**Work Paper WPSDGERECS0001**

**Revision 1**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Multifamily DHW RCx, Training, and Boiler Reset Controller**

**At-a-Glance Summary**

|  |  |
| --- | --- |
| Applicable Measure Codes: | N/A |
| **Measure Description:** | Central domestic hot water system controls and training |
| **Base Case Description:** | Central domestic hot water system with no controls |
| **Energy Impact Common Units:** | Dwelling Unit |
| **Energy Savings:** | Refer to Ex-Ante Database |
| **Gross Measure Cost ($/unit)** | Refer to Ex-Ante Database |
| **Measure Incremental Cost ($/unit):** | Refer to Ex-Ante Database |
| **Effective Useful Life (ID):** | WtrHt-HtPmp |
| **Measure Application Type:** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratios (ID):** | Res-Default>2 |
| **Important Comments:** |  |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 06/15/2012  06/22/2012 | Kelvin Valenzuela / SDGE  Peter Ford / SDGE | Adopted from SCGWP100315A – MF DHW RCx, Train-ing, and Reset Controller.doc, dated. March 22, 2010.  Revised NTG per DEER 2011 |
| 1 | 06/26/2014  08/21/2014 | Judelson Enriquez / RMS Energy Consulting, LLC | 1. Updated to new workpaper format and adopted SCG’s “SCGWP100315A\_Rev1\_MF CDHW Temp Reset Control\_cp20150527.docx” workpaper, dated May 22, 2014. Also, new savings calculation and values adopted. 2. Updated measure description, code summary for T24. 3. Revised EUL ID and value. 4. Generated calculation spreadsheet based on IOU statewide Calculation Template output.   - Updated to latest WP template.  - Referenced Ex-Ante Database wherever possible  - Added Section 2.5 READi Technology Fields |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

### 1.1a Measure Description

Through its Residential Retrofit Rebate Program, the Investor Owned Utilities (IOUs) of the State of California provides incentives to install additional controls on existing central domestic hot water (CDHW) systems that implements a temperature modulation protocol based off a real-time data stream or historical trending. Temperature modulation devices lower the temperature at times when hot water demand is expected to be low. A combined temperature modulation with monitoring control can automatically adjust control schedules based on measured hot water draw patterns. This modulation of supply temperature will reduce the demand on the water heating equipment and result in natural gas savings by reducing the energy lost due to mass output and pipe losses. This measure also looks to through this incentive provide training to the installers and its own inspectors to ensure the variety of hot-water systems are individually addressed to ensure each system is brought to proper working condition prior to installation of the controller.

Table 1 Measure Summary Table

|  |  |  |
| --- | --- | --- |
| Product Code | Measure name | Unit Definition |
| N/A | SDG&E - Multifamily DHW RCx, Training, and Boiler Reset Controller | Dwelling Unit |

1. Background

Central domestic hot water (CDHW) systems are common in multifamily (MF) buildings because they allow the tenants to receive hot water with minimal delays after they turn on the tap. The Multi Family Energy Efficiency Retrofit (MFEER) Program is a statewide program that targets property owners and managers of multifamily residential dwellings, homeowner’s associations and mobile home park associations. The program encourages property owners and managers to install qualifying energy efficiency products in common areas for residential apartments, mobile home parks and condominium complexes.

1. Baseline Condition and Associated Inefficiencies

The Baseline CDHW system continuously maintains a supply temperature of 135F. This is sufficient to meet the demand requirements at design conditions, but this temperature is excessive for every other time.

* 1. With 135F water running through the recirculation loop, the heat loss through the piping is considered to be at a maximum.
  2. Additionally, every water unit output from the system will result in the maximum amount of energy lost (through mass removal). Therefore any appliances that use hot water will consume the maximum amount of hot water heating energy with the Baseline CDHW system.

### 1.1b Delivery and Incentive Mechanism

The delivery method for the measure(s) in this workpaper is:

* Financial Support / Down-Stream Incentive - Deemed

The measure install type is:

* Retrofit Add-On (REA)

Therefore no existing demand based temperature controls are anticipated for the baseline.

### 1.1c Measure Requirements

1. Terms & Conditions

Only hot-water generation with recirculation systems used primarily for domestic hot-water heating uses qualify. The hot-water generator must be fueled by Natural Gas provided by the IOU offering this program. The incentive applies only to gas equipment affected by the installation of this controller (i.e., neither new construction nor fuel switching applications are eligible). Hot-water generation systems used for pools or spas do not qualify. The controller manufacture’s name, equipment model number, input capacity of the hot-water generator, the output capacity or thermal efficiency rating of the hot-water generator, and year the multifamily unit complex was built must be provided. If requested by the Utility, customers must provide proof of purchase to the Utility.

1. Market Applicability

These measures are applicable to multifamily properties only. The CDHW system must utilize a recirculation loop to be eligible for incentives.

## 1.2 DEER Differences Analysis

These specific measure energy saving results and calculation method are not included in the DEER 2014.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | DEER does not contain these measures. |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | N/A |

## 1.3 Code Analysis

The 2014 California Title 20 Appliance Efficiency Regulations [[[1]](#endnote-1)] include standards for both federally regulated appliances and nonfederally-regulated appliances that are sold or offered for sale in California; however, Title 20 does not govern the measure in this workpaper.

The 2013 California Title 24 Building Energy Efficiency Standards [[[2]](#endnote-2)] include standards to improve the energy efficiency of newly constructed building and additions and alterations to existing buildings for residential and nonresidential buildings. Section 110.3 mandates requirements for controls for hot water distribution systems and states “Service hot water systems with circulating pumps or with electrical heat trace systems shall be capable of automatically turning off the system.”

Federal DOE or EPA Energy Regulations do not govern the measures found in this workpaper.

Table 3 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 20 (2014) | N/A | N/A |
| Title 24 (2013) | 2013 Non-Residential Compliance Manual, Section 110.3 | July 1, 2014 |
| Federal Standards | N/A | N/A |

## 1.4 Measure Effective Useful Life

## Refer to the Ex-Ante Database for the NTG values.

Table 4 DEER EUL Value/Methodology

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| EUL ID | Market | Enduse | Measure | Sector |
| WtrHt-HtPmp | Residential | SHW | Heat Pump Water Heater | Res |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

Refer to the Ex-Ante Database for the NTG values.

Table 5 Net-to-Gross Ratio Summary Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NTGR\_ID | Description | Sector | BldgType | ProgDelivID |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | All |

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is zero. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with “DEER:” the TOU assigned to that measure should also be zero.

Table 6 TOU Summary Table

|  |  |
| --- | --- |
| Measure | % |
| Multifamily DHW RCx, Training, and Boiler Reset Controller | 0 |

# Section 2. Energy Savings & Demand Reduction Calculations

## 2.1 Electric Energy Savings Estimation Methodologies

## There are no electric energy savings associated with this measure.

## 2.2 Demand Reduction Estimation Methodologies

## There are no anticipated demand reductions associated with this measure.

## 2.3 Gas Energy Savings Estimation Methodologies

The goal of this analysis was to determine the annual gas savings (therms) of installing temperature modulation control on a CDHW system serving a multifamily building.

* + 1. Methodology

1. The initial step is to establish a simulation with as many similarities to the DEER database simulations as possible. This was done by referencing the prototypes published in 2005 [[[3]](#endnote-3)] and the initial eQuest default values. Below is a brief list of some of the key variables assumed in this manner:
   1. eQuest Default Occupancy, Lighting, Ventilation, Miscellaneous Load Schedules
      1. The most up-to-date eQuest schedules were chosen over the DEER 2005 schedules because the values found in 2005 analysis were relatively extreme and non-continuous compared to the newer schedules within the eQuest software.
   2. Design Domestic Hot Water Flow (GPM) is approximately 1.90GPM. This is a product from the eQuest and the relationship can be referenced in the equation below.
      * Daily Gal. / Person / Day = 20
      * Number of People = 36
      * Number of Active Hours / Day = 6.329
2. To further the accuracy of the simulation a few details were added to ensure that the measure was being applied to realistic conditions:
   1. The domestic hot water loop within the DEER Multi-Family model was altered to have 50% recirculation. This value was referenced within the DEER DHW Properties document under “Motels” [[[4]](#endnote-4)].
   2. A conservative estimated of the total heat loss through the piping (5F).
3. The measure variable that will be altered to quantify the energy savings is the Heating Schedule, which is a constant temperature of 135F for the baseline.
4. All other specific details can be referenced in the attached calculation support documents [[[5]](#endnote-5),[[6]](#endnote-6)].
   * 1. Calibration

With these variables in place, the baseline simulation was compared with the Residential Appliance Saturation (RASS) study. The table below shows the comparison between the two sources:

Table 7 Comparison between the RASS Study and the Baseline of the eQuest Simulation



Considering the statistical variance of the data collected by the RASS Study, the estimated error of 18% is deemed reasonable [[[7]](#endnote-7)].

* + 1. Measure

1. With a calibrated simulation, the demand based hot water temperature schedules were input into the simulation to emulate a demand based temperature controller.
2. The schedule was developed by referencing the eQuest default fractional load profiles on the domestic hot water circulation loops. It was assumed that a load factor of just above 0% would have a setpoint of 110F and a load factor of 67% would have a setpoint of 135F. Any load factor between the two reference points would simply be interpolated.

Table 8 Logic of the Simulated Demand Based Control Strategy

|  |  |
| --- | --- |
| **Load Factor** | **Set Point (F)** |
| 0% | 110F |
| 0-67% | Interpolated |
| 67%+ | 135F |

Below is a table detailing the demand based curves for the simulation used in this analysis.

Table 9 Proposed Temperature Modulation and Continuous Monitoring Controller Schedule



* + 1. Results

1. With this control strategy implemented the recirculation loop will require less heating in low usage periods due to the lower setpoint. The results are tabulated in the table below:

Table 10 Simulation Results



1. For further details it is recommended to reference the eQuest simulation and corresponding engineering spreadsheets [G,H].

## 2.4 Installation Rate

The installation rate (IR) is identified in the ex-ante database. For all the savings discussed above, there is an installation rate applied to values associated with the installation GSIA ID in Table 11. The GSIA ID is identified in the ex-ante implementation tables for all programs and measures. The installation rate (IR) is applied to the gross savings calculations using the values associated with the IDs below.

Table 11 Gross Savings Installation Adjustment (GSIA) IDs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID | Description | Sector | BldgType | UseCategory | TechType |
| Def-GSIA | Default GSIA | Any | Any | Any | Any |

## 2.5 READi Technology Fields

To support the development of the ED ex-ante tables, select fields from the ex-ante database will be identified in the work paper. For a full set of values associated with the measures in the work paper refer the Excel calculation template.

Table 12 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this work paper |
| Measure Case UseCategory | SHW |
| Measure Case UseSubCats | Heating |
| Measure Case TechGroups | LiquidCirc |
| Measure Case TechTypes | TempReset |
| Base Case TechGroups | LiquidCirc |
| Base Case TechTypes | TempReset |

# Section 3. Load Shapes

1. 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, for the sake of the E3 measure calculation, the closest load shape was chosen for this measure. See Table 13 for a list of all Building Types and Load Shapes. See the KEMA report for a more thorough discussion regarding the load shapes for this measure.

Table 13 Building Types and Load Shapes

|  |  |
| --- | --- |
| Building Type | Load Shape |
| Residential Multi-family | 19-RES-AllResidential-WAT\_HEAT |

1. Load Shapes for Calculation
   1. To account for the unique Domestic Hot Water usage that can occur in multifamily units, the following default schedules were used in the eQuest simulation [H]. These schedules were developed in two parts by the software developers of eQuest. The first portion is the design criteria where the maximum daily average consumption is calculated. The second portion is the fractional profile, which provides the variability throughout the day. The product of these two variables is the chart below.



Figure 1 DHW Demand for Weekdays, Saturdays and Sundays for Multifamily Buildings [[[8]](#endnote-8)]

* 1. In Figure 2 and 3 the daily operating conditions can be referenced for both control strategies.



Figure 2 Operating Conditions of the Baseline Controls System

* 1. Figure 2 above presents the hot water supply temperature (135°F), mixed water temperature -variable- (from the addition of makeup cold water to the return hot water in the recirculating loop), and including hot water draw schedule and hot water recirculation flow (both in gpm).



Figure 3 Operating Conditions of CDHW Temperature Modulation and Monitoring Controller

* 1. Temperature modulation control in Figure 3 was assumed to reduce the supply temperature by 22°F (135-113°F) from 1 am to 5 am in the morning, and reaching maximum setpoint temperature of 135°F during peak hot water demand at 8am and 5pm before it drops again at the night hours. A continuous monitoring system monitors different operation parameters of the DHW system and automatically provides system operation status and malfunction updates to system operators.
  2. All other load shapes associated with this analysis are defaulted within the eQuest simulation software and can be referenced within the attached simulation files directly. Below is a brief list of load shapes that fit into this category:
     1. Occupancy Fraction Profile
     2. Lighting Fraction Profile
     3. Task Lighting Fraction Profile
     4. Miscellaneous Load Fraction Profile
     5. …etc.

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

This measure is a retrofit measure and as such, the base case condition is to do nothing. Therefore the base case cost is $0.

## 4.2 Gross Measure Cost

The gross measure costs associated with this measure include the material and labor associated with the installation of the controller, sensors, utility hookup, equipment interfacing, adjustments needed to bring the system up to proper operating condition, and commissioning of the system upon completion of the installation. Based on SCG’s historical records associated with the Reset Controller measure the material and labor costs amounted to $1,400 per controller unit (or $1,400 / 35 dwelling units = $40 per dwelling unit). No cost information is available to account for additional cost to the customer associated with the RCx effort. It is anticipated these costs will be minor and will be absorbed into the labor costs already allocated to the installation of the controller.

Table 14 Gross Measure Cost Summary

|  |  |
| --- | --- |
| **Measure Description** | **Gross Measure Cost ($/dwelling unit)** |
| SDG&E - Multifamily DHW RCx, Training, and Boiler Reset Controller | $40 |

## 4.3 Incremental Measure Cost

The incremental measure costs associated with this measure are the same listed under Article 3.02 “Gross Measure Cost.” For reference the IMC is $40 per dwelling unit.

# Attachments

1. 

1. 
2. 
3. eQUEST Simulation file attached as a separate file. “DHWT Reset Controller eQUEST Simulation 1.1.zip”
4. Residential Appliance Saturation Study (RASS) attached as a separate file. “2009\_RASS\_Volume 2\_FINAL\_101310.pdf”

# References

1. [] The 2014 Appliance Efficiency Regulations – Title 20: http://www.energy.ca.gov/2014publications/CEC-400-2014-009/CEC-400-2014-009-CMF.pdf [↑](#endnote-ref-1)
2. [] The 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings – Title 24, Part 6: http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf [↑](#endnote-ref-2)
3. [] Attachment #1 - DEER 2005 Multifamily Prototype Model [↑](#endnote-ref-3)
4. [] Attachment #2 - DEER 2005 DHW Properties [↑](#endnote-ref-4)
5. [] Attachment #3- Calculation Support Documentation: Simulation Results and Summary. [↑](#endnote-ref-5)
6. [] Attachment #4 - Calculation Support Documentation: eQUEST Simulation files (zipped). Attached as a separate file. [↑](#endnote-ref-6)
7. [] Attachment #5 - Residential Appliance Saturation Study (RASS) [↑](#endnote-ref-7)
8. [] eQuest 3-64, <http://www.doe2.com/> [↑](#endnote-ref-8)