|  |
| --- |
| HVAC  Smart Thermostat, Residential  SWHC039-03 |

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Measure Name

Smart Thermostat, Residential

Statewide Measure ID

SWHC039-03

Technology Summary

A smart thermostatis a device that controls heating, ventilation, and air-conditioning (HVAC) equipment to regulate the temperature of the room or space in which it is installed, has the ability to make automated adjustments to the set point of the HVAC system to drive energy savings (electric and gas), and has the ability to communicate with sources external to the HVAC system. For connection, the smart thermostat may rely on a home area network (e.g. Wi-Fi) and an internet connection that is independent of the smart thermostat.

Measure Case Description

The measure case is defined as the installation of Residential smart thermostatwith two-way communication and automatic scheduling capabilities. Measure offerings are separated based on existing HVAC system types and delivery types because those parameters impact savings and NTG values.

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Offering ID** | **Description** | **HVAC Type** | **Delivery Type** |
| SWHC039A | Residential Smart Thermostat | Central AC with Gas Heat | DnDeemed |
| SWHC039B | Central Heat Pump | DnDeemed |
| SWHC039C | Central AC with Gas Heat | DnDeemDI |
| SWHC039D | Central Heat Pump | DnDeemDI |

Base Case Description

The base case is defined as either setback programmable thermostats or non-programmable thermostats.

The baseline characterization is based upon *the Smart Thermostat Program Process Evaluation* conducted for Pacific Gas and Electric Company (PG&E).[[1]](#footnote-1) This study administered participant surveys between October 2017 and February 2018 to ascertain customer experience with the program including motivation for participation, thermostat installation and use, the influence of the program on their purchase decision, and satisfaction. The study also gathered housing characteristics data including existing baseline conditions of the thermostat type controlling their corresponding HVAC equipment. The following table describes base case technology characterization as informed by referenced study.

Base Case Technology Characterization

|  |  |
| --- | --- |
| **Thermostat Type** | **Adjusted Survey Population of Thermostats** |
| Manual Thermostat | 11% |
| Programmable Thermostat | 76% |
| Smart Thermostat | 6% (Non-qualifying customers) |
| Other / Unknown | 7% |

Code Requirements

Thermostats are covered by the California Building Energy Efficiency Standards (Title 24), but the smart thermostat technology defined for this measure are not a subject to the standards.

This measure is not governed by the California Appliance Efficiency Standards (Title 20) or federal regulations.

Note that the applicable codes and standards for these measures dictate only that the thermostats be capable of shutting systems OFF and adjusting temperature setpoints during unoccupied hours. There are no requirements to shut down systems during unoccupied hours, or to make any specific unoccupied temperature setpoint adjustments

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| **Code** | **Applicable Code Reference** | **Effective Date** |
| CA Appliance Efficiency Regulations – Title 20 (2020) | None | January 1, 2020 |
| CA Building Energy Efficiency Standards – Title 24 (2019) | None | January 1, 2020 |
| Federal Standards | None | n/a |

Normalizing Unit

Household

Program Requirements

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

*Note that some of the implementation combinations below may not be allowed (or available) for some measure offerings by all program administrators.*

Implementation Eligibility

|  |  |  |  |
| --- | --- | --- | --- |
| **Applicable Offerings** | **Measure Application Type** | **Delivery Type** | **Sector** |
| SWHC039A, SWHC039B | Normal replacement | DnDeemed | Res |
| SWHC039C, SWHC039D | Normal replacement | DnDeemDI | Res |

The normal replacement measure application type is determined appropriate given baseline characterization determined by the Smart Thermostat Process Evaluation.[[2]](#footnote-2)

Eligible Products

**General Eligibility Requirements:[[3]](#footnote-3)**

The program administrator (PA) shall employ QA/QC procedures to ensure that the thermostat is installed in an eligible home and is attached to the type of HVAC equipment that is being incentivized, whether it is for natural gas or electricity savings.

The PA shall confirm that the customer has a newly purchased smart thermostat. At minimum, the PA shall obtain a copy of the thermostat sales receipt and the PA shall confirm the purchase date is on or after the program start date.

The PA shall determine customer eligibility prior to rebate payment. Upon request, all data associated with determining eligibility shall be provided to Energy Division of the California Public Utilities Commission (CPUC). All PAs shall extend this requirement to all third-party vendors that assist PAs with determining customer eligibility. To the extent that they are used to determine eligibility, data regarding dates of purchase, location of home, customer HVAC equipment type, pre-installation HVAC energy use, etc. shall be made available.

**Device Eligibility Requirements:**

The smart thermostat must be in full compliance with the ENERGYSTAR® Program Requirements and Product Specification for Connected Thermostats products Version 1.0 or later.[[4]](#footnote-4)

The customer must use the thermostat to control heating and/or cooling equipment supplied by fuels provided by the program administrator:

* For single-fuel utilities (or dual-fuel utilities in a portion of their service area where they only supply one fuel), only savings for the applicable delivered fuel may be claimed
* Eligible heating equipment: gas forced-air furnace, electric forced-air furnace, heat pump
* Eligible cooling equipment: central air conditioning

Eligible Building Types and Vintages

This measure is applicable for all residential building types (single family, multifamily, and mobile homes) of any vintage.

Eligible Climate Zones

This measure is applicable in all California Climate Zones with allowable measure savings claims as reported in corresponding energy savings tables. For some Climate Zones (primarily for Downstream programs, as determined by latest Impact Evaluation study[[5]](#footnote-5)), the measure is not expected to realize energy savings when controlling cooling and/or heating operating mode and/or energy consumption on controlled equipment is expected to increase in the measure case. For these cases, measure savings are zero out.

Program Exclusions

None.

Data Collection Requirements

Per Impact Evaluation[[6]](#footnote-6) recommendations, data collection requirements and additional work (to be supported by program evaluators) specifically needed to support further validation and/or evaluation of energy savings estimates from 2018PY Impact Evaluation, to include the following:

* “Differences between participants and comparison group households point to potential increasing trends in baseload consumption among participants. The next smart thermostat evaluation should develop methods for identifying trends in pre-installation consumption to include as a matching variable as well as other methods to minimize potential self-selection bias. Also, the current study could be updated with a new matched comparison group comprised of more recent program participants who were not available for inclusion within the existing evaluation timeframe.”
* “Load savings shapes are an increasingly important outcome from studies like this and further research is required to move them beyond the exploratory phase. This should not only provide better estimates of load savings shapes but also provide annual savings estimates that are consistent with those obtained from other methods, including the two-stage method used in this study.”

Use Category

HVAC

Electric Savings (kWh) and Gas Savings (therms)

The electric unit energy savings (UES) represents the per household heating and cooling energy savings from the installation of a smart thermostatin a residential household. The calculation approach accounts for the range in energy savings change associated with smart thermostat installations, and the results represent an average savings of the technology by the climate zone based on referenced studies and/or evaluations.

Savings for Downstream and Direct Install programs will expire on 12/31/2021.

Downstream Programs

Measure savings for Downstream programs are adopted directly from the **Impact Evaluation of Smart Thermostats Residential Sector - Program Year 2018 - CALMAC ID: CPU0205.01 - April 16, 2020 - DNV GL**.[[7]](#footnote-7) The evaluation takes a two-stage modeling approach to estimate the effect of smart thermostats on energy consumption. The approach uses variable degree-day PRISM[[8]](#footnote-8), site-level models with a matched comparison group in a difference-in-difference (DID) framework. For details on measure savings estimates methods refer to referenced study.[[9]](#footnote-9)

The Impact Evaluation included IOU-specific savings potentials. However, the study (originally) did not included IOU-weighted savings for overlapping Climate Zones and savings for Climate Zone 1. Further, the study did not delineate measure savings between central systems with electric heating (or heat pump heating) versus gas heating. After collaboration between IOUs and CPUC, measure savings were adjusted, and clarifications were provided by the CPUC to address these data gaps.[[10]](#footnote-10) Final measure savings estimates were provided by commission staff consultant to IOUs via email.[[11]](#footnote-11)

Direct Install programs

For Direct Install program, measure savings estimates from previous version of the workpaper (SWHC039-01) are retained given that latest 2018PY Impact Evaluation study did not specifically supported the evaluation of measure savings potentials from Direct Install programs.

Relevant studies leveraged to support measure impact analysis (for SHWHC039-1 version of the Workpaper) are summarized below. These studies support adequate experimental methods and supporting documentation for evaluation of the measure.

**Smart Thermostat Study: First Year Findings (PG&E, 2016).[[12]](#footnote-12)** Pacific Gas and Electric (PG&E)designed the Smart Thermostat Study as an Emerging Technologies Program scaled field placement (PG&E ET Study) to gather data from customer homes that have been randomly assigned to receive a free smart thermostat. The Study is a randomized encouragement design (RED) trial in which several thousand homes were randomly assigned to the encouraged group, all of whom were offered a free, directly-installed smart thermostat, and two thousand similar homes were randomly assigned to a control group, none of whom were offered a thermostat. Three different brands of thermostats were tested in the study; the goal was to install 1,000 of each type of thermostat in participants’ homes. Note that the regression models used in the analysis of this workpaper are modified from those published in the ET Report. See Methodology Overview Section for the details on the revised calculation methodology.

**PG&E Smart Thermostat Program Process Evaluation (Opinion Dynamics, 2018).[[13]](#footnote-13)** This process evaluation is based upon on participant surveys conducted between October 2017 and February 2018. Participants provided feedback on their experience with the program including their motivation for participation, thermostat installation and use, the influence of the program on their purchase decision, satisfaction, and housing characteristics.

**Methodology Overview (Direct Install)**

***HVAC Cooling***

Measure savings on HVAC cooling energy were estimated based on PGE’s Year 1 study. PGE’s Year 2 study[[14]](#footnote-14) was evaluated but not directly included in final calculation approach/methods given abnormalities further described in this Section. These studies were designed using a Randomized Encouragement Design (RED). A RED design is an appropriate alternative to a Randomized Control Trial (RCT), when it is known that not all the treatment customers will accept the treatment, i.e., when treatment is voluntary.

Energy savings were estimated by first using a statistical difference-in-differences (DID) approach, and second, using a fixed-effect regression approach. This two-step process allowed preliminary estimates of savings that are unconstrained by the assumptions of a regression model. Then, those estimates were refined using a regression approach.

As part of the statistical DID, the method compares the monthly usage of the encouraged customers to the randomly assigned control group customers, both during the participation period (treatment period) and for a time before participation started (pretreatment period). Comparison during the treatment period gives an unadjusted estimate of the impacts. This estimate is then corrected using the difference during the pretreatment period to adjust for any preexisting differences between the encouraged and control groups.

In the second step of the analysis, savings were estimated using regression models in which energy use is evaluated as a function of other explanatory variables (e.g., weather) that the statistical DID is unable to do. The models include the encouraged and control customers in both the treatment and pre-treatment periods.

***Approach***

The approach to developing statewide ex-ante estimate based on PG&E’s Year 1 Smart Thermostat Study results is described below. First, modifications to the ex-post models and associated rationale are described, followed by a description of the final ex-ante model and finally, the actual extrapolation approach and results.

**Modifications to the Ex-Post Models.** The regression models that were developed for the original analysis were developed with several goals in mind:

* Estimating ex-post impacts for three different thermostats, while accounting for the RED design.
* Attaining reasonable comparison between the statistical Difference in Difference (DID) and the regression output.
* Estimating monthly impacts with a primary focus on summer savings for electric customers.

The original ex-post analysis goals do not align with the goals of an annual ex-ante estimate. Through collaboration with the CPUC Ex Ante Review consultants, the EM&V consultant understood the goals of the ex-ante analysis to be as follows:

* Develop a model that is appropriate for extrapolation to weather conditions outside of what participants experienced.
* Attain a single estimate for smart thermostats that is representative of the types of thermostats that PG&E customers are installing, rather than three separate estimates.
* Develop a normalized annual estimate of savings without focusing on a specific season.

**Updated Ex-Ante Model.** Based on the ex-ante analysis goals, the EM&V consultant collaborated with CPUC Ex Ante Review consultants to develop an updated model that is appropriate for an ex-ante estimate. EM&V consultant also updated the analysis to estimate the annual savings directly rather than estimate savings at a monthly level. The updated model has the following characteristics:

* The model maintains the full structure of the DID and weather elements regardless of significance, which provides more stability for the estimates during extrapolation.
* The model employs a fixed effect approach.
* The model estimates the overall effect of the two thermostats with highest participation of the PGE program making up over 97% of the PG&E current rebates jointly.

The final ex ante model specification is below:

where:

*= the kWh consumption of customer in month*

*= a fixed effect for each customer*

*= an indicator that takes on a value of for each customer when month is in the treatment period*

*= an indicator which takes on a value of customer is in the encouraged group*

*= total cooling degrees for customer in month*

*= total heating degrees for customer in month*

*= the error for customer in month*

**Extrapolation.** To determine the most appropriate methodology for the ex-ante estimates of savings, the following points were considered:

* The PG&E First Year Study was not designed to be representative of all Californians.
* The PG&E First Year Study model was estimated using actual cooling degree days (CDD) and heating degree days (HDD) from the PG&E 23 weather stations, not CEC climate zone data.
* The results do not represent weather normal impacts, but actual ex-post impacts.
* Impacts from participants in PG&E hottest zones may not be representative of all California customers, i.e. the weather relationships estimated by the ex-ante regression model may not be applicable across the entire state.
* In the second year of the study (Year 2) we noted the following anomalies compared to the first year (Year 1):
  + The study participants experienced weather that was quite different with a more extreme summer.
  + The samples eroded due to move outs and other account changes. The shrinking samples made the encouraged effect even harder to detect.
  + Based on conducted survey, both control group customers and encouraged customers began installing smart thermostats, nearly 15% of each group installed thermostats independent of the program.
  + The savings patterns seemed to shift, with more savings being seen in the spring (and even winter) and less savings in the summer. These shifts in savings trends seemed counterintuitive.

General approach for supporting the analysis is summarized below.

**Estimate the average HVAC cooling + fan energy consumption using the DEER prototypes.** This was done by enabling latest single-family DEER prototype using the MASControl3 software application with the following assumptions: All 16 climates cones; Median Vintage - 2007; Central HVAC with Gas Furnace < 45 kBtuh; SEER14; AFUE 0.80; DEER weighted Thermostat Schedules; and CTZ2010 weather.

**Use ex-ante model to generate an annual savings estimate.** Generate a single annual savings estimate from the ex-ante model using First Year study data only. Second Year study data was evaluated but not directly included in final analysis due to the anomalies outlined above. The ex-ante model was used to estimate the annual savings attributable to the smart thermostats. To do this, the savings were estimated as a linear combination of the following parameters from the ex-ante model.

This estimate represents the annual savings for the encouraged group. A weighted acceptance rate was used to estimate the savings of the treated group under the RED.

**Use the ex-ante model to estimate an annual cooling baseline load and percent impact.** Use the ex-ante model to estimate the annual HVAC cooling baseline for the encouraged group and estimate the percent impact. When using the ex-ante model, the HVAC cooling baseline represents the ex-ante model estimate of weather responsive load based on the relationship between CDD and kWh. The HVAC cooling baseline load was then estimated for the encouraged group. This represents the ex-ante model estimate of weather responsive load absent the thermostat based on the estimated relationship between CDD and kWh. To estimate the cooling baseline load, we use the following linear combination of variables from the ex-ante model:

The annual savings estimate in percent terms was calculated by dividing the annual savings by the cooling baseline. The percentage impacts are reflective of how pilot participants responded to the treatment but using percentages allows us to scale the impacts to represent PG&E participants in each climate zone.

**Apply percentage impacts to DEER HVAC + fan cooling consumption estimates for each CEC climate zone to estimate impacts.** Apply the percent impact from step 2 to the HVAC cooling + fan energy consumption for a single-family home with central air conditioning (CAC) in each of the California 16 climate zones based on the single-family DEER prototype.

The final step in the analysis is to apply the annual percentage savings from the ex-ante model to the HVAC + fan cooling consumption for an average single-family home with CAC in each of the California 16 climate zones as estimated by the appropriate single-family DEER prototype. This provides an estimate of how other Californians would respond to the thermostats assuming they would respond similarly to the PG&E program participants.

One key advantage of the proposed approach is that it does not require applying parameter estimates (relationships) across very different climate zones (inland vs. coastal vs. desert) which would in turn would assume that all customers have the same relationship with weather regardless of their climate. It does, however, assume that all customers in the state would have a response that would be similar to those that participated in the pilot.

Results

The results of the extrapolation analysis are presented in this section. The ex-ante model output is presented first, followed by the cooling baseline, and finally the savings estimates.

***Ex-ante Model Output***

The figure below presents the output of the updated ex-ante model from Stata. As with any standard modeling output the parameter estimates are presented on the left and the associated statistics on the right. It should be noted that Stata does not output a typical r-squared value. However, the “within” r-squared is analogous to an r-squared from a regular OLS model (without fixed effects) and the statistic *rho* represents the total fraction of variation captured by the fixed effects.

**Ex-Ante Model Output**



**Ex-Ante Cooling Baseline Estimates versus. DEER HVAC + fan Cooling Baseline Estimates.[[15]](#footnote-15)** In this section, the HVAC cooling baseline estimate is presented from the ex-ante model, followed by the single family DEER HVAC + fan cooling baseline estimates, and finally, a comparison of the two.

The table below presents the ex-ante model estimate of the total baseline and the cooling baseline. The ex-ante cooling baseline is also presented as a percent of the total. The model estimates that the cooling load makes up between 3% and 48% of the total baseline load depending on the month of the year. The overall pattern makes sense given what is known about the climate zones included in the pilot, with the hottest months of the year occurring in the mid-summer months of July and August.

*Ex Ante Cooling Baseline Savings Estimates.[[16]](#footnote-16)*The ex-ante model estimate of the savings as a percent of the ex-ante cooling baseline results in savings that account for about 11% percent of the total HVAC cooling baseline at an annual level.

The table below documents the ex-ante impact for each climate zone. The impact is calculated by applying the 11% impact predicted by the model to the annual cooling load in each zone. The nominal impact (kWh) and the impact as a percent of the total annual load are presented below.[[17]](#footnote-17) Ex-Ante input models and hourly data reports will be provided on request.

***Measure Savings Scaling for Multifamily and Double-wide Mobile Homes (HVAC Cooling).***Given that the First Year and Second Year Emerging Technologies studies excluded evaluation of measure savings for multifamily and double-wide mobile homes, scaling (energy savings) factors were estimated for these residence types using the latest DEER2020 HVAC Upgrade measures based on the ratio of the normalized energy impacts (e.g., kWh/Ton) compared to the single family residence type.

The estimated adjustment factors vary by climate zone. However, no direct correlation was observed between the adjustment factors and climate zones, as there are several intricate factors varying among the climate zones that determine the energy impacts.

Further adjustments were applied to the multifamily scaling factor to account for variation in system capacity between the multifamily DEER models and system capacity seen by the program. This analysis was conducted using the DEER multifamily prototype adjusted from 1.0 ton (DEER defaulted - average per dwelling) to 2.0 tons (program informed average capacity per dwelling).

**Adjustment Factors for Double-wide Mobile Homes and Multifamily[[18]](#footnote-18)**

| **Climate Zone** | **Adjustment Factor - Double-wide Mobile Home** | **Adjustment Factor - Multifamily** |
| --- | --- | --- |
| CZ01 | 0.46 | 0.96 |
| CZ02 | 0.86 | 0.79 |
| CZ03 | 0.87 | 0.72 |
| CZ04 | 0.88 | 0.95 |
| CZ05 | 0.94 | 0.57 |
| CZ06 | 1.40 | 0.85 |
| CZ07 | 0.74 | 1.02 |
| CZ08 | 0.97 | 0.84 |
| CZ09 | 0.97 | 0.98 |
| CZ10 | 1.06 | 0.72 |
| CZ11 | 1.31 | 1.53 |
| CZ12 | 1.25 | 1.31 |
| CZ13 | 1.13 | 1.29 |
| CZ14 | 0.77 | 1.18 |
| CZ15 | 1.24 | 1.23 |
| CZ16 | 1.89 | 1.53 |

Peak Electric Demand Reduction (kW)

No peak demand reductions are included within this workpaper (for any of the supported programs) given that methodology supporting evaluation of measure savings (including AMI data) is not “granular” enough to adequately support evaluation of peak demand savings.

Gas Savings (Therms) - Direct install

*HVAC Heating*

Measure savings potential of gas heating previously evaluated by Southern California Edison (SCE)[[19]](#footnote-19) (and included in previous approved version of the Workpaper – SWHC039 Revision 1) were adopted for this measure, until an additional gas impact evaluation for Direct Install programs is conducted for revised savings potentials.

The energy impact analysis used a fixed-effects regression model and the heating setpoint data from SCT units collected by a manufacturer. The second baseline heating savings from this analysis for 16 climate zones in single-family building provided the basis for approximating gas savings potentials for multifamily and double-wide mobile homes. The most currently available residential DEER prototypes with baseline heating consumption were utilized to calculate adjustment factors and derive gas impacts for the multifamily and double-wide mobile home building types.

**Sample Adjustment Factors for Heating Savings using DEER Prototype Heating Consumptions (CZ09)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building Type** | **Annual Heating Energy**  **(Btu x 106) a** | **Annual Heating Energy**  **(Therms)** | **Annual Heating per System**  **(Therms)** | **Adjustment Factor** | **Savings Contribution** |
| Single family | 49.4 | 494.0 | 123.5 | 100.0% | 8.9% |
| Multifamily | 108.9 | 1,089.2 | 38.9 | 31.5% | 8.9% |
| Double-wide Mobile Home | 17.7 | 177.2 | 88.6 | 71.7% | 8.9% |

a. Space heating from MC3 annual consumption summary.

Life Cycle

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. EUL values are employed with CPUC authorized annual avoided costs and measure‐specific energy savings to determine lifecycle dollar benefits associated with a measure.

**Effective Useful Life Evaluation Protocol.** Per the California Energy Efficiency Evaluation Protocols,[[20]](#footnote-20) there are two allowable methods for EUL analysis: basic rigor and enhanced rigor. Both methods require survival analysis or other analysis methods that specifically control for right-censored data. Right-censored data are failures that might take place after data collection.

**Effective Useful Life Analysis and Results.[[21]](#footnote-21)** Using non-parametric Kaplan-Meier estimation methodology in the R statistical software, a survival analysis was used on data provided by two main smart thermostat vendors. Specifically, a survival analysis method was used on the thermostat connectivity data to account for right censorship in the data and to provide unbiased estimates of survival functions and rates.

The EUL analysis combined non-linear and linear results to quantify the uncertainty around the EUL estimates, which assisted with program implementation data, results on a weighted average value of 9.1 years.

The EUL specified for the smart communicating thermostat measure are specified below. The EUL ID is currently included in the PEAR database[[22]](#footnote-22).

Effective Useful Life and Remaining Useful Life

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **EUL ID** | **Value** | **Source** |
| EUL (yrs) | HV-SmartTstat | 9.1 | Original Source: Cadmus Group. 2019. “EUL analysis of Residential Smart Communicating Thermostat – Vendor A and B.” Memorandum to Andres Fergadiotti and Cassie Cuaresma, Southern California Edison. February 1.  California Public Utilities Commission (CPUC). 2020. “SupportTable\_EUL.CSV.” Obtained from PEAR database. |
| RUL (yrs) | n/a | n/a |  |

Base Case Material Cost ($/unit)

The base case material cost was obtained through online prices research from various retailer websites in the second quarter of 2020.[[23]](#footnote-23) The total equipment cost includes 8.75% tax. Shipping cost has not been included in the material price as majority of the retailers offer free shipping.

The installed market percent for baseline programmable, non-programmable, and smart thermostats was found using PG&E’s 2018 Evaluation[[24]](#footnote-24). The percentages of baseline equipment from the Base Case Description Section were used to weight the online retailer prices to establish a weighted baseline cost.

Weighted Baseline Material Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Equipment** | **Market Distribution** | **Material Cost per unit** | **Total Baseline Weighted Cost ($)[[25]](#footnote-25)** |
| Manual Thermostat | 12% | $ 39.06 | $61.11 |
| Programmable Thermostat (a) | 88% | $ 64.03 |

a. Unknown/Other thermostats were assumed to be programmable thermostats for the estimating market distribution

Measure Case Material Cost ($/unit)

The measure case cost for the smart thermostats was obtained through online prices research from various retailer websites in the second quarter of 2020. All the smart thermostat models are ENERGYSTAR certified and meet the workpaper eligibility requirements. The total equipment cost includes 8.75% tax. Shipping cost has not been included in the material price as majority of the retailers offer free shipping. Until more updated studies are done, the online retail point of sales pricing is the best available data to support the measure equipment cost.

The measure cost update is adjusted based on smart thermostat adoption in the Utility programs in 2018[[26]](#footnote-26). IOU program tracking data suggests that 80% of all smart thermostat rebate applications are for smart thermostat technology with occupancy sensing. The material cost per unit is adjusted to include only the standard features of smart thermostats. Furthermore, the program data shows that the majority of installations featured a handful of major models of smart thermostats. Online retailer cost data was weighted based on program participation percentages to establish the measure material costs.

The final (weighted) measure cost was estimated at $210.16.[[27]](#footnote-27)

**Cost Methodology/Approach.**

The incremental measure cost is the cost differential of the efficient option over the standard option attributable to features related to energy efficiency performance.[[28]](#footnote-28) A robust analysis would involve developing a taxonomy of features and determining the cost of each feature or component. This is generally done through such methods as product teardowns or hedonic price modeling. However, for thermostats, these methods become unwieldy because it is difficult to develop a standardized set of features due to various possible implementations of the technology and we may not find a reliable correlation between features and price.

Base Case Labor Cost ($/unit)

The base case labor cost was obtained from the RSMeans Online database in 2020. The bare labor hours (0.40 hours)[[29]](#footnote-29) of residential electrician time ($67.95)[[30]](#footnote-30) was used to estimate the labor cost. The average RSMeans regional cost index[[31]](#footnote-31) value for California (of 1.11) was used to adjust the national average hourly labor rate to the California region. The final labor cost for this measure was estimated at $30.18.

Measure Case Labor Cost ($/unit)

The labor costs for both the measure and base case are assumed to be the same. See Base Case Labor Cost.

Net-to-Gross (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The relevant NTG values for this measure are specified below. These values are based on the free ridership survey results published in the Program Year 2018 Impact Evaluation.[[32]](#footnote-32) This information was used to estimate weighted NTG values for both Downstream and Direct Install statewide programs and included in DEER2021[[33]](#footnote-33).

Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **NTG ID** | **Value** | **Source** |
| Downstream Deemed | Res-sAll-mHVAC-SCT-dn | 0.55 | Weighted NTG values for Direct Installed and Downstream programs as informed by "Impact Evaluation of Smart Thermostats, Residential Sector - Program Year 2018."  California Public Utilities Commission (CPUC). 2020. “SupportTable\_NTG2020.CSV.” Obtained from PEAR database. |
| Direct Install | Res-sAll-mHVAC-SCT-di | 0.90 |

Gross Savings Installation Adjustment (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method.

Gross Savings Installation Adjustment Rates

|  |  |  |
| --- | --- | --- |
| **Parameter** | **GSIA** | **Source** |
| GSIA | 1.0 | California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31. |

Non-Energy Impacts

Non-energy benefits for this measure have not been quantified.

DEER Differences Analysis

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Comment / Used for Workpaper** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | n/a |
| Reason for Deviation from DEER | The DEER 2021 database does not support measure evaluation on Smart Thermostat technology. |
| DEER Measure IDs Used | n/a |
| NTG | Source: DEER IDs: Res-sAll-mHVAC-SCT-dn, Res-sAll-mHVAC-SCT-di |
| GSIA | Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: DEER ID: HV-SmartTstat |

Revision History

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision Number** | **Revision Complete Date** | **Primary Author, Title, Organization** | **Revision Summary and Rationale for Revision** |
| 01 | 6/24/2019 | Kara Vega, TRC | Draft of consolidated text for this statewide measure is based upon: SCE17HC054, Revision 1 (May 31, 2019)  Measure costs were reassessed based on review of online retailers in 2019 Q2. |
|  | 06/28/2019 | Jennifer Holmes, Cal TF Staff | Revisions for submittal of version 01. |
| 02 | 8/1/2019 | Matthew Mendoza, SoCalGas | Addition of the research/analysis performed by Nexant to update the gas savings estimates. |
| 03 | 6/8/2020 | Lake Casco, TRC | Updated savings values and NTG based on PY2018 Impact Evaluation.  Added newest EUL ID for Smart Thermostat  Updated pricing based on 2020 online retailer data  Split measures between Downstream Direct Install and Downstream Deemed. Direct install measures maintain savings from the previous workpaper.  Downstream Deemed measures use new PY2018 Impact evaluation savings. |

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