Work Paper SCE13WH003

**Revision 2**

**Southern California Edison**

**Pipe Wrap**

**For Work Paper Reviewer Use Only**

**List all major comments that occurred during the review. This table may only be removed during management review.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Major Comment** | **Reviewer Name** | **Date** | **Outcome/Resolution** |
| E.g. Please remove measure LT-12345 (LD123) from this work paper because it is no longer eligible for incentives. | Reviewer 1 | 6/1/15 | E.g. Comment incorporated. LT-12345 was removed. |
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# At-a-Glance Summary

|  |  |
| --- | --- |
| **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 |
| **Units** | Home |
| **Energy Savings** | 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** | 13.0 |
| **Measure Installation Type** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratio** | Res-Default-HTR-di : 0.85  Res-Default>2: 0.55 |
| **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** |
| 0 | 6/18/2012 | Cassie Cuaresma/SCE | - Original workpaper for 2013 PC |
| 1 | 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 |
| 2 | 02/09/2016 | Jay Bhakta/SCE | -New template update for 2016 program year  -WP effective from 1/1/2016 thru 12/31/2016  -No value modifications |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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Cal TF website: <http://www.caltf.org/>

# 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.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Pipe wrap – mechanical insulation on hydronic piping serving domestic hot water system in Residential occupancy |
| Existing Condition | Existing hydronic piping serving domestic hot water system without thermal insulation |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | 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 Installation Types and Delivery Mechanisms

### The delivery method is:

### • Financial Support – Direct Install

### The program/install type is:

### • Retrofit Add-On (REA)

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | 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. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

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.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**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** |
| 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 |

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

This work paper includes measures that are offered via direct install activities into hard-to-reach (HTR) customer facilities. “Final Resolution E-4700”, dated December 18, 2014, defines specific criteria to classify customer facilities as HTR and also states that two criteria are sufficient to identify HTR customers if one of the criteria met is the geographic criteria.

SCE’s Commercial Direct Install program delivers free and low cost energy efficiency hardware retrofits through installation contractors to reduce peak demand and energy savings for small and medium commercial customers. The barriers for customer participation include limited capital resources, lack of expertise and understanding of the understanding of the benefits of energy efficiency, a suspicion of the “free offer” and its legitimacy, and language and cultural barriers. The program also addresses the ongoing concern with “split incentives”, where the customer is not the owner of the property, and therefore, lack incentive to improve their energy usage. SCE’s Commercial Direct Install program will track the following three (3) customer data points to identify direct install activities in HTR customer facilities. If geography and business size criteria are satisfied, SCE will identify the customer as HTR. If geography and language criteria are satisfied, SCE will identify the customer as HTR. Other measures in the Commercial Direct Install program will receive default NTG (NTGR\_ID: Com-Default>2), unless otherwise specified in DEER.

**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-WH-R4PipeIns-Elec | Pipe Insulation - Electric Water Heater | Res | HVAC | 13 | 4.3 |

### 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. |

Code Summary

|  |  |  |
| --- | --- | --- |
| **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 |

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

### 1.5.1 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].

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

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:

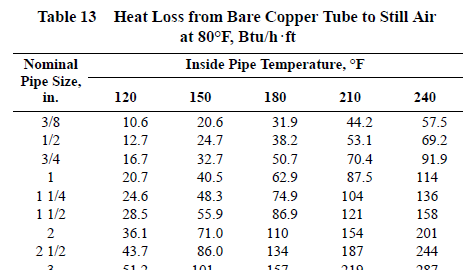
**Energy Simulation Input Parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| 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]:



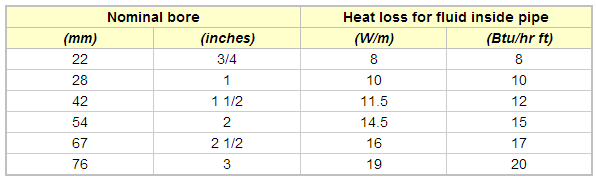
**Figure 1 ASHRAE Table for Heat Loss from Bare Copper Tube**

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).

**Energy Savings and Demand Reduction for Single Family Home**

|  |  |  |
| --- | --- | --- |
| Climate Zone | kWh Savings per Home | kW Reduction per Home |
| 6 | 152.50 | 0.01625 |
| 8 | 147.50 | 0.01625 |
| 9 | 147.50 | 0.01625 |
| 10 | 145.00 | 0.01625 |
| 13 | 145.00 | 0.02992 |
| 14 | 150.00 | 0.01501 |
| 15 | 117.50 | 0.02865 |
| 16 | 175.00 | 0.02992 |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

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

# Section 4. 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 Full and Incremental Measure Cost

**Full Measure Cost**

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

*FMC = 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*

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| WH-42194 | REA | $148 | $148 | N/A |

# Attachments

1. 

1. 

# References



[155]

[352]

[408]

[409]