Work Paper WPSCGNRWH120206A

**Revision 11**

**Southern California Gas Company**

**Storage Tank Water Heaters for Commercial & Industrial Applications**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | TBD |
| **Measure Description** | These measures apply to energy efficient storage water heaters used in commercial or industrial applications to produce hot water. Relative to standard models, energy efficient units typically have features such as larger surface areas for heat transfer and/or additional tank insulation. |
| **Base Case Description** | The base case for this workpaper is defined by the code/standard for storage size water heaters as referenced by Title 20. |
| **Units** | Per Cap-kBtuh |
| **Energy Savings** | Energy Savings differ by climate zone and building type. Refer to Excel Calculation Attachment. |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment. |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment. |
| **Effective Useful Life** | 15 Years; (DEER EUL ID: *WtrHt-Com*) |
| **Measure Installation Type** | Normal Replacement (NR), New Construction (New/NC) |
| **Net-to-Gross Ratio** | 0.6 (DEER NTGR ID: Com-Default>2yrs) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| C | Jan. 21, 2006 | Stu Knoke (EEA) | Original release |
| D | Nov. 20, 2008 | Stu Knoke (ICF) | Added to terms and conditions |
| 5 | May 18, 2012 | Stu Knoke (ICF) | Updated cost and efficiency data |
| 6 | May 27, 2014 | Miguel Urrea (SCG) | * Update to DEER 2014 saving values * Update Workpaper Template * Updated Cost Information |
| 7 | Dec. 15, 2014 | Joseph Pan (SCG) | Title 20 & 24 baseline change for small storage water heaters with input rate less than 75kBtuh. |
| 8 | April 03, 2015 | Miguel Urrea (SCG) | * Updated 40 Gal Storage Water Heater Tier EF from .7 to .67. Made changes to savings and cost to reflect update. * Added application type New Construction * Changed Midstream rebates to preferred delivery method instead of downstream. * Added Industrial and Agriculture building type applications |
| 9 | July 26, 2016 | Miguel Urrea (SCG) | * Updates per Water Heater Disposition (Attachment F) * Removed NC for Small Storage Water Heater * Apply DEER2015 NC values for Large Storage Water Heater * Adjust costs to include installation (Labor and Material) * Changed energy impacts to report per IOU * Added air quality emission requirements |
| 10 | October 16, 2018 | Matthew Mendoza (SCG) | * Incorporate the new efficiency rating of Uniform Energy Factor (UEF) * Added measures to account for UEF change and adoption of Medium and High Draw Storage Tank Water Heaters * Measure costs were updated using the 2010-2012 Ex Ante Measure Cost Study * Updated workpaper to the Statewide Workpaper Template |
| 11 | February 18, 2019 | Matthew Mendoza (SCG) | * Update Workpaper Savings with “DEER-WaterHeater-Calculator-v3.2\_rev25Sep2018” * Update Measure Application Types and Delivery Types |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

A storage water heater, as it pertains to this workpaper, is used to supply hot water to a facility’s end use. The storage water heaters covered within this workpaper are natural gas fired and are used for commercial and industrial applications to produce hot water. The measures in this workpaper relate to high efficiency water heaters as defined by thermal efficiency, Uniform Energy Factor (UEF) value, and/or Energy Factor (EF) value.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | High Efficiency Storage Water heater |
| Existing Condition | N/A |
| Code/Standard | Title 20: Section 1605.3(f) & Title 24: Section 110.3 |
| Industry Standard Practice | N/A |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| TBD |  |  |  | NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et |
| TBD |  |  |  | NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr01 |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr02 |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr03 |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr04 |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr05 |
| TBD |  |  |  | WPSCGNRWH120206\_Rev11\_Msr06 |

* **Eligibility requirements**: All storage water heating units must exceed the UEF or thermal efficiency values described in the following measure summary table to participate in the EE program.
* **Implementation and installation requirements**: This workpaper has savings values for many commercial and industrial building types. Non-Residential building types that are not explicitly included within the measure table tab within attachment A shall use the COM Building type designation.

The measures defined within this workpaper are offered as a Normal Replacement or New Construction (NR/NC) offering. Therefore, the baseline for each measure is to be defined by either Code or standard practice. In this case, all measures are evaluated against the code defined by Title 20, as elaborated on in section 1.4.2. The below table shows the measure and baseline descriptions.

**Measure Summary Table**

|  |  |  |
| --- | --- | --- |
| ***Measure ID*** | ***Measure Description*** | ***Baseline Description*** |
| NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et | Large Storage Water heater with input rating greater than 75 kBTUh and/or one of the following  • Thermal Efficiency greater than 83%  • UEF ≥ .48 for Medium Draw Units  • UEF ≥ .56 for High Draw Units | Large Gas Storage Water Heater, Et = 0.80, Stdby Loss = 0.56%/hr |
| NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et | Large Storage Water heater with input rating greater than 75 kBTUh and/or one of the following  • Thermal Efficiency greater than 90%  • UEF ≥ .76 for Medium Draw Units  • UEF ≥ .80 for High Draw Units | Large Gas Storage Water Heater, Et = 0.80, Stdby Loss = 0.56%/hr |
| WPSCGNRWH120206\_Rev11\_Msr01 | 30 Gallon Medium Draw water heater with a rating of ≥0.64 UEF; Savings Converted into Cap-kBTUh | Medium Draw 30 Gallon Gas Storage Water heater with a rating ≥ 0.60 UEF |
| WPSCGNRWH120206\_Rev11\_Msr02 | 40 Gallon Medium Draw water heater with a rating of ≥0.64 UEF; Savings Converted into Cap-kBTUh | Medium Draw 40 Gallon Gas Storage Water heater with a rating ≥ 0.58 UEF |
| WPSCGNRWH120206\_Rev11\_Msr03 | 50 Gallon Medium Draw water heater with a rating of ≥0.64 UEF; Savings Converted into Cap-kBTUh | Medium Draw 50 Gallon Gas Storage Water heater with a rating ≥ 0.56 UEF |
| WPSCGNRWH120206\_Rev11\_Msr04 | 30 Gallon High Draw water heater with a rating of ≥0.68 UEF; Savings Converted into Cap-kBTUh | High Draw 30 Gallon Gas Storage Water heater with a rating ≥ 0.65 UEF |
| WPSCGNRWH120206\_Rev11\_Msr05 | 40 Gallon High Draw water heater with a rating of ≥0.68 UEF; Savings Converted into Cap-kBTUh | High Draw 40 Gallon Gas Storage Water heater with a rating ≥ 0.64 UEF |
| WPSCGNRWH120206\_Rev11\_Msr06 | 50 Gallon High Draw water heater with a rating of ≥0.68 UEF; Savings Converted into Cap-kBTUh | High Draw 50 Gallon Gas Storage Water heater with a rating ≥ 0.63 UEF |

## 1.2 Technical Description

Commercial and industrial storage water heaters can be used in a variety of ways. These units can be utilized for domestic purposes or it could be used as process hot water. Storage water heaters heat and store water within the appliance at a thermostatically controlled temperature for delivery on demand. Cold water supplied into the storage water heater via the supply line will be stored under pressure and heated by a natural gas burner placed at the bottom of the water heater. The natural gas burner will turn on until the desired set point temperature inside the tank is reached. The high temperature water is then supplied on demand directly or through a recirculation loop, depending on the application.

High efficiency units are characterized by a high thermal efficiency value or high uniform energy factor. Both values take into consideration the amount of heat that is inputted into the system and the amount of heat that is successfully transferred into the water. Several factors are considered in high efficiency units, such as high-quality insulation and better heat transfer materials within the water heater, how the factors affect the energy ratings can be seen in section 1.4.2 and section 2.0.

## 1.3 Installation Types and Delivery Mechanisms

This measure will only be implemented using the Normal Replacement and New Construction installation types. The savings and useful life will only be evaluated for the 1st baseline, no second baseline will be needed. This measure offering will be extended to commercial customers of any building type.

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Normal Replacement (NR) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive  (DnDeemed) | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Incentive  (UpDeemed) | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The measures within DEER and the DEER-WaterHeater-Calculator-v3.2 generated by both SCG and Commission Staff. DEER measures for all small storage water heaters were provided by the approved water heater calculator and given in a Per Unit savings basis. This workpaper uses some assumptions to convert savings into a per Cap-kBTUh savings basis.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | Yes |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | N/A |
| DEER Version | DEER 2018 |
| Reason for Deviation from DEER | N/A |
| DEER Measure IDs Used | |  | | --- | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-MD-0p64UEF | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-MD-0p64UEF | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-MD-0p64UEF | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-HD-0p68UEF | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-HD-0p68UEF | | NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-HD-0p68UEF  NG-WtrHt-LrgStrg-Gas-gte75kBtuh—0p83Et  NG-WtrHt-LrgStrg-Gas-gte75kBtuh—0p90Et | |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| 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 | 0.6 |

Note: Direct install measures that are not hard-to-reach will use the default NTG value.

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

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

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| WtrHt-Com | Commercial Water Heater | Com | SHW | 15 | 0 |

### 1.4.2 Codes and Standards Analysis

The manufacturing of storage water heaters is federally regulated and have established standards within the California Code of Regulations. Title 20, Section 1605.1(f)[[1]](#endnote-2) shows the current standards for water heaters. For gas fired storage water heaters, units with an input rating greater than 75,000 BTUh, the following standards shown in Table 1 will apply. These standards were rated with thermal efficiency (%) and in maximum standby loss (Btu/hr).

**Table 1: Title 20 Standards for Large Water Heaters**



For small gas-fired storage water heaters, units with an input rating of less than or equal to 75,000 BTUh, Title 20 section 1605.1(f) shows the following, rated with Energy Factor (EF).

**Table 2: Title 20 Standards for Small Water Heaters**



As of December 29, 2016, the Department of Energy developed a final ruling within the Federal Registeriii which has changed the way that all residential and some commercial water heating technology would be rated. All water heaters within the scope of the ruling will no longer be rated with the Energy Factor (EF), thermal efficiency, or standby loss but now be using the Uniform Energy Factor (UEF). The UEF is the DOE’s newly developed metric for communicating the energy efficiency of water heaters. UEF ratings are determined by assigning water heaters into one of four different categories of hot water usage and then evaluating their performance based on that usage[[2]](#endnote-3). These categories are based on draw pattern and differ by the labels *very small, low, medium,* and *high*. This allows water heaters to be compared more easily between different types (i.e. Storage and Tankless), so long as they are being compared within those same bins. The final ruling from the Federal Register dated on December 29, 2016 can be found in *Attachment B*. The attachment contains the following table that can be referenced when evaluating the UEF of units that coincide with the current code standards of Title 20 for water heaters.

**Table 3: Equations to Convert Current Title 20 Code to UEF**





The final ruling also contains tables that define what is meant by the draw patterns of very small, low, medium, and high.

Section 429.17 (B) Determine the applicable draw pattern as follows:

(1) For consumer gas-fired water heaters, consumer oil-fired water heaters, consumer electric water heaters, tabletop water heaters, grid enabled water heaters, residential-duty commercial gas water heaters, residential-duty commercial oil filed water heaters: Use the New FHR (First Hour Rating) to select the applicable draw pattern from the table in this paragraph:

**Table 4: Storage Water Heater Draw Patterns**



(2) For instantaneous gas-fired water heaters, instantaneous electric water heaters, and residential-duty commercial electric instantaneous water heaters: Use New Max GPM to select the applicable draw pattern from the table in this paragraph:

**Table 5: Instantaneous Water Heater Draw Patterns**



### 1.4.3 Energy Star Criteria

The Current Energy star criteria for Commercial Water Heaters was last evaluated on March 20, 2013. The criteria covers high-efficiency gas storage and tankless water heaters.[[3]](#endnote-4)

**Table 6: Energy Star Commercial Water Heaters – Eligible Product Types**

|  |  |
| --- | --- |
| **Type** | **ENERGY STAR Requirements** |
| Gas Storage | > 75,000 BTU/hr input |
| <= 140 gallons storage capacity |
| Gas Tankless | >= 4,000 BTU/hr per gallon of stored water |

**Table 7: Energy Star Requirements for Qualified Commercial Gas Water Heaters**

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Type** | **ENERGY STAR Requirements** |
| Thermal Efficiency (TE) or Energy Factor (EF) | Storage; | TE >= 0.94 or EF >= 0.93 |
| Instantaneous |
| Maximum Standby Loss | Storage | <= 0.84 \* [(Input Rate / 800) +110(Volumer)1/2] (Btu/hr) |
| Instantaneous | N/A |
| Minimum Manufacturer Limited Warranty | Storage; | 3 years on tank and/or heat exchanger and 1 year on parts |
| Instantaneous |

This workpaper does not include a 3rd tier for Energy Star Rated equipment.

Code Summary

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Reference** |  | **Effective Dates** |
| Title 20 (2017) | Section 1605.1(f) Water Heaters (1) Large Water Heaters |  | October 29, 2013 |
| Title 20 (2017) | Section 1605.1(f) Water Heaters (2) Small Water Heaters |  | April 16, 2015 |
| Federal Register | Vol. 81, No. 250; Department of Energy, Rules and Regulations [Docket No. EERE-2015-BT-TP-0007] |  | December 29, 2016 |

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

### 1.5.1 Federal Register Vol. 81, Doc. #EERE-2015-BT-TP-0007

Attachment B:

* The effective date of this rule was December 29, 2016, proposed by the Department of Energy.
* This ruling was intended to change the way that residential water heating equipment is rated.
* In this final rule, DOE establishes a mathematical conversion factor between the values determined using the Energy Factor (EF), Thermal Efficiency (TE), and Standby Losses (SL) test procedures and the values would be determined using the uniform efficiency descriptor test procedure. The DOE used the conversion factors to derive minimum energy conservation standards in terms of UEF, which can be found in section 1.4.2. The standards denominated in UEF are neither more nor less stringent than the EF-denominated standards for consumer water heaters and for commercial water-heating equipment based on the thermal efficiency and standby loss metrics.
* This ruling has caused a shift in manufacturing to UEF rated appliances as opposed to EF rated appliances. This new workpaper update will address this shift by converting both baseline and measure cases to be rated with UEF, Medium and High Draw.

### 1.5.2 DEER Water Heater Calculator V3.2

* The DEER water heater calculator was updated in September 2018 to incorporate the new draw patterns and UEF ratings that were to be adopted within DEER.
* The past version and DEER entries were based on Energy Factor and have now been converted to UEF and will be incorporating only the medium and high draw patterns.
* The calculator uses historical groundwater temperatures along with measured hourly usages for all residential and many non-residential building types to calculate an estimation of gas savings for different rated units as it correlates to each building type.
* Calculation methodology and calculator was approved by the CPUC to be used in the generation of this workpaper.

### 1.5.3 2010-2012 WO017: Ex Ante Measure Cost Study

Attachment D:

* This Measure Cost Study (MCS) was utilized for cost data amongst all measures within this workpaper.
* This MCS was performed by Itron and published on May 27, 2014.
* The study was performed with the primary objective of developing ex ante measure cos estimates for measures supported by IOU Programs.
* The cost estimates provided by this study is the sole source of cost estimation within this workpaper.

## 1.6 Data Quality and Future Data Needs

The current savings data used within this workpaper was provided by the CPUC and can be found on the DEER READI Database as well as the DEER Water Heater Calculator v3.2. The cost data on the other hand has not been current to the new rating and may not accurately be represented to segregate between the medium and high draw patterns for the different rated volumes. This workpaper assumes that unit costs will remain consistent with the past units and the information found with the ITRON MCS will be used to supplement the cost data. A linear regression formula was developed using the Ex Ante Measure Cost Study to estimate the cost of the new UEF ratings. An explanation of this is found in section 4 of this workpaper. This will be addressed in future revisions.

# Section 2. Calculation Methodology

## 2.1 Conversion from Energy Factor to Uniform Energy Factor

The energy savings for the measures presented in this workpaper are estimated using the tool “DEER-WaterHeater-Calculator-v3.2”[[4]](#footnote-2), with energy factor (EF) values converted to uniform energy factor(UEF). The calculator was used to estimate energy consumption for both baseline and measure, the difference was taken as the measure savings. The DEER tool utilizes hourly output from the DOE2 building prototypes for hot water loads and ambient conditions to estimate hourly gas consumption. The baseline EF values in DEER have been converted to UEF for consistency with the new DOE efficiency requirements. Each measure will have two saving values for UEF medium and High draw instances. The following will show the calculation process.

The annual consumption is estimated with the expression below.

For each hour:

Where,

Currently DEER presents water heating measures and baselines with efficiency in energy factor(EF) values, this workpaper presents them in uniform energy factor(UEF) values.

This workpaper will use the adopted DOE[[5]](#footnote-3) process to convert EF values to UEF. It is important to note that while EF values were based on a single draw pattern, the UEF value is based on four different draw patterns.

The following is the DOE process to convert a non-condensing ultra-low NOx storage water heaters from EF value to UEF efficiency values.

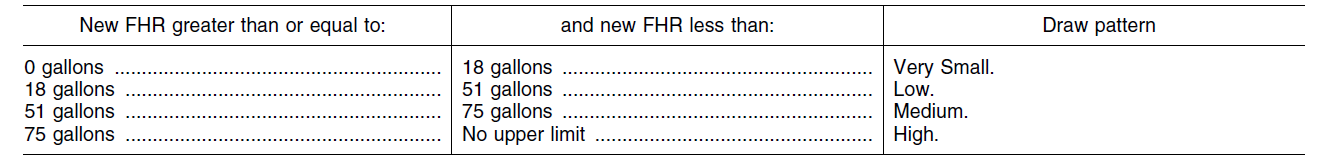
Where,

The new UEF efficiency value is dependent on four distinct draw patterns, hence a water heater will have one out of those four potential UEF values, as opposed to a single possible EF value. The four draw patterns are as followed: very small, low, medium and high. The water heater draw pattern depends on the first hour rating(FHR), FHR is defined as followed for a non-condensing ultra-low NOx water heater.

Where,

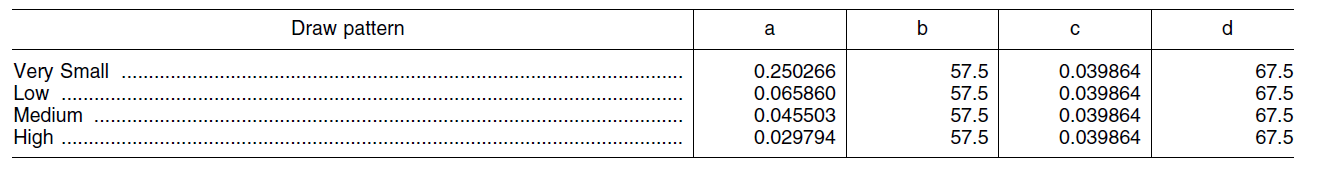
The four draw patterns associated with the new FHR are displayed in the table below.

Table I: First Hour Rating



The constant coefficients to compute UEF for each distinct draw pattern are in the following table.

Table II: Constant Coefficient for UEF WHAM



**Sample Calculation:**

To find the consumption for each measure and baseline, first the baseline must be converted to UEF through the process described above. Consider the DEER measure “RG-WtrHt-SmlStrg-Gas-lte75kBtuh-30G-0p65EF” whose code standard is a 30 gallon unit with an input capacity of 30 kBtuh and EF = 0.63.

First, we compute the new FHR by sorting the CEC database for units of 30 kBtuh capacity, 30-gallon storage and EF = 0.63, the average FHRP is equal to 52 gallons, the new FHR is estimated.

Which by table I, falls under a medium draw pattern.Proceeding to estimate the , in which the constant coefficients as prescribed by Table II for a medium draw pattern are used.

Finally, the UEF is computed for a medium draw,

The consumption for one hour of the year per the water heating schedule used in the “DEER-WaterHeater-Calculator-v3.2” will be calculated. Considering hour 8th which heats 0.6 gallons of water in climate zone 9 for a single-family dwelling.

The above result is for one hour of the year, the process will be conducted for all annual hours and summed to yield the annual water heater load. The savings will be computed as the difference between the measure annual sum and the baseline annual sum.

It is important to note that instantaneous water heaters will use a different method of converting from EF to UEF.[[6]](#endnote-5)

## 2.2 UEF Calculation for Large Commercial water Heaters

This workpaper utilizes the DEER savings values for large commercial water heaters but adds a UEF annotation for those large sized water heaters that have UEF ratings as opposed to thermal efficiency and standby loss ratings. In section 1, the requirements of UEF are added to the original requirements of the DEER measure. These UEF values were estimated within Attachment A, worksheet “AHRI Database + UEF Calcs”. The AHRI water heater database[[7]](#endnote-6) was used to first categorize which water heaters were classified as large. This classification stems from Title 20 Code; table f-3, shown below.

Machine generated alternative text:
Table F-2 
Standards for Large Water Heaters Effective October 29, 2003 
App 
GU gonge wate beaten 
Gas 
Gas samly 
Oil •ala 
instantnean 
wur supply 
EteÜic teaters 
241m 
B twygal 
B tutufgal 
10 
< 10 gal 
gal 
< 10 el 
78 
Q•8W 
0800 
03 + 
I Stmdby based on a F .enture fiffeært s&ed m eqmtims. V, is 
V. is in Md Q is input rate in 
2 Wata and 140 gallons of '*dry we rapircd the standby bs requirement if 
is therrülly R—12S. if a sbndingpibt is a famsistcdcomHsGm. 

Figure 1: Title 20 Standards for Large Water Heaters

The input to volume ratio was used for “Gas Storage Water Heaters” to isolate which water heaters in the AHRI Database should be involved with the calculation. The UEF calculation summarized within section 2.2 was then applied to all water heaters within the database to estimate the First Hour Rating, Medium Draw UEF, and High Draw UEF. The average values for the medium and high draw UEF ratings were then taken for both Tier 1 (>=83% TE) and Tier 2 (>=90% TE) large storage water heaters. These values are used in parallel with the original requirements for both large tier commercial water heating measures.

**Table 6: Average Large Tier UEF Values**

|  |  |  |
| --- | --- | --- |
|  | Tier 1 (>= 83% TE) | Tier 2 (>= 90% TE) |
| Average Medium Draw UEF | **0.48** | **0.63** |
| Average High Draw UEF | **0.56** | **0.72** |

## 2.3 Conversion from Per Unit Savings to Cap-kBTUh Savings

This workpaper modifies available DEER measures to convert the per unit savings to savings per input capacity of the unit for all small category storage water heaters. This was done by using the average input rating per small sized commercial water heater provided in the DEER water heater calculator. The corresponding input rate used in the calculator for each storage volume can be seen in attachment A, within the Energy Impact Tables\_Unit Conv tab. All therm savings per unit provided by the calculator were divided by their corresponding average input rating to find the savings per Cap-kBtuh input rating. These calculations can be found within Attachment A, sheet “Energy Impact Tables\_Unit Conv.”

The following table indicates which measures are taken directly from or created with the DEER READI tool.

READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-MD-0p64UEF | Medium Draw 30 Gallon Gas Storage Water Heater with >.64 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-MD-0p64UEF | Medium Draw 40 Gallon Gas Storage Water Heater with >.64 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-MD-0p64UEF | Medium Draw 50 Gallon Gas Storage Water Heater with >.64 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-HD-0p68UEF | High Draw 30 Gallon Gas Storage Water Heater with >.68 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-HD-0p68UEF | High Draw 40 Gallon Gas Storage Water Heater with >.68 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-HD-0p68UEF | High Draw 50 Gallon Gas Storage Water Heater with >.68 UEF | DEER-WaterHeater-Calculator-v3.2 |
| NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et | Large Gas Storage Water Heater, Et = 0.83, Stdby Loss = 0.56%/hr | DEER 2014 |
| NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et | Large Gas Storage Water Heater, Et = 0.90, Stdby Loss = 0.56%/hr | DEER 2014 |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. All measures within this workpaper are gas only measures that have a gas impact profile of “Annual.” Load shapes do not apply to this workpaper.

# Section 4. Costs

To develop cost estimates for both the base case storage water heaters and high efficiency storage water heaters, the ITRON Measure Cost Study was used. This cost study can be found in attachment D. to accommodate for the new UEF ratings, a cost regression was done using the data from the MCS. The regression cost calculator can be found in *attachment C*.

## 4.1 Base Case Cost

The base case costs for each measure is presented in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure ID** | **Base** | | |
| **Material Cost/Unit** | **Labor Cost/Unit** | **Total Cost** |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et* | $ 37.71 | $ 4.64 | $ 42.35 |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et* | $ 37.71 | $ 4.64 | $ 42.35 |
| *WPSCGNRWH120206\_Rev11\_ Msr01* | $ 21.93 | $ 9.73 | $ 31.66 |
| *WPSCGNRWH120206\_Rev11\_ Msr02* | $ 19.40 | $ 8.36 | $ 27.76 |
| *WPSCGNRWH120206\_Rev11\_ Msr03* | $ 20.49 | $ 8.90 | $ 29.39 |
| *WPSCGNRWH120206\_Rev11\_ Msr04* | $ 21.93 | $ 9.73 | $ 31.66 |
| *WPSCGNRWH120206\_Rev11\_ Msr05* | $ 19.40 | $ 8.36 | $ 27.76 |
| *WPSCGNRWH120206\_Rev11\_ Msr06* | $ 20.49 | $ 8.90 | $ 29.39 |

## 4.2 Measure Case Cost

Measure Case Costs for each measure is presented in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure ID** | **Measure** | | |
| **Material Cost/Unit** | **Labor Cost/Unit** | **Total Cost** |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et* | $ 40.85 | $ 4.64 | $ 45.49 |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et* | $ 48.17 | $ 4.64 | $ 52.80 |
| *WPSCGNRWH120206\_Rev11\_ Msr01* | $ 24.79 | $ 9.73 | $ 34.52 |
| *WPSCGNRWH120206\_Rev11\_ Msr02* | $ 24.18 | $ 8.36 | $ 32.54 |
| *WPSCGNRWH120206\_Rev11\_ Msr03* | $ 23.16 | $ 8.90 | $ 32.06 |
| *WPSCGNRWH120206\_Rev11\_ Msr04* | $ 26.29 | $ 9.73 | $ 36.02 |
| *WPSCGNRWH120206\_Rev11\_ Msr05* | $ 27.21 | $ 8.36 | $ 35.57 |
| *WPSCGNRWH120206\_Rev11\_ Msr06* | $ 26.60 | $ 8.90 | $ 35.49 |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| NR | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure ID** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et* | NR | $ 3.14 | $ 3.14 | N/A |
| *NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et* | NR | $ 10.45 | $ 10.45 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr01* | NR | $ 2.86 | $ 2.86 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr02* | NR | $ 4.78 | $ 4.78 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr03* | NR | $ 2.67 | $ 2.67 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr04* | NR | $ 4.36 | $ 4.36 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr05* | NR | $ 7.81 | $ 7.81 | N/A |
| *WPSCGNRWH120206\_Rev11\_ Msr06* | NR | $ 6.10 | $ 6.10 | N/A |

# Attachments

Attachment A – Measure Summary & Calculation Spreadsheet

Attachment B – Federal Register; Vol 81, No. 250; Department of Energy, Rules and Regulations (Docket No. EERE-2015-BT-TB-0007

Attachment C – Cost Regression

Attachment D - 2010-2012\_WO017\_Ex\_Ante\_Measure\_Cost\_Study\_-\_Final\_Report

# References

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7. AHRI Directory of Certified Product Performance; https://www.ahridirectory.org/Search/SearchHome. [↑](#endnote-ref-6)