**Work Paper SCE15WH003**

**Revision 1**

**Southern California Edison Company**

**Pipe Wrap**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | WH-42194 |
| **Measure Description:** | Pipe wrap – mechanical insulation on hydronic piping serving domestic hot water system in Residential occupancy |
| **Base Case Description:** | Existing hydronic piping serving domestic hot water system without thermal insulation |
| **Energy Impact Common Units:** | Home |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life (years):** | 13.0 |
| **Measure Application Type:** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratios:** | Res-Default-HTR-di : 0.85  Res-Default>2: 0.55 |
| **Important Comments:** | Energy and demand savings methodology utilizes 2014 DEER Residential Single Family (SFM) and Multi Family (MFM) prototypes.  **This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately.** |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13WH003.0 | No | 6/18/2012 | Cassie Cuaresma/SCE | - Original workpaper for 2013 PC |
| SCE13WH003.1 | Yes | 2/28/2014 | Andres Fergadiotti/SCE | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  -New eQUEST simulations for all measures  -New savings for all measures |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

The measure case is the installation of mechanical insulation (pipe wrap) on bare hydronic piping serving a domestic hot water (DHW) system for Residential occupancy, e.g. Residential Single Family. The base case is bare hydronic piping without pipe wrap.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| WH-42194 | Pipe Wrap replacing No Pipe Wrap |

**Eligibility Requirements**

* The measure is limited to mechanical insulation on the hydronic piping and excludes mechanical insulation on the domestic hot water storage tank and/or heater.
* The existing hydronic piping must not have pipe wrap.
* DHW system is served by an electric heater
* Per Title 24 requirements, pipe insulation thickness shall be 1 inch (on pipe diameters of less than 1 inch) and 1-1/2 inch (on pipe diameters above 1 inch and less than 1-1/2 inch) based on (a) fluid temperature range of 105-140 degree F, (b) conductivity range of 0.22-0.28 Btu-inch per hour per sqft per degree F, and (c) insulation mean rating temperature of 100 degree F.

## 1.2 Technical Description

The measure saves energy by limiting or retarding the heat loss (heat transfer) from the DHW hydronic loop to ambient space. This reduces the temperature drop in the DHW hydronic loop. Additionally, the measure can shorten the time that occupants are required to wait until the water is sufficiently hot to use.

Pipe wrap on DHW hydronic loops generally includes fiberglass insulation with a service jacket. Some installations may include closed cell fiber-free elastomeric thermal insulation. The operating and design temperatures on DHW hydronic loops are generally in the order of 120°F to 135°F.

## 1.3 Measure Application Type

### The delivery method is:

### • Financial Support – Direct Install

### The program/install type is:

### • Retrofit Add-On (REA)

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

The energy savings methodology in this workpaper uses the Residential Single Family and Multi-Family DEER prototypical buildings. This measure is not included in the 2014 DEER database.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes (Modified SFM and MFM Prototypes) |
| Deviation from DEER | N/A |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | N/A |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 3 below.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Res-Default-HTR-di | All other EEM with no evaluated NTGR; direct install hard-to-reach only. | Res | Any | DirInstall | 0.85 |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 |

\*Denotes that the column is taken from the DEER NTG Table.

Note that for the direct install delivery mechanism, a distinction between hard to reach and non-hard to reach markets will be made on a project by project basis. This work paper shows the NTG associated with a hard to reach direct install delivery mechanism and the residential defaulted NTG value, where in fact, a measure offered through direct install and is not “hard to reach” will receive a default NTG value.

**Installation Rate**

The installation rate (IR) is obtained from the support table in READi when available. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 4 below.

Table 4 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | GSIAValue\* |
| Def-GSIA | Default GSIA values | Res | Any | DirInstall | 1 |

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the workpaper refer the Excel calculation template. (In the event that the READi IDs do not support the technology in this workpaper simply indicate “Non-DEER”.)

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measure Case UseCategory | Service and Domestic Hot Water (SHW) |
| Measure Case UseSubCats | Water Distribution (Distribute) |
| Measure Case TechGroups | Liquid Circulation (LiquidCirc) |
| Measure Case TechTypes | Pipe Insulation (PipeIns) |
| Base Case TechGroups | Liquid Circulation (LiquidCirc) |
| Base Case TechTypes | Non-DEER |

### 1.4.2 Codes and Standards Analysis

**Title 24 (2013)**

This work paper assumes that the installation of mechanical insulation on hydronic piping will follow code requirements, where piping will serve domestic hot water system with fluid temperature range between 105*°*F and 140*°*F. In residential buildings, nominal pipe diameter is expected to be in most cases between ¾ inch and 1-1/2 inch requiring a minimum and maximum insulation thickness of 1.0 and 1.5 inch respectively at an insulation mean rating temperature of 100*°*F per Table 120.3-A Pipe Insulation Thickness of the Standards [352]. The related section is indicated below:

|  |
| --- |
| **SECTION 150.0 – MANDATORY FEATURES AND DEVICES**  2. **Water piping and cooling system line insulation thickness and conductivity.** Piping shall be insulated to the thicknesses as follows:  A. All domestic hot water system piping conditions listed below, whether buried or unburied, must be insulated and the insulation thickness shall be selected based on the conductivity range in TABLE 120.3-A and the insulation level shall be selected from the fluid temperature range based on the thickness requirements in TABLE 120.3-A:  i. The first 5 feet (1.5 meters) of hot and cold water pipes from the storage tank.  ii. All piping with a nominal diameter of 3/4 inch (19 millimeter) or larger.  iii. All piping associated with a domestic hot water recirculation system regardless of the pipe diameter.  iv. Piping from the heating source to storage tank or between tanks.  v. Piping buried below grade.  vi. All hot water pipes from the heating source to the kitchen fixtures.  B. In addition to insulation requirements, all domestic hot water pipes that are buried below grade must be installed in a water proof and non-crushable casing or sleeve that allows for installation, removal, and replacement of the enclosed pipe and insulation.  C. Pipe for cooling system lines shall be insulated as specified in Subsection A. Piping for steam and hydronic heating systems or hot water systems with pressure above 15 psig (103 kPa) shall meet the requirements in TABLE 120.3-A.  **EXCEPTION 1 to Section 150.0(j)2:** Factory-installed piping within space-conditioning equipment certified under Section 110.1 or 110.2.  **EXCEPTION 2 to Section 150.0(j)2:** Piping that serves process loads, gas piping, cold domestic water piping, condensate drains, roof drains, vents, or waste piping.  **EXCEPTION 3 to Section 150.0(j)2:** Piping that penetrates framing members shall not be required to have pipe insulation for the distance of the framing penetration. Metal piping that penetrates metal framing shall use grommets, plugs, wrapping or other insulating material to assure that no contact is made with the metal framing. Insulation shall butt securely against all framing members.  **EXCEPTION 4 to Section 150.0(j)2:** Piping installed in interior or exterior walls shall not be required to have pipe insulation if all of the requirements are met for compliance with Quality Insulation Installation (QII) as specified in the Reference Residential Appendix RA3.5.  **EXCEPTION 5 to Section 150.0(j)2:** Piping installed in attics with a minimum of 4 inches (10 cm) of attic insulation on top of the piping shall not be required to have pipe insulation. |

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | 2013 BUILDING ENERGY EFFICIENCY STANDARDS For Residential and Nonresidential Buildings [352], Section 150.0, Table 120.3-A | July 1, 2014 |

### 1.4.3 Non-DEER Study Review

Non-DEER data used in the preparation of this workpaper included “heat loss from pipe systems to air” data from CHAPTER 26 – Insulation for Mechanical Systems, 2005 ASHRAE Handbook—Fundamentals [155] and The Engineering Toolbox: Resources, Tools and Basic Information for Engineering and Design of Technical Applications [409].

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, EUL\_Summary\_10-1-08.xls [213], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

Table 7 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| WtrHt-WH-R4PipeIns-Elec | Non-Residential | HVAC | Pipe Wrap | 13 | N/A |

# Section 2. Energy Savings & Demand Reduction Calculations

Energy savings on the measure were estimated using 2014 DEER Residential Single Family (SFM) and Multi-Family (MFM) prototypes. The SFM prototype contains two single-story and two two-story homes in different configurations (orientations), each with a dedicated DHW hydronic system with a DHW heater and hydronic loop. Similarly, the MFM prototype contains two buildings with multiple living spaces and dedicated DHW systems serving each space (total of 24 circulation loops). Energy and demand savings were estimated using comparative (parametric) runs on the hydronic loop heat losses (eQUEST parameter: “CIRCULATION-LOOP (LOOP)/SUPPLY-UA”). Sample input parameters on the SFM prototype, Base Case (uninsulated/bare pipe) and Measure Case (insulated pipe), are presented in the table below:

**Table 8 Energy Simulation Input Parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| eQUEST Input Parameters | DEER Prototype from MASControl  (Insulated Pipe) | Base Case, Derated  (Bare Pipe) | Measure Case  (Insulated Pipe) |
| DHW type | Electricity | Electricity | Electricity |
| Design HW Temp, °F | 135.0 | 135.0 | 135.0 |
| Loop Design DT, °F | 80.0 | 80.0 | 80.0 |
| Process Flow, GPM | Default flow | Default flow | Default flow |
| DHW Demand Schedule | Default (e.g., DHW SF2 R-Lp Prc1) | Default (e.g., DHW SF2 R-Lp Prc1) | Default (e.g., DHW SF2 R-Lp Prc1) |
| DHW Loop Losses per ASHRAE (Btu/h-ft)  [Then converted to SUPPLY-UA: Btu/h-F] | 0.0 | 10.6 | 7.0 |
| Loop location | Not indicated | Zone | Zone |
| Assign Losses to | Dom Hot Water Loop | Dom Hot Water Loop | Dom Hot Water Loop |
| Setpoint Temperature (Fixed), °F | 135.0 | 135.0 | 135.0 |
| Combined Equipment capacity (Total of 4 homes), Mbtu/h | 0.20 | 0.20 | 0.20 |
| Tank Volume, Gallons per home | 40.0 | 40.0 | 40.0 |

The DEER prototype (in both SFM and MFM) includes a default heat loss (SUPPLY-UA) input parameter of 0.0 Btu/h-F (e.g., representative of an ideal insulated pipe system with no heat lost). This parameter was adjusted for both Base Case and Measure Case, based on the documentation described below. Units were converted from Btu/h-ft to Btu/h-F to be accepted by the energy model. No other eQUEST input parameters were modified during the energy simulations.

**Base Case (Un-Insulated Pipe)**

Base case heat loss was calculated using empirical documentation published by ASHRAE in CHAPTER 26 – Insulation for Mechanical Systems, 2005 ASHRAE Handbook—Fundamentals [155]:

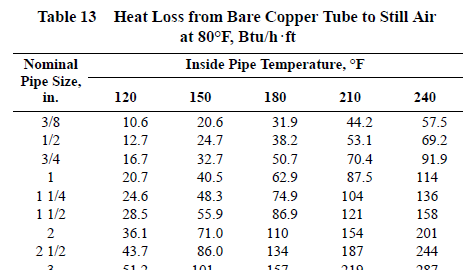


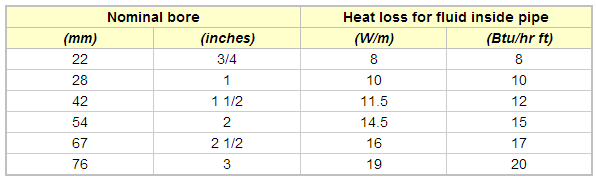
Figure 1 ASHRAE Table for Heat Loss from Bare Copper Tube

Assuming a design water temperature of 135°F, a temperature difference between the fluid and ambient in the order of 55 degree F, and a ¾” pipe diameter, the heat loss from the un-insulated piping was interpolated to be:

Per engineering judgment and assessment of the magnitude of savings, this parameter was further derated to a more conservative value of 10.6 Btu/h-ft. Thereafter, units on the parameter were then converted to Btu/h-F to be accepted in the energy model.

**Measure Case (Insulated Pipe)**

The measure case assumes that, although the hydronic loop is insulated, there is still some amount of heat loss to the surrounding air through the insulation, valves, and/or connections to the heater. Per The Engineering Toolbox [409] published documentation, Figure 2, heat loss on the insulated copper pipe is assumed to be 8.0 Btu/h-ft, assuming a water temperature of 135*°*F, a ¾” pipe diameter, and a 99*°*F temperature differential between the water temperature and ambient air. Further, this parameter was slightly derated to 7.0 Btu/h-ft to account for a slightly lower temperature difference between the fluid and ambient temperature. Thereafter, this parameter was converted to Btu/h-F to be accepted by the energy model.



Assumptions: 99°F temperature differential, 1 in. insulation, conductivity k = 0.3 Btu-in/ft2-h-°F

Figure 2 Heat Loss from Insulated Copper Pipes

**Energy Simulation and Results**

eQUEST simulations were performed for both Base and Measure cases, with the only adjustment being the heat loss (SUPPLY-UA) parameter, as shown in Table 8. As a conservative assumption, the location of the hydronic loop was assumed to be within the “Zone”, representing the lowest heat loss rate compare to alternative locations (Outdoor, Tunnel, or Underground) since the temperature difference between the fluid and ambient (zone) is the lowest.

All energy simulation runs utilized the DEER 2014 weather files (CTZ2010).

Since the DEER Residential prototypes include multiple homes and hydronic loops, the total kWh and kW savings resulted from the measure were divided by the number of homes/residencies or the number of hydronic loops. To determine the kW reduction for the DEER 2014 climate zone-specific peak periods, the hourly output for the simulation was examined. Savings on Residential Multi-Family prototype (lower savings than that on the Single Family prototype) were mapped to the Mobile Home - Double-Wide (DMO).

Table 9 Energy Savings and Demand Reduction for Single Family Home

|  |  |  |
| --- | --- | --- |
| Climate Zone | kWh Savings per Home | kW Reduction per Home |
| 6 | 153 | 0.01625 |
| 8 | 148 | 0.01625 |
| 9 | 148 | 0.01625 |
| 10 | 145 | 0.01625 |
| 13 | 145 | 0.02992 |
| 14 | 150 | 0.01501 |
| 15 | 118 | 0.02865 |
| 16 | 175 | 0.02992 |

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the HeatPump\_WtrHt-RC load shape. See Table 9 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 10 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Residential – Multi-Family | Residential | HeatPump\_WtrHt-RC |
| Residential – Single-Family | Residential | HeatPump\_WtrHt-RC |
| Residential – Double-Wide Mobile | Residential | HeatPump\_WtrHt-RC |

# 

# Section 4. Base Case & Measure Costs

## For direct install measures SCE directly utilizes one or more contractors as part of the program. The actual cost can vary by contractor, the date in which the work occurred, and by the volume of business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with SCE; therefore, the SCE program tracking system is the only source for this data.

## 4.1 Base Case Cost

For REA measures, the base case cost is $0.00.

## 4.2 Measure Case Cost

Cost information is based on documentation from RSMeans Residential Cost Data [408]. Assuming rubber tubing, flexible closed cell foam type of insulation, and 20 feet of piping per home, the total estimated costs including overhead and profit are: $66.60 for material and $81.40 for labor. Therefore, the total measure case cost is $148.00.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

The gross measure cost (GMC) is the cost to install an energy efficient measure. For REA measures, the GMC is the full cost to purchase and install the measure, as represented by the equation below:

*GMC = Measure Equipment (Material) Cost + Measure Labor Cost = $148.00*

### 4.3.2 Incremental Measure Cost

For REA, the incremental measure cost (IMC) is represented by the equation below:

*IMC = Measure Equipment (Material) Cost + Measure Labor Cost = $148.00*

# Attachments

1. 

1. 

# References



[31]

[155]

[213]

[351]

[352]

[408]

[409]

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |