**Work Paper PGECOPRO106**

**Direct Contact Water Heater**

**Revision # 3**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Direct Contact Water Heater**

**Measure Codes H16**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **H16** |
| **Measure Description:** | Replacement of process water boiler with new, direct contact water boiler. Must have Thermal Efficiency (TE) of 90% or better (AFUE > 88% if rated input capacity < 300MBtuh). |
| **Energy Impact Common Units:** | Per MBtuh (1,000 Btuh) of rated input capacity |
| **Base Case Description:** | Source: Describe the existing base case technology that will be replaced with the energy efficient technology (state: existing customer equipment or code/standard). Existing standard efficiency process boiler with assumed efficiency and operating hours.  Source: CEC boiler efficiency listings6, operating hours from Boiler Population Survey[[1]](#endnote-1). |
| **Base Case Energy Consumption:** | 36.7 therms / MBtuh / yr  Source: PG&E Calculations. Base case process boiler with typical efficiency of 80.2% per CEC boiler efficiency listings. |
| **Measure Energy Consumption:** | 30.0 therms / MBtuh / yr  Source: PG&E Calculations. Average boiler meeting program requirements of 90% efficiency or better. |
| **Energy Savings**  **(Base Case – Measure):** | 6.7 therms / MBtuh / yr  Source: PG&E Calculations. |
| **Costs Common Units:** | Per MBtuh (DEER2014 used KBtuh in database, but refers to the same MBtuh value, MBtuh is the industry reference) |
| **Base Case Equipment Cost ($/unit):** | $7.33 / MBtuh  Source: Southern California Gas (SCG) WP 2006-2008[[2]](#endnote-2) |
| **Measure Equipment Cost ($/unit):** | $12.53 / MBtuh  Source: SCG WP 2006-2008.2 |
| **Gross Measure Cost ($/unit)** | $5.20 / MBtuh  Source: SCG WP 2006-2008.2See Section 4 for explanation |
| **Measure Incremental Cost ($/unit):** | $5.20 / MBtuh  Source: SCG WP 2006-2008.2 |
| **Effective Useful Life (years):** | Source: DEER 2014 20 years |
| **Measure Application Type:** | Replace on Burnout (ROB), or New Construction (NC). |
| **Net-to-Gross Ratios:** | Source: DEER 2014 Default > 2 years 0.60 |
| **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 #** | **Revision Date** | | | **Section-by-Section Description of Revisions** | | **Author (Company)** |
| **Revision 0** | **04/11/2008** | | | **Original work paper: Direct Contact Water Heater PGECOPRO106 R0.doc** | | **Jim Kelsey and Nicolas Fauchier-Magnan (kW Engineering)** |
| **Revision 1** | | **05/12/2009** | **Revision 1**  **Changes in Calculation Methodology:** Savings in R0 differ from MDSS due to the use of savings from the process boiler workpaper. R0 and R1 use calculated savings for a direct contact boiler, therefore increased therm savings exist.  **Net –to-Gross (NTG) Ratio** changed per DEER2008 from 0.96 to 0.46 | | Charlene Spoor (PG&E) | |
| **Revision 2** | | **6/10/2012**  **8/22/2012** | **Net-To Gross changed in 2011 DEER to Com-Default>2yrs 0.60**  **Updated BLD, CZ and VIN to ANY per READI nomenclature** | | Charlene Spoor (PG&E) | |
| **Revision 3** | **05/21/2014** | | | **Updated to new template** | | **Charlene Spoor (PG&E Clci)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –*** For this measureonly direct contact water heaters for process end-uses qualify. In direct contact water heater systems design, heat from a flame comes into direct contact with small droplets of cold water which run through a stainless steel heat exchange media. Droplets composed from the process come into direct contact with rising heat from the flame and the water is heated directly. Boilers must meet efficiency requirements based on size as shown in

Table **1** below; please note that based on boiler size, the requirements apply to either AFUE (Annual Fuel Utilization Efficiency) or to thermal efficiency.

**Table 1 - Required Efficiency by Size**

|  |  |
| --- | --- |
| **Input Rating** | **Required Efficiency** |
| ≤300 MBtuh | AFUE ≥ 88% |
| > 300 MBtuh | Thermal Efficiency > 90% |

***Program Restrictions and Guidelines***

The measure applies to industrial process boilers and is not intended for domestic hot water or space heating.

***Terms and Conditions***

Boilers must meet a minimum thermal efficiency of 90% as installed (or AFUE > 88% for boilers with rated input ≤ 300MBtuh). The rebate is downstream, offered to the customer at the time of installation upon receipt of the customer application and invoice. This is not a direct install program.

***Market Applicability***

This measure is applicable to any industrial process boiler. The rebate is offered as Replace on Burnout (ROB) or New Construction (NC), replacing a standard efficiency boiler.

## 1.2 Product Technical Description

This measure encourages the replacement of standard-efficiency boilers with high-efficiency direct contact boilers. Direct contact boilers are designed to extract all possible energy from natural gas combustion; they use a submerged-flame burner where water is directly in contact with the burning gas. Figure 1 below[[3]](#endnote-3) shows an example of a design of a direct contact water heater.

**Figure 1 – Layout of a Direct-Contact Water Heater**



This measure specifically targets process boilers used by industrial end-use customers who manufacture a sellable product. Because process boilers run a significant fraction of the time, a gain in thermal efficiency of a process boiler can result in significant savings.

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2014 Database Format* hyperlink, DEER2014 for code update, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table 2 Measure Application Type[[4]](#endnote-4)

*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* |

## 1.4 Product Base Case and Measure Case Data

## 1.4.1 DEER Base Case and Measure Case Information

* The DEER 2014 data include: Equipment Useful Life, Net to Gross, Initial Service Rate

**Table 3 DEER User and Technology Table**



**Delta Wattage Assumption (ΔW):** This is a gas measure no delta wattage assumptions apply.

**EUL Electric Savings** **(ΔW): DEER Version and Impact IDs**

DEER gives a uniform value of 20 years EUL for all high-efficiency boilers. No EUL value is specified for standard-efficiency boilers, and it is assumed to be 20 years, as for high-efficiency boilers. See Measure IDs D03-066, D03-067 and D03-068, referenced as from CALMAC Report, September 2000.

**Hours of Operation: DEER Version 2014**

24 hours per day X 356 Days per year or 8760 hours per year.

**Net-to-Gross Assumption:** DEER 2014 does not specifically list a NTG for Water Heaters, therefore, the default NTG for measures offered more than 2 years of 0.60 is used.

Measure code H16 rebate is downstream, offered to the customer at the time of installation upon receipt of the customer application and invoice. This is not a direct install program.

Table 4 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 4 DEER Net-to-Gross Ratios

|  |  |
| --- | --- |
|  |  |
| Program Approach | NTG |
| Com Default > 2 Years | 0.60 |

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

* All commercial water heating measures that are not specifically called out in DEER2014 must use this default

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

DEER2014 gives a uniform value of 20 years EUL for all high-efficiency boilers. See Measure IDs D03-066, D03-067 and D03-068, referenced as from CALMAC Report, September 2000.

**Effective Useful Life: DEER Version 2014**

* The Effective Useful Life estimates were downloaded directly from DEER, they match the intended measures for climate zones and building types and vintages.

**In-service rate/first year installation rate**: GSIA is not specifically listed in DEER 2014 however the assumption is the ISR would be 1.

Measure code H16 rebate is downstream, offered to the customer at the time of installation upon receipt of the customer application and invoice. This is not a direct install program.

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

***Title 20:*** This measure falls under Title 20 of the California Energy Regulations. Under this regulation, all boilers for retail sale in California shall meet the efficiency requirements shown in

Table **1** below. It should be noted that for boilers over 300MBtuh, Title 20’s efficiency requirements apply to combustion efficiency, while the requirements of this measure apply to thermal efficiency. However, for most boilers listed in the CEC database,5 thermal and combustion efficiencies are equal.

**Table 5 - Title 20 Requirements for Boiler Combustion Efficiencies** **[[5]](#endnote-5)**



***Title 24:*** This measure does not fall under Title 24

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

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

There are no M&V or other studies which apply to Direct Contact Water Heaters. Information on the base and measure case are found in the other sub-sections of 1.4. Market Potential for California was estimated using the following studies and databases for this measure:

* A study of US industrial and commercial boiler population1
* CEC boiler inventory[[6]](#endnote-6)
* Economic data relating GDP per industry in California and in the US[[7]](#endnote-7)

## 

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

Title 20 requires a minimum combustion efficiency of 80% for all non-residential gas boilers with a maximum rated capacity over 300 MBtuh or 3-phase electrical supply. This covers all the boilers considered in this measure. Please note that the requirements of this measure apply to thermal efficiency, not combustion efficiency.

Process boiler baseline efficiency values were calculated based on efficiency listings published by the California Energy Commission (CEC)6 (referred to as the CEC inventory). Thermal efficiencies (not combustion efficiencies) were used to be consistent with the measure’s requirements. The CEC inventory includes over 3,000 gas boilers for steam and hot water production. The hot water boilers were sorted in order of increasing efficiency. The results are plotted in Figure 1.

The base case efficiency was calculated as a simple average of the thermal efficiencies of boilers listed in the CEC inventory. For the base case, only standard-efficiency boilers (boilers with thermal efficiency between 80% and 82%) were considered. Figure 2 below shows the number of boilers by efficiency level from the CEC database.

No direct contact water heaters are listed in the inventory and we performed out own efficiency benchmarking based on data from five different direct contact boiler manufacturers. Based on this benchmarking, we found that the average available direct contact boiler has an efficiency of 98.1%. Table 6 below shows the results of this benchmarking, and Table 7 represents the associated CEC efficiency data.

**Table 6– Direct Contact Water Heater Benchmarking[[8]](#endnote-8)**



**Table 7 Energy Savings Assumption (ΔW, ΔTherms):** 

**Base Case Costs and Measure Case Costs:**

All costs estimates in this document are based on a cost survey performed by Southern California Gas (SCG).2 SCG interviewed 6 different boiler manufacturers and got price estimates for boilers with capacities below 10 MMBtuh. This data was used to determine an average cost per MMBtuh both for the base case and for the measure.

Please note that the costs taken into account here are only the materials costs. It was assumed that installation costs were the same for the base case and the measure.

Table below presents the base case costs results:

Base case boiler costs approximately $28,752 / 3920(average input capacity MBtuh) = $7.33 per MBtuh

**Table 8 - Average Base Case Boiler Cost Results**



***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 provides references to sections that document the inputs for calculation:

**Table 9 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 | None | None | None | Section 1.4.1 |
| **Gas Savings** | None | 36.7 |  | 6.7 Therms per MBtuh | Section 2 |
| **Hours of operation** | None | 8760 | N/A | 8760 | Section 1.4.1 |
| **Full Cost** | None | $28,727 | N/A | $49,122 ($12.53 per MBtuh) | Section 4.3 |
| **Incremental Cost** | None | N/A | N/A | $20,370 ($5.20 per MBtuh) | Section 4.3 |
| **EUL /RUL** | None | 20 | N/A | 20 | Section 1.4.1 |
| **NTG** | One | 0.6 | N/A | 0.6 |  |
| **ISR** | No | 1 | N/A | 1 | Section 1.4.1 |
| **TOU Factor** | A/C projects only | N/A | N/A | N/A | Section 1.4.5 |

# Section 2. Calculation Methods

Table 10 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 this measure.

## 2.2. Demand Reduction Estimation Methodologies

* There is no anticipated demand reduction associated with this measure

## 2.3. Gas Energy Savings Estimation Methodologies

The key parameters for this energy savings calculation are the average input rating for each measure (see below), the baseline and measure boiler efficiencies (discussed above), and the equivalent full-load hours (see below). The following paragraphs describe how these parameters were determined and present the calculation steps and results.

***Average input rating***

Average input rating was calculated using an analysis of industrial and commercial boilers done for Oak Ridge National Labs in 2005.1 This analysis gives average input ratings of boilers in different industries across the US. To tailor these data to the California industry, we used economic data7 listing the GDP of different industry sectors, both nationwide and in California. Table below lists the summary data and results:

**Table 11- Average Boiler Input Rating by Industries**



***Capacity Factor and Equivalent full-load hours (EFLH)***

Boilers, like many gas systems, have modulating controls that allow them to operate at a fraction of their nominal capacity. As a result, the number of operating hours of a boiler is not an accurate representation of its energy consumption, and the average capacity factor needs to be taken into account. This capacity factor is the ratio of actual energy consumption during a certain time period and the consumption that would have occurred if the boiler were at full capacity during the same period (see formula below):



The capacity factor was calculated using the same method as for the average boiler efficiency: data from the analysis of industrial and commercial boilers1 was combined with industry-specific GDP data7 to get an accurate estimation of the average process boiler capacity factor in California. Equivalent full-load hours are calculated by multiplying the total operating hours of the boiler by its capacity factor. Data for calculating weighted average capacity factor is shown below in Table .

**Table 12 – Average Boiler Capacity Factor by Industries**



***Calculation method and fundamental assumptions***

For calculating energy savings, the following assumptions were used:

* New direct contact unit has the same input rating (measured in MBtuh) as the unit being replaced.
* Both units (old and new) deliver the same amount of hot water on an annual basis (i.e., customer demand for hot water does not change). The direct contact unit will thus have less full-load equivalent full-load hours than the base case unit.

With these assumptions, the energy saved by a new direct contact unit was calculated as follows:



Where:

Q = Energy saved (therms/yr), as a result of installing the direct contact water heater

EFLH = Equivalent Full-Load Hours (hrs/yr). See above for details on how the equivalent full load hours were estimated.

R = input rating (MBtuh, ie kBtu/h)

Eb = Efficiency (%) of the baseline unit being replaced

Em = Efficiency (%) of the new high-efficiency unit (also called the measure efficiency)

100 = Conversion factor from MBtuh to therms

The interim values and final results of the gas savings calculations are presented in Table below:

**Table 13- Gas Savings Calculations**



# *Section 3. Load Shapes*

Load shapes for base case and measure case are based on E3 calculator load shapes and follow a DEER 2014 Annual gas impact profile.

## 3.1 Base Case Load Shapes

Base case load shapes follow the DEER 2014 Annual gas impact profile.

## 3.2 Measure Load Shapes

Measure case load shapes follow a DEER 2014 Annual gas impact profile.

# 

# Section 4. Base Case & Measure Costs

**Table 14 DEER Base Case and Measure Cast Cost Definitions**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 Costs***

Table below presents the base case costs results:

Base case boiler costs approximately $28,752 / 3920(average input capacity MBtuh) = $7.33 per MBtuh, based on average input capacity in the survey performed 3,920MBtuh.

**Table 15 - Average Base Case Boiler Cost Results**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost/boiler** | **Total Base Case Cost/MBtuh** |
| H16 | NC | Existing, Code | $28,752 | $N/A | $N/A | $28,752 | $7.33 |
| H16 | ROB | Existing Code | $28,752 | $N/A | $N/A | $28,752 | $7.33 |

***4.2 Measure Costs***

Table16 below presents the measure equipment costs:

Measure cost, direct contact water heater is approximately $49,122 / 3920(average input capacity MBtuh) = $12.53 per MBtuh.

**Table 16 - Average Measure Case Boiler Cost Results**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** | **Total Base Case Cost/MBtuh** |
| H16 | ER | Existing Code | $49,122 | $N/A | $N/A | $49,122 | $12.53 |
| H16 | ROB | Existing Code | $49,122 | $N/A | $N/A | $49,122 | $12.53 |

***4.3 Incremental & Full Measure Costs***

Table 17 below presents the DEER 2014 Definitions of Incremental and Full Measure Costs. The full measure costs are equal to the measure costs and are presented in the table above.

**Table 17 DEER Incremental and Full Measure Cost Definition**

|  |  |  |  |
| --- | --- | --- | --- |
| **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.

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

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 = $49,122-$28,752 = $20,370 / 3920MBtuh = $5.20 per MBtuh

\*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 Type is: **ROB,** or **NC** so the Gross Measure Cost (GMC) is represented by the appropriate equation below:

IMC = Measure Equipment Cost – Base Case Equipment Cost

IMC = $49,122-$28,752 = $20,370 / 3920MBtuh = $5.20 per MBtuh

**Table 18 Summary Table for Section 4**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Base Case Total Cost** | **Measure Case Total Cost[[9]](#endnote-9)** | **Full Measure Case Cost** | **Incremental Measure Cost/per boiler** | **IMC per MBtuh** |
| **H16** | ROB | **$28,752** | **$49,122** | **$49,122** | **$20,370** | **$5.20** |
| **H16** | NC | **$28,752** | **$49,122** | **$49,122** | **$20,370** | **$5.20** |

# 

# References

1. “Characterization of the US Industrial / Commercial Boiler Population,” Oak Ridge National Laboratory by Energy and Environmental Analysis, Inc. , May 2005. [↑](#endnote-ref-1)
2. “Process Boilers (Including Direct Contact Water Heaters); Workpaper for PY2006-2008”, Energy and Environmental Analysis, Inc. for Southern California Gas Company, March 2006. [↑](#endnote-ref-2)
3. “High-Efficiency Direct-Contact Water Heater” by the Office of Industrial technologies – Energy Efficiency and Renewable Energy – U.S. Department of Energy. August 2001 [↑](#endnote-ref-3)
4. 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-4)
5. California Appliance Efficiency Regulations, CEC-400-2006-002-REV2, December 2006. [↑](#endnote-ref-5)
6. CEC efficiency data available online at <http://www.energy.ca.gov/appliances/appliance/excel_based_files/boilers/> [↑](#endnote-ref-6)
7. Bureau of Economic Analysis – Regional Economic Accounts – Gross Domestic Products by State –<http://www.bea.gov/regional/gsp/> - see also appendices [↑](#endnote-ref-7)
8. References used for benchmarking (snapshots of the webpages available in the appendix) :

   Ellis corporation: <http://www.elliscorp.com/>

   Armstrong international, Flo-Direct water heater: <http://armstrong-intl.com/files/common/allproductscatalog/flodirect.pdf>

   Kemco Systems, Direct Contact Water Heater: <http://www.kemcosystems.com/Water-System-Components/TE100-Water-Heater.html>

   Canada Office of Energy Efficiency, Ultra-High efficiency direct contact water heater: <http://oee.nrcan.gc.ca/publications/infosource/pub/ici/caddet/english/r438.cfm?attr=20>

   Sofame Technologies, Inc: <http://www.sofame.com/Benefits_eng.htm>

   QuikWater, High Efficiency Direct Contact Water Heater: <http://www.quikwater.com/qw_products_twintower.htm> [↑](#endnote-ref-8)
9. SCE, Measure Cost Revision 5 revised for PG&E by S.L. Blanc 2012

    [↑](#endnote-ref-9)