**Work Paper PGECOPRO107**

**Boiler Tuner-Up for Drycleaners**

**Revision # 5**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Mid Stream Boiler Tune-Up for Drycleaners**

**Measure Codes H301, H302, H303, H304, H305**

# At-a-Glance Summary

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | H301 | H302 | H303 | H304 | H305 |
| **Measure Description:** | Boiler tune up for small commercial dry cleaners. Tune-ups include boiler tube cleaning, burner cleaning, and hot water line insulation. Data indicates dry cleaner boiler types consist of 75% tube boilers and 25% kettle boilers.  9.5 hp tube type boilers | Boiler tune up for small commercial dry cleaners. Tune-ups include boiler tube cleaning, burner cleaning, and hot water line insulation. Data indicates dry cleaner boiler types consist of 75% tube boilers and 25% kettle boilers.  15 hp tube type boilers | Boiler tune up for small commercial dry cleaners. Tune-ups include boiler tube cleaning, burner cleaning, and hot water line insulation. Data indicates dry cleaner boiler types consist of 75% tube boilers and 25% kettle boilers.  20 hp tube type boiler | Boiler tune up for small commercial dry cleaners. Tune-ups include boiler tube cleaning, burner cleaning, and hot water line insulation. Data indicates dry cleaner boiler types consist of 75% tube boilers and 25% kettle boilers.  25 hp tube type boilers | Boiler tune up for small commercial dry cleaners. Tune-ups include boiler tube cleaning, burner cleaning, and hot water line insulation. Data indicates dry cleaner boiler types consist of 75% tube boilers and 25% kettle boilers.  15 hp average Kettle type boilers |
| **Energy Impact Common Units:** | Therm savings per boiler system | Therm savings per boiler system | Therm savings per boiler system | Therm savings per boiler system | Therm savings per boiler system |
| **Base Case Description:** | Source: PG&E Calculations, in field monitoring weighted average therms per boiler system. | Source: PG&E Calculations, in field monitoring weighted average therms per boiler system. | Source: PG&E Calculations, in field monitoring weighted average therms per boiler system. | Source: PG&E Calculations, in field monitoring weighted average therms per boiler system. | Source: PG&E Calculations, in field monitoring weighted average therms per boiler system. |
| **Base Case Energy Consumption:** | Source: Field verification and installation monitoring 5558 therms per boiler system. | Source: Field verification and installation monitoring  8775 therms /boiler system | Source: Field verification and installation monitoring  11700 therms/ boiler system | Source: Field verification and monitoring 14625 therm/boiler system | Source: Field verification and installation, kettle type boiler based on average 15 hp.  8940 therms /boiler system |
| **Measure Energy Consumption:** | Source: Field verification and installation monitoring 4784 therms/boiler | Source: Field verification and installation monitoring 7553 therms/boiler | Source: Field verification and installation monitoring  10070 therms/boiler | Source: Field verification and monitoring  12588 therms/boiler system | Source: Field verification and monitoring 8604 therms/boiler system |
| **Energy Savings (Base Case – Measure)** | Source: PG&E Calculations 774 therms/boiler | Source: PG&E Calculations 1222.5 therms/boiler | Source: PG&E Calculations 1630 therms/boiler | Source: PG&E Calculations 2037 therm/boiler system | Source: PG&E Calculations 336 therms /boiler system |
| **Costs Common Units:** | $ per boiler system | $ per boiler system | $ per boiler system | $ per boiler system | $ per boiler system |
| **Base Case Equipment Cost ($/unit):** | Source: PG&E Calculations 0 | Source: PG&E Calculations 0 | Source: PG&E Calculations 0 | Source: PG&E Calculations 0 | Source: PG&E Calculations 0 |
| **Measure Equipment Cost ($/unit):** | Source: PG&E Calculations $850 | Source: PG&E Calculations $850 | Source: PG&E Calculations $850 | Source: PG&E Calculations $850 | Source: PG&E Calculations $850 |
| **Gross Measure Cost ($/unit):** | Source: PG&E calculations $850 | Source: PG&E calculations $850 | Source: PG&E calculations $850 | Source: PG&E Calculations $850 | Source: PG&E Calculations $850 |
| **Effective Useful Life (years):** | 5 years—Source M&V study Sisson and Associates | 5 years—Source M&V study Sisson and Associates | 5 years—Source M&V study Sisson and Associates | 5 years—Source M&V study Sisson and Associates | 5 years—Source M&V study Sisson and Associates |
| **Measure Application Type:** | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). |
| **Net-to-Gross Ratios:** | Source: 2014 DEER Default  0.6 | Source: 2014DEER Default  0.6 | Source: 2014 DEER Default  0.6 | Source: 2014 DEER Default  0.6 | Source: 2014 DEER Default  0.6 |
| **Important Comments:** |  |  |  |  |  |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
| **Carolyn Weiner**  Manager, Appliance Products |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision 0** | **11/14/2008** | **Original work paper** | **Charlene Spoor (PGE)**  **Matrix Energy Services** |
| **Revision 1** | **05/14/09** | **Revision 1 incorporating comments from R0.**  **Change in NTG based on DEER08 from 0.96 to 0.46 for all non residential water heating measures.** | **Charlene Spoor (PGE)** |
| **Revision 2** | **10/22/2009** | **NTG reference changed from Bridge funding to 09-11 Planning** | **Charlene Spoor (PG&E)** |
| **Revision 3** | **6/11/2012**  **8/22/2012** | **NTG reference changed to 0.60 for all Com-Default>2yrs**  **Updated BLD, CZ and VIN to ANY per READI Requirements** | **Charlene Spoor (PG&E)** |
| **Revision 4** | **5/22/2014** | **Updated to new WP template for 7/1/14 filing** | **Charlene Spoor (PG&E)** |
| **Revision 5** | **4/1/2016** | **Ex ante format update** | **Tai Voong (PG&E)** |

# Table of Contents

[At-a-Glance Summary ii](#_Toc388524150)

[Work Paper Approvals iv](#_Toc388524151)

[Document Revision History v](#_Toc388524152)

[Table of Contents vi](#_Toc388524153)

[List of Tables vii](#_Toc388524154)

[List of Figures vii](#_Toc388524155)

[Section 1. General Measure & Baseline Data 1](#_Toc388524156)

[1.1 Product Measure Description & Background 1](#_Toc388524157)

[1.2 Product Technical Description 1](#_Toc388524158)

[1.3 Measure Application Type 2](#_Toc388524159)

[1.4 Product Base Case and Measure Case Data 2](#_Toc388524160)

[1.4.1 DEER Base Case and Measure Case Information 2](#_Toc388524161)

[1.4.2 Codes & Standards Requirements Base Case and Measure Information 3](#_Toc388524162)

[1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information 3](#_Toc388524163)

[1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases 5](#_Toc388524164)

[Section 2. Calculation Methods 6](#_Toc388524165)

[2.1 Electric Energy Savings Estimation Methodologies 7](#_Toc388524170)

[2.2. Demand Reduction Estimation Methodologies 7](#_Toc388524172)

[2.3. Gas Energy Savings Estimation Methodologies 7](#_Toc388524174)

[Section 3. Load Shapes 9](#_Toc388524267)

[3.1 Base Case Load Shapes 9](#_Toc388524268)

[3.2 Measure Load Shapes 10](#_Toc388524270)

[Section 4. Base Case & Measure Costs 11](#_Toc388524272)

[4.1 Base Case(s) Costs 11](#_Toc388524273)

[4.2 Measure Case Costs 11](#_Toc388524274)

[4.3 Incremental & Full Measure Costs 12](#_Toc388524275)

[4.3.1 Full Measure Cost 12](#_Toc388524276)

[4.3.2 Incremental Measure Costs 12](#_Toc388524277)

[References 14](#_Toc388524278)

# List of Tables

[Table 1 DEER Use and Technology Table 2](#_Toc324427642)

[Table 2 DEER Net-to-Gross Ratios 3](#_Toc324427643)

[Table 3 Site Overall Savings Tube Boilers 3](#_Toc324427644)

[Table 4 Site Overall Savings Kettle Boilers 4](#_Toc324427645)

[Table 5 Overall Savings 4](#_Toc324427646)

[Table 6 Summary of Inputs for Savings Calculations 6](#_Toc324427647)

[Table 7 Baseline for Measure Application Type 6](#_Toc324427648)

[Table 8 Tube Boiler Coefficients Summary 7](#_Toc324427649)

[Table 9 Kettle Boiler Coefficients Summary 8](#_Toc324427650)

Table 10 Base Case Types and Load Shapes………………………………………………………10

Table 11 Measure Case Building Types and Load Shapes………………………………………..10

Table 12 Measure Case Costs……………………………………………………………………… 11

Table 13 Summary Table for Section 4………………………………………………………………13

# List of Figures

Figure 1 Pre Retrofit Daily Boiler Load Profile……………………………………………………….10

Figure 2 Post Retrofit Daily Load Profile…..................................................................................10

# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –*** This is a mid-stream program that is targeted to Dry Cleaners and is not offered through the small business catalogs.

This Work Paper describes the savings potential associated with optimization of boiler operation as part of the Boiler Tune-up for Dry Cleaners program. The measure involves documenting boiler performance and operation, and then modifying boiler operation to improve boiler efficiency using existing boiler equipment and controls. This measure cleans the inside surface of the boiler tubes, reducing mineral build-up and restoring boiler efficiency.

The program will be performed by an outside service company to insure that the necessary expertise and resources are applied to the measure.

Measures to be utilized to improve boiler efficiency include:

* Boiler tube cleaning- mineral deposits are chemically removed from the inside of the boiler tubes,
* Reduce boiler cycling (on/off cycling and wide load swings),
* Burner cleaning- soot and build up are removed from the burner allowing more efficient combustion,
* Hot water line insulation- supply lines coming from the boiler are insulated to reduce heat loss to the environment.

Implementation of these measures on existing boilers typically can improve overall efficiency by more than 5%. To be conservative, the projected savings for this measure are based on achieving an improvement in boiler efficiency of 2%. Our data indicates that participation in the pilot program consists of 75% tube boilers and 25% kettle boilers.3 These figures were applied as weights to the separate savings measurements when averaging the two boiler types.

***Program Restrictions and Guidelines***

***Terms and Conditions***

Must be a dry cleaning facility within the PG&E service territory that has on-site equipment used for daily business.

***Market Applicability***

Applicable for all small business dry cleaners with tube or kettle boiler systems ranging in size from 9.5 to 25 HP.

Generally the savings yielded from kettle-type boiler systems are much lower than that from tube-type boiler systems. Programs implementers are advised to limit enrollment of kettle-type tune-ups to maintain cost-effective savings. For this reason, this work paper has based the savings of the kettle-type boiler systems on a single horsepower rating.

The rebate for measure H301, H302, H303, H304, and H305 is downstream provided to the contractor at the time of installation upon receipt of customer delivery. This is a Direct- install program.

## 1.2 Product Technical Description

Dry cleaners utilize gas-fired boilers to provide hot water for laundering and steam for pressing clothing. Despite heavy usage, it is often the case that dry cleaner proprietors lack due diligence in maintenance of this equipment; it is rare for dry cleaners to have their boilers de-scaled, installed boilers often lack any sort of filtering device to protect them from harsh incoming water, and generally, dry cleaners do not blow down their boilers after daily use. Without sufficient preventative maintenance, mineral deposits from incoming water form on the inner surface of the boiler tubes. This will result in reduction in heat transfer in the boiler tubes, consequently causing longer run times as the boiler tries to keep up with the need for steam and hot water. This measure cleans the inside surface of the boiler tubes, reducing mineral build-up and restoring boiler efficiency.

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2014Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table 1 Measure Application Type[[1]](#endnote-1)

*Identifies the measure application type in the Measure Implemenation table in DEER2011.*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| NC | New Construction | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

This measure is offered as ROB or NC based on the definitions listed above.

## 1.4 Product Base Case and Measure Case Data

## 1.4.1 DEER Base Case and Measure Case Information

* The DEER 2014 database include: Net to Gross values only for this measure
* Table 1 below summarizes the DEER Use an Technology types that match this measure.

**Table 1 DEER Use and Technology Table**



* The DEER data do not contain (not) the appropriate information for this (these) measure(s).

**Net-to-Gross Assumption:** DEER 2014 does not list the specific NTG for this measure, however it does refer to a default for any measure offered more than 2 years.

The rebate for measure H301, H302, H303, H304, and H305 are downstream provided to the contractor at the time of installation upon receipt of customer delivery. This is a Direct- install program.

Table 2 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 2 DEER Net-to-Gross Ratios

|  |  |
| --- | --- |
|  |  |
| Program Approach | NTG |
| Com Default > 2 yrs | 0.6 |

The NTG Ratios in Table 1 are appropriate for the measure(s) because:

* Measure has been offered for 2 years

**Effective Useful Life / Remaining Useful Life:**

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

*Boilers are only required to be inspected upon initial installation. Consequently, the de-scaling procedure is not subject to regulation.*

***Title 20:*** *This measure does not fall under Title 20 of the California Energy Regulations.*

***Title 24:*** *This measure does not fall under Title 24 of the California Energy Regulations.*

***Federal Standards:*** *This measure does not fall under Federal DOE or EPA Energy Regulations.*

*This measure is not governed by either state or federal codes and standards.*

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

The PG&E Boiler Tune-Up Pilot Program, implemented by Matrix Energy Services, Inc., performed de-scaling as part of a complete boiler tune-up for 200 dry cleaners. For verification purposes, Matrix Energy Services performed pre- and post- monitoring of a representative sample of dry cleaners receiving tune-ups in the service territory. The resulting savings from the monitored sites are given in Tables 3 and 4 below.

***Table 3 Site Level Savings - Tube Boilers***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Site ID*** | ***Pre Hrs/day*** | ***Post Hrs/day*** | ***HP*** | ***Pre Usage*** | ***Post Usage*** | ***Annual Therm Savings*** | ***Make*** |
| ***Site 1*** | ***7.33*** | ***5.44*** | ***20*** | ***15990*** | ***11880*** | ***4111*** | ***Parker*** |
| ***Site 2*** | ***8.00*** | ***6.75*** | ***15*** | ***13096*** | ***11041*** | ***2055*** | ***Thermo*** |
| ***Site 4*** | ***6.05*** | ***4.92*** | ***15*** | ***9905*** | ***8058*** | ***1847*** | ***Parker*** |
| ***Site 5*** | ***7.40*** | ***6.58*** | ***15*** | ***12117*** | ***10764*** | ***1353*** | ***Thermo*** |
| ***Site 6*** | ***4.35*** | ***3.60*** | ***15*** | ***7124*** | ***5899*** | ***1225*** | ***Parker*** |
| ***Site 7*** | ***6.37*** | ***5.87*** | ***15*** | ***10421*** | ***9608*** | ***813*** | ***Thermo*** |
| ***Site 09*** | ***4.85*** | ***4.12*** | ***9.5*** | ***5029*** | ***4274*** | ***755*** | ***Parker*** |
| ***Site 10*** | ***4.70*** | ***4.25*** | ***15*** | ***7689*** | ***6950*** | ***739*** | ***Thermo*** |
| ***Site 11*** | ***1.95*** | ***1.68*** | ***20*** | ***4257*** | ***3658*** | ***599*** | ***Parker*** |
| ***Site 12*** | ***6.41*** | ***6.06*** | ***15*** | ***10490*** | ***9918*** | ***572*** | ***Parker*** |
| ***Site 14*** | ***3.67*** | ***3.58*** | ***15*** | ***6010*** | ***5858*** | ***152*** | ***Thermo*** |
| ***AVG*** |  |  | ***15.86*** | ***9284*** | ***7991*** | ***1293*** |  |

***Table 4 Site-Level Savings - Kettle Boilers***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Site ID*** | ***Pre Hrs/day*** | ***Post Hrs/day*** | ***HP*** | ***Pre Usage*** | ***Post Usage*** | ***Annual Therm Savings*** | ***Make*** |
| ***Site 03*** | ***6.82*** | ***5.58*** | ***15*** | ***11164*** | ***9130*** | ***2033*** | ***Lattner*** |
| ***Site 08*** | ***4.62*** | ***4.35*** | ***25*** | ***12607*** | ***11852*** | ***755*** | ***Lattner*** |
| ***Site 13*** | ***6.88*** | ***6.73*** | ***15*** | ***11262*** | ***11009*** | ***253*** | ***Lattner*** |
| ***Site 15*** | ***3.61*** | ***3.52*** | ***15*** | ***5907*** | ***5760*** | ***147*** | ***Hurst*** |
| ***Site 16*** | ***5.90*** | ***5.85*** | ***25*** | ***16085*** | ***15961*** | ***124*** | ***Lattner*** |
| ***Site 17*** | ***5.83*** | ***5.76*** | ***15*** | ***9545*** | ***9422*** | ***123*** | ***Lattner*** |
| ***Site 181*** | ***4.11*** | ***4.06*** | ***20*** | ***8974*** | ***8855*** | ***120*** | ***Fulton*** |
| ***Site 191*** | ***2.97*** | ***2.94*** | ***9.5*** | ***3073*** | ***3047*** | ***25*** | ***Lattner*** |
| ***Site 201*** | ***6.22*** | ***6.22*** | ***25*** | ***16977*** | ***16970*** | ***7*** | ***Lattner*** |
| ***AVG*** |  |  | ***17.81*** | ***10621*** | ***10222*** | ***399*** |  |

Our data indicates that participation in the pilot program consists of 75% tube boilers and 25% kettle boilers. These figures were applied as weights to the separate savings measurements when averaging the two boiler types’ savings in Table 5.

***Table 5 Overall Savings***

|  |  |  |
| --- | --- | --- |
| ***Average Savings (Therms)– Tube Boilers*** | ***Average Savings (Therms) – Kettle Boilers*** | ***Weighted Average Savings (Therms)*** |
| ***1293*** | ***399*** | ***1069*** |

1293 \* 0.75 = 969.75

399 \* 0.25 = 99.75

969.75 + 99.75 = 1069.5

Sites showing low savings in some cases were due to proper maintenance on the part of the customers, including a daily chemical treatment. This treatment greatly reduces (though does not prevent entirely) mineral build up from incoming water, thereby reducing the savings potential of the tune-up measure.

Additional M&V reports include a Sisson and Associates[[2]](#endnote-2) program evaluation report for the Sempra Utilities (Souther California Gas Company), and Boiler Tube Cleaning Savings Calculation Report by Matrix Energy Services.

Delta Wattage Assumption (ΔW): This is a therm saving measure.

Net-to-Gross Assumption: 0.60 Source: 2014 DEER NTGR Values for, Com-Default>2yrs

In-service factor/first year installation rate: GSIA = 1 or 100% in service factor as this is a direct install program measure.

Hours of Operation: 5 days per week/ 10 hours per day

Effective Useful Life: Boiler tune-up should be preformed every 5 years, Sisson and Associates2.

## 

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

**Energy Savings Assumption (ΔW, ΔTherms):** This measure applies to existing boiler systems that are operating with less than optimum efficiency. Existing boiler systems will have experienced varying degrees of efficiency degradation depending on the quality of the initial installation and commissioning, routine performance evaluation and maintenance, and changes in operating requirements of the boiler systems. Thus this measure has the potential to be applied to all boiler systems ranging from recently installed systems to older systems.

The sample consists of two types, kettle and tube boilers, ranging from 9.5-25hp. Tube boilers have a greater surface area and thus are more prone to calcium buildup from incoming water and face a greater reduction in heat transfer as a result. Consequently tube boilers show greater savings from the de-scaling procedure than kettle boilers.

Two sites in the sample performed daily chemical treatment. The proprietors of Sites 12 and 13 were diligent in this regard and subsequently showed the lowest savings of any sites in the sample.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Gas avings Therms** | **Savings units** | **Reference** |
| **Any** | **Any** | **Any** | **774 to 2,037** | **Therms** | **HMG Calculations** |

**Hours of Operation**:

* Hours of Operation: 5 days per week/ 10 hours per day

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Hours of Operation hrs/yr** | **Reference** |
| **Any** | **Any** | **Any** | **2600** | **Sisson & Associates** |

**Base Case Costs and Measure Case Costs:** There are no costs associated with the base case as the equipment is pre-existing.

The cost of implementing this measure represents an incremental cost beyond the base case. Therefore, the Base Case costs are assigned a value of zero so that the Measure costs also represent the incremental costs.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Costs ($)** | | |  |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Base Case** | **Measure Case** | **IMC** | **Reference** |
| **Any** | **Any** | **Any** | **Nothing** | **$850** | **$850** | **Sisson and Associates** |

**Effective Useful Life:**

The tune-up service is a retrofit for the dry cleaners boilers. It is estimated that in order for the boiler to remain at peak efficiency, this procedure should be implemented every three to five years, provided that the proprietor does not perform daily maintenance. For the sake of this program it is recommended to perform this procedure every 5 years2. Proper maintenance following a de-scaling procedure will lengthen the time needed before a repeat of this service.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** |
| **Any** | **Any** | **Any** | **5** | **N/A** | **2014** |

Effective Useful Life: Boiler tune-up should be preformed every 5 years, Sisson and Associates2.

***1.4.5 Time-of-Use Adjustment Factor***

We are required by CPUC 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. Since this is not an A/C measure, the TOU adjustment factor is 0.

***1.5 Summary of Inputs for Savings Calculations***

The following table 6 provides references to sections that document the inputs for calculation:

**Table 6 Summary of Inputs for Savings Calculations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Measure Case Average Value** | **Reference Section** |
| **Electric Savings** | None | N/A | *N/A* | *N/A* | *Section 1.4.1* |
| **Gas Savings** | None | 0 |  |  | Section 2.3 |
| **Hours of operation** | None | 2600 | N/A | 2600 | Section 1.4.4 |
| **Full Cost** | ROB, NC | $850 | N/A | $850 | Section 1.4.4 |
| **Incremental Cost** | ROB, NC | $850 | N/A | $850 | Section 1.4.4 |
| **EUL /RUL** | None | None | N/A | 5 yrs | Section 1.4.4 |
| **NTG** | One | 0.6 | 0.6 | 0.6 | Section 1.4.1 |
| **ISR** | No | 1 | 1 | 1 | Section 1.4.3 |
| **TOU Factor** | *A/C projects only* | *N/A* | *N/A* | *N/A* | *Section 1.4.5* |

# Section 2. Calculation Methods

Table 3 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)** | **EUL** | Customer Average Baseline | Code Baseline |
| ***ROB* (replace-on-burnout)** | **EUL** | Code Baseline | N/A |
| ***NC* (new construction)** | **RUL/EUL-RUL** | Code Baseline | N/A |

Notes:

* For ROB measures, First Baseline is the baseline for the full EUL. There is no second baseline.
* For ER measures, First Baseline Period is the period for the RUL(remaining useful life),defined by the CPUC as RUL=1/3 EUL. Second baseline period for ER is Code baseline for the period EUL-RUL.

***2.1 Electric Energy Savings Estimation Methodologies***

* There are no electric energy savings associated with these measures.

***2.2. Demand Reduction Estimation Methodologies***

* There are no anticipated demand reduction associated with this measure

**2.3. Gas Energy Savings Estimation Methodologies**

Savings for this program were derived via pre- and post- installation analysis of therm usage on boilers at commercial dry cleaners. Data loggers were installed to indicate state changes of the boiler turning on or off, and gathered a minimum of two weeks pre and post installation data for all sites. Data for our analysis was collected such that pre and post installation periods each covered both the same length of time as well as the same composition of days (both periods beginning on a Monday and extending for two weeks, etc.), gathering the longest period of common composition possible for each site.

The following formulas were developed to present the estimated savings specific to each boiler size, number of hours of operation (per day), and the number of operating days per week.

***Savings = A\*HP\*261\*B***

A = Normalized Constant

261 = Number of days of operation

B = Operating hours per day

*Example for Site 01:* ***A=(Savings)/(HP\*261\*B)=(4111therms/yr)/(20hp\*261days/yr\*7.5hrs/day)=.105***

**Table 8 Tube Boiler Coefficients Summary**

|  |  |  |
| --- | --- | --- |
| **Cleaners** | **A Value:** | **B Value:** |
| Site 01 | .105 | 7.5 |
| Site 02 | .049 | 10.5 |
| Site 04 | .0589 | 8 |
| Site 05 | .0384 | 9 |
| Site 06 | .0368 | 8.5 |
| Site 07 | .0197 | 10.5 |
| Site 09 | .032 | 9.5 |
| Site 10 | .0315 | 6 |
| Site 11 | .0208 | 5.5 |
| Site 12 | .017 | 8.5 |
| Site 14 | .005 | 7.5 |
| **Average:** | .0376 | 8.3 |

***Annual Natural Gas Savings (Therms) for Tube Boilers:***

***Savings = .0376\*HP\*261\*B***

* ***Savings/HP = .0376\*261\*B = .0376\*261\*8.3 = 81.5 annual Therms per HP***

From this we determine the savings for each boiler size (i.e. 9.5hp boiler = 81.5therms \* 9.5hp = 774 therms per boiler).

**Table 9 Kettle Boiler Coefficients Summary**

|  |  |  |
| --- | --- | --- |
| **Cleaners** | **A Value:** | **B Value:** |
| Site 03 | .0577 | 9 |
| Site 08 | .0105 | 11 |
| Site 13 | .0068 | 9.5 |
| Site 15 | .0063 | 6 |
| Site 16 | .0021 | 9 |
| Site 17 | .0037 | 8.5 |
| Site 18 | .0027 | 8.5 |
| Site 19 | .002 | 5 |
| Site 20 | .00011 | 9 |
| **Average:** | .0102 | 8.4 |

***Annual Natural Gas Savings (Therms) for Kettle Boilers:***

***Savings = .0102\*HP\*261\*B***

* ***Savings/HP = .0102\*261\*B = .0376\*261\*8.4 = 22.4 annual Therms per HP***

In these calculations it is assumed that the cleaners are closed on weekends. For sites where this assumption does not hold, actual savings will be higher than calculated in this model. In accordance with Enhanced Level of Rigor requirements all savings calculations have 90% precision, encompassing both measurement and modeling error. A preliminary version of this equation has been used in Boiler Tube Cleaning Savings Calculation Report, Matrix Energy Services, Inc.[[3]](#endnote-3). The paper has been modified for purposes of simplification and ease of application *Annual Gas Savings:*

Energy Savings [therms/unit] = Annual Base Gas Usage – Annual Energy Efficient Gas Usage

See Table 1 and Table 2 for actual therm savings per site.

Average of 1069 therms/unit = Weighted average of measured base case usage – Weighted average of measured post retrofit gas usage

**Section 3. Load Shapes**

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

***3.1 Base Case Load Shapes***

The base case load shape would be expected to follow a typical non residential dry cleaning end use load shape.

The load shape for boiler usage at dry cleaners does not change with regards to the timing of energy use following a tune-up. However, the magnitude of the load drops significantly following implementation. Figure 3-1 below characterizes daily boiler run times before a tune-up.

**Figure 3-1 Pre-retrofit Daily Boiler Load Profile**



**24 hour 12:00am to 12:00am**

Table 10 Base Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Commercial Dry Cleaner | NON\_RES | Gas Annual |

***3.2 Measure Load Shapes***

For purposes of the net benefits estimates in the E3 calculator, what is required is the 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 measure load shape for this measure is determined by the E3 calculator based on the applicable non-residential market sector and the dry cleaning end-use.

Following a tune up, the data from the loggers indicate that there are significantly more state changes in the boiler throughout the day. The post cleaning profile shows that the boiler is cycling after tube cleaning whereas pre-retrofit usage is near continuous and thus the daily therm load is of greater magnitude. Following a de-scaling procedure, the boiler does not need to run as long in order to meet hot water demand as the cleaning increases the efficiency of heat transfer into the boiler tubes, allowing the boiler to heat the water more rapidly. The change in load profile following the tune-up is displayed in Figure 3 below.

**Figure 2 Post-Retrofit Daily Boiler Load Profile**



**24 hour 12:00am to 12:00am**

Table 11 Measure Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Commercial Dry Cleaner | NON\_RES | Gas Annual |

# Section 4. Base Case & Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Full Measure Cost (RUL)** | **Second Baseline Period Full Measure Cost (EUL – RUL)** |
| ***NC (new construction)*** | EUL | Calculated as Incremental Measure Cost | N/A |
| ***ROB(replace on burnout)*** | EUL | Calculated as Incremental Measure Cost | N/A |
| ***ER (early retirement)*** | RUL/  EUL-RUL | Calculated as Full Gross Measure Cost | Calculated as Negative Full Gross Base Case Cost |

## 4.1 Base Case(s) Costs

There are no costs associated with the base case as the equipment is pre-existing.

The cost of implementing this measure represents an incremental cost beyond the base case. Therefore, the Base Case costs are assigned a value of zero so that the Measure costs also represent the incremental costs.

## 4.2 Measure Case Costs

Cost of materials is roughly $100, based on several regional quotes. Labor costs show some degree of variation by region, as displayed in Table 10 below.

**Table 12 Measure Case Costs**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| H301 to H305 | ROB | 0 | $100 | $750 | N/A | $850 |
| H301 to H305 | NC | 0 | $100 | $750 | N/A | $850 |

All costs are noted as $ per measure unit

## 

## 4.3 Incremental & Full Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Full Measure Cost**  **(RUL Period/First Baseline)** | **Full Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ER | Measure Equipment Cost  +Measure Labor Cost | (-1)x(Base Equipment Cost  + Base Labor Cost) | Measure Equipment Cost  – Base Case Equipment Cost |
| ROB | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
| NC | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |

# *4.3.1 Full Measure Cost*

Full 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.

The incremental cost and full measure cost is $850, $100 for parts and an average of $750 for labor.

This Measure Application Type(s) is (are): **NC** or **ROB**, so the Full Measure Cost (FMC) is represented by the equation below (choose):

FMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

FMC = Measure Equipment Cost – Base Case Equipment *Cost*

*FMC = $850 per (unit) - $ 0 per (unit) = $ 85- per unit*

\*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

# *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: **ROB or NC** so the Gross Measure Cost (GMC) is represented by the equation below:

IMC = Measure Equipment Cost + Measure Labor Cost

*IMC = $100 per (unit)+ $ 750 per (unit) = $ 850 per (unit)*

**Table 13 Summary Table for Section 4**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Base Case Total Cost** | **Measure Case Total Cost[[4]](#endnote-4)** | **Full Measure Case Cost** | **Incremental Measure Cost** |
| **H301 to H305** | ROB | **$0** | **$850** | **$850** | **$850** |
| **H301 to H305** | NC | **$0** | **$850** | **$850** | **$850** |

# 

# References

1. The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls.* [↑](#endnote-ref-1)
2. *DEER2011\_NTGR\_2012-05-16.xls* from DEER Database for Energy-Efficient Resources; Version 2011 4.01 found at :<http://www.deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60>

   Under: DEER2011 Update Documentation linked at: [DEER2011 Update Net-To-Gross table](http://www.deeresources.com/DEER2011/download/DEER2011_NTGR_2012-05-16.xls)

   Cells: (U56)

   Sisson and Associates August 16, 2006 EM&V STUDY OF THE ADM MOBILE ENERGY CLINIC 2004-2005 NON-UTILITY ENERGY EFFICIENCY PROGRAM IMPLEMENTATIONS. [↑](#endnote-ref-2)
3. Boiler Cleaning Savings Calculations, Matrix Energy Services and ADM Associates. [↑](#endnote-ref-3)
4. SCE, Measure Cost Revision 5 revised for PG&E by S.L. Blanc 2012

    [↑](#endnote-ref-4)