**Work Paper PGE3PREF114**

**Chilled Glycol Pipe Insulation**

**Revision # 1**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Chilled Glycol Pipe Insulation**

**Measure Codes MBX, MBY, MBV, MBW**

**CLEAResult**

# At-a-Glance Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **MBX** | **MBY** | **MBV** | **MBW** |
| **Measure Description:** | This measure is for insulating previously uninsulated chilled glycol pipe lines in both indoor and outdoor applications for a refrigeration process end-use. | | | |
| **Energy Impact Common Units:** | Per linear foot of chilled glycol pipe insulation. | | | |
| **Base Case Description:** | Previously uninsulated pipe for transport of chilled glycol for process end-use. | | | |
| **Base Case Energy Consumption:** | Source: Base case energy usage varies by climate zone. | | | |
| **Measure Energy Consumption:** | Source: Measure kWh energy consumption varies based on climate zone. | | | |
| **Energy Savings**  **(Base Case – Measure):** | Source: Measure kWh energy savings varies based on climate zone. | | | |
| **Costs Common Units:** | Per linear foot of chilled glycol pipe insulated. | | | |
| **Base Case Equipment Cost ($/unit):** | Base case cost is $0.00. | | | |
| **Measure Equipment Cost ($/unit):** | Source: RS Means 2008. The measure equipment cost assumes the full cost of the pipe insulation. Measure Equipment Cost is $4.10/ln ft. | | | |
| **Gross Measure Cost ($/unit)** | RS Means 2008. The measure equipment cost assumes the full cost of the pipe insulation plus labor. Gross Measure Cost is $10.30/ ln ft. See Section 4 for explanation. | | | |
| **Measure Incremental Cost ($/unit):** | Source: RS Means 2008. See above explanation  REA = measure equipment cost – base case equipment cost. | | | |
| **Effective Useful Life (years):** | Source: DEER 2014. 11 Years. | | | |
| **Measure Application Type:** | This measure is a REA measure type. | | | |
| **Net-to-Gross Ratios:** | Source: DEER 2011. Agricultural Custom Default. NTG is 0.70. | | | |
| **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**  Principal, CES Products and Programs |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 06/22/2012 | Chilled Glycol Pipe Insulation | Danny Ng and Michael Corbett (Resource Solutions Group) |
| Revision 1 | 05/22/2014 | Updated Work Paper to New Format, Updated Weather Data | Sarah Schiller and Mike Diep (CLEAResult) |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –*** This measure is for insulating previously uninsulated chilled glycol pipe lines in both indoor and outdoor process cooling end-use applications. Indoor installations are only applicable in unconditioned spaces, which is typical. This measure requires that there be no existing pipe insulation.

**Program Restrictions and Guidelines**

This measure is only applicable to specific agricultural industry applications (the winery industry and dairy industry) for process end-use applications. Application of this measure is for the addition of pipe insulation on the existing chilled glycol pipe lines. This equipment is considered a REA measure type as defined by the utilty. The existing condition must either be previously uninsulated chilled glycol piping lines or the existing insulation must be past its expected useful life as defined in Section 1.4.2 below.

**Terms and Conditions:**

* Pipe diameter must be greater than or equal to 1 inch in diameter.
* The installed insulation must be at least 1 inch in thickness.
* Other installations can be considered assuming that the overall insulating value exceeds the requirements of this work paper.The rebate is based on the linear footage of the installed insulation for both indoor and outdoor chilled glycol piping.
  + Chilled fluid, other than glycol, can be considered assuming that the savings is consistent or exceeds the amount of this work paper.
* Product specifications and cut sheets must be provided in order to document that the product meets requirements.

**Market Applicability:**

This measure is to primarily serve PG&E’s Third Party Wine Industry Efficiency Solutions (WIES) Program and Dairy Industry Resource Advantage (DIRA) customers who have electricity distributed to the installation site by PG&E. These customers are associated with the wine industry and dairy industry such as owners and operators of wineries and dairies within the PG&E service territories. The intent of offering Chilled Glycol Pipe Insulation within the WIES and DIRA program is to help these PG&E customers reduce energy usage through a streamlined, cost-effective delivery. Winery and Dairy customers and the vendors that serve them are able to access rebates for this energy efficiency measure without the complication and delay associated with a custom incentive process.

The installation of insulation on previously uninsulated chilled glycol pipes is intended to capture energy savings from process load cooling of winery and dairy product. Installing insulation on pipes that contrain chilled fluid, other than chilled glycol, can be considered assuming that the savings is consistent or exceeds the savings of this work paper. Winery and dairy customers serviced by PG&E in climate zones 1, 2, 3, 4, 5, 11, 12, 13, and 16 can apply for the rebate. Qualifying rebates will be paid downstream based the installation of new pipe insulation on chilled glycol pipe lines with a customer provided proof of payment from a manufacturer or vendor.

## 1.2 Product Technical Description

Industrial winery customers with product cooling requirements typically have long runs of glycol pipe to supply tanks with the cooling capacity necessary to keep the product at an appropriate temperature.

Dairy customers also use chilled glycol in order to bring down the temperature of milk from cows to meet federal guidelines. The milk temperature typically leaves the cows at 98ºF and needs to be brought down to 40ºF. To accomplish this, the typical dairy uses a two stage plate cooler with ground temperature well water doing the first stage of cooling and then chilled glycol doing the second stage of cooling to bring the temperature down to 40ºF.

As the glycol circulates in the line it gains heat from the surrounding environment, forcing the chiller system to do additional work to maintain glycol temperature setpoints. By insulating the glycol pipes, the amount of heat transfer from the surrounding environment to the glycol will be reduced, thus saving energy by reducing the amount of work the compressor must do.

The glycol in the distribution lines gains heat mostly through conductive and convective heat transfer. The amount of heat that is gained is dependent on the thermal conductivity of the piping material, the ambient temperature, the glycol temperature, the surface area, number of hours the cooling system is used and the location of the pipe (indoor vs. outdoor).

Since no two facilities are exactly the same, calculated savings will be based on an average of what is most commonly seen in the field with variables leaning towards the more conservative side.

## 1.3 Measure Application Type

*This section discusses the effective useful life of both the base equipment and the measure.*

The DEER Ex Ante Database Format defines the terms as follows:

Table 1: Measure Application Type

*Identifies the measure application type in the Measure Implementation table in DEER2011.*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| REA | Retrofit Add On | Single baseline (above pre-existing), full measure costs required |

*Chilled Glycol Pipe Insulation is considered a REA measure and therefore qualifies under the Retrofit Add On (REA) application type. Since the base case assumes that the existing chilled glycol pipe lines are not insulated, this measure is for the addition of new insulation in order to achieve electricity savings.*

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The DEER2011 database does not contain the appropriate information for this measure. Though there is no measure for glycol pipe insulation or chilled pipe insulation, the relevant measures are pipe insulation for gas water heaters and insulation for bare suction lines.

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

**Title 20:** This measure does not fall under Title 20 of the California Energy Regulations.

**Title 24:** This measure does not fall under Title 24 of the California Energy Regulations.

Section 120.3 of the 2013 Title 24 Standards states the following for pipe insulation:

“The piping for all space-conditioning and service water-heating systems with fluid temperatures listed in TABLE 120.3-A shall have the amount of insulation specified in Subsection (a) or (b).”

This measure is an exception to this standard because the majority of the piping that is to be insulated is for process cooling as opposed to space-conditioning. This is validated in Exception 2 to Section 150.0(j)2 stated below:

“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.”

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

**Hours of Operation:** Hours of operation are based on the specific process for this measure: process cooling. There are no applicable codes or standards which govern hours of operation.

**Base Case Costs and Measure Case Costs**

**Costs:** There are no costs related to codes and standards. All cost estimates for this measure come from RS Means 2008 and can be found in Section 4 of this work paper.

**Effective Useful Life:** The effective useful life is taken from DEER 2014.[[1]](#endnote-2) Though there is no measure for glycol pipe insulation or chilled pipe insulation, the relevant measures are pipe insulation for gas water heaters and insulation for bare suction lines. Both of these have an Effective Useful Life of 11 years.

**Net-to-Gross Value:** Table 2 below summarizes all applicable Codes and Standards-based Net-to-Gross ratios for programs that may be used by this measure.

Table 2: Codes and Standards Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
| **Program Approach** | **NTG** | **Code or Standard** | |
| **Code or Std.** | **Reference** |
| Third Party Program | 0.70 | N/A | NonRes-sAg-mCust-ci |

The NTG Ratios in Table 2 are appropriate for the measure(s) because:

* There are no applicable codes or standards which define the NTG of this measure, therefore we are using the the Agriculture rate of 0.70 for all custom either electric or natural gas measures.[[2]](#endnote-3)

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

There are no EM&V or other studies which apply to these measures.

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

There are no further data or calculations provided for the support of the measures in this work paper.

### 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 3: Calculation Inputs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Measure Case Average Value** | **Reference Section** |
| **Electric Savings** | Insulation Thickness [inch] | 0 | N/A | 1 | Section 2.1 |
| **Gas Savings** | N/A | 0 | N/A | 0 | Section 2.3 |
| **Hours of operation** | BT | 8,373 | N/A | 8,373 | Section 2.1 |
| **Full Cost** | REA | $0.00 | N/A | $10.30 | Section 4 |
| **Incremental Cost** | REA | $0.00 | N/A | $10.30 | Section 4 |
| **EUL /RUL** | REA | N/A | N/A | 11 | Section 1.4.2 |
| **NTG** | One | 0.70 | N/A | 0.70 | Section 1.4.2 |
| **TOU Factor** | *A/C projects only* | N/A | N/A | N/A | *Section 1.4.5* |

\* Average values taken as average of all measures

**\*\*** Average hours taken across all applicable Climate Zones and for all hours when outdoor air temperature (dry-bulb) is greater than glycol temperature. A more detailed explanation of the source of this information is provided in Section 2.1 with a reference document to how it is calculated.

# Section 2. Calculation Methods

Table 4: Baseline by Measure Application Type

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
| ***REA (retrofit add on)*** | **EUL** | Customer Averarge Baseline | N/A |

Notes:

*Chilled Glycol Pipe Insulation is considered a Retrofit measure and therefore qualifies under the Retrofit Add On (REA) application type. Since the base case assumes that the existing chilled glycol pipe lines are not insulated, this measure is for the addition of new insulation in order to achieve electricity savings.*

## 2.1 Electric Energy Savings Estimation Methodologies

This measure is for the new addition of pipe insulation on chilled glycol lines, Retrofit Add On.

The baseline system in this case is the un-insulated glycol pipe lines. Many of the baseline assumptions were derived from actual glycol pipe insulation projects completed by participants in the Wine Industry Efficiency Solutions (WIES) program and the Dairy Industry Resource Advantage (DIRA) program. The baseline performance assumptions are as follows:

1. The heat transfer coefficient of outdoor air is 4.0 BTU/(hr.\*ft.2\*F). For indoor air, it is 1.4 BTU/(hr.\*ft.2\*F). This is an estimate based on the range of 0.5 to 4.4 for the free convection of air[[3]](#endnote-4).
2. Radiation effects are ignored. Solar radiation values drop off during other hours of the day and on average is only ½ of the maximum solar radiation value. In addition, piping is usually run along building walls, and so those hours of solar radiation are further cut in ½. With some piping in shaded areas and others not (or some piping along the north, south, east, or west wall), the variation on outside piping leads to greater uncertainty and inaccuracy in the calculation when trying to take into account radiation effects on heat transfer (than if these effects were ignored). Ignoring solar radiation effects for outdoor piping, specifically, results in more conservative savings estimates, as well.
3. The heat transfer coefficient of the glycol inside the pipe is 150 BTU/(hr.\*ft.2\*F). This number was again on the lower end where the range of the heat transfer coefficient for the forced convection of water can range typically from 8.8 to 1,761.2. Assuming a 50/50 mix of ethylene glycol and water mixture, the heat coefficient of the glycol mixture would be in the range of 6 to 1,255 (thermal conductivity of water is approximately 0.609 and thermal conductivity of glycol is 0.258; average thermal conductivity for the two is 0.434, which a 71% reduction factor on the thermal conductivity of water alone).For slower flows, it is expected that the convective heat transfer coefficient will be lower and thus a value of 150 was chosen.[[4]](#endnote-5)
4. There is convection and conduction radial heat transfer in this model.The thermal conductivity for PVC pipe is 0.11 BTU/(hr.\*ft.\*F).[[5]](#endnote-6),[[6]](#endnote-7)
5. Chilled glycol piping is typically PVC pipe. The normal size of the PVC pipe ranges from 2” to 4”.[[7]](#endnote-8) In this work paper, an average pipe size of 3” was used to determine the average energy savings. This is consistent with what has typically been observed in the field.
6. **For Wineries:** Wineries typically set up their glycol to be at two different temperatures. During cold stabilization, when the wine needs to be cooled down to approximately 30ºF (on average), the glycol is set to 20ºF. During the normal conditions, the glycol is then set to 40ºF to keep the wine cool during normal fermentation. Cold stabilization typically occurs in the winter time and is assumed to occur during the months of January and February for this work paper. The rest of the months consist of normal glycol temperatures. The average glycol temperature is thus 36.7ºF during the year.
7. **For Dairies:** Dairies typically set up their glycol to be the same temperature year round. Since the milk needs to be cooled down to 40ºF, the glycol temperature is typically set to 35ºF.
8. The chiller has an efficiency rating of 1.0 kW/ton. This is based on an average of the efficiencies of the chillers (1.2 kW/ton for air cooled chillers and 0.8 kW/ton for water cooled chillers estimated). These values are conservative with industrial refrigeration systems in the field.[[8]](#endnote-9)
9. Ambient temperature comes from weather data and is based on each climate zone.[[9]](#endnote-10)

The proposed system is insulated pipe. The proposed performance assumptions are as follows:

1. The insulation is 1-inch thick.
2. The insulation k-factor is 0.215 (BTU\*in/(hr.\*ft.2\*F)). This was obtained by taking a straight average of what recent participants actually bought to insulate their pipes. This value remains conservative with respect to the weighted average that produces a lower k-value.[[10]](#endnote-11) Other insulating projects may be considered if the k-factor is documented to provide additional or consistent savings within this work paper.
3. The rest of the performance assumptions are the same as those listed above for the baseline assumptions.

Calculations of the energy savings follow the methodology described below:

The overall heat flow is given by the equation:

 (BTU/hr. lost)

Where,

UA = overall thermal conductance (and its inverse is the overall thermal resistance)

The overall thermal resistance without insulation is given by the equation:

 (BTU/hr.- ºF)

The overall thermal resistance with insulation is given by the equation:

 (BTU/hr.- ºF)

Where,

hair = heat transfer from air to pipe

1.4 BTU/hr.-ft.2-F for still air (indoors)

4.0 BTU/hr.-ft.2-F for moving air (outdoors)

hglycol = heat transfer from glycol to pipe

150 BTU/hr.-ft.2-F

kpipe = thermal conductivity of pipe

0.11 BTU/hr.-ft.-F for PVC from baseline assumptions

226 BTU/hr.-ft.-F for Copper from baseline assumptions

8.67 BTU/hr.-ft.-F for Stainless Steel from baseline assumptions

kinsulation = thermal conductivity of insulation

0.215 BTU\*in/(hr.\*ft.2\*F) from proposed system assumptions

L = length of pipe, ft. from actual project samples

r1 = inner radius of pipe, ft.

r2 = outer radius of pipe, ft.

r3 = outer radius of insulation, ft. (outer pipe radius plus insulation thickness)

**kWh/year Reduction:** After the amount of heat that is absorbed by the glycol is calculated, the amount of energy used by the chiller to remove this heat can be calculated by the following equation:

kWhused = BTU/hr. lost / 12,000 BTU/hr./Ton x Effchiller x Hours

Where,

BTU/hr. lost = Overall heat flow (as calculated in the above section)

Effchiller = Average Chiller Efficiency, kW/ton

Hours = Hours when ambient temperature is greater than the desired glycol temperature, otherwise no load is assumed to be added to the chiller. These are the effective hours of heat load being added to the chiller that the chiller will need to reject. While the hours for the baseline (uninsulated pipe) and proposed (insulated pipe) are unchanged, the rate of heat transfer that is occurring is changed. This reduction in heat transfer rate is where the savings in energy comes from.

The energy savings for each measure is calculated by subtracting the total amount of energy lost from insulated pipe by the total amount of energy lost by un-insulated pipe.

kWhsaved = kWhused un-insulated – kWhused insulated

An analysis was done on actual projects to determine inputs to the above calculation that would best represent typical parameters for pipe sizing, pipe material, pipe length, etc… These parameters were then input into calculators for each specific climate zone, and energy savings were calculated for each case.[[11]](#endnote-12)

## 2.2. Demand Reduction Estimation Methodologies

The peak kW is calculated by taking the average ambient temperatures during the peak hours. The DEER peak dates[[12]](#endnote-13) for each climate zone are as follows:

Table 5: DEER Peak Loads

|  |  |
| --- | --- |
| **Climate Zone** | **Peak Dates** |
| 1 | Sep 30 to Oct 2 |
| 2 | Jul 22 to Jul 24 |
| 3 | Jul 17 to Jul 19 |
| 4 | Jul 17 to Jul 19 |
| 5 | Sep 3 to Sep 5 |
| 6 | Jul 9 to Jul 11 |
| 7 | Sep 9 to Sep 11 |
| 8 | Sep 23 to Sep 25 |
| 9 | Aug 6 to Aug 8 |
| 10 | Jul 8 to Jul 10 |
| 11 | Jul 31 to Aug 2 |
| 12 | Aug 5 to Aug 7 |
| 13 | Aug 14 to Aug 16 |
| 14 | Jul 9 to Jul 11 |
| 15 | Jul 30 to Aug 1 |
| 16 | Aug 6 to Aug 8 |

Using the average temperature within the time range for each DEER peak period, the peak kW is calculated using the following equation:

kW = BTU/hr. lost / 12,000 BTU/hr./Ton x Effchiller

Where,

BTU/hr. lost = Overall heat flow (as calculated in the above section except using the DEER peak period average temperature.)

Effchiller = Average Chiller Efficiency, kW/ton

Therefore, the DEER peak demand savings represent the savings that occur during the DEER peak period that result from the difference in temperature between the glycol line and the average outside air dry-bulb temperature taken during the DEER peak period.

The peak kW savings for each measure is calculated by subtracting the total amount of power required with insulated pipe from the total amount of power required by un-insulated pipe.

kWsaved = kWun-insulated – kWinsulated

## 2.3. Gas Energy Savings Estimation Methodologies

There are no gas energy savings associated with this measure.

# Section 3. Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the demand load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is called the Measure Load Shape and is the preferred load shape for use in the net benefits calculations. The measure equipment and controls may alter the typical end use profile, making it difficult to select a single demand profile to represent the measure category. The measure demand profile is expected to follow the same typical end use profile as the base case equipment, although slightly lower in overall demand.

The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and whatever load shape data were available at the time of the tool’s creation. In this case the measure load shape “Industrial Refrigeration” is most appropriate to show the possibility that the equipment could be run at any time during the year.

## 3.1 Base Case Load Shapes

The closest load shape chosen for this measure is the 13 = Industrial Refrigeration for wineries and 14 = Agricultural for dairies load shape. See Table for a list of all Building Types and Load Shapes.

Table 6: Base Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Manufacturing – Light Industrial | Industrial (wineries) | 13 = Industrial Refrigeration |
| Manufacturing – Light Industrial | Agricultural (dairies) | 14 = Agricultural |

## 3.2 Measure Load Shapes

There are no measure case load shapes applicable to this measure in the DEER 2011 database. The base case shapes shown below are to be used in the cost avoidance calculation.

Table 7: Measure Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Manufacturing – Light Industrial | Industrial (wineries) | 13 = Industrial Refrigeration |
| Manufacturing – Light Industrial | Agricultural (dairies) | 14 = Agricultural |

### Section 4. Base Case & Measure Costs

Table 8: Base Case EUL/RUL

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
| REA( retrofit add on) | EUL | Calculated as Full Gross Measure Cost | N/A |

## 4.1 Base Case(s) Costs

There are no base case costs as this measure applies to existing chilled glycol piping that is un-insulated.

## 4.2 Measure Case Costs

The following Measure Application Type is appropriate to this measure. The Measure Case Costs are:

Table 9: Equipment and Labor Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| MBX, MBY, MBV, MBW | REA | Bare Un-insulated Pipe | $4.10/Lin.Ft. | $3.52/Lin.Ft. | $2.68/Lin.Ft. | $10.30/Lin. Ft. |

*\*All costs are noted as U.S. Dollar $ per linear foot installed.*

The measure costs above are from RS Means 2008[[13]](#endnote-14) for insulation on 3” pipe.

## 4.3 Incremental & Full Measure Costs

Table 10: Full Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Full Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| REA | $10.30/Lin.Ft. | N/A | $10.30/Lin.Ft |

### *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: REAso 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 = $10.30/Lin.Ft. - $0.00/Ln.Ft.

FMC = $10.30/Lin.Ft

### *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 Types is:REA so the Incremental Measure Cost (IMC) is represented by the appropriate equation below:

IMC = (Measure Equipment Cost + Measure Labor Cost)

\*Note: Unless stated otherwise the measure case and base case labor costs are typically the same, reducing the equation to the following:

IMC = Measure Equipment Cost – Base Case Equipment Cost

IMC = $10.30/Lin.Ft. - $0.00/Ln.Ft.

IMC = $10.30/Lin.Ft.

Table 11: Summary Table of Incremental Measure Cost

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Base Case Total Cost** | **Measure Case Total Cost** | **Gross Measure Case Cost** | **Incremental Measure Cost** |
| MBX, MBY, MBV, MBW | REA | $0.00/Lin.Ft. | $10.30/Lin.Ft | $10.30/Lin.Ft. | $10.30/Lin.Ft. |

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# Input Appendices

1. DEER 2014 EUL Spreadsheet : “Input\_1\_DEER 2014-EUL- table-update\_2014-02-05” [↑](#endnote-ref-2)
2. DEER 2011 NTGR Spreadsheet : “Input\_2\_DEER2011\_NTGR\_2012-05-16” [↑](#endnote-ref-3)
3. Mills, A.F., Basic Heat & Mass Transfer Second Edition, Prentice Hall, New Jersey (1999), “Table 1.4: Orders of magnitude of average convective heat transfer coefficients”. p. 22 [↑](#endnote-ref-4)
4. <http://www.engineeringtoolbox.com/thermal-conductivity-liquids-d_1260.html> [↑](#endnote-ref-5)
5. Mills, A.F., Basic Heat & Mass Transfer Second Edition, Prentice Hall, New Jersey (1999), “Table A.1a: Solid metals: Melting point and thermal properties at 300 K”. p. 905 [↑](#endnote-ref-6)
6. Thermal Conductivity of some common materials:

   <http://www.engineeringtoolbox.com/thermal-conductivity-d_429.html> [↑](#endnote-ref-7)
7. Actual sample project data summary to document pipe size: “Input\_7\_Pipe\_Insulation\_Actual\_Data”

   [↑](#endnote-ref-8)
8. Statewide Manual Appendix C: Minimum Equipment Efficiency (p. 6) : “Input\_8\_App C Min Equipment Efficiency”

   [↑](#endnote-ref-9)
9. Weather data:

   Weather file location: Login to: <http://deeresources.com/> then navigate to <http://deeresources.com/index.php/deer2013-update-for-2014-codes> and refer to: "A workbook of the Weather Data used in DEER2011 and DEER2014 provides a detailed comparison of the two weather data sets." [↑](#endnote-ref-10)
10. Sample project data from 2010-2012 program cycle:

    “Input\_10\_CR\_Pipe\_Insulation\_Verification\_K\_Factor”

    [↑](#endnote-ref-11)
11. Savings Calculation Spreadsheet

    Dairies: “Input\_11\_Calculation\_Template\_PGE\_2013\_2014\_Chilled\_Glycol\_Pipe\_Insulation\_Dairies”

    Wineries: “Input\_11\_Calculation\_Template\_PGE\_2013\_2014\_Chilled\_Glycol\_Pipe\_Insulation\_Wineries” [↑](#endnote-ref-12)
12. Statewide Manual Section 1.4.9: DEER Peak Permanent peak demand reduction Calculations table (p. 1-17) : “Input\_12\_Customized\_1.0\_Policy”

    [↑](#endnote-ref-13)
13. RSMeans Mechanical Cost Data, 31st Annual Edition (2008). Piping Insulation pp. 105-118 [↑](#endnote-ref-14)