**Workpaper WPSDGENRHC0026**

**Programmable Thermostat**

**Revision 3**

**San Diego Gas & Electric Company**

**Programmable Communicating Thermostat for Demand Response**

# At-A-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **DM-XX – Programmable Communicating Thermostat for Demand Response** |
| **Measure Description:** | Programmable communicating thermostat capable of responding to automated setback demand response to control packaged AC/ heat pump applications |
| **Energy Impact Common Units:** | Per 1,000 sq ft footprint |
| **Base Case Description:** | Existing non-programmable, non-communicating manual thermostat  Source: DEER eQUEST Prototypes |
| **Base Case Energy Consumption:** | Various, depends on climate zone, and building type. Source: eQUEST models. |
| **Measure Energy Consumption:** | Various, depends on climate zone, and building type.  Source: eQUEST models. |
| **Energy Savings (Base Case – Measure)** | Various, depends on climate zone, and building type.  Source: eQUEST models. |
| **Costs Common Units:** | $ per unit |
| **Base Case Equipment Cost ($/unit):** | $0.00/unit |
| **Measure Equipment Cost ($/unit):** | Various. Refer to At-A-Glance Measure List[[1]](#endnote-1).  Source: DEER 2008, SDG&E |
| **Gross Measure Cost ($/unit)** | Various. Refer to At-A-Glance Measure List.  Source: DEER 2008[[2]](#endnote-2), SDG&E |
| **Measure Incremental Cost ($/unit):** | Various. Refer to At-A-Glance Measure List.  Source: DEER 2008, SDG&E |
| **Effective Useful Life (years):** | HV-ProgTstat  Source: DEER 2014-EUL-table-update\_2014-02-05.xlsx[[3]](#endnote-3) |
| **Program Type:** | REA |
| **Net-to-Gross Ratios:** | Com-Default>2yrs  Source: DEER2015-2016-NTG-Update-2015-10-20.xls |
| **Important Comments:** | Gross Measure Cost is assumed to equal the Incremental Measure Cost |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Author/Affiliation** | **Summary of Changes** |
| 0 | 3/5/2014 | Curtis Lee, kW Engineering | Original work paper for 2014 |
| 1 | 4/1/2014 | Curtis Lee, kW Engineering | * Formatted workpaper to current IOU template * Added inspection requirements |
| 2 | 11/26/2014 | Curtis Lee, kW Engineering Lisa Gartland, PhD, kW Engineering | * Calculated energy savings based on eQUEST models |
| 3 | 06/28/2016 | Martin Vu, RMS | * Updated the wp to address the April 14, 2015 Ex-Ante Review Team (EAR) Preliminary Review comments by:   + Removed the HTR-di net to gross reference and value as SDG&E is not targeting HTR customers. The implementation table was updated to use the (Com-Default > 2yrs) NTG ID rather than (Com-Default-HTR-di) NTG ID.   + The EUL-ID was changed in the workpaper and ex-ante database from “HVAC-Timeclocks” to HV-ProgrTstat” and also copied into the RUL\_ID.   + The Measure Cost Table was updated in compliance with the “ExAnte-DataStructure\_MeasureCostSpecification\_10-28-2014” guidance found on the DEER website. |

# Section 1. General Measure & Baseline Data

## 1.1a Product Measure Description & Background

### Catalog Description

* DM-XXProgrammable Communicating Thermostat for Demand Response

**Program Restrictions and Guidelines**

This workpaper documents the rationale for the savings methodologies and assumptions for the installation of programmable communicating thermostats (PCTs) on existing equipment, as offered by San Diego Gas and Electric’s Commercial Direct Install Program. SDG&E offers incentives to non-residential customers for installing qualifying, high-efficiency equipment.

**Terms and Conditions:**

Requirements from the Product Catalog[[4]](#endnote-4):

* Customers must have a SDG&E commercial electric account if applying for an electric measure, and a gas account if applying for a gas measure.
* All measures must be installed and operational before invoice is submitted.
* Install new smart thermostat per manufacturer instruction.
* Enable the Wi-Fi communication of the thermostat.
* Remotely test the operation of the HVAC system use the Wi-Fi feature.
* Customer must enroll in a demand response program.

**Additional requirements:**

Based on the CPUC Workpaper Disposition for Non-Residential HVAC Rooftop Quality Maintenance[[5]](#endnote-5), savings for this measure were to be reduced to 25% of the calculated energy savings based on the following statement:

The overriding issue is that program assumptions used to develop UES values are not being used to constrain measure implementation. As such, measure implementation can, and does, provide either no savings or negative savings. This leads staff to apply the following gross savings adjustment (GSA) multipliers to un‐adjusted savings:

*GSATstat Replace = \* 0.25*

***Market Applicability:*** This measure is applicable to non-residential customers with unitary HVAC equipment with DX cooling and gas heating or heat pumps. The measure is applicable in all SDG&E climate zones and for all building vintages. The intent of the incentive is to install programmable thermostats and respond to demand response events.

### 1.2 Product Technical Description

This measure involves the replacement of an existing non-programmable, non-communicating manual thermostat, with a new programmable communicating thermostat (PCT).

As with a programmable thermostat, the PCT enables automatic control of HVAC units. Programmable thermostats are used to schedule different fan operation and cooling and heating temperature set points during occupied and unoccupied periods in a facility. When programmable thermostats are adjusted and used properly, fans turn off when the facility is unoccupied, and heating and cooling set points are adjusted and controlled to reflect the needs of the facility during occupied and unoccupied periods.

In actuality, programmable thermostats are often operated incorrectly. Some programmable thermostats were never programmed properly from the start. Occupants can also cause inefficient HVAC operation by temporarily overriding set points, or by permanently reprogramming schedules and set points. The use of PCTs can improve HVAC operation by ensuring that thermostats are correctly programmed, and by regularly resetting them after occupants override settings. This can reduce annual heating and cooling energy use compared to the use of non-programmable and programmable non-communicating thermostats.

The PCT is also able to respond to demand response (DR) events. Demand response events occur on days when loads on the electrical distribution system are predicted to be very high. These events typically occur during hot, summer weather, due to increased cooling loads in buildings. During DR events, PCTs can be signaled to raise their cooling temperature set points in order to reduce the electricity demand from the facility’s HVAC unit(s). DR program participants can use PCTs to help reach their demand reduction target of 100 kW or 15% of their monthly average peak demand. The use of PCTs also allows SDG&E to potentially accrue demand savings from non-DR program participants. Note that potential impacts from DR are not quantified in this workpaper; see section 2.4 for further detail.

## 1.3 Installation Types and Delivery Mechanisms

The DEER measure application types are defined in the table below:

Table 1 Measure Application Type

Identifies the measure application type in the Measure Classification table in 2013-14 Statewide Customized Retrofit Offering Procedures Manual for Business.

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | Measures should be claimed as Early Retirement if the existing equipment is operational and has been shown to have a Remaining Useful Life (RUL) > 1 year, and compelling evidence exists showing the program induced replacement of the equipment. |
| ROB | Replace on Burnout | Measures should be claimed as Replace on Burnout in all circumstances where the equipment being replaced is non-operational. |
| NR | Normal Replacement | Measures should be claimed as Normal Replacement if the existing equipment is operational but there is insufficient evidence of Early Retirement (e.g. there is no evidence to show the existing equipment has an RUL > 1 year and the program induce early replacement of the equipment). |
| REA | Retrofit Add-On | Measures should be claimed as Retrofit Add-On if the measure is a control or other mechanism that is added to an existing operating piece of equipment that allows it to operate at higher system efficiencies (a typical case would be adding a VSD/VFD to an existing motor driven process). |
| NC | New Construction | Measures should be claimed as New Load if the measure results in new customer load (and is eligible for the retrofit program as defined in Section 1.4.3). |

**Table 2** Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |
| Retrofit First Baseline Only (REF) | Above Customer Existing | N/A | EUL | N/A |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

The PCT wp measure assumes a Retrofit Add-On (REA) measure since the thermostats will be added to the existing HVAC system to allow for additional control capabilities.

## 1.4 Measure Parameters

### 1.4.1 DEER Data

Table 3 DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER Version Referenced: DEER 2016, READI v2.4.3 |
| Reason for Deviation from DEER | The DEER 2016 database does not contain an updated measure for this PCT measure. |
| DEER Measure IDs Used | N/A. Only the 2008 Cost ID (ProgTStats) was referenced in the cost section of this wp. |

**Net-to-Gross Assumption:**

The Net-to-Gross ratio (NTGR) was obtained using the DEER 2016, READI v2.4.3 tool. The relevant NTGR for the wp measure is shown in Table 4.

Table 4: DEER Net-to-Gross Ratios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Program Delivery ID** |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any |

**Spillage Rate**

Spillage rates are not tracked in wps. Spillage rates are tracked in an external document, which will be supplied to the Commission Staff.

**Installation Rate**

The installation rate (IR) value was obtained using the DEER 2016, READI v2.4.3 tool. The relevant IR value for this wp measure is shown in the Table 5.

Table 5 Gross Savings Installation Adjustment Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective Useful Life and Remaining Useful Life:**

The effective useful life (EUL) and remaining useful life (RUL) values were obtained using the DEER 2016, READI v2.4.3 tool. DEER defines the RUL as 1/3 of the EUL value based on an estimate of the median number of years that a measure being replaced under the program would remain in place and operable had the program intervention not caused the replacement. The RUL value is only applicable to the first baseline period for an early retirement (ER) or retrofit (RET) measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in Table 6.

**Table 6** Effective Useful Life

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HV-ProgTstat | Programmable Thermostat | Res | HVAC | 11 | 11 |

## 1.4.2 Codes & Standards Requirements Base Case and Measure Information

This measure falls under the jurisdiction of Title 24 as listed below. We find that PCTs have the capability to respond to a demand response signal, and therefore exceed the functionality of thermostats that meet current 2013 Title-24 standards.

Table 7 Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2014) | N/A | N/A |
| Title 24 (2013) | Title 24, part 6 Section 110 Thermostats | July 1, 2014 |

**Section 110**

**Thermostats.** All unitary heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat.

**1. Setback Capabilities.** All thermostats shall have a clock mechanism that allows the building occupant to Program the temperature set points for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b). Space-conditioning systems shall be installed with controls that comply with the applicable requirements of Subsections (a) through (i).

**Section 120**

**Thermostatic Controls for Each Zone.** The supply of heating and cooling energy to each space-conditioning zone or dwelling unit shall be controlled by an individual thermostatic control that responds to temperature within the zone and that meets the applicable requirements of Section 120.2(b).

**EXCEPTION to Section 120.2(a):** An independent perimeter heating or cooling system may serve more than one zone without individual thermostatic controls if:

1. All zones are also served by an interior cooling system;

2. The perimeter system is designed solely to offset envelope heat losses or gains;

3. The perimeter system has at least one thermostatic control for each building orientation of 50 feet or more; and

4. The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

**(b) Criteria for Zonal Thermostatic Controls.** The individual thermostatic controls required by Section 120.2(a) shall meet the following requirements as applicable:

1. Where used to control comfort heating, the thermostatic controls shall be capable of being set, locally or remotely, down to 55°F or lower.

2. Where used to control comfort cooling, the thermostatic controls shall be capable of being set, locally or remotely, up to 85°F or higher.

3. Where used to control both comfort heating and comfort cooling, the thermostatic controls shall meet Items 1 and 2 and shall be capable of providing a temperature range or dead band of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

**EXCEPTION to Section 120.2(b)3:** Systems with thermostats that require manual changeover between heating and cooling modes.

4. Thermostatic controls for all unitary single zone, air conditioners, heat pumps, and furnaces, shall comply with the requirements of Section 110.2(c) and Reference Joint Appendix JA5 or, if equipped with DDC to the Zone level, with the Automatic Demand Shed Controls of Section 120.2(h).

**Appendix JA5 - Technical Specifications For Occupant Controlled Smart Thermostats**

* The Occupant Controlled Smart Thermostat (OCST)2 shall be self- certified by the manufacturer to the Energy Commission to meet the requirements described in this section. This document provides a high level technical specification for an OCST. All OCSTs shall comply with the

specifications set forth in this document or a specification approved by the Executive Director.

**JA5.2 Required Functional Resources**

**JA5.2.1 Setback Capabilities**

All OCSTs shall meet the requirements of Section 110.2(c). Thermostats

for heat pumps shall also meet the

requirements of Section 110.2(b).

* **JA5.2.2 Communication Capabilities**

OCSTs shall include communication capabilities enabled through either:

(a) At least one expansion port which will allow for the installation of a removable module containing a radio or physical connection port to enable communication; or

(b) Onboard communication device(s)

**Shut-off and Reset Controls for Space-conditioning Systems.** Each space-conditioning system shall be installed with controls that comply with the following:

1. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:

A. An automatic time switch control device complying with Section 110.9, with an accessible manual override that allows operation of the system for up to 4 hours; or

B. An occupancy sensor; or

C. A 4-hour timer that can be manually operated.

**EXCEPTION to Section 120.2(e)1:**Mechanical systems serving retail stores and associated malls, restaurants, grocery stores, churches, and theaters equipped with 7-day programmable timers.

2. The control shall automatically restart and temporarily operate the system as required to maintain:

A. A setback heating thermostat set point if the system provides mechanical heating; and

**EXCEPTION to Section 120.2(e)2A:** Thermostat setback controls are not required in nonresidential buildings in areas where the Winter Median of Extremes outdoor air temperature determined in accordance with Section 140.4(b)4 is greater than 32°F.

B. A setup cooling thermostat set point if the system provides mechanical cooling.

**EXCEPTION to Section 120.2(e)2B:**Thermostat setup controls are not required in nonresidential buildings in areas where the Summer Design Dry Bulb 0.5 percent temperature determined in accordance with Section 140.4(b)4 is less than 100°F.

**Federal Standards:** These measures do not fall under Federal DOE or EPA Energy 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 set points during unoccupied hours. There are no requirements to actually shut down systems during unoccupied hours, or to make any specific unoccupied temperature set point adjustments.

# 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

There are no M&V or other studies which apply to these measures. Information on the base and measure case is found in the sub-sections of 1.4.

## 

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Additionally, if a measure is assigned a DEER load shape the TOU assigned to that measure is zero.

Table 8 TOU Adjustment Factors

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure** | ***kWAC*** | ***kWTotal*** | **%** |
| Programmable Thermostat | 0 | 0 | 0 |

# Section 2. Calculation Methods

## 2.1 Assumptions and Calculations from other sources—Base and Measure Cases

eQUEST models were developed to estimate the energy savings for this measure. The prototypes were developed to run eQUEST version 3.64, which is an interface to the DOE 2.2 energy model program. This version of eQUEST was used instead of the latest 3.65 version, in order to use the Rocky Mountain Institute’s Model Manager spreadsheet-based software to make batch runs for the different iterations of building types, building vintages and weather files. The building types and vintages covered in this workpaper are listed in the tables below.

Table 9 Building Types and Vintages

|  |  |  |
| --- | --- | --- |
| **Building Types** |  | **Building Vintages** |
| Asm – Assembly |  | Pre-1978 |
| EPr – Education Primary |  | 1978-1992 |
| ESe – Education Secondary |  | 1993-2001 |
| Htl – Hotel |  | 2002-2005 |
| Mtl – Motel |  |  |
| RtS – Small Retail |  |  |

The types of buildings analyzed were chosen because they are: 1) prevalent building types covered under this program, 2) likely to use single-zone HVAC units with non-centralized thermostatic control, and 3) likely to be occupied during peak period hours. Only buildings constructed through 2005 were analyzed, in order to assess effects on the buildings most in need of and most likely to upgrade their HVAC systems.

The eQUEST models for each building type were based on building prototype specifications as defined by the *2004-05 Update of the Database for Energy Efficiency Resources (DEER)**[[6]](#endnote-6)*, developed by the California Energy Commission. DEER specifies the details of each prototype’s geometry, construction, HVAC systems, internal loads, occupancy, and operation. Differences between different building vintages are reflected by changes in roof and wall insulation, windows, lighting power density, equipment power density, HVAC system efficiency, and HVAC operating settings. Subsequent updates to DEER from 2008, 2011, and 2014 were also checked, and any pertinent changes to our prototypes were incorporated.

The latest 2014 version 2 weather files developed by the California Energy Commission were used to represent typical meteorological year (TMY) weather in California’s climate zones[[7]](#endnote-7). The weather files used for each climate zone are listed in the table below.

Table 10 Weather Files per Climate Zone

|  |  |  |
| --- | --- | --- |
| **Climate Zone** | **Annual Savings  Weather File** | **Weather Station** |
| 7 | CZ07RV2.BIN | Lindbergh Field Airport |
| 10 | CZ10RV2.BIN | March Air Force Base |
| 14 | CZ14RV2.BIN | Palmdale Airport |
| 15 | CZ15RV2.BIN | El Centro Naval Air Facility |

**Hours of Operation**:

* The hours of operation are based on the DEER prototype specifications9 for each building type.
* Hours represent the fan operation only. Proposed hours are weighted based on vintage.

Table 11 Hours of Operation by Climate Zone and Building Type

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type** | **Building Vintage** | **Climate Zone** | **Baseline Hours of Operation (hrs/yr)** | **Proposed Hours of Operation (hrs/yr)** | **Reference** |
| Asm – Assembly | EX | 7,10,14,15 | 8,760 | 4,296 | DEER |
| EPr – Education Primary | EX | 7,10,14,15 | 8,760 | 1,496 | DEER |
| ESe – Education Secondary | EX | 7,10,14,15 | 8,760 | TBD | DEER |
| Htl – Hotel | EX | 7,10,14,15 | 8,760 | TBD | DEER |
| Mtl – Motel | EX | 7,10,14,15 | 8,760 | TBD | DEER |
| RtS – Small Retail | EX | 7,10,14,15 | 8,760 | 3,938 | DEER |

## 1.5 Summary of Inputs for Savings Calculations

The following sections provide the inputs for calculation.

Table 12 Inputs for Savings Calculations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Measure Case Average Value** |
| **Electric Usage (kWh)** | CZ, BT | 560,205 | N/A | 486,503 |
| **Gas Usage (Therms)** | CZ, BT | 20,685 | N/A | 5,046 |
| **Hours of operation** | CZ, BT | 8,760 | N/A | 3,243 |
| **Full Cost** | CZ | $0.00 | N/A | $242.19 |
| **Incremental Cost** | CZ | N/A | N/A | $242.19 |
| **EUL /RUL** | None | HV-ProgTstat | HV-ProgTstat | HV-ProgTstat |
| **NTG** | None | Com-Default>2yrs | Com-Default>2yrs | Com-Default>2yrs |
| **ISR** | None | 1 | 1 | 1 |

Notes:

* For REA, baseline is based on the existing equipment; there is no second baseline.

**DM-XX – Programmable Communicating Thermostats**

Qualifying thermostats must replace existing, non-setback, non-programmable, mechanical type thermostats. Replacement of existing programmable thermostats or EMS control system replacements are not allowed. We have created energy models to estimate the savings for this measure.

## 2.1 Electric Energy Savings Estimation Methodologies

The DEER 2014 database does not contain an updated measure for catalog measure DM-XX. The closest DEER measures are outdated and not eligible to be used in incentive calculations. Therefore, energy models were developed to estimate energy savings.  
  
Energy savings from installing PCTs was estimated by assuming that PCTs setback the HVAC systems during unoccupied periods. The building occupied hours were defined in the DEER prototypes. It was assumed that the system fans would turn off one hour after occupied hours were over, and turn back on one hour before occupied hours began. During unoccupied periods, the thermostats were estimated to be setback to the following schedule:

Table 13 Thermostat Setback Schedule

|  |  |
| --- | --- |
| **Unoccupied Setpoints** | |
| Heating | 55⁰F |
| Cooling | 85⁰F |

The savings for this measure result from scheduling the PCTs to setback the heating and cooling setpoints during unoccupied periods.

Energy savings for each building type is comprised of the weighted average energy savings from each building vintage. Energy savings from each building vintage was averaged using DEER 2013-14 population weights[[8]](#endnote-8) to get the energy savings for each building type.

Based on the CPUC Workpaper Disposition for Non-Residential HVAC Rooftop Quality Maintenance4, the CPUC has found the previous savings estimates for this measure to be overly optimistic. The disposition noted that, among other things, this measure does not account for overriding time clock operation, or for facilities that require continuous space conditioning. Therefore, a gross savings adjustment (GSA) multiplier of 25% must be applied to the energy savings for this measure, to account for non-ideal installations.

The energy use is normalized to kWh per 1,000 square feet (kFP) by dividing by the square footage of each building.

**∆kWh per Area-1kFP for DM-XX:**

The electricity savings (kWh per Area-1kFP) for measure DM-XX is calculated from energy modeling results. The modeling results provide energy savings for four building vintages (1975-2003) for each building type in each climate zone. The energy savings for each building type in each climate zone was estimated by taking the weighted average savings from each building vintage as shown in the formula below:

Where,

WESBT = weighted energy savings per building type, kWh

BEUBV = baseline energy usage per building vintage, kWh

PEUBV = proposed energy usage per building vintage, kWh

WFBV = weighting factor per building vintage10, no units

The weighted energy savings for each climate zone is then normalized to the square footage of each building type as shown in the formula below:

Where,

NESBT = normalized energy savings, kWh / Area-1kFP

ABT = area of the building, sq ft

C = per 1000 sq ft, 1000, no units

Savings from the modeling results were multiplied by a factor of 25% as shown in the formula below:

Where,

ESBT = energy savings, kWh / Area-1kFP

GSA = gross savings adjustment, 0.25, no units

**Example for DM-XX – Primary School CZ07:**

A table showing the energy savings and weighting factors for primary schools is shown in the table below:

Table 14 Energy Savings and Weighting Factors for Primary Schools

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **Baseline Energy Usage (kWh)** | **Proposed Energy Usage (kWh)** | **Weighting Factors** |
| 1975 | 405,450 | 273,918 | 0.5808 |
| 1985 | 316,864 | 209,993 | 0.1507 |
| 1996 | 176,787 | 105,924 | 0.1550 |
| 2003 | 149,092 | 86,367 | 0.1135 |

Therefore the weighted energy savings for primary school (EPr) in climate zone 7 (CZ07) is:

The normalized energy savings for primary schools (EPr) in climate zone 7 (CZ07) is:

The energy savings for primary schools (EPr) in climate zone 7 (CZ07) is:

## 2.2. Demand Reduction Estimation Methodologies

The DEER 2014 database does not contain an updated measure for catalog measure DM-XX. The closest DEER measures are outdated and not eligible to be used in incentive calculations. Therefore, energy models were developed to estimate demand reduction.  
  
Demand reduction from installing PCTs was estimated by assuming that PCTs setback the HVAC systems during unoccupied periods. The building occupied hours were defined in the DEER prototypes. It was assumed that the system fans would turn off one hour after occupied hours were over, and turn back on one hour before occupied hours began. During unoccupied periods, the thermostats were estimated to be setback to the following schedule:

Table 15 Thermostat Setback Schedule

|  |  |
| --- | --- |
| **Unoccupied Setpoints** | |
| Heating | 55⁰F |
| Cooling | 85⁰F |

The savings for this measure result from scheduling the PCTs to setback the heating and cooling setpoints during unoccupied periods.

Demand reduction for each building type is comprised of the weighted average demand reduction from each building vintage. Demand reduction from each building vintage was averaged using DEER 2013-14 population weights10 to get the demand reduction for each building type.

Based on the CPUC Workpaper Disposition for Non-Residential HVAC Rooftop Quality Maintenance4, the CPUC has found the previous savings estimates for this measure to be overly optimistic. The disposition noted that, among other things, this measure does not account for overriding time clock operation, or for facilities that require continuous space conditioning. Therefore, a gross savings adjustment (GSA) multiplier of 25% must be applied to the demand reduction for this measure, to account for non-ideal installations.

The demand is normalized to kW per 1,000 square feet (kFP) by dividing by the square footage of each building.

**∆kW per Area-1kFP for DM-XX:**

The demand reduction (kW per Area-1kFP) for measure DM-XX is calculated from energy modeling results. The modeling results provide demand reduction for four building vintages (1975-2003) for each building type in each climate zone. The demand for each building type in each climate zone was estimated by taking the weighted demand reduction from each building vintage as shown in the formula below:

Where,

WDRBT = weighted demand reduction per building type, kW

BDBV = baseline demand per building vintage, kW

PDBV = proposed demand per building vintage, kW

WFBV = weighting factor per building vintage10, no units

The weighted demand reduction for each climate zone is then normalized to the square footage of each building type as shown in the formula below:

Where,

NDRBT = normalized demand reduction, kW / Area-1kFP

ABT = area of the building, sq ft

C = per 1000 sq ft, 1000, no units

Demand reduction from the modeling results were multiplied by a factor of 25% as shown in the formula below:

Where,

DRBT = demand reduction, kWh / Area-1kFP

GSA = gross savings adjustment, 0.25, no units

**Example for DM-XX – Primary School CZ07:**

A table showing the demand reduction and weighting factors for primary schools is shown in the table below:

Table 16 Demand Reduction and Weighting for Primary Schools

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **Baseline Demand (kW)** | **Proposed Demand (kW)** | **Weighting Factors** |
| 1975 | 2,109 | 2,121 | 0.5808 |
| 1985 | 1,707 | 1,725 | 0.1507 |
| 1996 | 992 | 994 | 0.1550 |
| 2003 | 840 | 835 | 0.1135 |

Therefore the weighted demand reduction for primary school (EPr) in climate zone 7 (CZ07) is:

The normalized demand reduction for primary schools (EPr) in climate zone 7 (CZ07) is:

The demand reduction for primary schools (EPr) in climate zone 7 (CZ07) is:

## 2.3. Gas Energy Savings Estimation Methodologies

The DEER 2014 database does not contain an updated measure for catalog measure DM-XX. The closest DEER measures are outdated and not eligible to be used in incentive calculations. Therefore, energy models were developed to estimate gas savings.  
  
Gas savings from installing PCTs was estimated by assuming that PCTs setback the HVAC systems during unoccupied periods. The building occupied hours were defined in the DEER prototypes. It was assumed that the system fans would turn off one hour after occupied hours were over, and turn back on one hour before occupied hours began. During unoccupied periods, the thermostats were estimated to be setback to the following schedule:

Table 17 Thermostat Setback Schedule

|  |  |
| --- | --- |
| **Unoccupied Setpoints** | |
| Heating | 55⁰F |
| Cooling | 85⁰F |

The savings for this measure result from scheduling the PCTs to setback the heating and cooling setpoints during unoccupied periods.

Gas savings for each building type is comprised of the weighted average gas savings from each building vintage. Gas savings from each building vintage was averaged using DEER 2013-14 population weights10 to get the gas savings for each building type.

Based on the CPUC Workpaper Disposition for Non-Residential HVAC Rooftop Quality Maintenance4, the CPUC has found the previous savings estimates for this measure to be overly optimistic. The disposition noted that, among other things, this measure does not account for overriding time clock operation, or for facilities that require continuous space conditioning. Therefore, a gross savings adjustment (GSA) multiplier of 25% must be applied to the energy savings for this measure, to account for non-ideal installations.

The energy use is normalized to therms per 1,000 square feet (kFP) by dividing by the square footage of each building.

**∆Therms per Area-1kFP for DM-XX:**

The gas savings (therms per Area-1kFP) for measure DM-XX is calculated from energy modeling results. The modeling results provide gas savings for four building vintages (1975-2003) for each building type in each climate zone. The gas savings for each building type in each climate zone was estimated by taking the weighted average savings from each building vintage as shown in the formula below:

Where,

WGSBT = weighted gas savings per building type, therms

BGUBV = baseline gas usage per building vintage, therms

PGUBV = proposed gas usage per building vintage, therms

WFBV = weighting factor per building vintage10, no units

The weighted gas savings for each climate zone is then normalized to the square footage of each building type as shown in the formula below:

Where,

NGSBT = normalized gas savings, therms/ Area-1kFP

ABT = area of the building, sq ft

C = per 1000 sq ft, 1000, no units

Savings from the modeling results were multiplied by a factor of 25% as shown in the formula below:

Where,

GSBT = gas savings, kWh / Area-1kFP

GSA = gross savings adjustment, 0.25, no units

**Example for DM-XX – Primary School CZ07:**

A table showing the energy savings and weighting factors for primary schools is shown in the table below:

Table 18 Energy Savings and Weighting Factors for Primary Schools

|  |  |  |  |
| --- | --- | --- | --- |
| **Vintage** | **Baseline Gas Usage (therms)** | **Proposed Gas Usage (therms)** | **Weighting Factors** |
| 1975 | 11,048 | 1,197 | 0.5808 |
| 1985 | 11,286 | 1,194 | 0.1507 |
| 1996 | 13,550 | 1,655 | 0.1550 |
| 2003 | 14,063 | 1,796 | 0.1135 |

The weighted gas savings for primary school (EPr) in climate zone 7 (CZ07) is:

The normalized gas savings for primary schools (EPr) in climate zone 7 (CZ07) is:

The gas savings for primary schools (EPr) in climate zone 7 (CZ07) is:

## 

## 2.4. Demand Response Load Drop Evaluation

Demand response load drop is evaluated Ex-Post, by site. Therefore, estimated savings are not included in this workpaper. The load drop from demand response events is evaluated in the following manner:

* The utilities calculate preliminary ex-post results for all demand response programs within 7-days after an event using the hourly Smart Meter data of participants.
* Preliminary ex-post results are reported to the CAISO and CPUC. These are often used to pay customers and aggregators.
* The preliminary ex-post results inform the SDG&E daily demand response forecasts.

Each demand response program is evaluated every year by a third party consultant on an ex-post basis. Each evaluation also includes a 10-year ex-ante forecast. The ex-post results and ex-ante forecasts are filed with the CPUC on April 1st each year. The ex-ante forecasts filed April 1st are used in all resource planning proceedings that require a demand response forecast for the year.

At a high level demand response ex-post results are calculated by comparing the energy use of customers on the event day to their energy use on similar days. Any conservation due to energy efficiency will lower energy use on both the similar days and the event days. The estimated demand response results represent the incremental effect of the demand response event above and beyond any conservation from the energy efficiency program. Therefore there is no double counting of the energy efficiency results in the DR calculation.

# Section 3. Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is a load shape that ideally represents the difference between the base equipment and the installed energy efficiency measure. This difference load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations. 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.

## 

## 3.1 Base Case Load Shapes

The closest load shape chosen for this measure is the *DEER: HVAC\_Split-Package\_HP* load shape. See Table 5 for a list of all Building Types and Load Shapes.

Table 18 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Asm | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| EPr | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| ESe | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| ECC | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| ERC | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| Gro | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| MBT | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| MLI | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| OfS | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| RSD | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| RFF | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| RtL | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| RtS | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |
| SCn | NON\_RES | *DEER: HVAC\_Split-Package\_HP* |

## 3.2 Measure Load Shapes

There are no measure case load shapes applicable to this measure. The base case shape is to be used in the cost avoidance calculation.

# Section 4. Base Case & Measure Costs

## 4.1 Base Case(s) Costs

The following Measure Application Types are appropriate to these measures. The Base Case Costs are based on leaving the existing thermostat in place, at no cost:

Table 19 Base Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Application Type** | **Baseline** | **Average Equipment Cost** | **Average Labor / Installation Cost** | **Maintenance / Other Cost** | **Average Total Base Case Cost** |
| DM-XX | REA | Existing Thermostats | $0.00 | $0.00 | $ N/A | $0.00 |

*All costs are noted as $ per unit*

There are no base case costs since the base case is the customer’s existing equipment.

## 4.2 Measure Case Costs

The following Measure Application Types are appropriate to these measures. The Measure Case Costs are based on installing a new PCT:

Table 20 Measure Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Application Type** | **Baseline** | **Average Equipment Cost** | **Average Labor / Installation Cost** | **Maintenance / Other Cost** | **Average Total Measure Case Cost** |
| DM-XX | REA | Existing Thermostats | $180.00 | $62.94 | $ N/A | $242.94 |

*All costs are noted as $ per unit*

Material cost for the measure case was provided by SDG&E based on their cost for EcoBee model PCTs. Labor costs are taken directly from DEER and multiplied by a climate multiplier to account for cost variation in each climate zone. Costs can be found in Appendix B2.

## 4.3 Incremental & Full Measure Costs

## 4.3.1 Gross Measure Costs

Gross Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type.

This Measure Application Types is: **REA,** so the Gross Measure Cost (GMC) is represented by the equation below:

**GMC** = Measure Equipment Cost + Measure Labor Cost

**Example:**

GMC = $180.00 + 62.92/unit = $ 242.92/unit

## 

**Base Case Costs and Measure Case Costs:**

* Costs of a PCT are based on manufacturer information gathered by SDG&E.
* Labor costs are based on the 2008 DEER Cost data2.
* The base case cost of equipment is assumed to be zero, or the cost of not replacing the existing thermostat.
* Material and labor costs were adjusted for each climate zone using the climate multipliers for each climate zone.

Table 21 Incremental and Full Measure Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Base Case** | **Measure Case** | **IMC** |
| EPr | Ex | CZ07 | $0.00 | $241.85 | $241.85 |
| EPr | Ex | CZ10 | $0.00 | $242.98 | $242.98 |
| EPr | Ex | CZ14 | $0.00 | $241.34 | $241.34 |
| EPr | Ex | CZ15 | $0.00 | $242.59 | $242.59 |

## 4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straightforward definition depending on the Measure Application type, the equation does vary.

This Measure Application Types is: **REA,** so the Incremental Measure Cost (IMC) is represented by the appropriate equation below:

**IMC** = Measure Equipment Cost + Measure Labor Cost

**Example:**

IMC = $80.00 + 62.92/unit = $ 242.92/unit

Table 22 Incremental and Full Measure Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Average Base Case Total Cost** | **Average Measure Case Total Cost** | **Average Gross Measure Case Cost** | **Average Incremental Measure Cost** |
| DM-XX | REA | $0.00 | $242.94 | $242.94 | $242.94 |

*All costs are noted as $ per unit*

# References

1. Appendix A – Energy and Cost Savings SDGE DM-XX [↑](#endnote-ref-1)
2. Appendix B – DEER Cost Data 2008 [↑](#endnote-ref-2)
3. Appendix C – EUL and RUL Data from DEER2014 [↑](#endnote-ref-3)
4. Appendix D – SDG&E Pre-Inspection Form [↑](#endnote-ref-4)
5. Appendix E – CPUC Non-Res HVAC Disposition [↑](#endnote-ref-5)
6. Appendix I – 2004-05 DEER Prototype Inputs [↑](#endnote-ref-6)
7. California Weather Files for 16 Climate Zones <http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data3.cfm/region=4_north_and_central_america_wmo_region_4/country=2_california_climate_zones/cname=California%20Climate%20Zones>  
    [↑](#endnote-ref-7)
8. Appendix J – DEER Population Weights

   **Table 4 - Baseline by Measure Application Type**

   |  |  |  |  |
   | --- | --- | --- | --- |
   | **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
   | ***ER* (early retirement)** | **RUL/EUL-RUL** | Customer Average Baseline | Code Baseline |
   | ***ROB* (Replace on Burnout)** | **EUL** | Code Baseline | N/A |
   | ***NR* (Normal Replacement** | **EUL** | Code Baseline | N/A |
   | **REA (Retrofit Add-On)** | **EUL** | Existing Baseline | Code Baseline |
   | ***NC* (New Construction)** | **EUL** | Code Baseline | N/A |

   |  |  |  |  |
   | --- | --- | --- | --- |
   | **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
   | ***ER* (early retirement)** | RUL/  EUL-RUL | Calculated as Full Gross Measure Cost | Measure Equipment Cost  – Base Case Equipment Cost |
   | ***ROB* (Replace on Burnout)** | EUL | Calculated as Incremental Measure Cost | N/A |
   | ***NR* (Normal Replacement** | EUL | Calculated as Incremental Measure Cost | N/A |
   | **REA (Retrofit Add-On)** | EUL | Calculated as Full Gross Measure Cost | N/A |
   | ***NC* (New Construction)** | EUL | Calculated as Incremental Measure Cost | N/A |

   |  |  |  |  |
   | --- | --- | --- | --- |
   | **Measure Application Type** | **Gross Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
   | ***ER* (early retirement)** | Measure Equipment Cost  +Measure Labor Cost | (-1)x(Base Equipment Cost  + Base Labor Cost) | Measure Equipment Cost  – Base Case Equipment Cost |
   | ***ROB* (Replace on Burnout)** | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
   | ***NR* (Normal Replacement** | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
   | **REA (Retrofit Add-On)** | Measure Equipment Cost  +Measure Labor Cost | N/A | Measure Equipment Cost  +Measure Labor Cost |
   | ***NC* (New Construction)** | Measure Equipment Cost | N/A | Measure Equipment Cost |

   [↑](#endnote-ref-8)