**Work Paper PGECODHW115**

**Boiler Controller**

**Revision #4**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Boiler Controller**

**Measure Codes: HA10, HA13**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes**** | HA10, HA13 |
| **Measure Description** | This workpaper for qualifying multifamily and lodging facilities in the PG&E gas service area covers the retrofit of a new “temperature modulation” boiler controller in the central water heating system for minimizing the supply & return water temperatures and piping heat losses. Some multifamily or lodging facilities may require more than one boiler controller. The total gas savings and total rebate amounts are based on the number of multifamily dwelling units or lodging guest rooms controlled by the new boiler controller or controllers. |
| **Energy Impact Common Units** | therms |
| **Base Case Description** | The “no control” base case is the existing water heating system without “temperature modulation” boiler control. |
| **Base Case Energy Consumption** | 186 therms/multifamily dwelling unit/yr  116 therms/lodging guest room/yr |
| **Measure Energy Consumption** | 184.0 therms/multifamily dwelling unit/yr for HA10  114.8 therms/lodging guest room/yr for HA13 |
| **Energy Savings**  **(Base Case – Measure)** | 2.0 therms/multifamily dwelling unit/yr for HA10  1.2 therms/lodging guest room/yr for HA13 |
| **Costs Common Units** | $ per measure unit |
| **Labor Cost ($/unit)** | $44.00 |
| **Measure Equipment Cost ($/unit)** | $28.55 measure equipment cost for HA10 and HA13 |
| **Gross Measure Cost ($/unit)** | $72.55 measure equipment cost for HA10 and HA13 |
| **Measure Incremental Cost ($/unit)** | $72.55 measure equipment cost for HA10 and HA13 |
| **Effective Useful Life (years)** | 15 years for HVAC - EMS, from 2014 DEER Version 2.0.1 READI Tool[[1]](#endnote-1) |
| **Measure Application Type** | Retrofit Add On (REA) |
| **Net-to-Gross Ratios** | 0.55 for Residential Default > 2 years, and 0.6 for Commercial Default > 2 years, from 2014 DEER READI Version 2.0.1 Tool1 |
| **Important Comments** | Assume 30 multifamily dwelling units or 30 hotel guest rooms per new boiler controller. |

# Document Revision History

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| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 03/26/2008 | PGECODHW115 Boiler Controller Work Paper, Rev. 0 | Southern California Gas Company |
| Revision 1 | 06/26/2012 | PGECODHW115 Boiler Controller Work Paper, Rev. 1 | Charlie Middleton (PG&E) |
| Revision 2 | 6/26/2014 | Ex Ante Database Format update | Charlie Middleton (PG&E) |
| Revision 3 | 8/25/2016 | Ex Ante Database Format update, REA Cost Update | Tai Voong (PG&E) |
| Revision 4 | 4/1/2017 | Sunset HA03 & HA07 | Tai Voong (PG&E) |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

Catalog Description: This workpaper for qualifying multifamily and lodging facilities in the PG&E gas service area covers the retrofit of a new “temperature modulation” boiler controller in the central water heating system for minimizing the supply & return water temperatures and piping heat losses. Some multifamily or lodging facilities may require more than one boiler controller. The total gas savings and total rebate amounts are based on the number of multifamily dwelling units or lodging guest rooms controlled by the new boiler controller or controllers. The “no control” base case is the existing water heating system without “temperature modulation” boiler control. The HA10 “temperature modulation” boiler controller measure saves about 2.0 therms/multifamily dwelling unit/yr. The HA13 “temperature modulation” boiler controller measure saves about 1.2 therms/lodging guest room/yr.

Program Restrictions and Guidelines: This workpaper for qualifying multifamily and lodging facilities in the PG&E gas service area covers the retrofit of a new “temperature modulation” boiler controller in the central water heating system for minimizing the supply & return water temperatures and piping heat losses. Some multifamily or lodging facilities may require more than one boiler controller. The total gas savings and total rebate amount is based on the number of multifamily dwelling units or lodging guest rooms controlled by the new boiler controller or controllers. The “no control” base case is the existing water heating system without “temperature modulation” boiler control.

## 1.2 Product Technical Description

This workpaper for qualifying multifamily and lodging facilities in the PG&E gas service area covers the retrofit of a new “temperature modulation” boiler controller in the central water heating system for minimizing the supply & return water temperatures and piping heat losses. Some multifamily or lodging facilities may require more than one boiler controller. The “Pro-Temp Controller” from PTControls.com is an example of a “temperature modulation” boiler controller.

## 1.3 Measure Application Type

The workpaper measures are Retrofit Add-On (REA) because of the retrofit of one or more new boiler in the existing water heating system.

## 1.4 Product Base Case and Measure Case Data

## 1.4.1 DEER Base Case and Measure Case Information

Table 1. DEER Use and Technology Table

|  |  |  |  |
| --- | --- | --- | --- |
|  | *DEER Use and Technology Table* | |  |
| **Use Category Description** | **Use Category** | **Use Sub Category Description** | **Use Sub Category** |
| Service and Domestic Hot Water | SHW | Water Heating | Heating |
| **Technology Groups Description** | **Technology Groups** | **Technology Types Descriptions** | **Technology Types** |
| Water Heating Equipment | WaterHtg\_eq | Boiler\_Et | Boiler\_Et |

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

The 2014 California Title Appliance Efficiency Regulations[[2]](#endnote-2) and 2013 California Title 24 Building Efficiency Standards[[3]](#endnote-3) do not have requirements for the workpaper measures.

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

DHW Commissioning and Control System for Lodging Facilities Workpaper for PY2007-2008, prepared by Energy and Environmenal Analysis, Inc., for Southern California Gas Company, March 2008[[4]](#endnote-4)

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

***1.4.4.1 Assumption from California 2014 Appliance Efficiency Regulations, Table F-2 - Standards for Large Water Heaters, Effective October 29, 20032***

1. This workpaper assumes avg. 80% thermal efficiency for the gas hot water supply boiler or large gas storage water heater in the central water heating system.

***1.4.4.2 Assumption from 2009 California Residential Appliance Saturation Survey (RASS), Volume 2 - Study Results, Table 2-21 - Gas UECs by Residence Type for all Households and for Households with Gas***

***Account Data******[[5]](#endnote-5)***

1. This workpaper assumes avg. 186 therms/multifamily dwelling unit/yr Unit Energy Consumption (UEC) for the “no control” base case.

***1.4.4.3 Assumptions from 2013 California Building Efficiency Standards (Title 24), Guest Room Occupancy Controls, Section 3.1.1 - Hotel Prototype, and Section 3.1.2 - Motel Prototype, October 2011[[6]](#endnote-6)***

1. Avg. 404 sq. ft. hotel guest room size
2. Avg. 322 sq. ft. motel guest room size
3. This workpaper assumes avg. 363 sq. ft. lodging guest room size = AVERAGE(404,322)

***1.4.4.4 Assumption from 2006 California Commercial End-Use Survey (CEUS), PG&E Results by Segment, Table 9-29, Lodging Natural Gas EUIs, Fuel Shares, and EIs, Page 192******[[7]](#endnote-7)***

1. This workpaper assumes avg. 116 therms/lodging guest room/yr for the “no control” base case = [31.98 kBtu/End-Use sq. ft. Energy Use Index (EUI)]\*(avg. 363 sq. ft. lodging guest room size, previous assumption)/(100,000 Btu/therm)

***1.4.4.5 Assumption from 2013 California Title 24 Building Efficiency Standards, Water and Space Heating ACM Improvement, Section 4.2.1 - DHW Recirculation System Performance Algorithms, October 2011[[8]](#endnote-8)***

1. “The PIER research performed field performance monitoring studies at more than thirty multifamily buildings across California. Using an energy flow analysis method, the research found that the average central DHW system efficiency is only 34%. Distribution system heat losses represent about one-third of the total system energy consumption, with recirculation loop loss being the dominant distribution heat loss component.” This workpaper assumes avg. 30% water heating gas consumption for supply & return water piping heat losses.

***1.4.4.6 Assumptions from 2013 California Building Efficiency Standards (Title 24), Water and Space Heating ACM Improvement, Table RE-4 - Recirculation Loop Supply temperature and Pump Operation Schedule, October 2011[[9]](#endnote-9)***

1. Avg. 135 deg. F supply water temperature for “no control” base case
2. Avg. 132.5 deg. F supply water temperature for HA10 and HA13

***1.4.4.7 Assumptions from PG&E energy audits and technology reviews***

1. Avg. 5 deg. F lower supply & return water piping temperature than supply water temperature
2. Avg. 60 deg. F supply & return water piping surroundings temperature

**1.4.4.8 Assumptions from DHW Commissioning and Control System for Lodging Facilities Workpaper for PY2007-2008, prepared by Energy and Environmenal Analysis, Inc., for Southern California Gas Company, March 20084**

1. For HA10 and HA13, the $28.55 measure equipment cost (in $ per measure unit) equals the gross measure cost or measure incremental cost.

## 1.4.5 Time-of-Use Adjustment Factor

The workpaper measures do not have a time-of-use (TOU) adjustment factor.

## 1.5 Summary of Inputs for Energy Savings Estimates

Table 2. Summary of Inputs for Energy Savings Estimates for Multifamily Facilities

|  |  |  |  |
| --- | --- | --- | --- |
| Input Variables for Energy Savings Estimates in Multifamily Facilities | “No Control” Base Case Values | HA10 “Temperature Modulation” Boiler Controller Values | Reference Sections |
| **Avg. thermal efficiency for the gas hot water supply boiler or large gas storage water heater in the central water heating system** | 80% thermal efficiency | 80% thermal efficiency | Section 1.4.4.1 |
| **Avg. therms/multifamily dwelling unit/yr Unit Energy Consumption (UEC) for the “no control” base case** | 186 therms | N/A | Section 1.4.4.2 |
| **Avg. water heating gas consumption for supply & return water piping heat losses** | 30% | 30% | Section 1.4.4.5 |
| **Avg. supply water temperature** | 135 deg. F | 132.5 deg. F | Section 1.4.4.6 |
| **Avg. lower supply & return water piping temperature than supply water temperature** | 5 deg. F | 5 deg. F | Section 1.4.4.7 |
| **Avg. supply & return water piping surroundings temperature** | 60 deg. F | 60 deg. F | Section 1.4.4.7 |

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Table 3. Summary of Inputs for Energy Savings Estimates for Lodging Facilities

|  |  |  |  |
| --- | --- | --- | --- |
| Input Variables for Energy Savings Estimates in Lodging Facilities | “No Control” Base Case Values | HA13 “Temperature Modulation” Boiler Controller Values | Reference Sections |
| **Avg. thermal efficiency for the gas hot water supply boiler or large gas storage water heater in the central water heating system** | 80% thermal efficiency | 80% thermal efficiency | Section 1.4.4.1 |
| **Avg. therms/lodging guest room/yr Unit Energy Consumption (UEC) for the “no control” base case** | 116 therms | N/A | Section 1.4.4.4 |
| **Avg. water heating gas consumption for supply & return water piping heat losses** | 30% | 30% | Section 1.4.4.5 |
| **Avg. supply water temperature** | 135 deg. F | 132.5 deg. F | Section 1.4.4.6 |
| **Avg. lower supply & return water piping temperature than supply water temperature** | 5 deg. F | 5 deg. F | Section 1.4.4.7 |
| **Avg. supply & return water piping surroundings temperature** | 60 deg. F | 60 deg. F | Section 1.4.4.8 |

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

The workpaper measures do not produce electric energy savings.

## 2.2. Demand Reduction Estimation Methodologies

The workpaper measures do not produce electric demand savings.

## 2.3. Gas Energy Savings Estimates

## 2.3.1. Gas Energy Savings Estimate for HA10 “Temperature Modulation” Boiler Controller for Multifamily Facilities

**Avg. 2.0 therms/multifamily dwelling unit/yr water heating gas savings for HA10 “temperature modulation” boiler controller =** (avg. 186 therms/multifamily dwelling unit/yr water heating gas consumption for base case)\*(avg. 30% water heating gas consumption for supply & return water piping heat losses)\*{1 - [(avg. 132.5 deg. F supply water temperature for HA10) - (avg. 5 deg. F lower supply & return water piping temperature) - (avg. 60 deg. F supply & return water piping surroundings temperature)]/[(avg. 135 deg. F supply water temperature for base case) - (avg. 5 deg. F lower supply & return water piping surface temperature than supply water temperature) - (avg. 60 deg. F supply & return water piping surroundings temperature)]}

**Avg. 184.0 therms/multifamily dwelling unit/yr water heating gas consumption for HA10 “temperature modulation” boiler controller =** [(avg. 186 therms/multifamily dwelling unit/yr water heating gas consumption for base case) - (avg. 2.0 therms/multifamily dwelling unit/yr water heating gas savings for HA10 “temperature modulation” boiler controller)]

## 2.3.3. Gas Energy Savings Estimate for HA13 “Temperature Modulation” Boiler Controller for Lodging Facilities

**Avg. 1.2 therms/lodging guest room gas savings for HA13 “temperature modulation” boiler controller =** (avg. 116 therms/lodging guest room/yr water heating gas consumption for base case)\*(avg. 30% water heating gas consumption for supply & return water piping heat losses)\*{1 - [(avg. 132.5 deg. F supply water temperature for HA13) - (avg. 5 deg. F lower supply & return water piping temperature) - (avg. 60 deg. F supply & return water piping surroundings temperature)]/[(avg. 135 deg. F supply water temperature for base case) - (avg. 5 deg. F lower supply & return water piping surface temperature than supply water temperature) - (avg. 60 deg. F supply & return water piping surroundings temperature)]}

**Avg. 114.8 therms/lodging guest room/yr water heating gas consumption for HA13 “temperature modulation” boiler controller =** (avg. 116 therms/lodging guest room/yr water heating gas consumption for base case) - (avg. 1.2 therms/lodging guest room/yr water heating gas savings for Sxx3 “temperature modulation” boiler controller)

# Section 3. Load Shapes

The multifamily facilities gas load shapes are embedded in the Section 1.4.4.2 Assumption from the 2009 California Residential Appliance Saturation Survey (RASS).5 The lodging facilities gas load shapes are embedded in the Section 1.4.4.4 Assumption from the 2006 California Commercial End-Use Survey (CEUS).7

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Costs

The base case equipment cost for all measures is $0.

## 4.2 Measure Case Costs

Refer to the Table 4 measure equipment cost (in $ per measure unit) that equals the gross measure cost or measure incremental cost.

Table 4. Measure Equipment Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Code | Measure Application Type | Measure Case Cost4 | Labor Case Cost10 | IMC/Full Measure Cost |
| **HA10 “temperature modulation” boiler controller for multifamily facilities** | REA | $28.55 | $44.00 | $72.55 |
| **HA13 “temperature modulation” boiler controller for lodging facilities** | REA | $28.55 | $44.00 | $72.55 |

## 4.3 Incremental & Full Measure Costs

Refer to the Table 4 measure case cost (in $ per measure unit) that equals the incremental measure cost and the full measure cost.

## 4.3.1 Gross Measure Cost

Refer to the Table 4 measure case cost (in $ per measure unit) that equals the gross measure cost.

## 4.3.2 Incremental Measure Cost

Refer to the Table 4 measure case cost (in $ per measure unit) that equals the incremental measure cost.

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# References

1. 2014 DEER READI Version 2.0.1 Tool, <http://www.deeresources.com/> [↑](#endnote-ref-1)
2. 2014 California Title 20 Appliance Efficiency Regulations, <http://www.energy.ca.gov/appliances/> [↑](#endnote-ref-2)
3. 2013 California Title 24 Building Efficiency Standards, <http://www.energy.ca.gov/title24/2013standards/> [↑](#endnote-ref-3)
4. DHW Commissioning and Control System for Lodging Facilities Workpaper for PY2007-2008, prepared by Energy and Environmental Analysis, Inc., for Southern California Gas Company, March 2008 [↑](#endnote-ref-4)
5. 2009 California Residential Appliance Saturation Survey (RASS), Volume 2 - Study Results, Table 2-21 - Gas UECs by Residence Type for all Households and for Households with Gas

   Account Data, <http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-V2.PDF> [↑](#endnote-ref-5)
6. 2013 California Title 24 Building Efficiency Standards, Guest Room Occupancy Controls, Section 3.1.1 - Hotel Prototype, and Section 3.1.2 - Motel Prototype, October 2011, [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/nonresidential/Lighting\_Controls\_Bldg\_Power/2013\_CASE\_NR\_Guest\_Room\_Occupancy\_Controls\_Oct\_2011.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Guest_Room_Occupancy_Controls_Oct_2011.pdf) [↑](#endnote-ref-6)
7. 2006 California Commercial End-Use Survey (CEUS), PG&E Results by Segment, Table 9-29, Lodging Natural Gas EUIs, Fuel Shares, and EIs, Page 192, <http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF> [↑](#endnote-ref-7)
8. 2013 California Title 24 Building Efficiency Standards , Water and Space Heating ACM Improvement, Section 4.2.1 - DHW Recirculation System Performance Algorithms, October 2011, [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/nonresidential/HVAC/2013\_CASE\_WH4\_Space-and-WaterHeating\_10.28.2011.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/HVAC/2013_CASE_WH4_Space-and-WaterHeating_10.28.2011.pdf) [↑](#endnote-ref-8)
9. 2013 California Title 24 Building Efficiency Standards, Water and Space Heating ACM Improvement, Table RE-4 - Recirculation Loop Supply temperature and Pump Operation Schedule, October 2011, [http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/nonresidential/HVAC/2013\_CASE\_WH4\_Space-and-WaterHeating\_10.28.2011.pdf](http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/HVAC/2013_CASE_WH4_Space-and-WaterHeating_10.28.2011.pdf)

   10 2016 RSMeans, Control component, sensor, electric operated, temperature; Electrician - 0.8 hour equals $44. [↑](#endnote-ref-9)