**Work Paper SCE13HC055**

**Process**

**Revision # 0**

**Southern California Edison**

**PA subtitle**

**Circulating Block Heater**

**Product sub-categories if applicable**

At-a-Glance Summary

|  |  |  |
| --- | --- | --- |
|  | Measure 1 | Measure 2 |
| **Measure description** | 37-199 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 200-799 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater |
| **Program delivery method** | Downstream | Downstream |
| **Measure application type** | Replace on Burnout (ROB), and New Construction (NC) | Replace on Burnout (ROB), and New Construction (NC) |
| **Base case description** | Source: Customer Existing  Existing thermo siphon heater on generator. | Source: Customer Existing  Existing thermo siphon heater on generator. |
| **Energy and demand impact common units** | Per unit | Per unit |
| **Peak Demand Reduction**  **(kW/unit)** | Varies by Climate Zone  CZ6 – 0.49002 kW | Varies by Climate Zone  CZ6 – 0.38972 kW |
| **Energy savings**  **(Base case – Measure)**  **(kWh/unit)** | Varies by Climate Zone  CZ6 – 3,928 kW | Varies by Climate Zone  CZ6 – 3,124 kW |
| **Gas savings**  **(Base case – Measure)**  **(therms/unit)** | 0 | 0 |
| **Full measure cost**[[1]](#footnote-1)  **($/unit)** | Source: Manufacturer Quote  $1,000 | Source: Manufacturer Quote  $1,800 |
| **Incremental measure cost[[2]](#footnote-2)**  **($/unit)** | Source: Manufacturer Quote  $250 | Source: Manufacturer Quote  $600 |
| **Effective useful life**  **(years)** | Source: DEER2014 (Motors-pump)  15 | Source: DEER2014 (Motors-pump)  15 |
| **Net-to-gross ratio(s)** | Source: DEER 2014 (ET-Default)  0.85 | Source: DEER 2014 (ET-Default)  0.85 |
| **Important comments** |  |  |

Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | Revision Date | Section-by-Section Description of Revisions | Author (Name, PA) |
| **0** | **4/10/2015** | **New Work Paper** | **Alfredo Gutierrez, SCE** |
|  |  |  |  |

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Commission Staff Review and Comment History

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| Revision # | Date Submitted to Commission Staff | Date Comments Received | Commission Staff Comments |
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General Measure & Baseline Data

* 1. Product Measures

**General Description**

The measure is a circulating block heater used on backup diesel generators. This measure will replace an existing thermo siphon heater with a recirculation pump and a smaller electric resistance heater. The measure will be tiered based upon the backup generator sizes shown below:

• 37-199 kW

• 200-799 kW

• 800-1099 kW

• 1100-2500 kW

The measures contained within this work paper can be found in the table below.

Table 1: Measures and Codes

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Code | Measure Name |
| PR-14541 | N/A | 37-199 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater |
| PR-28785 | N/A | 200-799 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater |
| PR-26010 | N/A | 800-1099 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater |
| PR-90678 | N/A | 1100-2500 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater |
| PR-64293 | N/A | 37-199 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater |
| PR-54146 | N/A | 200-799 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater |
| PR-84587 | N/A | 800-1099 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater |
| PR-93262 | N/A | 37-199 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater (New) |
| PR-93796 | N/A | 200-799 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater (New) |
| PR-92194 | N/A | 800-1099 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater (New) |
| PR-97000 | N/A | 1100-2500 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater (New) |
| PR-69302 | N/A | 37-199 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater (New) |
| PR-75840 | N/A | 200-799 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater (New) |
| PR-82783 | N/A | 800-1099 kW Backup Generator with Circulating Block Heater replacing Properly Sized Thermosiphon Heater (New) |

**Technical Description**

This technology has an integrated electric pump that circulates coolant throughout the engine block ensuring that there is a minimal temperature difference between the supply and return temperatures. The pump/heater (CBH) is an integral assembly. The existing thermo siphon heater is removed as a unit and the new CBH is inserted into the exact same location. It is a single unit installation within one housing with the mechanical element (pump) enclosed in the same "shell" as the smaller resistance heating element (relative to the thermo siphon) integral to the circulating block heater. Disconnect and reconnect points to existing hoses would not change unless improperly plumbed in the first place.

Along with the pump, a small resistance heater is used to heat the coolant within the engine block. When actual installations are completed, field inspections will verify if the existing resistance heater was replaced with smaller resistance heaters. By pumping the heated coolant, a more uniform temperature is obtained throughout the engine block. As a result of using a recirculation pump, a smaller electric resistance heater can be used to heat the coolant as there will be a more uniform temperature achieved through the mixing of fluid throughout the engine block.

The base case equipment is a thermo siphon heater. These types of heaters rely on the change in density (impacting buoyancy) in order to circulate the heated coolant. This type of circulation leads to non-uniform temperature distribution, where the coolant is warmer at the top of the block and colder at the bottom, which requires the electric resistance heater to operate for a longer duration. This also means that there is waste heat in sections of the block, as the heater must operate to maintain a certain temperature, so the top of the block will always be hotter than necessary.

The savings for these measures are taken from data collected by the Bonneville Power Administration (BPA) through their emerging technology program [A]. The data is collected from 17 different sites and includes both the existing thermo siphon heater and the circulating block heater.

* 1. Program Implementation Overview

**Implementation Methods**

The delivery method is:

* Financial Support - Down Stream Incentive – Deemed

The application type is Replace on Burnout (ROB), and New Construction (NEW).

**Program Restrictions and Guidelines**

**Eligibility Requirements**

* Existing backup generator (ROB) is eligible for incentive if it is not currently fitted with a Circulating Block Heater or device utilizing similar electro-mechanical system to heat generator block pre-warming fluid.
* New generator installation (NEW) where base design prescribes a pre-heating device other than Circulating Block Heater or similar device may also apply for incentive to upgrade from base design to efficient design including a Circulating Block Heater.

**Implementation Requirements**

* Installation of Circulating Block Heater should be performed by a qualified technician (i.e. generator maintenance technician or mechanical service technician).(ROB)
* Installer should assess and perform (if necessary) fluid hose adjustments that may be associated with the retrofit to enable the Circulating Block Heater to function at optimal energy efficiency. (ROB)
* These measures are approved for all Non-Residential building types for all SCE climate zones.

**Measure Application Type**

See Implementation Methods above.

* 1. Product Parameter Data
     1. DEER Data

Currently, DEER does not address circulating block heaters. DEER, does, however, contain measures for circulation pump time clock retrofits (D03-095) and other water heating measures (both gas and electric, NE-WtrHt-SmlInst-Elec-lte12kW-lt2G, NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p90Et, etc.). These measures, though, are not applicable proxies for circulating block heaters and cannot be used to determine the savings for the measures in this work paper. Also, DEER interactive effects will not be used as most backup generators are kept in non-conditioned or exterior spaces.

Table 2: DEER Difference Summary

|  |  |
| --- | --- |
| DEER | Used in Workpaper Approach? |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER base case used | No |
| DEER measure case used | No |
| DEER building types Used | No |
| DEER operating hours used | No |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Version | N/A |
| DEER ID and Measure Name (Sample) | N/A |

**Net-to-Gross**

Table 3: DEER Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| From DEER Tables | | | | | |
| NTGR\_ID | Description | Sector | Building Type | NTG | Program Delivery |
| ET-Default | Emerging Technologies approved by ED through work paper review | All | Any | 0.85 | Any |

**Effective Useful Life / Remaining Useful Life**

Table 4: DEER EUL Values/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | End Use | Measure | EUL (Years) | RUL (Years) |
| Motors-pump | Non-Residential | Process | Water Loop Pumps | 15 | 5 |

**In-Service Rate / First Year Installation Rate:**

Table 5: Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| From DEER Tables | | | | | |
| GSIA\_ID | Description | Sector | Building Type | GSIA Value | Program Delivery |
| Def-GSIA | Default GSIA values | Any | Any | 1.0 | Any |

**READi Technology Fields**

Table 6: READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | Process Heat |
| Measure Case UseSubCats | Preheating of liquids/solids |
| Measure Case TechGroups | Liquid Circulation |
| Measure Case TechTypes | Flow Plus Temperature Controls |
| Base Case TechGroups | Liquid Circulation |
| Base Case TechTypes | Temperature Reset Control |

* + 1. Codes & Standards Requirements Base Case and Measure Information

**Title 20:** The measures in this work paper are not covered by the 2014 Title 20 code [422].

**Title 24:** The measures in this work paper are not covered by the 2013 Title 24 code [355].

**Federal Standards:** Please note that the Air Quality Management District (AQMD) does set standards regarding what the definition of an emergency backup generator actually is and the allowable air emissions from backup generators. However, the allowable emissions do not impact savings calculations as backup generators are required to be ready at all times for use. Emission standards and are not covered in this work paper.

* + 1. Relevant EM&V Studies

There are no EM&V studies that have been used for this work paper.

* + 1. Relevant Workpaper Dispositions

There have been no dispositions on this work paper or any similar work paper.

* + 1. Other Sources for non-DEER Methods

The savings for the measures contained within this work paper are based on field monitoring data from the Bonneville Power Administration (BPA). This data was collected from numerous case studies that ran through the BPA’s Emerging Technology program. The data collected included average daily kWh and outside air (OA) temperature for both the preexisting thermo siphon heater and the retrofitted circulating block heater [A]. There are 17 sources of data, which are taken from different sites including waste water plants and data centers. The data was collected for different periods of time for each site, but on average, there are 2 months pre and post for each site used in the regression analysis performed for this work paper.

The Emerging Products study ET08SCE1020 “Air Source Heat Pump for Preheating of Emergency Diesel Backup Generators” [491] investigated the used of using air source heat pumps for this measure, but found that the use of air source heat pumps was not cost effective. This study serves to show that the current measures within this work paper were facilitated through SCE’s ET program, utilizing data from BPA that was analyzed through the ET program.

1. Calculation Methods
   1. Program Implementation Analysis

Table 7: Baseline by Measure Application Type

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Baseline | Baseline Technology | Duration |
| **ROB** | First | Standard (existing technology for this measure) | 15 |
| Second | N/A | N/A |
| **NEW** | First | Standard (existing technology for this measure) | 15 |
| Second | N/A | N/A |

* 1. Electric Energy Savings Estimation Methodologies

The savings for the measures in this work paper are found from BPA field monitored case study data referenced above. The BPA case studies provide OA temperature and daily average kWh for both the pre-existing thermo siphon heater and the measure. The data provided was then used to create multiple regression models for the different generator sizes where this measure will be offered. These regression models, along with the circulating block heater tool used for SCE’s customized program can be found in attachment 2. The raw data used to generate the regression models has not been attached to this work paper due to size limitations, however, it is available upon request.

DATA EXPLORATION

Temperature and Daily kWh Variation within Size Categories

While sites are assigned a size category of 1-4, this categorization corresponds only very loosely to the actual (baseline) usage, and is highly dependent on baseline heater size. There is significant variation and overlap across categories in generator size, heater size, and observed kWh usage.

Table 8: Site-Specific Heater Sizes

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Site Size Category | Generator Size kW | Baseline Heater Size kW | Existing Measured kW | Avg Baseline kWh | New Rated Heater Size kW | New Measured kW | Avg Treatment kWh |
| COCCH | 1 | 15 | 0.5 | 0.46 | 11.0 | 1 | 0.99 | 6.8 |
| Kid Kare | 1 | 40 | 1 | 0.89 | 21.1 | 1 | 0.99 | 13.4 |
| TCWWTP | 1 | 15 | 1 | 0.93 | 10.9 | 1 | 1.03 | 8.2 |
| HCNW | 1 | 600 | 6 | 4.3 | 52.0 | 6 | 5.4 | 46.8 |
| COCFD | 2 | 75 | 1 | 0.88 | 20.9 | 1 | 0.94 | 11.6 |
| COCTV | 2 | 100 | 1 | 0.88 | 20.9 | 1 | 0.92 | 7.2 |
| COMKR | 2 | 50 | 1 | 0.93 | 20.7 | 1 | 1 | 11.7 |
| COMW | 2 | 100 | 1 | 0.95 | 22.7 | 1 | 0.98 | 16.1 |
| KE ECAM | 2 | 65 | 1 | 0.93 | 22.3 | 1 | 0.99 | 12.5 |
| TCWP | 2 | 20 | 1 | 0.97 | 22.3 | 1 | 1.05 | 10.5 |
| BLDG210 | 2 | 250 | 2.5 | 2.22 | 47.1 | 3 | 2.8 | 24.2 |
| PCDC | 2 | 900 | 6[[3]](#footnote-3) | 4.62 | 48.4 | 6 | 5.5 | 44.1 |
| BayView | 3 | 150 | 1.5 | 1.39 | 33.3 | 1.5 | 1.34 | 14.9 |
| BNS GEN | 3 | 500 | 4.95 | 1.85 | 44.3 | 2.5 | 1.89 | 26.3 |
| *KRMC[[4]](#footnote-4)* | *3* | *1000* | *6* | *4.5* | *87.7* | *6* | *5.7* | *21.0* |
| COCWWTP | 3 | 664 | 6 | 5.9 | 112.8 | 3 | 2.9 | 40.8 |
| NQ | 4 | 1000 | 10 | 9.54 | 228.4 | 10 | 10.15 | 110.3 |

Observations take place at varying times of year, and there is significant variation in range of temperatures observed from site to site and from baseline to treatment periods. Some sites show significant temperature dependence in baseline usage, whereas other sites show no temperature dependence (often displaying remarkably consistent usage). Temperature dependence is observed at sites with larger baseline heater sizes (within a size category), and is consistent with a properly-sized heater. Temperature independence (flat baseline) is observed at sites with smaller baseline heater sizes, and is consistent with an undersized heater (reflecting the heater is running consistently on full).

The sites per size category that exhibit flat baselines (indicative of undersized heaters) suggest the following designation of undersized v. proper-sized heaters:

Table 9: Baseline Heater Size Ranges (as suggested by data)

|  |  |  |
| --- | --- | --- |
| Site Size Category | Undersized Heater Range | Proper-sized Heater Range |
| 1 | 1 kW and below | 2 kW and above |
| 2 | 1 kW and below | 2 kW and above |
| 3 | 5 kW and below | 6 kW and above |

Note: there is not enough data to determine the proper sizing range for size category 4 sites. Only one category 4 site was observed, with baseline heater size of 10 kW, and the data for this site suggests the heater was under-sized. The heater range applies only to baseline heater sizes; the new heaters all exhibit temperature dependence.

ESTIMATION METHODOLOGY

Undersized and proper-sized sites behave very differently, and thus should be modeled separately.

Baseline Usage for Undersized Sites

Undersized sites frequently showed remarkable consistency; individual sites did not display enough variation to warrant modeling. Therefore a single expected baseline usage[[5]](#footnote-5) was attributed for each site. Across sites, these usages exhibited a fairly linear relationship with heater size across site size categories.

Baseline Usage for Properly-Sized Sites

Baseline usage in properly-sized sites were modeled (for each size category) as a function of temperature. There were not enough sites or variation in the baseline heater size to model usage as a function of heater size as well as site size category. The model applied (per site size category) is:

Where:

*Daily\_kWh* is the daily usage (kWh) as collected

*Temperature* is the observed average outside air temperature (°F)

Treatment Usage (All Sites)

Measure undersized heaters were not an issue as in the baseline periods, therefore treatment usage was modeled as a function of temperature and new heater size for all sites. The model applied (per site size category) is:

Where:

*Daily\_kWh* is the daily usage (kWh) as collected

*New\_Heater\_Size* is the recorded new heater size (kW)

*Temperature* is the observed average outside air temperature (°F)

ESTIMATION RESULTS

Equation 1: Estimated Baseline Usage for Undersized Sites:

*daily\_kWh* = 20.2 \* *Baseline\_Heater\_Size* (1)

Table 10: Estimated Baseline Usage for Properly-Sized Sites (regression results)

|  |  |  |
| --- | --- | --- |
| Site Size Category | Regression Coefficients | |
| Intercept | Temp. |
| 1 | 105.91 | -1.178 |
| 2 | 88.92 | -0.701 |
| 3 | 139.85 | -0.932 |

Table 11: Estimated Treatment Usage (regression results)

|  |  |  |  |
| --- | --- | --- | --- |
| Site Size Category | Regression Coefficients | | |
| Intercept | Heater Size | Heater Size \* Temp. |
| 1 | 3.70 | 13.135 | -0.136 |
| 2 | 5.86 | 13.195 | -0.133 |
| 3 | 10.26 | 16.688 | -0.179 |
| *4* | *229.52* | *0* | *-2.577* |

Note: As only one site of size category 4 was observed, estimated treatment was not a function of new heater size (regression model was a function of temperature only).

SAVINGS ESTIMATES

Using the estimation results to estimate savings from a CBH installation in SCE territory requires the following items:

* Site size category
* Baseline heater size
* New heater size
* Climate zone (to determine average temperature)

Note that the range of observed temperatures are generally lower than those observed in SCE territory climate zones, particularly for baseline regression. These savings estimates thus are projecting heater performance for temperatures generally outside the observed range. Savings estimation is determined by the following steps:

* Determine whether baseline heater is *undersized* or *properly-sized* for the site size category[[6]](#footnote-6).
  + For *undersized* baseline heaters, average daily kWh is determined using Equation (1).
  + For *properly-sized* heaters, averaged daily kWh is determined for climate zone average temperature, using regression results in Table 10.
* Estimate treatment usage based on new heater size and climate zone average temperature, using regression results in Table 11.
* The difference in daily kWh can be projected into annual saving using preferred assumed days of operation.

Savings Estimation Sample Calculation[[7]](#footnote-7):

Sample 1: Climate Zone 6, site size category 1, baseline heater size 1 kW, new heater size 1 kW, annual operation 334 days / year.

* Designation: Undersized
* Annual Average Temperature: 61.5°F
* Baseline Daily kWh: 20.2 \* [Baseline Heater Size] = 20.2 kWh / day.
* Treatment Daily kWh: 3.70 + 13.135 \* [New Heater Size] – 0.136 \* [New Heater Size] \* [61.5°F] = 8.4 kWh / day
* Annual Savings: (20.2 kWh/day – 8.4 kWh/day) \* 334 days/year = 3,928 kWh/year.

Sample 2: Climate Zone 8, site size category 3, baseline heater size 6 kW, new heater size 6 kW, annual operation 334 days / year.

* Designation: Proper-sized
* Annual Average Temperature: 63.4°F
* Baseline Daily kWh: 139.85 – 0.932 \* [63.4°F] = 80.8 kWh / day.
* Treatment Daily kWh: 10.26 + 16.688 \* [New Heater Size] – 0.179 \* [New Heater Size] \* [63.4°F] = 42.1 kWh / day
* Annual Savings: (80.8 kWh/day – 42.1 kWh/day) \* 334 days/year = 12,908 kWh/year.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 12: Sample Savings - Climate Zone 6 | | | | | | |
|  | Baseline Heater Size | New Heater Size | Baseline Heater Designation | Baseline Daily kWh | Treatment Daily kWh | Annual kWh Savings |
| 1 | 1 | 1 | Undersized | 20.2 | 8.4 | 3,928 |
| 3 | 3 | Proper-Sized | 33.4 | 17.9 | 5,181 |
| 2 | 1 | 1 | Undersized | 20.2 | 10.9 | 3,124 |
| 6 | 6 | Proper-Sized | 45.8 | 35.8 | 3,349 |
| 3 | 2 | 2 | Undersized | 40.4 | 21.6 | 6,293 |
| 6 | 6 | Proper-Sized | 82.5 | 44.2 | 12,817 |
| 4 | 10 | 10 | Undersized | 202.0 | 71.0 | 43,753 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 13: Sample Savings - Climate Zone 8 | | | | | | |
|  | Baseline Heater Size | New Heater Size | Baseline Heater Designation | Baseline Daily kWh | Treatment Daily kWh | Annual kWh Savings |
| 1 | 1 | 1 | Undersized | 20.2 | 8.2 | 4,014 |
| 3 | 3 | Proper-Sized | 31.2 | 17.1 | 4,693 |
| 2 | 1 | 1 | Undersized | 20.2 | 10.6 | 3,208 |
| 6 | 6 | Proper-Sized | 44.5 | 34.3 | 3,412 |
| 3 | 2 | 2 | Undersized | 40.4 | 20.9 | 6,521 |
| 6 | 6 | Proper-Sized | 80.8 | 42.1 | 12,908 |
| 4 | 10 | 10 | Undersized | 202.0 | 66.1 | 45,389 |

Please note that DEER interactive effects are not used in the calculation of the energy savings as the equipment will either be installed outside or in an unconditioned room. Due to the equipment being installed either outside or in an unconditioned room, the energy savings will not vary by building type.

**Sensitivity Analysis**

In order to check the validity of using a yearly average temperature vs. a daily average temperature, a sensitivity analysis was performed for climate zones 6 and 15. The sensitivity analysis for both climate zone 6 and climate zone 15 is provided in this work paper for reference (attachment 3).

For climate zone 6, the average daily temperature was found and used with the regression models mentioned above. The savings using daily average temperature were on average, within 0.06% of the savings using the yearly average temperature, as seen below:

Table 14: Savings Comparison for Climate Zone 6

|  |  |  |  |
| --- | --- | --- | --- |
| Measure | Sensitivity Analysis Savings (kWh) | Original Savings (kWh) | % Difference in Savings |
| 37-199 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 3,926 | 3,928 | 0.04% |
| 200-799 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 3,122 | 3,124 | 0.05% |
| 800-1099 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 6,289 | 6,293 | 0.07% |
| 1100-2500 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 43,722 | 43,753 | 0.07% |

For climate zone 15, the average daily temperature was found and used with the regression models mentioned above. The savings using daily average temperature were on average, within 0.07% of the savings using the yearly average temperature, as seen below:

Table 15: Savings Comparison for Climate Zone 15

|  |  |  |  |
| --- | --- | --- | --- |
| Measure | Sensitivity Analysis Savings (kWh) | Original Savings (kWh) | % Difference in Savings |
| 37-199 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 4,553 | 4,552 | -0.01% |
| 200-799 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 3,735 | 3,734 | -0.02% |
| 800-1099 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 7,937 | 7,936 | -0.02% |
| 1100-2500 kW Backup Generator with Circulating Block Heater replacing Undersized Thermosiphon Heater | 55,556 | 55,545 | -0.02% |

Based on the results of the sensitivity analysis, the savings using the yearly average temperature seems to be an appropriate assumption for this work paper.

**First Baseline**

Sample energy savings for the first baseline can be found in Table 12 and Table 13 above.

**Second Baseline**

Please note that the measures have the same savings for the first and second baseline as there is no code/standard known to the author.

* 1. Demand Reduction Estimation Methodologies

The Demand reduction for each measure can be found by taking the energy savings and dividing by the total operating hours for each measure. As these measures are typically installed on backup generators which are required to kick on when needed (when the power goes out), the energy savings calculations assume that the circulating block heaters are enabled continuously for 334 days out of the year (accounting for maintenance). A sample calculation has been shown below:

Sample 3: Climate Zone 6, site size category 1, baseline heater size 1 kW, new heater size 1 kW, annual operation 334 days / year.

* Designation: Undersized
* Annual Average Temperature: 61.5°F
* Baseline Daily kWh: 20.2 \* [Baseline Heater Size] = 20.2 kWh / day.
* Treatment Daily kWh: 3.70 + 13.135 \* [New Heater Size] – 0.136 \* [New Heater Size] \* [61.5°F] = 8.4 kWh / day
* Annual Savings: (20.2 kWh/day – 8.4 kWh/day) \* 334 days/year = 3,928 kWh/year.

Annual kW Savings: 3,928 kWh/year / (334 days/year \* 24 hours/day) = 0.4900 kW

**First Baseline**

The energy savings for the first baseline can be found in attachment one.

**Second Baseline**

Please note that the measures have the same savings for the first and second baseline as there is no code/standard known to the author.

* 1. Gas Energy Savings Estimation Methodologies

There are no gas savings claimed for these measures.

**First Baseline**

N/A

**Second Baseline**

N/A

1. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the Industrial load shape. See table below for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 16: Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alternate Building Type | Load Shape |
| Agricultural | Industrial | Industrial |
| Assembly | Industrial | Industrial |
| Health/Medical - Clinic | Industrial | Industrial |
| Education - Community College | Industrial | Industrial |
| Education - Primary School | Industrial | Industrial |
| Education - Relocatable Classroom | Industrial | Industrial |
| Education - Secondary School | Industrial | Industrial |
| Education - University | Industrial | Industrial |
| Food Store | Industrial | Industrial |
| Grocery | Industrial | Industrial |
| Lodging - Guest Rooms | Industrial | Industrial |
| Health/Medical - Hospital | Industrial | Industrial |
| Lodging - Hotel | Industrial | Industrial |
| Industrial | Industrial | Industrial |
| Manufacturing - Bio/Tech | Industrial | Industrial |
| Misc - Commercial | Industrial | Industrial |
| Manufacturing - Light Industrial | Industrial | Industrial |
| Lodging - Motel | Industrial | Industrial |
| Health/Medical - Nursing Home | Industrial | Industrial |
| Office - Large | Industrial | Industrial |
| Office - Small | Industrial | Industrial |
| Restaurant - Fast-Food | Industrial | Industrial |
| Restaurant - Sit-Down | Industrial | Industrial |
| Retail - Multistory Large | Industrial | Industrial |
| Retail - Single-Story Large | Industrial | Industrial |
| Retail - Small | Industrial | Industrial |
| Storage - Conditioned | Industrial | Industrial |
| Storage - Unconditioned | Industrial | Industrial |
| Transportation - Communication - Utilities | Industrial | Industrial |
| Warehouse - Refrigerated | Industrial | Industrial |

1. Base Case, Measure, and Installation Costs

Table 17: Measure cost summary by application type for 37-199 kW backup generator

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Application Type | Base Case  Equipment Cost  ($/unit) | Measure  Equipment Cost  ($/unit) | Installation Cost  ($/Unit) | Incremental Measure Cost  ($/unit) | Full Measure Cost  (1st Baseline period)[[8]](#footnote-8)  ($/unit) | Full Base Cost  (2nd baseline period)[[9]](#footnote-9)  ($/unit) |
| **ROB** | $150 | $400 | N/A | $250 | N/A | N/A |
| **NC** | $150 | $400 | N/A | $250 | N/A | N/A |
| ER |  |  |  | N/A\* |  |  |
| REA |  |  |  | N/A\* |  |  |

\* IMC may be useful for determining program incentive.

Table 18: Measure cost summary by application type for 200-799 kW backup generator

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Application Type | Base Case  Equipment Cost  ($/unit) | Measure  Equipment Cost  ($/unit) | Installation Cost  ($/Unit) | Incremental Measure Cost  ($/unit) | Full Measure Cost  (1st Baseline period)[[10]](#footnote-10)  ($/unit) | Full Base Cost  (2nd baseline period)[[11]](#footnote-11)  ($/unit) |
| **ROB** | $600 | $1200 | N/A | $600 | N/A | N/A |
| **NC** | $600 | $1200 | N/A | $600 | N/A | N/A |
| ER |  |  |  | N/A\* |  |  |
| REA |  |  |  | N/A\* |  |  |

Table 19: Measure cost summary by application type for 800-1099 kW backup generator

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Application Type | Base Case  Equipment Cost  ($/unit) | Measure  Equipment Cost  ($/unit) | Installation Cost  ($/Unit) | Incremental Measure Cost  ($/unit) | Full Measure Cost  (1st Baseline period)[[12]](#footnote-12)  ($/unit) | Full Base Cost  (2nd baseline period)[[13]](#footnote-13)  ($/unit) |
| **ROB** | $600 | $1200 | N/A | $600 | N/A | N/A |
| **NC** | $600 | $1200 | N/A | $600 | N/A | N/A |
| ER |  |  |  | N/A\* |  |  |
| REA |  |  |  | N/A\* |  |  |

Table 20: Measure cost summary by application type for 1100-2500 kW backup generator

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Application Type | Base Case  Equipment Cost  ($/unit) | Measure  Equipment Cost  ($/unit) | Installation Cost  ($/Unit) | Incremental Measure Cost  ($/unit) | Full Measure Cost  (1st Baseline period)[[14]](#footnote-14)  ($/unit) | Full Base Cost  (2nd baseline period)[[15]](#footnote-15)  ($/unit) |
| **ROB** | $900 | $1500 | N/A | $600 | N/A | N/A |
| **NC** | $900 | $1500 | N/A | $600 | N/A | N/A |
| ER |  |  |  | N/A\* |  |  |
| REA |  |  |  | N/A\* |  |  |

* 1. Base Case(s) Costs

The base case equipment costs for these measures are found from equipment manufacturers quotes. DEER was not used as it does not address this type of measure.

* 1. Measure Case Costs

The measure case costs for these measures are also found from equipment manufacture quotes. DEER was not used as it does not address this type of measure.

* 1. Installation/Labor Costs

The labor costs for these measures come from SCE’s customized program for actual installation of this technology. DEER was not used as it does not address this type of measure.

* 1. Incremental & Full Measure Costs

Table 21: Incremental and full measure cost calculations

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Incremental Measure Cost  ($/unit) | Full Measure Cost  (1st Baseline period)  ($/unit) | Full Base Cost  (2nd baseline period)  ($/unit) |
| ROB/NEW | **Incremental Measure Cost** =  (Measure Equipment Cost + Measure Labor Cost) –  (Base Case Equipment Cost + Base Case Labor Cost) | N/A | N/A |
| ER | N/A | **Full Measure Cost** =  Measure Equipment Cost + Labor Cost | **Full Base Cost** =  (-1)\*(Second Base Case Equipment Cost + Labor Cost)[[16]](#footnote-16) |
| REA | N/A | **Full Measure Cost =**  Measure Equipment Cost + Labor Cost | N/A |

Table 22: Incremental and full measure cost values for 37-199 kW backup generator

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Incremental Measure Cost  ($/unit) | Full Measure Cost  ($/unit) | Full Base Cost  (2nd Baseline)  ($/unit) |
| ROB/NEW | $250 | N/A | N/A |
| ER | N/A |  |  |
| REA | N/A |  | N/A |

Table 23: Incremental and full measure cost values for 200-799 kW backup generator

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Incremental Measure Cost  ($/unit) | Full Measure Cost  ($/unit) | Full Base Cost  (2nd Baseline)  ($/unit) |
| ROB/NEW | $600 | N/A | N/A |
| ER | N/A |  |  |
| REA | N/A |  | N/A |

Table 24: Incremental and full measure cost values for 800-1099 kW backup generator

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Incremental Measure Cost  ($/unit) | Full Measure Cost  ($/unit) | Full Base Cost  (2nd Baseline)  ($/unit) |
| ROB/NEW | $600 | N/A | N/A |
| ER | N/A |  |  |
| REA | N/A |  | N/A |

Table 25: Incremental and full measure cost values for 1100-2500 kW backup generator

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Application Type | Incremental Measure Cost  ($/unit) | Full Measure Cost  ($/unit) | Full Base Cost  (2nd Baseline)  ($/unit) |
| ROB/NEW | $600 | N/A | N/A |
| ER | N/A |  |  |
| REA | N/A |  | N/A |

# Appendix 1 - Supplemental Files







# Appendix 2 – Commission Staff Comments / Review

Include embedded file(s) with Commission staff feedback.

# Appendix 3 - Measure Application Type Definitions

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the measure application type terms as follows:

Measure Application Type

|  |  |  |
| --- | --- | --- |
| Code | Description | Comment |
| ER | Early retirement | Measure applied while existing equipment still viable, or retrofit of existing equipment |
| EAR | Retrofit Add-on | Retrofit to existing equipment without replacement |
| ROB | Replace on Burnout | Measure applied when existing equipment fails or maintenance requires replacement |
| NC | New Construction | Measure applied during construction design phase as an alternative to a code-compliant standard design |

Baseline Technologies for UES and Cost calculations[[17]](#footnote-17)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Application Type | Baseline | Baseline Technology | Measure Cost Calculation | Duration |
| ER | First | Existing technology | Measure equipment cost + labor cost | RUL = 1/3\*EUL[[18]](#footnote-18) |
| Second | Code or standard | (-1)\*(Code/standard equipment cost + labor cost) | EUL - RUL |
| REA | First | Existing technology | Measure equipment cost + labor cost | EUL |
| Second | N/A | N/A | N/A |
| ROB | First | Code or standard | (Measure equipment cost + labor cost) – (Code/standard cost + labor cost) | Full EUL |
| Second | N/A | N/A | N/A |
| NC | First | Code or standard | (Measure equipment cost + labor cost) – (Code/standard cost + labor cost) | Full EUL |
| Second | N/A | N/A | N/A |

Measure cost overview developed by SCE:

**

# Appendix 4 – CPUC Quality Metrics

CPUC workpaper development actions to ensure quality are listed below, adapted from ex ante implementation scoring metrics described in Attachment 7 of Decision (D).13-09-023. The corresponding scoring metrics are shown below.

|  |  |
| --- | --- |
| **Metric** | **Workpaper Development Action to Ensure Quality** |
| 2 | Address all aspects of the Uniform Workpaper Template[[19]](#footnote-19) |
| 3a[[20]](#footnote-20) | Include appropriate program implementation background |
| 3b | Include analysis of how implementation approach influences development of ex ante values |
| 3c | Include all applicable supporting materials |
| 3d | Include an adequate[[21]](#footnote-21) description of assumptions or calculation methods |
| 4 | Pursue up-front collaboration on high impact measures with Commission staff prior to formal submission for review |
| 7 | Include analysis of recent and relevant existing data and projects that are applicable to workpaper technologies for parameter development that reflects professional care, expertise, and experience |
| 9 | Appropriately incorporate DEER assumptions, methods, and values for new or modified existing measures using professional care and expertise |
| 10 | Incorporate cumulative experience into workpaper through inclusion of an analysis of previous activities, reviews, and direction. (ED expects IOUs to immediately incorporate disposition guidance into workpapers to be submitted for formal review) |

# Appendix 5 – DEER Resources Flow Chart



# References



[31]

[351]

[355]

[422]

[436]

[491]

[A] Bonneville Power Administration (BPA). (2014). Emerging Technology field Test Results and Future Opportunities.

1. Full measure cost = measure equipment cost + measure labor cost [↑](#footnote-ref-1)
2. Incremental measure cost = Measure equipment cost – Baseline equipment cost [↑](#footnote-ref-2)
3. PCDC was reported to have a baseline heater size of 12 kW; this value is anomalously large and not consistent with other observable data. Based on measured kW and usage levels, a heater size of 6 is more plausible and more consistent. [↑](#footnote-ref-3)
4. Runtime logging for KRMC strongly suggest that the replacement heaters were significantly oversized for their needs. Therefore, the usage data are not representative of a site with an appropriately-sized heater. As a result, KRMC data are excluded from the analysis. [↑](#footnote-ref-4)
5. At sites where an overwhelming mode value was observed, the mode was used as the expected baseline usage. Otherwise, the mean baseline usage was used. [↑](#footnote-ref-5)
6. Until more data are collected for additional category 4 sites, savings for category 4 sites can only be estimated using the undersized heater methodology. [↑](#footnote-ref-6)
7. Note: decimal rounding may yield slightly different results in these examples. [↑](#footnote-ref-7)
8. Full measure cost = measure equipment cost + installation cost, for first baseline period [↑](#footnote-ref-8)
9. Full base cost = 2nd baseline equipment cost + installation cost, for the second baseline period [↑](#footnote-ref-9)
10. Full measure cost = measure equipment cost + installation cost, for first baseline period [↑](#footnote-ref-10)
11. Full base cost = 2nd baseline equipment cost + installation cost, for the second baseline period [↑](#footnote-ref-11)
12. Full measure cost = measure equipment cost + installation cost, for first baseline period [↑](#footnote-ref-12)
13. Full base cost = 2nd baseline equipment cost + installation cost, for the second baseline period [↑](#footnote-ref-13)
14. Full measure cost = measure equipment cost + installation cost, for first baseline period [↑](#footnote-ref-14)
15. Full base cost = 2nd baseline equipment cost + installation cost, for the second baseline period [↑](#footnote-ref-15)
16. The E3 calculator determines the net present value of the second baseline cost and subtracts it from the first baseline cost to determine the measure cost for the early retirement measure. According to the Energy Efficiency Policy Manual v.5 at page 32, the measure cost for an early-retirement case is “the full cost incurred to install the new high-efficiency measure or project, reduced by the net present value of the full cost that would have been incurred to install the standard efficiency second baseline equipment at the end of the [RUL] period”. [↑](#footnote-ref-16)
17. According to the Energy Efficiency Policy Manual v.5 at page 32, the measure cost for an early-retirement case is “the full cost incurred to install the new high-efficiency measure or project, reduced by the net present value of the full cost that would have been incurred to install the standard efficiency second baseline equipment at the end of the [RUL] period”. Page 33 elaborates that “the period between the RUL and EUL defines the second baseline calculation period…the measure cost for this period is the full cost of equipment, including installation, for the second baseline equipment measure”. [↑](#footnote-ref-17)
18. The Energy Efficiency Policy Manual v.5 at page 33 states “the remaining useful life (RUL)…[is established by DEER] as one-third of the expected useful life (EUL) for the equipment type”. [↑](#footnote-ref-18)
19. The Uniform Workpaper Template is not posted on the DEER website as of 4/21/14, and is currently in Microsoft Access Database format. [↑](#footnote-ref-19)
20. Metric 3 is not split among a – d in Attachment 7, however metric 3 was separated into four subcategories in this document for the purposes of identifying individual workpaper development actions to address quality. [↑](#footnote-ref-20)
21. “Adequate” is defined in Attachment 7 such that derivations of underlying assumptions of workpaper are easy to understand by the CPUC reviewer. [↑](#footnote-ref-21)