	
Annual Energy Reduction	3942.00 kWh		1806.75 kWh	

The demand reduction estimation is based on measured data for standard efficiency insulated holding cabinets and for high-efficiency insulated holding cabinets. The measured data are derived from tests conducted under ASTM Standard Test Method for the Performance of Hot Food Holding Cabinets.

Cabinet Size	Cabinet Volume	Normalized Idle Energy Rate	Total Idle Energy Rate
Full-Size	25 cubic ft	11.30 W/cubic ft	0.280 kW
Half-Size	10 cubic ft	5.70 W/cubic ft	0.050 kW

Measure Name	Peak Demand Savings	Annual Energy Savings
Full-Size Cabinet	0.720 kW	3942.00 kWh
Half-Size Cabinet	0.330 kW	1806.75 kWh

COMMERCIAL: Ice Machine

MEASURE DETAILS

Description

This measure applies to Energy Efficient air-cooled commercial ice makers in retrofit and new construction applications installed in conditioned spaces. Commercial ice makers are classified into three equipment types; ice-making heads (IMHs), remote condensing units (RCUs) and self-contained units (SCUs). The measure described here applies to ice makers that use a batch process to make cubed ice. The industry standard for energy use and performance of commercial ice machines is AHRI Standard 810. Key parameters reported for ice makers include the Equipment Type, Harvest Rate (lbs of ice/24hrs) and Energy Consumption Rate. The AHRI Directory of Certified Equipment150 lists these values by equipment manufacturer and model number.

Program Criteria

This incentive applies towards the purchase of new or replacement energy efficient Air-cooled ice machines. Used or rebuilt equipment is not eligible. Customers must provide proof that the appliance meets the energy efficiency specifications listed in the table below.

Unit of Measure

One ice machine

Baseline Equipment

Non-ENERGY STAR

High Efficiency Equipment

Equipment meeting and/or exceeding ENERGY STAR performance requirements.

Equipment Type	Ice Harvest Rate (IHR) (lbs/24 hrs)	Energy Use Rate (kWh/100 lbs)	Potable Water Limit (gal/100 lbs)	Federal Minimum Standard Energy Use Rate (kWh/100 lbs)
Ice Making Heads	< 450	≤ 8.72 - 0.0073*IHR	≤ 20	10.26 - 0.0086*IHR
	≥ 450	≤ 5.86 - 0.0009*IHR	≤ 20	6.89 - 0.0011*IHR
Remote Condensing Units	< 1000	≤ 7.52 - 0.0032*IHR	≤ 20	8.85 - 0.0038*IHR
	≥ 1000	≤ 4.34	≤ 20	5.10
	< 934	≤ 7.52 - 0.0032*IHR	≤ 20	8.85 - 0.0038*IHR
	≥ 934	≤ 4.51	≤ 20	5.30
Self-Contained Units	< 175	≤ 15.3 - 0.0399*IHR	≤ 30	18.0 - 0.069*IHR
	≥ 175	≤ 8.33	≤ 30	9.80

ALGORITHMS

$$\Delta kWh = (E_{.base,100lb} - E_{.he,100lb}) / 100 * DC * IHR * DAYS$$

$$\Delta kW = \Delta kWh / HRS * CF$$

DEFINITIONS & ASSUMPTIONS				
Variable	**Description**	**Value**	**Unit**	**Notes**
$E_{.base,100lb}$	Base energy use per 100lbs of ice	Table	kWh	
$E_{.he,100lb}$	Efficient energy use per 100lbs of ice	Table	kWh	
DC	Duty cycle of ice machine	75	%	Assumed 75%
IHR	Harvest rate	Table	lbs/day	
DAYS	Annual days of operation	365	days	
HRS	Annual operating hours	User input	hrs	
CF	Coincidence factor	100	%	
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

Example ***Savings Calculation:***

		Ice Harvest Rate (IHR)				
		101 - 300	**301 - 500**	**501 - 1000**	**1001 - 1500**	**> 1500**
Average IHR in Range		200	400	750	1250	1750
Energy Usage per 100 lbs	**Baseline (E_base,100lb)**	9.8	6.82	6.07	5.1	5.1
	Efficient (E_ee,100lb)	8.33	5.8	5.19	4.34	4.34
Daily Energy Usage	**Baseline**	14.7	20.5	34.1	47.8	66.9
	Efficient	12.5	17.4	29.2	40.7	57.0
Annual Energy Usage	**Baseline**	5,366	7,468	12,462	17,452	24,432
	Efficient	4,561	6,351	10,656	14,851	20,791
Average Power Demand	**Baseline**	0.613	0.853	1.423	1.992	2.789
	Efficient	0.521	0.725	1.216	1.695	2.373
Peak Demand Reduction (kW)		0.092	0.128	0.206	0.297	0.416
Annual Energy Reduction (kWh/yr)		805	1,117	1,807	2,601	3,641

Measure Name	Peak Demand Savings	Annual Energy Savings
101 - 300	0.092 kW	804.83 kWh
301 - 500	0.128 kW	1116.90 kWh
501 - 1000	0.206 kW	1806.75 kWh
1001 - 1500	0.297 kW	2600.63 kWh
> 1500	0.416 kW	3640.88 kWh

COMMERCIAL: Low-Flow Spray Nozzle

MEASURE DETAILS

Description

All pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. They reduce water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. Energy savings depend on the facility's method of water heating (electric resistance or heat pump). If the facility does not have electric water heating (i.e. gas or propane), there are no electric savings for this measure. The spray valves usually have a clip to lock the handle in the "on" position. Pre-rinse valves are inexpensive and easily interchangeable with different manufacturers' assemblies.

Program Criteria

Program follows ENERGY STAR guidelines, unless specified otherwise.

Unit of Measure

One spray valve

Baseline Equipment

The baseline equipment is assumed to be a spray valve with a flow rate of 2.25 gallons per minute.

High Efficiency Equipment

The efficient equipment is assumed to be a pre-rinse spray valve with a flow rate of 1.28 gallons per minute.

ALGORITHMS

$$\Delta kWh = GPD * \%_{.hot} * 8.34 * \Delta T * [(1 / \eta) / 3412]$$

DEFINITIONS & ASSUMPTIONS				
Variable	**Description**	**Value**	**Unit**	**Notes**
GPD	Water usage reduction	116.4	gpd	0.97 gpm 120 mins per day
$\%_{.hot}$	Percentage of water used by pre-rinse valve that is heated	69	%	
ΔT	Temperature rise through water heater	65	°F	
η	Water heater thermal efficiency	Dependent	-	Electric Resistance = 0.98; Heat Pump = 3.0
Constant	Energy content of heated water	8.34	BTU/gal/°F	
Constant	Factor to convert BTU to kWh	3412	BTU/kWh	
Measure Life	Expected duration of energy savings	5	yrs	

SAVINGS

Building type	Operating Schedule	Electric Resistance Savings	Heat Pump Savings	Demand Savings
	(Days/Year)	(kWh/year)	(kWh/year)	(kW)
Restaurants/Institutions	365	4752.69	1552.54	1.03
Dormitories	274	3567.77	1165.47	0.90
K-12 Schools	200	2604.21	850.71	0.79

Measure Name	Peak Demand Savings	Annual Energy Savings
Electric Resistance, Restaurants/Institutions	1.03 kW	4752.69 kWh
Electric Resistance, Dormitories	0.90 kW	3567.77 kWh
Electric Resistance, K-12 Schools	0.79 kW	2604.21 kWh
Heat Pump, Restaurants/Institutions	1.03 kW	1552.54 kWh
Heat Pump, Dormitories	0.90 kW	1165.47 kWh
Heat Pump, K-12 Schools	0.79 kW	850.71 kWh

COMMERCIAL: Freezer

MEASURE DETAILS

Description

This measure relates to the installation of a new reach-in commercial freezer meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption.

Program Criteria

This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

Unit of Measure

One freezer

Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a solid or glass door freezer meeting the minimum federal manufacturing standards. It is assumed that the volume for baseline is the average of the range. For example if range is 0 to 15, the average volume is 7.5.

High Efficiency Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a solid or glass door freezer meeting the minimum ENERGY STAR efficiency level standards.

ALGORITHMS

$$\Delta kWh = (E_{.base} - E_{.he}) * DAYS$$

$$\Delta kW = (\Delta kWh / HRS) * CF$$

DEFINITIONS & ASSUMPTIONS				
Variable	**Description**	**Value**	**Unit**	**Notes**
$E_{.base}$	Baseline equipment energy usage	See below	kWh	
$E_{.he}$	High efficiency equipment energy usage	See below	kW	
DAYS	Annual days of operation	365	days	
HRS	Annual operating hours	8760	hrs	
CF	Coincidence factor	1	-	
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

Volume	Typical Volume	Volumetric Factor (kWh/ft^3)		Fixed Energy (kWh)		Adjusted Energy (kWh/day)		Energy Savings (kWh/yr)	Demand Savings (kW)
		Base	Efficient	Base	Efficient	Base	Efficient		
Solid Door									
0 < V 15	7.5	0.400	0.250	1.380	1.250	4.380	3.125	458.08	0.052
15 < V < 30	22.5	0.400	0.400	1.380	-1.000	10.380	8.000	868.70	0.099
30 < V < 50	40.0	0.400	0.163	1.380	6.125	17.380	12.645	1728.28	0.197
50 < V	60.0	0.400	0.158	1.380	6.333	25.380	15.813	3491.96	0.399
Glass Door									
0 < V 15	7.5	0.750	0.607	4.100	0.893	9.725	5.446	1562.02	0.178
15 < V < 30	22.5	0.750	0.733	4.100	-1.000	20.975	15.493	2001.11	0.228
30 < V < 50	40.0	0.750	0.250	4.100	13.500	34.100	23.500	3869.00	0.442
50 < V	60.0	0.750	0.450	4.100	3.500	49.100	30.500	6789.00	0.775

Measure Name	Peak Demand Savings	Annual Energy Savings
Solid-Door, 0 < V 15	0.052 kW	458.08 kWh
Solid-Door, 15 < V < 30	0.099 kW	868.70 kWh
Solid-Door, 30 < V < 50	0.197 kW	1728.28 kWh
Solid-Door, 50 < V	0.399 kW	3491.96 kWh
Glass-Door, 0 < V 15	0.178 kW	1562.02 kWh
Glass-Door, 15 < V < 30	0.228 kW	2001.11 kWh
Glass-Door, 30 < V < 50	0.442 kW	3869.00 kWh
Glass-Door, 50 < V	0.775 kW	6789.00 kWh

COMMERCIAL: Refrigerator

MEASURE DETAILS

Description

This measure relates to the installation of a new reach-in commercial refrigerator meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial refrigerators are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption.

Program Criteria

This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

Unit of Measure

Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a solid or glass door refrigerator meeting the minimum federal manufacturing standards. It is assumed that the volume for baseline is the average of the range. For example if range is 0 to 15, the average volume is 7.5.

High Efficiency Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a solid or glass door refrigerator meeting the minimum ENERGY STAR efficiency level standards.

ALGORITHMS

$$\Delta kWh = (E_{.base} - E_{.he}) * DAYS$$

$$\Delta kW = (\Delta kWh / HRS) * CF$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$E_{.base}$	Baseline equipment energy usage	See below	kWh	
$E_{.he}$	High efficiency equipment energy usage	See below	kW	
DAYS	Annual days of operation	365	days	
HRS	Annual operating hours	8760	hrs	
CF	Coincidence factor	1	-	
Measure Life	Expected duration of energy savings	12	yrs	

SAVINGS

Volume	Typical	Volumetric Factor	Fixed Energy	Adjusted Energy	Energy	Demand

Volume	Volume	Base	Efficient	Base	Efficient	Base	Efficient	Savings	Savings
Solid Door									
0 < V 15	7.5	0.100	0.089	2.040	1.411	2.790	2.079	259.70	0.030
15 < V < 30	22.5	0.100	0.037	2.040	2.200	4.290	3.033	458.99	0.052
30 < V < 50	40.0	0.100	0.056	2.040	1.635	6.040	3.875	790.23	0.090
50 < V	60.0	0.100	0.060	2.040	1.416	8.040	5.016	1103.76	0.126
Glass Door									
0 < V 15	7.5	0.120	0.118	3.340	1.382	4.240	2.267	720.15	0.082
15 < V < 30	22.5	0.120	0.140	3.340	1.050	6.040	4.200	671.60	0.077
30 < V < 50	40.0	0.120	0.089	3.340	2.625	8.140	6.185	713.58	0.081
50 < V	60.0	0.120	0.110	3.340	1.500	10.540	8.100	890.60	0.102

Measure Name	Peak Demand Savings	Annual Energy Savings
Solid-Door, 0 < V 15	0.030 kW	259.70 kWh
Solid-Door, 15 < V < 30	0.052 kW	458.99 kWh
Solid-Door, 30 < V < 50	0.090 kW	790.23 kWh
Solid-Door, 50 < V	0.126 kW	1103.76 kWh
Glass-Door, 0 < V 15	0.082 kW	720.15 kWh
Glass-Door, 15 < V < 30	0.077 kW	671.60 kWh
Glass-Door, 30 < V < 50	0.081 kW	713.58 kWh
Glass-Door, 50 < V	0.102 kW	890.60 kWh

COMMERCIAL: Design Assistance

MEASURE DETAILS

Description
Design Assistance is available to building owners and their design teams to encourage the implementation of energy efficient building systems. Considering energy efficiency during the initial phases of planning and design greatly increase the feasibility of implementation. Incentives for energy efficiency are project-specific and offered as upfront assistance for additional costs incurred during the design phase. The long-term benefits include energy use reduction for the state of Hawaii and a reduction in operating costs, equipment lifecycle improvement for building owners, and improved

Program Criteria
- Application with written pre-approval from Hawaii Energy
- Project in planning or initial design phase
- Total resource benefit ratio greater than or equal to 1

Unit of Measure
n/a

Baseline Equipment
The baseline efficiency case assumes compliance with the efficiency requirements as mandated by the Hawaii State Energy Code or industry accepted standard practice.

High Efficiency Equipment
The high efficiency scenario is specific to each project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on comparing a base case analysis and enhanced cased analysis on equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The energy efficiency measures must be proven cost-effective, pass total resource benefit, and have a payback greater than or equal to 1.

ALGORITHMS

Gross energy and demand savings estimates for design assistance are calculated using engineering analysis and project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, or other engineering analysis and include estimates of savings, costs, and an evaluation of the project's cost-effectiveness.

SAVINGS

A base case and enhanced case model must be produced with a clear comparison. All assumptions, data, and formulas used in energy efficiency calculations must be clearly documented. Standard engineering principles must be applied, and all references cited. Energy saving calculations shall also reflect the interactive effects of other simultaneous technologies to prevent the overstatement of actual savings. Proposed base and enhanced cases must be performed by a qualified person or firm. In some cases, a professional engineer may be required to provide verification of the analysis.

COMMERCIAL: Energy Study

MEASURE DETAILS

Description
The Energy Study is an indirect impact product that offers Hawaii businesses with analysis services to identify energy saving opportunities. The goal of the energy study is to provide a method for commercial and industrial customers to learn how their business uses energy today and to identify measures that will help them save energy and reduce operating costs in the future. The focus is on a customer's core energy efficiency opportunities.

Program Criteria
• Program approval is required prior to the start of work on the energy study.
• The program reserves the right to review all materials that result from a program-supported study including, but not limited to, final reports, consultant recommendations, and metered data.
• The study must be performed by a qualified person or firm. A brief summary of the consultant's qualifications should be submitted with the application. In some cases, a professional engineer may be required to provide verification of the analysis.
• At any time, customers may contact program staff to discuss a project, get assistance in preparing an application, or with any program-related questions.

Unit of Measure
n/a

Baseline Equipment
n/a

High Efficiency Equipment
n/a

ALGORITHMS

Gross energy and demand savings estimates for energy studies are calculated using engineering analysis and project-specific details. Energy study analyses typically include estimates of savings, costs, and an evaluation of the cost-effectiveness of potential projects/upgrades.

SAVINGS

All assumptions, data and formulas used in energy efficiency calculations must be clearly documented. Standard engineering principles must be applied, and all references cited. Energy saving calculations shall also reflect the interactive effects of other simultaneous technologies to prevent the overstatement of the actual savings.

The Energy Study shall include the following information and be presented in the following format:

1) Executive Summary
    a) Energy Conservation Measures (ECMs) Proposed
    b) Summary of Baseline and Enhanced Case Assumptions
    c) Actionable Recommendations in “loading order.”

2) Technical Information and Analysis
    a) Energy Consumption Analysis
        i) Two years of billing data (weatherized and compared to some pertinent operating metric)
    b) Description of the project
    c) Proposed Energy Conservation Measures (ECM)
        i) Descriptive Name
        ii) Schematic System Drawing
        iii) Current Peak Demand (kW), Energy Usage (kWh), Effective Full Load Run Hours
        iv) Proposed Peak Demand (kW), Energy Usage (kWh), Effective Full Load Run Hours
        v) % Change for above
        vi) Estimated Installation Cost
        vii) Project timeline
        viii) Measure Life
        ix) Simple Payback
    d) Base case information
        i) Short term/spot baseline thermal, fluid, and electrical measurements for major equipment to be changed with ECMs
        ii) Permanent metering data (This metering will qualify for additional cost assistance)
        iii) Sizing/Performance Reviews (Pump Curves, Cooling Bin Data etc.)
    e) Enhanced case information
        i) How will performance be measured in the future.
        ii) Description of where energy savings occurs (lower run time, more efficient operations etc.)
    f) Estimated energy and demand savings associated with your proposed project
        i) Applicable figures and tables
        ii) Simple payback period and/or life cycle costs
    g) Estimated costs including design, materials, and installation

3) Appendix
    a) Raw and Analyzed Data (Cooling Models, Field Data, Pictures, Metering Data etc.)
    b) Building Plans (Mechanical, Electrical Schedules, Layouts etc.)

COMMERCIAL: Chiller

MEASURE DETAILS

Description

The following is a semi-prescriptive method for calculating chiller savings for chillers that are below 600 tons. Chillers larger than 600 tons will be treated as customized.

Program Criteria

To be eligible, chiller must meet or exceed IECC 2015 code, Path A or Path B. This encourages early adoption of IECC 2015 energy code.

Unit of Measure

Per chiller

Baseline Equipment

Hawaii Energy assumes Honolulu code IECC 2006

High Efficiency Equipment

Equipment must meet or exceed IECC 2015. Actual nameplate data for rated efficiency will be compared against IECC 2006 code minimum efficiency

ALGORITHMS

peak kW savings $= (\eta_{.bs} - \eta_{.he}) * TON * CF$

annual kWh savings $= (\eta_{.bs} - \eta_{.he}) * TON * EFLH$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
η.bs	Baseline rated efficiency, which depends on cooling capacity of	See worksheet	kW/ton	Hawaii Energy assumes Honolulu code IECC 2006
η.he	Proposed measure rated full load efficiency	See worksheet	kW/ton	Nameplate
TON	Unit of equipment cooling capacity	variable	tons	One ton of cooling = 12,000 BTU/h
EFLH	Annual operating hours	Table	hrs	See EFLH tab
CF	Coincidence factor	Table	-	See EFLH tab
Measure Life	Expected duration of energy savings	20	yrs	

SAVINGS

See accompanying Chiller Worksheet (C_HVAC_Chiller_WKST)

Step 1: Enter chiller nameplate data

Enter chiller type:	Air-cooled
Enter chiller tonnage:	150 tons
Enter building type:	Education
Enter your FL_ee here:	0.620 kW/ton
Enter your IPLV_ee here:	0.200 kW/ton

Step 2: Determine if it qualifies

Path A pass/fail:	pass
Path B pass/fail:	pass
IPLV_b from chart:	1.407 kW/ton
IPLV_delta:	1.207 kW/ton

Step 3: Calculate savings

CF:	0.74
EFLH:	2342 hours
kW savings:	133.955
kWh/yr savings:	423,948.68

IECC 2015 (ee)

Positive Displacement (Reciprocating, Rotary Screw, Scroll)	**Units: kW/ton**		**< 75 Tons**	**>= 75 tons & < 150 tons**	**>= 150 tons & < 300 tons**	**>= 300 tons & < 600 tons**	**>= 600 tons**
	Path A	FL	0.750	0.720	0.660	0.610	0.560
		IPLV	0.600	0.560	0.540	0.520	0.500
	Path B	FL	0.780	0.750	0.680	0.625	0.585
		IPLV	0.500	0.490	0.440	0.410	0.380

Centrifugal	**Units: kW/ton**		**< 150 Tons**	**>= 150 tons & < 300 tons**	**>= 300 tons & < 400 tons**	**>= 400 tons & < 600 tons**	**>= 600 tons**
	Path A	FL	0.610	0.610	0.560	0.560	0.560
		IPLV	0.550	0.550	0.520	0.500	0.500
	Path B	FL	0.695	0.635	0.595	0.585	0.585
		IPLV	0.440	0.400	0.390	0.380	0.380

Air-cooled with condenser	**Units: EER (Btu/W)**		**< 150 Tons**	**>= 150 Tons**	**Units: kW/ton**	**< 150 Tons**	**>= 150 Ton**
	Path A	FL	10.1	10.1	Path A	1.188	1.188
		IPLV	13.7	14		0.8759	0.8571
	Path B	FL	9.7	9.7	Path B	1.237	1.237
		IPLV	15.8	16.1		0.7595	0.7453

[Hawaii Energy internal reference only]

IECC 2006 (b)

		All Capacities
Positive Displacement (Reciprocating, Rotary Screw, Scroll)	COP	4.20 0.837 kW/ton
	IPLV	4.65 0.756 kW/ton

		< 150 tons	**>= 150 tons & <300 tons**	**>= 300 tons**
Centrifugal	COP	5.00 0.703 kW/ton	5.55 0.634 kW/ton	6.10 0.577 kW/ton
	IPLV	5.00 0.703 kW/ton	5.55 0.634 kW/ton	6.10 0.577 kW/ton

		< 150 tons	**>= 150 tons**
Air-cooled with condenser	COP	2.80 1.256 kW/ton	2.50 1.407 kW/ton
	IPLV	2.80 1.256 kW/ton	2.50 1.407 kW/ton

COMMERCIAL: A/C & Heat Pump

MEASURE DETAILS

Description

The replacement of package and split unit air conditioners with higher efficiency models.

Program Criteria

To be eligible, AC must meet or exceed CEE Proposed Standards, Tier 1 or Tier 2 or Advanced Tier

Unit of Measure

One ton of cooling capacity

Baseline Equipment

Honolulu code IECC 2006

High Efficiency Equipment

Equipment must meet or exceed IECC 2015. Actual nameplate data for rated efficiency will be compared against baseline equipment

ALGORITHMS

peak kW savings = $(\eta_{.bs} - \eta_{.he}) * TON * CF$

annual kWh savings = $(\eta_{.bs} - \eta_{.he}) * TON * EFLH$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\eta_{.bs}$	Baseline rated efficiency, which depends on cooling capacity of proposed equipment.	See worksheet	Btu/hr-W	< 65,000 BTU/hr units are rated in SEER. Hawai'i Energy assumes IECC 2006 code
$\eta_{.he}$	Proposed measure rated efficiency.	See worksheet	Btu/hr-W	< 65,000 BTU/hr units are rated in SEER. Hawai'i Energy requires CEE Proposed Standards Tier 1/2/Advanced
TON	Unit of equipment cooling capacity	variable	tons	one ton of cooling = 12,000 BTU/h
EFLH	Annual operating hours	Table	hrs	See EFLH tab
CF	Coincidence factor	Table	-	See EFLH tab
Measure Life	Expected duration of energy savings	15	yrs	

SAVINGS

See accompanying AC Worksheet (C_HVAC_AC_WKST)

Step 1: Enter AC nameplate data

Enter AC type:	Packaged
Enter AC size (Btuh):	60000
Enter building type:	Misc. Commercial
Enter your (S)EER:	12.2

Step 2: Determine if it qualifies

Tier 1 FL:	15	fail
Tier 2 FL:	16	fail
Tier 3 FL:	17	fail

Step 3: Calculate savings against baseline

(S)EER_bs:	9.7	1.24 kW/ton
(S)EER_ee:	12.2	0.98 kW/ton
Delta:	0.25 kW/ton	
CF:	0.70	
EFLH:	3050 hours	
kW savings:	0.887	
kWh/yr savings:	3,865.98	

Incentive qualifications: CEE Proposed Standards

	Tier 1		Tier 2		Advanced Tier	
	Packaged	Split	Packaged	Split	Packaged	Split
< 65,000	15 SEER	15 SEER	16 SEER	16 SEER	17 SEER	18 SEER
≥65,000 to 135,000	12.2 EER		12.2 EER		12.6 EER	
≥135,000 to 240,000	12.2 EER		12.2 EER		12.2 EER	
≥240,000 to 760,000	10.5 EER		10.8 EER		10.8 EER	
≥760,000	9.9 EER		10.4 EER		N/A	

Baseline specifications: IECC 2006 code

	Packaged	Split
< 65,000	9.7 SEER	10 SEER
≥65,000 to 135,000	10.3 EER	
≥135,000 to 240,000	9.7 EER	
≥240,000 to 760,000	9.5 EER	
≥760,000	9.2 EER	

COMMERCIAL: VFD Water Pump

MEASURE DETAILS

Description

Variable frequency drive and control installed on full speed pumps and fans, or damped fans, used in HVAC systems.

Program Criteria

* Require pre-notification before projects begin.
* The program reserves the right to perform on-site verifications, both pre- and post-installation.
* Existing equipment must not have a VFD. (i.e. – incentives are not available for replacement)
* VFDs on pumps larger than 200 hp may be analyzed on a custom basis
* The VFDs must actively control and vary the pump speed.

Unit of Measure

One VFD, per horsepower

Baseline Equipment

A chilled water or condenser water pump or HVAC fan with no VFD.

High Efficiency Equipment

Motor/pump with VFD installed.

ALGORITHMS

peak kW savings per pump hp = $kW_{.perHP} * LF / \eta * CF * SVG_{.d}$

annual kWh savings per pump hp = $kW_{.perHP} * LF / \eta * HRS * SVG_{.e}$

peak kW savings per fan hp = $kW_{.perHP} * LF / \eta * CF * SVG_{.d}$

annual kWh savings per fan hp = $kW_{.perHP} * LF / \eta * HRS * SVG_{.e}$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$kW_{.perHP}$	kW equivalent of 1 horse power	0.746	kW/HP	
LF	Load factor (% of full load power in	75%	-	LBNL
η	Rated motor efficiency	variable	-	WSU induction motor efficiency lookup table
$SVG_{.d}$	Demand savings factor, %. The assumed average reduction of full load enabled by the VFD as a result of lower speed or lower power need.	Table 1	-	

$SVG_{.e}$	Energy savings factor, %. The assumed average reduction of kWh enabled by the VFD as a result of lower speed or power operation over time.	Table 1	-	
HRS	Annual operating hours	Table 3	hrs	SCE13HC030.1
CF	Coincidence factor	Table 3	-	SCE13HC030.1
Measure Life	Expected duration of energy savings	15	yrs	

Table 1 (revised). Assumptions for VFD Savings Calculations

Controlled Motor System	SVG_d[1]	SVG_e[1]
Chilled Water Pump	41%	40%
Condenser Water Pump	41%	40%
HVAC Fan	29%	31%

Table 1 (revised) Notes:

1. California Municipal Utilities Association Energy Savings Calculator, Pump and Fan VFD Retrofit, see Table 2. Available at www.cmua.org. The most typical VFD operation (at 60-80% of rated flow) reduces load from 100% to 43%. However, at 0% flow the VFD is still drawing 5% load in the fan case and 27% load in the pump case.

Table 2. % load (at 70% required flow) and overall energy reduction from VFD given various baseline controls

Measure Savings	Constant Volume	Inlet Guide Vane, FC	Inlet Damper Box	Outlet Damper	Eddy Current Drive	Throttle Valve	Average
fan kW (typical)	57%	6%	31%	22%	N/A	N/A	29.00%
fan kWh (total)	50%	10%	36%	27%	N/A	N/A	30.68%
pump kW	57%	N/A	N/A	N/A	0.2	0.47	41.33%
pump kWh	51%	N/A	N/A	N/A	0.243	0.455	40.27%

Table 2 derived from CMUA Energy Savings Calculator-Pump and Fan VFD Retrofit. http://cmua.org/energy-efficiency-technical-resource-manual-2016/

SAVINGS

Table 3. VFD AHU Energy and Demand Savings per Hp (use Water Pump Reference table for efficiency η)

Cold Storage	CF[2]	Hours[3]	Demand Savings Fan (kW/HP)	Energy Savings Fan (kWh/HP)	demand savings chilled water pump (kW/hp)	Energy Savings chilled water pump (kWh/hp)	demand savings condenser water pump (kW/hp)	energy savings condenser water pump (kWh/hp)
Misc. Commercial	0.70	3,050	=0.114/η	=529.01/η	=0.161/η	=682.59/η	=0.161/η	=682.59/η
Cold Storage	0.70	3,050	=0.114/η	=529.01/η	=0.161/η	=682.59/η	=0.161/η	=682.59/η
Education	0.74	2,342	=0.120/η	=406.21/η	=0.170/η	=524.14/η	=0.170/η	=524.14/η
Grocery	0.70	3,050	=0.114/η	=529.01/η	=0.161/η	=682.59/η	=0.161/η	=682.59/η
Health	0.75	4,709	=0.122/η	=816.75/η	=0.172/η	=1053.87/η	=0.172/η	=1053.87/η
Hotel/Motel	0.24	1,952	=0.039/η	=338.56/η	=0.055/η	=436.86/η	=0.055/η	=436.86/η

Industrial	0.85	3,520	=0.138/η	=610.53/η	=0.195/η	=787.78/η	=0.195/η	=787.78/η
Office	0.70	2,603	=0.114/η	=451.48/η	=0.161/η	=582.55/η	=0.161/η	=582.55/η
Restaurant	0.70	3,050	=0.114/η	=529.01/η	=0.161/η	=682.59/η	=0.161/η	=682.59/η
Retail	0.76	3,379	=0.123/η	=586.07/η	=0.174/η	=756.22/η	=0.174/η	=756.22/η
Warehouse	0.70	3,050	=0.114/η	=529.01/η	=0.161/η	=682.59/η	=0.161/η	=682.59/η

Notes: 2. CF values from SCE13HC030.1 Air-cooled packaged chiller workpaper July 1, 2014

3. EFLH values from SCE13HC030.1 Air-cooled packaged chiller workpaper July 1, 2014

COMMERCIAL: VRF

MEASURE DETAILS

Description
Inverter driven variable refrigerant flow (VRF) air conditioning systems are direct expansion AC systems that utilize variable speed evaporator/condenser fans, and a combination of fixed and variable speed compressors along with most often multiple individual zone evaporators to provide the ability to more closely match the AC system's output with the building's cooling requirements.

Program Criteria
Eligible equipment shall have a minimum rated efficiency that is at least 15% higher than the energy code-compliant standard for equivalently-sized equipment.

Unit of Measure
One ton of cooling capacity

Baseline Equipment
Existing or Honolulu energy code-compliant conventional, packaged or split air conditioners and condensing units

High Efficiency Equipment
Air conditioning systems featuring a single outdoor unit, simultaneously serving multiple indoor zones with a variable-speed compressor, and labeled by the manufacturer as VRF. The proposed equipment rated efficiency is better than baseline equipment rated or measured efficiency.

ALGORITHMS

$$\text{peak kW savings per ton} = \{TON * [(1 / \eta_{.bs}) - (1 / \eta_{.he})] * CF\} / (1000\ W/kW)$$

$$\text{annual kWh savings per ton} = \{TON * [(1 / \eta_{.bs}) - (1 / \eta_{.he})] * HRS\} / (1000\ W/kW)$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\eta_{.bs}$	Baseline rated efficiency, which depends on cooling capacity of proposed equipment.	Table 1	Btu/hr-W	< 65,000 BTU/hr units are rated in SEER. Hawai'i Energy assumes IECC 2006 code.
$\eta_{.he}$	Proposed measure rated efficiency.	Table 1	Btu/hr-W	< 65,000 BTU/hr units are rated in SEER. Hawai'i Energy requires 15% above code.
TON	Unit of equipment cooling capacity	1	ton	12,000 Btu/hr = 1 ton
HRS	Annual operating hours	variable	hrs	see EFLH tab
CF	Coincidence factor	variable	-	see EFLH tab
Measure Life	Expected duration of energy savings	15	yrs	

Table 1: VRF Multisplit System, Program Efficiencies[1]

Unit Size, BTU/hr	90.1 2010 (S)EER_b	Recommended (S)EER_ee	90.1 2010 IEER_b	Recommended IEER_ee
<65,000 a/c air cooled	13	15.0	*N/A*	*N/A*
65,000-134,999 a/c air cooled	11.2	12.9	*13.1*	*15.1*
135,000-239,999 a/c air cooled	11	12.7	*12.9*	*14.8*
240,000-759,999 a/c air cooled	10	11.5	*11.6*	*13.3*
<65,000 heat pump[2] air cooled	13	15.0	*N/A*	*N/A*
65,000-134,999 heat pump air cooled	10.8	12.4	*12.7*	*14.6*
135,000-239,999 heat pump air cooled	10.4	12.0	*12.1*	*13.9*
>=240,000 heat pump air cooled	9.5	10.9	*11.0*	*12.7*
<65,000 water source	N/A		*N/A*	
65,000-134,999 water source	N/A		*N/A*	
135,000-239,999 water source	N/A		*N/A*	
240,000-759,999 water source	N/A		*N/A*	

Table 1 Sources: ANSI/ASHRAE/IES Standard 90.1 -2010, Table 6.8.1J; 2015 International Energy Conservation Code Tables C403.2.3(1) and C403.2.3(2)

Table 1 Footnotes:

1. These efficiences are as defined by the noted source to be considered for future program years. The Hawaii Energy PY7 TRM does not assign minimum efficiency requirements to VRFs. A bonus 20% energy savings are added on top of packaged/split a/c approved savings per ton. Proposed measure efficiency is set 15% higher than baseline. 2015 IECC Section C406.2 requires VRF systems to exceed minimum standard efficiencies by 10%.

2. VRF multisplit a/c and heat pump systems are newly differentiated. According to Hawaii Energy Program staff, no water source heat pumps and negligible air source heat pumps have been submitted to the program.

SAVINGS

Peak kW Savings/Ton by Building Type and Equipment Size (BTU/hr)

	<65,000	65,000 to 134,999	135,000 to 239,999	240,000 to 759,999	>760,000
Misc. Commercial	0.074	0.063	0.067	0.068	0.070
Cold Storage	0.123	0.105	0.111	0.114	0.117
Education	0.049	0.042	0.045	0.045	0.047
Grocery	0.209	0.178	0.189	0.193	0.200
Health	0.160	0.136	0.145	0.148	0.153
Hotel/Motel	0.147	0.126	0.134	0.136	0.141
Industrial	0.123	0.105	0.111	0.114	0.117
Office	0.123	0.105	0.111	0.114	0.117
Restaurant	0.184	0.157	0.167	0.171	0.176
Retail	0.147	0.126	0.134	0.136	0.141
Warehouse	0.110	0.094	0.100	0.102	0.106

Annual kWh Savings/Ton by Building Type and Equipment Size (BTU/hr)

Building Type	<65,000	65,000 to 134,999	135,000 to 239,999	240,000 to 759,999	>760,000

Misc. Commercial	730.40	624.10	662.60	676.70	698.80
Cold Storage	1254.50	1071.80	1138.20	1162.10	1200.00
Education	719.60	614.90	652.90	666.60	688.40
Grocery	1254.50	1071.80	1138.20	1162.10	1200.00
Health	1018.60	870.20	924.00	943.40	974.30
Hotel/Motel	730.20	623.90	662.50	676.40	698.50
Industrial	1018.60	870.20	924.00	943.40	974.30
Office	1215.80	1038.80	1103.00	1126.30	1163.00
Restaurant	815.90	697.10	740.20	755.80	780.40
Retail	640.30	547.10	580.90	593.20	612.50
Warehouse	1254.30	1071.80	1138.20	1162.10	1200.00

COMMERCIAL: Energy Management System

MEASURE DETAILS

Description
The installation of an energy management system in hotel guest rooms.

Program Criteria
• All entry and lanai doors must have door switches or other technologies that will de-energize the fan coil unit (FCU) when the door remains open.
• All main rooms must have occupancy sensors that will de-energize the FCU when no movement is detected for a given period of time (not to exceed 15 minutes).
• Thermostat controls must be preset.
• Applicant must be on a Commercial Rate Schedule (reference utility bill).

Unit of Measure
Number of Rooms

Baseline Equipment
No EMS controls

High Efficiency Equipment
Room EMS controls

ALGORITHMS

$$\Delta kWh = E_{.deemed} * \#_{.rooms}$$
$$\Delta kW = P_{.deemed} * \#_{.rooms}$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$E_{.deemed}$*	Energy savings per room, per unit	750	kWh	
$P_{.deemed}$	Demand savings per room, per unit	0.1	kW	
$\#_{.rooms}$	Number of rooms controlled by EMS	User input	-	
Measure Life	Expected duration of energy savings	15	yrs	

*EMS (energy management system) savings was established by HECO as an average of their previously rebated EMS projects.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Room EMS	0.100 kW	750.00 kWh

COMMERCIAL: Lighting

ALGORITHMS

kW savings per lamp = ΔW / 1000 * $IF_{.d}$ * CF * PF

kWh savings per lamp = ΔW / 1000 * $IF_{.e}$ * EFLH * PF

ΔW = $W_{.bs}$ - $W_{.he}$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔW	Difference between baseline and proposed efficient lamp wattage	See Table 1.	W	
$W_{.bs}$	Wattage of the baseline lamp	See Table 1.	W	
$W_{.he}$	Wattage of the proposed efficient lamp	See Table 1.	W	
$IF_{.d}$	Factor reflecting impact of lighting savings on cooling load	See Table 3.	-	
$IF_{.e}$	Factor reflecting impact of lighting savings on cooling energy	See Table 3.	-	
CF	Coincidence factor, % time equipment load corresponds with utility peak load	See Table 2.	-	
PF	Persistence factor, % of measures installed and operating	100%	-	
EFLH	Equivalent full load hours, or hours of lighting for business operation	See Table 2a & 2b.	hrs	
Measure Life	Expected duration of energy savings	See Table 1.	yrs	

MEASURE DETAILS

Table 1. Measure Descriptions

Lighting Type	Equipment Group	Equip Type	Equip Subtype	Equip Size	Size	Measure Life	W_b	W_ee	Delta_W	Note
LED Exit Sign	Lighting from Amplify	LED: Exit Sign	(None)	Promotional	Promotional	15	40	5.0	35.0	Base: (2) 20W inc. bulbs
LED Linear Type A	Lighting from Amplify	LED: Linear Type A	(None)	8' Lamp	8' Lamp	15	70.9	41.5	29.4	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting from Amplify	LED: Linear Type B	(None)	8' Lamp	8' Lamp	15	70.9	39.0	31.9	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting from Amplify	LED: Linear Type C	(None)	8' Lamp	8' Lamp	15	70.9	39.0	31.9	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type A	Lighting	LED: Linear Type A ; T5	(None)	4' Lamp	4' Lamp	15	32.3	23.2	9.1	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting	LED: Linear Type B ; T5	(None)	4' Lamp	4' Lamp	15	32.3	20.7	11.6	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting	LED: Linear Type C ; T5	(None)	4' Lamp	4' Lamp	15	32.3	20.7	11.6	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type A	Lighting	LED: Linear Type A ; T5 HO	(None)	4' Lamp	4' Lamp	15	62.0	30.0	32.0	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting	LED: Linear Type B ; T5 HO	(None)	4' Lamp	4' Lamp	15	62.0	27.5	34.5	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting	LED: Linear Type C ; T5 HO	(None)	4' Lamp	4' Lamp	15	62.0	27.5	34.5	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type A	Lighting from Amplify	LED: Linear Type A	(None)	4' Lamp	4' lamp	15	38.6	18.4	20.2	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting from Amplify	LED: Linear Type B	(None)	4' Lamp	4' lamp	15	38.6	15.9	22.7	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting from Amplify	LED: Linear Type C	(None)	4' Lamp	4' lamp	15	38.6	15.9	22.7	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type A	Lighting from Amplify	LED: Linear Type A	(None)	3' Lamp	3' lamp	15	33.5	16.0	17.5	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting from Amplify	LED: Linear Type B	(None)	3' Lamp	3' Lamp	15	33.5	13.5	20.0	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting from Amplify	LED: Linear Type C	(None)	3' Lamp	3' Lamp	15	33.5	13.5	20.0	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type A	Lighting from Amplify	LED: Linear Type A	(None)	2' Lamp	2' lamp	15	23.2	12.8	10.4	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type B	Lighting from Amplify	LED: Linear Type B	(None)	2' Lamp	2' lamp	15	23.2	10.3	12.9	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED Linear Type C	Lighting from Amplify	LED: Linear Type C	(None)	2' Lamp	2' lamp	15	23.2	10.3	12.9	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
LED--Omni-Directional lamp [1]	Lighting	LED: Omni-Directional	(None)	Screw Base	A19 screw base	15	24	7.5	16.5	BS: EISA post 2007 ; EE: Lighting_dimmable
LED--Omni-Directional lamp [1]	Lighting	LED: Omni-Directional	(None)	Pin Base	Pin Base	15	24	7.5	16.5	BS: EISA post 2007 ; EE: Lighting_dimmable
LED--MR16 lamp [1]	Lighting or Lighting from SBDIL	LED: MR16	(None)	(None)	(None)	15	50	5	45	BS: DLC, Standard, Non-Dim ; EE: Lighting_dimmable
LED--PAR20 lamp [1]	Lighting or Lighting from SBDIL	LED: PAR20	(None)	(None)	(None)	15	51	8.4	42.6	EISA watts base ; EE: Lighting_dimmable
LED--PAR30 lamp [1]	Lighting or Lighting from SBDIL	LED: PAR30	(None)	(None)	(None)	15	64	14.7	49.3	EISA watts base ; EE: Lighting_dimmable
LED--PAR38 lamp [1]	Lighting or Lighting from SBDIL	LED: PAR38	(None)	(None)	(None)	15	64	17.4	46.6	EISA watts base ; EE: Lighting_dimmable

LED-Decorative Candelabra 25W--(None)			(None)						21	EISA post 2007
LED-Decorative Candelabra 40W--(None)			(None)						36	EISA post 2007
LED-Decorative Med Base 40W--(None)			(None)						35	EISA post 2007
LED-Decorative Med Base 60W--(None)			(None)						54	EISA post 2007
LED Troffer	Lighting	LED: Troffer	(None)	1 ft. x 4 ft.		15	61.6	35.0	27	
LED Troffer	Lighting	LED: Troffer	(None)	2 ft. x 2 ft.		15	63.6	30.0	33.6	
LED Troffer	Lighting	LED: Troffer	(None)	2 ft. x 4 ft.		15	109.2	40.0	69.2	
LED U-bend [2]	Lighting	LED: U-bend Type A	(None)	2 ft. x 2 ft.		15	63.3	21.0	42.3	
LED U-bend [2]	Lighting	LED: U-bend Type B	(None)	2 ft. x 2 ft.		15	63.3	17.0	46.3	
LED U-bend [2]	Lighting	LED: U-bend Type C	(None)	2 ft. x 2 ft.		15	63.3	17.0	46.3	
LED U-bend [2]	Lighting	LED: U-bend Type A	(None)	4 ft.		15	63.3	35.0	28.3	
LED U-bend [2]	Lighting	LED: U-bend Type B	(None)	4 ft.		15	63.3	30.0	33.3	
LED U-bend [2]	Lighting	LED: U-bend Type C	(None)	4 ft.		15	63.3	30.0	33.3	
LED: HID replacement	Lighting	LED: Corn Cob	(None)	<35W		15	93	28.37	64.6	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
	Lighting	LED: Corn Cob	(None)	35W-149W		15	241	77.69	163.3	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
	Lighting	LED: Corn Cob	(None)	150W-220W		15	496	170.03	326.0	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL
	Lighting	LED: Corn Cob	(None)	>220W		15	970	269.77	700.2	BS: Xcel Energy, Input Wattage Guide (2016) ; EE: DLC, QPL

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp. 78-105. 2017 EISA W_ b are derived using the 2016 Pennsylvania Technical Reference Manual available at www.puc.pa.gov as well as ENERGY STAR product data (to match equipment lumens and wattages).

Notes: 1. Delta W for these measures represent a blend of dimmable and non-dimmable equipment. See C_Lighting_dimmable for details.

2. HE program in PY2016 assumes that U-bend lamps replace a single, 4' linear fluorescent lamp at 31.65 W (70% T8/30% T12 blend). EISA linear fluorescent wattages are similar, so no change to W_b for U bend LED.

SAVINGS

Table 2. Calculated Unit Savings: T12 to T8 with electronic ballast, per lamp

	Demand Savings (kW)				Energy Savings (kWh/year)			
Building Type	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**
Misc. Commercial	0.002	0.004	0.006	0.012	35.90	56.40	83.20	170.80
Cold Storage	0.004	0.007	0.010	0.020	34.50	54.30	80.00	164.30
Education	0.002	0.003	0.004	0.008	22.00	34.60	51.00	104.80
Grocery	0.007	0.011	0.016	0.034	48.30	76.00	112.00	230.00
Health	0.005	0.008	0.013	0.026	53.70	84.50	124.50	255.70
Hotel/Motel	0.005	0.008	0.012	0.024	41.00	64.50	95.00	195.20
Industrial	0.004	0.007	0.010	0.020	35.60	56.00	82.50	169.50
Office	0.004	0.007	0.010	0.020	23.30	36.60	54.00	110.90
Restaurant	0.006	0.010	0.014	0.030	43.80	68.90	101.50	208.50
Retail	0.005	0.008	0.012	0.024	34.90	54.90	81.00	166.30
Warehouse	0.004	0.006	0.009	0.018	34.50	54.30	80.00	164.30

Note: Deemed savings values. Values to be revisited in PY19.

Table 3. Calculated Unit Savings: T12/T8 Blended Baseline to T8 Low Wattage, per lamp

	25W T8 Savings		28W T8 Savings	
Building Type	**kW**	**kWh/yr**	**kW**	**kWh/yr**
Misc. Commercial	0.005	21.6	0.005	78.1
Cold Storage	0.009	37.4	0.009	75.1
Education	0.004	10.6	0.004	47.9
Grocery	0.015	87.4	0.015	105.1
Health	0.012	77.7	0.012	116.9
Hotel/Motel	0.011	54.4	0.011	89.2
Industrial	0.009	38.6	0.009	77.4
Office	0.009	25.3	0.009	50.7
Restaurant	0.014	73.9	0.014	95.3
Retail	0.011	46.3	0.011	76
Warehouse	0.008	33.3	0.008	75.1

Note: Deemed savings values. Values to be revisited in PY19.

Table 4. Calculated Unit Savings: Delamping (No Reflector)

	Demand Savings (kW)				Energy Savings (kWh/year)			
Building Type	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**
Misc. Commercial	0.006	0.008	0.010	0.023	80.0	118.9	149.2	333.0
Cold Storage	0.009	0.014	0.017	0.039	77.0	114.4	143.5	320.3
Education	0.004	0.006	0.007	0.015	49.1	73.0	91.5	204.3
Grocery	0.016	0.023	0.029	0.065	107.7	160.2	200.9	448.4
Health	0.012	0.018	0.022	0.05	119.8	178.0	223.4	498.5

Hotel/Motel	0.011	0.017	0.021	0.046	91.4	135.9	170.5	380.5
Industrial	0.009	0.014	0.017	0.039	79.4	118.0	148.0	330.3
Office	0.009	0.014	0.017	0.039	51.9	77.2	96.9	216.2
Restaurant	0.014	0.021	0.026	0.058	97.6	145.1	182.1	406.4
Retail	0.011	0.017	0.021	0.046	77.9	115.8	145.2	324.2
Warehouse	0.008	0.012	0.016	0.035	77.0	114.4	143.5	320.3

Note: Deemed savings values. Values to be revisited in PY19.

Table 5. Calculated Unit Savings: Delamping (With Reflector)

	Demand Savings (kW)				Energy Savings (kWh/year)			
Building Type	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**	**2' Lamp**	**3' Lamp**	**4' Lamp**	**8' Lamp**
Misc. Commercial	0.006	0.008	0.010	0.023	80.0	118.9	149.2	333.0
Cold Storage	0.009	0.014	0.017	0.039	77.0	114.4	143.5	320.3
Education	0.004	0.006	0.007	0.015	49.1	73.0	91.5	204.3
Grocery	0.016	0.023	0.029	0.065	107.7	160.2	200.9	448.4
Health	0.012	0.018	0.022	0.050	119.8	178.0	223.4	498.5
Hotel/Motel	0.011	0.017	0.021	0.046	91.4	135.9	170.5	380.5
Industrial	0.009	0.014	0.017	0.039	79.4	118.0	148.0	330.3
Office	0.009	0.014	0.017	0.039	51.9	77.2	96.9	216.2
Restaurant	0.014	0.021	0.026	0.058	97.6	145.1	182.1	406.4
Retail	0.011	0.017	0.021	0.046	77.9	115.8	145.2	324.2
Warehouse	0.008	0.012	0.016	0.035	77.0	114.4	143.5	320.3

Note: Deemed savings values. Values to be revisited in PY19.

Table 6. Calculated Unit Savings: Decorative LEDs

	Candelabra 25 W		Candelabra 40 W		Med Base 40 W		Med Base 60 W	
Building Type	**kW**	**kWh/yr**	**kW**	**kWh/yr**	**kW**	**kWh/yr**	**kW**	**kWh/yr**
Misc. Commercial	0.007	95.91	0.012	164.42	0.011	159.85	0.017	246.63
Cold Storage	0.013	124.31	0.022	213.11	0.021	207.19	0.033	319.66
Education	0.004	59.11	0.007	101.33	0.007	98.52	0.011	152.00
Grocery	0.020	127.56	0.034	218.68	0.033	212.61	0.051	328.02
Health	0.017	152.54	0.029	261.50	0.028	254.23	0.043	392.25
Hotel/Motel	0.016	115.69	0.027	198.33	0.026	192.82	0.040	297.50
Industrial	0.011	93.96	0.019	161.08	0.019	156.61	0.029	241.62
Office	0.012	62.98	0.020	107.96	0.019	104.96	0.030	161.94
Restaurant	0.017	116.49	0.029	199.70	0.028	194.15	0.043	299.55
Retail	0.014	93.18	0.023	159.74	0.023	155.31	0.035	239.62
Warehouse	0.010	89.02	0.017	152.61	0.017	148.37	0.026	228.91

Table 7. Calculated Unit Savings: LED Exit Signs (8760 HOURS)

	Demand Savings (kW)	Energy Savings (kWh/year)
BS: 40W inc. EE: 5W LED	0.035	306.60

Table 8. Calculated Unit Savings: LED Troffers

	Demand Savings (kW)			Energy Savings (kWh/year)		
Building Type	**1'x4' Fixture**	**2'x2' Fixture**	**2'x4' Fixture**	**1'x4' Fixture**	**2'x2' Fixture**	**2'x4' Fixture**
Misc. Commercial	0.009	0.011	0.022	121.49	153.46	316.05
Cold Storage	0.016	0.020	0.042	157.46	198.90	409.64
Education	0.006	0.007	0.014	74.87	94.58	194.79
Grocery	0.025	0.032	0.066	161.58	204.10	420.35
Health	0.021	0.027	0.055	193.22	244.06	502.66
Hotel/Motel	0.020	0.025	0.051	146.55	185.11	381.24
Industrial	0.014	0.018	0.037	119.02	150.34	309.63
Office	0.015	0.019	0.038	79.77	100.76	207.53
Restaurant	0.021	0.027	0.056	147.55	186.39	383.86
Retail	0.017	0.022	0.045	118.03	149.09	307.06
Warehouse	0.013	0.016	0.033	112.76	142.43	293.34

Table 9a. Calculated Unit Savings: Linear LED Lamps, Demand Savings

	Demand Savings (kW)											
Building Type	**2' Type A**	**2' Type B**	**2' Type C**	**3' Type A**	**3' Type B**	**3' Type C**	**4' Type A**	**4' Type B**	**4' Type C**	**8' Type A**	**8' Type B**	**8' Type C**
Misc. Commercial	0.003	0.004	0.004	0.006	0.006	0.006	0.007	0.007	0.007	0.009	0.010	0.010
Cold Storage	0.006	0.008	0.008	0.011	0.012	0.012	0.012	0.014	0.014	0.018	0.019	0.019
Education	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.007	0.007
Grocery	0.010	0.012	0.012	0.017	0.019	0.019	0.019	0.021	0.021	0.028	0.030	0.030
Health	0.008	0.010	0.010	0.014	0.016	0.016	0.016	0.018	0.018	0.024	0.026	0.026
Hotel/Motel	0.008	0.010	0.010	0.013	0.015	0.015	0.015	0.017	0.017	0.022	0.024	0.024
Industrial	0.006	0.007	0.007	0.009	0.011	0.011	0.011	0.012	0.012	0.016	0.017	0.017
Office	0.006	0.007	0.007	0.010	0.011	0.011	0.011	0.012	0.012	0.016	0.018	0.018
Restaurant	0.008	0.010	0.010	0.014	0.016	0.016	0.016	0.018	0.018	0.024	0.026	0.026
Retail	0.007	0.008	0.008	0.011	0.013	0.013	0.013	0.015	0.015	0.019	0.021	0.021
Warehouse	0.005	0.006	0.006	0.008	0.009	0.009	0.010	0.011	0.011	0.014	0.015	0.015

Table 9b. Calculated Unit Savings: Linear LED Lamps, Energy Savings

	Energy Savings (kWh/year)											
Building Type	**2' Type A**	**2' Type B**	**2' Type C**	**3' Type A**	**3' Type B**	**3' Type C**	**4' Type A**	**4' Type B**	**4' Type C**	**8' Type A**	**8' Type B**	**8' Type C**
Misc. Commercial	47.45	58.87	58.87	79.97	91.39	91.39	92.12	103.54	103.54	134.46	145.88	145.88

Cold Storage	61.51	76.30	76.30	103.65	118.45	118.45	119.40	134.20	134.20	174.28	189.07	189.07
Education	29.25	36.28	36.28	49.29	56.32	56.32	56.78	63.81	63.81	82.87	89.91	89.91
Grocery	63.11	78.30	78.30	106.36	121.55	121.55	122.52	137.71	137.71	178.83	194.02	194.02
Health	75.47	93.63	93.63	127.19	145.35	145.35	146.51	164.67	164.67	213.85	232.01	232.01
Hotel/Motel	57.24	71.01	71.01	96.47	110.24	110.24	111.12	124.89	124.89	162.19	175.96	175.96
Industrial	46.49	57.68	57.68	78.35	89.53	89.53	90.25	101.44	101.44	131.73	142.91	142.91
Office	31.16	38.66	38.66	52.51	60.01	60.01	60.49	67.99	67.99	88.29	95.79	95.79
Restaurant	57.64	71.50	71.50	97.13	111.00	111.00	111.89	125.75	125.75	163.31	177.18	177.18
Retail	46.10	57.20	57.20	77.70	88.79	88.79	89.50	100.59	100.59	130.64	141.73	141.73
Warehouse	44.04	54.64	54.64	74.23	84.82	84.82	85.50	96.10	96.10	124.80	135.39	135.39

Table 9c. Calculated Unit Savings: Linear LED Lamps, 4' T5/T5 HO

	Demand Savings (kW)						Energy Savings (kWh/year)					
Building Type	**T5 Type A**	**T5 Type B**	**T5 Type C**	**T5HO Type A**	**T5HO Type B**	**T5HO Type C**	**T5 Type A**	**T5 Type B**	**T5 Type C**	**T5HO Type A**	**T5HO Type B**	**T5HO Type C**
Misc. Commercial	0.003	0.004	0.004	0.010	0.011	0.011	41.56	52.98	52.98	146.15	157.57	157.57
Cold Storage	0.006	0.007	0.007	0.020	0.021	0.021	53.87	68.67	68.67	189.43	204.23	204.23
Education	0.002	0.002	0.002	0.007	0.007	0.007	25.61	32.65	32.65	90.07	97.11	97.11
Grocery	0.009	0.011	0.011	0.030	0.033	0.033	55.28	70.46	70.46	194.38	209.57	209.57
Health	0.007	0.009	0.009	0.026	0.028	0.028	66.10	84.26	84.26	232.44	250.60	250.60
Hotel/Motel	0.007	0.009	0.009	0.024	0.026	0.026	50.13	63.91	63.91	176.29	190.07	190.07
Industrial	0.005	0.006	0.006	0.017	0.019	0.019	40.72	51.90	51.90	143.18	154.37	154.37
Office	0.005	0.006	0.006	0.018	0.019	0.019	27.29	34.79	34.79	95.97	103.46	103.46
Restaurant	0.007	0.009	0.009	0.026	0.028	0.028	50.48	64.35	64.35	177.51	191.38	191.38
Retail	0.006	0.008	0.008	0.021	0.022	0.022	40.38	51.47	51.47	141.99	153.09	153.09
Warehouse	0.004	0.005	0.005	0.015	0.016	0.016	38.58	49.17	49.17	135.65	146.25	146.25

Table 10. Calculated Unit Savings: LED U-tubes

	Demand Savings (kW)						Energy Savings (kWh/year)					
Building Type	**2' X 2' Type A**	**2' X 2' Type B**	**2' X 2' Type C**	**4' Type A**	**4' Type B**	**4' Type C**	**2' X 2' Type A**	**2' X 2' Type B**	**2' X 2' Type C**	**4' Type A**	**4' Type B**	**4' Type C**
Misc. Commercial	0.014	0.015	0.015	0.009	0.011	0.011	193.19	211.46	211.46	129.25	152.09	152.09
Cold Storage	0.026	0.028	0.028	0.017	0.020	0.020	250.40	274.08	274.08	167.53	197.13	197.13
Education	0.009	0.010	0.010	0.006	0.007	0.007	119.07	130.33	130.33	79.66	93.73	93.73
Grocery	0.040	0.044	0.044	0.027	0.032	0.032	256.95	281.25	281.25	171.91	202.28	202.28
Health	0.034	0.037	0.037	0.023	0.027	0.027	307.26	336.32	336.32	205.57	241.89	241.89
Hotel/Motel	0.031	0.034	0.034	0.021	0.025	0.025	233.04	255.08	255.08	155.91	183.46	183.46
Industrial	0.023	0.025	0.025	0.015	0.018	0.018	189.27	207.17	207.17	126.63	149.00	149.00
Office	0.023	0.026	0.026	0.016	0.018	0.018	126.86	138.85	138.85	84.87	99.86	99.86
Restaurant	0.034	0.037	0.037	0.023	0.027	0.027	234.65	256.83	256.83	156.99	184.72	184.72
Retail	0.028	0.030	0.030	0.018	0.022	0.022	187.70	205.45	205.45	125.58	147.76	147.76
Warehouse	0.020	0.022	0.022	0.013	0.016	0.016	179.31	196.27	196.27	119.96	141.16	141.16

Note: LED tubes are assumed to be used in interior applications only.

Table 11. Calculated Unit Savings: LED Corn Cob

	Demand Savings (kW)				Energy Savings (kWh/year)			
Building Type	**<35W**	**35W-149W**	**150W-220W**	**>220W**	**<35W**	**35W-149W**	**150W-220W**	**>220W**
Misc. Commercial	0.021	0.053	0.105	0.226	295.18	745.87	1488.77	3198.09
Cold Storage	0.039	0.100	0.199	0.427	382.59	966.74	1929.64	4145.14
Education	0.013	0.034	0.068	0.146	181.92	459.69	917.55	1971.03
Grocery	0.061	0.155	0.309	0.663	392.59	992.02	1980.08	4253.50
Health	0.052	0.131	0.261	0.561	469.46	1186.26	2367.79	5086.35
Hotel/Motel	0.048	0.121	0.242	0.519	356.06	899.71	1795.84	3857.72
Industrial	0.035	0.088	0.175	0.376	289.18	730.73	1458.54	3133.16
Office	0.036	0.090	0.180	0.386	193.82	489.76	977.57	2099.95
Restaurant	0.052	0.131	0.262	0.564	358.51	905.91	1808.21	3884.30
Retail	0.042	0.106	0.212	0.456	286.79	724.66	1446.44	3107.16
Warehouse	0.031	0.077	0.154	0.332	273.97	692.28	1381.80	2968.30
Exterior	0.048	0.122	0.244	0.525	283.08	715.30	1427.75	3067.01

COMMERCIAL: Dimmable Lighting (Non-Linear LED)

MEASURE DETAILS

Description
Replacement of non-linear incandescent/compact fluorescent lamps with LED lamps.

Program Criteria
Incentivized LED lamps must be Energy Star labeled or Design Lights Consortium (DLC) listed.

Unit of Measure
One lamp

Baseline Equipment
Blended incandescent/compact fluorescent representative lamp as defined by baseline lamp wattage and percent contribution to blended baseline, in table below.

High Efficiency Equipment
LED lamp

ALGORITHMS

$$\text{kW savings per lamp} = \Delta W_{.dim} / 1000 * IF_{.d} * CF * PF$$

$$\text{kWh savings per lamp} = \Delta W_{.dim} / 1000 * IF_{.e} * EFLH * PF$$

$$\Delta W = W_{.bs} - W_{.he}$$

$$\Delta W_{.blend} = W_{.bs} - W_{.he,blend}$$

$$W_{.he,blend} = (W_{.he} * \%_{.dim} * SVG_{.dim}) + (W_{.he} * \%_{.non\text{-}dim})$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔW	Difference between baseline and proposed efficient lamp wattage	Table 1	W	
$\Delta W_{.blend}$	Δ_W including dimmable blend consideration	Table 1	-	
$\%_{.dim}$	Percent of lamps incentivized that are dimmable	Table 1	-	Historical program data
$\%_{.non\text{-}dim}$	Percent of lamps incentivized that are non-dimmable	Table 1	-	Historical program data
$SVG_{.dim}$	Percent savings from dimming lamps, from 2015 PA TRM, Table 3-5	36%	-	
$W_{.bs}$	Wattage of baseline lamp	Table 1	W	
$W_{.he}$	Wattage of proposed efficient lamp	Table 1	W	
$IF_{.d}$	Factor reflecting impact of lighting savings on cooling load	Table 3	-	

$IF_{.e}$	Factor reflecting impact of lighting savings on cooling energy	Table 3	-	
CF	Coincidence factor	Table 2	-	Per PY15 TRM, p. 83, CFs came from the California Energy Commission End Use Survey (www.energy.ca/gov/ceus/).
PF	Persistence factor	100%	-	
EFLH	Equivalent full load hours, or hours of lighting for business operation	Table 2	hrs	Per the PY15 TRM, EFLH from the DEER database were used to populate lamp kWH savings.
Measure Life	Expected duration of energy savings	Table 1	yrs	

Table 1. Measure Descriptions

36% 2015 PA TRM Table 3-5

Lighting Type	W_bs	Baseline Mix	W_ee[4]	Δ_W	% dim	% non-dim	dim watts	W_dim	W_non dim	Blend W_ee	Blend Δ_W	% Difference
LED: Omni-Directional, A19 Screw Base	24	20% inc., 80% CFL	7.8	*16.2*	12%	**88%**	0.936	0.599	6.864	7.463	16.54	2%
LED: Omni-Directional, Pin Base	24	20% inc., 80% CFL	7.8	*16.2*	12%	**88%**	0.936	0.599	6.864	7.463	16.54	2%
LED: MR16	50	100% inc.	6.5	*43.5*	66%	**34%**	4.29	2.7456	2.21	4.9556	45.04	4%
LED: PAR20	51	80% inc., 20% CFL	9	*42*	8%	**92%**	0.72	0.4608	8.28	8.7408	42.26	1%
LED: PAR30	64	80% inc., 20% CFL	6.4	*57.6*	27%	**73%**	1.728	1.1059	4.672	5.7779	58.22	1%
LED: PAR38	64	80% inc., 20% CFL	20.3	*43.7*	39%	**61%**	7.917	5.0669	12.383	17.45	46.55	7%

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp. 78-105

Notes: 1. New definition for PY7--Delta_W reflects avg baseline

2. Baseline and efficient 8' wattage from Pennsylvania 2016 TRM Appendix C: Lighting Audit and Design Tool http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

3. Assumed retrofit kit savings similar to A19 based on ENERGY STAR Product Finder data

4. Efficient lighting wattages are derived from historic Hawaii Energy measure data

SAVINGS

Calculated Dimmable LEDs

Building Type	HOURS	CF	IF_e	IF_d	MR16		PAR20		PAR30		PAR38		Omni-Directional	
					kWh/yr	kW	kWh/yr	kW	kWh/yr	kW	kWh/yr	kW	kWh/yr	kW
Misc. Commercial	4,325	0.30	1.056	1.075	205.71	0.015	193.01	0.014	265.90	0.019	212.60	0.015	75.54	0.005
Cold Storage	4,160	0.50	1.423	1.22	266.62	0.027	250.17	0.026	344.64	0.036	275.56	0.028	97.91	0.010
Education	2,653	0.20	1.061	1.039	126.78	0.009	118.95	0.009	163.88	0.012	131.03	0.010	46.56	0.003

Grocery	5,824	0.85	1.043	1.114	273.59	0.043	256.71	0.040	353.65	0.055	282.76	0.044	100.47	0.016
Health	6,474	0.65	1.122	1.233	327.16	0.036	306.97	0.034	422.90	0.047	338.13	0.037	120.14	0.013
Hotel/Motel	4,941	0.60	1.115	1.236	248.14	0.033	232.82	0.031	320.75	0.043	256.45	0.035	91.12	0.012
Industrial	4,290	0.50	1.043	1.074	201.53	0.024	189.09	0.023	260.50	0.031	208.29	0.025	74.01	0.009
Office	2,808	0.50	1.068	1.102	135.07	0.025	126.74	0.023	174.60	0.032	139.60	0.026	49.60	0.009
Restaurant	5,278	0.75	1.051	1.073	249.84	0.036	234.42	0.034	322.96	0.047	258.22	0.037	91.75	0.013
Retail	4,210	0.60	1.054	1.085	199.86	0.029	187.52	0.028	258.34	0.038	206.56	0.030	73.39	0.011
Warehouse	4,160	0.45	1.019	1.053	190.93	0.021	179.14	0.020	246.80	0.028	197.33	0.022	70.11	0.008

COMMERCIAL: Refrigerated Case Lighting

MEASURE DETAILS

Description

Lighting unit for illuminating refrigerated or freezer cases.

Program Criteria

New refrigerated cases do not qualify for this measure.

The qualifying technology must be specifically designed for refrigerated case lighting applications. For example, lamps in the DLC General Application: Case Lighting category qualify. An equivalent category of lamps rated by ENERGY STAR or Lighting Facts may qualify as well, pending Program approval.

Unit of Measure

One kit

Baseline Equipment

Linear fluorescent lamp unit

High Efficiency Equipment

LED replacement lamp unit

ALGORITHMS

delta_W = W_b-W_ee

kW savings per lamp = delta_W/1000*IF_d*CF*PF

kWh savings per lamp = delta_W/1000*IF_e*EFLH*PF

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
W_b	Wattage of the baseline lamp	11	W/ft	Hawai'i Energy Amplify data and Regional Technical Forum data
W_ee	Wattage of the proposed efficient lamp	5	W/ft	Opinion Dynamics deemed value based on other TRMs and RTF Calculator
delta_W	Difference between baseline and proposed efficient lamp wattage	6	W/ft	calculated
IF_d	Factor reflecting impact of lighting savings on cooling load	1.114	-	Grocery value from Hawai'i Energy Interactive Factors
IF_e	Factor reflecting impact of lighting savings on cooling energy	1.043	-	Grocery value from Hawai'i Energy Interactive Factors
CF	Coincidence factor, % time equipment load corresponds with utility peak load	100%	-	Assumed Grocery lighting in operation 5-9 PM

PF	Persistence factor, % of measures installed and operating	100%	-	
EFLH	Equivalent full load hours, or hours of lighting for business operation	6205	hrs	17 hours per day, 365 days/year, from 2016 PA
Measure Life	Expected duration of energy savings	16	yrs	

Table 1. Measure Descriptions

Lighting Type	W_b [1]	W_ee	Delta_W	Baseline description
4' retrofit kit	44	20	24	40W F40 T12
5' retrofit kit	55	25	30	40W F40 T12
6' retrofit kit	66	30	36	40W F40 T12

Note: 1. Baseline wattages for general service, decorative, and linear fluorescents were updated for PY2017 to reflect EISA standard minimum wattages reported in the 2016 Pennsylvania (PA) Technical Reference Manual.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
4-foot lamp	0.027 kW	155.32 kWh
5-foot lamp	0.033 kW	194.15 kWh
6-foot lamp	0.040 kW	232.99 kWh

Note: 1. Assumed hours as for linear fluorescents in grocery. The impact of higher efficiency lighting on refrigeration performance is included in the above calculation assuming an average EER of 7.

COMMERCIAL: Light Occupancy Sensor

MEASURE DETAILS

Description
This measure is for wall switch sensors that controls the use of lighting in areas around the facility with variable use such as laundry, storage, garage, or spare areas.

Program Criteria
All types of sensors (e.g. infrared, ultrasonic) are eligible.

Unit of Measure
One sensor

Baseline Equipment
Manual switch

High Efficiency Equipment
Occupancy sensor installed

ALGORITHMS

$$\Delta E = (P\_ctrl / 1000) * HRS * RTR * PF * IF\_e$$
$$\Delta P = (P\_ctrl / 1000) * CF * PF * IF\_d$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
P_ctrl	Total wattage controlled by sensor	56.32	W	Hawaii Energy Technical Reference Manual PY2015 deems 2L T8 with 0.88 ballast
RTR	Run time reduction factor from sensor	0.33	-	
HRS	Hours of lighting operation	3650	hrs	10 hrs/day, 365 days/yr
IF_e	Factor reflecting impact of lighting savings on cooling energy	1	-	
IF_d	Factor reflecting impact of lighting savings on cooling load	1	-	
Constant	Conversion factor from W to kW	1000	W/kW	
PF	Persistance factor	1.00	-	
CF	Coincidence factor	0.12	-	
Measure Life	Expected duration of savings	8	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Occupancy Sensor	0.007 kW	67.84 kWh

COMMERCIAL: Stairwell Bi-level Dimming Controls

MEASURE DETAILS

Description
Stairwell lighting typically operates continuously at full output despite very low, intermittent use. Bi-level stairwell dimming lights utilizes either an ultra-sonic or infrared motion sensor to detect motion in stairwells. Solid state controls are used to dim fixtures to lower light levels when a space is unoccupied.

Program Criteria
Energy Star/DLC, UL compliant.

Unit of Measure
One sensor

Baseline Equipment
No bi-level dimming lights with occupancy sensors

High Efficiency Equipment
Bi-level dimming lights with occupancy sensors

ALGORITHMS

peak kW savings per fixture = [kW_b-(kW_ee,dim*UF/100)+(kW_ee,full*OF/100)]*IF_d*CF*PF
kWh savings per fixture = [kW_b*EFLH-(kW_ee,dim*EFLH*UF+kW_ee,full*EFLH*OF)]*IF_e*PF

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
kW_bs	Baseline kW load of continuous operation stairwell fixture.	User Input	kW	
kW_ee,dim	kW load of stairwell fixture in dim or low level mode when unoccupied.	User Input	kW	
kW_ee,full	kW load of stairwell fixture in full power mode when occupied.	User Input	kW	
UF	Unoccupied fraction	Table 1	%	
OF	Occupied fraction	Table 1	%	
IF_e	Factor reflecting impact of lighting savings on cooling energy	1	-	
IF_d	Factor reflecting impact of lighting savings on cooling load	1	-	
EFLH	Equivalent full load hours, or hours of lighting for business operation	8760	hrs	
PF	Persistance factor	1.00	-	
CF	Coincidence factor	1.00	-	
Measure Life	Expected duration of savings	14	yrs	

Table 1. Occupancy Types and Fractions

Building Type	Stairwell Type	Occupied Fraction (OF)[1]	Unoccupied Fraction (UF)
High Rise > 10 Floors	Free Access	10%	90%
	Exit Only	5%	95%
Low Rise <= 10 Floors	Free Access	20%	80%
	Exit Only	10%	90%

1. Hawaii Energy Technical Reference Manual PY2015, p.104-105.

SAVINGS

Sample Worksheet

Baseline Operation:

Location	Type	Qty	Watt	Total Watt	M-F Hours	Sat Hours	Sun Hours	Annual Op Hours	On Peak Demand Hours	Off Peak kW Demand	On Peak kW Demand	Annual Energy Use (kWh/yr)
Stairwell	*32W T8*	*205*	*34*	6970	*24*	*24*	*24*	8760	*4*	6.97	6.97	61057

Bi-Level Operation[2]:

Location	Access	Type	Qty	Watt	Total Watt	M-F Hours	Sat Hours	Sun Hours	Annual Op Hours	On Peak Demand Hours	Off Peak Demand (kW)	On Peak Demand (kW)	Annual Energy Use (kWh/yr)
Stairwell--Low Rise	Exit Only	*Dim*	*205*	*6*	1230	21.6	21.6	21.6	7884	3.6	1.23	1.11	9697
	Exit Only	*Full Power*	*205*	*60*	12300	2.4	2.4	2.4	876	0.4	12.3	1.23	10775
										Savings:		**4.63**	**40585**

2. This worksheet is set up to calculate results for the specific bi-level scenario indicated only. Dimmed and full power hours in columns G through I must be manually updated per selection of location and access.

COMMERCIAL: Energy Advantage

The following documents how savings are calculated for the Energy Advantage projects within Amplify.

Each Energy Advantage application contains one or more Spaces, which represent different parts of a building affected by a project. Within each space the user selects the existing lighting equipment (e.g. base case) and the new lighting equipment (e.g. enhanced case) from the Amplify database, which has wattage values sourced from the product's specification. Baseline wattages are referenced from the current TRM commercial prescriptive lighting values. In addition, Amplify does allow for the possibility that each space may have its own unique operating schedule.

The Hours per Year (EFLH) value for each Space is calculated based on a user-entered start time and ed time for each day of the week, modified by a user-entered set of holidays during which times the building is assumed to be inactive. The EFLH value can vary for different measures within the same Energy Advantage application due to various operating schedules entered per space. In the case where a user does not enter values for hours of operation, the default value used is 2,274 hours, which is based on an operating schedule of 8 AM to 5 PM Monday through Friday, with eight holidays per year. The eight holidays assumed include:

- New Year's Day,
- Martin Luther King Day,
- President's Day,
- Memorial Day,
- Independence Day,
- Labor Day,
- Thanksgiving Day, and
- Christmas Day

It's important to note that the specific holidays don't matter since it is simply a quantity (# Holidays * Hours/Day) is used to adjust an annual total.

Formula:
EFLH = (Sum (Hours per Day of Week) * 52.142857) – ((Number of Holidays) * Average Operating Hours per Day)
*Default: EFLH = (9*5*52.142857) – (8*9) = 2,274.4 hours/year*

Where: Hours per Day of Week is evaluated for each day of the week and is equal to:
WHEN End Hours > Start Hours THEN End Hours - Start Hours
WHEN End Hours < Start Hours THEN End Hours - Start Hours + 24
WHEN End Hours = Start Hours THEN 24

COMMERCIAL: Anti-Sweat Heater Controls

MEASURE DETAILS

Description

Anti-sweat heater controls sense the relative humidity in the air outside of a refrigerated display case and reduces or shuts off the glass door and/or frame anti-sweat heaters based on dew point temperature. Heat generated by an ASH is also load on the display case refrigeration system. Thus, reduction in ASH duty cycle will also have an interactive effect on the refrigeration energy. As a result, compressor run time and energy consumption are reduced.

Program Criteria

1. Pre-notification before project begins.
2. Controls must be installed on all doors of the refrigerator or freezer.
3. The following situations DO NOT qualify for this incentive:
   a. New refrigerators and freezers
   b. Refrigerators and freezers with existing controls being replaced with new controls
   c. Walk-in refrigerators and freezers manufactured after January 1, 2009
4. The rebate is awarded based on the total linear feet of the doors controlled by Anti-Sweat Heater Controls and incentivized at a rate of $40 per linear foot.

Unit of Measure

Linear feet

Baseline Equipment

No anti-sweat controls installed.

High Efficiency Equipment

Anti-sweat control installed.

ALGORITHMS

annual Peak kW savings from ASH per door	=SVG_d,ash * W_b,door/1000 * CF
annual kWh savings from ASH	=SVG_d,ash * W_b,door/1000 * HRS_ash
annual kW savings from Compressor	=SVG_cooling / EER / 1000* CF
annual kWh savings from Compressor	=SVG_cooling / EER / 1000 * HRS_comp

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
SVG_d,ash	ASH demand savings factor	50%	-	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf

SVG_d,comp	Compressor demand savings factor	17.5%	-	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
SVG_cooling	=BaseWatts/door*SVG_d_Comp	-	W	
Watt_b,door	Baseline door heater power	200.00	W	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
Btu_b,door	Baseline door heater power (3.413 Btu/h per W)	682.6	Btu/hr	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
EER	Compressor energy efficiency ratio	5.43	Btu/hr/W	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
HRS_ash	Hours of base ASH operation per	8760	hrs	
HRS_comp	Compressor run time	5700	hrs	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
RH_avg	Typical Store relative humidity	45%	-	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf
CF	Coincidence factor	0.85	-	
Measure Life	Expected duration of savings	12	yrs	SDG&E Statewide Express Efficiency Program - https://www.sdge.com/sites/default/files/regulatory/Express%20and%20SBS%20Workpapers.pdf

SAVINGS

Annual Peak kW savings from ASH	0.085	kW
Annual kWh savings from ASH	876	kWh
SVG_cooling	119.455	Btu/hr/door
Annual Peak kW savings from Compressor	0.0187	kW
Annual kWh savings from Compressor	125.395	kWh

Total Cooling Savings:	119.455	Btu/hr/door
Total Peak Power Savings:	0.104	kW/door
Total Annual Energy Savings:	1001.39	kWh/door
Per Linear Foot calculation:		
Door width	35	inches
	12	inches per ft
Bottom door length	2.92	feet
Peak kW savings per linear foot	0.036	kW/ft
Annual kWh savings per linear foot	343.34	kWh/ft

Measure Name	Peak Demand Savings	Annual Energy Savings
ASH Control	0.036 kW	343.34 kWh

COMMERCIAL: Vending Miser

MEASURE DETAILS

Description
Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.

Program Criteria
Vending machine must be refrigerated and/or employ an active lamp.

Unit of Measure
One control unit

Baseline Equipment
The baseline efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

High Efficiency Equipment
The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

ALGORITHMS

$$\Delta E = P * HRS * SVG$$
$$\Delta P = \Delta E / HRS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
P	Rate power of connected equipment	Table	kW	
HRS	Annual operating hours	8760	hrs	24 hrs/day, 7 days/wk
SVG	Savings fact for connected equipment	Table	%	
Measure Life	Expected duration of savings	8	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Refrigerated beverage vending maching (cans or bottles)	0.184 kW	1612 kWh
Refrigerated	0.124 kW	1086 kWh
Non-refrigerated snack vending machine	0.044 kW	387 kWh
All (Average)	0.117 kW	1028 kWh

COMMERCIAL: Water Cooler Timer

MEASURE DETAILS

Description
Similar to the timers you might use to control lights in your home, plug-in appliance timers allow you to pre-program the times that various appliances in your business are turned on and drawing electricity. So you could pre-program the water cooler so it turns on one hour before the office opens and turns off again after everyone leaves.

Program Criteria
Timers must be digital, include an internal rechargeable battery, and 7 day programmable on/off settings.

Unit of Measure
One timer unit

Baseline Equipment
No timer

High Efficiency Equipment
Timer installed

ALGORITHMS

	Energy Usage	
Type of Water Cooler	Cold Only (kWh/day)	Hot/Cold (kWh/day)
ENERGY STAR	0.16	1.20
Conventional	0.29	2.19

Hours per Day	24
Days per year	365

Base Case Usage	Cold Only	Hot/Cold
ENERGY STAR USAGE (kWh/year)	58	438
Conventional (kWh/year)	106	799

Enhanced Case Usage	Cold Only	Hot/Cold
ENERGY STAR USAGE (kWh/year)	21	157
Conventional (kWh/year)	38	287

Energy Savings	Cold Only	Hot/Cold
ENERGY STAR USAGE (kWh/year)	37	281
Conventional (kWh/year)	68	512

Average Savings (kWh/year)	**53**	**397**

SAVINGS

It is assumed that half of all water coolers are Energy Star and half are not:

- 50% Energy Star
- 50% Conventional

It is assumed that half of all water coolers are cold only and half are hot + cold dispenser:

- 50% Cold Only
- 50% Hot + Cold

The energy savings figure will be based on the average of the above-mentioned percentages.

Persistence Factor = 90%

Energy Savings = 225 x 90% = 202.5 kWh/year

Taking a conservative approach, the demand savings will based on the following calculation and methodology:
Demand Savings = 225 kWh/year divided by 8760 hrs/year = 0.026 kW
Coincidence Factor = 75%

Note: Based on utilization of 3 of the 4 peak hours (6PM-9PM). 5PM-6PM is not counted since most offices close at 5PM and the timer should be set to turn off cooler 1 hour after office closes which is 6PM.

Coincidence Demand Savings = 0.026 kW x .75 = 0.020 kW
Persistence = 90% (10% of people will disconnect)

Peak Demand Savings = 0.020 kW x .90 = 0.018 kW

Measure Name	Peak Demand Savings	Annual Energy Savings
Water Cooler Timer	0.018 kW	202.50 kWh

COMMERCIAL: Case Night Cover

MEASURE DETAILS

Description
Installation of night covers on existing, open-type refrigerated display cases to reduce extra cooling load caused by infiltration and radiation.

Program Criteria
Project pre-approval required.

Unit of Measure
Linear foot of cooler space

Baseline Equipment
The baseline efficiency case is the annual operation of open-display cooler cases

High Efficiency Equipment
The high-efficiency case is the use of night covers to protect the exposed areas of display cooler cases during unoccupied store hours.

ALGORITHMS

peak kW savings/ft = 0*
annual kWh savings/ft = SVG_kW * HRS

* Assumes covers are used during off peak hours--midnight to 6 am

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
SVG_kW	Reduced power use of refrigerated display case	Table 1	-	Original factors from Southern Cal Edison 1997 paper
HRS	Hours per year that cases are covered	2407	hrs	8760 minus (average of 45 Hawai'i supermarkets open hours)
Measure Life	Expected duration of savings	5	yrs	DEER 2014

Table 1. Power Savings Factor for Refrigerated Cases	kW/ft[1]
Low Temp (less than 0 F)	0.03
Medium Temp (0F to 30 F)	0.02
High Temp (35 F to 55 F)	0.01
Average	**0.02**

Source: Pennsylvania Technical Reference Manual, Errata Update February 2017, p.403,
http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

[1] Google search of refrigerated display cases yields a range of typical sizes--4', 5', 6', 6.5', 8'.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Case Night Cover	0.000 kW/ft	48.14 kWh/ft

COMMERCIAL: VFD Booster Pump

MEASURE DETAILS

Description

The purpose of this measure is to reduce energy consumption through more efficient domestic water booster systems by installing a VFD and/or reducing pump HP. Pump improvements can be done to optimize the design and control of water pumping systems.

Program Criteria

• Booster Pump applications require pre-notification before equipment is purchased and installed.

• The new Booster Pump System's total horsepower must be equal to or less than that of the existing system.

• The system horsepower reduction must be between 0 to 129 hp. For projects with greater than 129hp, please contact the program. Booster Pump applications do not apply to New Construction.

Unit of Measure

One pump

Baseline Equipment

Assumed to be a non-optimized existing pumping system. Baseline pumps are assumed to run 60% of the time.

High Efficiency Equipment

Assumed to be an optimized pumping system meeting applicable program efficiency requirements. The proposed Booster Pump System must be a more efficient design than the existing system. (i.e. Installed with VFD.). All pump motors must meet NEMA Premium Efficiency standards. As in the base case, enhanced pumps are assumed to run 60% of the time. Savings result from two aspects: (1) reduced horsepower and (2) reduced speed on the motor due to VFD. VFD load reduction is assumed to be 15% conservatively.

ALGORITHMS

annual Peak kW savings per reduced HP = (0.746 kW / 1 hp) / η_pump * CF

annual kWh savings per reduced HP = (0.746 kW / 1 hp) / η_pump * LF * HRS

annual kW savings from VFD per HP = (0.746 kW / 1 hp) / η_pump * CF * SVG_vfd

annual kWh savings from VFD per HP = (0.746 kW / 1 hp) / η_pump * LF * HRS * SVG_vfd

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
η_pump	Efficiency of the pump system	100%	-	The PY2015 Hawaii TRM makes
LF	Loading factor--% of time pump actually operates	60%	-	
SVG_vfd	VFD savings factor, % power reduction	15%	-	

HRS	Operating hours	8760	hrs	24 hrs/day, 7 days/wk
Constant	Conversion from HP to kW	0.746	kW/HP	
CF	Savings fact for connected equipment	50%	-	
Measure Life	Expected duration of savings	15	yrs	

SAVINGS

Source of Savings	Peak Demand Savings	Annual Energy Savings
HP Reduction	0.373 kW/hp	3920.98 kWh/hp
VFD Installation	0.056 kW/hp	588.15 kWh/hp

Notes: The PY2015 TRM indicated that 2012 EM&V review comments recommended claiming 500-700 kWh per hp from VFDs. Otherwise, "The energy and demand impacts are based on HECO's evaluation from past projects and monitoring" (Hawaii Energy Technical Reference Manual PY2015, p.124)

COMMERCIAL: Electronically Commutated Motor

MEASURE DETAILS

Description
Electronically Commutated Motor is a fractional horsepower DC motor often used in commercial refrigeration, replacing shaded pole motor. Typical motor size 10-140 W. ECM also used in fan coil units.

Program Criteria
1. New Construction projects and Retrofits from standard efficiency shaded pole motors to ECM in fan coil units (FCUs) are eligible
2. All ECMs replacing standard efficient shaded pole motors installed in existing refrigeration cases up to 1 HP in size may qualify for an incentive
3. ECM must be coupled with integrated controllers

Unit of Measure
One ECM motor

Baseline Equipment
4-pole (1800 RPM) demand of 107 W

High Efficiency Equipment
High efficiency DC/EC demand of 54 W

ALGORITHMS

peak kW savings per W	= (kW_bs - kW_ee)	refrigeration
annual kWh savings per W	= (kWh_bs - kWh_ee)	refrigeration
peak kW savings per motor	= (kW_bs - kW_ee) * CF	fan coil
annual kWh savings per motor	= (kW_bs - kW_ee) * HRS	fan coil

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
kW_bs	Demand of existing motor technology	Table	kW	The PY2015 Hawaii TRM makes
kW_ee	Demand of new electronically commutated motor	Table	kW	
kWh_bs	Energy use of existing motor technology	Table	kWh	
kWh_ee	Energy use of new electronically commutated motor	Table	kWh	24 hrs/day, 7 days/wk
HRS	Annual operating hours	4380	hrs	
CF	Savings fact for connected equipment	0.5	-	
Measure Life	Expected duration of savings	15	yrs	

Table 1: Approved ECM- Values

Technology	kW_bs [1]	kW_ee	kWh_bs	kWh_ee

Shaded Pole motor for refrigeration	0.002	N/A	18.0	N/A
ECM motor for refrigeration	N/A	0.001	N/A	8.7
Baseline motor on AHU fan	0.107	N/A	N/A	N/A
ECM motor on AHU fan	N/A	0.054	N/A	N/A

Source: Hawai'i Energy Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp.130-135

Notes: 1. For ECM in refrigeration, demand (W) and energy consumption values (kWh) are expressed per rated W. Presumably, this means for every rated W of ECM motor, an equivalent Shaded Pole motor draws 2 W.
For ECM in a fan coil unit, demand(W) and energy consumption (kWh) values are gross for an assumed motor.

SAVINGS

Table 2: Demand and Energy Savings for ECM motors

Measure Name	Peak Demand Savings	Annual Energy Savings
ECM motor-refrigeration [2]	0.001 kW	9.30 kWh
ECM motor on AHU fan	0.027 kW	232.14 kWh

Notes: 2. Refrigeration ECM values are savings per rated motor W

COMMERCIAL: Premium Efficiency Motor

MEASURE DETAILS

Description

This measure relates to the installation of premium efficiency three phase Open Drip Proof (ODP) and Totally Enclosed Fan-Cooled (TEFC) motors less than or equal to 200 HP, meeting minimum qualifying efficiency for the following HVAC applications: supply fans, return fans, exhaust fans, chilled water pumps, and boiler feed water pumps.

Program Criteria

- Incentives apply to both ODP and TEFC enclosures with 1200 RPM, 1800 RPM or 3600 RPM motors.
- Motors must meet minimum efficiency requirements as shown in the Table below.
- Motors greater than 200 hp will be given consideration under the Hawaii Energy Customized Program.
- If motors are not listed, submit manufacturer specifications, motor curve and performance data to Hawaii Energy for consideration

Unit of Measure

Per horse power

Baseline Equipment

2007 EISA nominal efficiency (as defined in NEMA MG1 Table 12-12) motors.

High Efficiency Equipment

The qualified efficiency table includes motors that are 1-200 hp NEMA Design A/B, 460 volts, TEFC or ODP, and 1200rpm, 1800 rpm, or 3600 rpm.

ALGORITHMS

peak kW savings per HP = $kW_{\_perHP}$ * **[(**1 / $\eta_{\_base}$**) - (**1 / $\eta_{\_ee}$**)]**

annual kWh savings per HP = $kW_{\_perHP}$ * **[(**1 / $\eta_{\_base}$**) - (**1 / $\eta_{\_ee}$**)]** * LF * HRS

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$kW_{\_perHP}$	kW equivalent of 1 horse power	0.746	kW/HP	
$\eta_{\_base}$	Efficiency of baseline motor	81.7%	-	EISA 2007, avg 1 HP
$\eta_{\_ee}$	Efficiency of energy efficient motor	84.3%	-	HE requirement, avg 1 HP
LF	Loading factor--% of time pump actually operates	75%	-	Hawaii Energy PY15 TRM
HRS	Annual operating hours	2190	hrs	Hawaii Energy PY15 TRM, 6 hours
Measure Life	Expected duration of savings	15	yrs	

Table 1: Qualifying Motor Efficiency Table

Motor Size (hp)	3600 RPM (2-pole)		1800 RPM (4-pole)		1200 RPM (6-pole)	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	80.0	84.0	86.4	87.5	83.8	84.0
1.5	86.5	87.5	87.3	88.5	87.5	89.2
2	86.5	88.5	87.3	88.5	88.5	90.1
7.5	90.2	91.7	91.7	93.0	91.7	92.4
10	91.7	91.7	92.3	93.0	92.4	92.4
15	91.6	92.4	93.6	93.6	92.4	93.0
20	92.4	93.0	93.6	94.1	93.0	93.0
25	93.0	93.6	94.1	94.5	93.6	94.1
30	92.4	93.6	94.6	94.5	94.1	94.1
40	93.6	94.1	94.5	95.0	94.5	95.0
50	94.1	94.5	95.0	95.4	94.5	95.0
60	94.5	95.0	95.4	95.8	95.0	95.4
75	95.0	95.4	95.4	95.8	95.4	95.4
100	95.4	95.4	95.8	96.2	95.4	95.8
125	95.4	95.8	95.8	96.2	95.8	95.8
150	95.8	96.2	96.2	96.5	95.8	96.2
200	95.8	96.2	96.2	96.8	95.8	96.2

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Premium Efficiency Motor	0.028 kW/hp	46.46 kWh/hp

COMMERCIAL: VFD Pool Pump

MEASURE DETAILS

Description
Variable frequency drive and control installed on single speed, commercial pool pump motor of equivalent horsepower.

Program Criteria
Pre-approval required. Pumps greater than 3 hp in size may be handled as a custom measure.

Unit of Measure
One pump

Baseline Equipment
The baseline efficiency case is a single speed pump.

High Efficiency Equipment
The high efficiency case is a 2-speed or variable speed pump.

ALGORITHMS

peak kW savings per pump hp = 1 hp*0.746 kW/hp/eff*CF*SVG_d
annual kWh savings per pump hp = 1 hp*0.746 kW/hp/eff*HRS*SVG_e

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
eff	motor efficiency	0.8	-	
SVG_d	demand savings factor, %	0.1	-	
SVG_e	energy savings factor, %	0.55	-	
CF	coincidence factor, % time savings correspond with utility peak.	1	-	
HRS	hours of pump operation per year	2190	hrs	6 hours per day, 365 days
Measure Life	expected duration of energy savings	15	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
VFD Pool Pump	0.090 kW/hp	1123.20 kWh/hp

COMMERCIAL: Condominium Submetering

MEASURE DETAILS

Description

This program is to assist master-metered condominiums and their Association of Apartment Owners (AOAO) efforts to reduce energy consumption and implement the current submetering proposal as one that will insure both equity and fairness in allocating energy costs as well as encouraging energy conservation through direct feedback of personal energy use to tenants.
The combination of billing submeters, along with education, peer group comparisons and special equipment offerings, will assist the tenant achieve significant energy conservation and efficiency.

Program Criteria

The manufacturer's submetering system model type to be installed (meter and CTs) must have been tested by an independent third party that is Nationally Rated Testing Laboratory certified for ANSI C12.1. The certification documentation must be provided to the Program prior to installation. Additionally, manufacturers must have a factory-quality compliance procedure in place to ensure meter accuracy. Documentation of this procedure must be available to the Program upon request. The submeter must be UL, CSA or ETL listed (Electrical Safety).

Requirements:

• The metering system must remain in place and billing to occur for a period of at least five (5) years or a pro-rated portion of the incentive will be recovered by Hawaii Energy. Provide Hawaii Energy with energy meter data for analysis purposes.
• A joint educational and monitoring program will be undertaken with AOAO to assist in the verification of savings and development of an ongoing energy incentive offering for other condominiums in Hawaii.

Unit of Measure

Per tenant unit

Baseline Equipment

The base case is no submetering. Baseline Annual Energy Usage is the actual average usage (kWh/year) based on historical usage for past 24 months (or as appropriate) for entire condominium (master metered) divided by the number of condominium units. Baseline demand (kW) is the Average Historical Demand divided by the number of condominium units.

Building Types	Demand Baseline (kW)	Energy Baseline (kWh/year)
Condominium	1.42	7,200

High Efficiency Equipment

The high efficiency case is with submetering. It is expected there will be a 10% reduction in energy usage and 8% reduction in peak demand during (5PM – 9PM).

Building Types	Efficient Case (kW)	Efficient Case (kWh/year)

Condominium	1.30	6,480

ALGORITHMS

Building Types	Gross Customer Savings (kW)	Gross Customer Savings (kWh/year)
Condominium	0.113	720

Operational Factor	Adjustment Factor
Persistence Factor (pf)	1.00
Demand Coincidence Factor (cf)	1.00

Building Types	Net Customer Savings (kW)	Net Customer Savings (kWh/year)
Condominium	0.113	720

SAVINGS

Example Savings Calculation:

Submetering (Condominium)

Average Master Meter Energy Usage (kWh/month)		180,000	kWh per month
Number of tenant Units	÷	300	Units
Average Tenant Energy Usage (Example)		600	kWh per home per month
	x	12	month per year
Baseline Annual Household Energy Usage		7,200	kWh per Year
Average Master Meter Demand (kW)		425	
Number of tenant Units	÷	300	
Baseline Demand (kW)		1.42	kW
Energy Reduction		10.0%	
Actively Informed Household Energy Usage		6,480	kWh per Year
Baseline Annual Household Energy Usage		7,200	kWh per Year
Actively Informed Household Energy Usage	-	6,480	kWh per Year
Gross Customer Level Energy Savings		720	kwh per Year
Gross Customer Level Energy Savings		720	kwh per Year
Persistance Factor	x	1.0	
Net Customer Level Savings		720	kwh per Year

Submetering Energy Savings		720	kWh / Year Savings	
Baseline Household Demand		1.42	kW	HECO 2008 Load Study
Peak Demand Reduction		8.00%		
Actively Informed Household Demand		1.30	kW	
Baseline Household Demand		1.42	kW	
Actively Informed Household Demand	-	1.30	kW	
Gross Customer Demand Savings		0.113	kW	
Gross Customer Demand Savings		0.113	kW	
Persistance Factor	x	1.0		
Coincidence Factor	x	1.0		
		0.113	kW	
Condominium Sub-Metering Demand Savings		0.113	kW Savings	

COMMERCIAL: Small Business Submetering

MEASURE DETAILS

Description

This program is to assist master-metered small businesses to reduce energy consumption that will insure both equity and fairness in allocating energy costs as well as encouraging energy conservation through direct feedback of personal energy use to business tenants.

The combination of billing submeters, along with education, peer group comparisons and special equipment offerings, will assist the tenant achieve significant energy conservation and efficiency.

Program Criteria

The manufacturer´s submetering system model type to be installed (meter and CTs) must have been tested by an independent third party that is Nationally Rated Testing Laboratory certified for ANSI C12.1. The certification documentation must be provided to the Program prior to installation. Additionally, manufacturers must have a factory-quality compliance procedure in place to ensure meter accuracy. Documentation of this procedure must be available to the Program upon request. The submeter must be UL, CSA or ETL listed (Electrical Safety).

Requirements:

• The metering system must remain in place and billing to occur for a period of at least five (5) years or a pro-rated portion of the incentive will be recovered by Hawaii Energy. Provide Hawaii Energy with energy meter data for analysis purposes.

• A joint educational and monitoring program will be undertaken with the businesses to assist in the verification of savings and development of an ongoing energy incentive offering for other condominiums in Hawaii.

Unit of Measure

Baseline Equipment

The base case is no submetering.

Building Types	Demand Baseline (kW)	Energy Baseline (kWh/year)
Small Business	3.00	10,800

High Efficiency Equipment

The high efficiency case is with submetering.

Building Types	Efficient Case (kW)	Efficient Case (kWh/year)
Small Business	2.76	9,720

ALGORITHMS

Building Type	Demand Savings (kW)	Annual Energy Savings (kWh/year)
Small Business	0.24	1080

Operational Factor	Adjustment Factor
Persistence Factor (PF)	1
Coincidence Factor (CF)	1

SAVINGS

Example Savings Calculation:

Small Business Submetering

Average Tenant Energy Usage		900	kWh per business per month (Schedule G)
	x	12	
Baseline Business Energy Usage		10,800	kWh per Year
Energy Reduction		10.0%	
Actively Informed Business Energy Usage		9,720	kWh per Year
Baseline Business Energy Usage		10,800	kWh per Year
Actively Informed Business Energy Usage	-	9,720	kWh per Year
Gross Customer Level Energy Savings		1,080	kwh per Year
	x	1,000	Watts per kW
	÷	8,760	Hours per Year
Average 24/7 Demand Reduction		123	Watts
Gross Customer Level Energy Savings		1,080	kwh per Year
Persistance Factor	x	1.0	
Net Customer Level Savings		1,080	kwh per Year
Submetering Energy Savings		1,080	kWh / Year Savings
Baseline Business Demand		3.00	kW
Peak Demand Reduction		8.00%	
Actively Informed Business Demand		2.76	kW
Baseline Business Demand		3.00	kW
Actively Informed Business Demand	-	2.76	kW
Gross Customer Demand Savings		0.240	kW
Gross Customer Demand Savings		0.240	kW
Persistance Factor	x	1.00	
Coincidence Factor	x	1.00	
		0.240	kW
Small Business Demand Savings		0.24	kW Savings

COMMERCIAL: Solar Water Heater

MEASURE DETAILS

Description
The installation of a heat pump water heater in place of a standard electric water heater or existing less efficient heat pump water heater.

Program Criteria
Must comply with Solar Rating and Certification Corporation (SRCC) standards.

Unit of Measure
Solar kW

Baseline Equipment
Baseline usage is a 0.9 COP Electric Resistance Water Heater or heat pump with a COP of 3.5.
The baseline water heater energy consumption is by a single 4.0 kW electric resistance element that is

High Efficiency Equipment
Solar water heater

ALGORITHMS

peak kW demand removed = Avg_kW(existing)*CF
annual kWh displaced = System_Cap*365 days*(1-Derate%)*Perform%/3412 BTU/kWh/COP

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
System_Cap	total rated output capacity of panel array, BTU/day, determined by rated output capacity of panel * number of panels	user input	BTU	
Derate%	percent adjustment to rated output for array tilt and orientation, where Tilt Derate+Orientation Derate=Derate%	see table 1	-	
Perform%	remaining capacity after accounting for impacts to performance (e.g. shading)	user input	-	
COP	efficiency of existing water heating system	see table 2	-	
Avg_kW (existing)	average demand of existing electric water heater	user input	kW	derived from engineering calculations or measured data
CF	coincidence factor, % time equipment load corresponds with utility peak load	user input	-	heat pump water heater assumes 8% CF
Measure Life	expected duration of energy savings	20	yrs	

Table 1: Derate Adjustment (%) due to Tilt and Orientation

Orientation (° to true North)	Orientation Derate %	Collector Tilt (degrees)	Tilt Derate %
0-89	prohibited	0-13	prohibited
90-105	0.25	14-40	0.000
105-115	0.10	40-45	0.050
115-125	0.05	45-50	0.100
125-225	0.00	50-55	0.150
225-235	0.05	55-60	0.200
235-245	0.10	60.0	0.250
245-255	0.15	>60	prohibited
255-270	0.20		
271-360	prohibited		

Source: Current Hawaii Energy Solar Hot Water Incentive Worksheet

Table 2: COP of Existing Water System

Water Heater Type	COP
Electric Resistance W.H.	0.90
Electric Heat Pump W.H.	3.50

SAVINGS

Example: *350,000 BTU/day rated output at 90 degree orientation and 20 degree tilt; existing electric resistance water heater at 2 kW average load.*

peak kW reduced	0.160
annual kWh displaced	31201.15

COMMERCIAL: Re/Retro-commissioning

MEASURE DETAILS

Description

Hawaii Energy incentivizes the actions of building owners to evaluate the effectiveness and efficiency of current building systems to optimize performance.

These actions will be documented in a Commissioning Report that shall include:

- Executive summary of all activities included in the commissioning process.
- Introduction section, including names and contact information for the Building Owner, Building Manager, RCx Trade Ally.
- Detailed building and energy systems description, including estimates of the equipment usage
- Detailed operational scheduling of the major systems.
- Detailed report of all optimization measures identified.
- Cost estimate, energy savings estimate and simple payback for all recommended operational actions, sequencing, and equipment enhancements.
- Pre- and post-data logging.
- Testing and Balancing (TAB) of HVAC system.
- Functional testing of the EMS, if equipped.
- Detailed operations and maintenance review.
- Documentation of O&M refresher training for facility staff.
- Assessment of existing equipment over-sizing and recommendations for right-sizing when HVAC equipment needs replacement, including, but not limited to recommended capital items.

Program Criteria

Program pre-approval is required prior to the start of any energy consumption analysis. Projects can be whole building or by system if determined cost-effective by Hawaii Energy.

Eligible program participants must:

- Own or operate a high energy usage facility that has at least 50,000 square feet of conditioned space or that consumes at least 1,000,000 kWh/year.
- Receive electric service from Hawaiian Electric Companies (e.g., HECO, MECO or HELCO) and pay a Hawaii public benefits fund surcharge on their electric bill.
- For retro-commissioning, building has been in service for at least 2 years and has never been commissioned before. For recommissioning, it has been at least 5 years since the last commissioning activity.
- Be willing to commit up to 100% of the incentive value to implement energy conservation measures (ECMs) found to have a 2- year or less payback. Any implemented ECMs are eligible for Hawaii Energy's prescriptive and custom incentives.
- Grant Hawaii Energy access to their facility's billing data and other required data to establish an initial benchmark rating via ENERGY STAR Portfolio Manager®.
- Grant Hawaii Energy access to the facility itself for on-going program assessment, monitoring and measurement purposes.
- Be willing to invest facility management time, typically between 8-16 hours, to support multiple site visits and data requests from the RCx consultant.
- Perform at least two weeks of metering of all major building systems prior to the implementation of any ECMs and at least two weeks of post metering. The cost of "pre" and "post" metering may be included in the total project cost by the commissioning agent. The metering plan shall be included in the proposal.

- The participant's commissioning specialist shall be certified by a nationally recognized building commissioning organization such as the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), AABC Commissioning Group (ACG), Building Commissioning Association (BCA), National Environmental Balancing Bureau (NEBB) or similar organization acceptable to Hawaii Energy.
- If participant wishes to use a non-certified contractor to perform the Retro-Commissioning or Enhanced Commissioning project, an exception may be granted at Hawaii Energy's sole discretion if:
  1. The proposed contractor provides evidence of having completed similar commissioning projects for two or more buildings of at least 50,000 square feet (conditioned space) each, and
  2. 2. The proposed contractor submits at least two verifiable and satisfactory references from customers or clients who used the contractor to complete the similar projects.
- All retro-commissioning work performed (to include, but not limited to, documentation and reporting) must follow guidelines recommended by an approved commissioning organization. The commissioning specialist must indicate in their report the organization's guidelines which were followed for the retro-commissioning process.
- The cost of replacement of major end use items may be included in the total project cost from the commissioning agent. Cost of routine maintenance activities identified by the commissioning agent shall not be included in the total project.

Unit of Measure

Any kWh and kW savings brought about by and verified by the retro-commissioning study, such as process optimization, schedule or set-point changes, and routine maintenance.

Baseline Equipment

Pre-commissioning operating procedures.

High Efficiency Equipment

Post-commissioning operating procedures.

ALGORITHMS

(Custom)

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Re|Retro-Commissioning	Custom	Custom

RESIDENTIAL: Air Purifier

MEASURE DETAILS

Description
Energy efficient domestic room air purifier.

Program Criteria
Air purifier must be ENERGY STAR certified.

Unit of Measure
One air purifier

Baseline Equipment
Non-ENERGY STAR air purifier

High Efficiency Equipment
ENERGY STAR certified air purifier

ALGORITHMS

$$\Delta kW_{.peak} = \{CAP * [(1 / \eta_{.bs}) - (1 / \eta_{.he})]\} / 1000 * CF$$

$$\Delta kWh_{.annual} = \{HRS * CAP * [(1 / \eta_{.bs}) - (1 / \eta_{.he})] + (8760 - HRS) * (P_{.stdby,bs} - P_{.stdby,he})\} / 1000$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
CAP	Capacity	100	CADR	
$\eta_{.bs}$	Baseline efficiency rating	1.0	CADR/W	ENERGY STAR: EPA research on available models, 2011.
$\eta_{.he}$	High efficiency rating	3.0	CADR/W	ENERGY STAR: EPA research on available models, 2011.
$P_{.stdby,bs}$	Baseline standby power	1.0	W	
$P_{.stdby,he}$	High efficiency standby power	0.6	W	
CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	67%	-	16 hrs/day
HRS	Equipment annual operating hours	5840	hrs/yr	16 hrs/day, 365 days/year
Constant	Watt/Kilowatts conversion.	1000	W/kW	
Measure Life	Expected duration of energy savings	9	yrs	Appliance Magazine: Portrait of the U.S. Appliance Industry, 1998.

SAVINGS

	Baseline	Enhanced	
Operating power	0.100	0.033	kW
Operating energy	584.00	194.67	kWh/yr
Standby energy	2.92	1.75	kWh/yr
Total energy	586.92	196.42	kWh/yr

Measure Name	Peak Demand Savings	Annual Energy Savings
Room Air Purifier	0.045 kW	390.50 kWh

RESIDENTIAL: Clothes Washer

MEASURE DETAILS

Description
Energy Efficient Clothes Washer

Program Criteria
ENERGY STAR certified

Unit of Measure
One washer

Baseline Equipment
Clothes washer meeting minimum federal requirements as of March 2015.

High Efficiency Equipment
Three tiers of efficient equipment:
1) Energy Star or CEE Tier 1 certified
2) Energy Star Most Efficient, or CEE Tier 2 certified
3) CEE Tier 3 certified

ALGORITHMS

$$\Delta E = [(CAP * (1 / IMEF\_base) * CYCLES) * (\%E\_wash,base + (\%E\_heat,base * \%HEATER\_electric) + (\%E\_dry,base * \%DRYER\_electric))] - [(CAP * (1 / IMEF\_he) * CYCLES) * (\%E\_wash,he + (\%E\_heat,he * \%HEATER\_electric) + (\%E\_dry,he * \%DRYER\_electric))]$$

$$\Delta P = (\Delta E / HRS) * CF$$

$$\Delta E\_lifetime = \Delta E * (Measure\ Life)$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Tier 1	Tier 2	Tier 3	Unit	Notes
CAP	Average clothes washer capacity in ft3	3.45	3.45	3.45	ft^3	Based on analysis of all models meeting federal minimum standards in NEEP Mid-Atlantic TRM V6
IMEF_base	Integrated Modified Energy Factor of baseline unit	1.66	1.66	1.66	-	Based on analysis of all models meeting federal minimum standards in NEEP Mid-Atlantic TRM V6

IMEF_he	Integrated Modified Energy Factor of efficient unit	2.26	2.74	2.92	-	Minimum qualifying IMEF for various efficiency tiers; weighted average based on the relative number of front-loading vs. top-loading washers available in each tier. See NEEP Mid-Atlantic TRM V6.
CYCLES	Average number of washer cycles per washer per year	313	313	313	-	NEEA Dryer Field Study, 2014 (Table 45)[1]
%E_wash,base	Percentage of total energy consumption for clothes washer operation for a baseline model	8%	8%	8%	%	Based on analysis of all models meeting federal minimum standard in NEEP Mid-Atlantic TRM V6
%E_heat,base	Percentage of total energy consumption for water heating for a baseline model	31%	31%	31%	%	Based on analysis of all models meeting federal minimum standard in NEEP Mid-Atlantic TRM V6
%E_dry,base	Percentage of total energy consumption for clothes drying for a baseline model	61%	61%	61%	%	Based on analysis of all models meeting federal minimum standard in NEEP Mid-Atlantic TRM V6
%E_wash,he	Percentage of total energy consumption for clothes washer operation for efficient unit	8%	14%	14%	%	Based on analysis of all models meeting requirements for each tier in NEEP Mid-Atlantic TRM V6
%E_heat,he	Percentage of total energy consumption for water heating for efficient unit	23%	10%	10%	%	Based on analysis of all models meeting requirements for each tier in NEEP Mid-Atlantic TRM V6
%E_dry,he	Percentage of total energy consumption for clothes drying for efficient unit	69%	76%	76%	%	Based on analysis of all models meeting requirements for each tier in NEEP Mid-Atlantic TRM V6
%DRYER_electric	Percentage of dryers assumed to be electric	81%	81%	81%	%	Based on Evergreen Baseline Study (2014) on percentage of homes with secondary fuel sources (Figure 22)

%HEATER_electric	Percentage of water heating assumed to be electric	50%	50%	50%	%	Based on Evergreen Baseline Study (2014) on percentage of homes with electric water heaters (scaled down to account for likelihood that homes with electric water heating use less hot water than those with solar or gas water heating due to smaller home and household size)
HRS	Average number of run hours per washer per year	297	297	297	hrs	57 minutes/cycle based on NEEA Dryer Field Study, 2014[1]
CF	Coincidence Factor	5.7%	5.7%	5.7%	%	
Measure Life	Expected duration of savings	11	11	11	yrs	ENERGY STAR Market & Industry Scoping Report, 2011[3]

[1] https://www.neea.org/docs/default-source/reports/neea-clothes-dryer-field-study.pdf

[2] https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Clothes Washer Tier 1	0.022 kW	114.07 kWh
Clothes Washer Tier 2	0.030 kW	156.80 kWh
Clothes Washer Tier 3	0.034 kW	176.37 kWh

RESIDENTIAL: Clothes Dryer

MEASURE DETAILS

Description
Energy efficient clothes dryer as specified below replacing a baseline clothes dryer.

Program Criteria
ENERGY STAR certified

Unit of Measure
One dryer

Baseline Equipment
Clothes dryer meeting minimum federal requirements (blended average of pre-1/1/15 and post-1/1/15 federal standards).

High Efficiency Equipment
ENERGY STAR certified electric clothes dryer ≥ 4.4 ft3

ALGORITHMS

$$\Delta E = [(LOAD / CEF\_base) - (LOAD / CEF\_he)] * CYCLES$$
$$\Delta P = (\Delta E / HRS) * CF$$
$$\Delta E\_lifetime = \Delta E * (Measure\ Life)$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
LOAD	Average total weight (lbs) of clothes per drying cycle	8.45	lbs	Based on ENERGY STAR product criteria testing.[1]
CEF_base	Combined Energy Factor (lbs/kWh) of the baseline unit	3.15	-	Blended average of early replacement (80%) and replace on burnout (20%) baselines, using federal minimum CEF. From 1994-2014, minimum CEF was 3.01 (early replacement baseline). Since 2015, minimum CEF has been 3.73 (replace on burnout baseline).
CEF_he	Combined Energy Factor (lbs/kWh) of the efficient unit	3.93	-	Based on ENERGY STAR product criteria testing.
CYCLES	Average number of dryer cycles per	311	-	NEEA Dryer Field Study, 2014.[2]

HRS	Average run hours per dryer per year	290	hrs	56 minutes/cycle based on NEEA Dryer Field Study, 2014.[2]
CF	Coincidence factor	5.7%	-	Based on analysis of clothes dryer load shape curve from DOE PNNL study. See Tab 2 for calculation.[3]
Measure Life	Expected duration of savings	14	yrs	ENERGY STAR Market & Industry Scoping Report, 2011.[4]

[1] https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

[2] https://www.neea.org/docs/default-source/reports/neea-clothes-dryer-field-study.pdf

[3] http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20110.pdf

[4] https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Clothes Dryer	0.033 kW	165.58 kWh

RESIDENTIAL: Refrigerator

MEASURE DETAILS

Description
ENERGY STAR certified refrigerator as specified below replacing a non-ENERGY STAR refrigerator and turning in the existing refrigerator to be recycled. Also, turn-in only refrigerators rebate available.

Program Criteria
ENERGY STAR certified

Unit of Measure
One refrigerator

Baseline Equipment
Non-ENERGY STAR refrigerator

High Efficiency Equipment
ENERGY STAR certified refrigerator

ALGORITHMS

$$\Delta E\_replace = E\_base - E\_he$$
$$\Delta E\_replace\&turn\ in = (E\_base - E\_he) + 717$$
$$\Delta P\_replace = (E\_base - E\_he) / HRS$$
$$\Delta P\_replace\&turn\ in = (E\_base - E\_he + 717) / HRS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
E_base	Energy usage of baseline refrigerator	540	kWh	
E_he	Energy usage of efficient refrigerator	435	kWh	
HRS	Annual operating hours	8760	hrs	
DC	Duty cycle of compressor	70	%	Assumed to be 70%
PF	Persistance factor	100%	-	
CF	Coincidence factor	100%	-	
Measure Life	Expected duration of savings	14	yrs	

Energy Savings Opportunities for Program Sponsors

Opportunity	Annual Savings			
	Per Unit		Aggregate U.S. Potential	
	kWh	$	MWh	$ million
1. Increase the number of buyers that				

purchase ENERGY STAR qualified refrigerators. • 9.3 million units were sold in 2008. • 70 percent were not ENERGY STAR. • 6.5 million potential units per year could be upgraded.	105	11.64	675,928	75
2. Decrease the number of units kept on the grid when new units are purchased. • 8.7 million primary units were replaced in 2008. • 44 percent remained in use, whether they were converted to second units, sold, or given away. • 3.8 million units are candidates for retirement every year.	717	79.53	2,746,062	305
3. Decrease the number of second units. • 26 percent of households had a second refrigerator in 2008. • 29.6 million units are candidates for retirement.	859	95.28	25,442,156	2,822
4. Replace pre-1993 units with new ENERGY STAR qualified models. • 19 percent of all units in use in 2008 were manufactured before 1993. • 27.3 million total potential units are candidates for targeted replacement.	730	81	19,946,440	2,212

Sources: See endnote 10.

Energy and Cost Comparison for Upgrading to ENERGY STAR

Purchase Decision	New Non-ENERGY STAR Qualified Refrigerator	New ENERGY STAR Qualified Refrigerator
Annual Consumption	540 kWh	435 kWh
	$60	$48
Annual Savings	–	105 kWh
	–	$12
Average Lifetime	12 years	12 years
Lifetime Savings	–	1,260 kWh
	–	$140
Price Premium	–	$30 - $100
Simple Payback Period	–	3-9 years

Note: Calculations based on shipment-weighted average annual energy consumption of 2008 models. An ENERGY STAR qualified model uses 20 percent less energy than a new non-qualified refrigerator of the same size and configuration.

Source: See endnote 10.

Energy and Cost Comparison for Removing a Second Refrigerator from the Grid

Fate of Unit	Post-1993 Unit		Pre-1993 Unit	
	Remains on the Grid	Removed from the Grid	Remains on the Grid	Removed from the Grid
Annual Consumption	640 kWh	–	1,131 kWh	–
	$71	–	$125	–
Annual Savings	–	640 kWh	–	1,131 kWh
	–	$71	–	$125
Average Lifetime*	6	–	6	–
Lifetime Savings*	–	3,840 kWh	–	6,788 kWh
		$426		$752

	–	$426	–	$753
Removal Cost	–	$50 - $100	–	$50 - $100
Simple Payback Period	–	1-2 years	–	<1 year

*Assumes unit has six years of functionality remaining.

Sources: See endnote 10.

SAVINGS

New Non-ENERGY STAR Refrigerator		540		Table 4.1.1.f
New ENERGY STAR Refrigerator	-	435		Table 4.1.1.f
		105	kWh/yr	Table 4.1.1.e

#1 - Purchase of ENERGY STAR Refrigerator		105		Table 4.1.1.e
#2 - Removal of old unit from service (off the grid)	+	717		Table 4.1.1.e
#1+#2 = Purchase ES and recycle old unit		822	kWh/yr	

	Energy Use	Ratio	Contribution		
Post-1993 Refrigerator	640	55.4%	354.54		Table 4.1.1.g
Pre-1993 Refrigerator	1131	44.6%	+ 504.46		Table 4.1.1.g
			859.00	kWh/yr	

Measure Name	Peak Demand Savings	Annual Energy Savings
ES Refrigerator w/ turn-in	0.134 kW	822.00 kWh
Turn-in only	0.140 kW	859.00 kWh
ES Refrigerator w/o turn-in	0.017 kW	105.00 kWh

RESIDENTIAL: Television

MEASURE DETAILS

Description
ENERGY STAR V7.0 televisions. This measure is for a midstream incentive to retailers to stock, promote, and sell televisions which meet or exceed ENERGY STAR Version 7.0.

Program Criteria
ENERGY STAR certified

Unit of Measure
One television

Baseline Equipment
Non-ENERGY STAR 7.0 cetified television

High Efficiency Equipment
ENERGY STAR 7.0 certified television

ALGORITHMS

peak kW savings per TV = [(Watts_base -Watts_ee) /1000] x *CF*
annual kWh savings per TV = (Watts_base -Watts_ee) /1000 x HOURS_Active x 365

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
Watts_base	Baseline connected Watts (active)	User Input	W	Baseline power consumption is drawn from ENERGY STAR "Consumer Electronics Calculator" [1]
Watts_ee	Energy efficient connected Watts (active)	User Input	W	ENERGY STAR V7.0 Program Requirements. [2]
CF	Demand Coincidence Factor	0.22	-	Based on Efficiency Vermont TRM, 2015 for coincident usage between 5-7PM.
HRS_Active	Average hours of use per day in Active Mode	5	hrs	Average television active power reported in ENERGY STAR "Consumer Electronics Calculator".

Measure Life	Expected duration of energy savings	6	yrs	Average television lifetime estimated in ENERGY STAR "Consumer Electronics Calculator" referencing Appliance Magazine, Portrait of the U.S. Appliance Industry 2000.

Note: 1. https://www.energystar.gov/sites/default/files/asset/document/Consumer_Electronics_Calculator.xlsx
2. https://www.energystar.gov/sites/default/files/FINAL%20Version%207.0%20Television%20Program%20Requirements%20%28Dec-2014%29.pdf

Non-4K

Screen size		Max Power			Demand Savings		TEC			Energy Savings	
(in)		(W)			(kW)		(kWh/yr)			(kWh/yr)	
Min	Max	Base	ES7	ME16	ES7	ME16	Base	ES7	ME16	ES7	ME 16
40	45	54	37	27	0.017	0.027	99	68	50	31	49
45	50	69	45	33	0.024	0.036	126	82	61	44	65
50	55	74	52	38	0.022	0.036	135	95	70	40	65
55	60	87	57	42	0.030	0.045	159	104	77	55	82
60	80	88	66	49	0.022	0.039	161	120	89	40	71
Average		74	51	38	0.023	0.036	136	94	69	42	66

4K

Screen size		Max Power			Demand Savings		TEC			Energy Savings	
(in)		(W)			(kW)		(kWh/yr)			(kWh/yr)	
Min	Max	Base	ES7	ME16	ES7	ME16	Base	ES7	ME16	ES7	ESME 16
40	45	81	37	27	0.044	0.054	148	68	50	80	98
45	50	104	45	33	0.059	0.070	189	82	61	107	128
50	55	111	52	38	0.059	0.073	203	95	70	108	132
55	60	131	57	42	0.074	0.088	238	104	77	134	161
60	80	132	66	49	0.066	0.083	241	120	89	120	152
Average		112	51	38	0.060	0.074	204	94	69	109.8	134

Non-4k	40%	0.0092	Non-4k	40%	16.80
4k	60%	0.036	4k	60%	65.88
	CF	0.220		ΔkWh	82.68
	ΔkW	0.00994			

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Television	0.010 kW	82.68 kWh

RESIDENTIAL: Soundbar

MEASURE DETAILS

Description
This measure is for a midstream incentive to retailers to stock, promote, and sell soundbars which meet or exceed ENERGY STAR Version 3.0.

Program Criteria
ENERGY STAR certified

Unit of Measure
One soundbar

Baseline Equipment
Non-ENERGY STAR v3.0 cetified soundbar

High Efficiency Equipment
ENERGY STAR v3.0 certified soundbar

ALGORITHMS

Peak kW Savings/Soundbar = PF x [(Watts$_{_bs,active}$ - Watts$_{_ee,active}$) /1000] x CF

Annual kWh Savings/Soundbar = PF x {[(Watts$_{_bs,active}$ - Watts$_{_ee,active}$) * HRS$_{_active}$] + [Watts$_{_bs,idle}$ - Watts$_{_ee,idle}$) * HRS$_{_idle}$] + [Watts$_{_bs,sleep}$ - Watts$_{_ee,sleep}$) * HRS$_{_sleep}$]}/1000

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
Watts$_{_bs,active}$	Baseline Watts (active)	30	W	Fraunhofer Center for Sustainable Energy Systems. 2014.[1]
Watts$_{_bs,idle}$	Baseline Watts (idle)	12	W	
Watt$_{_bs,sleep}$	Baseline Watts (sleep)	4	W	
Watt$_{_ee,active}$	Energy efficient watts (active)	20.2	W	Energy Solutions Report on RPP - Citing EPA Internal Analysis of Energy Star V2.0 Soundbars.[2]
Watt$_{_ee,idle}$	Energy efficient watts (idle)	3.5	W	
Watt$_{_ee,sleep}$	Energy efficient watts (sleep)	0.5	W	
HRS$_{_active}$	Hours per year in active mode	1580.0	hrs	Fraunhofer Center for Sustainable Energy Systems. 2014.[3]
HRS$_{_idle}$	Hours per year in idle mode	730.0	hrs	
HRS$_{_sleep}$	Hours per year in sleep mode	6450.0	hrs	

CF	Coincidence factor	0.220	-	Assuming same CF as Televisions. Based on Efficiency Vermont TRM, 2015 for coincident usage between 5-7PM.
PF	Persistence factor	100%	-	
Measure Life	Expected duration of energy savings (years)	7	yrs	Energy Star Assumption - Via NEEP Mid-Atlantic TRM Version 6

Note: 1.https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf
2.https://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556d387fe4b0d8dc09b24c28/1433221247215/RPP+Methodology+for+Developing+UEC+Estimates_Final.pdf
3.https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Soundbar	0.002 kW	44.26 kWh

RESIDENTIAL: Window AC

MEASURE DETAILS

Description

The early removal of an existing inefficient room window air conditioning unit from service and replacement with a new ENERGY STAR qualifying unit, or the addition of a high efficiency unit.

Program Criteria

Older, inefficient unit must still be functional.

Unit of Measure

One window AC unit

Baseline Equipment

Existing inefficient 8500 Btu/hr room air conditioning unit at 9.8 EER, or a new unit built after 2014 with minimum federal standard 10.9 CEER.

High Efficiency Equipment

New 8500 Btu/hr room air conditioning unit with 11.4 CEER.

ALGORITHMS

$$\Delta kW_{.peak} = [CAP * (1 / (C)EER_{.bs} - 1 / CEER_{.he})] / 1000 * PF * CF$$

$$\Delta kWh_{.annual} = [CAP * (1 / (C)EER_{.bs} - 1 / CEER_{.he})] / 1000 * PF * HRS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$(C)EER_{.bs}$	Baseline rated efficiency.	See table 1	BTU/hr/W	
$CEER_{.he}$	Proposed measure rated efficiency.	See table 1	BTU/hr/W	
CF	Coincidence factor	0.5	-	Deemed; 50% VRFs operational between 5-9 pm
HRS	Equivalent full load cooling hours	1825	hrs	Deemed; 5 hrs per day cooling
CAP	Cooling capacity of window AC unit	8500	BTU/hr	Average size of window AC units rebated in PY15.
PF	Persistence factor	1	-	
Constant	Watt/Kilowatt conversion.	1000	W/kW	
Measure Life	Expected duration of energy savings	9	yrs	

Table 1: Residential HVAC program efficiencies

Unit Type	$(C)EER_{.bs}$ [1]	$CEER_{.he}$ [2]
Window AC with recycling	9.8	11.4

Window AC without recycling	10.9	11.4

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, p.35-36.

Note: 1. Window AC "with recycling" EER from 2000 federal standard; "without recycling" CEER from 2014 federal standard.
2. Window AC minimum efficiency criteria set at ENERGY STAR standard for louvered sides without reverse cycle. Refer to ENERGY STAR Program Requirements for Room Air Conditioner v4.0.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Window AC w/ recycling	0.061 kW	222.16 kWh
Window AC w/o recycling	0.017 kW	62.42 kWh

RESIDENTIAL: VRF Split

MEASURE DETAILS

Description

Inverter driven variable refrigerant flow (VRF) air conditioning systems are direct expansion AC systems that utilize variable speed evaporator/condenser fans, and a combination of fixed and variable speed compressors along with most often multiple individual zone evaporators to provide the ability to more closely match the AC system's output with the building's cooling requirements.

Program Criteria

SEER rating of 18.0 or higher.

Unit of Measure

A "small VRF" is defined as less than 2 tons of cooling capacity. A "large VRF" is 2 tons or more.

Baseline Equipment

Base case efficiency is 10.9 SEER.

High Efficiency Equipment

The high efficiency case is 18 SEER.

ALGORITHMS

VRF Splits < 2 Tons peak kW savings/ton = (12,000 BTU/hr capacity*[1/(S)EER_b-1/(S)EER_ee]*CF)/1000 W/kW*PF*PY15_small

VRF Splits < 2 annual kWh savings/ton = (12,000 BTU/hr capacity*[1/(S)EER_b-1/(S)EER_ee]*HOURS)/1000 W/kW*PF*PY15_small

VRF Splits >= 2 Tons peak kW savings/ton = (12,000 BTU/hr capacity*[1/(S)EER_b-1/(S)EER_ee]*CF)/1000 W/kW*PF*PY15_large

VRF Splits >= 2 annual kWh savings/ton = (12,000 BTU/hr capacity*[1/(S)EER_b-1/(S)EER_ee]*HOURS)/1000 W/kW*PF*PY15_large

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
(S)EER_b	baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment.	See table 1	BTU/hr/W	Units less than 65,000 BTU/hr are rated in SEER rather than EER.
(S)EER_ee	proposed measure rated efficiency, BTU/hr-W.	See table 1	BTU/hr/W	Units less than 65,000 BTU/hr are rated in SEER rather than EER.
CF	coincidence factor, percent of time savings correspond with utility peak	0.5	-	Deemed value; 50% VRFs operational between 5-9 pm
HOURS	equivalent full load cooling hours	1825	hrs	Deemed value; 5 hrs per day cooling

ton	unit of equipment cooling capacity	12,000	BTU	
PY15_small	From a review of PY2015 rebates processed, the average size of a small unit	1.28	ton	
PY15_large	From a review of PY2015 rebates processed, the average size of a large unit	2.58	ton	
PF	Persistence factor	1	-	
Measure Life	Expected duration of energy savings	15	yrs	

Table 1: Residential HVAC program efficiencies

Unit Type	Unit Size, BTU/hr	average size (BTU/hr)[1]	(S)EER_b	(S)EER_ee[2]
VRF Split A/C	small (<2 tons)	15360	10.9	18.0
VRF Split A/C	large (2+ tons)	30960	10.9	18.0

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, p.35-36.

Note: 1. Average of PY2015 measures rebated in those categories.
2. Window a/c minimum efficiency criteria set at ENERGY STAR standard for louvered sides without reverse cycle.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
small (<2 tons)	0.278 kW	1014.41 kWh
large(2+ tons)	0.560 kW	2044.67 kWh

RESIDENTIAL: Central A/C Retrofit

MEASURE DETAILS

Description

Early removal of an existing inefficient central air conditioning unit from service, prior to its measure and natural end of life, and replacement with a higher efficient unit.

Program Criteria

Contact Hawai'i Energy's residential team for more information.

Unit of Measure

One unit

Baseline Equipment

Older inefficient central air conditioning unit

High Efficiency Equipment

New central air conditioning unit with higher Energy Efficiency Ratio

ALGORITHMS

$$\Delta E = HRS * CAP * [(1 / \eta\_base) - (1 / \eta\_he)] / 1000$$
$$\Delta P = CF * CAP * [(1 / \eta\_base) - (1 / \eta\_he)] / 1000$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
CAP	Cooling capacity	12000	BTU/hr	1 TON of cooling
η_base	Baseline Energy Efficiency Ratio	9.8	EER	
η_he	Energy efficient unit Energy Efficiency	13	EER	
HRS	Number of hours on low speed	2920	hrs	8 hrs/day, 365 days/yr
Constant	Conversion from W to kW	1000	-	
CF	Coincidence factor	75%	-	
Measure Life	Expected duration of savings	15	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
1-ton Central AC Retrofit	0.226 kW	880.13 kWh
3-ton Central AC Retrofit	0.678 kW	2640.38 kWh

RESIDENTIAL: Central A/C Tune Up

MEASURE DETAILS

Description
Maintenance of a residential central A/C system.

Program Criteria
Contact Hawai'i Energy's residential team for more information.

Unit of Measure
One tune up

Baseline Equipment
Pre-tune up central air conditioning unit

High Efficiency Equipment
Post-tune up central air conditioning unit

ALGORITHMS

$$\Delta E = [(CAP_{.avg} / \eta_{.avg}) * HRS * AF_{.op}] / 1000$$
$$\Delta P = (P_{.avg} * CF) - (P_{.avg} * CF * AF_{.rt})$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
$CAP_{.avg}$	Average AC unit cooling capacity	36000	BTU/hr	3 ton of cooling
$P_{.avg}$	Average AC unit power demand	2.77	kW	
$\eta_{.avg}$	Average AC unit EER	13	EER	
$AF_{.op}$	Adjustment factor for operational problems[1]	8%	-	
HRS	Annual hours of operation	1460	hrs	
$AF_{.rt}$	Adjustment factor for post tune-up run time[2]	92%	-	
Constant	Conversion from W to kW	1000	-	
CF	Coincidence factor	33%	-	
Measure Life	Expected duration of savings	1	yrs	

[1] Accounts for impacts to performance due to incorrect refrigerant charge, clogged AHU filter, dirty condenser coil.

[2] A reduction in run time will occur once tune up is completed, lowering coincidence factor.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Residential AC Tune Up	0.073 kW	323.45 kWh

RESIDENTIAL: Ceiling Fan

MEASURE DETAILS

Description

ENERGY STAR ceiling fan with high efficiency motor and CFL bulbs, replacing fan with standard efficiency motor and (three) integral incandescent bulbs.

Program Criteria

Ceiling fan must have an ENERGY STAR label and include lighting.

Unit of Measure

One unit

Baseline Equipment

Standard efficiency motor with three integral incandescent bulbs.

High Efficiency Equipment

ENERGY STAR high efficiency motor with CFL bulbs.

ALGORITHMS

peak kW savings/fan $= [(\%_{.low} * (Low_{.kW,base} - Low_{.kW,ee}) + \%_{.med} * (Med_{.kW,base} - Med_{.kW,ee}) + \%_{.high} * (High_{.kW,base} - High_{.kW,ee})) + ((Inc_{.kW} - CFL_{.kW}) * WHF_{.d})] * CF$

annual kWh savings/fan $= [(\%_{.low} * (Low_{.kW,base} - Low_{.kW,ee}) + \%_{.med} * (Med_{.kW,base} - Med_{.kW,ee}) + \%_{.high} * (High_{.kW,base} - High_{.kW,ee})) * HRS_{.fan} + ((Inc_{.kW} - CFL_{.kW}) * WHF_{.e}) * HRS_{.light}] * CF$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\%_{.low}$	percent of time on low speed	40%	-	
$\%_{.med}$	percent of time on medium speed	40%	-	
$\%_{.high}$	percent of time on high speed	20%	-	
$Low_{.kW,base}$	low speed baseline fan motor wattage	0.0152	kW	
$Low_{.kW,ee}$	low speed efficient fan motor wattage	0.0117	kW	0.008 kW per current ENERGY STAR criteria and min air flow setting
$Med_{.kW,base}$	medium speed baseline fan motor wattage	0.0348	kW	
$Med_{.kW,ee}$	medium speed efficient fan motor wattage	0.0314	kW	0.030 kW per current criteria and min air flow setting
$High_{.kW,base}$	high speed baseline fan motor wattage	0.0725	kW	

$High_{.kW,ee}$	high speed efficient fan motor wattage	0.0715	kW	0.067 kW per current criteria and min air flow setting
$Inc_{.kW}$	baseline wattage of 3 incandescent	0.129	kW	EISA baseline effective 2014
$CFL_{.kW}$	wattage of 3 efficient CFL bulbs	0.060	kW	
CF	Coincidence factor	11%	-	
$HRS_{.fan}$	Hours of fan operation per year	1022	hrs	2.8 hours per day, 365 days
$HRS_{.light}$	Hours of light operation per year	840	hrs	2.3 hours per day, 365 days
$WHF_{.d}$	Waste heat factor to account for cooling load savings from efficent lighting	1.21	-	
$WHF_{.e}$	Waste heat factor to account for cooling energy savings from efficent lighting	1.07	-	
Measure Life	expected duration of energy savings	5	yrs	

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, pp. 43

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Ceiling Fan	0.010 kW	65.01 kWh

RESIDENTIAL: Dehumidifier

MEASURE DETAILS

Description
The deployment of an energy efficient domestic dehumidifier.

Program Criteria
Dehumidifier must be ENERGY STAR certified.

Unit of Measure
One dehumidifier

Baseline Equipment
Non-ENERGY STAR dehumidifier

High Efficiency Equipment
ENERGY STAR certified dehumidier

ALGORITHMS

$$\Delta kW_{.peak} = [(CAP * 0.473) / 24] * (1 / \eta_{.bs} - 1 / \eta_{.he}) * CF$$
$$\Delta kWh_{.annual} = [(CAP * 0.473) / 24] * (1 / \eta_{.bs} - 1 / \eta_{.he}) * HRS$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
CAP	Capacity	See Table	pints/day	
$\eta_{.bs}$	Baseline efficiency rating	See Table	L/kWh	ENERGY STAR: EPA research on available models, 2011.
$\eta_{.he}$	High efficiency rating	See Table	L/kWh	ENERGY STAR: EPA research on available models, 2011.
CF	Coincidence factor, percent of time equipment load corresponds with utility peak.	36%	-	
HRS	Equipment annual operating hours	3185	hrs/yr	NREL: Measure Guideline: Supplemental Dehumidification in Warm-Humid Climates. Miami (Climate Zone 1) hours at 60% set point.
Constant	Liters/pints conversion	0.473	L/pt	
Measure Life	Expected duration of energy savings	12	yrs	ENERGY STAR: EPA Research, 2012.

SAVINGS

Capacity (pints/day)	Avg. Capacity [1] (pints/day)	ENERGY STAR Product % [2]	Baseline Efficiency [3] (≥ L/kWh)	Enhanced Efficiency [4] (≥ L/kWh)	Baseline kWh	Enhanced kWh	Savings kWh
≤25	25.00	0.55%	1.35	2	1,162.43	784.64	377.79

> 25 to ≤35	30.25	19.94%	1.35	2	1,406.54	949.41	457.12
> 35 to ≤45	44.47	5.26%	1.5	2	1,861.11	1,395.83	465.28
> 45 to ≤ 54	50.00	23.27%	1.6	2	1,961.60	1,569.28	392.32
> 54 to ≤ 75	68.78	39.89%	1.7	2	2,539.62	2,158.68	380.94
> 75 to ≤ 185	106.12	11.08%	2.5	2.8	2,664.46	2,378.98	285.48
Average	59.34		1.68	2.09	2,213.10	1,783.39	429.71

Notes: 1,2. Weighted average of capacities based on units listed in ENERGY STAR Certified Product List. Accessed 2018/09/21.

3. Federal minimum standard efficiency.

4. ENERGY STAR program critieria efficiency.

Measure Name	Peak Demand Savings	Annual Energy Savings
Dehumidifier	0.049 kW	429.71 kWh

RESIDENTIAL: Smart Thermostat

MEASURE DETAILS

Description
Thermostat controlling residential cooling loads during unoccupied and nighttime hours, replacing a manual thermostat serving a ducted central a/c system.

Program Criteria
Programmable thermostat with ENERGY STAR label

Unit of Measure
One thermostat

Baseline Equipment
Manual thermostat

High Efficiency Equipment
Programmable thermostat

ALGORITHMS

peak kW savings/thermostat = 0

annual kWh savings/thermostat = $[CAP_{.cool} / (1000\ W/kW)] * [1 / (SEER * EFF_{.duct})] * EFLH_{.cool} * ESF_{.cool}$

DEFINITIONS & ASSUMPTIONS				
Variable	**Description**	**Value**	**Unit**	**Notes**
$CAP_{.cool}$	Cooling capacity of a/c unit	36000	BTU/hr	
SEER	Seasonal Energy Efficiency Ratio	11.9	BTU/hr/W	
$EFF_{.duct}$	Duct system efficiency	0.8	-	
$ESF_{.cool}$	Energy savings factor for cooling	0.02	-	
PF	Persistence factor	1	-	
$EFLH_{.cool}$ [1]	Equivalent full load cooling hours	1825	hrs	
CF [1]	Coincidence factor	0.5	-	
Measure Life	Expected duration of savings	11	yrs	

Source: Pennsylvania 2016 Technical Reference Manual, p.79.

Note: 1. Values assumed for Residential HVAC measure by Hawaii Energy .

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Smart Thermostat	0.000 kW	138.03 kWh

RESIDENTIAL: Solar Attic Fan

MEASURE DETAILS

Description
Solar-powered attic fan assumed to reduce 10% of existing air conditioning load (non-peak) and energy usage.

Program Criteria
Contact Hawai'i Energy's residential team for more information.

Unit of Measure
One unit

Baseline Equipment
No attic fan.

High Efficiency Equipment
Solar-powered attic fan in air-conditioned home

ALGORITHMS

peak kW savings/fan = $AC_{.cap}$ / 1000 * (1 / EER) * $\%_{.svgs,ac}$ * PF * CF
annual kWh savings/fan = $AC_{.cap}$ / 1000 * (1 / EER) * EFLH * $\%_{.svgs,ac}$ * PF

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\%_{.svgs,ac}$	Percentage of a/c load savings from solar attic fan	10%	-	
$AC_{.cap}$	Cooling capacity of existing air conditioner	8500	BTU	Average of PY14 window A/C units incentivized by Hawaii Energy
EER	Full load cooling efficiency of existing air conditioner	9.8	BTU/hr/kW	
EFLH	Equivalent full load cooling hours for existing air conditioner	1825	hrs	
CF	Coincidence factor	0.000	-	
PF	Persistence factor	100%	-	
Measure Life	Expected duration of energy savings	20	yrs	

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, pp. 46

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings

Solar Attic Fan	0.000 kW	158.29 kWh

RESIDENTIAL: Whole-House Fan

MEASURE DETAILS

Description
A fan that pulls hot air from the living space and exhausts through attic and roof or ductwork.

Program Criteria
Contact Hawai'i Energy's residential team for more information.

Unit of Measure
One fan.

Baseline Equipment
No fan installed.

High Efficiency Equipment
Fan installed.

ALGORITHMS

peak kW savings/fan = $AC_{.cap}$ / 1000 * (1 / EER) * $\%_{.svgs,ac}$ * PF * CF
annual kWh savings/fan = $AC_{.cap}$ / 1000 * (1 / EER) * EFLH * $\%_{.svgs,ac}$ * PF

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$\%_{.svgs,ac}$	Percent of a/c load savings from solar attic fan	20%	-	KEMA-Xenergy, Inc.[1]
$AC_{.cap}$	Cooling capacity of existing air conditioner	8500	BTU	Average of PY14 window A/C units incentivized by Hawaii Energy
EER	Full load cooling efficiency of existing air conditioner	9.8	BTU/hr/kW	
EFLH	Equivalent full load cooling hours for existing air conditioner	1825	hrs	
CF	Coincidence factor	0.590	-	
PF	Persistence factor	1	-	
Measure Life	Expected duration of energy savings	20	yrs	

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, pp. 49-50

Note: 1. KEMA-Xenergy, Inc. Impact Evaluation of the 2001 Statewide Low Income Energy Efficiency (LIEE) Program. April 8, 2003. calmac.org/publications/2001_LIEE_Impact_Evaluation.pdf

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Whole House Fan	0.102 kW	316.58 kWh

RESIDENTIAL: LED

MEASURE DETAILS

Description
The replacement of a standard incandescent lamp or spiral compact fluorescent lamp with a light emitting diode in both Residential Single Family and Multi-family homes. Lamps must comply with Energy Star and UL.

Program Criteria
ENERGY STAR label

Unit of Measure
One lamp

Baseline Equipment
Breakdown of CFL vs incandescent is based on a burn-out ratio of 9000 hours to 2000 hours. In 9000 hours, 4.5 incandescents will burn out and 1 CFL will burn out, for a total of 5.5 burnt-out bulbs. This equates to a replacement rate of 81.8% incandescents and 18.2% CFLs. Within each category of incandescents or CFLs, the breakdown of wattages is based on actual Hawaii Energy Program statistics.

High Efficiency Equipment
The high efficiency case is a mixture of 5.5 W, 7.6 W, 12.6 W, and 17.1 W LED bulbs. These wattages, as well as the percentage breakdown of wattages, is based on actual Hawaii Energy Program statistics.

ALGORITHMS

peak kW savings/lamp = $(kW_{.base} - kW_{.LED}) * CF * PF$
annual kWh savings/lamp = $(kW_{.base} - kW_{.LED}) * HRS * PF$
annual kWh savings/lamp, military = $[kW_{.base} - (kW_{.LED} * 1.50)] * HRS * PF$

DEFINITIONS & ASSUMPTIONS				
Variable	**Description**	**Value**	**Unit**	**Notes**
$kW_{.base}$	Baseline wattage of average incandescent bulb	See Table 1	kW	
$kW_{.LED}$	Wattage of average CFL bulb	See Table 2	kW	
CF	Coincidence factor	0.12	-	
PF	Persistence factor	0.96	-	Informed by 2012 EM&V report
HRS	Hours of lamp operation per year	See Table 1	hrs	
Measure Life	Expected duration of energy savings	15	yrs	

Table 1. Baseline Lamp Characteristics

Lamp Types	Demand Baseline 2007-2020 (kW.b07)	Demand Baseline post-2020 (kW.b20)	Hours per Day, non-military	Hours per Day, military	HE Penetration Rate	Total kWh_07, non-military	Total kWh_07, military	Total kWh_20, non-military	Total kWh_20, military
Incandescent non-specialty	0.072	0.023	2.3	3.45	2.40%	1.45	2.18	0.46	0.70
Incandescent non-specialty	0.053	0.018	2.3	3.45	26.50%	11.79	17.69	4.00	6.01
Incandescent non-specialty	0.043	0.015	2.3	3.45	24.70%	8.92	13.37	3.11	4.67
Incandescent non-specialty	0.029	0.009	2.3	3.45	28.20%	6.87	10.30	2.13	3.20
Decorative / globe; 650-1300 lumens	0.072	0.072	2.3	3.45					
Decorative / globe; 575-649 lumens	0.053	0.053	2.3	3.45					
Decorative / globe; 500-574 lumens	0.043	0.043	2.3	3.45					
Decorative / globe; 300-499 lumens	0.029	0.029	2.3	3.45					
Decorative / globe; 150-349 lumens	0.025	0.025	2.3	3.45					
Decorative / globe; 90-149 lumens	0.015	0.015	2.3	3.45					
Decorative / globe; <90 lumens	0.010	0.010	2.3	3.45					
CFL	0.026	0.026	2.3	3.45	0.50%	0.11	0.16	0.11	0.16
CFL	0.023	0.023	2.3	3.45	5.90%	1.14	1.71	1.14	1.71
CFL	0.014	0.014	2.3	3.45	5.50%	0.65	0.97	0.65	0.97
CFL	0.013	0.013	2.3	3.45	6.30%	0.69	1.03	0.69	1.03
Total Average Baseline Energy (kWh)						**31.61**	**47.41**	**12.29**	**18.44**
Total Average Demand (kW)						**0.038**		**0.015**	

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, p.32

Note: Baseline kW assumptions reflect federal minimum standards for general use and specialty bulbs imposed by the Energy Independence and Security Act (EISA) for 2007 and 2020, as summarized in the 2016 Pennsylvania Technical Reference Manual (puc.pa.gov).

Table 2. Efficient Lamp Characteristics

Demand Baseline (kW.LED)	Hours per Day, non-military	Hours per Day, military	HE Penetration %	Total kWh, non-military	Total kWh, military
0.0171	2.3	3.5	8%	1.15	1.72
0.0126	2.3	3.5	29%	3.07	4.60
0.0076	2.3	3.5	57%	3.64	5.46
0.0055	2.3	3.5	6%	0.28	0.42
Total Average Energy (kWh)				**8.13**	**12.19**
Total Average Demand (kW)				**0.01**	

SAVINGS

	2007-2020	Post-2020
Average peak kW savings/lamp	**0.003**	**0.001**
Average annual kWh savings/lamp, non-military	**22.54**	**3.99**
Average annual kWh savings/lamp, military	**33.81**	**5.99**

Measure Name	Peak Demand Savings	Annual Energy Savings
LED (non-military)	0.003 kW	22.54 kWh
LED (military)	0.003 kW	33.81 kWh

RESIDENTIAL: Lighting Occupancy Sensor

MEASURE DETAILS

Description

This measure is for wall switch sensors that controls the use of lighting in areas around the home with variable use such as laundry, storage, garage, bedrooms or spare areas.

Program Criteria

This measure is for wall switch sensors that controls the use of lighting in areas around the home with variable use such as laundry, storage, garage, bedrooms or spare areas. Occupancy sensors must comply with Energy Star and UL Listing.

Unit of Measure

One unit

Baseline Equipment

The base case is assumed to be two light bulbs (one 60-W incandescent and one 15-W CFL) in operation 2.3 hours per day.

High Efficiency Equipment

The enhanced case is assumed to be the same two bulbs in operation with 33% reduction in run time.

ALGORITHMS

ΔE = KW*HRS_b*365 - KW*HRS_e*365

ΔP = no demand reduction

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	0	kW	
KW	Total power demand, 2 bulbs	0.075	kW	sum 60 watt + 15 watt
$HRS_{.base}$	Hours per day, baseline	2.30	hrs	
$HRS_{.ee}$	Hours per day, enhanced	1.54	hrs	67% * 2.3 hrs/day; 33% runtime reduction
CF	Coincidence factor	12%	-	
Measure Life	Expected duration of savings	8	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Residential Light Occupancy Sensor	0.000 kW	20.78 kWh

RESIDENTIAL: Advanced Power Strips

MEASURE DETAILS

Description
Load sensing advanced power strips. This measure involves the purchase and installation of a new Tier 1 or Tier 2 load sensing advanced power strip in place of a power strip with no automated power shutoff function.

Program Criteria
Tier 1 or Tier 2 qualified power strip with automated power shutoff capability

Unit of Measure
One power strip

Baseline Equipment
Code-compliant or standard efficiency power strip.

High Efficiency Equipment
Tier 1: The high efficiency equipment is an advanced power strip. If the exact number of plugs in the strip is unknown, savings is based on a 6-plug strip, as shown below. If the exact number of plugs in the strip is known, such as part of the Hawaii Energy online kit promotions, then the respective savings value may be used based on the actual size of the advanced power strip.

Tier 2: Savings is based on an IR-OS Tier 2 APS product.

ALGORITHMS

peak kW savings/smart strip = $[(KWH_{.plug} * NUM_{.plug}) / HRS] * CF * PF$
annual kWh savings/smart strip = $KWH_{.plug} * NUM_{.plug} * PF$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$KWH_{.plug}$	Average deemed kWh per receptacle ("outlet") on the strip	See Table 1	kWh	
$NUM_{.plug}$	Number of plug outlets per power strip	6	-	Average of 5 and 7-plug strips
PF	Persistence factor	80%	-	Hawai'i Energy estimate
HOURS	Annual hours of equipment operation	8760	hrs	assumes no manual shutoff of equipment
CF	Coincidence factor	100%	-	% of maximum hourly watt savings on average that were realized from 5-9 pm for residential A/V equipment (see Valmiki and Corradini).
Measure Life	Expected duration of energy savings	5	yrs	

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015. Measure Savings Calculations, pp. 55 for Measure Life, PF, #plugs

Table 1. Deemed Savings Values for Advanced Power Strips

	Tier 1-5 plug[1]	Tier 1-7 plug[1]	Tier 2- 8 plug[2]	Average Tier 1
kWh/unit savings	56.50	102.80	149.00	79.65
Number of plugs/unit	5	7	6	6
Calculated kWh/plug savings	11.30	14.69	24.83	12.99

Note: 1. Refer to "Akamai Power Strips" unit savings calculations noted in the PY2015 Hawaii TRM, citing "NYSERDA Measure Characterization for Advanced Power Strips". The original source for these values cannot be identified, although NYSERDA's 2011 "Advanced Power Strips Research Report" is available on their website https://www.nyserda.ny.gov/Residents-and-Homeowners/Your-Home/Power-Management.
2. Values are derived from Valmiki and Corradini, 2015.

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Tier 1	0.007 kW	62.37 kWh
Tier 2	0.014 kW	119.20 kWh

SOURCES

Evergreen Economics. Baseline Energy Appliance,Equipment and Building Characteristics Study Report.
Valmiki, M. and A. Corradini. Tier 2 Advanced Power Strips in Residential and Commercial Applications. San Diego Gas & Electric Emerging Technologies Program, Technology Assessment Report. April 2015. The test APS used in the study is shown with 6 controlled receptacles.

RESIDENTIAL: Switch Plug

MEASURE DETAILS

Description
A power switch that acts as the interface between the wall outlet and the appliance. It prevents phantom energy drain by disconnecting the attached appliance without having to remove the power cord.

Program Criteria

Unit of Measure
One switch

Baseline Equipment
No switch installed

High Efficiency Equipment
Switch plug installed

ALGORITHMS

peak kW savings = $(W_{.stby} * CF) / 1000$

annual kWh savings = $kWh_{.stby}$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$W_{.stby}$	Standby power draw of attached load	3.073	W	Determined based on probability of attached equipment type. [1]
$kWh_{.stby}$	Annual standby energy consumption of attached load	26.85	kWh	Determined based on probability of attached equipment type. [1]
Constant	Conversion constant	1000	W/kW	
CF	Coincidence factor	83%	-	New Mexico TRM
Measure Life (Y	Expected duration of savings	5	yrs	

Note: 1. Based on data from Lawrence Berkeley National Laboratory: Low-Power Mode Energy Consumption in California Homes, 2008. See accompanying Power Switch Calculation (R_PlugProcess_Power Switch_CALC).

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Switch Plug	0.003 kW	26.85 kWh

RESIDENTIAL: VFD Pool Pump

MEASURE DETAILS

Description

A variable speed residential pool pump motor in place of a standard single speed motor of equivalent horsepower.

Program Criteria

New construction homes do not qualify.

Unit of Measure

One unit

Baseline Equipment

The baseline efficiency equipment is assumed to be a single speed residential pool pump.

High Efficiency Equipment

The high efficiency equipment is a variable speed residential pool pump.

ALGORITHMS

$$\Delta E = KW_{.base} * SVG_{.e} * HRS$$
$$\Delta P = KW_{.base} * SVG_{.d} * CF$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
$KW_{.base}$	Power demand of baseline equipment	0.7	kW	
$SVG_{.e}$	Saving factor for energy reduction	55%	-	
$SVG_{.d}$	Saving factor for demand reduction	90%	-	
HRS	Annual hours of operation	1551.25	hrs	4.25 hrs/day, 365 days/yr
CF	Coincidence factor	0.95%	-	
Measure Life	Expected duration of savings	10	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Res. VFD Pool Pump	0.006 kW	597.23 kWh

RESIDENTIAL: Heat Pump Water Heater

MEASURE DETAILS

Description
The installation of a heat pump water heater in place of a standard electric water heater.

Program Criteria
Rebate applications for water heaters are provided by the retailers at the time of purchase or a customer can visit our website and download the form. Rebate applications must include an original purchase receipt showing brand and model number.

Unit of Measure
One unit

Baseline Equipment
The base case is a standard electric resistance water heater (SERWH), COP 0.90.

High Efficiency Equipment
The high efficiency case is the installation of a heat pump water heater, COP 2.26.

ALGORITHMS

(see below)

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
P_base	Power demand of baseline equipment	0.7	kW	
SVG_e	Saving factor for energy reduction	55%	-	
SVG_d	Saving factor for demand reduction	90%	-	
HRS	Annual hours of operation	1551.25	hrs	4.25 hrs/day, 365 days/yr
CF	Coincidence factor	14.3%	-	8.6 min/hr for 4 hours
Measure Life	Expected duration of savings	10	yrs	

Energy per Day (BTU) = (Gallons per Day) x (lbs. per Gal.) x (Temp Rise) x (Energy to Raise Water Temp)

Hot Water needed per Person		13.3	gallons / day / person	HE
Average Occupants	x	3.77	persons	KEMA 2008
Household Hot Water Usage		50.1	gallons / day	
Mass of Water Conversion		8.34	lbs / gallon	
Finish Temperature of Water		130	deg. F Finish Temp	

Initial Temperature of Water	-	75	deg. F Initial Temp	
Temperature Rise		55	deg. F Temperature Rise	
Energy to Raise Water Temp		1.0	BTU / deg. F / lbs.	
Energy per Day (BTU) Needed in Tank		23,000	BTU / day	

Energy per Day (BTU) Needed in Tank		23,000	BTU / day	
BTU to kWh Energy Conversion	÷	3,412	BTU / kWh	
Energy per Day		6.74	kWh / day	
Days per Month	x	30.4	days / month	
Energy per Month		204.92	kWh / month	
Months per Year	x	12	months	
Energy Needed to Heat Water per Year		2,459.05	kWh / year	
Elec. Res. Water Heater Efficiency	÷	0.90	COP	
Base SERWH Energy Usage per Year		2,732.28	kWh / Year	KEMA 2008 - HECO
Energy Needed to Heat Water per Year		2,459.05	kWh / year	
Heat Pump Water Heater Efficiency	÷	2.26	COP	
Heat Pump Energy Usage per Year		1,088.08	kWh / Year	KEMA 2008 - HECO
Base SERWH Energy Usage per Year		2,732.28	kWh / Year	
Heat Pump Energy Usage per Year	-	1,088.08	kWh / Year	
Residential Heat Pump Energy Savings		1,644.20	kWh / Year	

Base SERWH Element Power Consumption		4.000	kW	
Coincidence Factor	x	0.143		8.6 minutes per hour
Base SERWH On Peak Demand		0.572	kW On Peak	KEMA 2008
Heat Pump Power Consumption		4.500	kW	
Coincidence Factor	x	0.080		4.8 minutes per hour
Heat Pump On Peak Demand		0.360	kW On Peak	
Base SERWH On Peak Demand		0.572	kW On Peak	
Heat Pump On Peak Demand	-	0.360	kW On Peak	
Residential Heat Pump Demand Savings		0.212	kW On Peak	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Heat Pump WH	0.212 kW	1644.20 kWh

RESIDENTIAL: Solar Water Heater

MEASURE DETAILS

Description

Replacement of Electric Resistance Water Heater with a Solar Water Heater designed for a 90% Solar Fraction. The new Solar Water Heating systems most often include an upgrade of the hot water storage tank sized at 80 or 120 gallons.

Program Criteria

Rebate applications for water heaters are provided by the retailers at the time of purchase or a customer can visit our website and download the form. Rebate applications must include an original purchase receipt showing brand and model number. New construction single-family homes do not qualify.

Unit of Measure

One unit

Baseline Equipment

Baseline usage is a 0.9 COP Electric Resistance Water Heater. The baseline water heater energy consumption is by a single 4.0kW electric resistance element that is controlled thermostatically on/off controller based of tank finish temperature set point. The tank standby loss differences between baseline and high efficiency case are assumed to be negligible.

High Efficiency Equipment

Solar Water Heater designed for a 90% Solar Fraction. The Solar Systems use solar thermal energy to heat the water 90% of the time and continue to utilize electricity to operate the circulation pump and provide heating through a 4.0 kW electric resistance element when needed.

ALGORITHMS

(see below)

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
Perf_F	SWH system performance factor	94.0%	-	
PF	Persistence factor	93%	-	
HRS	Annual hours of equipment	8760	hrs	
CF	Coincidence factor	14.25%	-	
Measure Life	Expected duration of energy savings	20	yrs	

Energy per Day (BTU) = (Gallons per Day) x (lbs. per Gal.) x (Temp Rise) x (Energy to Raise Water Temp)

Hot Water needed per Person		13.3	gallons / day / person	HE
Average Occupants	x	3.77	persons	KEMA 2008

Household Hot Water Usage		50.1	gallons / day	
Mass of Water Conversion		8.34	lbs / gallon	
Finish Temperature of Water		130	deg. F Finish Temp	
Initial Temperature of Water	-	75	deg. F Initial Temp	
Temperature Rise		55	deg. F Temperature Rise	
Energy to Raise Water Temp		1.0	BTU / deg. F / lbs.	
Energy per Day (BTU) Needed in Tank		23,000	BTU / day	

Energy per Day (BTU) Needed in Tank		23,000	BTU / day	
BTU to kWh Energy Conversion	÷	3,412	BTU / kWh	
Energy per Day		6.74	kWh / day	
Days per Month	x	30.4	days / month	
Energy per Month		204.92	kWh / month	
Months per Year	x	12	months	
Energy Needed to Heat Water per Year		2,459.05	kWh / year	
Elec. Res. Water Heater Efficiency	÷	0.90	COP	
Base SERWH Energy Usage per Year		2,732.28	kWh / Year	KEMA 2008 - HECO
Design Annual Solar Fraction		90%	Water Heated by Solar System	
		10%	Water Heated by Remaining Backup Element	
Energy Usage per Year at the Meter		2,732.28	kWh / Year	
	x	10%	Water Heated by Remaining Backup Element	
Back Up Element Energy Used at Meter		273.23	kWh / Year	
Circulation Pump Demand		0.082	kW	KEMA 2008
Pump Hours of Operation	x	1,292	Hours per Year	KEMA 2008
Pump Energy Usage per Year		105.94	kWh / Year	
Back Up Element Energy Used at Meter		273.23	kWh / Year	72%
Pump Energy Usage per Year	+	105.94	kWh / Year	28%
Design Solar System Energy Usage		379.17	kWh / Year	
Base SERWH Energy Usage per Year		2,732.28	kWh / Year	
Design Solar System Energy Usage	-	379.17	kWh / Year	
Design Solar System Energy Savings		2,353.11	kWh / Year	
Design Solar System Energy Savings		2,353.11	kWh / Year	
Performance Factor		0.94		HE
Persistance Factor	x	0.93		KEMA 2008
		2,057.09	kWh / Year	KEMA 2008

Base SERWH Element Power Consumption		4.000	kW	
Coincidence Factor	x	0.143	cf	
Base SERWH On Peak Demand		0.570	kW On Peak	KEMA 2008
Base SERWH On Peak Demand		0.570	kW On Peak	
Solar System Metered on Peak Demand	-	0.110	kW On Peak	KEMA 2008
		0.460	kW On Peak	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Solar Water Heater	0.460 kW	2057.09 kWh

RESIDENTIAL: Solar Water Heater Tune Up

MEASURE DETAILS

Description
Tune-up residential solar water heating systems for optimum performance.

Program Criteria
Systems must be more than 3 years old and can only receive a tune-up incentive once every 5 years.

Unit of Measure
One system

Baseline Equipment
See Definitions & Assumptions

High Efficiency Equipment
See Definitions & Assumptions

ALGORITHMS

$\Delta E = E\_base - E\_op$
$\Delta P = P\_base - P\_op$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
E_base	kWh per Unit, group "All" [1]	577	kWh	
E_op	kWh per Unit, group "Operating" [1]	328	kWh	
P_base	On Peak Demand, group "All" [1]	0.079	kW	
P_op	On Peak Demand, group "Operating" [1]	0.05	kW	
Measure Life	Expected duration of savings	5	yrs	

[1] KEMA 2005-2007 Energy and Peak Demand Impact Evaluation Report

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Solar WH Tune Up	0.029 kW	249.00 kWh

RESIDENTIAL: Faucet Aerator

MEASURE DETAILS

Description
Efficient Low-Flow Aerators (bathroom and kitchen).

Program Criteria
Qualfied aerators are provided directly by Hawai'i Energy via online store or direct-install program.

Unit of Measure
One aerator

Baseline Equipment
2.2 GPM Aerator

High Efficiency Equipment
1.5 GPM Aerator

ALGORITHMS

annual kWh savings $= (gpm_{base} - gpm_{low}) * MPD * (PH / FH) * 8.3 * (T_{mix} - T_{inlet}) * 365 * (RE * 3412)^{(-1)}$

peak kW savings $= (gpm_{base} - gpm_{low}) * 60 * S * (T_{mix} - T_{inlet}) * (RE * 3412)^{(-1)} * CF$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Bathroom	Kitchen	Unit	Notes
gpm_{base}	Baseline flow rate	2.2		gal/min	
gpm_{low}	Efficient flow rate	1.5		gal/min	
MPD	Usage time	1.6	4.5	min/day	Cadmus and Opinion Dynamics. Showerhead and Faucet Aerator Meter Study. Memorandum prepared for Michigan Evaluation Working Group. 2013
PH	People per household, multi-family.	2.6		people/house	Evergreen Baseline Study (2014) – Appendix C; Average number of occupants – Table C.3 (total average) Table C.4 (MF and SF averages). [1]
	People per household, single-family.	3.24			
FH	Fixtures per household, multi-family.	1.66	1	fixtures/house	Evergreen Baseline Study (2014) –Appendix C; Average number of bathrooms –Table C.3 (total average) Table C.4 (MF and SF averages). [1 2]
	Fixtures per household, single-family.	2.13	1		

Constant	Conversion factor	8.3		Btu/gal/˚F	Engineering constant
$T_{\_mix}$	Temperature at end use	86	93	˚F	Cadmus and Opinion Dynamics. Showerhead and Faucet Aerator Meter Study. Memorandum prepared for Michigan Evaluation Working Group. 2013
$T_{\_inlet}$	Average ground water temperature	75		˚F	Honolulu Board of Water Supply.
RE	Recovery efficiency, electric resistance.	0.98		-	Electric Resistance ER from AHRI
	Recovery efficiency, heat pump water heater.	2		-	Heat Pump WH and Solar WH from ENERGYSTAR
	Recovery efficiency, solar water heater.	1.8		-	
Constant	Conversion factor	3412		Btu/kWh	Engineering constant
CF	Coincidence factor	0.022		-	Illinois TRM v6. Volume 3.
PF	Persistence factor, MFDI	1		-	
	Persistence factor, online retail.	0.51		-	Illume: Overview of Energy Savings "Kit" Programs, 2015.
Measure Life	Duration of savings	5		yrs	

Notes: 1. The Evergreen Baseline Study includes Hawaii specific data.
2. Added 1 to qty of faucet aerators to include kitchen sink.

Table 1: **Heating Type Distribution, Online Marketplace.**

Electric Resistance	56%
Electric On-Demand	3%
Heat Pump	0%
Solar	31%
Gas	10%

SAVINGS

Table 2: Detailed Savings by Category.

			kWh	kW
SERWH	Multi-family	Bathroom	17.48	0.025
		Kitchen	133.56	0.041
	Single-family	Bathroom	16.98	0.025
		Kitchen	166.44	0.041
HPWH	Multi-family	Bathroom	8.57	0.012
		Kitchen	65.45	0.020
	Single-family	Bathroom	8.32	0.012
		Kitchen	81.56	0.020
SWH	Multi-family	Bathroom	9.52	0.014
		Kitchen	72.72	0.022
	Single-family	Bathroom	9.24	0.014
		Kitchen	90.62	0.022

Table 3 **: Online Marketplace Blended Savings.**

	kWh	kW
Bathroom	6.40	0.018
Kitchen	55.75	0.030

RESIDENTIAL: Low-Flow Showerhead

MEASURE DETAILS

Description
Efficient Low-Flow Showerheads (fixed or handheld)

Program Criteria

Qualified showerheads are provided directly by Hawai'i Energy via online store or direct-install program.

Unit of Measure
One showerhead

Baseline Equipment
2.5 GPM Showerhead

High Efficiency Equipment
1.5 GPM Showerhead

ALGORITHMS

annual kWh savings = $(gpm_{\_base} - gpm_{\_low}) * MPS * SPD * (PH / FH) * 8.3 * (T_{\_mix} - T_{\_inlet}) * 365 * (RE * 3412)^{(-1)}$

peak kW savings = $(gpm_{\_base} - gpm_{\_low}) * 60 * 8.3 * (T_{\_mix} - T_{\_inlet}) * (RE * 3412)^{(-1)} * CF$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
$gpm_{\_base}$	Baseline flow rate	2.5	gal / min	
$gpm_{\_low}$	Efficient flow rate	1.5	gal / min	
MPS	Minutes per shower	7.8	min / shower	Cadmus and Opinion Dynamics. Showerhead and Faucet Aerator Meter Study. Memorandum prepared for Michigan Evaluation Working Group. 2013
SPD	Average showers per day, per person	0.6	shower / day / person	
PH	People per household, multi-family.	2.60	people / house	Evergreen Baseline Study (2014) – Appendix C; Average number of occupants – Table C.3 (total average) Table C.4 (MF and SF averages). [1]
	People per household, single-family.	3.24		

FH	Shower fixtures per household, multi-family.	1.66	fixtures / house	Evergreen Baseline Study (2014) – Appendix C; Average number of bathrooms – Table C.3 (total average) Table C.4 (MF and SF averages) [1]
	Shower fixtures per household, single-family.	2.13		
Constant	Conversion factor	8.3	Btu / gal / ˚F	Engineering constant
$T_{\_mix}$	Temperature at end use	101	˚F	Cadmus and Opinion Dynamics. Showerhead and Faucet Aerator Meter Study. Memorandum prepared for Michigan Evaluation Working Group. 2013
$T_{\_inlet}$	Average ground water temperature	75	˚F	Honolulu Board of Water Supply.
RE	Recovery efficiency, SERWH	0.98	-	Electric Resistance ER from AHRI
	Recovery efficiency, HPWH	2	-	Heat Pump WH and Solar WH from ENERGYSTAR
	Recovery efficiency, SWH	1.8	-	
Constant	Conversion factor	3412	Btu/kWh	Engineering constant
PF	Persistence factor, MFDI.	1	-	
	Persistence factor, online retail.	0.59	-	Illume: Overview of Energy Savings "Kit" Programs, 2015.
CF	Coincidence factor	0.0278	-	Illinois TRM v6. Volume 3.
Measure Life	Duration of savings	5	yrs	

Notes: 1. The Evergreen Baseline Study includes Hawaii specific data.
2. Added 1 to qty of faucet aerators to include kitchen sink.

Table 1: **Heating Type Distribution, Online Marketplace.**

Electric Resistance	56%
Electric On-Demand	3%
Heat Pump	0%
Solar	31%
Gas	10%

SAVINGS

Table 2: **Detailed Savings by Category.**

	Annual Energy Savings	Peak Demand Savings
SERWH, MF	172.67 kWh	0.108 kW
SERWH, SF	167.70 kWh	0.108 kW
HPWH, MF	84.61 kWh	0.053 kW
HPWH, SF	82.17 kWh	0.053 kW
SWH, MF	94.01 kWh	0.059 kW
SWH, SF	91.30 kWh	0.059 kW

Table 3 **: Online Marketplace Blended Savings.**

	kWh	kW
LF Showerhead	73.18	0.079

RESIDENTIAL: Peer Group Comparison

MEASURE DETAILS

Description
Letters mailed monthly to participants educating and encouraging residents to reduce energy consumption. Comparing resident's energy usage to other similar homes is the driving factor in motivating energy reduction habits.

Program Criteria
Systems must be more than 3 years old and can only receive a tune-up incentive once every 5 years.

Unit of Measure
Per residential unit

Baseline Equipment
A residential unit that does not receive peer comparison reports

High Efficiency Equipment
A residential unit that does receive regular peer comparison reports

ALGORITHMS

$$\Delta E = SVG\_deemed * E\_avg,year$$
$$\Delta P = \Delta E / HRS\_deemed$$

DEFINITIONS & ASSUMPTIONS

Variable	Description	Value	Unit	Notes
ΔE	Annual energy reduction	Calculated	kWh	
ΔP	Peak power demand reduction	Calculated	kW	
E_avg,year	kWh per Unit, group "All"	6633	kWh	Utility billing data
SVG_deemed	kWh per Unit, group "Operating"	0.80%	-	
HRS_deemed	On Peak Demand, group "All"	3000	hrs	Hawai'i Energy PY15 TRM
Measure Life	Expected duration of savings	1	yrs	

SAVINGS

Measure Name	Peak Demand Savings	Annual Energy Savings
Peer Group Comparison	0.018 kW	53.06 kWh