# Hawaii Energy Efficiency Program

July 1, 2017 through June 30, 2018

# Technical Reference Manual (TRM)

# PY 2017

Measure Savings Calculations

*Hawai'i Energy – PY2017 Technical Reference Manual*

*Program Year July 1, 2017 to June 30, 2018*

**Applicable Program Year:** PY 2017 (July 1, 2017 through June 30, 2018)

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**Approvals:**

**Hawai'i Energy**

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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.

# 3. Glossary

The following glossary provides definitions for necessary assumptions needed to calculate measure savings.

**Attribution Factor (AF):** The Attribution Factor is the amount of savings attributable to the program impact. It is calculated by subtracting from one the % free ridership.

**Baseline Efficiency (ηbase):** The assumed standard efficiency of equipment, absent a Hawaii Energy program.

**Coincidence Factor (CF):** Coincidence factors represent the fraction of connected load expected to be "on" and using electricity coincident with the system peak period.

**Connected Load:** The maximum wattage of the equipment, under normal operating conditions, when the equipment is "on".

**Freeridership (FR):** A program's free ridership rate is the percentage of program participants deemed to be free riders. A free rider refers to a customer who received an incentive through an energy efficiency program who would have installed the same or a smaller quantity of the same high efficiency measure on their own within one year if the program had not been offered.

**Full Load Hours (FLH):** The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).

**High Efficiency (ηeffic):** The efficiency of the energy-saving equipment installed as a result of an efficiency program.

**Incremental Cost:** The cost difference between the installed cost of the high efficiency measure and the standard efficiency measure.

**Lifetimes:** The number of years (or hours) that the new high efficiency equipment is expected to function. These are generally based on engineering lives, but sometimes adjusted based on expectations about frequency of remodeling or demolition.

**System Loss Factor (SLF):** The marginal electricity losses from the generator to the customer meter – expressed as a percent of meter-level savings. The Energy Line Loss Factors vary by period. The Peak Line Loss Factors reflect losses at the time of system peak, and are shown for two seasons of the year (winter and summer). Line loss factors are the same for all measures.

**Load Factor (LF):** The fraction of full load (wattage) for which the equipment is typically run.

**Net-to-Gross Ratio (NTGR):** The fraction of gross measure savings realized by the program impact. It includes the gross verification adjustment and free ridership or attribution adjustment.

**Operating Hours (HOURS):** The annual hours that equipment is expected to operate.

**Persistence Factor (PF):** The fraction of gross measure savings obtained over the measure life.

**Spillover (SPL):** Spillover refers to energy-efficient equipment installed in any facility in the program service area due to program influences, but without any financial or technical assistance from the Program. It is expressed as a percent or fraction of the gross savings attributable to program participation.

**Total Resource Benefits (TRB):** The present value of benefits from the program savings resulting from avoided energy and capacity costs for the utility and their ratepayers.

# 4. Reference Tables

## 4.1 Lighting Operating Hours and Peak Load Coincidence

*Table 4.1. 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* | 4325 | 0.30 |
| Cold Storage | 3420 | 2760 | 4160 | 0.50 |
| Education | 2298 | 2340 | 2653 | 0.20 |
| Grocery | 4910 | 3890 | 5824 | 0.85 |
| Health | 4710 | 3885 | 6474 | 0.65 |
| Hotel/Motel | 1950 | 1670 | 4941 | 0.60 |
| Industrial | 3220 | 2580 | 4290 | 0.50 |
| Office | 2615 | 2990 | 2808 | 0.50 |
| Restaurant | 4830 | 4830 | 5278 | 0.75 |
| Retail | 3825 | 4180 | 4210 | 0.60 |
| 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.

## 4.2 Cooling Load Interactive Factors by Building Type

*Table 4.2. 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

## 4.3 Gross Customer to Net Program Savings

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

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

Where:

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

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

*Table 4.3*

| County Customer to System Loss Factor | | |
|---|---|---|
| Oahu | Maui | Hawaii |
| 11.17% | 9.96% | 9.00% |

Net-to-Gross Ratio (NTGR)

The Net-to-Gross Ratio used was estimated using the following information from the Evergreen (EM&V)

*Table 4.4*

| New Net-to-Gross Factors | | |
|---|---|---|
| Program | | Net-to-Gross |
| BEEM | Business Energy Efficiency Measures | 0.75 |
| CBEEM | Custom Business Energy Efficiency Measures | 0.75 |
| BESM | Business Services and Maintenance | 0.95 |
| BHTR | Business Hard to Reach | 0.99 |
| REEM | Residential Energy Efficiency Measures | 0.79 |
| CESH | Custom Energy Solutions for the Home | 0.65 |
| RESM | Residential Services and Maintenance | 0.92 |
| RHTR | Residential Hard to Reach | 1.00 |
| Effective Program Total Based on PY11 Portfolio Performance | | 0.78 |

## 4.4 Persistence Factor

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

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

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

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

## 4.5 Load Shapes and Demand Coincidence Factors

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

## 4.6 Development of Avoided Cost

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

**Proxy Avoided Cost Development**

The Program's avoided cost is calculated based on the PY2015 PBFA Contract Renewal Guidelines to use an initial $0.161/kWh avoided cost figure for 2015 and escalate it at 3% per year. The capacity impact was based on the utility revised avoided costs. The capacity avoided cost for the Program takes into account a prorated demand value based on O‘ahu demand achievements of 76% in PY13. Section 4.7, Total Resource Benefit, gives the complete 25-year forecast for Avoided Cost.

## 4.7 Total Resource Benefits

The Total Resource Benefit (TRB) is the estimated total net present value (NPV) of the avoided cost for the utility from the reduced lifetime demand (kW) and lifetime energy (kWh) from energy efficiency projects and measures. The utility costs were determined based on PY15 guidelines to use an initial $0.161/kWh avoided cost figure and escalate it at 3% per year. Hence, the starting value for avoided cost in 2017 is $0.171/kWh. The TRB incorporates avoided transmission and distribution costs into the avoided energy and capacity costs. The time value of money is represented by a discount rate of 6%. The discount rate is used to convert all costs and benefits to a “net present value” for comparing alternative costs and benefits in the same years’ dollars. The analysis is carried out over a 25 year period, which coincides with the maximum effective useful life for any measure in the Hawai‘i Energy portfolio.

**Demonstration TRB Values Using Modified Current EEPS Utility Avoided Cost**

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

| | | | Utility Avoided Costs* | | NPV for each Year | | NPV Cumulative from Final Year | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Period** | **NPV Multiplier** | **$/kW/yr.** | **$/kWh/yr.** | **$/kW/yr.** | **$/kWh/yr.** | **$/kW/yr.** | **$/kWh/yr.** |
| 2017 | 1 | 1.00 | | $ 0.171 | $ - | $ 0.1708 | $ - | $ 0.1708 |
| 2018 | 2 | 0.94 | | $ 0.176 | $ - | $ 0.1660 | $ - | $ 0.3368 |
| 2019 | 3 | 0.89 | | $ 0.181 | $ - | $ 0.1613 | $ - | $ 0.4980 |
| 2020 | 4 | 0.84 | $ 904.0 | $ 0.187 | $ 759 | $ 0.1567 | $ 759 | $ 0.6548 |
| 2021 | 5 | 0.79 | $ 986.0 | $ 0.192 | $ 781 | $ 0.1523 | $ 1,540 | $ 0.8070 |
| 2022 | 6 | 0.75 | $ 856.0 | $ 0.198 | $ 640 | $ 0.1480 | $ 2,180 | $ 0.9550 |
| 2023 | 7 | 0.70 | $ 750.0 | $ 0.204 | $ 529 | $ 0.1438 | $ 2,708 | $ 1.0988 |
| 2024 | 8 | 0.67 | $ 663.0 | $ 0.210 | $ 441 | $ 0.1397 | $ 3,149 | $ 1.2385 |
| 2025 | 9 | 0.63 | $ 590.0 | $ 0.216 | $ 370 | $ 0.1358 | $ 3,519 | $ 1.3742 |
| 2026 | 10 | 0.59 | $ 527.0 | $ 0.223 | $ 312 | $ 0.1319 | $ 3,831 | $ 1.5061 |
| 2027 | 11 | 0.56 | $ 474.0 | $ 0.230 | $ 265 | $ 0.1282 | $ 4,096 | $ 1.6343 |
| 2028 | 12 | 0.53 | $ 1,020.0 | $ 0.236 | $ 537 | $ 0.1246 | $ 4,633 | $ 1.7589 |
| 2029 | 13 | 0.50 | $ 1,066.0 | $ 0.244 | $ 530 | $ 0.1210 | $ 5,163 | $ 1.8799 |
| 2030 | 14 | 0.47 | $ 964.0 | $ 0.251 | $ 452 | $ 0.1176 | $ 5,615 | $ 1.9975 |
| 2031 | 15 | 0.44 | $ 875.0 | $ 0.258 | $ 387 | $ 0.1143 | $ 6,002 | $ 2.1118 |
| 2032 | 16 | 0.42 | $ 795.0 | $ 0.266 | $ 332 | $ 0.1110 | $ 6,334 | $ 2.2228 |
| 2033 | 17 | 0.39 | $ 724.0 | $ 0.274 | $ 285 | $ 0.1079 | $ 6,619 | $ 2.3307 |
| 2034 | 18 | 0.37 | | $ 0.282 | $ - | $ 0.1048 | $ 6,619 | $ 2.4355 |
| 2035 | 19 | 0.35 | | $ 0.291 | $ - | $ 0.1019 | $ 6,619 | $ 2.5374 |
| 2036 | 20 | 0.33 | | $ 0.300 | $ - | $ 0.0990 | $ 6,619 | $ 2.6364 |
| 2037 | 21 | 0.31 | | $ 0.308 | $ - | $ 0.0962 | $ 6,619 | $ 2.7326 |
| 2038 | 22 | 0.29 | | $ 0.318 | $ - | $ 0.0935 | $ 6,619 | $ 2.8261 |
| 2039 | 23 | 0.28 | | $ 0.327 | $ - | $ 0.0908 | $ 6,619 | $ 2.9169 |
| 2040 | 24 | 0.26 | | $ 0.337 | $ - | $ 0.0883 | $ 6,619 | $ 3.0051 |
| 2041 | 25 | 0.25 | | $ 0.347 | $ - | $ 0.0858 | $ 6,619 | $ 3.0909 |

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

## 4.8 Effective Useful Life

**Version Date & Revision History:**

**Draft date:** July 1, 2013

**Revision date:** May 1, 2018

**Referenced Documents:**

• Econorthwest TRM Review – 6/23/10
• DEER (The Database for Energy Efficient Resources) – 10/1/08

**TRM Review Actions:** • 6/23/10 Rec. – Adopt DEER values in those cases where there is a greater than 20 percent difference between DEER and current TRM. – Adopted

**Major Changes:**

• Hawaii Energy will adopt DEER EUI values across the board and will follow DEER changes as they are updated unless obvious differences for Hawaii applications are identified.

• 7/7/2015 – Changed Commercial Solar Water Heating effective useful life from 15 to 20 years to be consistent with residential SWH and historical data available through literature review. The measure Effective Useful Life estimated for each measure is shown in the following table:

| Residential (R) Business (B) | Measure Type | Description | DEER Effectve Useful Life (EUL) |
|---|---|---|---|
| REEM | Water Heating | Solar Water Heating | 20 |
| R | | Heat Pumps | 10 |
| R | Lighting | CFL | 6 |
| R | | LED | 15 |
| R | Air Conditioning | VRF Split | 15 |
| R | | Window AC w/recycling | 9 |
| R | | Ceiling Fans | 5 |
| R | | Solar Attic Fans | 20 |
| R | | Whole House Fans | 20 |
| R | Appliances | Refrigerator (<$600) | 14 |
| R | | Refrigerator w/Recycling | 14 |
| R | | Garage Refrigerator/Freezer Bounty | 14 |
| R | | Clothes Washer (Tier II/III) | 11 |
| R | | Set top box | 5 |
| R | | Pool VFD Controller Pumps | 10 |
| R | | Advanced Power Strip | 5 |
| R | Control Systems | Room Occupancy Sensors & Timers | 8 |
| R | | Peer Group Comparison | 1 |
| R | | Whole House Energy Metering | 4 |
| R | | Water cooler timer | 8 |
| CESH | Custom | Efficiency Project Auction | 5 |
| RESM | Design and Audits | Efficiency Inside | 15 |
| R | Tune Ups | Solar Water Heater Tune Up | 5 |
| R | Tune Ups | Central Air Conditional Retrofit | 15 |
| RHTR | Hard to Reach Grants | CFL Exchange | 6 |
| R | | Refrigerator w/Recycling | 14 |
| R | | Solar Water Heating | 20 |
| R | Direct Install | Energy Saving Kits | 6 |

| Residential (R) Business (B) | Measure Type | Description | DEER Effectve Useful Life (EUL) |
|---|---|---|---|
| BEEM | Water Heating | Solar Water Heating - Electric Resistance | 20 |
| B | | Solar Water Heating - Heat Pump | 20 |
| B | | Heat Pump - conversion - Electric Resistance | 10 |
| B | | Heat Pump Upgrade | 10 |
| B | | Single Family Solar Water Heating | 20 |
| B | Lighting | Ceramic Metal Halide | 14 |
| B | | CFL | 3 |
| B | | Delamp w/Reflector (2', 4', 8') | 14 |
| B | | Delamp | 14 |
| B | | ENERGY STAR LED Dimmable A19 | 15 |
| B | | ENERGY STAR LED Dimmable w/Controls | 15 |
| B | | ENERGY STAR LED Non-Dimmable | 15 |
| B | | ENERGY STAR LED Non-Dimmable A19 | 15 |
| B | | LED Exit Signs | 16 |
| B | | LED FIXTURE | 15 |
| B | | LED Refrigerator Case Lighting | 16 |
| B | | LED STREET AND PARKING LOT FIXTURE | 15 |
| B | | Sensors | 8 |
| B | | Stairwell Bi-Level Dimming Fluorescent | 14 |
| B | | T12 to T8 Low Wattage | 14 |
| B | | T12 to T8 Standard (2/3) | 14 |
| B | | T8 to T8 Low Wattage | 14 |
| B | HVAC | Chillers | 20 |
| B | | Chiller Plant Efficiency kW/Ton Meter | 20 |
| B | | Garage Active Ventilation Control | 8 |
| B | | Package Units | 15 |
| B | | VFR Split System - New Construction | 15 |
| B | | VFR Split System - Existing | 15 |
| B | | VFD - AHU | 15 |
| B | | VFD - Chilled Water/Condenser Water | 15 |

| Residential (R) Business (B) | Measure Type | Description | DEER Effectve Useful Life (EUL) |
|---|---|---|---|
| B | Water Pumping | VFD Dom Water Booster Packages | 15 |
| B | | VFD Pool Pump | 15 |
| B | Motors | CEE Tier 1 + Premium Efficiency Motors | 15 |
| B | | ECM w/Controller - evap fan motors | 15 |
| B | | ECM - Fan Coil Fans | 15 |
| B | Industrial Process | Kitchen Exhaust Hood Demand Ventilation | 15 |
| B | | Refrigerated Case Night Covers | 10 |
| B | Building Envelope | Cool Roof | 10 |
| B | | Window Tinting | 10 |
| B | Business Equipment | ENERGY STAR Refrigerator | 14 |
| B | | Clothes Washer | 11 |
| B | | Energy Savings Kit | 6 |
| B | Control Systems | Hotel Room Occupancy Controls | 8 |
| B | | Condominium submetering | 8 |
| B | | Small Business submetering | 8 |
| CBEEM | Customized | Custom <= 5 years | 5 |
| B | | Custom > 5 years | 13 |
| B | | Efficiency Project Auction | 10 |
| BESM | Design and Audits | Benchmarking Metering | 1 |
| B | | Decision Maker - Real time submeters | 1 |
| B | | Energy Audit | N/A |
| B | | Energy Study Implementation - 100% | N/A |
| B | | Energy Study Assistance - 50% | N/A |
| B | | Design Assistance - 50% | N/A |
| B | | Water/Wastewater Catalyst | 15 |
| BHTR | Direct Install | SBDI | 14 |
| B | Grants | Water cooler timer | 5 |
| B | Restaurant | SBDI - Kitchen Exhaust Hood Demand Ventilation | 15 |
| B | | Low flow spray rinse nozzles | 5 |
| B | | ENERGY STAR Kitchen Equipment | 12 |
| B | | SBDI - Lighting | 14 |
| B | Customized | Customized Retrofit | VARIES |
| B | Customized | Transformer | 25 |

# 5. Commercial Measures

## 5.1 Appliances

### 5.1.1 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** | October 5, 2011 |
| **Review Date** | May 1, 2018 |

**Unit of Measure**:
One refrigerator

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

*Table 5.1*

| | 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 5.2*

| | 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.

**ALGORITHMS**

$$\Delta \boldsymbol{E}_{\boldsymbol{replace}} = E_{base} - E_{he}$$

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

$$\Delta \boldsymbol{P}_{\boldsymbol{replace}} = \frac{E_{base} - E_{he}}{HRS}$$

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

*Table 5.3*

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

**SAVINGS**

*Table 5.4*

| **Opportunity** | | | | **Energy Usage** | **Reference** |
|---|---|---|---|---|---|
| New Non-ENERGY STAR | | | | 540 | Table 5.1.6 |
| New ENERGY STAR Refrigerator | | | - | 435 | Table 5.1.6 |
| | | | | 105kWh/Year | Table 5.1.5 |
| | | | | | |
| #1 - Purchase of ENERGY STAR Refrigerator | | | | 105 | Table 5.1.5 |
| #2 - Removal of Old Unit from Service (off the grid) | | | + | 717 | Table 5.1.5 |
| #1 + #2 = Purchase ES and Recycle old unit | | | | 822kWh/Year | |
| | **Energy Usage** | **Ratio** | **Contribution** | | |
| Post-1993 Refrigerator | 640 | 55% | 354.54 | | Table 5.1.7 |
| Pre-1993 Refrigerator | 1,131 | 45% | 504.46 | | Table 5.1.7 |
| | | | | 859 kWh/Year | |

*Table 5.5*

**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.**<br>• 9.3 million units were sold in 2008.<br>• 70 percent were not ENERGY STAR.<br>• 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.**<br>• 8.7 million primary units were replaced in 2008.<br>• 44 percent remained in use, whether they were converted to second units, sold, or given away.<br>• 3.8 million units are candidates for retirement every year. | 717 | 79.53 | 2,746,062 | 305 |
| **3. Decrease the number of second units.**<br>• 26 percent of households had a second refrigerator in 2008.<br>• 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.**<br>• 19 percent of all units in use in 2008 were manufactured before 1993.<br>• 27.3 million total potential units are candidates for targeted replacement. | 730 | 81 | 19,946,440 | 2,212 |

Sources: See endnote 10.

*Table 5.6*

## 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 5.7*

**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 5.8*

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

## 5.2 Building Envelope

### 5.2.1 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** | October 5, 2011 |
| **Review Date** | May 1, 2018 |

**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.

**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 10 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**

ΔkWh = SF / 1000 * ΔkWhkSF

| |
|---|
| **ΔkWh = 0.25 kWh / square feet** |

**Demand Savings**

ΔkW = ΔkW x CF

Demand Savings per square feet

ΔkW = 0.0001/SF * 0.50

| |
|---|
| **ΔkW = 0.00005 kW / 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.

### 5.2.2 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** | May 1, 2018 |

**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
- 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 5.9*

| Savings | Hotel | Office | Other | Average |
|---|---|---|---|---|
| Energy Savings (kWh/sqft) | 5.60 | 4.50 | 4.50 | 4.90 |
| Demand Savings (kW/sqft) | 0.001 | 0.001 | 0.002 | 0.001 |

| Savings | Hotel | Office | Other | Average |
|---|---|---|---|---|
| Energy Savings (kWh/ft2) | 5.6 | 4.5 | 4.5 | **4.9** |
| Demand Savings (kW/ft2) | 0.0014 | 0.0008 | 0.0016 | **0.0013** |

**Persistence Factor**
1.0

**Coincidence Factor**
1.0

**Lifetime**
10 years (DEER)

## 5.3 Commercial Kitchen

### 5.3.1 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** | May 1, 2018 |

**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.

**Baseline Efficiency:**

*Table 5.10*

| 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 5.11*

| 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 |
| 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 5.12*

| Performance | < 15 Pans | 15-28 Pans | > 28 Pans |
|---|---|---|---|
| Annual Energy Savings (kWh per oven) | 11,604 | 16,003 | 23,756 |
| Estimated Demand Reduction (kW per oven) | 2.3 | 3.1 | 4.6 |

**Operating Hours**

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

**Demand Coincidence Factor**

CF = 0.84

**Lifetime**

12 years

### 5.3.2 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** | May 1, 2018 |

**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 (≥70%) and must not exceed the maximum idle energy rate of 1.6 kW (≤ 1.6kW).

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

- 

**Baseline Efficiency:**

*Table 5.13*

| 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 5.14*

| 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 |
| **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 5.15*

| Performance | Half Size | Full Size |
|---|---|---|
| Annual Energy Savings (kWh per oven) | 1,988 | 1,879 |
| Estimated Demand Reduction (kW per oven) | 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

### 5.3.3 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** | October 5, 2011 |
| **Review Date** | May 1, 2018 |

**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**

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

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

$$\boldsymbol{P}_{\boldsymbol{in,per\ HP}} = \frac{P_{out,per\ HP}}{\eta}$$

*Table 5.16*

| DEFINITIONS & ASSUMPTIONS | | | | |
|---|---|---|---|---|
| $\Delta P$ | Power demand reduction | Calculated | $kW$ | |
| $\Delta E$ | Energy reduction | Calculated | $kWh$ | |
| $P_{in,per\ HP}$ | Input demand of controlled fan per HP | 0.38 | $kW$ | Table 5.3.8[1] |
| $P_{out,per\ HP}$ | Output power of fan per HP | Calculated | $kW$ | |
| $\eta$ | Efficiency factor of fan system | 0.90 | --- | Table 5.3.8[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 5.17:* 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 |
| | 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 5.18: Kitchen Demand-Controlled Ventilation Power Demand & Energy Savings*

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

[1] Original manufacturer report is no longer available

### 5.3.4 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** | May 1, 2018 |

**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.

**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 5.19: ENERGY STAR Criteria for Electric Single and Double Sided Griddles*

| Performance Parameters | Electric Griddles |
|---|---|
| Heavy-Load Cooking Energy Efficiency | >= 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.

ΔkWh = kWh(base) – kWh(eff)

ΔkWh(base or eff) = kWh(cooking) + kWh(idle) + kWh(preheat)

kWh(cooking) = [LB(food) x E(food)/Cook(eff)] x Days

kWh(idle) = IdleEnergy x [DailyHrs – LB(food)/Capacity – PreheatTime/60] x Days

kWh(preheat) = PreheatEnergy x Days

*Table 5.20*

<table>
<tr><th>Parameter</th><th>Description</th><th>Value</th><th>Source</th></tr>
<tr><td>Daily Hrs</td><td>Daily Operating Hours</td><td>12 hours</td><td>FSTC</td></tr>
<tr><td>Preheat Time</td><td>Time to Preheat (min)</td><td>15 min</td><td>FSTC</td></tr>
<tr><td>E(food)</td><td>ASTM defined Energy to Food</td><td>0.139 kWh/lb</td><td>FSTC</td></tr>
<tr><td>Days</td><td>Number of days of operation</td><td>365 days</td><td>FSTC</td></tr>
<tr><td>CookEff</td><td>Cooking energy efficiency (%)</td><td rowspan="3">See Table below</td><td rowspan="2">FSTC,<br>ENERGY STAR</td></tr>
<tr><td>IdleEnergy</td><td>Idle energy rate (kW)</td></tr>
<tr><td>Capacity</td><td>Production capacity (lbs/hr)</td><td>FSTC</td></tr>
</table>

| | | | |
|---|---|---|---|
| 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 5.21: 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 |

*Table 5.22*

| 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/yr per linear foot)** | **4929** |
| **Demand (kW per linear foot)** | **1.13** |

| | |
|---|---|
| **Energy Savings (kWh/year per linear foot)** | **757.88** |
| **Demand Savings (kW per linear foot)** | **0.173** |

**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

**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).

### 5.3.5 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** | May 1, 2018 |
| **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:

$\Delta$kWh/year = 3,258 kWh/pan

$\Delta$kW = 2.23 kW

**Savings Algorithms**

*Table 5.23*

## SAVINGS

| | | |
|---|---|---|
| **Average daily operation** | 12 | hours |
| **Annual days of operation** | 365 | days |
| **Food cooked per day** | 100 | pounds |
| **Number of pans per unit** | 3 | |

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

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

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

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

**Operating Hours**

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

**Demand Coincidence Factor**

CF = 1.0

**Persistence**

100% persistence factor

**Lifetime**

12 years

**Measure Costs**

Incremental cost = $2,000

### 5.3.6 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** | May 1, 2018 |

**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 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 Methods[183] that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

*Table 5.24: 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 | >= 80% | >= 80% |
| Idle Energy Rate | <+ 1.0 kW | <= 1.1 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.

ΔkWh = kWh(base) – kWh(eff)

ΔkWh(base or eff) = kWh(cooking) + kWh(idle) + kWh(preheat)

kWh(cooking) = [LB(food) x E(food)/Cook(eff)] x Days

kWh(idle) = IdleEnergy x [DailyHrs – LB(food)/Capacity – PreheatTime/60] x Days

kWh(preheat) = PreheatEnergy x Days

*Table 5.25*

| 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 5.26*

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 |

*Table 5.27*

| 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 (kW) per Vat | 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 (kW) per Vat | 3.55 | 3.74 |

| Savings | Standard | Large Vat |
|---|---|---|
| Energy Savings (kWh/year) per Vat | 1093.09 | 2659.29 |
| Demand Savings (kW) per Vat | 0.250 | 0.607 |

**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

**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).

### 5.3.7 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** | May 1, 2018 |

**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.

**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 5.28: 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) | - | 0.720 |
| Annual Energy Savings (kWh/year) | - | 3942.00 |
| Incremental Measure Cost ($) | | 2336 |
| Estimated Useful Life (years) | 12 | 12 |

*Table 5.29: Insulated Hot Food Holding Cabinet - Half Size*

| Performance | Baseline | High Efficiency Qualifying Model |
|---|---|---|
| Demand (kW) | 0.38 | 0.05 |
| Annual Energy Use (kWh/year) | 2081 | 274 |
| Estimated Demand Reduction (kW) | - | 0.330 |
| Annual Energy Savings (kWh/year) | - | 1806.75 |
| 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 5.30: 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)

### 5.3.8 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** | May 1, 2018 |

**Referenced Documents:**

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

**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.

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

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

Where:

- 100 = conversion factor to convert $kWh_{base,\ per\ 100lb}$ and $kWh_{ee,\ per\ 100lb}$ 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

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 unites, and remote condensing units) are eligible for incentives. Performance data is based on ARI Standard 810.

*Table 5.31*

**Energy Efficiency Requirements**

| Equipment Type | Ice Harvest Rate Range (lbs of ice/24 hrs) | Energy Effficient 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 | ≤ 8.72 - 0.0073H | ≤ 20 | 10.26 - 0.0086H |
| | ≥ 450 | ≤ 5.86 - 0.0009H | ≤ 20 | 6.89 - 0.0011H |
| Remote Condensing Units | < 1,000 | ≤ 7.52 - 0.0032H | ≤ 20 | 8.85 - 0.0038H |
| | ≥ 1,000 | ≤ 4.34 | ≤ 20 | 5.10 |
| Remote Condensing Units | < 934 | ≤ 7.52 - 0.0032H | ≤ 20 | 8.85 - 0.0038H |
| | ≥ 934 | ≤ 4.51 | ≤ 20 | 5.30 |
| Self-Contained Units | < 175 | ≤ 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:

*Table 5.32*

| 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**

12 years

### 5.3.9 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** | May 1, 2018 |
| **Review Date** | |

**Referenced Documents:**

- Evergreen TRM Review – 1/15/14

**TRM Review Actions:**

- 10/5/11 – Currently Under Review.

**Major Changes:**

- n/a

**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. Typical hours of operation has been assumed to be 2 hours per day.

**Baseline Efficiencies:**

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

**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:**

**ALGORITHMS**

ΔE = ΔWATER * HOT * 8.34 *ΔT * [(1 / η) / 3412]

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

**SAVINGS**

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

**Demand Coincidence Factor**

TBD

**Persistence**

TBD

**Lifetime**

5 years

**Measure Costs and Incentive Levels**

T0he actual measure installation cost should be used (including material and labor).

### 5.3.10 Refrigerators & Freezers

**HAWAII ENERGY NOMENCLATURE**

| | |
|---|---|
| **Equipment Group** | Commercial Kitchen |
| **Equipment Type** | Reach-in Refrigerator \| Reach-in Freezer |
| **Equipment Subtype** | Sold 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** | October 5, 2011 |
| **Review Date** | May 1, 2018 |

**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.

**Energy and Demand Savings:**

Annual Energy Savings (kWh/year) = $(kWh_{base} – kWh_{ee}) * 365$

Demand Savings = Annual Energy Savings / Hours * CF

**Operating Hours**

8760 hours/year

**Demand Coincidence Factor**

CF = 1.0

**Lifetime**

12 years

*Table 5.33: 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 |

*Table 5.34: 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 |

## 5.4 Energy Study Grant

### 5.4.1 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** | October 5, 2011 |
| **Review Date** | May 1, 2018 |

**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 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 cased analysis on equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The energy efficiency measures must be proven cost-effective, pass total resource benefit, and have a payback greater than or equal to 1.

**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

### 5.4.2 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
    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

## 5.5 HVAC - Heating, Ventilation and Air Conditioning Measures

### 5.5.1 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.

#### 5.5.1.1 Water Cooled Chiller Efficiency

**High Efficiency Chiller - 15% higher than IECC 2006**

*Table 5.35: 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 |

#### 5.5.1.2 Air Cooled Chiller Efficiency

*Table 5.36: 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 | |

#### 5.5.1.3 Water Cooled Energy Savings

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

*Table 5.37: 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 |

#### 5.5.1.4 Air Cooled Energy Savings

*Table 5.38: 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 |

#### 5.5.1.5 Water Cooled Demand Savings

*Table 5.39: 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 |

#### 5.5.1.6 Air Cooled Demand Savings

*Table 5.40: 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)

### 5.5.2 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

**ALGORITHMS**[2]

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

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

*Table 5.41*

| **DEFINITIONS & ASSUMPTIONS** | | **INPUT VALUES** |
|---|---|---|
| $\Delta \boldsymbol{P}$ | Power demand reduction | Calculated |

[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.

| | | |
|---|---|---|
| $\Delta E$ | Energy reduction | Calculated |
| $\eta_{base}$ | Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment. (S)EER | Table 5.5.8 |
| $\eta_{he}$ | Proposed higher efficiency rating, BTU/hr-W. (S)EER | Table 5.5.8 |
| $CF$ | coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm | Table 5.5.8[3] |
| $HRS$ | equivalent full load cooling hours | Table 5.5.9[4] |
| $ton$ | unit of equipment cooling capacity | 12,000 BTU/hr |
| $Measure\ Life$ | expected duration of energy savings | 15 years |

*Table 5.42: Packaged/Split Air Conditioner Baseline and Minimum Required Efficiencies*

| Unit Size, BTU/hr | $\eta_{base}$ (S)EER | Minimum $\eta_{he}$ (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:*

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 5.43: 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 |
|---|---|---|---|---|---|

[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.

| | | | | | |
|---|---|---|---|---|---|
| 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 5.44: 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 |

### 5.5.3 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**

$$\Delta \boldsymbol{P}_{\boldsymbol{peak,per\ HP}} = CF \times \left(\frac{LF \times SF_{power}}{\eta}\right) \times \left(1\ HP \times \frac{0.746\ kW}{1\ HP}\right)$$

$$\Delta \boldsymbol{E}_{\boldsymbol{annual,per\ HP}} = HRS \times \left(\frac{LF \times SF_{energy}}{\eta}\right) \times \left(1\ HP \times \frac{0.746\ kW}{1\ HP}\right)$$

*Table 5.45*

| **DEFINITIONS & ASSUMPTIONS** | **INPUT VALUES** |
|---|---|

| | | |
|---|---|---|
| $\Delta P$ | Power reduction | Calculated |
| $\Delta E$ | Energy reduction | Calculated |
| $LF$ | Load factor (% of full load power in typical operation) | 75% |
| $\eta$ | Motor efficiency | 92% |
| $SF_{power}$ | Power demand savings factor, % | Table 5.5.12 |
| $SF_{energy}$ | Energy savings factor, % | Table 5.5.12 |
| $CF$ | Coincidence factor, percent of time savings correspond with utility peak, 5 pm to 9 pm | Table 5.5.12 |
| $HRS$ | Hours of pump operation per year | Table 5.5.12 |
| $Measure\ Life$ | Expected duration of energy savings | 15 |

*Table 5.46: 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 5.5.14.
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 5.47*

| | |
|---|---|
| **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** |

*Table 5.48: 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

### 5.5.4 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

**ALGORITHMS**[5]

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

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

*Table 5.49*

| **DEFINITIONS & ASSUMPTIONS** | **INPUT VALUES** | **Notes** |
|---|---|---|

[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.

| | | | |
|---|---|---|---|
| **(S)EER_b** | Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment. | Table 5.5.16 | 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 5.5.16 | 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 5.50: 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 |
| >=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 5.51: 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 5.52: 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 |
| 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 |

### 5.5.5 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** | May 1, 2018 |

**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** =0.10kW/room*#ROOMS

**annual kWh savings per room** =750kWh/room*#ROOMS

*Table 5.53*

| DEFINITIONS & ASSUMPTIONS | | INPUT VALUES | Notes |
|---|---|---|---|
| **kW/room** | deemed demand savings per hotel room/unit | 0.100 | kW |
| **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 5.54: Savings per Hotel Room EMS Controls*

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

## 5.6 Lighting Measures

### 5.6.1 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:**

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 5.55*
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):

*Table 5.56*

| | CFL Energy Reduction | | |
|---|---|---|---|
| Building Type | < 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 5.57*

| Military Residential Values | kWh/year | kW |
| --- | --- | --- |
| CFLs | 46.2 | 0.004 |

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

*Table 5.58*

| | CFL Demand Reduction | | |
| --- | --- | --- | --- |
| Building Type | < 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)

### 5.6.2 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**

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

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

**delta_W** =W_b-W_ee

*Table 5.59*

| **DEFINITIONS & ASSUMPTIONS** | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.6 |
| **W_b** | wattage of the baseline lamp | Table 5.6.6 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.6 |
| **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 32 |
| **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 5.6.6 |

*Table 5.60: 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.*

**SAVINGS**[6]

*Table 5.61: 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 |
| 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 |

[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.

*Table 5.62: 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 5.63: 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 |

*Table 5.64: 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 |

### 5.6.3 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%.

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.

**SAVINGS**[7]

### 5.6.3.1 Approved T12 to T8 with electronic ballast

*Table 5.65: T12 to Standard T8 Lamp Demand Savings per Lamp by Building Type and Lamp Size*

| | Demand Savings (kW) | | | |
|---|---|---|---|---|
| **Building Type** | **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 5.66: T12 to Standard T8 Energy Savings per Lamp by Building Type and Lamp Size*

| | Energy Savings (kWh/year) | | | |
|---|---|---|---|---|
| **Building Type** | **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 |
| 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 |

[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.

### 5.6.3.2 T12 to T8 Low Wattage

*Table 5.67: 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 5.68: 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 |

### 5.6.4 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 5.69*

| | 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.

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

**ALGORITHMS**

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

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

**delta_W** =W_b-W_ee

*Table 5.70*

| DEFINITIONS & ASSUMPTIONS[8] | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.17 |
| **W_b** | wattage of the baseline lamp | Table 5.6.17 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.17 |
| **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 5.71: 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 |
| | 2' lamp | 15.00 | 16.20 | 8.50 |

## SAVINGS

*Table 5.72: 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 |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 5.73: 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 |

### 5.6.5 Non-Linear LED Lamps

**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**

$$\Delta \boldsymbol{P}_{\boldsymbol{ndim}} = P_{base} - P_{LED}$$

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

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

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

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

*Table 5.74*

**DEFINITIONS & ASSUMPTIONS**

| | | | |
|---|---|---|---|
| $\Delta P_{ndim}$ | Power demand difference between non-dimmable and baseline | Table 5.6.22 | $kW$ |
| $P_{base}$ | wattage of the baseline lamp | Table 5.6.21 | $kW$ |
| $P_{LED}$ | wattage of the proposed efficient lamp | Table 5.6.21 | $kW$ |
| $\Delta P_{dim}$ | Power demand difference between dimmable and baseline<br>0.36 => dimmable demand reduction, 2015 PA TRM Table 3-5 | Table 5.6.22 | $kW$ |
| $\Delta P_{blend}$ | Power demand difference between blended and baseline | Table 5.6.22 | $kW$ |
| $\%_{dim}$ | Percentage of LEDs that are dimmable | Table 5.6.22 | % |
| $\%_{ndim}$ | Percentage of LEDs that are non-dimmable | Table 5.6.22 | % |
| $IF_d$ | 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 5.6.23 | % |
| $PF$ | persistence factor, % of measures installed and operating | 100 | % |
| $HRS$ | equivalent full load hours, or hours of lighting for business operation | Table 5.6.23 | $hrs$ |
| **Measure Life** | expected duration of energy savings | 15 | $yrs$ |

## SAVINGS

*Table 5.75: 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 5.76: 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 |
| 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 |

*Table 5.77: 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 |
| 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)

### 5.6.6 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 5.78*

| 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/xe/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:

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

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

**delta_W** =W_b-W_ee

Exterior use savings algorithms:

**kW savings per unit** =delta_W/1000*ExtrCF*PF

**kWh savings per unit** =delta_W/1000*ExtrHrs*PF

**delta_W** =W_b-W_ee

*Table 5.79*

| **DEFINITIONS & ASSUMPTIONS**[9] | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.26 |
| **W_b** | wattage of the baseline lamp | Table 5.6.26 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.26 |
| **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)

*Table 5.80: 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 5.81: 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 5.82: 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 5.83: 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 5.84: LED Corn Cob Energy Savings by Building Type & Wattage Range*

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

### 5.6.7 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**

| | |
|---|---|
| **kW savings per lamp** | =delta_W/1000*IF_d*CF*PF |
| **kWh savings per lamp** | =delta_W/1000*IF_e*EFLH*PF |
| **delta_W** | =W_b-W_ee |

*Table 5.85*

| **DEFINITIONS & ASSUMPTIONS**[11] | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | 35 |
| **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 |

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

| | | |
|---|---|---|
| **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 |

**SAVINGS**[12]

*Table 5.86: 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.

### 5.6.8 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 5.6.5 for details.

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

**ALGORITHMS**

| | |
|---|---|
| **kW savings per unit** | =delta_W/1000*IF_d*CF*PF |
| **kWh savings per unit** | =delta_W/1000*IF_e*EFLH*PF |
| **delta_W** | =W_b-W_ee |

*Table 5.87*

| e | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.22 |
| **W_b** | wattage of the baseline lamp | Table 5.6.21 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.21 |
| **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 |

**SAVINGS**

**See section 5.6.5 for more details on savings calculation. Recessed Can measure savings based on PAR30 lamp savings calculations.**

*Table 5.88: 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 5.89: 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 |
| Hotel/Motel | 271.52 |
| Industrial | 220.52 |
| Office | 147.80 |
| Restaurant | 273.39 |
| Retail | 218.69 |
| Warehouse | 208.92 |

### 5.6.9 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** | February 23, 2018 |
| **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**

| | |
|---|---|
| **delta_W** | =(W_b-W_ee) per linear foot |
| **Lighting kWh savings per lamp** | =delta_W/1000*IF_e*EFLH*PF |
| **kW savings per lamp** | = delta_W/1000*IF_d*CF*PF |

*Table 5.90*

| DEFINITIONS & ASSUMPTIONS | | | |
|---|---|---|---|
| **W_b** | wattage of the baseline lamp | 11 watts per foot | average baseline wattage from Regional Technical Forum for display case LED |
| **W_ee** | wattage of the proposed efficient lamp | 5 watts per foot | average efficient wattage from Regional Technical Forum for display case LED |
| **delta_W** | difference between baseline and proposed efficient lamp wattage | 6 watts per foot | calculated |
| **IF_d** | factor reflecting impact of lighting savings on cooling load | 1.114 | Grocery value from Hawaiʻi Energy Interactive Factors Table |
| **IF_e** | factor reflecting impact of lighting savings on cooling energy | 1.043 | Grocery value from Hawaiʻi Energy Interactive Factors Table |
| **CF** | coincidence factor, percent of time equipment load corresponds with utility peak load | 100% | Assumed Grocery lighting in operation 5-9 PM |
| **PF** | persistence factor, % of measures installed and operating | 100% | |
| **EFLH** | equivalent full load hours, or hours of lighting for business operation (17 hours per day, 365 days/year) | 6205 | PA TRM. Assumes 6,205 annual operating hours and 50,000 lifetime hours. Most case lighting runs continuously (24/7) but some can be controlled. 6,205 annual hours of use can be used to represent the mix. Using grocery store hours of use (4,660 hr) is too conservative since case lighting is not tied to store lighting. |
| **Measure Life** | expected duration of energy savings | 16 years | CA DEER 2014 |

## SAVINGS

*Table 5.91: Demand & Energy Savings per lamp*

| | Peak Demand Savings (kW) | Energy Savings (kWh/year) |
|---|---|---|
| 4-foot lamp | 0.027 | 155.32 |
| 5-foot lamp | 0.033 | 194.15 |
| 6-foot lamp | 0.040 | 232.99 |

### 5.6.10 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)

**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.

**Baseline & High Efficiency:**

*Table 5.92*

| 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.
- 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).

### 5.6.11 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**

| | |
|---|---|
| **kW savings per unit** | =delta_W/1000*IF_d*CF*PF |
| **kWh savings per unit** | =delta_W/1000*IF_e*EFLH*PF |
| **delta_W** | =W_b-W_ee |

*Table 5.93*

| **DEFINITIONS & ASSUMPTIONS**[13] | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.40 |
| **W_b** | wattage of the baseline lamp | Table 5.6.40 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.40 |
| **IF_d** | factor reflecting impact of lighting savings on cooling load | Table 3.2 |

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

| | | |
|---|---|---|
| **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 5.94: 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 5.95: 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 |

*Table 5.96: 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 |

### 5.6.12 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 5.97*

| 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/xe/Marketing/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**

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

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

**delta_W** =W_b-W_ee

*Table 5.98*

| **DEFINITIONS & ASSUMPTIONS**[14] | | |
|---|---|---|
| **delta_W** | difference between baseline and proposed efficient lamp wattage | Table 5.6.45 |
| **W_b** | wattage of the baseline lamp | Table 5.6.45 |
| **W_ee** | wattage of the proposed efficient lamp | Table 5.6.45 |
| **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 5.99: 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 5.100: LED U-bend Power Demand Savings by Building Type, LED Size, & LED Type*

| **Building Type** | **Demand Savings (kW)** | | | | | |
|---|---|---|---|---|---|---|
| | **2 ft.** | | | **4 ft.** | | |
| | **Type A** | **Type B** | **Type C** | **Type A** | **Type B** | **Type C** |
| Misc. Commercial | 0.01364 | 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 |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 5.101: 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 |

### 5.6.14 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_controlled/1000*CF*PF*IF_d

**kWh savings per sensor** =W_controlled/1000*EFLH*RTR*PF*IF_e

*Table 5.102*

| **DEFINITIONS & ASSUMPTIONS** | | **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% |
| **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 5.103: Occupancy Sensor Power Demand & Energy Savings*

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

### 5.6.15 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**

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

**kWh savings per fixture** =[kW_b*EFLH-(kW_ee,dim*EFLH*UF+kW_ee,full*EFLH*OF)]*IF_e*PF

*Table 5.104*

| **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 |
| **UF** | unoccupied fraction | Table 5.6.51 |
| **OF** | occupied fraction | Table 5.6.51 |

| | | |
|---|---|---|
| **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 5.105: 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 5.106: 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 5.107: 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** |

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

### 5.6.16 Small Business Direct Install Lighting

**The following documents how savings are calculated for the SBDIL projects within Amplify.**

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

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

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

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

Formula:

EFLH = ( Sum (Hours per Day of Week) * 52.142857 ) – ((Number of Holidays) * Average Operating Hours per Day)

*Default:* *EFLH = (9*5*52.142857) – (8*9) = 2,274.4 hours/year*

Where: Hours per Day of Week is evaluated for each day of the week and is equal to:

WHEN End Hours > Start Hours THEN End Hours - Start Hours

WHEN End Hours < Start Hours THEN End Hours - Start Hours + 24

WHEN End Hours = Start Hours THEN 24

## 5.7 Plug/Process Load Measures

### 5.7.1 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**

**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 5.108*

| **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 5.109: 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 | |
| | | |
| 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: (Peak kW Savings per Linear Foot) = (Total Peak Power Savings) / (Bottom Door Length)
(Annual kWh Savings per Linear Foot) = (Total Annual Energy Savings) / (Bottom Door Length)

### 5.7.2 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:

$\Delta$kWh = (kWrated)(Hours)(SAVE)

$\Delta$kW = $\Delta$kWh/ Hours

Where:

kWrated = 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

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

**Vending Machine and Cooler Controls Savings Factors**

*Table 5.110*

| Machine Type | kW Savings | kWh/year Savings |
|---|---|---|
| Refrigerated beverage vending maching (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

### 5.7.3 Water Cooler Timer ($H_2$Off)

**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.

**Baseline Efficiencies:**

No timer

*Table 5.111*

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

| | |
|---|---|
| Hours per Day | 24 |
| Days per year | 365 |

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

**High Efficiency:**

*Table 5.112*

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

**Energy Savings:**

*Table 5.113*

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

**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**

**<u>Demand Savings:</u>**

Taking a conservative approach, the demand savings will based on the following calculation and methodology:

Demand Savings = 225 kWh/year divided by 8760 hrs/year = 0.026 kW

Coincidence Factor = 75%

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

Coincidence Demand Savings = 0.026 kW x .75 = 0.020 kW

Persistence = 90% (10% of people will disconnect)

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

**Lifetime**

5 years

**<u>Savings Algorithms</u>**

*Table 5.114*

| | |
|---|---|
| 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**

| | |
|---|---|
| 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% |

## 5.8 Pumps and Motors

### 5.8.1 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:**

- 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.

## SAVINGS

*Table 5.115*

**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** |
| 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** |

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

*Table 5.116*

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

### 5.8.2 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 |
| **annual kWh savings per motor** | =(kW_pre-kW_post)*HOURS |

*Table 5.117*

| DEFINITIONS & ASSUMPTIONS | | | | |
|---|---|---|---|---|
| **kW/W_pre** | demand of existing motor technology | Table 5.8.4 | | |
| **kW/W_post** | demand of new electronically commutated motor | Table 5.8.4 | | |
| **kWh/W_pre** | energy use of existing motor technology | Table 5.8.4 | | |
| **kWh/W_post** | energy use of new electronically commutated motor | Table 5.8.4 | | |
| **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 5.118: 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 5.119: 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

### 5.8.3 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.

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

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

*Table 5.120*

| Commercial Pool Pump | | | |
|---|---|---|---|
| Pool Pump Horesepower | | 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** |
| **Energy Savings per year** | | **1123** | **kWh/year per HP** |

**Deemed Lifetime of Efficient Equipment**
The estimated useful life for a variable speed pool pump is 15 years.

## 5.9 Submetering

### 5.9.1 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).

**Requirements:**

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

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

**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 5.121*

| 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 5.122*

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

**Energy and Demand Savings (for illustration purposes only):**

*Table 5.123*

| 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 |

*Table 5.124: **Example** Savings Calculation*

| **Submetering (Condominium)** | | | | |
|---|---|---|---|---|
| Average Master Meter Energy Usage (kWh/month) | | 180,000 | kWh per month | |
| Number of tenant Units | ÷ | 300 | Units | |
| Average Tenant Energy Usage (Example) | | 600 | kWh per home per month | |
| | x | 12 | month per year | |
| Baseline Annual Household Energy Usage | | 7,200 | kWh per Year | |
| | | | | |
| Average Master Meter Demand (kW) | | 425 | | |
| Number of tenant Units | ÷ | 300 | | |
| Baseline Demand (kW) | | 1.42 | kW | |
| | | | | |
| Energy Reduction | | 10.0% | | |
| Actively Informed Household Energy Usage | | 6,480 | kWh per Year | |
| | | | | |
| Baseline Annual Household Energy Usage | | 7,200 | kWh per Year | |
| Actively Informed Household Energy Usage | - | 6,480 | kWh per Year | |
| Gross Customer Level Energy Savings | | 720 | kwh per Year | |
| | | | | |
| Gross Customer Level Energy Savings | | 720 | kwh per Year | |
| Persistance Factor | x | 1.0 | | |
| Net Customer Level Savings | | 720 | kwh per Year | |
| | | | | |
| Submetering Energy Savings | | 720 | kWh / Year Savings | |
| | | | | |
| Baseline Household Demand | | 1.42 | kW | HECO 2008 Load Study |
| | | | | |
| Peak Demand Reduction | | 8.00% | | |
| | | | | |
| Actively Informed Household Demand | | 1.30 | kW | |
| | | | | |
| Baseline Household Demand | | 1.42 | kW | |
| Actively Informed Household Demand | - | 1.30 | kW | |
| Gross Customer Demand Savings | | 0.113 | kW | |
| | | | | |
| Gross Customer Demand Savings | | 0.113 | kW | |
| Persistance Factor | x | 1.0 | | |
| Coincidence Factor | x | 1.0 | | |
| | | 0.113 | kW | |
| | | | | |
| Condominium Sub-Metering Demand Savings | | 0.113 | kW Savings | |

**Notes**

- 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 AOAO securing the approval, installing and utilizing the submeters for billing purposes.
- There is no minimum reduction in electrical use to be required by AOAO to retain the incentive.

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

### 5.9.2 Small Business Submetering Pilot

<u>**HAWAII ENERGY NOMENCLATURE**</u>

| | |
|---|---|
| **Equipment Group** | Submetering |
| **Equipment Type** | Small Business |
| **Equipment Subtype** | Actual Savings |
| **Equipment Size** | None |

<u>**VERSION HISTORY**</u>

| | |
|---|---|
| **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.

- 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 5.125*

| 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 5.126*

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

**Energy and Demand Savings:**

*Table 5.127*

| 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 |

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.

*Table 5.128: **Example** Savings Calculation*

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

**Incentives/Incremental Cost**

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

## 5.10 Water Heating

### 5.10.1 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 5.129*

| **DEFINITIONS & ASSUMPTIONS** | | **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 | |
| **Derate%** | percent adjustment to rated output for array tilt and orientation, where Tilt Derate+Orientation Derate=Derate% | Table 5.10.2 | |
| **Perform%** | remaining capacity after accounting for impacts to performance (e.g. shading) | user input | |

| | | | |
|---|---|---|---|
| **COP** | efficiency of existing water heating system | Table 5.10.3 | |
| **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 5.130: 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 5.131: 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-

**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 5.132: **Sample** Power Demand & Energy Savings*

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

## 5.11 Other Commercial Measures

### 5.11.1 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.
- 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.
- 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.

**Measure Life**

3 years (In PY17, the measure life increased from 1 year to 3 years after a review of similar programs from around the country.)

**SAVINGS**

| | |
|---|---|
| **peak kW savings** | Custom calculated or measured |

| | |
|---|---|
| **annual kWh savings** | Custom calculated or measured |

# 6. Residential Measures

## 6.1 Appliances

### 6.1.1 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**

**annual kWh savings per washer** = [(CAP * 1/IMEF_base * CYCLES) * (%E_wash,base + (%E_heat,base * %HEATER_electric) + (%E_dry,base * %DRYER_electric))] - [(CAP * 1/IMEF_he * CYCLES) * (%E_wash,he + (%E_heat,he * %HEATER_electric) + (%E_dry,he * %DRYER_electric))]

**peak kW savings per washer** = (ΔkWh/Hours)*CF

**lifetime kWh savings per washer** = *ΔkWh * (Measure Life)*

*Table 6.1*

| **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)[15]. |
| **%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 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 |

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

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 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 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[16] |
| **Measure Life** | Estimate useful life | 14 | 14 | 14 | ENERGY STAR Market & Industry Scoping Report, 2011[17] |
| **CF** | Coincidence Factor | 5.7% | 5.7% | 5.7% | |

**SAVINGS**

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

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

*Table 6.2*

| | 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 |

### 6.1.2 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 ≥ 4.4 $ft^3$

**Program criteria:**
ENERGY STAR certified

**ALGORITHMS**

**annual kWh savings per washer** = (*LOAD/CEF_base - LOAD/CEF_he) * CYCLES*

**peak kW savings per washer** = (ΔkWh/Hours)*CF

**lifetime kWh savings per washer** = *ΔkWh * (Measure Life)*

*Table 6.3*

| **Definitions and Assumptions** | | **INPUT VALUES** | **Notes** |
|---|---|---|---|
| LOAD | Average total weight (lbs) of clothes per drying cycle | 8.45 | Based on ENERGY STAR product criteria testing.[18] |

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

| | | | |
|---|---|---|---|
| **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.[19] |
| **HRS** | Average run hours per dryer per year | 290 | 56 minutes/cycle based on NEEA Dryer Field Study, 2014.[20] |
| **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.[21] |
| **Measure Life** | Estimate useful life | 14 | ENERGY STAR Market & Industry Scoping Report, 2011.[22] |

## SAVINGS

*Table 6.4*

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

[19] https://www.neea.org/docs/default-source/reports/neea-clothes-dryer-field-study.pdf
[20] https://www.neea.org/docs/default-source/reports/neea-clothes-dryer-field-study.pdf
[21] http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20110.pdf
[22] https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

### 6.1.3 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**

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

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

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

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

*Table 6.5*

| **DEFINITIONS & ASSUMPTIONS** | | | |
|---|---|---|---|
| $\boldsymbol{E_{base}}$ | Energy usage of the baseline equipment | 540 | $kWh$ |
| $\boldsymbol{E_{he}}$ | Energy usage of the higher efficiency equipment | 435 | $kWh$ |
| $\boldsymbol{\Delta E}$ | Energy reduction | Calculated | $kWh$ |

| | | | |
|---|---|---|---|
| $CF$ | coincidence factor, percent of time equipment load corresponds with utility peak load | 100 | % |
| $PF$ | persistence factor, % of measures installed and operating | 100 | % |
| $HRS$ | Annual operating hours | 8760 | $hrs$ |
| **Measure Life** | expected duration of energy savings | 14 | $yrs$ |

*Table 6.6*

| Opportunity | | | Energy Usage | Reference |
|---|---|---|---|---|
| New Non-ENERGY STAR | | | 540 | Table 6.1.8 |
| New ENERGY STAR Refrigerator | | - | 435 | Table 6.1.8 |
| | | | 105kWh/Year | Table 6.1.7 |
| | | | | |
| #1 - Purchase of ENERGY STAR Refrigerator | | | 105 | Table 6.1.7 |
| #2 - Removal of Old Unit from Service (off the grid) | | + | 717 | Table 6.1.7 |
| #1 + #2 = Purchase ES and Recycle old unit | | | 822kWh/Year | |
| | **Energy Usage** | **Ratio** | **Contribution** | |
| Post-1993 Refrigerator | 640 | 55% | 354.54 | Table 6.1.9 |
| Pre-1993 Refrigerator | 1,131 | 45% | 504.46 | Table 6.1.9 |
| | | | 859 kWh/Year | |

*Table 6.7*

## 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.**<br>• 9.3 million units were sold in 2008.<br>• 70 percent were not ENERGY STAR.<br>• 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.**<br>• 8.7 million primary units were replaced in 2008.<br>• 44 percent remained in use, whether they were converted to second units, sold, or given away.<br>• 3.8 million units are candidates for retirement every year. | 717 | 79.53 | 2,746,062 | 305 |
| **3. Decrease the number of second units.**<br>• 26 percent of households had a second refrigerator in 2008.<br>• 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.**<br>• 19 percent of all units in use in 2008 were manufactured before 1993.<br>• 27.3 million total potential units are candidates for targeted replacement. | 730 | 81 | 19,946,440 | 2,212 |

Sources: See endnote 10.

*Table 6.8*

**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 6.9*

**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 6.10*

**SAVINGS**

*Table 6.11*

| | 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 |

## 6.2 Electronics

### 6.2.1 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 23

**Efficient equipment**:
ENERGY STAR certified TV

**Program criteria:**
ENERGY STAR certified

**ALGORITHMS**

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

**annual kWh savings per TV** = (Watts_base -Watts_ee) /1000 x HOURS_Active x 365

*Table 6.12*

| DEFINITIONS & ASSUMPTIONS | INPUT VALUES | Notes |
|---|---|---|

| | | | |
|---|---|---|---|
| **Watts_base** | Baseline connected Watts (active) | **SAVINGS** Table 6.2.2 | Baseline power consumption is drawn from ENERGY STAR "Consumer Electronics Calculator"[23]. |
| **Watts_ee** | Energy efficient connected Watts (active) | **SAVINGS** Table 6.2.2 | ENERGY STAR V7.0 Program Requirements[24]. |
| **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 6.13*

**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 | ME 16 |
| 40 | 45 | 54 | 37 | 27 | 0.017 | 0.027 | 99 | 68 | 50 | 31 | 49 |
| 45 | 50 | 69 | 45 | 33 | 0.024 | 0.036 | 126 | 82 | 61 | 44 | 65 |
| 50 | 55 | 74 | 52 | 38 | 0.022 | 0.036 | 135 | 95 | 70 | 40 | 65 |
| 55 | 60 | 87 | 57 | 42 | 0.03 | 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 |

**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 |

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

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 6.14*

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

### 6.2.2 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** $=PF \times [(Watts_{BASE\text{-}ACTIVE} - Watts_{EE\text{-}ACTIVE}) / 1000] \times CF$

**Annual Energy (kWh) Savings Per Soundbar** $=PF \times \{[(Watts_{BASE\text{-}ACTIVE} - Watts_{EE\text{-}ACTIVE}) * Hours\_Active] + [Watts_{BASE\text{-}IDLE} - Watts_{EE\text{-}IDLE}) * Hours\_Idle] + [Watts_{BASE\text{-}SLEEP} - Watts_{EE\text{-}SLEEP}) * Hours\_Sleep]\} / 1000$

**Lifetime Energy (kWh) Savings Per Soundbar** $=\Delta kWh \times Measure\_Life$

*Table 6.15*

| **DEFINITIONS & ASSUMPTIONS** | | **INPUT VALUES** | **Notes** |
|---|---|---|---|
| **$Watts_{BASE\text{-}ACTIVE}$** | Baseline Watts (active) | 30 | Fraunhofer Center for Sustainable Energy Systems. 2014[25]. |
| **$Watts_{BASE\text{-}IDLE}$** | Baseline Watts (idle) | 12 | |
| **$Watts_{BASE\text{-}SLEEP}$** | Baseline Watts (sleep) | 4 | |

[25]https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf

| | | | |
|---|---|---|---|
| **$Watts_{EE-ACTIVE}$** | Energy efficient watts (active) | 20.2 | Energy Solutions Report on RPP - Citing EPA Internal Analysis of Energy Star V2.0 Soundbars[26]. |
| **$Watts_{EE-IDLE}$** | 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[27]. |
| **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 6.16*

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

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

## 6.3 HVAC

### 6.3.1 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.

**ALGORITHMS**

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

*Table 6.17*

| **DEFINITIONS & ASSUMPTIONS** | | **INPUT VALUES** | **Notes** |
|---|---|---|---|
| **(S)EER_b** | Baseline rated efficiency, BTU/hr-W, which depends on cooling capacity of proposed equipment. | Table 6.3.2 | 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 6.3.2 | 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% | |
| **Measure Life** | expected duration of energy savings | 9 years<br>15 years | Window AC (source: CA DEER 2014)<br>VRF (source: CA DEER 2014) |

*Table 6.18: Residential HVAC program efficiencies*[28]

| Unit Type | Unit Size, BTU/hr | average size (BTU/hr)[1] | (S)EER_b | (S)EER_ee[2] |
|---|---|---|---|---|

[28] 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.

| | | | | |
|---|---|---|---|---|
| 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 6.19: Peak kW Savings by Building Type and Equipment Size (BTU/hr)*

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

*Table 6.20: Annual kWh Savings by Building Type and Equipment Size (BTU/hr)*

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

*Table 6.21: Deemed kW and kWh savings for Room A/C*

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

### 6.3.2 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**

**peak kW savings** $\Delta kW = CF * CAP * [(1/\eta\_base) - (1/\eta\_he)]/1{,}000$

**annual kWh savings** $\Delta kWh = HRS * CAP * [(1/\eta\_base) - (1/\eta\_he)]/1{,}000$

*Table 6.22*

| DEFINITIONS & ASSUMPTIONS[29] | | INPUT VALUES | Notes |
|---|---|---|---|
| **HRS** | percent of time on low speed | 2,920 | Based on 8 hr/day, 365 day/year |

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

| | | | |
|---|---|---|---|
| **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 6.23*

| **Central AC Replacement** | | | |
|---|---|---|---|
| Average Unit Cooling Capacity | 12000 | BTU/Hr | Equals 1 Ton Cooling Capacity |
| Energy Efficiency Ratio | 9.8 | EER | DOE Federal Test Procedure 10CFR 430, Appendix F |
| | 1224.5 | Watts/kW | |
| | 1000 | Watts/kW | |
| | 1.22 | kW | |
| Conventional Full Load Demand | 1.22 | kW | |
| Honolulu Full Load Equivalent Cooling Hours | 2920 | 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 | 13 | EER | Minimum Energy Star Rated Window AC |
| Full Load Demand | 923.1 | Watts | |
| Conversion | 1000 | Watts/kW | |
| Full Load Demand | 0.92 | kW | |
| High Efficiency Demand | 0.92 | kW | |
| Cooling Hours | 2920 | Hours per Year | |
| High Efficiency Energy Usage | 2695.4 | kWh per Year | |
| Annual Energy Savings | 880.13 | kWh per Year (PER TON) | |
| Coincidence Factor | 75% | | |
| Demand Peak Savings | 0.226 | kW/TON | |

**SAVINGS**

*Table 6.24*

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

### 6.3.3 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 6.25*

| **DEFINITIONS & ASSUMPTIONS** | | **INPUT VALUES** | **Notes** |
|---|---|---|---|
| **HRS** | Operating hours of A/C unit | 1,460 | |
| **CF** | coincidence factor, percent of time savings correspond with utility peak 5pm -9 pm | Table 6.3.10 | % 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 6.26*

| **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 Factor[30] | | 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% | |
| 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 |

**<u>SAVINGS</u>**

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

*Table 6.27*

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

### 6.3.4 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**

**peak kW savings per fan** = [(%low*(Low_kW_base-Low_kW_ee) + % med*(Med_kW_base-Med_kW_ee) + %high*(High_kW_base-High_kW_ee)) + ((Inc_kW-CFL_kW)*WHFd)]*CF

**annual kWh savings per fan** = [(%low*(Low_kW_base-Low_kW_ee) + % med*(Med_kW_base-Med_kW_ee) + %high*(High_kW_base-High_kW_ee))*HOURS_fan + ((Inc_kW-CFL_kW)*WHFee)*HOURS_light]*CF

*Table 6.28*

| **DEFINITIONS & ASSUMPTIONS**[31] | | **INPUT VALUES** | **Notes** |
|---|---|---|---|
| **%low** | percent of time on low speed | 40% | |

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

| | | | |
|---|---|---|---|
| **%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 | |

**SAVINGS**

*Table 6.29*

| | |
|---|---|
| **peak kW savings per fan** | **0.012** |
| **annual kWh savings per fan** | **65** |

### 6.3.5 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**

**peak kW savings per fan** =AC_cap/1000*(1/EER)*%svgs_ac*PF*CF

**annual kWh savings per fan** =AC_cap/1000*(1/EER)*EFLH*%svgs_ac*PF

*Table 6.30*

| **DEFINITIONS & ASSUMPTIONS**[32] | | **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 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 | |

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

| | | | |
|---|---|---|---|
| **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 6.31*

| | |
|---|---|
| **peak kW savings per fan** | **0.00** |
| **annual kWh savings per fan** | **158** |

### 6.3.6 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** | May 1, 2018 |

**Measure Description:**
A whole house fan is a ventilation system, usually placed centrally within a home that pulls air from the living space into an attic for purposes of increased circulation. In warm climates such as Hawaii, this serves to cool the home, by pulling in cooler outside air and evacuating warmer air that has been built up or trapped within the house. Whole house fan is assumed to reduce 20% of existing air conditioning load energy usage.

**Unit of Measure**:
One fan

**Baseline equipment**:
No fan installed

**Efficient equipment**:
Fan installed

**Program criteria:**

**Major Changes:**

- Clarification: In PY15 TRM, the average capacity of an existing air conditioner was given as 1.0 kW, or 9800 btu/h. In PY16 TRM, the average capacity of an existing air conditioner was changed to 0.87 kW, or 8500 btu/h, based on a review of actual Hawaiʻi Energy program statistics from PY14. Thus, the resultant energy savings value was reduced. The PY17 TRM measure is the same as PY16. The demand savings value also changed from PY15 to PY16 due to an error in PY15 with whole house fan demand reduction listed at 85%, rather than 20%.

**ALGORITHMS**

**peak kW savings per fan** = AC_cap/1000*(1/EER)*%svgs_ac*PF*CF

**annual kWh savings per fan** = AC_cap/1000*(1/EER)*EFLH*%svgs_ac*PF

*Table 6.32*

| **DEFINITIONS & ASSUMPTIONS**[33] | | **INPUT VALUES** |
|---|---|---|
| **%svgs_ac**[34] | percent of a/c load savings from whole house fan | 20% |
| **AC_cap**[35] | 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 6.33*

| | |
|---|---|
| **peak kW savings per fan** | **0.10** |
| **annual kWh savings per fan** | **317** |

[33] Hawaii Energy Efficiency Program Technical Reference Manual, PY 2015, July 1 2015-June 30, 2016. Measure Savings Calculations, pp.49-50.

[34] 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

[35] Average of PY14 window A/C units incentivized by Hawaii Energy

## 6.4 Lighting

### 6.4.1 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**

**peak kW savings per lamp** =kW_b*CF*PF-kW_cfl*CF*PF

**annual kWh savings per lamp** =kW_b*HOURS*PF-kW_cfl*HOURS*PF

*Table 6.34*

| DEFINITIONS & ASSUMPTIONS | | INPUT VALUES | Notes |
|---|---|---|---|
| **kW_b** | baseline wattage of average residential bulb | Table 6.4.2 | |
| **kW_cfl** | wattage of average CFL bulb | Table 6.4.3 | |
| **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 6.4.2 | |
| **Measure Life** | expected duration of energy savings | 6 years | |

*Table 6.35: Baseline Lamp Characteristics[36]*

| Lamp Types | Retired Baseline W | Demand Baseline '07 EISA (kW_b) | Demand Baseline post 2020 (kW_b_20) | Hours per Day, non-military | Hours per Day, military | HE Penetration % | Total kWh[2], non-military | Total kWh, military |
|---|---|---|---|---|---|---|---|---|
| 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** | |

*Table 6.36: Efficient Lamp Characteristics[37]*

| Demand | | | HE Penetration % | | Total kWh, military |
|---|---|---|---|---|---|

[36] 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.

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

| **Baseline (kW_cfl)** | **Hours per Day, non-military** | **Hours per Day, military** | | **Total kWh[2], non-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 6.37*

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

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.

### 6.4.2 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.
- 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 6.38*

| 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:**

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 6.39*

| 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 6.40: Operational Adjustments*

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

### Energy Savings:

*Table 6.41: 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 6.42*

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

### Measure Life

15 years

## 6.5 Plug/Process Load

### 6.5.1 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 6.43: Tier 1*

| **Advanced Power Strips** | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | *NYSERDA Measure Characterization* |
| Savings per Unit | kWh | | 56.5 | 102.8 | | |
| Plugs per Unit | plugs | ÷ | 5 | 7 | | *for Advanced Power Strips* |
| 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 | |
| **Demand Savings** | | | | **0.007** | **kW** | |

*Table 6.44*

**From PGE report Tables 10 & 11[38]:**

| | 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

38 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

## 6.6 Pumps & Motor

### 6.6.1 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.

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

Where:

| | |
|---|---|
| Unit | = variable speed pool pump |
| $\Delta$ 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 6.45*

| | | |
|---|---|---|
| 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 6.46*

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

**Energy and Demand Savings**

*Table 6.47*

| | | |
|---|---|---|
| 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**

*Table 6.48*

| | | |
|---|---|---|
| Average Pool Pump Horesepower | 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.

## 6.7 Water Heating

### 6.7.1 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:**

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

**Energy Savings:**

*Table 6.49*

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

## Savings Algorithms

*Table 6.50*

| 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 | |
| Coincedence 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)

### 6.7.2 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.

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 6.51*

| 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 6.52*

**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 | |
| 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 | | |
| 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 | KEMA 2008 | |
| | | 2,057 | | kWh / Year | KEMA 2008 | |
| **Residential Solar Water Heater Energy Savings** | | **2,057.00** | | **kWh / Year Savings** | KEMA 2008 | |
| 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 | |
| Solar System Metered on Peak Demand | | - | 0.11 | kW On Peak | KEMA 2008 |
| | | | 0.46 | kW On Peak | |

| | | |
|---|---|---|
| **Residential Solar Water Heater Demand Savings** | **0.460** | **kW Savings** |

*Table 6.53*

| | | |
|---|---|---|
| **SWH** | **Peak Demand Savings (kW)** | 0.460 |
| | **Annual Energy Savings (kWh)** | 2057 |

### 6.7.3 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**

**peak kW savings per system tune-up** = P_base – P_op

**annual kWh savings per system tune-up** = E_base – E_op

*Table 6.54*

| **DEFINITIONS & ASSUMPTIONS** | | **INPUT VALUES** |
|---|---|---|
| **E_base** | On Peak Demand for group "All" | 577[1] |
| **E_op** | On Peak Demand for group "Operating" | 328[1] |
| **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: [1]KEMA 2005-2007 Energy and Peak Demand Impact Evaluation Report

**SAVINGS**

*Table 6.55*

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

## 6.8 Other Residential Measures

### 6.8.1 Multifamily Direct-Install Kits

**HAWAII ENERGY NOMENCLATURE**

| | |
|---|---|
| **Equipment Group** | MFDI |
| **Equipment Type** | |
| **Equipment Subtype** | |
| **Equipment Size** | |

**VERSION HISTORY**

| | |
|---|---|
| **Draft Date** | July 1, 2015 |
| **Revision Date** | |
| **Review Date** | |

**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:**

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 actually 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 heading 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 actually 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.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 actually 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:

- 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 actually 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 actually 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 actually 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.

*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)

### 6.8.2 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**

$$\Delta P = \frac{\Delta E}{HRS_{deemed}}$$

$$\Delta E = SVG_{deemed} \times E_{avg,year}$$

| **DEFINITIONS & ASSUMPTIONS** | | Value | Unit | Notes |
|---|---|---|---|---|
| $\Delta P$ | Peak power demand reduction | Calculated | $kW$ | |
| $\Delta E$ | Annual energy reduction | Calculated | $kWh$ | |
| $E_{avg,year}$ | Average annual billed energy consumption | 6,633 | $kWh$ | Utility billing data |
| $SVG_{deemed}$ | Deemed savings factor | 0.89 | % | |
| $HRS_{deemed}$ | Deemed hours per year of active energy reduction | 3000 | $hrs$ | Hawai’i Energy PY15 TRM |
| **Measure Life** | Expected duration of energy savings | 1 | $yrs$ | |

**SAVINGS**

| Measure Name | Peak Demand Savings (kW) | Annual Energy Savings (kWh) |
|---|---|---|
| Peer Group Comparison | 0.0197 | 59.03 |

### 6.8.3 Home Energy Savings Kits

**Measure ID:**

**Version Date & Revision History:**

Draft date: 12-15-2015

**Referenced Documents:**

- 

**Measure Description:**

Customized kits can be built using different energy saving devices of varying quantities. Savings for each kit will be calculated based on energy savings list below This online kit promotion may contain various combinations of the following components:

- A19 LED (60 watt equivalent)
- BR30 LED (65 watt equivalent)
- 1 CFL
- Advanced power strip
- Low-flow showerhead*
- Faucet aerator*

*The savings claim for each household for water measures 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:**

Baseline lighting = blend of incandescent/CFL = 37.6 watts (see 9.2.1)
Showerhead = 2.5 gpm
Faucet = 2.2 gpm

**Enhanced Efficiencies:**

CFL = 13 watts
LED = 10 watts
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:**

For LED lightbulbs: 0.96
For CFL lightbulbs: 0.96
For advanced power strip: 0.80
For showerheads: 0.59
For faucet aerators: 0.51

**Peak Demand Coincidence Factor:**

For LED lightbulbs: 0.12
For CFL lightbulbs: 0.12
For advanced power strip: 1.00
For showerheads: N/A (no demand savings claimed, too small)
For faucet aerators: N/A (no demand savings claimed, too small)

**Measure Lives:**

For LED lightbulbs: 15 years
For CFL lightbulbs: 6 years
For advanced power strip: 5 years
For showerheads and faucet aerators: 5 years

**Energy Savings Algorithm:**

For A19 LED and BR30 LED:
Use TRM value of 22.5 kWh per year (see Section 9.2.2 Light Emitting Diode (LED))

For CFL:
Use TRM value of 17.0 kWh per year (see Section 9.2.1 Compact Fluorescent Lamp (CFL))

For advanced power strip

Using TRM value of 102.8 kWh/year savings for 7-plug power strip (see Section 9.4.3 Smart Strips) and applying persistence factor of 0.80 = 102.8 kWh * 0.80 = 82.2 kWh per year

For water saving measures (low-flow showerheads and faucet aerators), the energy and demand savings calculation depend on a number of factors:

- type of water heating (standard electric-resistance, heat pump, electric tankless, solar)
- number of occupants (1, 2, 3, 4, 5, 6, 7, 8+)
- number of faucets in the home (it was calculated that the average SF/MF home has 2.8 faucets)
- number of showers in the home (It was calculated that the average SF/MF home has 1.8 showerheads)

See separate document for detailed energy savings calculations.

For low-flow showerhead:

| Water Heater Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| electric resistance | 51.1 | 68.0 | 102.0 | 136.0 | 170.0 | 204.0 | 238.0 | 272.0 |
| heat pump | 17.5 | 23.3 | 35.0 | 46.6 | 58.3 | 70.0 | 81.6 | 93.3 |
| electric tankless/on-demand | 39.4 | 52.4 | 78.7 | 104.9 | 131.1 | 157.3 | 183.5 | 209.7 |
| solar water heating | 6.6 | 13.1 | 19.7 | 26.3 | 32.9 | 39.4 | 46.0 | 52.6 |

For faucet aerator:

| Water Heater Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| electric resistance - MF+SF average | 11.5 | 23.0 | 34.4 | 45.9 | 57.4 | 68.9 | 80.4 | 91.8 |
| heat pump - MF+SF average | 4.9 | 9.8 | 14.6 | 19.5 | 24.4 | 29.3 | 34.1 | 39.0 |
| on demand | 8.5 | 16.9 | 25.4 | 33.8 | 42.3 | 50.7 | 59.2 | 67.7 |
| SWH | 6.5 | 13.0 | 19.5 | 26.0 | 32.5 | 39.0 | 45.5 | 52.0 |

**Demand Savings Algorithm**

For A19 LED and BR30 LED:

Use TRM value of 0.0032 kW (see Section 9.2.2 Light Emitting Diode (LED))

For CFL:

Use TRM value of 0.0024 kW (see Section 9.2.1 Compact Fluorescent Lamp (CFL))

For advanced power strip

Using TRM value of 102.8 kWh/year savings for 7-plug power strip (see Section 9.4.3 Smart Strips) and operating hours of 8760 hours per year and applying persistence factor = 102.8 kWh * 0.80 ÷ 8760 = 0.0094 kW

For low-flow showerhead:

Peak demand savings is difficult to quantify and almost negligible. Therefore, demand savings= 0.

For faucet aerator:

Peak demand savings is difficult to quantify and almost negligible. Therefore, demand savings= 0.

| | Energy Savings (kWh/year) | Demand Savings (kW) |
|---|---|---|
| **A19 LED** | 22.5 | 0.0032 |
| **BR30 LED** | 22.5 | 0.0032 |
| **CFL** | 17.0 | 0.0024 |
| **Advanced power strip** | 82.2 | 0.0094 |
| **Low-flow showerhead** | See table above | 0 |
| **Faucet Aerator** | See table above | 0 |

# 7. Custom Measures

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

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

In PY17, Hawaiʻi Energy has moved some formerly prescriptive projects to the custom category, mainly for the reason that these projects occur infrequently. These include Transformers, Residential New Construction, and Heat Pump Water Heater-to-Heat Pump Water Heater upgrades.

## 7.1 Transformers

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

## 7.2 Residential New Construction

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

## 7.3 Commercial Heat Pump Water Heater to Heat Pump Water Heater Upgrades

Commercial heat pump water heater to heat pump water heaters retrofits are eligible for custom incentives on the grounds that the current building code allows for standard electric resistance water heaters (SERWH) in this application. For this reason, SERWH may be treated as the baseline efficiency for this type of project. Projects of this nature are infrequent and may be evaluated on a case-by-case basis.

## 7.4 Chillers

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

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

## 7.5 VFD

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