![seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND]

Energy Efficiency Obligation Scheme

Guidelines for claiming energy savings from pipe insulation projects

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Contents

1. Introduction

The insulation of thermal piping systems can reduce heat lose and result in improved thermal system efficiency. This improved efficiency results in overall energy savings. Energy savings arising from the insulation of thermal piping systems can be claimed in the case where an obligated party has been material to the savings achieved and can meet additionality requirements as specified in the EEOS guidance. As with other project types, applications the claim energy savings resulting from such projects can be made through the Energy Efficiency Obligation Scheme's (EEOS) Project Evaluation Platform (PEP).

Obligated parties (OPs) may engage directly with clients or use third party administrators to assist companies in undertaking pipe insulation projects. Non-Residential Energy Credit (NREC) applications can be completed to claim energy credits associated with these projects once the appropriate Measurement and Verification (M&V) of energy savings has been completed.

To claim energy credits from pipe insulation projects, the OP must complete the following:

- An M&V plan detailing the proposed project and methodology selection
- An M&V report detailing the completion of the M&V process as specified in the M&V plan
- Proof that OP was material to completion of the project. (i.e. client declaration stating contribution and involvement of OP)
- Proof of completion of project to Industry standards (i.e. site photos, invoices, audit reports, etc)

This document outlines the requirements, suggested methodologies, and relevant M&V approaches to undertaking a pipe insulation project with the intent of submitting the relevant energy savings for evaluation under the SEAI's EEOS.

2. Requirements for Pipe Insulation Projects

Obligated Parties who wish to claim energy savings made as part of a pipe insulation project must first clearly identify and document a suitable means to authenticate all energy savings achieved as part of the project.

Additionally, the obligated Party must clearly demonstrate the process by which the energy efficiency improvements were identified, what options were explored and the process by which a methodology was selected.

This should be done by means of an M&V plan.

 The M&V plan should detail the following:

- What do we want to do? Why do we want to do it? (what's the OPs role) How are we going to do it?
- How will we measure and verify the savings (and what are they measured against)?
- How will we ensure that the savings (energy and financial) will continue to be delivered over the lifetime of the action?

The M&V plan should also show consideration for **additionality and materiality** in the planning phase by detailing the following:

- How can we provide a demonstrably material contribution and how can the energy efficiency action identified meet the additionality requirement?

It is also recommended that preliminary calculations are conducted in the planning phase, to ensure realistic expectation on the part of the client, and so that the OP can assess the potential energy savings achievable from the project.

3. Determination of energy savings from pipe insulation

There are two appropriate methods for measuring and verifying energy savings as part of a Lighting upgrade project:

a) **metered savings**, whereby the savings resulting from an energy efficiency measure are measured and verified by metering energy use and comparing it against a predetermined baseline.

b) **scaled savings**, whereby the savings resulting from an energy efficiency measure are measured and verified using engineering calculations and supporting documentation.

Metered savings for a pipe insulation project require that OPs gather sufficient energy usage data for a period prior to the implementation of energy efficiency measures. From this data a baseline then must be established. Data must then be gathered on usage after the implantation of the energy efficiency measures. For pipe insulation projects, 12 months of data is required for both baseline data and results data. This is in order to ensure accurate comparison when considering influencing factors such as production and ambient temperature.

Scaled savings for a pipe insulation project require that OPs complete engineering calculations in order to determine the energy savings achieved as part of the project. This is done by calculating the heat loss of the original non-insulated piping system, and of the insulated piping system after all upgrades have been completed.

Scaled savings may only be used where establishing robust measured data for a specific installation is difficult or disproportionately expensive. Due to the nature of pipe insulation projects scaled savings are sometimes deemed to be the more appropriate M&V methodology. Therefore, the SEAI have developed a calculation tool to assist OPs in the M&V process, and to standardise all calculations received as part of pipe insulation projects (See "*Pipe Insulation Heat Loss Calculation Tool*" section below). This standardised process eliminates the need for a traditional M&V report to be submitted as part of an NREC application.

The OP must justify their M&V methodology selection alongside a submission of the SEAIs Pipe Insulation Heat Loss Calculation tool, relevant proof of materiality and additionality, and evidence that the works have been completed to the required industry standard.

4. Pipe Insulation Heat Loss Calculation Tool

The SEAI have developed a tool to assist OPs in the process of determining scaled savings from pipe insulation projects. The purpose of this is to standardise all calculations received as part of pipe insulation projects. This tool uses user input data to determine the heat loss from and uninsulated pipe system, and an insulated pipe system. This allows for the influence of the installation of piping insulation to be calculated in the form of energy savings.

This tool is recommended for use in all pipe insulation projects where scaled savings have been determined as the appropriate M&V methodology. The tool calculates the energy savings based on the following formulas:

- o Conductive heat loss from uninsulated pipe system:

$$Q = \frac{2\pi L (\Delta T)}{\left[\ln \dfrac{\frac{r_o}{r_i}}{k} \right]}$$

Where:

Q = heat transfer from cylinder or pipe (W)

k = thermal conductivity of piping material (W/mK or W/m °C)

L = length of cylinder or pipe (m)

ΔT = Temperature difference between fluid and ambient temperature (°C)

r_o = radius of outer pipe surface

r_o = radius of internal pipe surface

- Conductive heat loss through an insulated cylinder or pipe is:

$$Q_{ins} = \frac{2\pi L(\Delta T)}{\left[\ln\frac{\frac{r_o}{r_i}}{k}\right] + \left[\ln\frac{\frac{r_s}{r_o}}{k_s}\right]}$$

Where:

Q_{ins} = heat transfer from cylinder or pipe (W)

r_s = outside radius of insulation (m)

k_s = thermal conductivity of insulation material (W/mK or W/m °C)

- This equation with inside convective heat resistance can be expressed as:

$$Q_{ins} = \frac{2\pi L(\Delta T)}{\left[\frac{1}{h_c r_i}\right] + \left[\ln\frac{\frac{r_o}{r_i}}{k}\right] + \left[\ln\frac{\frac{r_s}{r_o}}{k_s}\right]}$$

Where:

h_c = convective heat transfer coefficient (W/m^{2}K)

User Guide

The tool allows for the user to input data to determine the energy savings for a specific pipe group. These results can then be recorded in the tool, to cater for projects with multiple pipe groups.

A pipe group is defined by the system parameters which are entered by the user. These are as follows:

Pipe Linear Length	**m**
Pipe internal diameter	mm
Pipe external diameter	mm
Fluid operating temperature	°C
Ambient temperature	°C
Pipe thermal conductivity	W/mK
Thermal system efficiency factor	%
Insulation thermal conductivity	W/mK
Surface Emissivity of insulation	
Insulation thickness	mm
Outside diameter of insulated pipe	mm
Annual operating hours	

The tool can also cater for the insulation of ancillary items within pipe systems (flanged valves, in-line pumps, etc). To allow for the increased surface area of these items, the equivalent of 1m of linear length should be allowed for each piece, with the diameter kept the same as the associated pipework group.

The Pipe insulation calculation tool has two tabs for users to interact with: Calculator and Supporting Data.

Calculator

The first is the "**Calculator**" tab. This tab contains three components: Energy savings calculator, Output overview, and the results recorder.

Energy Savings Calculator

Pipe Group - Input Data			
Pipe Group Reference:			
Pipe:	Linear Length		m
	Inside Diameter (D1)		mm
	Outside Diameter (D2)		mm
	Fluid Operating Temperature		°C
	Ambient Temperature		°C
	Pipe Material		
	Pipe material Thermal Conductivity (W/mK)		
	Thermal System Efficiency factor		
	Insulation Material		
	Thermal Conductivity of Insulation		
	Surface Emmisivity of aluinium foil		
	Insulation Thickness		mm
	Outside Diameter (D3)		mm
	Annual operatal Hours		

Summary of energy savings:			0	
Input	Length of pipe upgrade		0	metres
	Nom. Diameter of pipe			mm
	Thermal System Efficiency factor		0%	
	Annual operatal Hours		0	hours
Output	Heat loss per unit area			W/m²
	Heat Loss saved per linear length			W/m
	Pipe Group Energy saved per annaum			kWh
	Pecentage savings			
	Carbon Savings			Kg CO$_2$

Here, the user inputs the required pipe group parameters to determine the energy savings relevant to the insulation of that specific pipe group.

Output Overview

Output : Heat Loss & Energy Saving calculation						
Description	Unit of measure	Bare or uninsulated Pipe	Insulated Pipe	Heat Loss saving from insulation	Correction Percentage adjustment factor	Thermal System Efficiency factor
Heat Loss per Unit Area	W/m²					0%
Surface Temperature	°C					
Heat Loss per Unit Length	W/m				90%	0%

The output overview provides a summary of the surface temperature and heat loss for the bare and insulated pipe for the purpose of comparison. Here the user is required to enter a **Correction Adjustment Factor relevant** to the specific pipe group. This should account for deviations in insulation quality, insulation coverage, or deviations relevant to the system parameters used.

Results Recorder

Results		
Record calculation results here:		
Pipe Group	Reference:	Final Energy Savings (kWh)
P1		
P2		
P3		
P4		
P5		
P6		
P7		
P8		
P9		
P10		
P11		
P12		
P13		
P14		
P15		
P16		
P17		
P18		
P19		
P20		
P21		
P22		
P23		
P24		
P25		
Total Final Energy Savings (kWh)		**0**

Once the calculations have been complete for a specific pipe group, the results can be recorded, along with a pipe group reference. The user can enter up to 25 pipe groups using the calculator. The project total is provided for submission.

Supporting data

The second tab of the tool is the "**Supporting Data**" tab. Here, users are required to enter supporting data for each pipe group. Images must be uploaded of the pipe group before and after the installation of insulation. Supporting documents, such as insulation data sheets, should also be added here. A screenshot of the calculator results for that pipe group must be included, in order to verify the parameters used and the energy savings entered in the results recorded.

Worked Example

This example is based on the insulation of 4 pipe groups on a site.

The first pipe group, PG A1, contains 20 metres of uninsulated 150 mm diameter bare carbon steel pipe with a thermal conductivity of 54 W/mK, being upgraded with 50 mm rockwool with aluminium foil external surface coating on the insulation. The system thermal efficiency is established as 90%. The fluid operating temperature is 85 ^{0} Celsius hot water which is operational for 8,000 hours per annum. A correction factor of 90% is applied due to the presence of multiple flanges and right-angle bends along the pipe system. The site natural gas energy savings resulting from the insulation of this pipe group are thus determined from the calculator tool as 72,452 kWh per annum.

Pipe Group - Input Data

Pipe Group Reference:
PG A1

Pipe:			
	Linear Length	20	m
	Inside Diameter (D1)	150	mm
	Outside Diameter (D2)	168	mm
	Fluid Operating Temperature	85.0	°C
	Ambient Temperature	9.0	°C
	Pipe Material	Plain Carbon Steel	
	Pipe material Thermal Conductivity (W/mK)	54	
	Thermal System Efficiency factor	90%	
	Insulation Material	Rockwool	
	Thermal Conductivity of Insulation	0.034	
	Surface Emmisivity of aluinium foil	0.9	
	Insulation Thickness	50	mm
	Outside Diameter (D3)	268	mm
	Annual operatal Hours	8000	

Summary of energy savings:			PG A1	
Input	Length of pipe upgrade		20	metres
	Nom. Diameter of pipe		159	mm
	Thermal System Efficiency factor		90%	
	Annual operatal Hours		8,000	hours
Output	Heat loss per unit area		881	W/m²
	Heat Loss saved per linear length		453	W/m
	Pipe Group Energy saved per annaum		72,452	kWh
	Pecentage savings		96%	
	Carbon Savings		14,701	Kg CO$_2$

This result is captured and recorded in the results recorded and supporting data tab under pipe group 1.

Results		
Record calculation results here:		
Pipe Group	**Reference:**	**Final Energy Savings (kWh)**
P1	PG A1	72,452
P2		
P3		
P4		
P5		
P6		
P7		
P8		
P9		
P10		
P11		
P12		
P13		
P14		
P15		
P16		
P17		
P18		
P19		
P20		
P21		
P22		
P23		
P24		
P25		
Total Final Energy Savings (kWh)		**72,452**

Pipe Group 1		
Please insert photos of before and after for pipe upgrade, along with Screenshot of Pipe Calculator results		
Pipe Group Reference	PG A1	
Before	After	Calculator

This process is repeated for the remaining three pipe groups in the system. The energy savings for each result are recorded, and the supporting data added.

The Total energy savings from the site can be obtained once all pipe groups have been entered. The total for the four pipe groups on this site is 307,885 kWh.

Results		
Record calculation results here:		
Pipe Group	**Reference:**	**Final Energy Savings (kWh)**
P1	PG A1	72,452
P2	PG A2	109,437
P3	PG B1	35,133
P4	PG C1	90,863
P5		
P6		
P7		
P8		
P9		
P10		
P11		
P12		
P13		
P14		
P15		
P16		
P17		
P18		
P19		
P20		
P21		
P22		
P23		
P24		
P25		
Total Final Energy Savings (kWh)		**307,885**

5. Appendix A

Reference Material

- o CIBSE Guide C Chapter 3: https://www.cibse.org/knowledge-research/knowledge-portal/guide-c-reference-data-2007
- o ASHRAE Guide: Chapter 23 Insulation for Mechanical Systems
- o Chemical Engineer's Guide: A Guide for Chemical Engineers in Process, Design and Plant Operations.
- o https://cheguide.com/heat_loss_insulation.html
- o Carbon Conversion factors L https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/
- o Applied Thermodynamics for Engineering Technologists: Eastop & McConkey 5th Edition 1993

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