

Hawaii Energy Efficiency Program

July 1, 2016 through June 30, 2017

Technical Reference Manual (TRM)

PY 2016

Measure Savings Calculations



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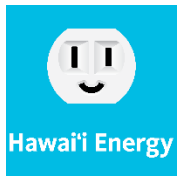
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1. Introduction

The Hawaii Energy Technical Reference Manual (TRM) provides methodologies and deemed values for estimating demand and energy savings from residential and non-residential efficiency measures approved in the Hawaii Energy program plan. Previous versions of the TRM can be found at <https://hawaiienergy.com/about/information-reports>

2. Format Description

Eligible measures are grouped in general categories of similar technologies. The appropriate calculation approaches, input variables and assumptions, and outputs are consistently presented for each general measure category as follows:

Hawaii Energy Nomenclature: Approved program measures are assigned a specific naming convention that follows equipment group, equipment type, equipment subtype, and equipment size.

Unit of Measure: the fundamental unit by which demand and energy savings are defined.

Baseline equipment: a description of the assumed, less efficient or standard option that could be or would have been installed.

Efficient equipment: a description of the higher-efficiency option that is supported by the HE program.

Program criteria: a description of performance specifications, installation and/or operating conditions required for that equipment to be eligible in the HE program.

Savings algorithms: Commonly accepted mathematical formulas for estimating demand and energy savings expected from eligible efficiency measure operation at the customer site. First year and/or annual savings are indicated unless otherwise specified.

Definitions and assumptions: descriptions and assumed values for variables and parameters used in energy savings algorithms. These model characteristics of the equipment and/or the customer site where the equipment is installed and operating. Measure life, the expected duration of measure operation with full realization of estimated demand and energy savings, is also defined here.

Demand and Energy Savings Estimates (per unit): Approved and/or calculated unit savings values for the range of assumed equipment and/or site characteristics considered eligible for the Hawaii Energy program.



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3. Common Tables

Table 3.1 Lighting Operating Hours and Peak Load Coincidence by Building Type

Building Type	LFL EFLH	CFL EFLH	LED EFLH	LFL/CFL/LED CF
Misc. Commercial	3655	3386	4290	0.3
Cold Storage	3420	2760	4325	0.5
Education	2298	2340	4160	0.2
Grocery	4910	3890	2653	0.85
Health	4710	3885	5824	0.65
Hotel/Motel	1950	1670	6474	0.6
Industrial	3220	2580	4941	0.5
Office	2615	2990	2808	0.5
Restaurant	4830	4830	5278	0.75
Retail	3825	4180	4210	0.6
Warehouse	4770	4730	4160	0.45

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. LFL=linear fluorescent.
 LFL/CFL/LED CF and LED EFLH from LED Tables reported in PY15 TRM, p.92. Original CFs applied to linear fluorescent lamps not found at the cited link.

Table 3.2: Cooling Load Interactive Factors by Building Type

Building Type	IF_e	IF_d
Misc. Commercial	1.056	1.075
Cold Storage	1.423	1.220
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

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



4. Commercial Measures

4.1 Appliances

4.1.1 Refrigerator

HAWAII ENERGY NOMENCLATURE

Equipment Group	Appliances
Equipment Type	Refrigerator
Equipment Subtype	Trade-up
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	
Review Date	October 5, 2011

Unit of Measure:

One refrigerator

Baseline equipment:

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

Table 4.1.1.a

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

Efficient equipment:

The high efficiency case Energy Star energy usage based on 2009 Energy Star Calculator Information and DOE Refrigerator Market Profile for the appliances is as follows:

Table 4.1.1.b

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

Program criteria:

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



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ALGORITHMS

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

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

$$\Delta P_{replace} = \frac{E_{base} - E_{he}}{HRS}$$

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

Table 4.1.1.c

DEFINITIONS & ASSUMPTIONS			
<i>E_{base}</i>	Energy usage of the baseline equipment	540	<i>kWh</i>
<i>E_{he}</i>	Energy usage of the higher efficiency equipment	435	<i>kWh</i>
<i>ΔE</i>	Energy reduction	Calculated	<i>kWh</i>
<i>ΔP</i>	Power demand reduction	Calculated	<i>kW</i>
<i>CF</i>	Coincidence factor, percent of time equipment load corresponds with utility peak load	100	%
<i>PF</i>	Persistence factor, % of measures installed and operating	100	%
<i>HRS</i>	Equivalent full load hours, or hours of lighting for business operation	8760	<i>hrs</i>
Measure Life	Expected duration of energy savings	14	<i>yrs</i>

SAVINGS

Table 4.1.1.d

Opportunity	Energy Usage	Reference
New Non-ENERGY STAR	540	Table 4.1.1.f
New ENERGY STAR Refrigerator	- 435	Table 4.1.1.f
	<u>105kWh/Year</u>	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	<u>822kWh/Year</u>	



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	<u>Energy Usage</u>	<u>Ratio</u>	<u>Contribution</u>	
Post-1993 Refrigerator	640	55%	354.54	Table 4.1.1.g
Pre-1993 Refrigerator	1,131	45%	<u>504.46</u>	Table 4.1.1.g
			859kWh/Year	

Table 4.1.1.e

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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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.				



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Table 4.1.1.f

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
<p>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.</p> <p>Source: See endnote 10.</p>		



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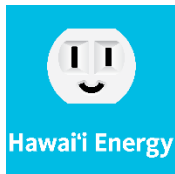
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Table 4.1.1.g

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.				

Table 4.1.1.h

	Peak Demand Savings (kW)	Energy Savings (kWh)
ES Refrigerator	0.012	105
ES Refrigerator with Turn-In	0.176	822



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4.2 Building Envelope

4.2.1 Cool Roof

HAWAII ENERGY NOMENCLATURE

Equipment Group	Building Envelope
Equipment Type	Cool Roof
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- Evergreen TRM Review – 2/23/12
- (1) Maximum value to meet Cool Roof standards under California's Title 24
- (2) Itron. 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. December 2005.
- (3) 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
- (4) 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.2.01, "Technology and Measure Cost Data", California Public Utilities Commission, October 26, 2005
- (5) Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

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.

Definition of Efficient Equipment

The efficient condition is a roof with a solar absorptance of 0.30.



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Definition of Baseline Equipment

The baseline condition is a roof with a solar absorptance of 0.80.

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.

Deemed Measure Cost

The full installed cost for retrofit applications is \$8,454.67 per one thousand square feet (4).

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Coincidence Factor

The coincidence factor (CF) is 0.50.

Energy Savings

$$\Delta \text{kWh} = \text{SF} / 1000 * \Delta \text{kWhkSF}$$

$$\Delta \text{kWh} = 0.25 \text{ kWh} / \text{square feet}$$

Demand Savings

$$\Delta \text{kW} = \Delta \text{kW} \times \text{CF}$$

Demand Savings per square feet

$$\Delta \text{kW} = 0.0001 / \text{SF} * 0.50$$

$$\Delta \text{kW} = 0.00005 \text{ kW} / \text{square feet}$$

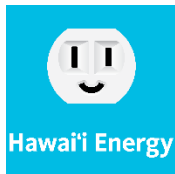
Baseline Adjustment

There are no expected future code changes to affect this measure.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs.



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4.2.2 Window Film

HAWAII ENERGY NOMENCLATURE

Equipment Group	Building Envelope
Equipment Type	Window Film
Equipment Subtype	New Replacement
Equipment Size	None

VERSION HISTORY

Draft Date	March 4, 2016
Revision Date	
Review Date	

Referenced Documents:

Basis for a Prescriptive Window Film Rebate Program (Attachment G) prepared for HECO (XENERGY Inc.) November 5, 1999

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- Rebate increased from \$0.35 to \$1.00 per square foot
- Changed from 0.4 shading coefficient (SC) to 0.5 SC
- 3/4/2016 – added section for baseline efficiency description

Description:

- *Warranty* – Film must have a minimum five-year manufacturer's warranty and one-year installer's warranty
- *Conditioned Space* – Rebates shall be paid on actual square footage of glass in a conditioned space
- *Eligible Types* – Windows may be clear or factory tinted, single or double pane, but must not have reflected glass. All orientations are eligible.
- *Unshaded* – Windows significantly shaded by buildings, trees or awnings are not eligible for rebates.
- *Replacement Film* – Replacement of deteriorated window film is eligible for 50% of the rebate if the customer did not receive a rebate for the existing film.

Equipment Qualifications:

- Shading Coefficient < 0.5



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- Solar Heat Gain Coefficient (SHGC) < 0.435
- $SC = 0.87 * SHGC$
- Replacement of deteriorated window film is eligible for 50% of the incentive if the customer did not receive an incentive from the existing window film. The incentive will be rounded up.

Baseline Efficiency:

The baseline efficiency for this measure is no window tinting.

Energy and Demand Savings:

Table 4.2.2.a

Savings	Hotel	Office	Other	Average
Energy Savings (kWh/ft ²)	5.6	4.5	4.5	4.9
Demand Savings (kW/ft ²)	0.0014	0.0008	0.0016	0.0013

Persistence Factor

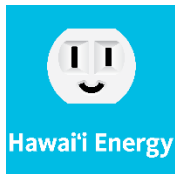
1.0

Coincidence Factor

1.0

Lifetime

10 years (DEER)



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4.3 Commercial Kitchen

4.3.1 Combination Ovens

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Combination Oven
Equipment Subtype	None
Equipment Size	<15 Pans 15 – 18 Pans >28 Pans

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- U.S. Department of Energy, Energy Star website:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO
- Energy Star Commercial Kitchen Equipment Savings Calculator
- PG&E Work Paper PGEFST105 (Revision 3) – June 8, 2012
- Arkansas TRM Version 2.0 Volume 2
- KEMA report titled “Business Programs: Deemed Savings Parameter Development”, November 2009 - Coincidence factor for food service building type listed as 0.84

TRM Review Actions:

- Currently Under Review.

Measure 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.



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Baseline Efficiency:

Table 4.3.1.a

Parameter	< 15 Pans	15-28 Pans	> 28 Pans
Assumptions			
% Time in Steam Mode	50%	50%	50%
Preheat Energy (kWh/day)	3.0	3.75	5.63
Convection Idle Energy Rate (kW)	1.5	3.75	5.25
Steam Idle Energy Rate (kW)	10.0	12.5	18.0
Convection Cooking Energy Efficiency (%)	65%	65%	65%
Steam Cooking Energy Efficiency (%)	40%	40%	40%
Convection Production Capacity (lbs/hour)	80	100	275
Steam Production Capacity (lbs/hour)	100	150	350
Lbs of Food Cooked/day	200	250	400
Total Energy			
Annual Energy Consumption (kWh)	35,263	48,004	74,448
Demand (kW)	6.8	9.2	14.3

High Efficiency:

Table 4.3.1.b

Parameter	< 15 Pans	15-28 Pans	> 28 Pans
Assumptions			
% Time in Steam Mode	50%	50%	50%
Preheat Energy (kWh/day)	1.5	2.0	3.0
Convection Idle Energy Rate (kW)	1.0	2.5	4.0



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Steam Idle Energy Rate (kW)	5.0	6.0	9.0
Convection Cooking Energy Efficiency (%)	70%	70%	70%
Steam Cooking Energy Efficiency (%)	50%	50%	50%
Convection Production Capacity (lbs/hour)	100	152	325
Steam Production Capacity (lbs/hour)	120	200	400
Lbs of Food Cooked/day	200	250	400
Total Energy			
Annual Energy Consumption (kWh)	23,658	32,001	50,692
Demand (kW)	4.5	6.1	9.7

Energy Savings

Energy usage calculations are based on 12 hours a day, 365 days per year (4,380 hours/year). The different sizes for the combination ovens (< 15 pans, 15-28 pans, and > 28 pans) have proportional operating energy rates.

Table 4.3.1.c

Performance	< 15 Pans	15-28 Pans	> 28 Pans
Annual Energy Savings (kWh)	11,604	16,003	23,756
Estimated Demand Reduction (kW)	2.6	3.7	5.4

Operating Hours

12 hrs/day, 365 day/year = 4,380 hours/year

Demand Coincidence Factor

CF = 0.84



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Lifetime

12 years



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4.3.2 Convection Ovens

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Convection Oven
Equipment Subtype	None
Equipment Size	Full Size Half Size

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- U.S. Department of Energy, Energy Star website:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO
- Energy Star Commercial Kitchen Equipment Savings Calculator
- PG&E Work Paper PGEFST105 (Revision 3) – June 8, 2012
- Arkansas TRM Version 2.0 Volume 2
- KEMA report titled “Business Programs: Deemed Savings Parameter Development”, November 2009 - Coincidence factor for food service building type listed as 0.84

TRM Review Actions:

- Currently Under Review.

Measure 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.

- **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 ($\geq 70\%$) and must not exceed the maximum idle energy rate of 1.6 kW ($\leq 1.6\text{kW}$).



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- **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 ($\geq 70\%$) and must not exceed the maximum idle energy rate of 1.0 kW ($\leq 1.0\text{kW}$).



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Baseline Efficiency:

Table 4.3.2.a

Parameter	Half Size	Full Size
Assumptions		
Preheat Energy (kWh/day)	1.0	1.5
Idle Energy Rate (kW)	1.5	2.0
Cooking Energy Efficiency (%)	65%	65%
Production Capacity (lbs/hour)	45	70
Lbs of food cooked/day	100	100
Energy per pound of food (kWh/lb)	0.0732	0.0732
Total Energy		
Annual Energy Consumption (kWh)	9,692	12,193
Demand (kW)	1.86	2.34

High Efficiency:

Table 4.3.2.b

Parameter	Half Size	Full Size
Assumptions		
Preheat Energy (kWh/day)	0.9	1.0
Idle Energy Rate (kW)	1.0	1.6
Cooking Energy Efficiency (%)	70%	70%
Production Capacity (lbs/hour)	50	80
Lbs of food cooked/day	100	100
Energy per pound of food (kWh/lb)	0.0732	0.0732



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Total Energy		
Annual Energy Consumption (kWh)	7,704	10,314
Demand (kW)	1.48	1.98

Energy Savings

Energy usage calculations are based on 12 hours a day, 365 days per year. The different sizes for the holding cabinets (half size and full size) have proportional operating energy rates.

Table 4.3.2.c

Performance	Half Size	Full Size
Annual Energy Savings (kWh)	1,988	1,879
Estimated Demand Reduction (kW)	0.38	0.36

Operating Hours

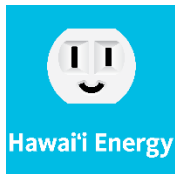
12 hrs/day, 365 day/year = 4,380 hours/year

Demand Coincidence Factor

CF = 0.84

Lifetime

12 years



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4.3.3 Demand Controlled Ventilation

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Demand Control Ventilation
Equipment Subtype	Kitchen Fan
Equipment Size	None

VERSION HISTORY

Draft Date

Revision Date

Review Date October 5, 2011

Measure 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.

Unit of Measure: Fan HP

Baseline equipment:

100% on/off kitchen exhaust fan

Efficient equipment:

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

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

ALGORITHMS

$$\Delta P_{peak,per\ HP} = CF \times \left[\frac{(1\ HP) \times \left(0.746 \frac{kW}{HP} \right)}{\eta} - (1\ HP \times P_{in,per\ HP}) \right]$$



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$$\Delta E_{\text{annual,per HP}} = HRS \times \left[\frac{(1 \text{ HP}) \times \left(0.746 \frac{\text{kW}}{\text{HP}}\right)}{\eta} - (1 \text{ HP} \times P_{\text{in,per HP}}) \right]$$

$$P_{\text{in,per HP}} = \frac{P_{\text{out,per HP}}}{\eta}$$

Table 4.3.3.a

DEFINITIONS & ASSUMPTIONS				
ΔP	Power demand reduction	Calculated	kW	
ΔE	Energy reduction	Calculated	kWh	
$P_{\text{in,per HP}}$	Input demand of controlled fan per HP	0.38	kW	Table 4.3.1.b ¹
$P_{\text{out,per HP}}$	Output power of fan per HP	Calculated	kW	
η	Efficiency factor of fan system	0.90	---	Table 4.3.1.b ¹
CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	100	%	
PF	Persistence factor, % of measures installed and operating	100	%	
HRS	Annual operating hours; 16 hrs/day, 7 days/wk, 52 wks/yr	5824	hrs	
Measure Life	Expected duration of energy savings	15	yrs	

SAVINGS

Table 4.3.3.b: Impact of Reduced Fan Speed and Ventilation on Load and Energy Use

	% rated RPM	% Run Time	Operating Hours/Yr	Output kW/HP	System Efficiency	Input kW/HP	kWh/HP/yr
	100%	5%	291.2	0.746	0.9	0.829	241
	90%	20%	1164.8	0.544	0.9	0.604	704
	80%	25%	1456	0.382	0.9	0.424	618
	70%	25%	1456	0.256	0.9	0.284	414
	60%	15%	873.6	0.161	0.9	0.179	156
	50%	10%	582.4	0.093	0.9	0.103	60
	40%	0%	0	0.048	0.9	0.053	0
	30%	0%	0	0.02	0.9	0.022	0
	20%	0%	0	0.015	0.9	0.017	0

¹ Original manufacturer report is no longer available



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	10%	0%	0	0.01	0.9	0.011	0
Totals :		100%	5824	2.28		2.53	2194.03
					Weight Avg. ($P_{in,per\ HP}$)	0.38	

Source: Melink Detailed Energy Savings Report referenced in Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations pp.136-137

Table 4.3.3.c: Kitchen Demand-Controlled Ventilation Power Demand & Energy Savings

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
Kitchen Demand-Controlled Ventilation	0.45	2633



4.3.4 Electric Griddle

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Electric Griddle
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- The industry standard for energy use and cooking performance of griddles are ASTM F1275-03: Standard Test
- Method for the Performance of Griddles and ASTM F1605-01: Standard Test Method for the Performance of Double-Sided Griddles
- ENERGY STAR Commercial Griddles Program Requirements Version 1.1, effective May 2009 for gas griddles and effective January 1, 2011 for electric.
- Database for Energy Efficient Resources, 2008, http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls
- Assumptions based on PG&E Commercial Griddles Work Paper developed by FSTC, May 22, 2012.

TRM Review Actions:

- Currently Under Review.

Major Changes:

- New measure

Measure Description:

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.



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

Baseline and Efficiency Standard

Key parameters for defining griddle efficiency are Heavy Load Cooking Energy Efficiency and Idle Energy Rate. There are currently no federal minimum standards for Commercial Griddles, however, the American Society of Testing and Materials (ASTM) publishes Test Methods¹⁵⁵ that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

ENERGY STAR efficiency requirements apply to single and double sided griddles. The

ENERGY STAR criteria should be reviewed on an annual basis to reflect the latest requirements.

Table 4.3.4.a: ENERGY STAR Criteria for Electric Single and Double Sided Griddles

Performance Parameters	Electric Griddles
Heavy-Load Cooking Energy Efficiency	$\geq 70\%$
Idle Energy Rate	≤ 320 watts per ft ²

Energy Savings:

Annual savings can be calculated by determining the energy consumed by a standard efficiency griddle as compared with an ENERGY STAR rated griddle.

$$\Delta \text{kWh} = \text{kWh}(\text{base}) - \text{kWh}(\text{eff})$$

$$\Delta \text{kWh}(\text{base or eff}) = \text{kWh}(\text{cooking}) + \text{kWh}(\text{idle}) + \text{kWh}(\text{preheat})$$

$$\text{kWh}(\text{cooking}) = [\text{LB}(\text{food}) \times \text{E}(\text{food}) / \text{Cook}(\text{eff})] \times \text{Days}$$



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$$\text{kWh}(\text{idle}) = \text{IdleEnergy} \times [\text{DailyHrs} - \text{LB}(\text{food})/\text{Capacity} - \text{PreheatTime}/60] \times \text{Days}$$

$$\text{kWh}(\text{preheat}) = \text{PreheatEnergy} \times \text{Days}$$

Table 4.3.4.b

Parameter	Description	Value	Source
Daily Hrs	Daily Operating Hours	12 hours	FSTC
Preheat Time	Time to Preheat (min)	15 min	FSTC
E(food)	ASTM defined Energy to Food	0.139 kWh/lb	FSTC
Days	Number of days of operation	365 days	FSTC
CookEff	Cooking energy efficiency (%)	See Table below	FSTC, ENERGY STAR
IdleEnergy	Idle energy rate (kW)		
Capacity	Production capacity (lbs/hr)		FSTC
Preheat Energy	kWh/day		FSTC
LB(food)	Food cooked per day (lb/day)		FSTC

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.

Table 4.3.4.c: Baseline and Efficient Assumptions for Electric Griddles

Parameter	Baseline Electric Griddles	Efficient Electric Griddles
Preheat Energy (kWh/ft)	1.33	0.67
Idle Energy Rate (kW/ft)	0.80	0.64
Cooking Energy Efficiency (%)	65%	70%
Production Capacity (lbs/h/ft)	11.7	16.33
Lbs of food cooked/day/ft	33.33	33.33



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Table 4.3.4.d

Base (kWh/year) per linear foot	
Cooking	2602
Idle	2599
Preheat	485
Total Base Energy Usage (kWh)	5686
Demand (kW)	1.30

Efficient (kWh/year) per linear foot	
Cooking	2416
Idle	2268
Preheat	245
Total Efficient Energy Usage (kWh)	4929
Demand (kW)	1.13

Energy Savings (kWh/year) per linear foot	757
Demand Savings (kW)	0.17

Operating Hours

The average steam cooker is assumed to operate 4,380 hours per year.

Demand Coincidence Factor

Coincidence factor is 1.0 because the cooking equipment is assumed to operate throughout the on-peak demand periods (5PM – 9PM).

Persistence

100% persistence factor



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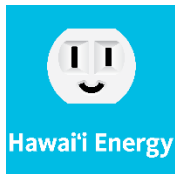
Lifetime

12 years – DEER (2008)

Measure Costs and Incentive Levels

Incremental cost = \$774

(Assumptions based on PG&E Commercial Griddles Work Paper developed by FSTC, May 22, 2012).



4.3.5 Electric Steam Cooker

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Steam Cooker
Equipment Subtype	None
Equipment Size	1-pan 2-pan 3-pan 4-pan 5-pan 6-pan

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- ENERGY STAR Commercial Kitchen Equipment Savings Calculator: Steam Cooker Calcs.
- PG&E Work Paper PGECOFST104 Commercial Steam Cooker Revision #4 (5/22/12)

TRM Review Actions:

- Currently Under Review.

Measure 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.

Baseline Efficiencies:

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:

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.

Energy Savings:

Unit savings are deemed based on study results:



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Δ kWh/year = 3,258 kWh/pan

Δ kW = 2.23 kW

Savings Algorithms

Table 4.3.5.a

Steam Cooker Calculations for the ENERGY STAR Commercial Kitchen Equipment Calculator

Inputs

	USER ENTRY	
	Electric	
Average daily operation	12	hours
Annual days of operation	365	days
Food cooked per day	100	pounds
Number of pans per unit	3	
Incremental cost	\$2,000	

Assumptions

	Electric		
	Conventional	ENERGY STAR	
Type	steam generator	boilerless	
Water Use	40	3	gallons/hour
Time in constant steam mode	40%	40%	
Cooking energy efficiency	30%	50%	
Production capacity per pan	23.3	16.7	pounds/hour
Number of preheats per day	1	1	
Preheat length	15	15	minutes
Preheat energy rate	6,000	6,000	W
Idle energy rate	1,200	400	W
ASTM energy to food	30.8		Wh/pound
Equipment lifetime	12		years

Calculations

	Electric		
	Conventional	ENERGY STAR	
Annual operation	4,380		hours
Daily preheat energy	1,500	1,500	Wh
Daily cooking energy	10,267	6,160	Wh
Daily idle time	10.32	9.75	hour
Daily idle energy	37,052	14,382	Wh
Total daily energy	48,819	22,042	Wh

Annual energy consumption per steam cooker

	Conventional	ENERGY STAR	Savings (3 Pan)	Savings per Pan
Electric Usage (kWh/year)	17,819	8,045	9,774	3258

Operating Hours

The average steam cooker is assumed to operate 4,380 hours per year.



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Demand Coincidence Factor

CF = 1.0

Persistence

100% persistence factor

Lifetime

12 years

Measure Costs

Incremental cost = \$2,000



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4.3.6 Fryer

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Commercial Fryer
Equipment Subtype	None
Equipment Size	Large Vat Standard Vat

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- The industry standards for energy use and cooking performance of fryers are ASTM Standard Test Method for the Performance of Open Deep Fat Fryers (F1361) and ASTM Standard Test Method for the Performance of Large Vat Fryers (FF2144).
- ENERGY STAR Version 2.0, effective April 22, 2011
- Assumptions based on PG&E Commercial Fryers Work Paper developed by FSTC, June 13, 2012

TRM Review Actions:

- Currently Under Review.

Measure 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.

Baseline and Efficiency Standard

Key parameters for defining fryer efficiency are Heavy Load Cooking Energy Efficiency and Idle Energy Rate. 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



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inches to 24 inches wide with a vat capacity greater than 50 pounds. The ENERGY STAR criteria should be reviewed on an annual basis to reflect the latest requirements.

There are currently no federal minimum standards for Commercial Fryers, however, the American Society of Testing and Materials (ASTM) publishes Test Methods¹⁸³ that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

Table 4.3.6.a: ENERGY STAR Criteria and FSTC Baseline for Open Deep-Fat Electric Fryers

Performance Parameters	ENERGY STAR Electric Fryer Criteria	
	Standard Fryers	Large Vat Fryers
Heavy-Load Cooking Energy Efficiency	$\geq 80\%$	$\geq 80\%$
Idle Energy Rate	$<+ 1.0 \text{ kW}$	$\leq 1.1 \text{ kW}$

Energy Savings:

Annual savings can be calculated by determining the energy consumed by a standard efficiency fryer as compared with an ENERGY STAR rated fryer.

$$\Delta \text{kWh} = \text{kWh}(\text{base}) - \text{kWh}(\text{eff})$$

$$\Delta \text{kWh}(\text{base or eff}) = \text{kWh}(\text{cooking}) + \text{kWh}(\text{idle}) + \text{kWh}(\text{preheat})$$

$$\text{kWh}(\text{cooking}) = [\text{LB}(\text{food}) \times \text{E}(\text{food}) / \text{Cook}(\text{eff})] \times \text{Days}$$

$$\text{kWh}(\text{idle}) = \text{IdleEnergy} \times [\text{DailyHrs} - \text{LB}(\text{food}) / \text{Capacity} - \text{PreheatTime} / 60] \times \text{Days}$$

$$\text{kWh}(\text{preheat}) = \text{PreheatEnergy} \times \text{Days}$$



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Table 4.3.6.b

Parameter	Description	Value	Source
Daily Hrs	Daily Operating Hours	12 hours	FSTC
Preheat Time	Time to Preheat (min)	15 min	FSTC
E(food)	ASTM defined Energy to Food	0.167 kWh/lb	FSTC
Days	Number of days of operation	365 days	FSTC
CookEff	Cooking energy efficiency (%)	See Table below	FSTC, ENERGY STAR
IdleEnergy	Idle energy rate (kW)		
Capacity	Production capacity (lbs/hr)		FSTC
Preheat Energy	kWh/day		FSTC
LB(food)	Food cooked per day (lb/day)		FSTC

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

Table 4.3.6.c

Baseline and Efficient Assumptions for Electric Standard and Large Vat Fryers

Parameter	Baseline Electric Fryers		Efficient Electric Fryers	
	Standard	Large Vat	Standard	Large Vat
Preheat Energy (kWh/ft)	2.3	2.5	1.7	2.1
Idle Energy Rate (kW/ft)	1.05	1.35	1.00	1.1
Cooking Energy Efficiency (%)	75%	70%	80%	80%
Production Capacity (lbs/h/ft)	65	100	70	110
Lbs of food cooked/day/ft	150	150	150	150



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Table 4.3.6.d

Baseline Electric Fryers	Standard	Large Vat
Cooking	12191	13062
Idle	3619	5051
Preheat	840	913
Total Energy Usage (kWh/year) per Vat	16649	19026
Demand	3.80	4.34

Efficient Electric Fryers	Standard	Large Vat
Cooking	11429	11429
Idle	3507	4170
Preheat	621	767
Total Energy Usage (kWh/year) per Vat	15557	16366
Demand	3.55	3.74

Savings	Standard	Large Vat
Energy Savings (kWh/year) per Vat	1093	2659
Demand Savings (kW)	0.25	0.61

Operating Hours

The average steam cooker is assumed to operate 4,380 hours per year.

Demand Coincidence Factor

Coincidence factor is 1.0 because the cooking equipment is assumed to operate throughout the on-peak demand periods (5PM – 9PM).



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Persistence

100% persistence factor

Lifetime

12 years – DEER (2008)

Measure Costs and Incentive Levels

Incremental cost = \$769

(Assumptions based on PG&E Commercial Fryers Work Paper developed by FSTC, May 22, 2012).



4.3.7 Hot Food Holding Cabinet

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Hot Food Holding Cabinet
Equipment Subtype	None
Equipment Size	Full Size Half Size

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- PG&E Work Paper PGEFST105 (Revision 3) – June 8, 2012

TRM Review Actions:

- Currently Under Review.

Measure 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.

- **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.



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Baseline Efficiency:

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:

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.

Energy 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/ft³.

Table 4.3.7.a: Insulated Hot Food Holding Cabinet - Full Size

Performance	Baseline	High Efficiency Qualifying Model
Demand (kW)	1	0.28
Annual Energy Use (kWh/year)	5475	1533
Estimated Demand Reduction (kW)	-	0.72
Annual Energy Savings (kWh/year)	-	3942
Incremental Measure Cost (\$)		2336
Estimated Useful Life (years)	12	12

Table 4.3.7.b: Insulated Hot Food Holding Cabinet - Half Size

Performance	Baseline	High Efficiency Qualifying Model
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Demand (kW)	0.38	0.05
Annual Energy Use (kWh/year)	2081	274
Estimated Demand Reduction (kW)	-	0.33
Annual Energy Savings (kWh/year)	-	1807
Incremental Measure Cost (\$)		381
Estimated Useful Life (years)	12	12

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.

Table 4.3.7.c: Measure ASTM test results for Hot Food Holding Cabinets

Cabinet Size	Cabinet Volume (ft ³)	Normalized Idle Energy Rate (W/ft ³)	Total Cabinet Idle Energy Rate (W)
Full-Size	25	11.3	0.28
Half-Size	10	5.7	0.05

Operating Hours

15 hr/day, 365 day/year = 5,475 hours/year

Demand Coincidence Factor

CF = 1.0

Lifetime

12 years

Measure Costs

The incremental cost for ENERGY STAR hot food holding cabinet is \$2,336 (full size) & \$381 (half size)



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4.3.8 Ice Machine

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Commercial Ice Machine
Equipment Subtype	None
Equipment Size	IHR 101-300 IHR 301-500 IHR 501-1000 IHR 1001-1500 IHR >1500

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- PG&E Work Paper PGECOFST108 Commercial Ice Machines Revision 3 – May 30, 2012

TRM Review Actions:

- Currently Under Review.

Major Changes:

- New measure

Measure 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.



Baseline and Efficiency Standard:

The Energy Efficient criteria for ice makers define efficiency requirements for both energy and potable water use.

Market Applicability

Hospitals account for 39.4 percent of all commercial icemaker purchases, followed by hotels (22.3 percent), restaurants (13.8 percent), retail outlets (8.5 percent), schools (8.5 percent), offices (4.3 percent), and grocery stores (3.2 percent).

Measure Savings Calculations:

Annual electric savings can be calculated by determining the energy consumed for baseline ice makers compared against ENERGY STAR performance requirements using the harvest rate of the more efficient unit. Peak demand savings can then be derived from the electric savings.

$$\Delta \text{kWh} = (\text{kWh}_{\text{base, per 100lb}} - \text{kWh}_{\text{ee, per 100lb}}) / 100 \times \text{DC} \times \text{H} \times 365$$

$$\Delta \text{kW} = \Delta \text{kWh} / \text{HRS}$$

Where:

- 100 = conversion factor to convert $\text{kWh}_{\text{base, per 100lb}}$ and $\text{kWh}_{\text{ee, per 100lb}}$ into maximum kWh consumption per pound of ice.
- DC = Duty Cycle of the ice maker representing the percentage of time the ice machine is making ice
- H = Harvest Rate (lbs of ice made per day)
- 365 = days per year
- kWh = Annual energy savings
- HRS = Annual operating hours
- CF = 1.0



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The baseline and energy efficient energy usage per 100lbs of ice produced is dependent on the category of ice maker, as well as the capacity of the energy efficient ice maker. The equations used to determine the energy per 100lbs of ice produced can be seen below.

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 Table below.

This specification covers machines generating 60 grams (2 oz.) or lighter ice cubes, as well as flaked, crushed, or fragmented ice machines that meet the Energy Efficiency thresholds by Ice harvest (IHR) rate listed below. Only air cooled machines (icemaker heads, self-contained units, and remote condensing units) are eligible for incentives. Performance data is based on ARI Standard 810.

Table 4.3.8.a

Energy Efficiency Requirements

Equipment Type	Ice Harvest Rate Range (lbs of ice/24 hrs)	Energy Efficient Ice Makers		Federal Minimum Standard Energy Consumption Rate (kWh/100 lbs ice) (H = Harvest Rate)
		Energy Consumption Rate (kWh/100 lbs ice) (H = Harvest Rate)	Potable Water Use Limit (gal/100 lbs ice)	
Ice Making Heads	<450	$\leq 8.72 - 0.0073H$	≤ 20	$10.26 - 0.0086H$
	≥ 450	$\leq 5.86 - 0.0009H$	≤ 20	$6.89 - 0.0011H$
Remote Condensing Units	< 1,000	$\leq 7.52 - 0.0032H$	≤ 20	$8.85 - 0.0038H$
	$\geq 1,000$	≤ 4.34	≤ 20	5.10
Remote Condensing Units	< 934	$\leq 7.52 - 0.0032H$	≤ 20	$8.85 - 0.0038H$
	≥ 934	≤ 4.51	≤ 20	5.30
Self-Contained Units	< 175	$\leq 15.3 - 0.0399H$	≤ 30	$18.0 - 0.069H$
	≥ 175	≤ 8.33	≤ 30	9.80

Example Savings Calculations

Savings calculation for varying Harvest Rates (H) can be seen below:



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Table 4.3.8.b

Performance	IHR	IHR	IHR	IHR	IHR
Ice Harvest Rate (IHR) (lbs per 24 hrs.)	101-300	301-500	501-1,000	1,001-1,500	> 1,500
Average IHR Used in Energy Calculations (lbs/day)	200	400	750	1,250	1,750
Baseline Model Energy Usage (kWh/100 lbs)	9.8	6.82	6.07	5.1	5.1
Energy Efficient Model Energy Usage (kWh/100 lbs)	8.33	5.8	5.19	4.34	4.34
Baseline Model Daily Energy Consumption (kWh)	14.7	20.5	34.1	47.8	66.9
Energy Efficient Model Daily Energy Consumption (kWh)	12.5	17.4	29.2	40.7	57
Baseline Model Average Demand (kW)	0.613	0.853	1.421	1.992	2.789
Energy Efficient Model Average Demand (kW)	0.521	0.725	1.215	1.695	2.373
Estimated Demand Reduction (kW)	0.092	0.128	0.206	0.297	0.416
Baseline Model Annual Energy Consumption (kWh/yr)	5,366	7,468	12,452	17,452	24,432
Energy Efficient Model Annual Energy Consumption (kWh/yr)	4,561	6,351	10,645	14,851	20,791
Estimated Annual Energy Savings (kWh/yr)	805	1,117	1,807	2,601	3,641
Electric Cost (\$/kWh)	\$0.25	\$0.25	\$0.25	\$0.25	\$0.25
Baseline Model Annual Energy Cost (\$/yr)	\$1,342	\$1,867	\$3,113	\$4,363	\$6,108
Energy Efficient Model Annual Energy Cost (\$/yr)	\$1,140	\$1,588	\$2,661	\$3,713	\$5,198
Estimated Annual Energy Cost Savings (\$/yr)	\$201	\$279	\$452	\$650	\$910
Estimated Incremental Cost	\$306	\$266	\$249	\$589	\$939
Estimated Useful Life (EUL)	12	12	12	12	12

Demand Coincidence Factor

CF = 1.0

Lifetime



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12 years

4.3.9 Low Flow Spray Nozzles for Food Service (Retrofit)

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Low Flow Spray Nozzle
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- Evergreen TRM Review – 1/15/14

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

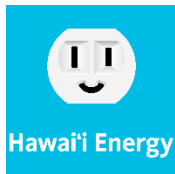
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Measure Description:

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.

Baseline Efficiencies:

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



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High Efficiency:

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

Energy Savings:

$$\Delta \text{kWh} = \Delta \text{Water} \times \text{HOT}_{\%} \times 8.33 \times (\Delta T) \times (1/\text{EFF}^*) / 3413$$

ΔWater = Water savings (gallons)

$\text{HOT}_{\%}$ = The percentage of water used by the pre-rinse spray valve that is heated = 69%

8.33 = The energy content of heated water (Btu/gallon/°F)

ΔT = Temperature rise through water heater (°F) = 65°F

*EFF1 = Water heater thermal efficiency (electric resistance) = 0.98

*EFF2 = Water heater thermal efficiency (heat pump) = 3.0

3413 = Factor to convert Btu to kWh

Table 4.3.9.a

Building Type	Operating Schedule (Day/year)	kW Savings	Electric Resistance (kWh/yr) Savings	Heat Pump (kWh/yr) Savings
Restaurants/Institutions	365	1.03	4,753	1,553
Dormitories	274	0.9	3,568	1,165
K-12 Schools	200	0.79	2,604	851

Demand Coincidence Factor

TBD

Persistence

TBD



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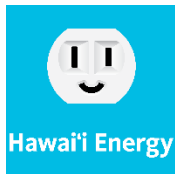
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Lifetime

5 years

Measure Costs and Incentive Levels

The actual measure installation cost should be used (including material and labor).



4.3.10 Solid Door Refrigerators & Freezers

HAWAII ENERGY NOMENCLATURE

Equipment Group	Commercial Kitchen
Equipment Type	Reach-in Refrigerator Reach-in Freezer
Equipment Subtype	Solid Door Glass Door
Equipment Size	0<V<15 (1 Door) 15<V<30 (1 Door) 30<V<50 (2 Door) 50<V (3 Door)

VERSION HISTORY

Draft Date	
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- Southern California Edison Work Paper SCE13CC001 Commercial Reach-In Refrigerators and Freezers – April 6, 2012

Measure Description:

This measure relates to the installation of a new reach-in commercial refrigerator or freezer meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial refrigerators and 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. 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.

Baseline Efficiencies:

In order for this characterization to apply, the baseline equipment is assumed to be a solid or glass door refrigerator or 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:

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



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Energy and Demand Savings:

$$\text{Annual Energy Savings (kWh/year)} = (\text{kWh}_{\text{base}} - \text{kWh}_{\text{ee}}) * 365$$

$$\text{Demand Savings} = \text{Annual Energy Savings} / \text{Hours} * \text{CF}$$

Operating Hours

8760 hours/year

Demand Coincidence Factor

CF = 1.0

Lifetime

12 years

Table 4.3.10.a: High Efficiency v. Baseline Efficiency Tables for Solid Door Refrigerators and Freezers

Volume (cubic feet)	Typical Volume (cubic feet)	Volumetric Factor (kWh/ft3)	Fixed Energy Usage (kWh)	Enhanced Case (kWh/day)
Solid-door Reach-in Refrigerator				
0 < V < 15	7.5	0.089	1.411	2.08
15 ≤ V < 30	22.5	0.037	2.200	3.03
30 ≤ V < 50	40	0.056	1.635	3.88
50 ≤ V	60	0.060	1.416	5.02
Solid-Door Reach-In Freezer				
0 < V < 15	7.5	0.250	1.250	3.13
15 ≤ V < 30	22.5	0.400	-1.000	8.00
30 ≤ V < 50	40	0.163	6.125	12.65
50 ≤ V	60	0.158	6.333	15.81
Glass-door Reach-in Refrigerator				
0 < V < 15	7.5	0.118	1.382	2.27
15 ≤ V < 30	22.5	0.140	1.050	4.20
30 ≤ V < 50	40	0.089	2.625	6.18
50 ≤ V	60	0.110	1.500	8.10
Glass-Door Reach-In Freezer				
0 < V < 15	7.5	0.607	0.893	5.45
15 ≤ V < 30	22.5	0.733	-1.000	15.49
30 ≤ V < 50	40	0.250	13.500	23.50
50 ≤ V	60	0.450	3.500	30.50

Volume (cubic feet)	Typical Volume (cubic feet)	Volumetric Factor (kWh/ft3)	Fixed Energy Usage (kWh)	Base Case (kWh/day)
Solid-door Reach-in Refrigerator				
0 < V < 15	7.5	0.10	2.04	2.79
15 ≤ V < 30	22.5	0.10	2.04	4.29
30 ≤ V < 50	40	0.10	2.04	6.04
50 ≤ V	60	0.10	2.04	8.04
Solid-Door Reach-In Freezer				
0 < V < 15	7.5	0.40	1.38	4.38
15 ≤ V < 30	22.5	0.40	1.38	10.38
30 ≤ V < 50	40	0.40	1.38	17.38
50 ≤ V	60	0.40	1.38	25.38
Glass-door Reach-in Refrigerator				
0 < V < 15	7.5	0.12	3.34	4.24
15 ≤ V < 30	22.5	0.12	3.34	6.04
30 ≤ V < 50	40	0.12	3.34	8.14
50 ≤ V	60	0.12	3.34	10.54
Glass-Door Reach-In Freezer				
0 < V < 15	7.5	0.75	4.10	9.73
15 ≤ V < 30	22.5	0.75	4.10	20.98
30 ≤ V < 50	40	0.75	4.10	34.1
50 ≤ V	60	0.75	4.10	49.1



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Table 4.3.10.b: Energy and Demand Savings for Solid Door Refrigerators and Freezers

Volume (cubic feet)	Typical Volume (cubic feet)	Base Case (kWh/day)	Enhanced Case (kWh/day)	Energy Savings (kWh/day)	Energy Savings (kWh/year)	Demand Savings (kW)
Solid-door Reach-in Refrigerator						
0 < V < 15	7.5	2.79	2.08	0.71	259.15	0.030
15 ≤ V < 30	22.5	4.29	3.03	1.26	459.90	0.053
30 ≤ V < 50	40	6.04	3.88	2.16	788.40	0.090
50 ≤ V	60	8.04	5.02	3.02	1102.30	0.126
Solid-Door Reach-In Freezer						
0 < V < 15	7.5	4.38	3.13	1.25	456.25	0.052
15 ≤ V < 30	22.5	10.38	8.00	2.38	868.70	0.099
30 ≤ V < 50	40	17.38	12.65	4.73	1726.45	0.197
50 ≤ V	60	25.38	15.81	9.57	3493.05	0.399
Glass-door Reach-in Refrigerator						
0 < V < 15	7.5	4.24	2.27	1.97	719.05	0.082
15 ≤ V < 30	22.5	6.04	4.20	1.84	671.60	0.077
30 ≤ V < 50	40	8.14	6.18	1.96	715.40	0.082
50 ≤ V	60	10.54	8.10	2.44	890.60	0.102
Glass-Door Reach-In Freezer						
0 < V < 15	7.5	9.73	5.45	4.28	1562.20	0.178
15 ≤ V < 30	22.5	20.98	15.49	5.49	2003.85	0.229
30 ≤ V < 50	40	34.1	23.50	10.60	3869.00	0.442
50 ≤ V	60	49.1	30.50	18.60	6789.00	0.775



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4.4 Energy Study Grant

4.4.1 Design Assistance

HAWAII ENERGY NOMENCLATURE

Equipment Group	Energy Study Grant
Equipment Type	Design Assistance
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	September 20, 2011
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- n/a

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- 12/22/11 – Program requirement changed to require project be in planning or initial design phase.

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 comfort for building users.

Program Requirements:

- 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

Energy and Demand 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



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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.

Savings 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.

Baseline Efficiency

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

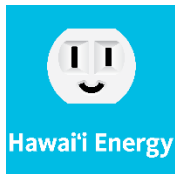
The high efficiency scenario is specific to each project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on comparing a base case analysis and enhanced case analysis on equipment efficiencies and operating characteristics and are determined on 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.

Persistence Factor

PF = 1 since all custom projects require verification of equipment installation.

Incentives

- Incentive applications are processed on a first-come, first-serve basis
- Incentives are 50% limited to a maximum of \$15,000



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4.4.2 Energy Study

HAWAII ENERGY NOMENCLATURE

Equipment Group	Energy Study Grant
Equipment Type	Energy Study
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	September 20, 2011
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- n/a

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- n/a

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 Requirements:

- 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

Energy and Demand 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.

Savings 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.

Energy Study

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 performance will 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



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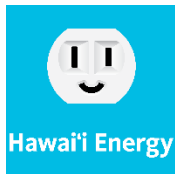
g) Estimated costs including design, materials, and installation

3) Appendix

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

Incentives

Incentives are limited to 50% of the cost of the study up to \$15,000



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4.5 HVAC - Heating, Ventilation and Air Conditioning Measures

4.5.1 Chillers

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Chiller
Equipment Subtype	Air-cooled Centrifugal Positive Displacement
Equipment Size	Various

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	April 12, 2016
Review Date	

Referenced Documents:

- Econorthwest TRM Review – 6/23/10
- IECC 2006

TRM Review Actions:

- 6/23/10 Rec. #23 – Utilize IECC 2006 Efficiencies as the Baseline Efficiency and Efficient Packaged

Unit 15% better than IECC 2006 – Adopted

- 6/23/10 Rec. #24 - break down the savings by chiller type and size. Conduct additional research for future program years to calibrate claimed savings for Hawaii customer base. - Adopted

Major Changes:

- Chiller efficiency selected at 15% improvement over IECC 2006.
- 4/12/2016 – Added second requirement of 15% improvement over IECC for full load efficiency (COP) in addition to 15% improvement over IECC for part load efficiency (IPLV) per requirements of IECC 2006. Qualifying chillers must meet both COP and IPLV efficiency requirements.

Description: The replacement of chillers with Energy Efficiency above the code efficiency values in place at the time of permitting the project. In multiple unit chiller plants, a review of operational chillers will be conducted to determine what fraction of installed chillers will be incentivized. This is to avoid paying for standby units.



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4.5.1.1 Water Cooled Chiller Efficiency

High Efficiency Chiller - 15% higher than IECC 2006

Table 4.5.1.a: IECC 2006 minimum kW/Ton vs. Hawai'i Energy efficiency

		IECC 2006 IPLV (kW/Ton)	Hawaii Energy Premium Efficiency (kW/Ton)
Reciprocating	All	0.70	0.61
Rotary Screw and Scroll	< 150 tons	0.68	0.59
	150-300 tons	0.63	0.55
	> 300 tons	0.57	0.50
Centrifugal	< 150 tons	0.67	0.58
	150-300 tons	0.60	0.52
	> 300 tons	0.55	0.48

4.5.1.2 Air Cooled Chiller Efficiency

Table 4.5.1.b: Air Cooled Chiller Efficiency Requirements

2006 IECC

Equipment Type	Size	Min Eff	Type	kW/ton	15% Better kW/ton	Test Procedure
Air cooled, with condenser, electrically operated	< 150 tons	2.80	COP	1.256	1.068	ARI 550/590
		2.80	IPLV	1.256	1.068	
	>= 150 tons	2.50	COP	1.407	1.196	
		2.50	IPLV	1.407	1.196	



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4.5.1.3 Water Cooled Energy Savings

High Efficiency Chiller - 15% higher than IECC 2006 - Energy Reduction (kWh/Ton)

Table 4.5.1.c: Water Cooled Chiller Energy Savings

Building Type	Reciprocating	Rotary Screw or Scroll			Centrifugal		
	All	<150	150-300	>300	<150	150-300	>300
Misc. Commercial	312.5	303.6	281.2	254.4	299.1	267.8	245.5
Cold Storage	536.7	521.3	483.0	437.0	513.7	460.0	421.7
Education	307.9	299.1	277.1	250.7	294.7	263.9	241.9
Grocery	536.7	521.3	483.0	437.0	513.7	460.0	421.7
Health	435.7	423.3	392.1	354.8	417.0	373.5	342.3
Hotel/Motel	312.4	303.5	281.2	254.4	299.0	267.8	245.5
Industrial	435.7	423.3	392.1	354.8	417.0	373.5	342.3
Office	520.1	505.3	468.1	423.5	497.8	445.8	408.7
Restaurant	349.0	339.0	314.1	284.2	334.1	299.2	274.2
Retail	273.9	266.1	246.5	223.1	262.2	234.8	215.2
Warehouse	536.7	521.3	483.0	437.0	513.7	460.0	421.7

4.5.1.4 Air Cooled Energy Savings

Table 4.5.1.d: Air Cooled Chiller Energy Savings

Air Cooled Chiller Energy Savings (kWh/Ton)		
Building Type	Chiller <150 tons	Chiller >= 150 tons
Misc. Commercial	559.5	627.9
Cold Storage	960.9	1078.5
Education	551.2	618.7
Grocery	960.9	1078.5
Health	780.1	875.6
Hotel/Motel	559.3	627.8
Industrial	780.1	875.6
Office	931.3	1045.2
Restaurant	624.9	701.4
Retail	490.5	550.5
Warehouse	960.9	1078.5



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4.5.1.5 Water Cooled Demand Savings

Table 4.5.1.e: Water Cooled Chiller Demand Savings

High Efficiency Chiller - 15% higher than IECC 2006 - Demand Reduction (kW/Ton)

Building Type	Reciprocating	Rotary Screw or Scroll			Centrifugal		
	All	<150	150-300	>300	<150	150-300	>300
Misc. Commercial	0.064	0.062	0.058	0.052	0.061	0.055	0.050
Cold Storage	0.072	0.070	0.065	0.059	0.069	0.062	0.057
Education	0.084	0.082	0.076	0.068	0.080	0.072	0.066
Grocery	0.056	0.054	0.050	0.045	0.053	0.048	0.044
Health	0.071	0.069	0.064	0.058	0.068	0.061	0.056
Hotel/Motel	0.055	0.053	0.049	0.044	0.052	0.047	0.043
Industrial	0.064	0.062	0.058	0.052	0.061	0.055	0.050
Office	0.048	0.047	0.043	0.039	0.046	0.041	0.038
Restaurant	0.056	0.054	0.050	0.045	0.053	0.048	0.044
Retail	0.069	0.067	0.062	0.056	0.066	0.059	0.054
Warehouse	0.063	0.061	0.057	0.051	0.060	0.054	0.050



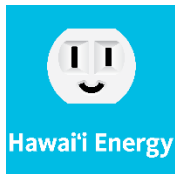
4.5.1.6 Air Cooled Demand Savings

Table 4.5.1.f: Air Cooled Chiller Demand Savings

Air Cooled Chiller Demand Savings (kW/Ton)		
Building Type	Chiller <150 tons	Chiller >= 150 tons
Misc. Commercial	0.094	0.106
Cold Storage	0.094	0.106
Education	0.038	0.042
Grocery	0.16	0.179
Health	0.122	0.137
Hotel/Motel	0.113	0.127
Industrial	0.094	0.106
Office	0.094	0.106
Restaurant	0.141	0.158
Retail	0.113	0.127
Warehouse	0.085	0.095

Measure Life

20 years (DEER)



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4.5.2 Conventional Air Conditioners and Condensing Units—Packaged/Split

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Packaged Split
Equipment Subtype	Air-cooled Water/Evaporatively-cooled
Equipment Size	<65,000 >=65,000 <135,000 >=135,000 <240,000 >=240,000 <760,000 >=760,000

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	
Review Date	October 5, 2011

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

Efficient equipment:

Conventional, packaged or split air conditioners and condensing units whose rated efficiency is better than baseline equipment rated or measured efficiency

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

ALGORITHMS²

$$\Delta P_{peak, per\ ton} = CF \times \left(12000 \frac{BTU}{hr} \right) \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{he}} \right) \left(\frac{1\ kW}{1000\ W} \right)$$
$$\Delta E_{annual, per\ ton} = HRS \times \left(12000 \frac{BTU}{hr} \right) \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{he}} \right) \left(\frac{1\ kW}{1000\ W} \right)$$

² HVAC equipment of this type may be specified by cooling capacity in BTU per hour, or in tons. 1 ton of cooling capacity is equal to 12,000 BTU/hr of cooling capacity. To determine total equipment energy savings, multiply the energy savings per ton by the total rated (nominal) cooling capacity of the proposed equipment.



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Table 4.5.2.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES
ΔP	Power demand reduction	Calculated
ΔE	Energy reduction	Calculated
η_{base}	Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment. (S)EER	Table 4.5.3.b
η_{he}	Proposed higher efficiency rating, BTU/hr-W. (S)EER	Table 4.5.3.b
CF	coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm	Table 4.5.3.b ³
HRS	equivalent full load cooling hours	Table 4.5.3.c ⁴
ton	unit of equipment cooling capacity	12,000 BTU/hr
Measure Life	expected duration of energy savings	15 years

Table 4.5.2.b: Packaged/Split Air Conditioner Baseline and Minimum Required Efficiencies

Unit Size, BTU/hr	η_{base} (S)EER	Minimum η_{he} (S)EER ^b	$\frac{kW}{ton_{base}}$	Minimum $\frac{kW}{ton_{he}}$
<65,000 air cooled ^a	9.7	11.2	1.364	1.159
65,000-134,999 air cooled	10.3	11.8	1.165	0.990
135,000-239,999 air cooled	9.7	11.2	1.237	1.052
240,000-759,999 air cooled	9.5	10.9	1.263	1.074
>=760,000 air cooled	9.2	10.6	1.304	1.109
<65,000 water/evaporative cooling ^c	12.1	13.9	0.992	0.862
65,000-134,999 water/evaporative cooling	11.5	13.2	1.043	0.907
135,000-239,999 water/evaporative cooling	11	12.7	1.091	0.949
240,000-759,999 water/evaporative cooling	11	12.7	1.091	0.949

Source: 2006 International Energy Conservation Code, Table 503.2.3(1), full load rated efficiency baseline. Air-cooled equivalent kW/ton are as reported in the PY16 TRM.

Notes:

³ Hawaii Energy TRM has published deemed unit savings tables by building type and cooling capacity range since 2011. These tables are likely derived from California DEER database simulated savings. Future TRM versions will consider utilizing literature values for CF and HOURS to calculate savings.

⁴ See footnote 13.



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- a) Code efficiency for air-cooled packaged system applied as per direction from Econorthwest in 2011. Code compliant air-cooled split systems at this size are rated 10.0 SEER.
- b) Proposed measure efficiency is set 15% higher than baseline.
- c) water/evaporatively cooled a/c measures are newly differentiated

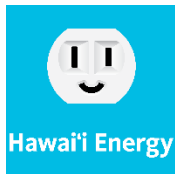
SAVINGS

Table 4.5.2.c: Approved peak kW savings per ton by building type and cooling capacity (BTU/hr)

Building Type	<65,000 BTU/hr	65,000 to 134,999	135,000 to 239,999	240,000 to 759,999	>=760,000 BTU/hr
Misc. Commercial	0.061	0.052	0.056	0.057	0.059
Cold Storage	0.102	0.087	0.093	0.095	0.098
Education	0.041	0.035	0.037	0.038	0.039
Grocery	0.174	0.149	0.158	0.161	0.166
Health	0.133	0.114	0.121	0.123	0.127
Hotel/Motel	0.123	0.105	0.111	0.114	0.117
Industrial	0.102	0.087	0.093	0.095	0.098
Office	0.102	0.087	0.093	0.095	0.098
Restaurant	0.153	0.131	0.139	0.142	0.147
Retail	0.123	0.105	0.111	0.114	0.117
Warehouse	0.092	0.079	0.084	0.085	0.088
Military	0.190	0.190	0.190	0.190	0.190

Table 4.5.2.d: Approved annual kWh savings per ton by building type and cooling capacity (BTU/hr)

Building Type	<65,000 BTU/hr	65,000 to 134,999	135,000 to 239,999	240,000 to 759,999	>=760,000 BTU/hr
Misc. Commercial	608.7	520.1	552.2	563.9	582.3
Cold Storage	1045.4	893.2	948.5	968.4	1000.0
Education	599.7	512.4	544.1	555.5	573.7
Grocery	1045.4	893.2	948.5	968.4	1000.0
Health	848.8	725.2	770.0	786.2	811.9
Hotel/Motel	608.5	519.9	552.1	563.7	582.1
Industrial	848.8	725.2	770.0	786.2	811.9
Office	1013.2	865.7	919.2	938.6	969.2
Restaurant	679.9	580.9	616.8	629.8	650.3
Retail	533.6	455.9	484.1	494.3	510.4
Warehouse	1045.4	893.2	948.5	968.4	1000.0
Military	559.5	559.5	559.5	559.5	559.5



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4.5.3 VFD on Chilled Water/Condenser Water Pump; AHU

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	VFD
Equipment Subtype	Air Handler Fan Chilled Water Pump Condenser Water Pump
Equipment Size	None

VERSION HISTORY

Draft Date	March 4, 2016
Revision Date	May 19, 2016
Review Date	

Measure Description:

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

Unit of Measure:

One VFD

Baseline equipment:

A chilled water/condenser water motor/pump with no VFD. The pump/motor is assumed to be a 10 HP motor running at full power for 6000 hours per year.

Efficient equipment:

Motor/pump with VFD installed.

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)
- For existing facilities, motor HP must be between 3 and 100.
- For new facilities, motor HP must be between 3 and 50.
- The VFDs must actively control and vary the pump speed.

ALGORITHMS

$$\Delta P_{peak,per\ HP} = CF \times \left(\frac{LF \times SF_{power}}{\eta} \right) \times \left(1\ HP \times \frac{0.746\ kW}{1\ HP} \right)$$
$$\Delta E_{annual,per\ HP} = HRS \times \left(\frac{LF \times SF_{energy}}{\eta} \right) \times \left(1\ HP \times \frac{0.746\ kW}{1\ HP} \right)$$



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Table 4.5.3.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES
ΔP	Power reduction	Calculated
ΔE	Energy reduction	Calculated
LF	Load factor (% of full load power in typical operation)	75%
η	Motor efficiency	92%
SF_{power}	Power demand savings factor, %	Table 4.5.4.b
SF_{energy}	Energy savings factor, %	Table 4.5.4.b
CF	Coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm	Table 4.5.4.b
HRS	Hours of pump operation per year	Table 4.5.4.b
$Measure\ Life$	Expected duration of energy savings	15

Table 4.5.3.b: Assumptions for VFD Savings Calculations

Controlled Motor System	SF_{power}	SF_{energy}	PY2015 CF ¹	HOURS ²	Calculated ³ $SF_{power} \times CF$
Chilled Water Pump	N/A	24.74%	1.63	6000	0.403
Condenser Water Pump	N/A	24.74%	1.63	6000	0.403
HVAC Fan	N/A	20.85%	1.58	3720	0.329

Notes:

1. Pump CF is derived in the PY2015 TRM assuming DSMIS deemed kW savings of 0.245 per HP and average kW savings for a 10 HP pump of 1.50.
2. Hours by Building Type are shown in Table 4.5.4.d.
3. In other TRM sources (e.g. PA TRM), VFD load savings factor differs from energy savings factor. Since both SF_{power} and CF are unknowns for Hawaii Energy, we combine into one factor to derive the peak kW output correctly below.

SAVINGS

Table 4.5.3.c

peak kW savings per pump HP	0.245
annual kWh savings per pump HP	902.7
peak kW savings per fan HP	0.200
annual kWh savings per fan HP	471.7



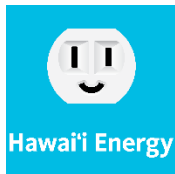
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Table 4.5.3.d: VFD AHU Energy and Demand Savings by Building Type

Building Type	Hours	Demand Savings (kW/HP)	Energy Savings (kWh/HP)
Misc. Commercial	3,720	0.20	471.69
Cold Storage	6,389	0.20	810.12
Education	3,665	0.20	464.72
Grocery	6,389	0.20	810.12
Health	5,187	0.20	657.71
Hotel/Motel	3,719	0.20	471.57
Industrial	5,187	0.20	657.71
Office	6,192	0.20	785.14
Restaurant	4,155	0.20	526.85
Retail	3,261	0.20	413.49
Warehouse	6,389	0.20	810.12

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations p 112



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4.5.4 Variable Refrigerant Flow (VRF) Air Conditioners and Heat Pumps: Packaged/Split

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Split
Equipment Subtype	Air cooled Water/Evaporatively-cooled
Equipment Size	Varies

VERSION HISTORY

Draft Date	March 4, 2016
Revision Date	
Review Date	

Measure 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.

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

Efficient 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.

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

ALGORITHMS⁵

⁵ HVAC equipment of this type may be specified by cooling capacity in BTU per hour, or in tons. 1 ton of cooling capacity is equal to 12,000 BTU/hr of cooling capacity. To determine total equipment energy savings, multiply the energy savings per ton by the total rated (nominal) cooling capacity of the proposed equipment.



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peak kW savings per ton $= (12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * CF) / 1000 \text{ W/kW}$

annual kWh savings per ton $= (12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * \text{HOURS}) / 1000 \text{ W/kW}$

Table 4.5.4.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES	Notes
(S)EER_b	Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment.	Table 4.5.5.b	Units less than 65,000 BTU/hr are rated in SEER rather than EER. Hawaii Energy assumes Honolulu code IECC 2006
(S)EER_ee	Proposed measure rated efficiency, BTU/hr-W.	Table 4.5.5.b	Units less than 65,000 BTU/hr are rated in SEER rather than EER. Hawaii Energy applies a default 15% better than code qualifying efficiency.
CF	coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm	Table 3.1	
HOURS	equivalent full load cooling hours	Table 3.2	
ton	unit of equipment cooling capacity	12,000 BTU/hr	
Measure Life	expected duration of energy savings	15 years	

Table 4.5.4.b: VRF Air Conditioning Systems, Baseline and Minimum Program Efficiencies

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 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



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>=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	

Source: ANSI/ASHRAE/IES Standard 90.1 2010, Table 6.8.1J

Notes:

- 1) These efficiencies 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 requires VRF to exceed minimum standard efficiencies by 10%.
- 2) VRF multi-split 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

Table 4.5.4.c: Peak kW 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	>=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

Table 4.5.4.d: 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	>=760,000
Misc. Commercial	730.4	624.1	662.6	676.7	698.8
Cold Storage	1254.5	1071.8	1138.2	1162.1	1200.0
Education	719.6	614.9	652.9	666.6	688.4
Grocery	1254.5	1071.8	1138.2	1162.1	1200.0



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Health	1018.6	870.2	924.0	943.4	974.3
Hotel/Motel	730.2	623.9	662.5	676.4	698.5
Industrial	1018.6	870.2	924.0	943.4	974.3
Office	1215.8	1038.8	1103.0	1126.3	1163.0
Restaurant	815.9	697.1	740.2	755.8	780.4
Retail	640.3	547.1	580.9	593.2	612.5
Warehouse	1254.5	1071.8	1138.2	1162.1	1200.0



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4.5.5 Hotel Room Energy Management System (EMS) Controls

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Controls
Equipment Subtype	Guest Room Energy Management System
Equipment Size	None

VERSION HISTORY

Draft Date
Revision Date
Review Date

Unit of Measure:
Number of Rooms

Baseline equipment:
No EMS controls

Efficient equipment:
Room EMS controls

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).

ALGORITHMS

peak kW savings per room = $0.10\text{kW}/\text{room} * \#\text{ROOMS}$

annual kWh savings per room = $750\text{kWh}/\text{room} * \#\text{ROOMS}$

Table 4.5.5.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES	Notes
kW/room	deemed demand savings per hotel room/unit	0.100	kW



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kWh/room	deemed energy savings per hotel room/unit	750.00	kWh
#ROOMS	input number of rooms controlled by installed EMS system		rooms
Measure Life	expected duration of energy savings	8	years

SAVINGS

Table 4.5.5.b: Savings per Hotel Room EMS Controls

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
Hotel Room EMS Controls	0.100	750.00



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4.6 Lighting Measures

4.6.1 Compact Fluorescent Lighting (CFL)

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Fluorescent: CFL
Equipment Subtype	None
Equipment Size	Various

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	
Review Date	

Referenced Documents:

- Econorthwest TRM Review – 6/23/10
- The California Energy Commission California Commercial End Use Summary
<http://www.energy.ca.gov/ceus/>
- DEER - The Database for Energy Efficient Resources
- Evergreen TRM Review – 2/23/12
- Evergreen TRM Review – 1/15/14

TRM Review Actions:

- 6/23/10 Rec. 15 – For PY 2010, revise lighting hours of operation and peak coincidence factors, conduct additional research to evaluate the assumed hours of operation and coincidence factor for Hawaii customer base. - Adopted
- 6/23/10 Rec. # 16 – Consider developing commercial CFL measure categories by lamp size - Adopted.
- 10/5/11 – Currently Under Review.
- 8/1/12 – Added military housing CFL algorithm.

Major Changes:

- Wholesale replacement of prior TRM using DEER operational data and CEUS Commercial CFL Data
- Added interactive effect factors for energy and demand Table 3.

Description:



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A compact fluorescent lamp is a type of fluorescent lamp. Many CFL's are designed to replace an incandescent lamp and can fit in the existing light fixtures formerly used for incandescent lamps. CFLs typically replace 100 watts or less of incandescent.

CFL retrofit savings are determined by the delta wattage between the incandescent and CFL lamp, annual hours of operation, and the percent of peak period the lamps are on. The average delta wattage is typically a readily available value. The annual hours, persistence factor and peak percent are utilized based on DEER data.

Although the breakdown of lamp sizes installed is reasonable, the savings for this measure could be broken up based on lamp size. This would allow greater flexibility in matching claimed savings to actual projects completed. Savings for each wattage category are based on the savings for typical CFL lighting replacement projects from DEER, with the DEER wattage categories are shown below:

Table 4.6.1.a

CFL Wattage Reduction

	CFL Wattage Reduction		
	< 16W	16-26W	> 26W
Average Savings (W)	32	39.5	46

Energy Savings: (see Table 3.2 for Interactive Effect):



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Table 4.6.1.b

Building Type	CFL Energy Reduction		
	< 16W	16-26W	> 26W
All Commercial	131.5	162.3	189.0
Misc. Commercial	131.5	162.3	189.0
Cold Storage	126.5	156.1	181.8
Education	80.7	99.6	115.9
Grocery	177.0	218.5	254.5
Health	196.8	242.9	282.9
Hotel/Motel	150.2	185.4	215.9
Misc. Industrial	130.4	161.0	187.5
Office	85.4	105.4	122.7
Restaurant	160.5	198.1	230.6
Retail	128.0	158.0	184.0
Warehouse	126.5	156.1	181.8

Military Housing CFL energy savings: 46.2 kWh

Table 4.6.1.c

Military Residential Values	kWh/year	kW
CFLs	46.2	0.004

Demand Savings: (see Table 3.2 for Interactive Effect):



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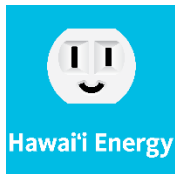
Table 4.6.1.d

Building Type	CFL Demand Reduction		
	< 16W	16-26W	> 26W
All Commercial	0.016	0.020	0.023
Misc. Commercial	0.010	0.012	0.014
Cold Storage	0.016	0.020	0.023
Education	0.006	0.008	0.009
Grocery	0.027	0.034	0.039
Health	0.021	0.026	0.030
Hotel/Motel	0.019	0.024	0.028
Misc. Industrial	0.016	0.020	0.023
Office	0.016	0.020	0.023
Restaurant	0.024	0.030	0.035
Retail	0.019	0.024	0.028
Warehouse	0.014	0.018	0.021

Military Housing CFL demand savings: 0.004 kW

Measure Life

3 years (DEER)



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4.6.2 Fluorescent Delamping

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Fluorescent: Delamping with Reflectors Delamping without Reflectors
Equipment Subtype	None
Equipment Size	2-ft lamp 3-ft lamp 4-ft lamp 8-ft lamp

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	May 19, 2016
Review Date	

Measure Description:

The ballasts are re-wired for de-lamping.

Unit of Measure:

One lamp

Baseline equipment:

T8 lamp operating in an existing multi-lamp fixture that is a candidate for delamping

Efficient equipment:

Permanently removed T8 lamp in a retrofitted fixture that may include a new reflector

Program criteria:

Removal of tombstone (lamp holder) required for each lamp removed

ALGORITHMS

$$\text{kW savings per lamp} = \Delta W / 1000 * IF_d * CF * PF$$

$$\text{kWh savings per lamp} = \Delta W / 1000 * IF_e * EFLH * PF$$

$$\Delta W = W_b - W_{ee}$$

Table 4.6.2.a

<u>DEFINITIONS & ASSUMPTIONS</u>		
delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.2.b



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W_b	wattage of the baseline lamp	Table 4.6.2.b
W_ee	wattage of the proposed efficient lamp	Table 4.6.2.b
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
Measure Life	expected duration of energy savings	Table 4.6.2.b

Table 4.6.2.b: Delamping Measure Assumed Wattage Reductions

Lighting Type	Size	Measure Life	Delta_W
Delamping with Reflectors	2' Lamp	14	18.5
Delamping with Reflectors	8' Lamp	14	77
Delamping with Reflectors	4' Lamp	14	34.5
Delamping without Reflectors	8' Lamp	14	77
Delamping without Reflectors	4' Lamp	14	34.5
Delamping without Reflectors	2' Lamp	14	18.5

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016, pp.78-105.

SAVINGS⁶

Table 4.6.2.c: Delamping Measure Demand Savings per Lamp Removed, No Reflector

Approved Delamping, No Reflector	Demand Savings (kW)			
Building Type	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	0.006	0.008	0.010	0.023
Cold Storage	0.009	0.014	0.017	0.039
Education	0.004	0.006	0.007	0.015
Grocery	0.016	0.023	0.029	0.065

⁶ Demand and energy savings per lamp estimates as reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016. These are applied as deemed values to estimate lighting savings for the current program year.



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Health	0.012	0.018	0.022	0.050
Hotel/Motel	0.011	0.017	0.021	0.046
Industrial	0.009	0.014	0.017	0.039
Office	0.009	0.014	0.017	0.039
Restaurant	0.014	0.021	0.026	0.058
Retail	0.011	0.017	0.021	0.046
Warehouse	0.008	0.012	0.016	0.035

Table 4.6.2.d: Delamping Measure Energy Savings per Lamp Removed, No Reflector

Approved Delamping No Reflector	Energy Savings (kWh/year)			
Building Type	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	80.0	118.9	149.2	333.0
Cold Storage	77.0	114.4	143.5	320.3
Education	49.1	73.0	91.5	204.3
Grocery	107.7	160.2	200.9	448.4
Health	119.8	178.0	223.4	498.5
Hotel/Motel	91.4	135.9	170.5	380.5
Industrial	79.4	118.0	148.0	330.3
Office	51.9	77.2	96.9	216.2
Restaurant	97.6	145.1	182.1	406.4
Retail	77.9	115.8	145.2	324.2
Warehouse	77.0	114.4	143.5	320.3

Table 4.6.2.e: Delamping Measure Demand Savings per Lamp Removed, with Reflector

Approved Delamping with Reflectors	Demand Savings (kW)			
Building Type	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	0.006	0.008	0.010	0.023
Cold Storage	0.009	0.014	0.017	0.039
Education	0.004	0.006	0.007	0.015
Grocery	0.016	0.023	0.029	0.065
Health	0.012	0.018	0.022	0.050
Hotel/Motel	0.011	0.017	0.021	0.046
Industrial	0.009	0.014	0.017	0.039
Office	0.009	0.014	0.017	0.039
Restaurant	0.014	0.021	0.026	0.058
Retail	0.011	0.017	0.021	0.046
Warehouse	0.008	0.012	0.016	0.035

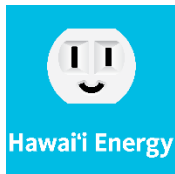


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Table 4.6.2.f: Delamping Measure Energy Savings per Lamp Removed, with Reflector

Approved Delamping with Reflectors	Energy Savings (kWh/year)			
Building Type	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	80.0	118.9	149.2	333.0
Cold Storage	77.0	114.4	143.5	320.3
Education	49.1	73.0	91.5	204.3
Grocery	107.7	160.2	200.9	448.4
Health	119.8	178.0	223.4	498.5
Hotel/Motel	91.4	135.9	170.5	380.5
Industrial	79.4	118.0	148.0	330.3
Office	51.9	77.2	96.9	216.2
Restaurant	97.6	145.1	182.1	406.4
Retail	77.9	115.8	145.2	324.2
Warehouse	77.0	114.4	143.5	320.3



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4.6.3 Linear Fluorescent Lamps

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Fluorescent: T12 to 28W LWT8 T12 to Standard T8 T8 to 28W LWT8
Equipment Subtype	None
Equipment Size	2-ft lamp 3-ft lamp 4-ft lamp 8-ft lamp

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	May 19, 2016
Review Date	

Unit of Measure:

One lamp

Baseline equipment:

Less-efficient linear fluorescent lamp operating in an existing fixture or specified for a new fixture

Efficient equipment:

High performance or low wattage (28W or lower) T8 fluorescent lamp installed and operating in a new or existing fixture

Program criteria:

Lamp requirements:

- Both T8 lamps and electronic ballasts must be installed.
- 265 mA lamps in lengths of 2 and 3 ft. (whether straight or U- bend)
- HO (high output) 400 mA lamps will also be accepted.
- Lamp efficacy must be > 82 lumens per watt.
- 20,000-hour lamp life (3 hours per start) lamps.
- Minimum Color Rendering Index (CRI) of 75.

Ballast requirements:

- Operate at 20 kHz or greater.
- Rated a Class P thermal protection.
- Rated a Class A sound level.
- Have a minimum power factor of 90%.
- Have a maximum of 1.7 crest factor.
- Have a total harmonic distortion (THD) not to exceed 20% (equal to magnetic ballasts).
- Comply with FCC Rules and Regulations, Part 18 for both EMI and RFI.
- Have a reduced lamp flicker maximum of 10%.



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LW T8 Fluorescent requirements:

- Must be 25-watt or 28-watt and qualified under CEE.
- Initial lamp efficacy must be > 93 lumens per watt.

T8 High Performance Electronic Ballast requirements:

- Ballast must be qualified under CEE Specifications. Visit www.cee1.org for list of qualifying lamps and ballasts.

SAVINGS⁷

4.6.3.1 Approved T12 to T8 with electronic ballast

Table 4.6.3.a: T12 to Standard T8 Lamp Demand Savings per Lamp by Building Type and Lamp Size

Building Type	Demand Savings (kW)			
	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	0.002	0.004	0.006	0.012
Cold Storage	0.004	0.007	0.010	0.020
Education	0.002	0.003	0.004	0.008
Grocery	0.007	0.011	0.016	0.034
Health	0.005	0.008	0.013	0.026
Hotel/Motel	0.005	0.008	0.012	0.024
Industrial	0.004	0.007	0.010	0.020
Office	0.004	0.007	0.010	0.020
Restaurant	0.006	0.010	0.014	0.030
Retail	0.005	0.008	0.012	0.024
Warehouse	0.004	0.006	0.009	0.018

Table 4.6.3.b: T12 to Standard T8 Energy Savings per Lamp by Building Type and Lamp Size

Building Type	Energy Savings (kWh/year)			
	2' Lamp	3' Lamp	4' Lamp	8' Lamp
Misc. Commercial	35.9	56.4	83.2	170.8
Cold Storage	34.5	54.3	80.0	164.3
Education	22.0	34.6	51.0	104.8
Grocery	48.3	76.0	112	230.0
Health	53.7	84.5	124.5	255.7

⁷ Demand and energy savings per lamp estimates as reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016. These are applied as deemed values to estimate lighting savings for the current program year.



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Hotel/Motel	41.0	64.5	95.0	195.2
Industrial	35.6	56.0	82.5	169.5
Office	23.3	36.6	54.0	110.9
Restaurant	43.8	68.9	101.5	208.5
Retail	34.9	54.9	81.0	166.3
Warehouse	34.5	54.3	80.0	164.3

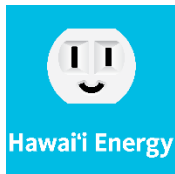
4.6.3.2 T12 to T8 Low Wattage

Table 4.6.3.c: T12 to 28W or Low Wattage T8 Savings per Lamp by Building Type

Building Type	Demand Savings (kW)	Energy Savings (kWh/year)
Misc. Commercial	0.005	78.1
Cold Storage	0.009	75.1
Education	0.004	47.9
Grocery	0.015	105.1
Health	0.012	116.9
Hotel/Motel	0.011	89.2
Industrial	0.009	77.4
Office	0.009	50.7
Restaurant	0.014	95.3
Retail	0.011	76.0
Warehouse	0.008	75.1

Table 4.6.3.d: T12 to Low Wattage T8 Savings per Lamp by Building Type

Building Type	Demand Savings (kW)	Energy Savings (kWh/yr)
Misc. Commercial	0.005	21.6
Cold Storage	0.009	37.4
Education	0.004	10.6
Grocery	0.015	87.4
Health	0.012	77.7
Hotel/Motel	0.011	54.4
Industrial	0.009	38.6
Office	0.009	25.3
Restaurant	0.014	73.9
Retail	0.011	46.3
Warehouse	0.008	33.3



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4.6.4 Linear LED Lamps

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Linear Type A Linear Type B Linear Type C
Equipment Subtype	None
Equipment Size	2-ft. Lamp 4-ft. Lamp

VERSION HISTORY

Draft Date	November 30, 2011
Revision Date	
Review Date	

Unit of Measure:

One lamp

Baseline equipment:

Representative average lamp blending fluorescent T12 and T8 wattage rounded to the nearest hundredth.

Table 4.6.4.a

	Lamp	Watts	%Blend
2' Linear T8 or T12 baseline	T12	21.00	20%
	T8	15.00	80%
	Weighted baseline	16.20	
4' Linear T8 or T12 baseline	T12	42.00	20%
	T8	29.58	80%
	Weighted baseline	32.06	

Watts Source: Standard market available lamps

Blend Source: Program estimate

Efficient equipment:

LED linear replacement lamp

Type A installation: Ballast left in place, reduced savings due to losses.

Type B installation: Bypassing fluorescent ballast and utilizing internal LED driver.

Type C installation: Removing fluorescent ballast and utilizing an external driver; more efficient than the Type B internal driver, however also consumes a little more power.

Therefore, this Program assumes Types B & C energy and demand savings to be equivalent. However, a Type C installation is preferred for longevity due to use of an external LED driver and complete removal of the fluorescent ballast. This is the reason for the increased incentive level for Type C installations.



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Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS

$$\text{kW savings per lamp} = \text{delta_W} / 1000 * \text{IF_d} * \text{CF} * \text{PF}$$

$$\text{kWh savings per lamp} = \text{delta_W} / 1000 * \text{IF_e} * \text{EFLH} * \text{PF}$$

$$\text{delta_W} = \text{W_b} - \text{W_ee}$$

Table 4.6.4.b

DEFINITIONS & ASSUMPTIONS ⁸		
delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.4.c
W_b	wattage of the baseline lamp	Table 4.6.4.c
W_ee	wattage of the proposed efficient lamp	Table 4.6.4.c
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
Measure Life	expected duration of energy savings	15

Table 4.6.4.c: Power Demand Reduction Calculation

Installation Type	Size	W_b	W_ee	delta_W
Type A	4' lamp	32.06	17.50	14.56
	2' lamp	16.20	10.50	5.70
Type B	4' lamp	32.06	15.00	17.06
	2' lamp	16.20	8.50	7.70
Type C	4' lamp	32.06	15.00	17.06

⁸ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.



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	2' lamp	15.00	16.20	8.50
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SAVINGS

Table 4.6.4.d: Linear LED Power Demand Savings by Building Type, Lamp Size, & Installation Type

Building Type	Demand Savings (kW)					
	2 ft.			4 ft.		
	Type A	Type B	Type C	Type A	Type B	Type C
Misc. Commercial	0.00184	0.00248	0.00248	0.00470	0.00550	0.00550
Cold Storage	0.00348	0.00470	0.00470	0.00888	0.01041	0.01041
Education	0.00118	0.00160	0.00160	0.00303	0.00355	0.00355
Grocery	0.00540	0.00729	0.00729	0.01379	0.01615	0.01615
Health	0.00457	0.00617	0.00617	0.01167	0.01367	0.01367
Hotel/Motel	0.00423	0.00571	0.00571	0.01080	0.01265	0.01265
Industrial	0.00306	0.00413	0.00413	0.00782	0.00916	0.00916
Office	0.00314	0.00424	0.00424	0.00802	0.00940	0.00940
Restaurant	0.00459	0.00620	0.00620	0.01172	0.01373	0.01373
Retail	0.00371	0.00501	0.00501	0.00948	0.01111	0.01111
Warehouse	0.00270	0.00365	0.00365	0.00690	0.00808	0.00808

Table 4.6.4.e: Linear LED Energy Savings by Building Type, Lamp Size, & Installation Type

Building Type	Energy Savings (kWh/year)					
	2 ft.			4 ft.		
	Type A	Type B	Type C	Type A	Type B	Type C
Misc. Commercial	26.03	35.17	35.17	66.50	77.92	77.92
Cold Storage	33.74	45.58	45.58	86.19	100.99	100.99
Education	16.04	21.67	21.67	40.98	48.02	48.02
Grocery	34.62	46.77	46.77	88.44	103.63	103.63
Health	41.40	55.93	55.93	105.76	123.92	123.92
Hotel/Motel	31.40	42.42	42.42	80.21	93.99	93.99
Industrial	25.50	34.45	34.45	65.15	76.33	76.33
Office	17.09	23.09	23.09	43.66	51.16	51.16
Restaurant	31.62	42.71	42.71	80.77	94.63	94.63
Retail	25.29	34.17	34.17	64.61	75.70	75.70
Warehouse	24.16	32.64	32.64	61.72	72.32	72.32

4.6.5 Non-Linear LED Lamps



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HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: MR16 LED: Omni-Directional LED: PAR20 LED: PAR30 LED: PAR38
Equipment Subtype	None
Equipment Size	Pin Base Screw Base (for Omni-Directional only)

VERSION HISTORY

Draft Date	October 31, 2016,
Revision Date	April, 2017
Review Date	

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

Efficient equipment:

LED lamp

Program criteria:

Incentivized LED lamps must be Energy Star labeled, LED Lighting Facts listed or Design Lights Consortium (DLC) listed.

ALGORITHMS

$$\Delta P_{ndim} = P_{base} - P_{LED}$$

$$\Delta P_{dim} = P_{base} - (1 - 0.36)P_{LED}$$

$$\Delta P_{blend} = \%_{dim}(\Delta P_{dim}) + \%_{ndim}(\Delta P_{ndim})$$

$$\text{kW savings per lamp} = \Delta P_{blend} \times IF_d \times CF \times PF$$

$$\text{kWh savings per lamp} = \Delta P_{blend} \times HRS \times IF_e \times PF$$



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Table 4.6.5.a

DEFINITIONS & ASSUMPTIONS			
ΔP_{ndim}	Power demand difference between non-dimmable and baseline	Table 4.6.5.c	kW
P_{base}	wattage of the baseline lamp	Table 4.6.5.b	kW
P_{LED}	wattage of the proposed efficient lamp	Table 4.6.5.b	kW
ΔP_{dim}	Power demand difference between dimmable and baseline 0.36 => dimmable demand reduction, 2015 PA TRM Table 3-5	Table 4.6.5.c	kW
ΔP_{blend}	Power demand difference between blended and baseline	Table 4.6.5.c	kW
% $_{dim}$	Percentage of LEDs that are dimmable	Table 4.6.5.c	%
% $_{ndim}$	Percentage of LEDs that are non-dimmable	Table 4.6.5.c	%
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2	---
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2	---
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 4.6.5.d	%
PF	persistence factor, % of measures installed and operating	100	%
HRS	equivalent full load hours, or hours of lighting for business operation	Table 4.6.5.d	hrs
Measure Life	expected duration of energy savings	15	yrs

SAVINGS

Table 4.6.5.b: Power Demand Calculation

Lamp	Base Case Incandescent Demand (kW)	Percent Incandescent Base	Base Case CFL Demand (kW)	Percent CFL Base	Base Mix Demand (kW)	Enhanced Case LED Demand (kW)
MR16	0.0500	100%	n/a	0%	0.0500	0.0065
PAR20 8 deg.	0.0600	80%	0.0150	20%	0.0510	0.0086
PAR20 25 deg.	0.0550	80%	0.0130	20%	0.0466	0.0090
PAR30 Short Neck ¹	0.0750	80%	0.0200	20%	0.0640	0.0163
PAR30 Long Neck ¹	0.0750	80%	0.0200	20%	0.0640	0.0163
PAR38 25 deg.	0.0750	80%	0.0200	20%	0.0640	0.0203
A-19	0.0600	20%	0.0150	80%	0.0240	0.0078

¹ PAR30 lamp savings used for short neck, long neck, and approved recessed-can retrofit kit

Table 4.6.5.c: Power Demand Reductions

Lamp	N-dim Demand Reduction (kW)	%N-Dim	Dim Demand Reduction (kW)	%Dim	Blended Demand Reduction (kW)
MR16	0.0435	34%	0.0458	66%	0.0450
PAR20 8 deg.	0.0424	92%	0.0455	8%	0.0426



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PAR20 25 deg.	0.0376	92%	0.0408	8%	0.0379
PAR30 Short Neck ¹	0.0477	73%	0.0536	27%	0.0493
PAR30 Long Neck ¹	0.0477	73%	0.0536	27%	0.0493
PAR38 25 deg.	0.0437	61%	0.0510	39%	0.0466
A-19	0.0162	88%	0.0190	12%	0.0165



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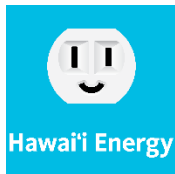
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Table 4.6.5.d: Energy & Power Demand Savings

			Blended Commercial Lighting									
			MR16		PAR20		PAR30 Short Neck/Long Neck		PAR38 25 deg.		A-19	
Building Type	Hours of Operation ¹	Peak Coincidence Factor ²	Energy Savings (kWh/year)	Demand Savings (kW)	Energy Savings (kWh/year)	Demand Savings (kW)	Energy Savings (kWh/year)	Demand Savings (kW)	Energy Savings (kWh/year)	Demand Savings (kW)	Energy Savings (kWh/year)	Demand Savings (kW)
Misc. Commercial	4,325	0.30	205.73	0.015	183.85	0.013	225.09	0.016	212.60	0.015	75.53	0.005
Cold Storage	4,160	0.50	266.65	0.027	238.29	0.025	291.75	0.030	275.56	0.028	97.89	0.010
Education	2,653	0.20	126.79	0.009	113.31	0.008	138.73	0.010	131.03	0.010	46.55	0.003
Grocery	5,824	0.85	273.62	0.043	244.52	0.038	299.37	0.047	282.77	0.044	100.45	0.016
Health	6,474	0.65	327.19	0.036	292.39	0.032	357.99	0.039	338.13	0.037	120.12	0.013
Hotel/Motel	4,941	0.60	248.16	0.033	221.76	0.030	271.52	0.037	256.45	0.035	91.11	0.012
Misc. Industrial	4,290	0.50	201.55	0.024	180.11	0.022	220.52	0.026	208.29	0.025	73.99	0.009
Office	2,808	0.50	135.09	0.025	120.72	0.022	147.80	0.027	139.60	0.026	49.59	0.009
Restaurant	5,278	0.75	249.87	0.036	223.29	0.032	273.39	0.040	258.22	0.037	91.73	0.013
Retail	4,210	0.60	199.88	0.029	178.62	0.026	218.69	0.032	206.56	0.030	73.38	0.011
Warehouse	4,160	0.45	190.95	0.021	170.64	0.019	208.92	0.023	197.33	0.022	70.10	0.008

1 The Database for Energy Efficient Resources (DEER)

2California Commercial End Use Summary (CEUS)



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4.6.6 LED Corn Cob

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Corn Cob
Equipment Subtype	None
Equipment Size	<150W 150W-249W 250W-399W 400W-499W

VERSION HISTORY

Draft Date
Revision Date
Review Date

Unit of Measure:

LED Corn Cob unit

Baseline equipment:

Metal halide lamp

Table 4.6.11.a

Existing Lamp Size Range	Excel MH Baseline	LED Wattage	Wattage Reduction	
50-100	93	20	73	Watts
150-175	173	36	137	Watts
250	295	54	241	Watts
400	456	106	350	Watts

<https://www.xcelenergy.com/staticfiles/xcel/Marketing/MN-Bus-Lighting-Input-Wattage-Guide.pdf>

Efficient equipment:

LED Corn Cob

Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS

Interior use savings algorithms:

$$\text{kW savings per unit} = \Delta W / 1000 * IF_d * CF * PF$$

$$\text{kWh savings per unit} = \Delta W / 1000 * IF_e * EFLH * PF$$



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$$\text{delta_W} = W_b - W_ee$$

Exterior use savings algorithms:

$$\text{kW savings per unit} = \text{delta_W} / 1000 * \text{ExtrCF} * \text{PF}$$

$$\text{kWh savings per unit} = \text{delta_W} / 1000 * \text{ExtrHrs} * \text{PF}$$

$$\text{delta_W} = W_b - W_ee$$

Table 4.6.6.b

DEFINITIONS & ASSUMPTIONS⁹		
delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.6.c
W_b	wattage of the baseline lamp	Table 4.6.6.c
W_ee	wattage of the proposed efficient lamp	Table 4.6.6.c
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
ExtrCF	Exterior lighting CF	0.75
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
ExtrHrs	Exterior lighting hours of operation	12 hours/day
Measure Life	expected duration of energy savings	15 ¹⁰

⁹ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.

¹⁰ 2015 PA TRM, Rev June 2015 - Section 3.1.2 New Construction Lighting (p.226)



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Table 4.6.6.c: LED Corn Cob Power Demand Reduction

Equipment size	W _b	W _{ee}	Delta W
50-100 Watts	93	20	73
150-175 Watts	173	36	137
250 Watts	295	54	241
400 Watts	456	106	350

SAVINGS

Table 4.6.6.d: Exterior-use LED Corn Cob Power Demand Savings by Wattage Range

Building Type	Demand Savings (kW)			
	<150W	150W-249W	250W-399W	400W-499W
Exterior	0.055	0.103	0.181	0.263

Table 4.6.6.e: Exterior-use LED Corn Cob Energy Savings by Wattage Range

Building Type	Energy Savings (kW)			
	<150W	150W-249W	250W-399W	400W-499W
Exterior	319.74	600.06	1,055.58	1,533.00

Table 4.6.6.f: LED Corn Cob Power Demand Savings by Building Type & Wattage Range

Building Type	Demand Savings (kW)			
	<150W	150W-249W	250W-399W	400W-499W
Misc. Commercial	0.024	0.044	0.078	0.113
Cold Storage	0.045	0.084	0.147	0.214
Education	0.015	0.028	0.050	0.073
Grocery	0.069	0.130	0.228	0.331
Health	0.059	0.110	0.193	0.281
Hotel/Motel	0.054	0.102	0.179	0.260
Industrial	0.039	0.074	0.129	0.188
Office	0.040	0.075	0.133	0.193
Restaurant	0.059	0.110	0.194	0.282
Retail	0.048	0.089	0.157	0.228
Warehouse	0.035	0.065	0.114	0.166

Table 4.6.6.g: LED Corn Cob Energy Savings by Building Type & Wattage Range

Building Type	Energy Savings (kWh/year)			
	<150W	150W-249W	250W-399W	400W-499W



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Misc. Commercial	333.41	625.71	1,100.70	1,598.52
Cold Storage	432.14	811.00	1,426.64	2,071.89
Education	205.48	385.63	678.37	985.19
Grocery	443.43	832.20	1,463.94	2,126.05
Health	530.26	995.14	1,750.58	2,542.34
Hotel/Motel	402.17	754.76	1,327.72	1,928.23
Industrial	326.64	613.00	1,078.35	1,566.06
Office	218.92	410.86	722.75	1,049.63
Restaurant	404.94	759.96	1,336.87	1,941.51
Retail	323.93	607.92	1,069.40	1,553.07
Warehouse	309.45	580.75	1,021.61	1,483.66



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4.6.7 LED Exit Signs

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Exit Sign
Equipment Subtype	None
Equipment Size	New LED fixture

VERSION HISTORY

Draft Date	January, 2010
Revision Date	May 19, 2016
Review Date	

Unit of Measure:

One sign

Baseline equipment:

Existing incandescent or compact fluorescent lighted exit sign fixture

Efficient equipment:

LED lighted exit sign fixture

Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS

$$\text{kW savings per lamp} = \text{delta_W} / 1000 * \text{IF_d} * \text{CF} * \text{PF}$$

$$\text{kWh savings per lamp} = \text{delta_W} / 1000 * \text{IF_e} * \text{EFLH} * \text{PF}$$

$$\text{delta_W} = \text{W_b} - \text{W_ee}$$

Table 4.6.7.a

<u>DEFINITIONS & ASSUMPTIONS</u> ¹¹		
delta_W	difference between baseline and proposed efficient lamp wattage	35

¹¹ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.



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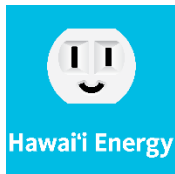
W_b	wattage of the baseline lamp	40
W_ee	wattage of the proposed efficient lamp	5
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	100%
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or annual hours of exit light operation	8760
Measure Life	expected duration of energy savings	15

SAVINGS¹²

Table 4.6.7.b: Demand & Energy Savings per lamp

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
LED Exit Sign	0.035	307

¹² Demand and energy savings per lamp estimates as reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016. These are applied as deemed values to estimate lighting savings for the current program year.



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4.6.8 LED Recessed Can

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Hardwired Recessed Can Kit
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date
Revision Date
Review Date

Unit of Measure:

One lamp.

Baseline equipment: PAR30 Short Neck 75W incandescent (80%) & 20W CFL (20%)

Efficient equipment: LED PAR30, 16.3W. Subject to dimmable & non-dimmable blend, see section 4.6.7 for details.

Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS

$$\text{kW savings per unit} = \Delta W / 1000 * IF_d * CF * PF$$

$$\text{kWh savings per unit} = \Delta W / 1000 * IF_e * EFLH * PF$$

$$\Delta W = W_b - W_{ee}$$

Table 4.6.8.a

e		
delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.8.c
W_b	wattage of the baseline lamp	Table 4.6.8.b
W_ee	wattage of the proposed efficient lamp	Table 4.6.8.b
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2



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IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
Measure Life	expected duration of energy savings	15

SAVINGS

See section 4.6.7 for more details on savings calculation. Recessed Can measure savings based on PAR30 lamp savings calculations.

Table 4.6.8.b: LED Recessed Can Demand Savings (kW) by Building Type

Building Type	Demand Savings – Blended dimmable/non-dimmable (kW)
Misc. Commercial	0.016
Cold Storage	0.030
Education	0.010
Grocery	0.047
Health	0.039
Hotel/Motel	0.037
Industrial	0.026
Office	0.027
Restaurant	0.040
Retail	0.032
Warehouse	0.023

Table 4.6.8.c: LED Recessed Can Energy Savings (kWh/year) by Building Type

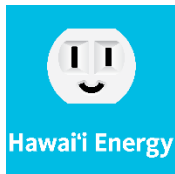
Building Type	Energy Savings – Blended dimmable/non-dimmable (kWh/year)
Misc. Commercial	225.09
Cold Storage	291.75
Education	138.73
Grocery	299.37
Health	357.99



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Hotel/Motel	271.52
Industrial	220.52
Office	147.80
Restaurant	273.39
Retail	218.69
Warehouse	208.92



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4.6.9 LED Refrigerated Case Lighting

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Refrigerated Case Lighting
Equipment Subtype	None
Equipment Size	4-ft. retrofit kit 5-ft. retrofit kit 6-ft. retrofit kit

VERSION HISTORY

Draft Date	October 3, 2011
Revision Date	May 19, 2016
Review Date	

Unit of Measure:

One kit

Baseline equipment:

Linear fluorescent lamp unit for illuminating refrigerated or freezer cases

Efficient equipment:

LED replacement lamp unit

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.

ALGORITHMS

Lighting kWh savings per lamp = $\text{delta_W} / 1000 * \text{EFLH} * \text{PF}$

Compressor kWh savings per lamp = $\text{Lighting kWh savings per lamp} / \text{COP}$

Total kWh savings per lamp = $\text{Lighting kWh savings per lamp} + \text{Compressor kWh savings per lamp}$

kW savings per lamp = $\text{Total kWh savings per lamp} / \text{EFLH}$

delta_W = $\text{W_b} - \text{W_ee}$



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Table 4.6.9.a

DEFINITIONS & ASSUMPTIONS¹³		
delta_W	difference between baseline and proposed efficient lamp wattage	17
W_b	wattage of the baseline lamp	40
W_ee	wattage of the proposed efficient lamp	23
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	100%
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation (17 hours per day, 365 days/year)	6205
COP	Compressor Coefficient of Performance (unitless efficiency)	1.12
Measure Life	expected duration of energy savings (years)	5

SAVINGS

Table 4.6.9.b: Demand & Energy Savings per lamp

	Peak Demand Savings (kW)	Energy Savings (kWh)
LED Refrigerated Case Lighting	0.032	199.7

¹³ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.



4.6.10 LED Street and Exterior Lighting

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Street and Exterior
Equipment Subtype	None
Equipment Size	Various

VERSION HISTORY

Draft Date	July 1, 2015
Revision Date	
Review Date	

Referenced Documents:

- PG&E Work Paper PGECOLTG151 (8/29/12)

TRM Review Actions:

- 8/1/14 – Currently Under Review.

Major Changes:

- New Measure

Measure Description:

Replacement of exterior HID fixtures with LED luminaires in outdoor street and exterior area applications.

Light emitting diode (LED) technology has proven to be an effective lighting source that can offer substantial savings over typical high intensity discharge (HID) lighting technologies.

The light is easily controllable and can be turned on and off instantly or dimmed for added energy savings at dawn and dusk.

LED streetlights are available from a variety of vendors and offer many advantages over traditional streetlight technologies.

- No mercury or other hazardous chemical and gasses in the LEDs
- Long lifetimes and highly reliable service, greatly reducing maintenance costs
- White light available in color temperatures from “warm” to “cool” with high CRI providing high-quality white light.



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Baseline & High Efficiency:

Table 4.6.10.a

Measure Name	Building Type	Base Case Wattage (W)	Measure Case Wattage (W)	Delta Watts (kW)	Annual Operating Hours	Energy Savings (kWh/yr)	Demand Reduction (kW)	Unit Definition	EUL
LED Street/Exterior Lighting - Replace up to a 70 W Lamp with LED	ANY	85	50	0.035	4100	144	0.0350	Fixture	12
LED Street/Exterior Lighting - Replace 71 to 100 W Lamp with LED	ANY	120	70	0.050	4100	205	0.0500	Fixture	12
LED Street/Exterior Lighting - Replace 101 to 150 W Lamp with LED	ANY	176	110	0.066	4100	271	0.0660	Fixture	12
LED Street/Exterior Lighting - Replace 151 to 200 W Lamp with LED	ANY	234	150	0.084	4100	344	0.0840	Fixture	12
LED Street/Exterior Lighting - Replace 201 to 250 W Lamp with LED	ANY	293	192	0.101	4100	414	0.1010	Fixture	12
LED Street/Exterior Lighting - Replace 251 to 310 W Lamp with LED	ANY	363	225	0.138	4100	566	0.1380	Fixture	12
LED Street/Exterior Lighting - Replace 311 to 400 W Lamp with LED	ANY	468	265	0.203	4100	832	0.2030	Fixture	12
Average Energy and Demand Savings						397	0.097		
Coincidence Factor (CF)	0.75								
Average Delta kW	0.097								
Peak Demand Savings	0.073								

Energy Savings:

Energy savings is based on the average kW reduction multiplied by hours of operation. Hours of operation is based on 4100 hours/year.

Average energy savings = 397 kWh/year

Demand Savings:

Demand savings is based on the average kW reduction = 0.097 kW

- Coincidence Factor = 0.75
- Coincidence factor is based on lights being on during 6PM-9PM which is 3 out of the 4 peak demand hour period.

Peak Demand Savings = CF x 0.097 = 0.073 kW

Program Restrictions and Guidelines

To qualify for an incentive, the following requirements must be met:

- The LEDs must replace high intensity discharge, low pressure sodium, or incandescent lighting.
- Proposed fixture must be ENERGY STAR, Design Lights Consortium (DLC) listed or Lighting Facts.
- The pole/arm-mounted area and roadway luminaires must meet a minimum efficacy of 60 lumens per watt.



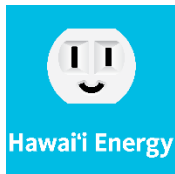
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- Luminaire/enclosure type must be certified by NEMA/IEC as wet location for exterior parking, roadway, area, or wall-mounted luminaires and damp (or wet) location for parking garage luminaires.
- Not to exceed the power supply manufacturer's maximum recommended case temperature or TMP when measured during in-situ operation. Note: This performance characteristic is separate and distinct from thermal requirements established by UL, which governs safety rather than longevity of the power supply.
- Luminaires must possess a power factor greater than 0.9.
- The LEDs must possess less than 20% of total harmonic distortion.
- A written warranty must be issued to the customer guaranteeing repair or replacement of defective electrical parts (including light source and power supplies) for a minimum of three (3) years from the date of purchase.
- A product cut sheet and installation instructions must be provided.

Measure Life = 12 years (source: PG&E white paper).

Hours of Operation = 4100 hours/year (based on HECO Schedule F).



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4.6.11 LED Troffer

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: Troffer
Equipment Subtype	None
Equipment Size	1 ft. x 4 ft. 2 ft. x 2 ft. 2 ft. x 4 ft.

VERSION HISTORY

Draft Date

Revision Date

Review Date

Unit of Measure:

One troffer unit

Baseline equipment:

Linear fluorescent fixture

Efficient equipment:

LED troffer

Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS

$$\text{kW savings per unit} = \Delta W / 1000 * IF_d * CF * PF$$

$$\text{kWh savings per unit} = \Delta W / 1000 * IF_e * EFLH * PF$$

$$\Delta W = W_b - W_{ee}$$

Table 4.6.11.a

DEFINITIONS & ASSUMPTIONS¹⁴	
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¹⁴ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.



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delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.11.b
W_b	wattage of the baseline lamp	Table 4.6.11.b
W_ee	wattage of the proposed efficient lamp	Table 4.6.11.b
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
Measure Life	expected duration of energy savings	15

Table 4.6.11.b: LED Troffer Power Demand Reduction

Equipment size	W_b	W_ee	Delta W
1ft. X 4ft.	61.6	35	26.6
2ft. X 2ft.	63.6	30	33.6
2ft. X 4ft.	109.2	40	69.2

SAVINGS

Table 4.6.11.c: LED Troffer Power Demand Savings (kW) by Building Type & Fixture Size

Building Type	1'x4' Fixture	2'x2' Fixture	2'x4' Fixture
Misc. Commercial	0.009	0.011	0.022
Cold Storage	0.016	0.020	0.042
Education	0.006	0.007	0.014
Grocery	0.025	0.032	0.066
Health	0.021	0.027	0.055
Hotel/Motel	0.020	0.025	0.051
Industrial	0.014	0.018	0.037
Office	0.015	0.019	0.038
Restaurant	0.021	0.027	0.056
Retail	0.017	0.022	0.045
Warehouse	0.013	0.016	0.033

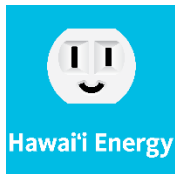


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Table 4.6.11.d: LED Troffer Energy Savings (kWh/year) by Building Type & Fixture Size

Building Type	1'x4' Fixture	2'x2' Fixture	2'x4' Fixture
Misc. Commercial	121.5	153.5	316.1
Cold Storage	157.5	198.9	409.6
Education	74.9	94.6	194.8
Grocery	161.6	204.1	420.4
Health	193.2	244.1	502.7
Hotel/Motel	146.5	185.1	381.2
Industrial	119.0	150.3	309.6
Office	79.8	100.8	207.5
Restaurant	147.6	186.4	383.9
Retail	118.0	149.1	307.1
Warehouse	112.8	142.4	293.3



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4.6.12 LED U-bend

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED: U-bend Type A LED: U-bend Type B LED: U-bend Type C
Equipment Subtype	None
Equipment Size	2 x 2 ft. 4 ft.

VERSION HISTORY

Draft Date

Revision Date

Review Date

Unit of Measure:

One lamp

Baseline equipment:

Fluorescent U-bend lamp,

Table 4.6.10.a

2'x2' FB U-bend baseline	Lamp	Watts	%Blend	Source	Ballast Factor
	T12	71.00	30%	Xcel energy	Normal
	T8	60.00	70%	Xcel energy	Normal
Weighted baseline		63.30			

<https://www.xcelenergy.com/staticfiles/xcel/MN-Bus-Lighting-Input-Wattage-Guide.pdf>

Efficient equipment:

LED U-bend lamp,

- 2 ft. – The two-foot LED retrofit replaces an existing 4 ft. fluorescent U-bend with a 2 ft. LED lamp. A standard 2 ft. x 2 ft. fixture has two U-bend lams. Therefore, the LED lamp wattage is calculated as two-times the 2 ft. linear lamp wattage [2*(LED: Linear 2' Lamp)]
- 4 ft. – The four-foot LED retrofit replaces an existing 4 ft. fluorescent U-bend with a 4 ft. LED U-bend. A standard 2 ft. x 2 ft. fixture has two U-bend lams. Therefore, the LED lamp wattage is calculated as two-times the 4 ft. linear lamp wattage [2*(LED: Linear 4' Lamp)]

Program criteria:

All LED lamps and fixtures must be listed by ENERGY STAR®, Design Lights Consortium (DLC) or LED Lighting Facts®.

ALGORITHMS



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$$\text{kW savings per unit} = \Delta W / 1000 * IF_d * CF * PF$$

$$\text{kWh savings per unit} = \Delta W / 1000 * IF_e * EFLH * PF$$

$$\Delta W = W_b - W_{ee}$$

Table 4.6.12.b

DEFINITIONS & ASSUMPTIONS¹⁵		
delta_W	difference between baseline and proposed efficient lamp wattage	Table 4.6.12.c
W_b	wattage of the baseline lamp	Table 4.6.12.c
W_ee	wattage of the proposed efficient lamp	Table 4.6.12.c
IF_d	factor reflecting impact of lighting savings on cooling load	Table 3.2
IF_e	factor reflecting impact of lighting savings on cooling energy	Table 3.2
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	Table 3.1
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	Table 3.1
Measure Life	expected duration of energy savings	15

Table 4.6.12.c: LED U-bend Power Demand Reduction

Equipment Type	Equipment Size	W_b	W_ee	Delta W
LED: U-bend Type A	2 ft. x 2 ft.	63.3	21	42.3
LED: U-bend Type B		63.3	17	46.3
LED: U-bend Type C		63.3	17	46.3
LED: U-bend Type A	4 ft.	63.3	35	28.3
LED: U-bend Type B		63.3	30	33.3
LED: U-bend Type C		63.3	30	33.3

SAVINGS

Table 4.6.12.d: LED U-bend Power Demand Savings by Building Type, LED Size, & LED Type

Building Type	Demand Savings (kW)
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¹⁵ As reported and approved in the Hawaii Energy Efficiency Program Technical Reference Manual, PY2015, July 1 2015-June 30 2016.



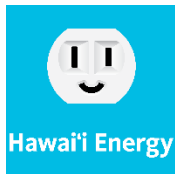
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	2 ft.			4 ft.		
	Type A	Type B	Type C	Type A	Type B	Type C
Misc. Commercial	0.01364	0.01493	0.01493	0.00913	0.01074	0.01074
Cold Storage	0.02580	0.02824	0.02824	0.01726	0.02031	0.02031
Education	0.00879	0.00962	0.00962	0.00588	0.00692	0.00692
Grocery	0.04005	0.04384	0.04384	0.02680	0.03153	0.03153
Health	0.03390	0.03711	0.03711	0.02268	0.02669	0.02669
Hotel/Motel	0.03137	0.03434	0.03434	0.02099	0.02470	0.02470
Industrial	0.02272	0.02486	0.02486	0.01520	0.01788	0.01788
Office	0.02331	0.02551	0.02551	0.01559	0.01835	0.01835
Restaurant	0.03404	0.03726	0.03726	0.02277	0.02680	0.02680
Retail	0.02754	0.03014	0.03014	0.01842	0.02168	0.02168
Warehouse	0.02004	0.02194	0.02194	0.01341	0.01578	0.01578

Table 4.6.12.e: LED U-bend Energy Savings by Building Type, LED Size, & LED Type

Building Type	Energy Savings (kWh/year)					
	2 ft.			4 ft.		
	Type A	Type B	Type C	Type A	Type B	Type C
Misc. Commercial	193.19	211.46	211.46	129.25	152.09	152.09
Cold Storage	250.40	274.08	274.08	167.53	197.13	197.13
Education	119.07	130.33	130.33	79.66	93.73	93.73
Grocery	256.95	281.25	281.25	171.91	202.28	202.28
Health	307.26	336.32	336.32	205.57	241.89	241.89
Hotel/Motel	233.04	255.08	255.08	155.91	183.46	183.46
Industrial	189.27	207.17	207.17	126.63	149.00	149.00
Office	126.86	138.85	138.85	84.87	99.86	99.86
Restaurant	234.65	256.83	256.83	156.99	184.72	184.72
Retail	187.70	205.45	205.45	125.58	147.76	147.76
Warehouse	179.31	196.27	196.27	119.96	141.16	141.16



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4.6.13 Controls: Occupancy Sensor

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Controls: Occupancy Sensor
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	
Review Date	October 5, 2011

Unit of Measure:

One sensor

Baseline equipment:

Manual switch

Efficient equipment:

Occupancy sensor installed

ALGORITHMS

peak kW savings per sensor = $W_{\text{controlled}} / 1000 * CF * PF * IF_d$

kWh savings per sensor = $W_{\text{controlled}} / 1000 * EFLH * RTR * PF * IF_e$

Table 4.6.13.a

<u>DEFINITIONS & ASSUMPTIONS</u>		VALUE
W_controlled	total wattage being controlled by sensor ¹	56.32
RTR	reduction in total run time allowed by sensor	33%
IF_d	factor reflecting impact of lighting savings on cooling load	1
IF_e	factor reflecting impact of lighting savings on cooling energy	1
CF	coincidence factor, percent of time sensor savings corresponds with utility peak load	12%



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PF	persistence factor, % of measures installed and operating	100%
EFLH	hours of lighting operation ²	3650
Measure Life		8

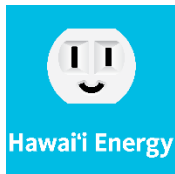
Footnotes:

1. Hawaii Energy Technical Reference Manual PY2015 deems 2L T8 with 0.88 ballast factor controlled by one sensor
2. Operating hours assume 10 hours per day, 365 days per year

SAVINGS

Table 4.6.13.b: Occupancy Sensor Power Demand & Energy Savings

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
Occupancy Sensor	0.007	67.84



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4.6.14 Controls: Stairwell Bi-Level Dimming Lights

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Controls: Stairwell Bi-Level Dimming
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	March 30, 2014
Revision Date	
Review Date	

Unit of Measure:

One fixture

Baseline equipment:

No bi-level dimming lights with occupancy sensors

Efficient equipment:

Bi-level dimming lights with occupancy sensors

Program criteria:

Energy Star/DLC/LED Lighting Facts, UL compliant.

ALGORITHMS

$$\text{peak kW savings per fixture} = [\text{kW}_b - (\text{kW}_{ee,dim} * \text{UF} / 100) + (\text{kW}_{ee,full} * \text{OF} / 100)] * \text{IF}_d * \text{CF} * \text{PF}$$

$$\text{kWh savings per fixture} = [\text{kW}_b * \text{EFLH} - (\text{kW}_{ee,dim} * \text{EFLH} * \text{UF} + \text{kW}_{ee,full} * \text{EFLH} * \text{OF})] * \text{IF}_e * \text{PF}$$

Table 4.6.14.a

DEFINITIONS & ASSUMPTIONS		
kW_b	baseline kW load of continuous operation stairwell fixture	user input
kW_{ee,dim}	kW load of stairwell fixture in dim or low level mode when unoccupied	user input
kW_{ee,full}	kW load of stairwell fixture in full power mode when occupied	user input



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UF	unoccupied fraction	Table 4.6.14.b
OF	occupied fraction	Table 4.6.14.b
IF_d	factor reflecting impact of lighting savings on cooling load	1
IF_e	factor reflecting impact of lighting savings on cooling energy	1
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	100%
PF	persistence factor, % of measures installed and operating	100%
EFLH	equivalent full load hours, or hours of lighting for business operation	8760
Measure Life	expected duration of energy savings, yrs	14

Table 4.6.14.b: Occupancy Types & 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

Table 4.6.14.c: Baseline Power Demand & Energy Usage Calculation

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

Table 4.6.14.d: Bi-level Dimming Power Demand & Energy Usage EXAMPLE

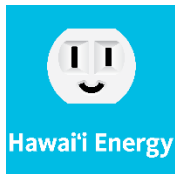
Location	Fixture Type	Fixture Qty	Enhanced Fixture Wattage	Enhanced Total Wattage	M-F Hours	Sat Hours	Sun Hours	Annual Op Hours	On Peak Demand Hours	Enhanced Off Peak kW Demand	Enhanced On Peak kW Demand	Enhanced Annual Energy Use (kWh/yr)
Stairwell--Low Rise	Bi-Level Lighting: Dimmed	205	6	1230	21.6	21.6	21.6	7884	3.6	1.23	1.11	9697
	Bi-Level Lighting: Full Power	205	60	12300	2.4	2.4	2.4	876	0.4	12.3	1.23	10775
Savings											4.63	40585



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Note: This is an example of the specific bi-level scenario indicated only. Dimmed and full power hours are manually updated per project.



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4.7 Plug/Process Load Measures

4.7.1 Anti-Sweat Heater Controls

HAWAII ENERGY NOMENCLATURE

Equipment Group	Plug/Process Load
Equipment Type	Anti-Sweat Heater Controls
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date

Revision Date

Review Date

Measure 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.

Unit of Measure:

Linear feet

Efficient equipment:

Anti-Sweat Heater controls

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.

Source: Hawaii Energy Anti-Sweat Heater (ASH) Controls Incentive Worksheet
https://hawaiienergy.com/images/business/ASHControls_worksheet_PY2016_v7.pdf

ALGORITHMS



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annual Peak kW savings from ASH per door =SVG_d_ASH*BaseWatts/door/1000*CF

annual kWh savings from ASH =SVG_d_ASH*BaseWatts/door/1000*HOURS

annual kW savings from Compressor =SVG_cooling/EER/1000*CF_groc

annual kWh savings from Compressor =SVG_cooling/EER/1000*EFLH

Table 4.7.1.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES	Notes
SVG_d_ASH	ASH demand savings factor, %	50%	
SVG_d_Comp	Compressor demand savings factor, %	17.5%	
SVG_cooling	=BaseWatts/door*SVG_d_Comp		
BaseWatts/door	Baseline door heater power	200	watts/door
BaseWatts/door	Baseline door heater power (3.413 Btu/h per W)	682.6	Btu/hr/door
EER	Compressor energy efficiency ratio	5.43	Btu/hr/watt
CF_groc	Grocery store coincidence factor	85%	
HOURS	hours of base ASH operation per year	8,760	24 hours per day, 365 days
HOURS_Comp	Compressor run time	5,700	hours/year
Measure Life	expected duration of energy savings	12	years
Avg.StoreRH	Typical Store relative humidity	45%	

SAVINGS

Table 4.7.1.b: Anti-Sweat Heater Controls Power Demand & Energy Savings Calculations

annual Peak kW savings from ASH	0.085	
annual kWh savings from ASH	876	
SVG_cooling	119	Btu/hr/door
annual Peak kW savings from Compressor	0.019	
annual kWh savings from Compressor	125	

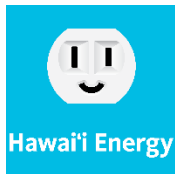


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Total Cooling Savings:	119	Btu/hr/door
Total Peak Power Savings:	0.104	kW/door
Total Annual Energy Savings:	1001	kWh/door
Per Linear Foot calculation:		
Door width	35	inches
	12	inches per ft
Bottom door length	2.92	Linear Feet
Peak kW savings per linear foot	0.036	kW/ft
Annual kWh savings per linear foot	343.3	kWh/ft

Note: $(\text{Peak kW Savings per Linear Foot}) = (\text{Total Peak Power Savings}) / (\text{Bottom Door Length})$
 $(\text{Annual kWh Savings per Linear Foot}) = (\text{Total Annual Energy Savings}) / (\text{Bottom Door Length})$



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4.7.2 Transformer

HAWAII ENERGY NOMENCLATURE

Equipment Group	Plug/Process Load
Equipment Type	Transformer (Single Phase) Transformer (Three Phase)
Equipment Subtype	Tier 1 Tier 2
Equipment Size	Various

VERSION HISTORY

Draft Date	November 25, 2014
Revision Date	
Review Date	

Unit of Measure:

One transformer

Baseline equipment:

NEMA TP-1 (current federal minimum standard level)

Efficient equipment:

CEE Tier I (single phase)

CEE Tier II (single or three phase)

Program criteria:

Transformers must be listed in CEE Qualified Products List (QPL) to be considered for incentive.

QPL Source: <http://library.cee1.org/content/transformersqplfebruary2015/>

ALGORITHMS

$$\begin{aligned}
 \text{Peak kW Savings per W} &= \frac{\Delta E_{base,loss} - \Delta E_{he,loss}}{HRS \cdot kVA} \\
 \text{Annual kWh Savings per W} &= \frac{\Delta E_{base,loss} - \Delta E_{he,loss}}{kVA} \\
 \text{Peak kW Savings} &= CF \cdot (\Delta P_{base,loss} - \Delta P_{he,loss}) \\
 \text{Annual kWh Savings} &= HRS \cdot (\Delta P_{base,loss} - \Delta P_{he,loss})
 \end{aligned}$$

Table 4.7.2.a

DEFINITIONS & ASSUMPTIONS



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$\Delta P_{base,loss}$	Power loss of baseline transformer	Table 4.7.2.b Table 4.7.2.c	kW	$\Delta P_{base,loss} = \frac{\Delta E_{base,loss}}{(8760 \frac{hrs}{yr})}$
$\Delta P_{he,loss}$	Power loss of energy efficient transformer	Table 4.7.2.b Table 4.7.2.c	kW	$\Delta P_{he,loss} = \frac{\Delta E_{he,loss}}{(8760 \frac{hrs}{yr})}$
$\Delta E_{base,loss}$	Annual energy loss of baseline transformer	Table 4.7.2.b Table 4.7.2.c	$\frac{kWh}{yr}$	
$\Delta E_{he,loss}$	Annual energy loss of high efficiency transformer	Table 4.7.2.b Table 4.7.2.c	$\frac{kWh}{yr}$	
CF	Coincidence factor, percent of time equipment load corresponds with utility peak load	100	%	
HRS	Equivalent full load hours, or hours of business operation	8760	hrs	
Measure Life	Expected duration of energy savings	15	yrs	

Table 4.7.2.b: Total losses & energy savings associated with CEE Tier 1 level for single-phase transformers

kVA	Total Losses (kWh/yr)		Energy Savings vs. Baseline (kWh/yr)	Demand Savings vs. Baseline (kW)
	Baseline	Tier 1	Tier 1	Tier 1
15	1,058	740	318	0.04
25	1,533	1,073	460	0.05
37.5	2,070	1,449	621	0.07
50	2,606	1,824	782	0.09
75	3,449	2,414	1,035	0.12
100	4,292	3,005	1,287	0.15
150	6,056	4,239	1,817	0.21
167	6,656	4,659	1,997	0.23
250	9,198	6,439	2,759	0.31
333	11,231	7,862	3,369	0.38

Source: http://library.cee1.org/sites/default/files/library/7905/Specification_Low_Voltage_Dry_Type_2012.pdf

Table 4.7.2.c: Total losses & energy savings associated with CEE Tiers for three-phase equipment

kVA	Total Losses (kWh/yr)	Energy Savings vs. Baseline (kWh/yr)	Demand Savings vs. Baseline (kW)
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	Baseline	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
15	1,380	966	736	414	644	0.05	0.07
25	1,993	1,395	1,073	598	920	0.07	0.11
30	2,300	1,610	1,242	690	1,058	0.08	0.12
45	3,173	2,221	1,683	952	1,490	0.11	0.17
75	4,599	3,219	2,460	1,380	2,139	0.16	0.24
112.5	6,209	4,346	3,346	1,863	2,863	0.21	0.33
150	7,818	5,473	4,139	2,345	3,679	0.27	0.42
225	10,348	7,243	4,139	3,105	6,209	0.35	0.71
300	12,877	9,014	5,151	3,863	7,726	0.44	0.88
450	18,166	12,716	6,922	5,450	11,244	0.62	1.28
500	19,929	13,950	7,512	5,979	12,417	0.68	1.42
750	27,594	19,316	10,118	8,278	17,476	0.94	1.99
1000	33,726	23,608	12,571	10,118	21,155	1.16	2.41

Source: http://library.cee1.org/sites/default/files/library/7905/Specification_Low_Voltage_Dry_Type_2012.pdf

SAVINGS

Table 4.7.2.d: Transformer Power Demand & Energy Savings by Phase Type, kVA, & Tier

kVA	Energy Savings vs. Baseline (kWh/yr)		Demand Savings vs. Baseline (kW)	
	Tier 1	Tier 2	Tier 1	Tier 2
Single-phase				
15	318		0.04	
25	460		0.05	
37.5	621		0.07	
50	782		0.09	
75	1,035		0.12	
100	1,287		0.15	



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150	1,817		0.21	
167	1,997		0.23	
250	2,759		0.31	
333	3,369		0.38	
Three-phase				
15	414	644	0.05	0.07
25	598	920	0.07	0.11
30	690	1,058	0.08	0.12
45	952	1,490	0.11	0.17
75	1,380	2,139	0.16	0.24
112.5	1,863	2,863	0.21	0.33
150	2,345	3,679	0.27	0.42
225	3,105	6,209	0.35	0.71
300	3,863	7,726	0.44	0.88
450	5,450	11,244	0.62	1.28
500	5,979	12,417	0.68	1.42
750	8,278	17,476	0.94	1.99
1,000	10,118	21,155	1.16	2.41



4.7.3 Vending Miser

HAWAII ENERGY NOMENCLATURE

Equipment Group	Plug/Process Load
Equipment Type	Vending Miser
Equipment Subtype	All Non-Refrigerated Refrigerated: Beverage Refrigerated: Non-Beverage
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	
Review Date	

Referenced Documents:

⁽¹⁾ USA Technologies Energy Management Product Sheets (2006).
http://www.usatech.com/energy_management/energy_productsheets.php. Accessed 9/1/09.

TRM Review Actions:

- n/a

Major Changes:

- none

Measure 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.

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta \text{kWh} = (\text{kW}_{\text{rated}})(\text{Hours})(\text{SAVE})$$
$$\Delta \text{kW} = \Delta \text{kWh} / \text{Hours}$$

Where:

kW_{rated} = Rated kW of connected equipment. See Table below for default rated kW by connected equipment type.

Hours = Operating hours of the connected equipment: default of 8,760 hours



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SAVE = Percent savings factor for the connected equipment. See table below for values.

Vending Machine and Cooler Controls Savings Factors

Table 4.7.3.a

Machine Type	kW Savings	kWh/year Savings
Refrigerated beverage vending machine (cans or bottles)	0.184	1612
Refrigerated	0.124	1086
Non-refrigerated snack vending machine	0.044	387
All (Average)	0.117	1028

Baseline Efficiency

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

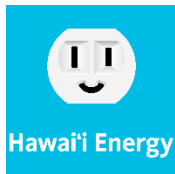
The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Hours

It is assumed that the connected equipment operates 24 hours per day, 7 days per week for a total annual operating hours of 8,760.

Measure Life

8 Years



4.7.4 Water Cooler Timer (H₂Off)

HAWAII ENERGY NOMENCLATURE

Equipment Group	Plug/Process Load
Equipment Type	Water Cooler Timer
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date

Revision Date

Review Date

Referenced Documents:

- LBNL 2007
<http://enduse.lbl.gov/info/LBNL-56380%282007%29.pdf>
- EPA2012
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=WA#specs

TRM Review Actions:

- Currently Under Review.

Major Changes:

- N/A

Measure Description:

Many businesses have water coolers, often equipped with both cold and hot water spigots. Unbeknownst to many, however, is how much energy is used to continuously keep that water hot and cold. Think about it: Water coolers are generally plugged in 24/7, so they're ready and waiting to make a nice cup of hot tea if someone happens to drop by the office at 3 a.m.

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.



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Baseline Efficiencies:

No timer

Table 4.7.4.a

Type of Water Cooler	Energy Usage	
	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

High Efficiency:

Table 4.7.4.b

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

Energy Savings:

Table 4.7.4.c

Energy Savings	Cold Only	Hot/Cold
ENERGY STAR USAGE (kWh/year)	37	281
Conventional (kWh/year)	68	512
Average Savings (kWh/year)	53	397



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Energy Savings Assumptions:

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
--

Demand Savings:

Taking a conservative approach, the demand savings will be 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
--



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Lifetime

5 years

Savings Algorithms

Table 4.7.4.d

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

Weekday OFF (Hour/Day) 12
Weekend OFF (Hour/Day) 24
Weekday (Day/week) 5
Weekend (Day/week) 2
Weekday (Week/year) 52
Weekend (Week/year) 52

Hours OFF 5616
Hours per Year 8760
Hours OFF (%) 64%
Hours ON (%) 36%

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

Operating Hours



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Weekday OFF (Hour/Day)	12
Weekend OFF (Hour/Day)	24
Weekday (Day/week)	5
Weekend (Day/week)	2
Weekday (Week/year)	52
Weekend (Week/year)	52

Hours OFF	5616
Hours per Year	8760
Hours OFF (%)	64%
Hours ON (%)	36%

4.8 Pumps and Motors

4.8.1 Booster Pumps

HAWAII ENERGY NOMENCLATURE

Equipment Group	Pumps and Motors
Equipment Type	Booster Pumps
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	May 23, 2011
Revision Date	May 19, 2016
Review Date	

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.

Efficient 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.

Program criteria:



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- 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.



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SAVINGS

Table 4.8.1.a

Domestic Water Booster Packages

REDUCED HP

Motor Energy Consumption		0.746 kW / hp
Run Time	x	8760 hrs / year
Percent Run Time	x	60% percent run / day
Yearly Savings per HP Reduction		3921 Total kWh savings / hp / year
3921 kWh Reduction / HP / Year		

Demand Savings per HP		0.746 kW savings per hp
Coincidence Factor	x	50% peak coincidence factor
Peak Demand Savings		0.373 kW savings per hp during peak hour (5 p.m. to 9 p.m.)
0.373 Peak kW Reduction / HP		

INSTALLATION OF VFD

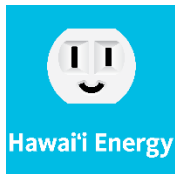
Motor Energy Consumption		0.746 kW / hp
Percent Load Reduction with VFD	x	15% percent load reduction
Demand Savings per HP		0.112 kW savings per hp
Run Time	x	8760 hrs / year
Energy Savings per hp with VFD		980.24 kWh savings / hp / year
Percent Run Time	x	60% pump percent run time
Total Energy Savings per hp with VFD		588 Total kWh savings / hp / year
588.15 kWh Reduction / HP / Year		

EM&V review comments recommend 500 - 700 kWh savings (Feb. 23, 2012)

Demand Savings per HP		0.112 kW savings per hp
Coincidence Factor	x	50% peak coincidence factor
Peak Demand Savings		0.056 kW savings per hp during peak hour (5 p.m. to 9 p.m.)
0.056 Peak kW Reduction / HP		

Table 4.8.1.b

Source of Savings (per HP)	Demand Savings (kW)	Energy Savings (kWh/yr)
Reduced HP	0.373	3921
Installation of VFD	0.056	588.15



4.8.2 Electronically Commutated Motors (ECM)

HAWAII ENERGY NOMENCLATURE

Equipment Group	Pumps and Motors
Equipment Type	ECM Fan Motor
Equipment Subtype	A/C Fan Coil Refrigeration
Equipment Size	None

VERSION HISTORY

Draft Date	
Revision Date	
Review Date	October 5, 2011

Measure 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.

Unit of Measure:

One ECM motor

Baseline equipment:

4-pole (1800 RPM) demand of 107 W

Efficient equipment:

High efficiency DC/EC demand of 54 W

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

Source: Hawaii Energy ECM Worksheet
https://hawaiienergy.com/files/business/ECM_FanCoilUnits_worksheet_PY2016_HT.pdf

ALGORITHMS

peak kW savings per W $= (kW/W_{pre} - kW/W_{post})$

annual kWh savings per W $= (kWh/W_{pre} - kWh/W_{post})$

peak kW savings per motor $= (kW_{pre} - kW_{post}) * CF$



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$$\text{annual kWh savings per motor} = (\text{kW}_{\text{pre}} - \text{kW}_{\text{post}}) * \text{HOURS}$$

Table 4.8.2.a

DEFINITIONS & ASSUMPTIONS				
kW/W_{pre}	demand of existing motor technology	Table 4.8.2.b		
kW/W_{post}	demand of new electronically commutated motor	Table 4.8.2.b		
kWh/W_{pre}	energy use of existing motor technology	Table 4.8.2.b		
kWh/W_{post}	energy use of new electronically commutated motor	Table 4.8.2.b		
CF	coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm	0.5	%	
HOURS	annual operating hours	4380	hrs	
Measure Life	expected duration of energy savings	15	yrs	

Table 4.8.2.b: ECM Energy Usage Calculation

Technology	Baseline demand ¹	Efficient demand	Baseline annual energy consumption	Efficient annual energy consumption
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: Hawaii Energy Efficiency Program 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 4.8.2.c: ECM Motor Power Demand & Energy Savings

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
ECM motor-refrigeration ¹	0.001	9.3
ECM motor on AHU fan	0.0265	232

¹ Refrigeration ECM values are savings per rated motor W



4.8.3 Pool Pump VFD

HAWAII ENERGY NOMENCLATURE

Equipment Group	Pumps and Motors
Equipment Type	Pool Pump
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	
Review Date	October 5, 2011

Referenced Documents:

- n/a

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- 12/15/11 – Updated algorithm average pump size from 1.5 HP pump to 1 HP pump. Updated baseline and high efficiency calculations accordingly.

Measure Description

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

Definition of Efficient Equipment

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

Definition of Baseline Equipment

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

$$\Delta \text{kWh} = (\text{kWBASE} \times \text{Hours}) \times 55\%$$

Where:

Unit	= 2-speed or variable speed pool pump
ΔkWh	= Average annual kWh reduction
Hours	= Average annual operating hours of pump
kWBASE	= connected kW of baseline pump
55%	= average percent energy reduction from switch to 2-speed or variable speed pump (1)



Baseline Efficiency

The baseline efficiency case is a single speed pump.

High Efficiency

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

Energy and Demand Savings

Demand Savings: 0.093 kW / HP

Energy Savings: 1123 kWh per year / HP

- (1) Davis Energy Group (2008). Proposal Information Template for Residential Pool Pump Measure Revisions. Prepared for Pacific Gas and Electric Company; Page 2.

SAVINGS



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Table 4.8.3.a

Commercial Pool Pump

Pool Pump Horsepower	1 HP
Efficiency	0.8
Hours of operation per day	6 hours
Number of days pool in use	365 days per year
1 HP Equals	0.746 kW

Baseline

Pump Size	1.00 HP
kW / HP	x 0.75 kW / HP
	0.75 kW
Efficiency	÷ 0.80
Based Demand	0.93 kW
Hours of operation	x 6 hours/day
Base Energy Usage per day	5.60 kWh/day
Base Energy Usage per year	2042 kWh/year

High Efficiency

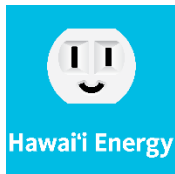
Base Demand	0.93 kW
Demand Reduction	10%
High Efficiency Demand	0.839 kW
Base Energy Usage	2042 kWh/year
Energy Reduction	55%
High Efficiency Energy Usage	919 kWh/year

Demand Savings	0.093 kW per HP
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Energy Savings per year	1123 kWh/year per HP
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Deemed Lifetime of Efficient Equipment

The estimated useful life for a variable speed pool pump is 10 years.



4.9 Submetering

4.9.1 Condominium Submetering

HAWAII ENERGY NOMENCLATURE

Equipment Group	Submetering
Equipment Type	Condominium Unit
Equipment Subtype	Actual Savings
Equipment Size	None

VERSION HISTORY

Draft Date	March 4, 2016
Revision Date	
Review Date	

Referenced Documents:

- n/a

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- 3/4/2016 – added measure description and equipment qualifications

Measure 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.

Equipment Qualifications:

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).



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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 AOA to assist in the verification of savings and development of an ongoing energy incentive offering for other condominiums in Hawaii.

Baseline

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.

Table 4.9.1.a

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

High Efficiency

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).

Table 4.9.1.b

Building Types	Efficient Case (kW)	Efficient Case (kWh/year)
Condominium	1.30	6,480

Energy and Demand Savings (for illustration purposes only):



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Table 4.9.1.c

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



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Table 4.9.1.d: **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
Persistence 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
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Peak Demand Reduction	8.00%
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Actively Informed Household Demand	1.30 kW
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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
Persistence Factor	x 1.0
Coincidence Factor	x 1.0
	0.113 kW

Condominium Sub-Metering Demand Savings 0.113 kW Savings

Notes



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- Incentive payment will be made upon billing individual tenants.
- Incentive payment cannot exceed 50% of total project cost.
- The payment of the incentive will be based on the AOA securing the approval, installing and utilizing the submeters for billing purposes.
- There is no minimum reduction in electrical use to be required by AOA to retain the incentive.

Measure Life:

8 years (based on DEER. Similar technology as time-clocks and occupancy sensors)



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4.9.2 Small Business Submetering Pilot

HAWAII ENERGY NOMENCLATURE

Equipment Group	Submetering
Equipment Type	Small Business
Equipment Subtype	Actual Savings
Equipment Size	None

VERSION HISTORY

Draft Date	March 4, 2016
Revision Date	
Review Date	

Referenced Documents:

- n/a

TRM Review Actions:

- 10/5/11 – Currently Under Review.

Major Changes:

- 3/4/2016 – Added measure description and equipment qualifications

Measure 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.

Equipment Qualifications:

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.



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- 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.

Baseline

The base case is no submetering

Table 4.9.2.a

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

High Efficiency

The high efficiency case is with submetering

Table 4.9.2.b

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

Energy and Demand Savings:

Table 4.9.2.c

Building Types	Gross Customer Savings (kW)	Gross Customer Savings (kWh/year)
Small Business	0.24	1,080

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



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It is expected there will be at least 10% reduction in energy usage and 8% reduction in peak demand during (5PM – 9PM), however, there is no minimum reduction in electrical use to be required to retain the incentive.



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Table 4.9.2.d: **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

Persistence 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

Persistence Factor x 1.00

Coincidence Factor x 1.00

0.240 kW

Small Business Demand Savings 0.24 kW Savings

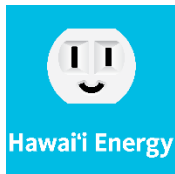


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Incentives/Incremental Cost

- Incentive payment will be made upon billing individual tenants.
- Incentive payment cannot exceed 50% of total project cost.



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4.10 Water Heating

4.10.1 Heat Pump Water Heater

HAWAII ENERGY NOMENCLATURE

Equipment Group	Water Heating
Equipment Type	Heat Pump WH
Equipment Subtype	Replace Electric Resistance Water Heater Replace Heat Pump Water Heater
Equipment Size	5 to 11.25 Tons >11.25 Tons

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	
Review Date	October 5, 2011

Measure 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.

Unit of Measure:

One heat pump

Baseline equipment:

Standard electric water heater or heat pump water heater

Efficient equipment:

High efficiency heat pump water heater

Program criteria:

ALGORITHMS

peak kW savings/ton	=Base Power*CF_base - HPWH Power*CF_HP
annual kWh savings/ton	=Base WH Energy Usage - HPWH Energy Usage
Base WH Energy Usage	=Energy per Day per ton*Days/Yr/COP_base
HPWH Energy Usage	=Energy per Day per ton*Days/Yr/COP_HP



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Table 4.10.1.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES
Energy per Day ¹	13.3 gallons/day/person*3.77 persons*8.34 lbs/gallon*(130 deg.F-75 deg.F)*1.0[BTU/deg. F/lb]	22981 BTU
Energy per Day per ton ²	12,000 BTU/ton/3412kWh/BTU	3.5
Days/Yr		365
COP_base		Table 4.10.1.b
COP_HP		Table 4.10.1.b
CF_base		Table 4.10.1.b
CF_HP		Table 4.10.1.b
Base Power (kW/ton) ³	=Base WH Energy Usage/(10 hrs/day*365 days/yr)/3650 hours/yr	Table 4.10.1.b
HPWH Power (kW/ton) ⁴	=HPWH Energy Usage/(10 hrs/day*365 days/yr)/3650 hours/yr	Table 4.10.1.b
Measure Life	expected duration of energy savings	10 years

- Notes:
1. Assumed in Hawaii Energy PY7 TRM, p.123;
 2. Assumed in Hawaii Energy PY7 TRM, p.123;
 3. Depend on baseline water heater;
 4. Hawaii Energy PY7 TRM assumes 30.4 days/month*12 months/year

Table 4.10.1.b: Water Heater Parameters

	COP_base	COP_HP	CF_base	CF_HP	Base Power	HPWH Power ¹
Electric resistance water heater	0.98	N/A	0.143	N/A	0.4	N/A
Heat pump water heater	N/A	3.5	0.08	0.08	N/A	0.3

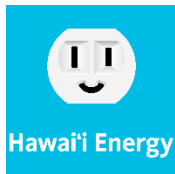
Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, p.123
Table 1.13.1.a footnotes:

1. Heat pump power consumption value of 0.3 kW reported in the PY7 TRM appears to be derived based on 943 kWh/ton *savings*, rather than heat pump energy usage of 367 kWh/ton.

SAVINGS

Table 4.10.1.c: Heat Pump Water Heater Power Demand & Energy Savings

	Heat Pump WH replacing Resistance WH
peak kW saved/ton	0.03
annual kWh saved/ton	943



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4.10.2 Solar Water Heater

HAWAII ENERGY NOMENCLATURE

Equipment Group	Water Heating
Equipment Type	Solar Water Heater
Equipment Subtype	Replace Electric Resistance Water Heater Replace Heat Pump Water Heater
Equipment Size	None

VERSION HISTORY

Draft Date	May 30, 2011
Revision Date	July 7, 2015
Review Date	

Unit of Measure:

Per unit

Baseline equipment:

Baseline usage is an Electric Resistance Water Heater or Heat Pump.

Efficient equipment:

Solar water heater

Program criteria:

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

ALGORITHMS

peak kW demand removed =Avg_kW(existing)*CF

annual kWh displaced =System_Cap*365 days*(1-Derate%)*Perform%/3412 BTU/kWh/COP

Table 4.10.2.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES	Notes
System_Cap	total rated output capacity of panel array, BTU/day, determined by rated output capacity of panel * number of panels	user input	



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Derate%	percent adjustment to rated output for array tilt and orientation, where $Tilt\ Derate + Orientation\ Derate = Derate\%$	Table 4.10.2.b	
Perform%	remaining capacity after accounting for impacts to performance (e.g. shading)	user input	
COP	efficiency of existing water heating system	Table 4.10.2.c	
Avg_kW(existing)	average demand of existing electric water heater	user input	derived from engineering calculations or measured data per TRM
CF	coincidence factor, percent of time equipment load corresponds with utility peak load, 5 pm to 9 pm	user input	heat pump water heater assumes 8% CF
Measure Life	expected duration of energy savings	20 years	

Table 4.10.2.b: Derate Adjustment (%) Due to Tilt & Orientation

Orientation (degrees to true North)	Orientation Derate %	Collector Tilt (degrees)	Tilt Derate %
0-89	prohibited	0-13	prohibited
90-105	25%	14-40	0%
105-115	10%	40-45	5%
115-125	5%	45-50	10%
125-225	0%	50-55	15%
225-235	5%	55-60	20%
235-245	10%	60.0	25%
245-255	15%	>60	prohibited
255-270	20%		
271-360	prohibited		

Source: Current Hawaii Energy Solar Hot Water Incentive Worksheet

Table 4.10.2.c: Coefficient of Performance of Existing Water Heating System

Water Heater Type	COP
Electric Resistance Water Heater	0.90
Electric Heat Pump Water Heater	3.50

Source: Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations p 112

SAVINGS

-Example-



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The following savings is an example based on:

- 350,000 BTU/day
- 90 deg. Orientation, 20 deg. Tilt
- Existing electric resistance water heater at 2kW average load

Table 4.10.2.d: Sample Power Demand & Energy Savings

	Peak Demand Savings (kW)	Energy Savings (kWh/yr)
Solar Water Heater	0.16	31,201



4.11 Other Commercial Measures

4.11.1 Re-Commission / Retro-Commission

HAWAII ENERGY NOMENCLATURE

Equipment Group	Whole Building Assistance
Equipment Type	Retro-Commissioning
Equipment Subtype	Re-Commission Retro-Commission
Equipment Size	None

VERSION HISTORY

Draft Date

Revision Date

Review Date

Unit of Measure:

No initial savings. This measure provides incentives for evaluating savings opportunities that can be then undertaken by the customer and incentivized by the Program.

Baseline equipment:

Pre-commissioning operating procedures.

Efficient equipment:

Post-commissioning operating procedures.

Program criteria:

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 profiles.
- 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.



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- 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.

ELIGIBILITY CHECKLIST

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. The proposed contractor submits at least two verifiable and satisfactory references from customers or clients who used the contractor to complete the similar projects.



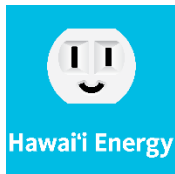
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- All retro-commissioning work performed (to include, but not limited to, documentation and reporting) must follow guidelines recommended by an approved commissioning organization. The commissioning specialist must indicate in their report the organization's 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.

SAVINGS

peak kW savings	Custom calculated or measured
annual kWh savings	Custom calculated or measured



5 Residential Measures

5.1 Appliances

5.1.1 Clothes Washer

HAWAII ENERGY NOMENCLATURE

Equipment Group	Appliances
Equipment Type	Clothes Washer
Equipment Subtype	Tier 1 Tier 2 Tier 3
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	November 14, 2013
Review Date	June 23, 2015

Measure Description:

Energy Efficient Clothes Washer

Unit of Measure:

One washer

Baseline equipment:

Clothes washer meeting minimum federal requirements as of March 2015.

Efficient 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

Program criteria:

ENERGY STAR certified

ALGORITHMS

$$\text{annual kWh savings per washer} = [(CAP * 1/IMEF_{\text{base}} * CYCLES) * (\%E_{\text{wash,base}} + (\%E_{\text{heat,base}} * \%HEATER_{\text{electric}}) + (\%E_{\text{dry,base}} *$$



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$$\text{peak kW savings per washer} = \frac{[(\text{CAP} * 1/\text{IMEF}_{\text{he}} * \text{CYCLES}) * (\%E_{\text{wash,he}} + (\%E_{\text{heat,he}} * \% \text{HEATER}_{\text{electric}}) + (\%E_{\text{dry,he}} * \% \text{DRYER}_{\text{electric}}))] - (\Delta \text{kWh/Hours}) * \text{CF}}{(\Delta \text{kWh/Hours}) * \text{CF}}$$

$$\text{lifetime kWh savings per washer} = \Delta \text{kWh} * (\text{Measure Life})$$

Table 5.1.1.a

DEFINITIONS & ASSUMPTIONS		Tier 1	Tier 2	Tier 3	Notes
CAP	Average clothes washer capacity in ft ³	3.45	3.45	3.45	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
CYCLES	Average number of washer cycles per washer per year	313	313	313	NEEA Dryer Field Study, 2014 (Table 45) ¹⁶ .
%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
%DRYER_electric	Percentage of dryers assumed to be electric	81%	81%	81%	Based on Evergreen Baseline Study (2014) on percentage of

¹⁶<https://www.neea.org/docs/default-source/reports/neeaa-clothes-dryer-field-study.pdf>



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					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)
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 for details
%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



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					each tier in NEEP Mid-Atlantic TRM V6
HRS	Average number of run hours per washer per year	297	297	297	57 minutes/cycle based on NEEA Dryer Field Study, 2014 ¹⁷
Measure Life	Estimate useful life	14	14	14	ENERGY STAR Market & Industry Scoping Report, 2011 ¹⁸
CF	Coincidence Factor	5.7%	5.7%	5.7%	

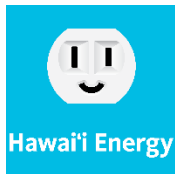
SAVINGS

Table 5.1.1.b

	Tier 1	Tier 2	Tier 3
Peak Demand Savings per Washer (kW)	0.022	0.030	0.034
Annual Savings per Washer (kWh)	114.07	156.80	176.37

¹⁷<https://www.neea.org/docs/default-source/reports/neeaclothesdryerfieldstudy.pdf>

¹⁸https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf



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5.1.2 Clothes Dryer

HAWAII ENERGY NOMENCLATURE

Equipment Group	Appliances
Equipment Type	Clothes Dryer
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date
Revision Date
Review Date

Measure Description:

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

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).

Efficient equipment:

ENERGY STAR certified electric clothes dryer $\geq 4.4 \text{ ft}^3$

Program criteria:

ENERGY STAR certified

ALGORITHMS

$$\text{annual kWh savings per washer} = (\text{LOAD}/\text{CEF}_{\text{base}} - \text{LOAD}/\text{CEF}_{\text{he}}) * \text{CYCLES}$$

$$\text{peak kW savings per washer} = (\Delta \text{kWh}/\text{Hours}) * \text{CF}$$

$$\text{lifetime kWh savings per washer} = \Delta \text{kWh} * (\text{Measure Life})$$

Table 5.1.2.a

<u>Definitions and Assumptions</u>	INPUT VALUES	Notes
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LOAD	Average total weight (lbs) of clothes per drying cycle	8.45	Based on ENERGY STAR product criteria testing. ¹⁹
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 dryer per year	311	NEEA Dryer Field Study, 2014. ²⁰
HRS	Average run hours per dryer per year	290	56 minutes/cycle based on NEEA Dryer Field Study, 2014. ²¹
CF	Coincidence factor during peak period	5.7%	Based on analysis of clothes dryer load shape curve from DOE PNNL study. See Tab 2 for calculation. ²²
Measure Life	Estimate useful life	14	ENERGY STAR Market & Industry Scoping Report, 2011. ²³

SAVINGS

Table 5.1.2.b

Annual Energy Savings per Dryer (kWh)	165.58
Peak Demand Savings per Dryer (kW)	0.033

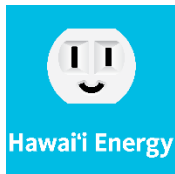
¹⁹https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

²⁰<https://www.neea.org/docs/default-source/reports/neeaclothesdryerfieldstudy.pdf>

²¹<https://www.neea.org/docs/default-source/reports/neeaclothesdryerfieldstudy.pdf>

²²http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20110.pdf

²³https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf



5.1.3 Refrigerator

HAWAII ENERGY NOMENCLATURE

Equipment Group	Appliances
Equipment Type	Refrigerator
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	November 14, 2013
Review Date	June 23, 2015

Measure 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.

Unit of Measure:

One refrigerator

Baseline equipment:

Non-ENERGY STAR refrigerator

Efficient equipment:

ENERGY STAR certified refrigerator

Program criteria:

ENERGY STAR certified

ALGORITHMS

$$\begin{aligned}\Delta E_{replace} &= E_{base} - E_{he} \\ \Delta E_{replace \& \text{ turn in}} &= (E_{base} - E_{he}) + 717 \\ \Delta P_{replace} &= \frac{E_{base} - E_{he}}{HRS} \\ \Delta P_{replace \& \text{ turn in}} &= \frac{(E_{base} - E_{he}) + 717}{HRS}\end{aligned}$$



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Table 5.1.3.a

DEFINITIONS & ASSUMPTIONS			
E_{base}	Energy usage of the baseline equipment	540	<i>kWh</i>
E_{he}	Energy usage of the higher efficiency equipment	435	<i>kWh</i>
ΔE	Energy reduction	Calculated	<i>kWh</i>
CF	coincidence factor, percent of time equipment load corresponds with utility peak load	100	%
PF	persistence factor, % of measures installed and operating	100	%
HRS	Annual operating hours	8760	<i>hrs</i>
Measure Life	expected duration of energy savings	14	<i>yrs</i>

Table 5.1.3.b

Opportunity	Energy Usage	Reference
New Non-ENERGY STAR	540	Table 5.1.3.d
New ENERGY STAR Refrigerator	- 435	Table 5.1.3.d
	<u>105kWh/Year</u>	Table 5.1.3.c
#1 - Purchase of ENERGY STAR Refrigerator	105	Table 5.1.3.c
#2 - Removal of Old Unit from Service (off the grid)	+ 717	Table 5.1.3.c
#1 + #2 = Purchase ES and Recycle old unit	<u>822kWh/Year</u>	
	Energy Usage Ratio Contribution	
Post-1993 Refrigerator	640 55% 354.54	Table 5.1.3.e
Pre-1993 Refrigerator	1,131 45% 504.46	Table 5.1.3.e
	<u>859kWh/Year</u>	



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Table 5.1.3.c

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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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.				



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Table 5.1.3.d

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.

Table 5.1.3.e

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.

Table 5.1.3.f



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SAVINGS

Table 5.1.3.g

	Demand Savings (kW)	Energy Savings (kWh)
ES Refrigerator with Turn-In	0.034	822
Bounty (Turn in only)	0.034	859
New ES Refrigerator Only (No Turn-In)	0.017	105



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5.2 Electronics

5.2.1 Televisions

HAWAII ENERGY NOMENCLATURE

Equipment Group	Electronics
Equipment Type	TV
Equipment Subtype	None
Equipment Size	\$15 \$8

VERSION HISTORY

Draft Date

Revision Date

Review Date

Measure 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.

Unit of Measure:

One television

Baseline equipment:

See Footnote 24

Efficient equipment:

ENERGY STAR certified TV

Program criteria:

ENERGY STAR certified

ALGORITHMS

$$\text{peak kW savings per TV} = [(Watts_base - Watts_ee) / 1000] \times CF$$

$$\text{annual kWh savings per TV} = (Watts_base - Watts_ee) / 1000 \times HOURS_Active \times 365$$

Table 5.2.1.a

<u>DEFINITIONS & ASSUMPTIONS</u>	INPUT VALUES	Notes
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Watts_base	Baseline connected Watts (active)	Table 5.2.1.b	Baseline power consumption is drawn from ENERGY STAR "Consumer Electronics Calculator" ²⁴ .
Watts_ee	Energy efficient connected Watts (active)	Table 5.2.1.b	ENERGY STAR V7.0 Program Requirements ²⁵ .
CF	Demand Coincidence Factor	0.22	Based on Efficiency Vermont TRM, 2015 for coincident usage between 5-7PM.
HOURS_Active	Average hours of use per day in Active Mode	5	Average television active power reported in ENERGY STAR "Consumer Electronics Calculator".
Measure Life	Expected duration of energy savings	6 years	Average television lifetime estimated in ENERGY STAR "Consumer Electronics Calculator" referencing Appliance Magazine, Portrait of the U.S. Appliance Industry 2000.

SAVINGS

Table 5.2.1.b

Non-4K

Screen size (in)		Max Power (W)			Demand Savings (kW)		TEC (kWh/yr)			Energy Savings (kWh/yr)	
Min	Max	Base	ES7	ME16	ES7	ME16	Base	ES7	ME16	ES7	ME16
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	0.03	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	42.0	66

²⁴https://www.energystar.gov/sites/default/files/asset/document/Consumer_Electronics_Calculator.xlsx

²⁵<https://www.energystar.gov/sites/default/files/FINAL%20Version%207.0%20Television%20Program%20Requirements%20%28Dec-2014%29.pdf>



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4K

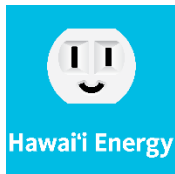
Screen size (in)		Max Power (W)			Demand Savings (kW)		TEC (kWh/yr)			Energy Savings (kWh/yr)	
Min	Max	Base	ES7	ME16	ES7	ME16	Base	ES7	ME16	ES7	ESME 16
40	45	81	37	27	0.044	0.054	148	68	50	80	98
45	50	104	45	33	0.059	0.07	189	82	61	107	128
50	55	111	52	38	0.059	0.073	203	95	70	108	132
55	60	131	57	42	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	0.06	0.074	204	94	69	109.8	134

Non-4k	40%	0.0092
4k	60%	0.036
	CF	0.220
	ΔkW	0.0099

Non-4k	40%	16.8
4k	60%	65.88
	ΔkWh	82.680

Table 5.2.1.c

	Peak Demand Savings per TV (kW)	Annual Energy Savings per TV (kWh)
Average Television	0.010	82.7



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5.2.2 Soundbars

HAWAII ENERGY NOMENCLATURE

Equipment Group	Electronics
Equipment Type	Soundbars
Equipment Subtype	None
Equipment Size	\$15 \$8

VERSION HISTORY

Draft Date
Revision Date
Review Date

Unit of Measure:

One soundbar

Baseline equipment:

The baseline efficiency equipment is based on a 2014 study on the energy consumption of consumer electronics in U.S. Homes in 2013.

Efficient equipment:

The high efficiency equipment are soundbars that meet or exceed ENERGY STAR version 3.0

Program criteria:

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

ALGORITHMS

Peak Demand (kW) Savings Per Soundbar $= PF \times [(Watts_{BASE-ACTIVE} - Watt_{SEE-ACTIVE}) / 1000] \times CF$

Annual Energy (kWh) Savings Per Soundbar $= PF \times \{[(Watts_{BASE-ACTIVE} - Watt_{SEE-ACTIVE}) * Hours_Active] + [Watts_{BASE-IDLE} - Watt_{SEE-IDLE}] * Hours_Idle + [Watts_{BASE-SLEEP} - Watt_{SEE-SLEEP}] * Hours_Sleep\} / 1000$

Lifetime Energy (kWh) Savings Per Soundbar $= \Delta kWh \times Measure_Life$

Table 5.2.2.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES	Notes
Watts_{BASE-ACTIVE}	Baseline Watts (active)	30	



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Watts_{BASE-IDLE}	Baseline Watts (idle)	12	Fraunhofer Center for Sustainable Energy Systems. 2014 ²⁶ .
Watts_{BASE-SLEEP}	Baseline Watts (sleep)	4	
Watts_{EE-ACTIVE}	Energy efficient watts (active)	20.2	Energy Solutions Report on RPP - Citing EPA Internal Analysis of Energy Star V2.0 Soundbars ²⁷ .
Watts_{EE-IDLE}	Energy efficient watts (idle)	3.5	
Watts_{EE-SLEEP}	Energy efficient watts (sleep)	0.5	
Hours_Active	Hours per year in active mode	1580.0	Fraunhofer Center for Sustainable Energy Systems. 2014 ²⁸ .
Hours_Idle	Hours per year in idle mode	730.0	
Hours_Sleep	Hours per year in sleep mode	6450.0	
CF	Coincidence factor, percent of time savings correspond with utility peak 5 pm-9 pm	0.220	Assuming same CF as Televisions. Based on Efficiency Vermont TRM, 2015 for coincident usage between 5-7PM.
PF	Persistence factor (% of measures installed and operational)	100%	
Measure_Life	Expected duration of energy savings (years)	7	Energy Star Assumption - Via NEEP Mid-Atlantic TRM Version 6

SAVINGS

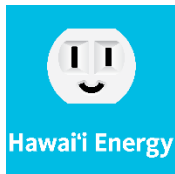
Table 5.2.2.b

	Peak Demand Savings per Soundbar (kW)	Annual Energy Savings per Soundbar (kWh)
Soundbars	0.002	44.3

²⁶<https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf>

²⁷https://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556d387fe4b0d8dc09b24c28/1433221247215/RPP+Methodology+for+Developing+UEC+Estimates_Final.pdf

²⁸<https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf>



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5.3 HVAC

5.3.1 Window AC & VRF AC

HAWAII ENERGY NOMENCLATURE

VRF Split System AC

Equipment Group	HVAC
Equipment Type	VRF Split System AC
Equipment Subtype	None
Equipment Size	≤2 Tons >2 tons

VERSION HISTORY

Draft Date	February 24, 2011
Revision Date	April 17, 2015
Review Date	

HAWAII ENERGY NOMENCLATURE

Room AC with Recycling

Equipment Group	HVAC
Equipment Type	Window AC
Equipment Subtype	Trade-In Recycler Incentive; Trade-In Recycler Incentive; Trade-In
Equipment Size	None

VERSION HISTORY

Draft Date	December 23, 2014
Revision Date	June 23, 2015
Review Date	

Unit of Measure:

One unit

Baseline equipment:

None or small or large VRF Split or Room A/C with recycling

Efficient equipment:

High efficiency small or large VRF Split or Room A/C with recycling

Program criteria:

Installation of a small or large VRF Split or Room A/C with recycling or existing (lower efficiency) small or large VRF Split or Room A/C with recycling.



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ALGORITHMS

peak kW savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * CF) / 1000 \text{ W/kW*PF}$
annual kWh savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * \text{HOURS}) / 1000 \text{ W/kW*PF}$
VRF Splits < 2 Tons peak kW savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * CF) / 1000 \text{ W/kW*PF*PY15_small}$
VRF Splits < 2 annual kWh savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * \text{HOURS}) / 1000 \text{ W/kW*PF*PY15_small}$
VRF Splits >= 2 Tons peak kW savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * CF) / 1000 \text{ W/kW*PF*PY15_large}$
VRF Splits >= 2 annual kWh savings per ton	$=(12,000 \text{ BTU/hr capacity} * [1/(S)EER_b - 1/(S)EER_ee] * \text{HOURS}) / 1000 \text{ W/kW*PF*PY15_large}$

Table 5.3.1.a

DEFINITIONS & ASSUMPTIONS		INPUT VALUES	Notes
(S)EER_b	Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment.	Table 5.3.1.b	Units less than 65,000 BTU/hr are rated in SEER rather than EER.
(S)EER_ee	Proposed measure rated efficiency, BTU/hr-W.	Table 5.3.1.b	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 5pm -9 pm	0.5	deemed; 50% VRFs operational between 5-9 pm
HOURS	equivalent full load cooling hours	1825	deemed; 5 hrs per day cooling
ton	unit of equipment cooling capacity	12,000 BTU/hr	
PY15_small	From a review of PY2015 rebates processed, the average size of a small unit	1.28	Tons
PY15_large	From a review of PY2015 rebates processed, the average size of a large unit	2.58	Tons
PF	persistence factor (% of measures installed and operational)	100%	



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Measure Life	expected duration of energy savings	9 years	
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Table 5.3.1.b: Residential HVAC program efficiencies²⁹

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	16.0
VRF Split A/C	large (2+ tons)	30960	10.9	16.0
Window A/C with recycling	~3/4 ton	8500	9.8	11.2

SAVINGS

Table 5.3.1.c: Peak kW Savings/Ton by Building Type and Equipment Size (BTU/hr)

Building Type	small VRF	large VRF
Single Family/Multifamily Residential	0.225	0.453

Table 5.3.1.d: Annual kWh Savings/Ton by Building Type and Equipment Size (BTU/hr)

Building Type	small VRF	large VRF
Single Family/Multifamily Residential	819.74	1,652.29

Table 5.3.1.e: Deemed kW and kWh savings for Room A/C

	peak kW	annual kWh
Room A/C 8500 BTU/hr	0.054	198

²⁹ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, p.35-36.

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.



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Program Year July 1, 2016 to June 30, 2017

5.3.2 Central AC Retrofit

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Central AC
Equipment Subtype	Retrofit
Equipment Size	None

VERSION HISTORY

Draft Date	June 20, 2014
Revision Date	
Review Date	

Measure 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.

Unit of Measure:

One unit

Baseline equipment:

Older inefficient central air conditioning unit

Efficient equipment:

New central air conditioning unit with higher Energy Efficiency Ratio

Program criteria:

ALGORITHMS

$$\begin{aligned}\text{peak kW savings } \Delta kW &= CF * CAP * [(1/\eta_{\text{base}}) - (1/\eta_{\text{he}})]/1,000 \\ \text{annual kWh savings } \Delta kWh &= HRS * CAP * [(1/\eta_{\text{base}}) - (1/\eta_{\text{he}})]/1,000\end{aligned}$$

Table 5.3.2.a

<u>DEFINITIONS & ASSUMPTIONS</u>³⁰	INPUT VALUES	Notes
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³⁰ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp. 43



Hawai'i Energy – PY2016 Technical Reference Manual

Program Year July 1, 2016 to June 30, 2017

HRS	percent of time on low speed	2,920	Based on 8 hr/day, 365 day/year
CAP	Btu/hour 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 Ratio	13.0	EER
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	75%	
Measure Life	expected duration of energy savings	15 years	

Table 5.3.2.b

Central AC Replacement

Average Unit Cooling Capacity	12000	BTU/Hr	Equals 1 Ton Cooling Capacity DOE Federal Test Procedure 10CFR 430, Appendix F
Energy Efficiency Ratio	<u>9.8</u>	EER	
	1224.5	Watts/kW	
	<u>1000</u>	Watts/kW	
	1.22	kW	

Conventional Full Load Demand	1.22	kW	
Honolulu Full Load Equivalent Cooling Hours	<u>2920</u>	Hours per Year	Based on 8 hr/day, 365 day/year
Conventional AC Annual Energy Consumption	3575.5	kWh per Year	

High Efficiency Central AC	12000	BTU/hr	Equals 1 Ton Cooling Capacity
Energy Efficiency Ratio	<u>13</u>	EER	Minimum Energy Star Rated Window AC
Full Load Demand	923.1	Watts	
Conversion	<u>1000</u>	Watts/kW	
Full Load Demand	0.92	kW	

High Efficiency Demand	0.92	kW	
Cooling Hours	<u>2920</u>	Hours per Year	
High Efficiency Energy Usage	2695.4	kWh per Year	



Hawai'i Energy – PY2016 Technical Reference Manual

Program Year July 1, 2016 to June 30, 2017

Annual Energy Savings	880.13	kWh per Year (PER TON)
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Coincidence Factor 75%

Demand Peak Savings	0.226	kW/TON
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SAVINGS

Table 5.3.2.c

Estimated system size:	3 ton
peak kW savings per 3-tons	0.678
annual kWh savings per 3-tons	2,640.38



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Program Year July 1, 2016 to June 30, 2017

5.3.3 Central AC Tune Up

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Central AC
Equipment Subtype	Tune Up
Equipment Size	None

VERSION HISTORY

Draft Date
Revision Date
Review Date

Measure Description:

Maintenance of a residential central A/C system.

Unit of Measure:

One unit

Baseline equipment:

Pre-tune up central air conditioning unit

Efficient equipment:

Post-tune up central air conditioning unit

Program criteria:

ALGORITHMS

Table 5.3.3.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES	Notes
HRS	Operating hours of A/C unit	1,460	



Hawai'i Energy – PY2016 Technical Reference Manual

Program Year July 1, 2016 to June 30, 2017

CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	Table 5.3.3.b	% of maximum hourly watt savings on average that were realized in a 5-9 pm time period for residential A/V equipment (see Valmiki and Corradini).
Measure Life	expected duration of energy savings	1 year	

Table 5.3.3.b

Home A/C Tune Up – Single Multi-family Residential Home

Average AC unit Size 3 ton unit

Average AC Unit EER 13.0 EER

EER to kW Conversion 12

÷ 13.0 EER

Average AC Unit kW/Ton 0.923 kW/Ton

Average AC unit Size 3 ton unit

Equivalent Full Load Run Hours (EFLRH) x 1,460 hrs./Year

Post Tune Up – Average Energy Consumption 4,043 kWh/Year

Pre Tune Up A/C Operational Problems EFLRH Adjustment Factor³¹ 8%

Post Tune Up – Average Energy Consumption 4,043 kWh/Year

Pre Tune Up A/C Operational Problems EFLRH Adjustment x 108%

Pre Tune Up - Average Energy Consumption 4,367 kWh/Year

Post Tune Up - Average Energy Consumption - 4,043 kWh/year

Post Tune Up – Average Energy Savings 323 kWh/Year

Persistence Factor x 1.0

AC Tune Up Energy Savings 323 kWh / Year

Average AC Unit Demand 2.77 kW

Persistence Factor 1.00

Pre Tune Up Coincidence Factor x 0.33

Pre Tune Up On Peak Demand 0.914 kW

AC Unit Demand will not change. A reduction in operational hours will occur once tune up is completed. This lowers Coincidence Factor

Pre Tune Up Coincidence Factor 0.33

Post Tune Up Run Time Adjustment Factor x 92%

³¹Accounts for impacts to performance due to incorrect refrigerant charge, clogged AHU filter, dirty condenser coil.



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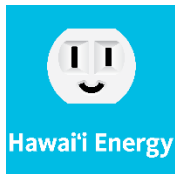
Program Year July 1, 2016 to June 30, 2017

Post Tune Up Coincidence Factor		0.3036	
Average AC Unit Demand		2.77	
Persistence Factor	x	1.00	
Post Tune Up On Peak Demand		0.841	kW
Pre Tune Up On Peak Demand		0.914	kW
Post Tune Up On Peak Demand	-	0.841	kW
AC Tune Up Demand Savings		0.073	kW

SAVINGS

Table 5.3.3.c

Building Types		Peak Demand Savings (kW)	Energy Savings (kWh/year)
Residential Household		0.073	323.45



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5.3.4 Ceiling Fans

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Fan
Equipment Subtype	Ceiling w/Light Kit
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	June 23, 2015
Review Date	

Measure Description:

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

Unit of Measure:

One unit

Baseline equipment:

Standard efficiency motor with three integral incandescent bulbs

Efficient equipment:

ENERGY STAR high efficiency motor with CFL bulbs

Program criteria:

ALGORITHMS

$$\begin{aligned}\text{peak kW savings per fan} &= [(\% \text{low} * (\text{Low_kW_base} - \text{Low_kW_ee}) + \% \text{med} * (\text{Med_kW_base} - \text{Med_kW_ee}) + \% \text{high} * (\text{High_kW_base} - \text{High_kW_ee})) + ((\text{Inc_kW} - \text{CFL_kW}) * \text{WHF}_d)] * \text{CF} \\ \text{annual kWh savings per fan} &= [(\% \text{low} * (\text{Low_kW_base} - \text{Low_kW_ee}) + \% \text{med} * (\text{Med_kW_base} - \text{Med_kW_ee}) + \% \text{high} * (\text{High_kW_base} - \text{High_kW_ee})) * \text{HOURS_fan} + ((\text{Inc_kW} - \text{CFL_kW}) * \text{WHF}_{ee}) * \text{HOURS_light}] * \text{CF}\end{aligned}$$



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Table 5.3.4.a

DEFINITIONS & ASSUMPTIONS³²		INPUT VALUES	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	0.015	
Low_kW_ee	low speed efficient fan motor wattage	0.012	0.008 kW per current ENERGY STAR criteria and min air flow setting
Med_kW_base	medium speed baseline fan motor wattage	0.035	
Med_kW_ee	medium speed efficient fan motor wattage	0.031	0.030 kW per current criteria and min air flow setting
High_kW_base	high speed baseline fan motor wattage	0.073	
High_kW_ee	high speed efficient fan motor wattage	0.072	0.067 kW per current criteria and min air flow setting
Inc_kW	baseline wattage of three incandescent bulbs	0.129	EISA general purpose baseline effective 2014
CFL_kW	wattage of three efficient CFL bulbs	0.060	
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	11%	
HOURS_fan	hours of fan operation per year	1022	2.8 hours per day, 365 days per year
HOURS_light	hours of light operation per year	840	2.3 hours per day, 365 days per year
WHFd	waste heat factor to account for cooling load savings from efficient lighting	1.21	
WHFee	waste heat factor to account for cooling energy savings from efficient lighting	1.07	
Measure Life	expected duration of energy savings	5 years	

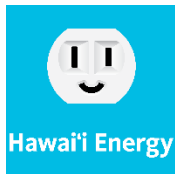
³² Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp. 43



SAVINGS

Table 5.3.4.b

peak kW savings per fan	0.012
annual kWh savings per fan	65



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Program Year July 1, 2016 to June 30, 2017

5.3.5 Solar Attic Fan

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Fan
Equipment Subtype	Solar Attic
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	April 29, 2016
Review Date	

Unit of Measure:

Fan serving whole home

Baseline equipment:

No attic fan

Efficient equipment:

Solar-powered attic fan in air-conditioned home

Program criteria:

ALGORITHMS

$$\text{peak kW savings per fan} = \text{AC_cap}/1000 * (1/\text{EER}) * \% \text{svgs_ac} * \text{PF} * \text{CF}$$

$$\text{annual kWh savings per fan} = \text{AC_cap}/1000 * (1/\text{EER}) * \text{EFLH} * \% \text{svgs_ac} * \text{PF}$$

Table 5.3.5.a

DEFINITIONS & ASSUMPTIONS³³		INPUT VALUES	Notes
%svgs_ac	percent of a/c load savings from solar attic fan	10%	
AC_cap	cooling capacity of existing air conditioner	8500	average of PY14 window A/C units

³³ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp. 46



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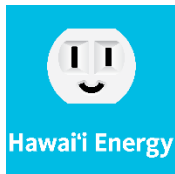
Program Year July 1, 2016 to June 30, 2017

			incentivized by Hawaii Energy
EER	full load cooling efficiency of existing air conditioner	9.8	
EFLH	equivalent full load cooling hours for existing air conditioner	1825	
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	0.000	
PF	persistence factor (% of measures installed and operational)	100%	
Measure Life	expected duration of energy savings	20 years	

SAVINGS

Table 5.3.5.b

peak kW savings per fan	0.00
annual kWh savings per fan	158



5.3.6 Whole House Fan

HAWAII ENERGY NOMENCLATURE

Equipment Group	HVAC
Equipment Type	Fan
Equipment Subtype	Whole House
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	April 17, 2015
Review Date	

Measure Description:

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

Unit of Measure:

One fan

Baseline equipment:

No fan installed

Efficient equipment:

Fan installed

Program criteria:

ALGORITHMS

$$\text{peak kW savings per fan} = \text{AC_cap}/1000 * (1/\text{EER}) * \% \text{svgs_ac} * \text{PF} * \text{CF}$$

$$\text{annual kWh savings per fan} = \text{AC_cap}/1000 * (1/\text{EER}) * \text{EFLH} * \% \text{svgs_ac} * \text{PF}$$

Table 5.3.6.a

<u>DEFINITIONS & ASSUMPTIONS</u> ³⁴	INPUT VALUES
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³⁴ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp.49-50.



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Program Year July 1, 2016 to June 30, 2017

%svgs_ac³⁵	percent of a/c load savings from solar attic fan	20%
AC_cap³⁶	cooling capacity of existing air conditioner	8500
EER	full load cooling efficiency of existing air conditioner	9.8
EFLH	equivalent full load cooling hours for existing air conditioner	1825
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	0.590
PF	persistence factor (% of measures installed and operational)	100%
Measure Life	expected duration of energy savings	20 years

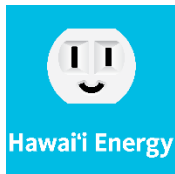
SAVINGS

Table 5.3.6.b

peak kW savings per fan	0.10
annual kWh savings per fan	317

³⁵ 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

³⁶ Average of PY14 window A/C units incentivized by Hawaii Energy



5.4 Lighting

5.4.1 Residential Compact Fluorescent Lamp

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	Fluorescent: CFL
Equipment Subtype	None
Equipment Size	Various

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	April 17, 2015
Review Date	

Measure Description:

Replacing incandescent lamp with standard screw-in, ENERGY STAR CFL

Unit of Measure:

One lamp

Baseline equipment:

Incandescent lamp

Efficient equipment:

ENERGY STAR CFL

ALGORITHMS

$$\text{peak kW savings per lamp} = \text{kW}_b * \text{CF} * \text{PF} - \text{kW}_{\text{cfl}} * \text{CF} * \text{PF}$$

$$\text{annual kWh savings per lamp} = \text{kW}_b * \text{HOURS} * \text{PF} - \text{kW}_{\text{cfl}} * \text{HOURS} * \text{PF}$$

Table 5.4.1.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES	Notes
kW_b	baseline wattage of average residential bulb	Table 5.4.1.b	



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Program Year July 1, 2016 to June 30, 2017

kW_cfl	wattage of average CFL bulb	Table 5.4.1.c	
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	12%	
PF	persistence factor, % of measures installed and operating	96%	
HOURS	hours of lamp operation per year	Table 5.4.1.b	
Measure Life	expected duration of energy savings	6 years	



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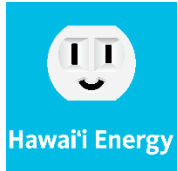
Program Year July 1, 2016 to June 30, 2017

Table 5.4.1.b: Baseline Lamp Characteristics³⁷

Lamp Types	Retired Baseline	Demand Baseline '07 EISA	Demand Baseline post 2020	Hours per Day, non-military	Hours per Day, military	HE Penetration %	Total kWh ² , non- military	Total kWh, military
	W	(kW_b)	(kW_b_20)					
Incandescent	100-150	0.072	0.023	2.3	3.45	2.40%	1.45	2.18
Incandescent	75	0.053	0.018	2.3	3.45	26.50%	11.79	17.69
Incandescent	60	0.043	0.015	2.3	3.45	24.70%	8.92	13.37
Incandescent	40	0.029	0.009	2.3	3.45	28.20%	6.87	10.30
CFL		0.026		2.3	3.45	0.50%	0.11	0.16
CFL		0.023		2.3	3.45	5.90%	1.14	1.71
CFL		0.014		2.3	3.45	5.50%	0.65	0.97
CFL		0.013		2.3	3.45	6.30%	0.69	1.03
Total Average Baseline Energy (kWh)							31.61	47.41
Total Average Demand (kW)							0.0376	

³⁷ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, p.28

1. Mix of CFL and incandescent assumes 81.8% incandescent replacement rate, and 18.2% CFL replacement rate, annually, which reflects 1 CFL burnout per every 4.5 CFL burnout in 9000 hours of operation.
2. Values differ slightly than shown in published table when converted from static values to calculations.



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Table 5.4.1.c: Efficient Lamp Characteristics³⁸

Demand Baseline (kW_cfl)	Hours per Day, non- military	Hours per Day, military	HE Penetration %	Total kWh ² , non- military	Total kWh, military
0.026	2.3	3.5	2%	0.44	0.65
0.023	2.3	3.5	33%	6.37	9.56
0.014	2.3	3.5	24%	2.82	4.23
0.013	2.3	3.5	42%	4.58	6.88
Total Average Energy (kWh)				14.21	21.32
Total Average Demand (kW)				0.0168	

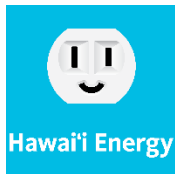
SAVINGS

Table 5.4.1.d

peak kW savings per lamp	0.0024
annual kWh savings per lamp, non-military	16.7
annual kWh savings per lamp, non-military	25.0

³⁸ Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, p.28

1. Mix of CFL and incandescent assumes 81.8% incandescent replacement rate, and 18.2% CFL replacement rate, annually, which reflects 1 CFL burnout per every 4.5 CFL burnout in 9000 hours of operation.
2. Values differ slightly than shown in published table when converted from static values to calculations.



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5.4.2 Residential LED

HAWAII ENERGY NOMENCLATURE

Equipment Group	Lighting
Equipment Type	LED
Equipment Subtype	None
Equipment Size	Various

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	May 19, 2016
Review Date	

Referenced Documents:

- Evergreen TRM Review – 2/23/12
- Evergreen TRM Review – 1/15/14

TRM Review Actions:

- 10/5/11 – Currently Under Review.
- 4/8/15 – Revised LED savings values per PY12 TRM Review

Major Changes:

- 11/21/11 – Updated tables and text in the following headings:
 - Measure description
 - Baseline efficiencies
 - High efficiency
 - Energy savings
 - Savings algorithm
- Updates made to capture a broader range of lamp types (two wattages per lamp type) and obtain more accurate savings calculations.
- 11/21/11 – Changed the following text under *Energy Savings* heading: 1) “LED Gross Savings before operational adjustments” was changed to “LED Savings before...” and 2) “CFL Net Savings after operational adjustments” was changed to “LED Savings after...”
- 11/21/11 – Under *Energy Savings* heading changed table to only one building type because savings are calculated the same between single and multi-family housing.
- Removed the 1.08 size adjustment factor.
- 4/8/15 – Changed persistence factor from 0.8 to 0.96 to be consistent with CFL bulbs.
- 4/17/15 – Baseline efficiency for CFL and for LED shall be the same.
- 4/17/15 – Adjust baseline to be a mixture of incandescents and CFLs.



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- 4/17/15 – Adjust baseline percentages based on Program statistics of CFLs and incandescents and a burn-out ratio of 4.5:1 (incandescents:CFL). Burn-out ratio from 2014 DEER data.
- 4/17/15 – Adjust enhanced case to be a mixture of LEDs based on actual Program statistics.
- 5/19/2016 – Added measure life.

Measure 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.

Baseline Efficiencies:

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.

Table 5.4.2.a

Baseline Efficiency					
Lamp Types	Demand Baseline (kW)	Hours per Day	Energy Baseline (kWh/year)	%	Totals
Incandescent	0.072	2.3	60.4	2.4%	1.45
Incandescent	0.053	2.3	44.5	26.5%	11.79
Incandescent	0.043	2.3	36.1	24.7%	8.92
Incandescent	0.029	2.3	24.3	28.2%	6.87
CFL	0.026	2.3	21.8	0.5%	0.12
CFL	0.023	2.3	19.0	5.9%	1.12
CFL	0.014	2.3	11.9	5.5%	0.65
CFL	0.013	2.3	10.6	6.3%	0.67
Total Baseline Energy (kWh)					31.58
Total Average Demand (kW)					0.0376

High Efficiency:



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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.

Table 5.4.2.b

Enhanced Efficiency					
Lamp Types	Demand Baseline (kW)	Hours per Day	Energy Baseline (kWh/year)	%	Totals
LED	0.0171	2.3	14.4	8%	1.20
LED	0.0126	2.3	10.6	29%	3.09
LED	0.0076	2.3	6.4	57%	3.62
LED	0.0055	2.3	4.6	6%	0.26
Total Baseline Energy (kWh)					8.17
Total Average Demand (kW)					0.0097

Table 5.4.2.c: Operational Adjustments

Operational Factor	Adjustment Factor
Persistence Factor (pf)	0.96
Demand Coincidence Factor (cf)	0.12

Energy Savings:

Table 5.4.2.d: LED Savings

Wattage Delta (kW)	0.0279
Annual Operating hours	839.5
Total Baseline Energy (kWh/year)	31.58
Total High Efficiency Energy (kWh/year)	8.17
Energy Delta (kWh/year)	23.41
Persistence Factor (pf)	0.96
Annual Energy Savings (kWh/year)	22.5
Persistence Factor (pf)	0.96
Peak Coincidence Factor	0.12
Peak Demand Savings (kW)	0.0032



Military savings

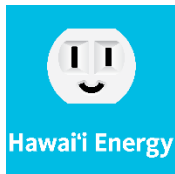
Based on EM&V review 1/15/14, military homes have 50 percent more operating hours than non-military homes, or 1,259.3 hours per year instead of 839.5 hours per year.

Table 5.4.2.e

Type	Demand Savings (kW)	Energy Savings (kWh/yr)
Non-Military	0.0032	22.5
Military	0.0032	33.8

Measure Life

15 years



5.5 Plug/Process Load

5.5.1 Advanced Power Strips

HAWAII ENERGY NOMENCLATURE

Equipment Group	Plug/Process Load
Equipment Type	Advanced Power Strip
Equipment Subtype	Tier 1 Tier 2
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	October 31, 2016
Review Date	

Referenced Documents:

- 11/22/11 – Advanced Power Strip kWh savings updated based on NYSERDA Measure Characterization for Advanced Power Strips.

TRM Review Actions:

- Evergreen TRM Review – 1/15/14

Major Changes:

- 6/23/2015 – Removed power strip cost data.
- 12/11/2015 – Added persistence factor of 0.80 (estimate) to account for some smart strips that are never installed or uninstalled.
- 10/31/2016 – Added Tier 2 advanced smart strip measure savings

Measure Description

Tier 1:

Load sensing advanced power strips (APS) eliminate standby loads when equipment has not been turned off. This measure involves the purchase and installation of load sensing advanced power strips in place of a code-compliant or standard efficiency power strip. Savings is based on the average savings per plug of a 5-plug strip and a 7-plug strip.

Tier 2:



Tier 2 APS eliminate standby loads when equipment has not been turned off and reduce excess energy usage that results from leaving equipment on when not in use. Additional sensors such as infrared (IR) or occupancy sensors (OS) detect activity in the room, allowing the APS to switch off loads when no activity is detected.

Definition of Efficient 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.

Definition of Baseline Equipment

The baseline efficiency equipment is a code-compliant or standard efficiency power strip.

Savings Algorithms

Table 5.5.1.a: Tier 1

Advanced Power Strips					NYSERDA Measure Characterization for Advanced Power Strips
Savings per Unit	kWh	56.5	102.8		
Plugs per Unit	plugs	÷ 5	7		
Savings per Plug	kWh/plug	11.3	14.686		
Average Savings per Plug			13.0 kWh		
			6 plugs/unit		
		x	0.8 PF		
Advanced Power Strip Energy Savings			62.4 kWh per Unit first year		
Hours of Operation		8760	hours/year		



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Demand Savings	0.007 kW
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Table 5.5.1.b

From PGE report Tables 10 & 11³⁹:

	IR-OS simulated savings [kWh]	IR-OS pre-post savings [kWh]	Average Savings	
Energy	118	110	114.00	kWh
Demand	0.016	0.01	0.013	kW
Tier 2 Power Strip Energy Savings			114.0	kWh
Demand Savings			0.013	kW

Measure Life

5 years

Savings cited from PG&E's Emerging Technologies Program, Project ET13PGE1441 - February 2016

http://www.aesc-inc.com/download/tier_2_aps_final_report_et13pge1441.pdf

39 Savings cited from PG&E's Emerging Technologies Program, Project ET13PGE1441 - February 2016

http://www.aesc-inc.com/download/tier_2_aps_final_report_et13pge1441.pdf



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5.6 Pumps & Motor

5.6.1 Pool Pump VFD

HAWAII ENERGY NOMENCLATURE

Equipment Group	Pumps & Motors
Equipment Type	Pool Pump VFD
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	
Review Date	November 14, 2013

Referenced Documents:

- Davis Energy Group (2008). Proposal Information Template for Residential Pool Pump Measure Revisions. Prepared for Pacific Gas and Electric Company; Page 2.
- Residential Retrofit High Impact Measure Evaluation Report. The Cadmus Group. February 8, 2010.

TRM Review Actions:

- 4/9/12 – Measure updated per EMV report February 23, 2012. Coincidence Factor of .0862 added. Added algorithm for Evergreen with 4.25 hours in place of 6 hours per day. Added Cadmus Group reference.
- 10/5/11 – Currently Under Review.
- 11/14/13 – No changes are recommended.

Major Changes:

- n/a

Measure Description

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

Definition of Efficient Equipment



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

Definition of Baseline Equipment

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

$$\Delta \text{ kWh} = (\text{kWBASE} \times \text{Hours}) \times 55\% \text{ BASE}$$

Where:

Unit = variable speed pool pump

$\Delta \text{ kWh}$ = Average annual kWh reduction

Hours = Average annual operating hours of pump

kWBASE = connected kW of baseline pump

55% = average percent energy reduction (*Davis Energy Group, 2008*)

Baseline Efficiency

The baseline efficiency case is a single speed pump.

Table 5.6.1.a

Based Demand	0.70 kW
Base Energy Usage per day	2.97 kWh/day
Base Energy Usage per year	1085 kWh/year



High Efficiency

The high efficiency case is variable speed pump.

Table 5.6.1.b

Demand Reduction	10%
High Efficiency Demand	0.63 kW
Energy Savings	55%
High Efficiency Energy Usage	488 kWh/year

Energy and Demand Savings

Table 5.6.1.c

Demand Savings	1.278 kW
Coincidence Factor	0.0862 kW

Energy Savings per year	597 kWh/year
Peak Demand Reduction	0.006 kW

Savings Algorithm



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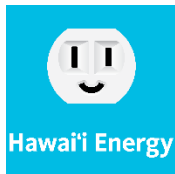
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Table 5.6.1.d

Average Pool Pump Horsepower	0.75 HP
Efficiency	0.8
Hours of operation per day	4.25 hours
Number of days pool in use	365 days per year
1 HP Equals	0.746 kW
Based Demand	0.70 kW
Base Energy Usage per day	2.97 kWh/day
Base Energy Usage per year	1085 kWh/year
Demand Reduction	10%
High Efficiency Demand	0.63 kW
Energy Savings	55%
High Efficiency Energy Usage	488 kWh/year
Demand Savings	1.278 kW
Coincidence Factor	0.0862 kW
Energy Savings per year	597 kWh/year
Peak Demand Reduction	0.006 kW

Lifetime of Efficient Equipment

The estimated useful life for a variable speed pool pump is 10 years.



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5.7 Water Heating

5.7.1 Heat Pump Water Heaters

HAWAII ENERGY NOMENCLATURE

Equipment Group	Water Heating
Equipment Type	Heat Pump Water Heater
Equipment Subtype	None
Equipment Size	None

VERSION HISTORY

Draft Date	March 2, 2011
Revision Date	June 23, 2015
Review Date	

Referenced Documents:

- From Salesforce Measures (Impact)
- October 2004 (KEMA Report)
- Evergreen TRM Review – 2/23/12
- Evergreen TRM Review – 1/15/14

TRM Review Actions:

- 10/5/11 – Currently Under Review.
- 11/14/13 – Adjusted savings to be consistent with the most recent product specifications.
- 06/23/15 – Reviewed for PY15. Removed reference to incentive amount (\$).

Major Changes:

- Recognizing the growing product availability and sales efforts regarding residential heat pumps, increase educational efforts.
- Changed base SERWH element power consumption from 4.5 kW to 4.0 kW

Measure Description:

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.

Baseline Efficiencies:



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The base case is a standard electric resistance water heater (SERWH).

Energy Savings:

Table 5.7.1.a

Measure	Energy Savings (kWh/year)	Demand Savings (kW)
Base Case (SERWH)	2732	0.57
Enhanced Case (HPWH)	1088	0.36
Savings	1644	0.21



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Savings Algorithms

Table 5.7.1.b

Heat Pump Water Heater				
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 per Day per Person		HE
Average Occupants	x	3.77 Persons		KEMA 2008
Household Hot Water Usage		50.1 Gallons per Day		
Mass of Water Conversion		8.34 lbs/gal		
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 kWh / BTU		
Energy per Day (kWh)		6.7 kWh / Day		
Days per Month	x	30.4 Days per Month		
Energy (kWh) per Month		205 kWh / Month		
Days per Year	x	365 Days per Year		
Energy (kWh) Needed in Tank to Heat Water per Year		2,459 kWh / Year		
Elec. Res. Water Heater Efficiency	÷	0.90 COP		
Base SERWH Energy Usage per Year at the Meter		2,732 kWh / Year		KEMA 2008 - HECO
Energy (kWh) Needed to Heat Water per Year		2,459 kWh / Year		
Heat Pump Water Heating Efficiency	÷	2.26 COP		
Heat Pump Water Heating Energy Usage		1,088 kWh / Year		
Base SERWH Energy Usage per Year at the Meter		2,732 kWh / Year		
Heat Pump Water Heating Energy Usage	-	1,088 kWh / Year		
Residential Heat Pump Water Heating Energy Savings		1644 kWh / Year		
Heat Pump Power Consumption		4.5 kW		
Coincidence Factor	x	0.08 cf		4.80 Minutes per hour
		0.36 kW On Peak		
Base SERWH Element Power Consumption		4.0 kW		
Coincidence Factor	x	0.143 cf		8.6 Minutes per hour
Base SERWH On Peak Demand		0.57 kW On Peak		KEMA 2008
Base SERWH On Peak Demand	-	0.57 kW On Peak		
Heat Pump Water Heater Demand	-	0.36 kW On Peak		KEMA 2008
		0.21 kW On Peak		
Residential Heat Pump Water Heating Demand Savings		0.21 kW Savings		



Operating Hours

See Table above.

Load Shape

TBD

Freeridership/Spillover Factors

TBD

Persistence Factor

Coincidence Factor

0.143 (based on 8.6 minutes per hour for 4 hours)

Lifetime

10 years (DEER)



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5.7.2 Solar Water Heater

HAWAII ENERGY NOMENCLATURE

Equipment Group	Water Heating
Equipment Type	Solar Water Heater
Equipment Subtype	\$500 Direct \$500 IBD
Equipment Size	None

VERSION HISTORY

Draft Date	February 24, 2010
Revision Date	April 8, 2015
Review Date	

Measure 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.

Unit of Measure:

One system

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.

Demand Baseline has been determined by field measurements by KEMA 2005-07 report. The energy baseline also comes from the KEMA 2005-07 report and is supported by engineering calculations shown in this TRM.

Efficient 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.

Solar Contractors do not favor Photo-Voltaic powered DC circulation pumps as they have proven less reliable in the field than an AC powered circulation pump.

The electric resistance elements in the high efficiency case do not have load control timers on them.



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The energy is the design energy of a 90% solar fraction system with circulation pump usage as metered by KEMA 2008.

The on peak demand is the metered demand found by KEMA 2008.

Program criteria:

Systems must comply with Hawaii Energy Solar Standards and Specifications which call out:

- Panel Ratings
- System Sizing
- Installation orientation de-rating factors
- Hardware and mounting systems

ALGORITHMS

Table 5.7.2.a

e		INPUT VALUES
Perf_F	SWH system performance factor	94.4%
PF	persistence factor (% of measures installed and operational)	93%
HOURS	annual hours of equipment operation	8760
CF	coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm	
Measure Life	expected duration of energy savings	20 years

SAVINGS

Table 5.7.2.b

Solar Water Heater - Non-Military Single Family Home

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 per Day per Person	HE KEMA 2008
Average Occupants	x	3.77	Persons	
Household Hot Water Usage		50.141	Gallons per Day	
Mass of Water Conversion		8.34	lbs/gal	



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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	kWh / BTU
Energy per Day (kWh)	6.7		kWh / Day
Days per Month	x	30.4	Days per Month
Energy (kWh) per Month	205		kWh / Month
Days per Year	x	365	Days per Year
Energy (kWh) Needed in Tank to Heat Water per Year	2,459		kWh / Year
Elec. Res. Water Heater Efficiency	÷	0.90	COP
Base SERWH Energy Usage per Year at the Meter	2,732		kWh / Year
			KEMA 2008 - HECO
Design Annual Solar Fraction	90%	Water Heated by Solar System	Program Design
	10%	Water Heated by Remaining Backup Element	
Energy Usage per Year at the Meter	2,732		kWh / Year
	x	10%	Water Heated by Remaining Backup Element
Back Up Element Energy Used at Meter	273.2		kWh / Year
Circulation Pump Energy	0.082		kW
			KEMA 2008
Pump Hours of Operation	x	1,292	Hours per Year
			KEMA 2008
Pump Energy used per Year	106		kWh / Year
Back Up Element Energy Used at Meter	273		kWh / Year
			72%
Pump Energy used per Year	+	106	kWh / Year
			28%
Design Solar System Energy Usage	379		kWh / Year



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Base SERWH Energy Usage per Year at the Meter	2,732	kWh / Year	
Design Solar System Energy Usage	-	379	kWh / Year
Design Solar System Energy Savings		2,353	kWh / Year
Design Solar System Energy Savings		2,353	kWh / Year
Performance Factor	0.94	pf	HE
Persistence Factor	x	0.93	pf
		2,057	kWh / Year

KEMA
2008
KEMA
2008

Residential Solar Water Heater Energy Savings	2,057.00	kWh / Year Savings
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KEMA
2008

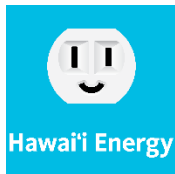
Base SERWH Element Power Consumption	4.0	kW	
Coincidence Factor	x	0.143	cf
Base SERWH On Peak Demand		0.57	kW On Peak
Base SERWH On Peak Demand	-	0.57	kW On Peak
Solar System Metered on Peak Demand	-	0.11	kW On Peak
		0.46	kW On Peak

8.6
Minutes
per hour
KEMA
2008

Residential Solar Water Heater Demand Savings	0.460	kW Savings
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Table 5.7.2.c

SWH	Peak Demand Savings (kW)	0.460
	Annual Energy Savings (kWh)	2057.00



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5.7.3 Solar Water Heating Tune-up

HAWAII ENERGY NOMENCLATURE

Equipment Group	Water Heating
Equipment Type	Solar Water Heater
Equipment Subtype	Tune Up
Equipment Size	None

VERSION HISTORY

Draft Date	February 21, 2011
Revision Date	
Review Date	

Measure Description:

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

Unit of Measure:

One system

Baseline equipment:

See Definitions & Assumptions

Efficient equipment:

See Definitions & Assumptions

Program criteria:

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

ALGORITHMS

$$\text{peak kW savings per system tune-up} = P_{\text{base}} - P_{\text{op}}$$

$$\text{annual kWh savings per system tune-up} = E_{\text{base}} - E_{\text{op}}$$

Table 5.7.3.a

<u>DEFINITIONS & ASSUMPTIONS</u>		INPUT VALUES
E_base	On Peak Demand for group "All"	577 ¹
E_op	On Peak Demand for group "Operating"	328 ¹



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P_base	kWh per Unit for group "All"	0.079 ¹
P_op	kWh per Unit for group "Operating"	0.050 ¹
Measure Life	expected duration of energy savings	5 years

Source: ¹KEMA 2005-2007 Energy and Peak Demand Impact Evaluation Report

SAVINGS

Table 5.7.3.b

Peak Demand Savings per Household (kW)	0.029
Annual Energy Savings per Household (kWh)	249.0



5.8 Other Residential Measures

5.8.1 Multifamily Direct-Install Kits

HAWAII ENERGY NOMENCLATURE

Equipment Group
Equipment Type
Equipment Subtype
Equipment Size

VERSION HISTORY

Draft Date July 1, 2015
Revision Date
Review Date

TRM Review Actions:

- 7/1/2015 – Pending review by EM&V

Major Changes:

- New measure

Measure Description:

The Hawaii Energy/Honeywell team went in to multifamily residential buildings and offered free installation of energy efficiency devices, including light bulbs, low flow showerheads and faucet aerators, and an advanced power strip. The savings claim for each household depends on the type of water heating for each home, as well as the occupancy for each home (this data was collected by the team).

Baseline Efficiencies:

100 W incandescent (replaced with 23 W CFL)

75 W incandescent (replaced with 20 W CFL)

60 W incandescent (replaced with 13 W CFL)

Showerhead = 2.5 gpm

Faucet = 2.2 gpm



Enhanced Efficiencies:

23 W CFL to replace the 100 W incandescent

20 W CFL to replace the 75 W incandescent

13 W CFL to replace the 60 W incandescent

Advanced power strip (7 plugs) for home entertainment system or home office

Low-flow showerheads = 1.5 gpm (40% reduction)

Low-flow faucet aerators = 1.5 gpm (32% reduction)

Persistence Factor:

Given that this measure was directly installed by the Hawaii Energy/Honeywell team, persistence factors are:

For CFL lightbulbs: 0.96

For advanced power strip: 0.96

For showerheads and faucet aerators: 1.00

Peak Demand Coincidence Factor:

For CFL lightbulbs: 0.12

For advanced power strip: 1.00

For showerheads and faucet aerators: 0.2

Measure Lives:

For CFL lightbulbs: 6 years

For advanced power strip: 5 years

For showerheads and faucet aerators: 5 years

Energy Savings Algorithm:



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For advanced power strip: See 0, Smart Strips

- Savings = 102.8 kWh per year * 0.96 pf = 98.7 kWh per year, first-year
- Given that this device was a 7-plug strip, the 7-plug strip value was used, rather than the TRM assumption of an average 6-plug unit.

For light bulbs:

- For each bulb replaced, the reduced wattage was calculated. Run time was assumed to be 2.3 hours per day per bulb, 365 days per year. Persistence factor is 0.96 and measure life = 6 years.
- 100 W replacement = 23 W CFL = 62.1 kWh per year savings
- 75 W replacement = 20 W CFL = 44.3 kWh per year savings
- 60 W replacement = 13 W CFL = 37.9 kWh per year savings

For low-flow showerheads:

- Given standard electric resistance water heating: PY14 TRM value of 306 kWh for an average family size of 3.77 people. This value was normalized on a per person basis of 81.2 kWh. Then the value was multiplied by the actual occupancy of the household. These values were assumed to be the same regardless of individual electric resistance water heating in the residential unit or system level electric resistance water heating in the building. Also, these values were assumed to be the same regardless of individually metered electrical billing at the apartment or master-metered electrical billing at the building.

Table 5.8.1.a

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - Elect	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3
Indiv Meter - Sys WH - Elect	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3
Master Meter - Indiv WH - Elect	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3
Master Meter - Sys WH - Elect	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3

- Given heat pump water heating: Starting with the PY14 TRM value of 2460 kWh per year required for heating all water for an average family size of 3.77 people, this value was divided by an average COP of 2.26 for heat pump water heaters, for 1088 kWh per year. Then the value was added up given 6% tank and pipe losses, for 1157 kWh per year. Given the assumption that showers account for 28% of all hot water use, heat pump water heating consumption for an average family is 324 kWh per year. By reducing shower water consumption by 40% with the low-flow showerhead, heat pump water heating consumption is reduced to 195 kWh per year per family, for a savings of 130 kWh per year per family. Per person energy savings is 34.5 kWh per person per year. Finally, the value was multiplied by the actual occupancy of the household.



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Savings is assumed to be the same regardless of individual heat pump, central heat pump, individually metered billing, or master-metered billing.

Table 5.8.1.b

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - HP	34.5	69.0	103.5	137.9	172.4	206.9	241.4	275.9
Indiv Meter - Sys WH - Cent HP	34.5	69.0	103.5	137.9	172.4	206.9	241.4	275.9
Master Meter - Indiv WH - HP	34.5	69.0	103.5	137.9	172.4	206.9	241.4	275.9
Master Meter - Sys WH - HP	34.5	69.0	103.5	137.9	172.4	206.9	241.4	275.9

- Given on-demand electric water heating: Starting with the PY14 TRM value of 2460 kWh per year required for heating all water for an average family size of 3.77 people, this value was divided by an average efficiency of 0.98 for on-demand/instantaneous water heaters, for 2510 kWh per year. Then the value was added up given 2% tank and pipe losses, for 2561 kWh per year. Given the assumption that showers account for 28% of all hot water use, heat pump water heating consumption for an average family is 717 kWh per year. By reducing shower water consumption by 40% with the low-flow showerhead, on-demand water heading consumption is reduced to 430 kWh per year per family, for a savings of 287 kWh per year per family. Per person energy savings is 76.1 kWh per person per year. Finally, the value was multiplied by the actual occupancy of the household. Savings is assumed to be the same regardless of individually metered billing or master-metered billing. There are no central on-demand water heating systems, only individual systems.

Table 5.8.1.c

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - OD	76.1	152.2	228.3	304.4	380.5	456.6	532.7	608.8
Master Meter - Indiv WH - OD	76.1	152.2	228.3	304.4	380.5	456.6	532.7	608.8

- Given boiler water heating: Savings were assumed to be the same for boiler water heating as for standard electric resistance water heating because gas-fired boilers were not in the scope of this measure. An electric-fired boiler is essentially the same as a standard electric resistance water heater. Savings are assumed to be the same regardless of individually metered billing or master-metered billing. There are no individual boiler water heaters in apartments, only central boilers.

Table 5.8.1.d

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Sys WH - Boiler	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3
Master Meter - Sys WH - Boiler	81.2	162.3	243.5	324.7	405.8	487.0	568.2	649.3

For faucet aerators:



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- Given standard electric-resistance water heating: PY14 TRM value for savings per year for an average family size of 3.77 people for faucet aerators is 65 kWh (assuming 90% efficiency). This value was normalized on a per person basis of 17.2 kWh. Then the value was multiplied by the actual occupancy of the household. These values were assumed to be the same regardless of individual electric resistance water heating in the residential unit or system level electric resistance water heating in the building. Also, these values were assumed to be the same regardless of individually metered electrical billing at the apartment or master-metered electrical billing at the building.

Table 5.8.1.e

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - Elect	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9
Indiv Meter - Sys WH - Elect	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9
Master Meter - Indiv WH - Elect	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9
Master Meter - Sys WH - Elect	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9

- Given heat pump water heating: Starting with the PY14 TRM value of 58.44 kWh savings per year for a family of 3.77 for faucet aerators (assuming 100% efficiency), this value was divided by an average COP of 2.26 for heat pump water heaters, for 25.9 kWh per year. Then the value was added up given 6% tank and pipe losses, for 27.6 kWh per year per family, or 7.3 kWh per year per person. Finally, the value was multiplied by the actual occupancy of the household. Savings is assumed to be the same regardless of individual heat pump, central heat pump, individually metered billing, or master-metered billing.

Table 5.8.1.f

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - HP	7.3	14.6	21.9	29.3	36.6	43.9	51.2	58.5
Indiv Meter - Sys WH - Cent HP	7.3	14.6	21.9	29.3	36.6	43.9	51.2	58.5
Master Meter - Indiv WH - HP	7.3	14.6	21.9	29.3	36.6	43.9	51.2	58.5
Master Meter - Sys WH - HP	7.3	14.6	21.9	29.3	36.6	43.9	51.2	58.5

- Given on-demand electric water heating: Starting with the PY14 TRM value of 58.44 kWh savings per year for a family of 3.77 for faucet aerators (assuming 100% efficiency), this value was divided by an average efficiency of 98% for on-demand/instantaneous water heaters, for 59.6 kWh per year. Then the value was added up given 2% tank and pipe losses, for 60.8 kWh per year per family, or 16.1 kWh per year per person. Finally, the value was multiplied by the actual occupancy of the household. Savings is assumed to be the same regardless of individually metered billing, or master-metered billing. There is only individual on-demand water heating, no central systems.



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Table 5.8.1.g

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Indiv WH - OD	16.1	32.3	48.4	64.6	80.7	96.8	113.0	129.1
Master Meter - Indiv WH - OD	16.1	32.3	48.4	64.6	80.7	96.8	113.0	129.1

- Given boiler water heating: Savings were assumed to be the same for boiler water heating as for standard electric resistance water heating because gas-fired boilers were not in the scope of this measure. An electric-fired boiler is essentially the same as a standard electric resistance water heater. Savings are assumed to be the same regardless of individually metered billing or master-metered billing. There are no individual boiler water heaters in apartments, only central boilers.

Table 5.8.1.h

Water Heater Type	1	2	3	4	5	6	7	8
Indiv Meter - Sys WH - Boiler	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9
Master Meter - Sys WH - Boiler	17.2	34.5	51.7	69.0	86.2	103.4	120.7	137.9

Demand Savings Algorithm

For lightbulbs:

- Peak coincidence demand factor is 0.12.
- 100 W replacement = 77 watt reduction * 0.96 pf * 0.12 cf = 0.0089 kW
- 75 W replacement = 55 watt reduction * 0.96 pf * 0.12 cf = 0.0063 kW
- 60 W replacement = 47 watt reduction * 0.96 pf * 0.12 cf = 0.0054 kW

For advanced power strip:

- 98.7 kWh savings per year/8760 hours per year = 0.0113 kW peak demand reduction

For low-flow showerheads

- Electric-resistance = PY14 TRM value = 0.1144 kW (see PY14 TRM)
- Heat pump = 0.1008 kW
- On-demand = assumed the same as electric-resistance (conservative value)

For faucet aerators:

- Electric-resistance = TRM value = 0.017 kW (see PY14 TRM)
- Heat pump = TRM value = 0.0936 kW
- On-demand = assumed the same as electric-resistance (conservative value)



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5.8.2 Peer Group Comparison

HAWAII ENERGY NOMENCLATURE

Equipment Group	Decision Making
Equipment Type	Report
Equipment Subtype	Peer Group Comparison
Equipment Size	None

VERSION HISTORY

Draft Date
Revision Date
Review Date

Measure 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.

ALGORITHMS

$$\Delta P = \frac{\Delta E}{HRS_{deemed}}$$

$$\Delta E = SVG_{deemed} \times E_{avg,year}$$

<u>DEFINITIONS & ASSUMPTIONS</u>		Value	Unit	Notes
ΔP	Peak power demand reduction	Calculated	<i>kW</i>	
ΔE	Annual energy reduction	Calculated	<i>kWh</i>	
$E_{avg,year}$	Average annual billed energy consumption	6,633	<i>kWh</i>	Utility billing data
SVG_{deemed}	Deemed savings factor	0.89	%	
HRS_{deemed}	Deemed hours per year of active energy reduction	3000	<i>hrs</i>	Hawai'i Energy PY15 TRM
Measure Life	Expected duration of energy savings	15	<i>yrs</i>	



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SAVINGS

Measure Name	Peak Demand Savings (kW)	Annual Energy Savings (kWh)
Peer Group Comparison	0.0197	59.03