2018 RESIDENTIAL WATER HEATERS
California Public Utilities Commission, Energy Division
March 1, 2018

1. Review Summary and Covered Workpapers

SCG submitted a calculation methodology for review in the fall of 2017. CPUC staff has elected to review this methodology as part of the 2018 Phase 1 workpaper review so that the outcome can be used for all covered measures moving forward. At this time, this review covers the following measure technologies:

- Gas and conventional electric storage water heaters with 30, 40 and 50 gallon capacities
- Small gas instantaneous water heaters

This disposition updates impacts for water heaters now covered by Uniform Energy Factor (UEF) requirements. This disposition is based on review of draft calculation methods submitted by Southern California Gas (SCG) along with EAR team review of published calculation methods and water heaters currently listed in the CEC and AHRI databases with UEF ratings. Direction in this disposition applies to all measures similar to those described in the workpaper list below. CPUC staff notes that this list is not exhaustive and this disposition shall apply to any measures including saving derived from water heaters covered by a UEF rating. Furthermore, direction covering the development of ex ante savings shall also apply to custom projects for similar measures.

ID	PA	Title
PGECODHW104	PGE	Gas Water Heater
PGECODHW106	PGE	Electric Storage Water Heater
PGECODHW122	PGE	Instantaneous Gas Hot Water Heater
WPSCGNRWH120206A	SCG	Storage Tank Water Heaters for Commercial and Industrial Applications
WPSCGNRWH120206B	SCG	Tankless Water Heaters For Commercial Applications
WPSCGREWH120919A	SCG	Tankless Water Heaters for Single Family and Multifamily Applications
WPSDGENRWH1206	SDG	WPSDGENRWH1206_Rev1_SF_Instantaneous WH for Commercial Applications_FINAL_20180102.zip
WPSDGEREWH0024	SDG	WPSDGEREWH0024_Rev0_SF_ StorageTank WH__FINAL_20171228.zip

2. Development of Measure and Code Baseline Technology Definitions

The EAR team used the following procedure to develop code baseline and measure technology definitions, measure definitions and energy impacts.

2.1. Measure Categories

The objective of the EAR team analysis was to identify typical water heater performance characteristics, in terms of recovery efficiency (RE) and standby losses for all classes of water heaters covered by the most recent USDOE requirements for Uniform Energy Factor (UEF). Table 1 includes the water heater type, size and draw patterns covered by the EAR team analysis. The EAR team analysis did not cover heat pump water heaters or any water heaters with a "very low" testing draw pattern.

Table 1 - Instantaneous and Conventional Storage Water Heater Rating Categories[1]

Energy Type	Type	Criteria	Draw Pattern	Volume (gal)
Gas	Instantaneous	> 50,000 Btu/h, ≤ 200,000 Btu/h	Low Medium High	≤2
Gas	Storage	≤ 75,000 Btu/h	Low Medium High	30 40 50 55 60 75 80
Gas	Residential-Duty, Storage	> 75,000, ≤ 105,000 Btu/h	Low Medium High	50 60 75 80
Electricity	Instantaneous	≤ 12 kW	Low Medium High	≤2
Electricity	Residential-Duty, Instantaneous	> 12 kW, ≤ 58.6 kW	Low Medium High	≤2
Electricity	Storage	-	Low Medium High	30 40 50 55 60 75 80

2.2. Methods for Calculation of Performance Characteristics

The EAR team analyzed all units reported in either the CEC appliance database or the AHRI database with reported UEF values. Only units with at least a reported UEF value were included in the analysis.

2.2.1. Standby Losses

Standby losses are not reported in either the CEC or the AHRI database and are calculated using Equation 1, which is identical to the equation used in the DEER water heating calculator.

Equation 1 - DEER Standby Loss

$$SL = \frac{\frac{R}{E} - 1}{\left(\frac{2}{4,0} - \frac{1}{R \times P} \right)}$$

Where:

Standby Losses = Tank-UA x 67.5ºF

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[1] http://www.energy.ca.gov/title24/2016standards/documents/2016_water_heater_efficiency_guide.pdf

> *RE = Recovery Efficiency*
>
> *EF = Rated Energy Factor*
>
> *P = Input Power Btu/hr*

If EF is not reported, the EAR team calculated EF using the set of equations provided in *"Test Procedures for Consumer and Commercial Water Heaters[2]"*. The sets of equations vary for each type of water heater and for each, as do the regression coefficients used to convert the original energy factor to new uniform energy factor. Instead solving the equations for the new UEF, they are solved for the EF. If RE is not reported, the EAR team did not include the water heater in the analysis.

Figure 1 compares the standby loss calculated using the DEER methods (Equation 1) to the standby loss calculated following the DOE test methods. Figure 2 compares reported EF to the calculated EF when using the reported UEF and the USDOE methods. Because of the variance in results between the two methods, the DEAR team chose to use the DEER methods that relied on reported EF and RE whenever available. Because both the code and EnergyStar level[3] water heaters are non-condensing the regression coefficients for non-condensing (standard or low NO_x) water heaters were used for all water heaters.

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[2] https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf
[3] Among the EnergyStar level water heaters (not exceeding but meeting the EnergyStar UEF requirements), the ones with the highest recovery efficiency (83%) are non-condensing

**Figure 1 - Comparison of Stanby Loss Using Equation 1 vs. DOE Methods**
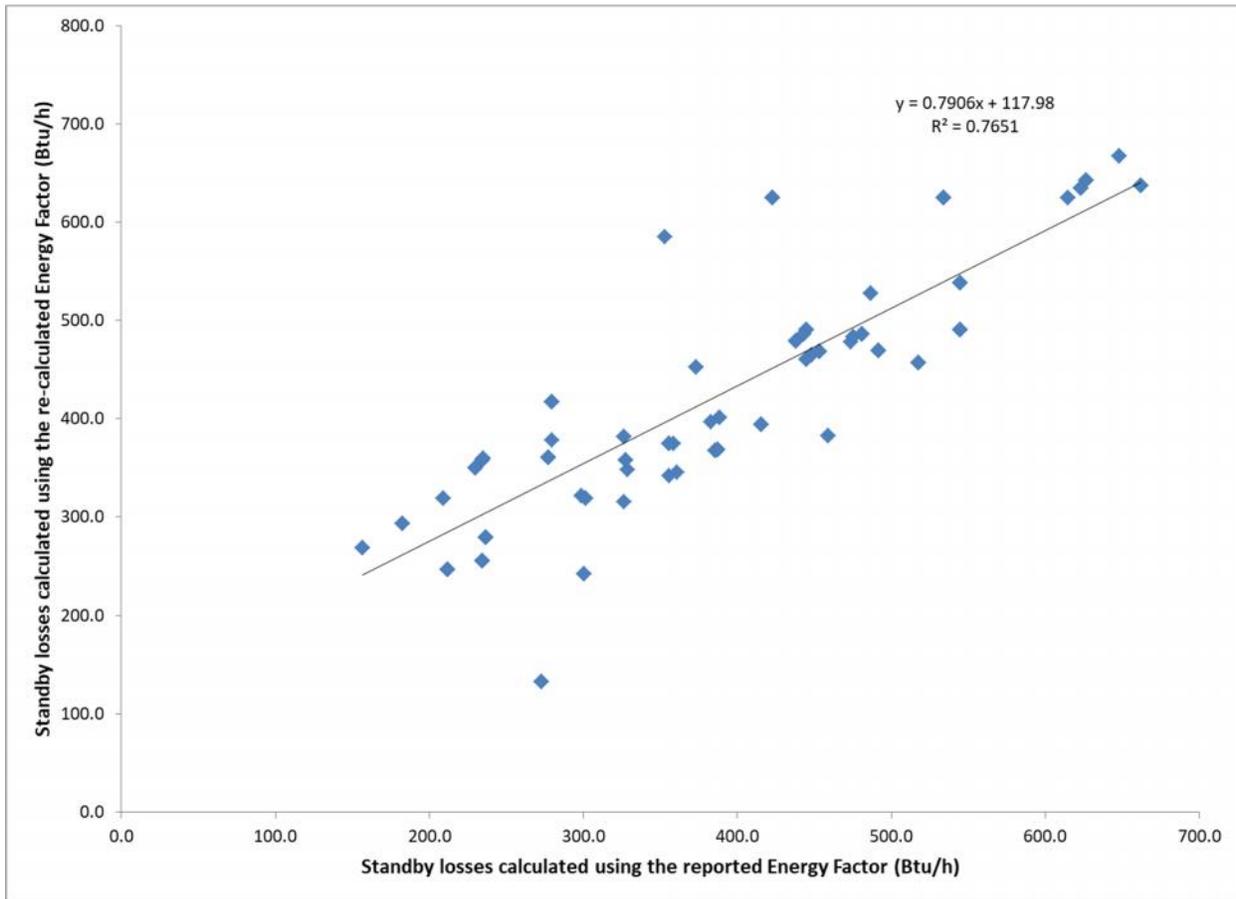
Figure 2 - Comparions of Reported Energy Factor to Calculated Energy Factor Using Reported UEF and DOE Methods
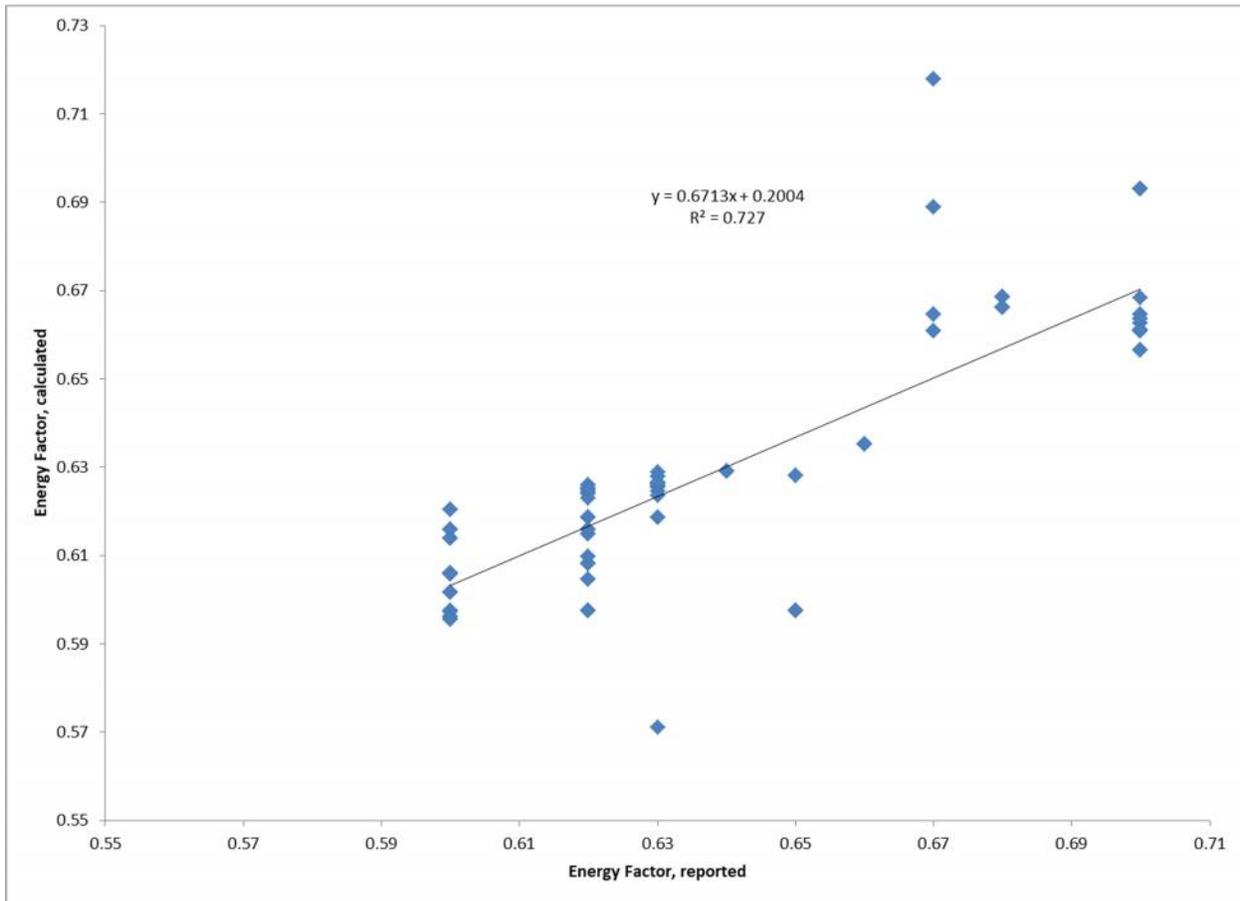
2.3. Pre-Existing, Code Baseline and Measure Characteristics

The EAR team analyzed all water heaters with reported UEF values in both the CEC and AHRI databases to develop code baseline and measure characteristics[4].

2.3.1. Pre-Existing Characteristics

Pre-existing performance characteristics are unchanged from previous versions of DEER.

2.3.2. Code Baseline Characteristics

Code baseline characteristics are based on a subset of listed water heaters that are within a tolerance of the minimum code required UEF. Generally, there were enough water heaters in the database for water heaters that were within the code baseline requirement and about one percent greater than the code baseline requirement. In a small number of cases this tolerance needed to be increased so that enough water heaters were available to calculate typical

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[4] See attached workbook: "CEC+AHRI_WaterHeaterAnalysis_12Feb2018-1.xlsx"

performance characteristics. Table 2 shows the tolerances used for calculating code baseline characteristics for each measure category.

Table 2 - Tolerance Matrix for Calculating Code Baseline Characteristics

Water Heater Category	Tolerance above minimum code requirement		
	LOW DRAW	MEDIUM DRAW	HIGH DRAW
Instantaneous (gal) 2	1.5%	1.0%	1.0%
Storage (gal) 30	1.0%	1.0%	10.0%
Storage (gal) 40	1.0%	1.0%	1.0%
Storage (gal) 50	1.0%	8.0%	1.0%
Storage (gal) 55	1.0%	1.0%	1.0%
Storage (gal) 60	1.0%	1.0%	1.0%
Storage (gal) 75	1.0%	1.0%	1.0%
Storage (gal) 80	1.0%	1.0%	1.0%

2.3.3. Measure Characteristics

SCG has proposed that the measure definition be set at the EnergyStar minimum UEF level for all measure categories. Measure characteristics are based on a subset of listed water heaters that are within a tolerance of the minimum EnergyStar required UEF. Generally, there were enough water heaters in the databases that were within EnergyStar requirements and about one percent above EnergyStar requirements. Table 3 shows the tolerances used for calculating measure performance characteristics for each measure category.

Table 3 - Tolerance Matrix for Calculating Measure Characteristics

Water Heater Category	Tolerance above EnergyStrar requirement		
	LOW DRAW	MEDIUM DRAW	HIGH DRAW
Instantaneous (gal) 2	1.0%	5.0%	5.0%
Storage (gal) 30	1.0%	1.0%	5.0%
Storage (gal) 40	1.0%	5.0%	5.0%
Storage (gal) 50	1.0%	5.0%	5.0%
Storage (gal) 55	1.0%	1.0%	1.0%
Storage (gal) 60	1.0%	1.0%	1.0%
Storage (gal) 75	1.0%	1.0%	1.0%
Storage (gal) 80	1.0%	1.0%	1.0%

3. Water Heater Analysis Workbook

The attached workbook "CEC+AHRI_WaterHeaterAnalysis_12Feb2018-1.xlsx" was used by the EAR team to analyze performance data for water heaters with published UEF values. The workbook requires the input of the tolerance matrices shown in Table 2 and Table 3 so that the upper efficiency boundary is high enough to include a sufficient number of water heaters for calculation of typical code and measure performance characteristics (RE and Standby Loss).

For each bin and water heater type, the spreadsheet reports the following:

- **Inventory:** the quantity of water heaters from the database in each bin that meet the code or measure criteria

- **Recovery efficiency:** the average recovery efficiency of the water heaters in each bin that meet the code or measure criteria

- **Energy factor:** the average energy factor (reported or recalculated) of the water heaters in each bin that meet the code or measure criteria

- **Input power:** the average input power of the water heaters in each bin that meet the code or measure criteria

- **Standby losses:** the average standby losses of the water heaters in each bin that meet the code or measure criteria

- **UEF:** the re-calculated UEF based on the average information reported above

None of the 30 gallons medium draw gas storage water heater in the CEC or AHRI directories meets the EnergyStar requirements. The technology has been defined based on the 40 gallon medium draw gas storage water heater since the Energy Star requirement for the 30 and 40 gallon medium draw gas storage water heater are the same.

No 40 gallons low draw gas storage water heaters are present in the CEC or AHRI directories. The technology for this water heater is based on the data gathered for 30 gallons low draw gas storage water heaters. This approach is conservative as the minimum code efficiency for 30 gallons low draw is greater than for 40 gallons water heaters.

4. DEER Water Heater Calculator

The EAR team updated the DEER water heating calculator[5] to include the following measure categories aligned with those originally proposed by SCG:

- 30, 40, 50 gas storage: medium and high draw
- Small instantaneous: low, medium and high draw

5. Measure Impacts Comparison Workbook

The EAR team developed a workbook that compares impacts for the new EnergyStar qualifying water measures using UEF ratings to older DEER measures using EF ratings[6].

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[5] DEER-WaterHeater-Calculator-v3.1.xlsm
[6] DEER-WaterHeater-EnergyImpacts_Comparison-12Feb2018-1.xlsm