EiiF STUDY **2021**

The insulation contribution to decarbonise industry

The energy and CO_2 savings potential of industrial insulation in EU 27

WE POWER SUSTAINABILITY

EiiF Study 2021
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Executive summary

The industrial insulation industry, driven by its daily experience, knows that there is a significant energy savings and emissions mitigation potential related to improved thermal insulation in EU 27 industry. This potential is currently untapped despite its being financially attractive to implement, its offering multiple benefits to industry and the environment and its being urgently needed to help the EU become carbon neutral in 2050.

The European Industrial Insulation Foundation (EiiF) commissioned the consultancy company Ecofys in 2012 to study industrial insulation potential but, given today's challenges, it was time to update and adapt the figures and to investigate how the process of harnessing this potential can be accelerated.

EiiF's TIPCHECK experience, with about 2.500 thermal energy audits carried out over the past 10 years, shows that industry is using insulation systems which are neither cost-effective under current market conditions nor energy efficient. Old and outdated technical specifications, mainly focusing on process and safety requirements, are still widely used in industry today. It is also observed that, in many cases, thermal insulation in industry is poorly maintained and parts remain uninsulated. This practice results in excessive heat losses and, as a consequence, high levels of avoidable greenhouse gas emissions.

Poor insulation not only leads to increased energy costs and unnecessary emissions but also to higher thermal stresses, which can accelerate wear and lead to more frequent breakdowns. Other effects of poor insulation include reduced product quality and increased maintenance costs. In many cases, the loss of energy in climate-controlled workspaces creates an additional burden on cooling systems.

Depending on the temperature, the increasing share of uninsulated and/or damaged insulation systems today varies from 2% to 10%.

Several factors contribute to the tendency in industry to insulate less rather than implement more energy-efficient insulation systems: the pressure to reduce investment and maintenance costs, an increasing lack of insulation know-how and split responsibilities for energy and maintenance budgets.

Against this backdrop, EiiF has investigated the savings potential by improving thermal insulation in EU industry, including the electricity sector. However, as it is impossible to account for all aspects, this study concentrates on the savings potential analysis at temperature levels above ambient temperature only and refers to cold insulation aspects in a separate chapter.

This study builds on the methodology created by Ecofys for its 2012 study “Climate protection with rapid payback” with updated energy consumption figures of industrial sectors.

To analyse the savings potential, the study takes the energy losses from the current insulation practice and compares them with the scenario where everything is insulated according to the energy classes for insulation defined by the German guideline VDI 4610.

General assumptions about energy losses resulting from different process components and the current practice in insulation in industry have been used to define the picture of technical insulation today and its average density of the heat flow rate in W/m² per temperature range.

Both factors (the estimations and the current practice) are based on EiiF members' know-how, the experience gained from about 2.500 TIPCHECK thermal energy audits carried out mainly in European plants as well as literature references, considering the performance of current technical specifications in industry and the average maintenance levels in EU industries.

Current practice for technical insulation		VDI 4610 energy class scenarios		The potential
Energy loss estimate per sector and currently used density of the heat flow rates	vs.	Density of the heat flow rates according to VDI 4610	=	Energy savings & greenhouse gas emissions reduction potential in EU 27 industry
Technical specifications and maintenance levels in insulation		Proper maintenance		

Table 1: Comparison for analysing energy savings and greenhouse gas emissions reduction potential

A savings potential was found to exist across all regions, sectors and equipment and at all operating temperatures. The potential varies between regions and sectors, due to differences in the energy use, the temperature profiles and the energy sources.

However, and based on the detailed analysis of this study, a general rule can be defined for surfaces which can be insulated: upgrading insulation systems to VDI 4610 energy class C will reduce about 88% of the current energy loss in the low-temperature and in the middle-temperature levels. In the high-temperature level about 78% of the energy loss will be reduced.

The EiiF Study 2021 analyses that 14 Mtoe of energy can be saved by applying energy class C systems according to VDI 4610 Part 1, offering the potential to reduce the EU's CO_2 equivalent emissions by 40 Mt every year.

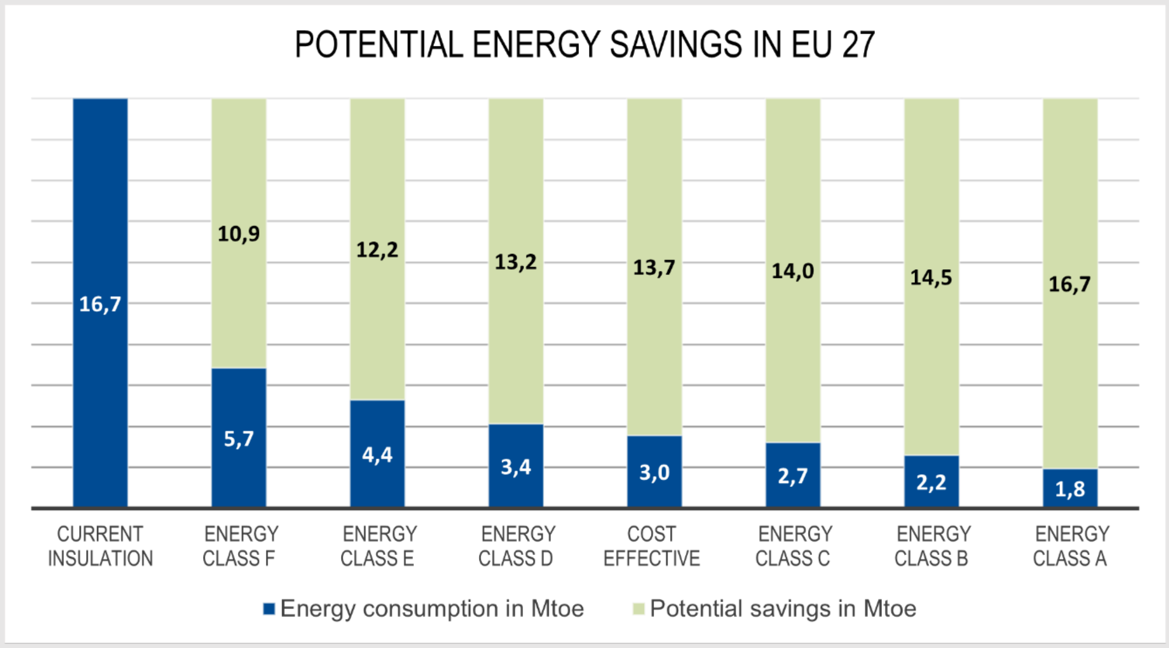

Figure 1: Contribution of technical insulation in EU 27 industry

The main part of the potential comes from insulating uninsulated and/or damaged systems and introducing maintenance programmes to ensure that the insulation performance is not reduced over time. The remaining part of the potential would come from improving insulation on currently insulated surfaces.

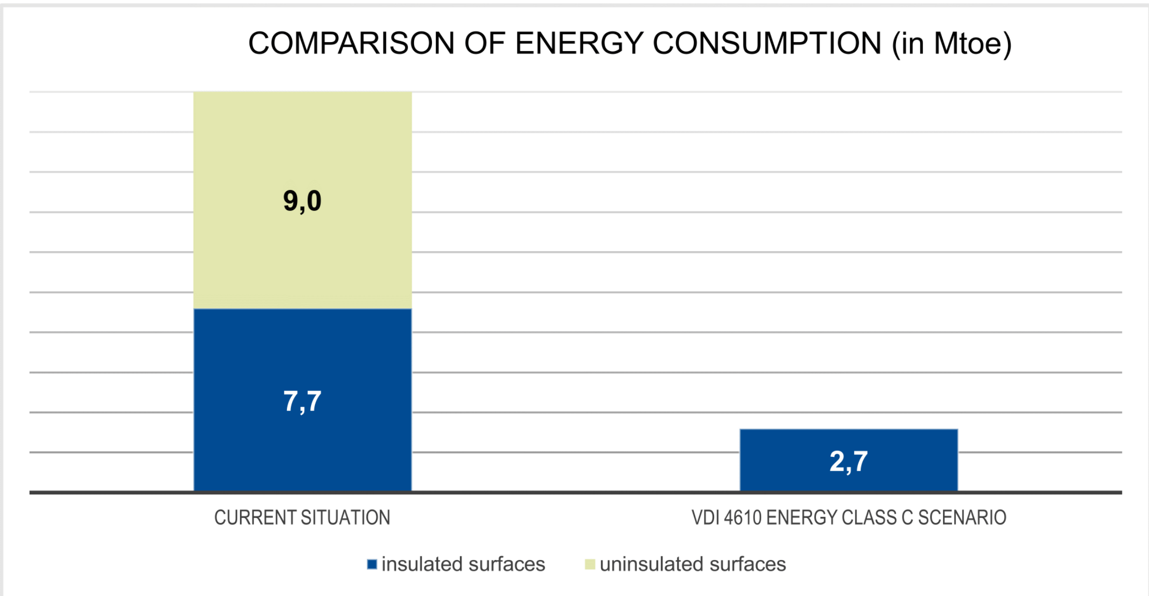

Figure 2: Energy consumption if insulation systems are upgraded to VDI 4610 energy class C

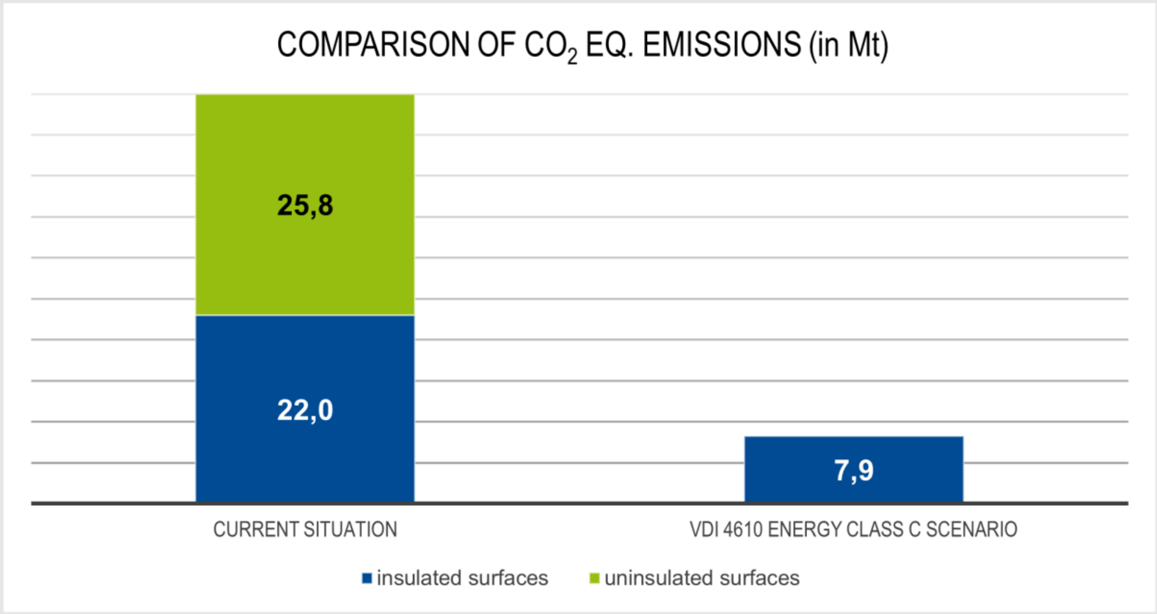

Figure 3: CO_2 eq. emissions if insulation systems are upgraded to VDI 4610 energy class C

The identified annual energy savings potential of 14 Mtoe is equivalent to:

1. The annual energy consumption of 10 million EU households
2. The annual energy consumption of all households in Hungary, Czech Republic and Slovakia
3. The annual energy consumption of 20 million cars

(The calculation of the above equivalents is based on the figures from the Odyssee-Mure EU project and statistics from Eurostat.)

Consistently upgrading industrial insulation systems in Europe according to the VDI 4610 energy classes would quickly deliver multiple benefits not only for our climate but also for the EU and for its industry. The insulation technology needed already exists and just needs to be better utilised. Tailored policy actions could significantly accelerate the uptake.

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1. Introduction

Scope of the study

There is a significant energy savings and greenhouse gas mitigation potential related to thermal insulation in industry. This potential is currently untapped despite being cost-effective in terms of implementation. The EiiF Study 2021 analyses the size of the potential, explains why the potential remains untapped and concludes what is needed to harness this insulation potential.

The EiiF Study 2021 aims to answer the following two questions in order to analyse the size of the potential:

1. What are the current energy losses in industrial processes related to insulation systems, by sector and by country?
2. What are the energy savings and the greenhouse gas emissions mitigation potentials resulting from insulating currently uninsulated parts, fixing damaged systems and upgrading insulated parts to energy class C according to VDI 4610 Part 1 systems?

As it is impossible to account for all aspects and as the majority of industrial processes take place in hot applications, this study concentrates on the savings potential analysis at temperature levels above ambient temperature only. Furthermore, uninsulated parts in cold processes are less common: the effects of inadequate cold insulation are better detectable as condensation formation is most often followed by ice formation. Nevertheless, if cold systems are not properly insulated, and if the insulation is insufficiently dimensioned, damaged or not consistently maintained, it can cause immediate condensation problems, in addition to large-scale energy losses. Cold insulation aspects are therefore referred to separately in Chapter 2.4.

The EiiF Study exclusively considers electricity production from gas, coal, oil and biomass sources. However, insulation energy efficiency potential also exists in carbon-free energy sources such as in nuclear and some renewable technologies.

Why insulate?

Industrial processes use a different type of energy source to generate heat for a variety of applications, from steam production to dryer units. The larger the share of heat that is used productively, the higher the efficiency of the process.

To reduce heat loss, thermal insulation is therefore applied to equipment like boilers, ovens, pipes, tanks and vessels. This allows an efficiency gain that reduces the energy use per unit of output and the corresponding greenhouse gas emissions.

In many cases, insulation also plays an important role in personal protection, process control, product stabilisation, freeze protection, noise control and fire protection. Poor insulation not only leads to increased energy costs, but also to higher thermal stresses, which can accelerate wear and subsequently lead to more frequent breakdowns. Other effects of poor insulation can include reduced product quality, increased maintenance costs and additional burdens on air conditioning, wherever excess heat is lost to workspaces.

Why is the potential still there?

Industrial insulation experts* observe that in many cases, thermal insulation in industry is poorly maintained and that some parts remain uninsulated and create thermal bridges, resulting in excessive heat losses and increased CO_2 equivalent emissions. They also note that the level of the insulation applied is typically based on requirements specifying the maximum surface temperature that the equipment is allowed to reach to avoid personal injuries or on the generic maximum heat loss rates permitted.

In general, technical specifications for insulation in industrial plants have not been updated and therefore specified insulation solutions for energy conservation are based on the energy prices and the environmental requirements from 10, 20 or even 30 years ago.

A good example is the additional cost for the CO_2 eq. emissions allowance, which was not considered when the technical specification was written but today and even more so tomorrow, plays an important role in the design of cost-effective insulation solutions. Moreover, the performance levels defined in the past are often not properly maintained, leading to damaged systems or even uninsulated components which cause high and avoidable energy losses and emissions.

According to experts' experience, there are usually several reasons why companies fail to make detailed assessments of the cost-effectiveness of insulation or correctly maintain existing insulation:

- There may be a general lack of information amongst the main decision makers about the large energy savings potential of industrial insulation
- Split or unclear responsibilities for decisions on maintenance and energy management
- Insulation is a relatively small part of investments and therefore is often not considered or specified well enough during the design phase or retrofit programmes
- Insulation is not the core business of the main decision makers
- There may be a lack of information about improvements in insulation materials and in the design of modern insulation systems

**The group of experts that provided input for this study represent different insulation companies and most of them are certified TIPCHECK engineers trained by EiiF in insulation energy appraisals (TIPCHECK = Technical Insulation Performance Check). All experts within the group have extensive experience with insulation projects and throughout their careers, have held various positions in the insulation industry.*

Methodology

Various sources have been used as inputs for analysing the insulation potential in EU industry. The core methodology for calculating the energy savings and the CO_2 eq. emissions reduction potential in technical insulation is based on the methodology developed by Ecofys in 2012 for the study: "Climate protection with rapid payback" with updated inputs such as energy consumption and the experience gained from about 2.500 TIPCHECK energy audits, which has further improved the assumptions taken in this EiiF 2021 study.

EiiF, comprising the main stakeholders from the technical insulation sector in Europe, has trained more than 200 engineers as energy auditors for thermal insulation systems over the past ten years and has brought together the most experienced technical community in the insulation sector. This community of experts has greatly contributed to this study.

Table 2 gives a schematic overview of the data sources and the results of the study.

INPUT	OUTPUT
Energy Statistics - ENERDATA	Potential energy savings and CO_2 eq. emissions reduction from insulating uninsulated equipment and repairing damaged insulation
Insulation Study 2012 - ECOFYS	
Emission factors – German and Dutch references*	
Energy classes for insulation – VDI 4610	Potential energy savings and CO_2 eq. emissions reduction from upgrading the insulation performance of the current insulation systems
Insulation experts – TIPCHECK engineers	
TIPCHECK (energy survey) results	

** Bundesgesetzblatt Jahrgang 2020 Teil I Nr.37 & Nederlandse lijst van energiedragers en standaard CO_2 emissiefactoren.*

Table 2: Overview of the data sources and the results of the study

The energy loss in an industrial facility related to heat transfer through process component walls depends on three parameters:

1. The energy consumption of the plant: the amount and the source of the energy which is used in the process
2. Process parameters such as medium temperatures and process technologies, taking into account the fact that some industrial processes operating at high temperatures do not require insulation, e.g. cooling lines in the steel industry
3. The condition of the installed insulation systems

The energy consumption per sector and country and the energy sources were obtained from the Odyssee-Mure EU project, a database from Enerdata.

The 2012 Ecofys study “Climate protection with rapid payback” defined, on the basis of literature and expert assessments, the working temperature per industrial process and general assumptions about the practices in the insulation works at European level as well as the consequences of the lack of maintenance in industry. Today, we can still consider these assumptions as valid since the insulation practice in industry remains unchanged.

For example, in the refinery sector Ecofys estimates that 80% of the energy consumed is used for heating industrial processes operating above 300 °C. 5% of this energy is considered as energy loss through process component walls. About 3% of this energy loss comes from uninsulated or insulated but damaged surfaces and 2% from insulated surfaces where heat losses are reduced but still occur.

The output of this study, the contribution of industrial insulation to energy savings and to CO_2 eq. emissions reduction in European industry, is defined by upgrading the current insulation practices to the performance levels according to the VDI 4610 energy classes (VDI 4610 Part 1).

The emissions factors per source of energy, which are used to express the potential mitigation of greenhouse gas emissions, are average values used by the German and Dutch administrations (Bundesgesetzblatt Jahrgang 2020 Teil I Nr. 37 & Nederlandse lijst van energiedragers en standaard CO_2 emissiefactoren).

This study therefore relies on expert assumptions and secondary data from a variety of sources.

Outline of this report

The structure of this report is as follows:

- Chapter 2 describes the industrial sector and the current practices for insulation in industry
- Chapter 3 highlights the economic aspects of insulation systems (lifecycle analysis)
- Chapter 4 introduces the VDI 4610 energy classes for insulation solutions in industry
- Chapter 5 describes the energy savings and greenhouse gas emissions mitigation potential of industrial insulation
- Chapter 6 explains how industrial insulation can contribute to decarbonising European industry and help the EU reach its 2030 energy efficiency target
- In Chapter 7 recommendations are given on how to tap the potential quickly

2. The level of industrial insulation today

2.1 The insulation specifications and the level of maintenance

Nowadays all companies define their own technical specifications for insulation systems. In general, there is no regulation for the performance level of insulation to be installed in European industry. In some countries there are guidelines that specify performance levels but mostly for new installations. So far no country has established binding obligations for the industry sector.

According to industry experts, most plants are operated with insulation systems designed to meet safety criteria, i.e. defining the maximum surface temperature, condensation prevention, process needs or just a generic maximum density of the heat flow rate. Specifications which call for cost-effective and energy-efficient solutions are an exception.

A comparison of today's building and industry insulation requirements illustrates that, for temperatures which can be ten times higher in industry, the same or even only half of the building insulation thickness is used.

	POWER PLANT	BUILDING Code (walls) *before 2010*	BUILDING Code (walls) *2016*
TEMPERATURE	250°C	18°C - 22°C	18°C - 22°C
HEAT LOSS	150 W/m² *AGI Q101*	< 10 W/m² *EU average*	< 4 W/m² *EU average*
INSULATION THICKNESS	100 mm	0 - 50 mm	100 - 250 mm

Table 3: Comparing insulation performance in industry with requirements for building insulation

The insulation solution varies from application to application depending on many design factors such as the geometry of the component, the surface temperature, sensitivity to corrosion or the need for fire-proof materials. However, the main variables for calculating the density of the heat flow rate in a component expressed in W/m^2 are the differences in temperature between a surface and its surroundings and the performance of the installed insulation solution. As it would be impossible to account for all the different aspects, this study concentrates on an analysis of three temperature levels for each sector and reflects on temperatures below ambient (cold insulation) in Chapter 2.4:

- Low temperature (from ambient temperature to 100 °C)
- Middle temperature (from 100 °C to 300 °C)
- High temperature (above 300 °C)

The average heat flow rate per unit of surface at a given temperature level also varies from region to region. Within the scope of this study, it was not possible to account for such variations as even within sectors there can be significant differences.

The following densities of the heat flow rates were defined as general values for the three temperature ranges:

- 100 W/m^2 for insulated components operating at low temperatures (< 100 °C). As energy losses are affected by temperature differences, low-temperature systems typically have lower rates than middle-temperature and high-temperature applications
- 150 W/m^2 for insulated surfaces operating in middle-temperature and high-temperature applications (> 100 °C)

These values have been inferred from the standards specifications of six companies, four in the energy sector, one in the brewery sector and a provider of boiler systems (Ecofys, 2012).

The density of heat flow rate of 150 W/m² for temperatures above 100 °C is furthermore recommended in the working document Q 101 of the AGI guideline issued in 2000. The AGI Q 101 was and is widely used in industry and beyond German borders, and EiiF has been informed that it will be updated soon with an improved lower heat flow rate value which will impact future projects but not the current insulation situation. The total energy loss of a component results from multiplying the density of the heat flow rate by the component surface and its operational time. The values for the densities of the heat flow rate introduced above refer to insulated surfaces.

However, not all surfaces are insulated. Industry experience in general shows that in a typical European plant 10-19% of insulation is damaged or missing. For the U.S. industry, King (2010) estimates that 10-30% of all exposed mechanical insulation becomes damaged or missing within one to three years of operation. Lettich (2003) presents two typical case studies of U.S. plants, a chemical plant and a refinery, in which about 20% of all insulation is damaged. In the 2.500 TIPCHECK thermal energy audits carried out between 2010 and 2020 there was no plant in which the TIPCHECK engineers did not find uninsulated and/or damaged insulation systems.

It is reported back to EiiF by its members that today there is even an alarming tendency of insulation users to insulate less. The reasons for this may be the pressure to reduce investment and maintenance costs in combination with an increasing lack of insulation know-how and split responsibilities for energy and maintenance budgets in industrial plants. Clients asking for energy-efficient solutions are a very rare exception.

Based on the information above and additional expert assessments, the share of equipment without insulation or covered with damaged insulation in this study is conservatively estimated to be 10%, 6% and 2% for low-temperature, middle-temperature and high-temperature surfaces respectively.

The density of the heat flow rate over surfaces without insulation or with damaged insulation is predominantly dependent on the surface temperature and the remaining degree of insulation (in the case of damaged insulation).

The average values in Table 4 are based on thermal calculations in accordance with the international standard ISO 12241.

Temperature level	Low temperature (<100 °C)		Middle temperature (100 °C – 300 °C)		High temperature (> 300 °C)	
Component surface	with insulation	with damaged insulation or uninsulated	with insulation	with damaged insulation or uninsulated	with insulation	with damaged insulation or uninsulated
Share in %	90%	10%	94%	6%	98%	2%
Average heat loss rate per unit of surface	100 W/m^2	1.000 W/m^2	150 W/m^2	3.000 W/m^2	150 W/m^2	10.000 W/m^2

Table 4: Density of the heat flow rate of current insulation systems over surfaces without insulation or with damaged insulation at different temperatures

2.2 Energy consumption in industry

Insulation plays a role in the energy consumption of all industrial processes working with fluids at a temperature other than ambient. In processes such as electricity generation where steam produces electricity in a turbine, petroleum refining where oil is heated up to be cracked and produces petroleum derivates or, in more general terms, in the manufacturing sector where hot air or steam is used for different applications, insulation is present to reduce energy consumption.

As we will explain in Chapter 2.3, the energy loss in industry that can be reduced by insulation is estimated as a percentage of the thermal energy consumption by sector and by energy source. The energy consumption per country and per sector together with general assumptions taken from technical literature and the experience of insulation engineers define the current energy losses in industry which are linked to heat transfer through process components walls.

This study uses the 2017 energy consumption figures from Enerdata per energy source of the different sectors where insulation is relevant, including the electricity generation sector. The energy intelligence and consultancy company Enerdata participates in the Odyssee-Mure EU project, providing comprehensive monitoring of energy consumption and efficiency trends as well as an evaluation of the energy efficiency policy measures by sector for EU countries.

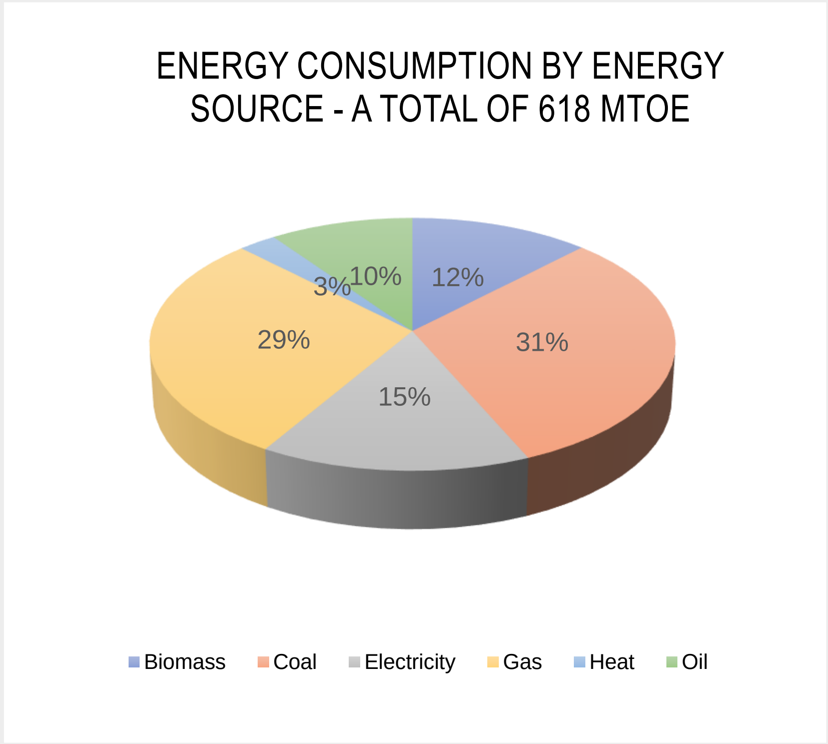


Figure 4: Energy consumption by source in EU 27 industry (Enerdata Odyssee-Mure EU project)

The figures from Enerdata, together with the experience gained from 2.500 TIPCHECK energy audits, allow EiiF to better estimate which part of this energy is used to generate heat (thermal energy) and which part of this thermal energy can be influenced by the performance of the installed insulation systems.

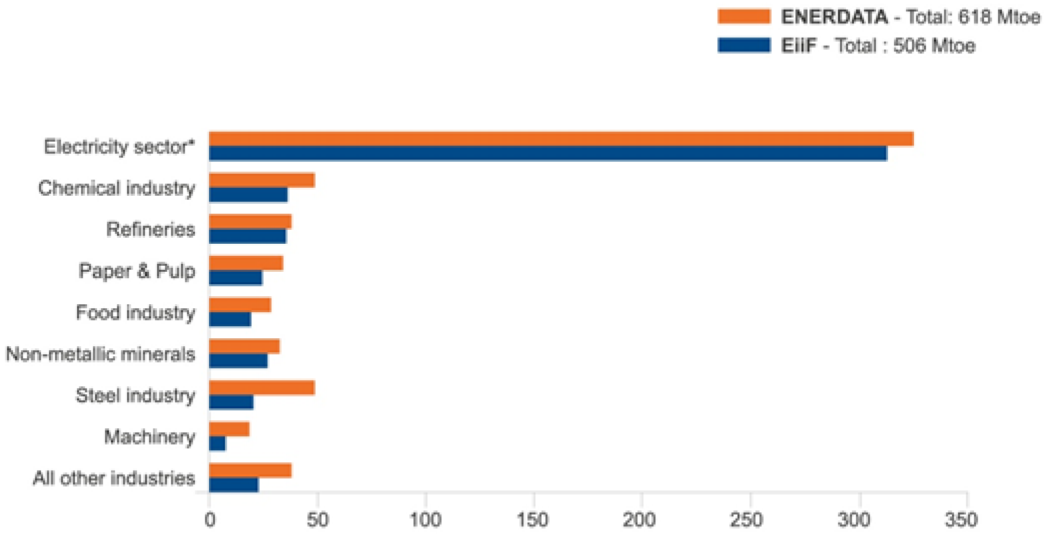
On this basis, EiiF estimated the total thermal energy consumption in EU industry to be 506 Mtoe whereas the total energy consumption given by Enerdata for the year 2017 was 618 Mtoe.

This difference comes mainly from:

- The fact that part of the energy, mainly electricity, is used for mechanical work or lighting where insulation does not play any role. For example, EiiF only considers 1,52 Mtoe out of 93,25 Mtoe of electricity consumption in order to represent the electricity consumed in electric furnaces

- Some processes working with hot fluids require that energy (e.g., cooling lines) be released or do not allow insulation at all. In order to reflect this reality, EiiF considers, for example, only 10% of coal consumption in the steel industry

Figure 5 represents the real energy consumption in EU industry by sector in 2017 and the EiiF estimate in order to calculate the energy loss which can be reduced by improving insulation.

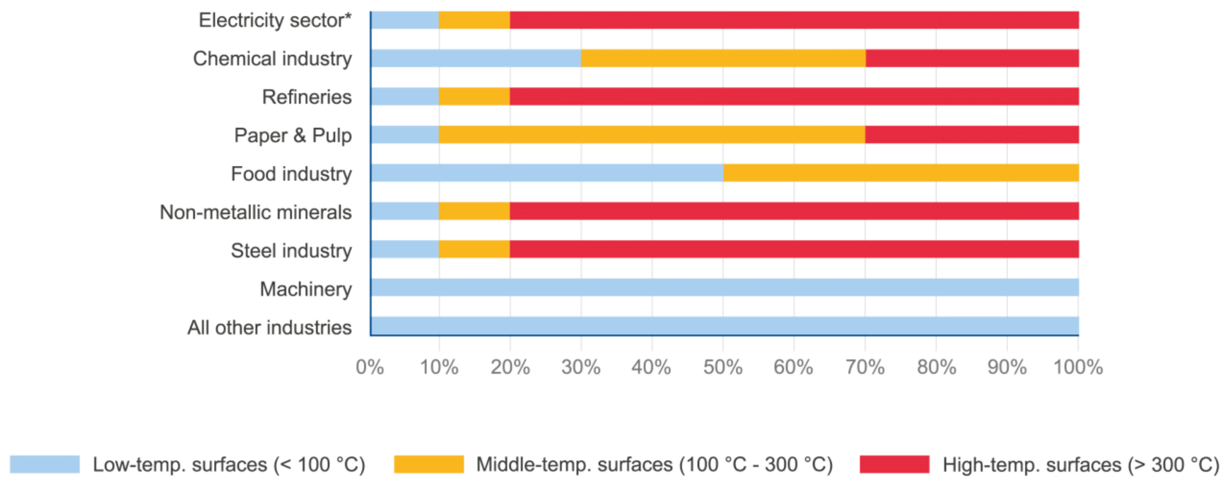


Electricity sector only refers to gas, coal, oil and biomass technologies

Figure 5: Energy consumption in EU 27 industry by sector in 2017 and the EiiF estimate

Considered for each sector, the energy that has been used is distributed over low-temperature, middle-temperature and high-temperature applications in terms of shares of the surface area (Ecofys, 2012).

This distribution takes into account that, due to cascading of energy use, high-temperature processes (e.g. in the electricity sector) also involve low-temperature surfaces. Figure 6 shows that some sectors predominately involve high-temperature surfaces, whereas others predominately involve only low-temperature surfaces.



**Electricity sector only refers to gas, coal, oil and biomass technologies*

Figure 6: Distribution of energy consumption by temperature and sector

2.3 Energy losses in industry

To calculate the current energy loss in industry, the different temperature profiles of different sectors (Chapter 2.2) are considered and a percentage of the energy input per temperature level is defined. This percentage represents energy loss over surfaces which are or can be insulated.

The amount of thermal energy which is lost over surfaces normally only represents a small fraction of the energy input in a process. A share of thermal energy input is converted into useable work driving the conversion of raw materials or intermediates into final products. Energy which is not converted to useable work or services can be considered lost.

Not all losses occur due to heat loss over surfaces which could be insulated (the following is based on U.S. DOE-ITP, 2004):

- Losses occur in energy conversion systems (e.g., power generation, boilers, heat exchangers, process heaters, pumps, motors) where efficiencies are thermally or mechanically limited by materials of construction and equipment design other than insulation

- In some cases, heat-generating processes are not optimally located near heat sinks, and it may be economically impractical to recover the excess energy
- Energy is sometimes lost simply because it cannot be stored
- Energy is also lost from processes when waste heat is not recovered and when waste by-products with energy value are not utilised
- Energy may leave the process with the product, cooling water, flue or exhaust gas

Therefore, the actual thermal energy loss over surfaces which could be insulated depends on the specific application.

For example, pipes with a large diameter have less heat loss expressed per unit of energy throughput as compared to those with a smaller diameter. In lower temperature processes, energy is consumed mainly via smaller, insulated, steam or hot water-based equipment, where losses over the surface area represent a more significant fraction of the energy used.

The 2012 Ecofys study “Climate protection with rapid payback” extrapolates from five case studies and additional expert assessments the following share of thermal energy input that is currently lost over surfaces which are or can be insulated. The estimated share of thermal energy that is lost over surfaces which are or can be insulated is 1,2% for the electricity sector, 9,6% for low-temperature, 6,7% for middle-temperature and 5,0 % for high-temperature processes in all other industries.

Electricity sector	**Manufacturing and refinery sector**		
Full range of temperatures	**Low temperature**	**Middle temperature**	**High temperature**
	<100 °C	100 °C – 300 °C	>300 °C
1,2%	9,6%	6,7%	5,0%

Table 5: Share of energy input currently lost over surfaces in industry (in the electricity and the manufacturing and refinery sectors)

These percentages, applied to different sectors and different countries in EU industry (including the electricity sector), add up to 16,7 Mtoe as the current losses over surfaces which are or can be insulated. Figures 7 and 8 show the split per sector and per energy source.

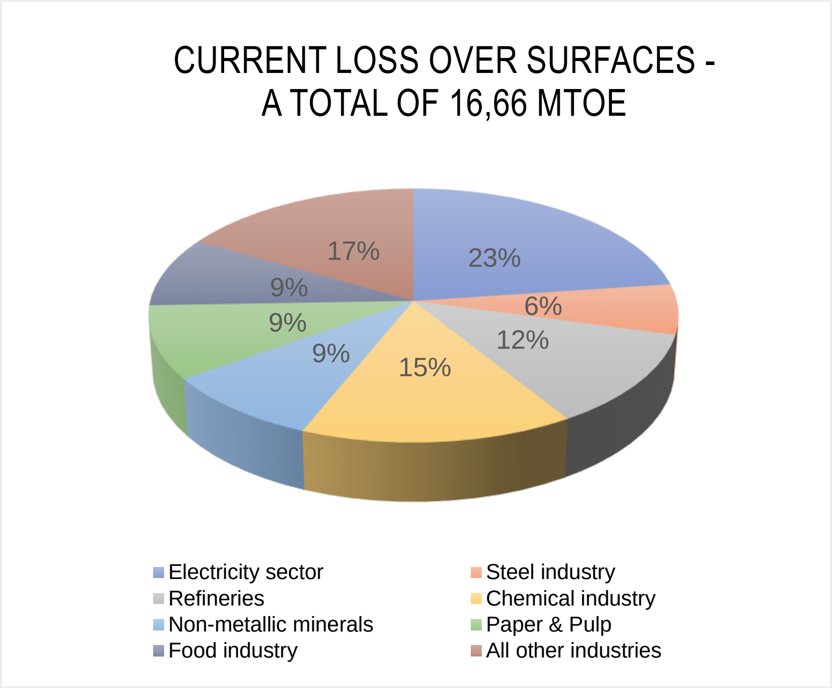


Figure 7: Current loss over surfaces by sector in EU 27 industry

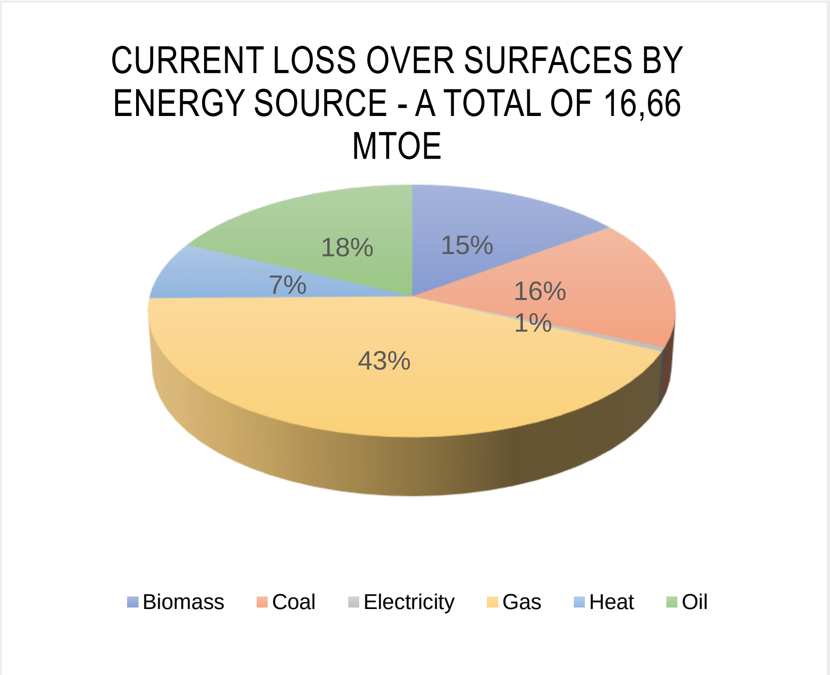


Figure 8: Current loss over surfaces per energy source in EU 27 industry

Any combustion process for creating energy has CO_2 eq. emissions associated with it. The following values have been considered to estimate the emissions related to the energy loss over surfaces by energy source in the EU. The following values are average values from the German and Dutch administrations (Bundesgesetzblatt Jahrgang 2020 Teil I Nr. 37 and the Nederlandse lijst van energiedragers en standaard CO_2 emissiefactoren).

- Gas 238 gr CO_2 eq./kWh
- Coal 380 gr CO_2 eq./kWh
- Oil 317 gr CO_2 eq./kWh
- Biomass 197 gr CO_2 eq./kWh
- Heat 40 gr CO_2 eq./kWh

The current 16,7 Mtoe of energy loss represents 48 Mt of CO_2 eq. emissions (direct emissions from combustion without considering internal industrial processes which may modify the final emissions).

2.4 Cold insulation systems in industry

In principle, experts talk of “cold insulation” wherever medium temperature is below the temperature of ambient air. The temperature range of “cold insulation” is therefore between -273 °C and ambient temperature.

The main duty of insulation systems is the reduction of heat flow rates. Regarding hot insulation, the heat flow rate is from the object towards ambient air, whereas in cold insulation it is the other way around: from ambient air to the object.

“Energy losses from operational installations in industry and the building services occur by heat being released to the environment, if the installation operates at temperatures above the ambient temperature, and by heat being gained from the environment, if the installation operates at temperatures below the ambient temperature" (VDI 4610, Part 1).

Compared to hot insulation systems, cold insulation systems have, however, more requirements to fulfil other than limiting heat loss or respectively heat gain. Cold insulations always need to avoid the threat of moisture entering the insulation material. This moisture results from condensation of water vapour out of ambient air, whenever the temperature of the object or inside the insulation material is below the dew point. Water vapour will be transported into the insulation system by differences in the overall pressure (air movement) and through differences in the partial water vapour pressure (water vapour diffusion) between ambient air and the object to be insulated. Therefore, it is first of all the minimisation of moisture in the insulation which determines the design of a cold insulation system. If this threat is not prevented, water and/or ice immediately form at those parts of the insulation system where temperature is below the dew point temperature or the freezing point of water.

Annex C “Examples of ice formation in cold insulation systems and condensation on uninsulated parts” shows the typical consequences if cold insulation systems fail.

Condensation in the insulation material considerably reduces the insulating effect. The thermal conductivity of water is 20 times that of air and the thermal conductivity of ice is 100 times that of air. Extensive heat gain of the cold medium is the consequence.
Heat gains in processes working with liquified gases (e.g., LNG units) lead to the physical phenomenon of liquid evaporating. This so-called “boil-off” effect has an important economic impact on the running costs of a plant.

The consequences of ineffective or damaged cold insulation systems are not just energy related. In addition to heat gains, negative effects on the industrial process can also occur:

- Water can cause corrosion under insulation (CUI) and on the inner surface of the cladding. This can lead to material failure and cause severe accidents like bursting pipes

- Water and ice increase the weight of the insulated system. Cold piping can collapse under this additional load

Cold insulations have, in general, a limited service life expectancy: They are unstable systems, which, for physical reasons, react sensitively to damage. They must be regularly maintained, including routine checks of sealings and interruptions. This is not only needed to save decent volumes of energy but also to keep industrial processes running.

The energy savings and greenhouse gas emissions mitigation potential analysis in Chapter 5 does not compare today's cold insulation levels with applicable VDI 4610 energy classes for cold insulation systems. This is mainly due to the fact that for designing a cold insulation system more specific requirements need to be considered than just its energy performance. However, this does not mean that there would not be energy savings potential in cold applications.

3. Economic aspects of insulation systems (lifecycle analysis)

Analysing typical specifications of industrial insulation systems shows that today most of them are determined by the following aspects:

- Operating aspects: securing of production processes
- Condensation prevention in cold installations
- Aspects of occupational safety and personnel protection
- Maximum permissible heat loss

Specifications calling for cost-effective and energy-efficient solutions are an exception. However, it is always worthwhile to consider economic aspects as they result in reduced production costs over time. The energy efficiency aspect not only contributes to decarbonising industry but also reduces carbon taxes as well as energy costs for the producer.

The economic aspects of industrial insulation systems are defined by the energy price and the operational time as well as the lifetime of the industrial plant. To design an economical insulation system over the plant's lifetime, the economical or cost-effective insulation thickness needs to be calculated.

The economical insulation thickness is defined according to the German guideline VDI 2055 as the insulation layer thickness at which the total sum of the investment in the insulation system and the cost of the remaining heat loss are at a minimum considering the expected lifetime of the system. In other words, it is the minimum total cost of ownership.

The cost-effective insulation thickness is specific for each application and it is defined by:

1. Investment costs K_{inv} (including material, installation and the expenditure for interest and maintenance).
2. Heat loss costs K_q over the expected service time n

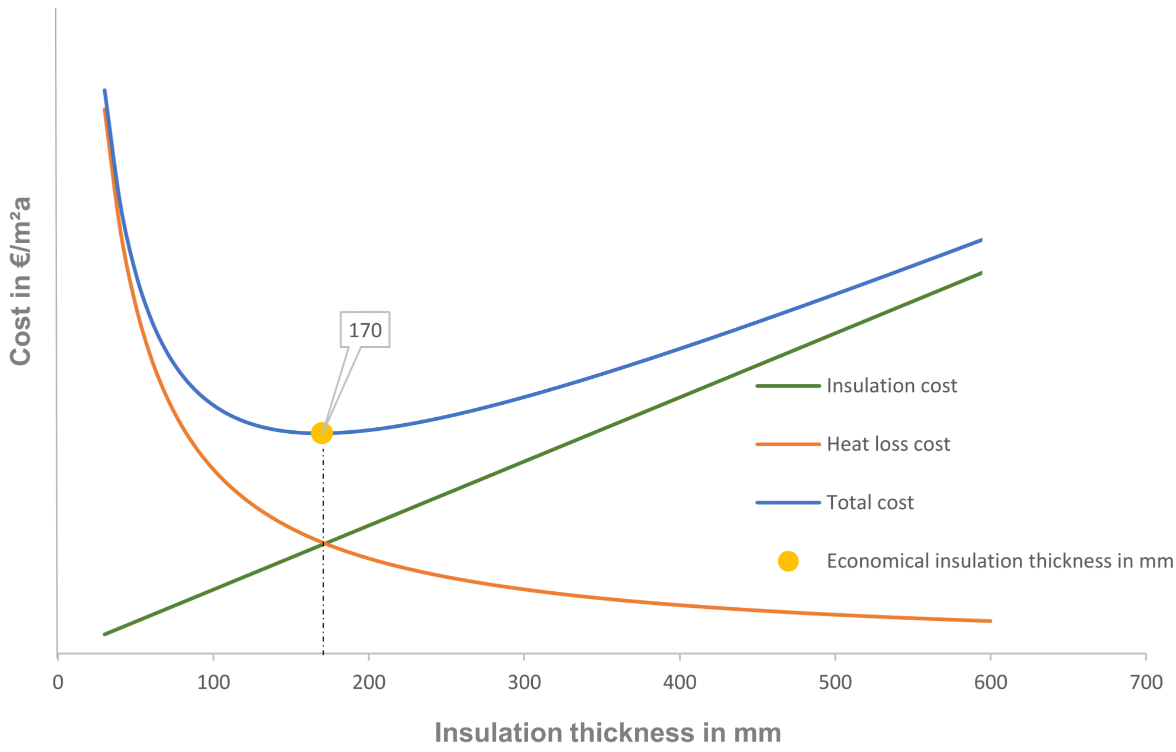


Figure 9: Evaluation of economical insulation thickness, minimum total cost of ownership

The economical insulation layer thickness depends predominantly on the following parameters:

- Medium temperature
- Thermal conductivity of the insulation material

- Annual operation time
- Expected service time (lifecycle)
- Heat price

By this definition, the cost for the insulation user over the service time is lowest if an economical insulation solution is installed. In other words, investments in economical insulation systems pay off and save energy. The figure below shows the total costs of two different insulation solutions over a 15-year service time.

The costs of the current typical insulation solution (usually fulfilling process or safety requirements only) are used as a reference.

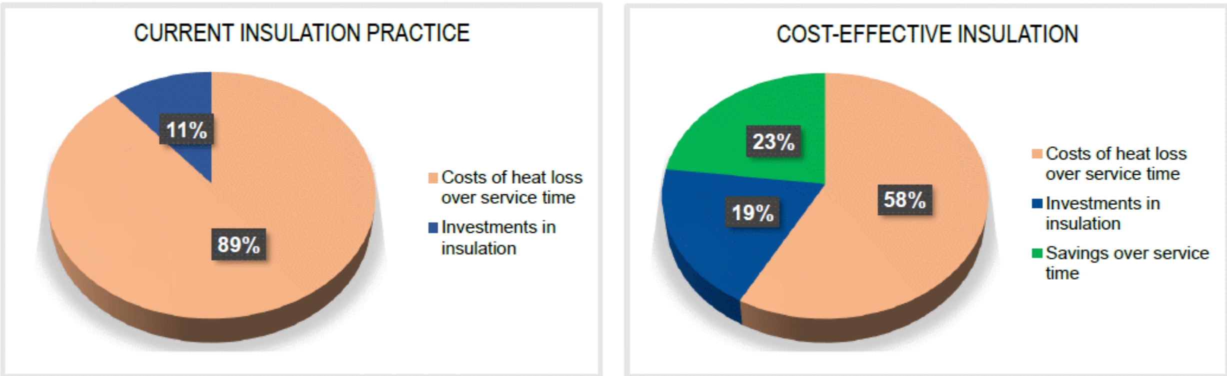


Figure 10: Comparison of total cost of ownership for current and cost-effective insulation systems

Figure 10 shows that although cost-effective insulation requires a higher initial investment, it will lead to lower costs over the total insulation service time because of the reduced energy loss: 58% of the total cost instead of 89% (Ecofys, 2012).

<u>Costs for current typical insulation:</u>

11% investment in insulation + 89% costs for energy due to heat loss = 100%

<u>Costs for cost-effective insulation:</u>

19% investment in insulation + 58% costs for energy due to heat loss = 77%

The cost-savings that can be achieved depend on characteristics of the specific application. As a general rule, the achievable cost savings of improved insulation increase with longer annual operational and service lifetimes and higher energy prices.

The main potential for technical insulation originates from uninsulated components where the economical insulation thickness investment provides not only a better total cost of ownership but also short payback times. EiiF's TIPCHECK experience gained over the course of about 2.500 thermal audits carried out worldwide shows that insulating uninsulated equipment and repairing damaged insulation offers payback periods of two years on average and often just a few months. Depending on the temperature, the share of uninsulated and/or damaged insulation systems in a typical plant varies from 10% to 2%.

LOW-TEMPERATURE < 100 °C	MIDDLE-TEMPERATURE 100 °C - 300 °C	HIGH-TEMPERATURE > 300 °C
10%	**6%**	**2%**

Table 6: Share of industrial equipment without insulation or with damaged insulation systems

The economical insulation thickness should include the cost of carbon taxes in the cost of the energy. Chapter 4 introduces the energy classes defined by the VDI 4610. The VDI 4610 energy classes are defined by the total amount of greenhouse gas emissions considering manufacturing and operations.

Based on the parameters in Table 7, the calculated cost-effective solution for this study represents solutions that range between energy class C and D (see Chapter 5).

Energy cost	37	c€/Kwh
Operational time	6.000	h
Annual energy price variation	3	%
Discount rate	3	%
Service time	15	years

Table 7: Input for economical insulation thickness calculation

In addition to the short payback times a second aspect which is widely overlooked is the impact of uninsulated systems. Many industrial processes are very energy intensive. To keep process temperatures in industry at high levels (up to 600 °C and more), an intensive energy input in the system is needed. The high temperatures in industry lead to very high heat losses on uninsulated equipment adding to energy-intensive consumption for the entire system.

This can best be demonstrated by a TIPCHECK example: TIPCHECK's thermal energy audit experience shows that typical equipment like valves and flanges in industrial plants are very often uninsulated.

If a standard DN 150/6-inch valve remains uninsulated and the medium temperature of the process is at a temperature of 150 °C all year (operational time 8.760 hours), the annual energy loss for this one valve is 10.600 kWh. By insulating the valve with a standard and cost-effective insulation solution, about 10.000 kWh can be saved and an energy loss of only 600 kWh remains. To get a better idea of the impact, the saved 10.000 kWh of thermal energy could be transformed with a thermodynamic efficiency of 40% into 4.000 kWh of electric energy. Using the 4.000 kWh to charge the battery of an electric car like a TESLA Model S, one could drive more than 20.000 km.

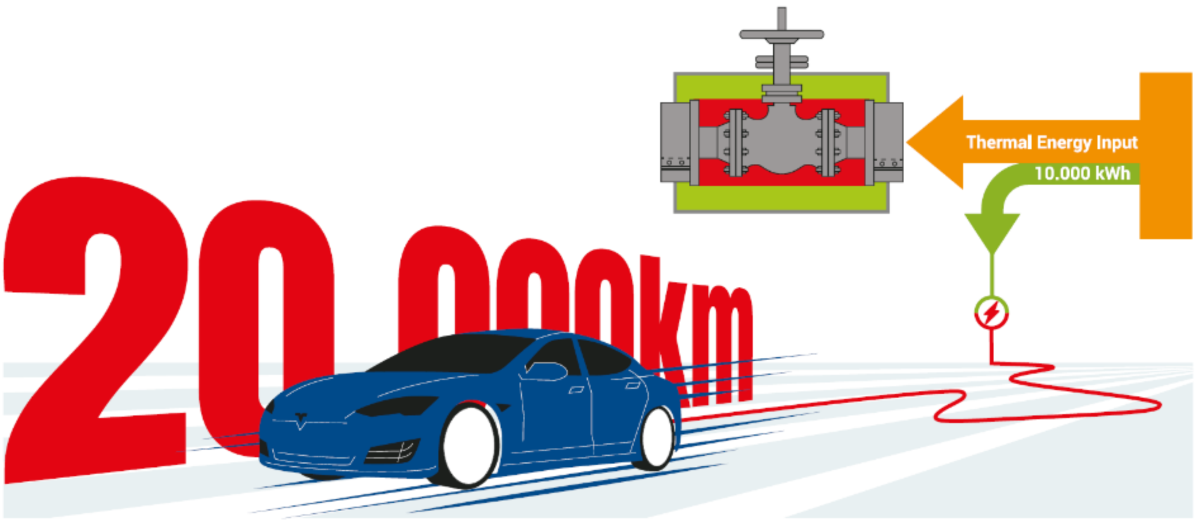


Figure 11: The saved energy of insulating one DN 150 valve at 150 °C can be used to drive a Tesla 20.000 km

Examples like the one above and TIPCHECK energy audits successfully build awareness of the benefits of better insulation systems. 3 out of 4 TIPCHECK clients immediately invest or plan to invest in the recommended insulation solutions after a TIPCHECK audit. The TIPCHECK results are convincing due to the very short payback periods making improving insulation a very attractive investment. In addition, more sustainable insulation systems create safer and better working conditions and increase the energy efficiency of a facility.

4. Energy classes for technical insulation: setting insulation levels of tomorrow

In January 2009, a group of German insulation experts met for the first time at the headquarters of the German association of engineers (VDI) in Düsseldorf to discuss the establishment of a VDI guideline to define energy efficiency classes for technical insulation. 10 years later, in January 2018, the German VDI Guideline 4610, Sheet 1 “Energy Efficiency of Technical Installations – Aspects of Heat and Cold Protection” was published. It defines 7 energy efficiency classes for technical insulation systems. This means that, based on VDI 4610, existing insulation systems can be evaluated or new insulation systems can be planned with graduated energy-efficiency requirements.

All the different energy class performance levels have been analysed in this study. The study uses energy class C as a reference for calculating the potential contribution of industrial insulation to the decarbonisation of EU industry.

The principles of classification

It is of great importance for the evaluation of an insulation system to look at “the insulation system as such” which is comprised of pipelines and insulated surfaces as well as the existing installations and fittings (valves and flanges) and separately at equipment which cannot be improved by better insulation like installation-related thermal bridges (e.g., supports, pipe suspension).

This is because the insulation system cannot influence the energy losses via the installation-related thermal bridges which are defined by the way the plant is or was built. These installation-related thermal bridges can also be improved and built in a way that thermal losses are reduced to a minimum, but the techniques and measures to do this are different and usually not within the scope of the insulation specification. Therefore, the installation-related thermal bridges and their influence on reducing greenhouse gas emissions were not considered in this study.

The reference point for definition of the energy classes corresponds to the minimum of greenhouse gas emissions during the production of the insulation (insulation material with cladding and sub-constructions) and the operation of the system over time (6.000 operational hours per year and a service lifetime of 10 years). Greenhouse gas emissions during installation can remain unconsidered. The minimum of greenhouse gas emissions represents the reference point as the ecological optimum (see Figure 12: VDI 4610 energy classes).

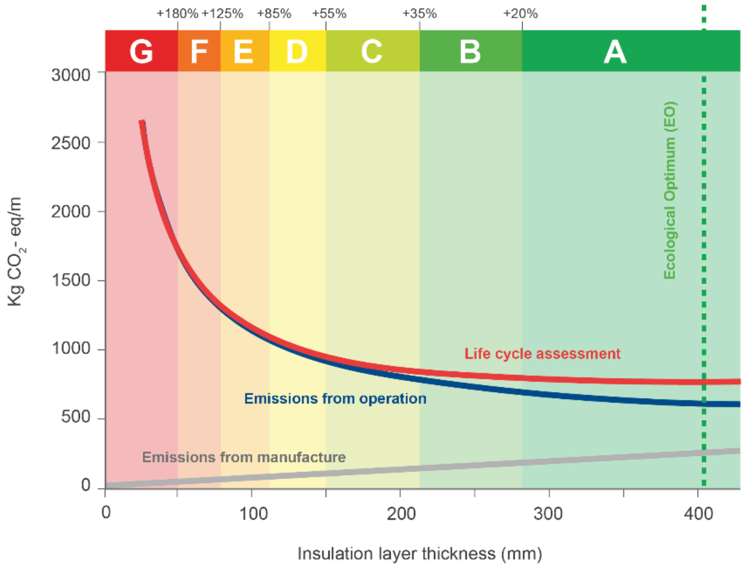


Figure 12: VDI 4610 energy classes

The VDI 4610 energy classes make it possible to precisely identify the performance of an industrial insulation system and to classify its ecological footprint. From the best and most ecological solution with energy class A down to inefficient solutions below energy class F, which waste energy and money while emitting avoidable emissions.

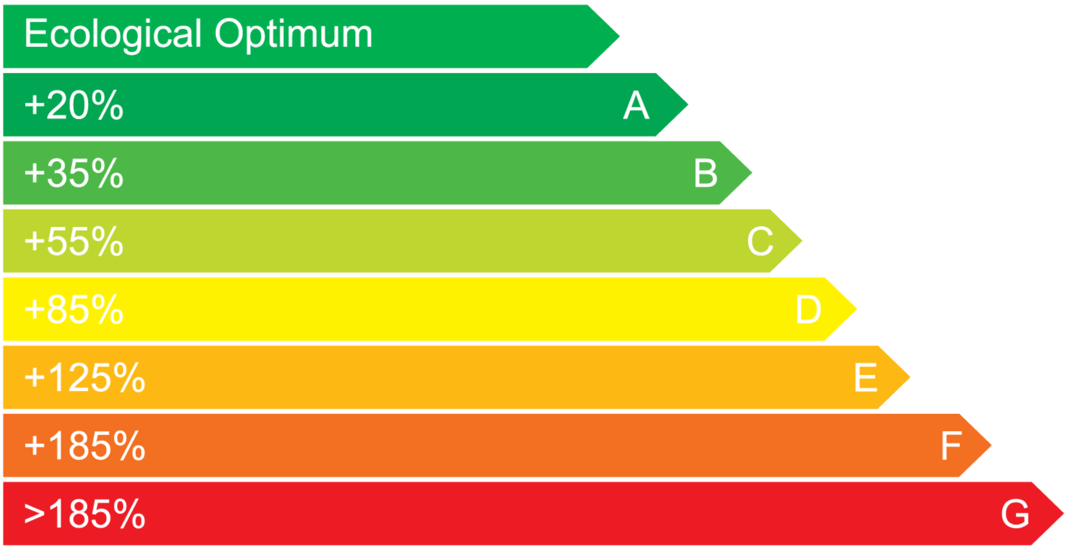


Figure 13: Energy classes for technical insulation according to VDI 4610 Part 1

Each insulation system made of any insulation material can be assigned to an energy efficiency class with the installed or intended insulation thickness based on its calculated energy loss. The thermal protection of operational systems in industry and in technical building equipment is an essential component in the reduction of energy losses – as shown and evaluated in this study – and enables operators to use the system in an energy-efficient manner. Due to the VDI 4610 classification, planned insulation measures are comparable and gain transparency in terms of insulation material selection and cost structure.

EiiF and experts in insulation technology hope that the introduction of the VDI 4610 energy efficiency classes will lead to innovations in technical insulation systems, and furthermore to adjustments in specifications for insulation which clearly place the ecological aspects in the foreground, thus setting tomorrow's levels of technical insulation today.

5. The energy savings and greenhouse gas emissions mitigation potential of industrial insulation

This study tries to answer the question: How big is the potential of industrial insulation to reduce energy consumption in industrial processes and the corresponding CO_2 eq. emissions in EU 27 industry.

Current practice for technical insulation (see Chapter 2)		VDI 4610 energy class scenarios (see Chapter 4)		The potential (see this chapter)
Thermal energy loss estimate per sector and currently used density of the heat flow rates	vs.	Density of the heat flow rates according to the VDI 4610	=	Energy savings & greenhouse gas emissions reduction potential in EU 27 industry
Technical specifications and maintenance levels in insulation		Proper maintenance		

Table 8: Comparison for analysing the energy savings and greenhouse gas emissions reduction potential

To analyse the reduction potential of energy loss, the first step was to evaluate and define the current average densities of the heat flow rates: 100 W/m^2 for low temperature levels and 150 W/m^2 for middle and high temperature levels.

In addition, the densities of the heat flow rates for uninsulated surfaces and for surfaces covered with damaged insulation were evaluated and defined: 1.000 W/m^2 for low temperatures, 3.000 W/m^2 for middle temperatures and 10.000 W/m^2 for high temperatures.

The average density of the heat flow rate (W/m^2) of the current insulation practice				
Temperature level	**W/m^2 values for insulated surfaces**	**W/m^2 values for uninsulated and/or damaged surfaces**	**Share of uninsulated and/or damaged surfaces**	**Average W/m^2 values**
low temp.	100 W/m^2	1.000 W/m^2	10%	190 W/m^2
middle temp.	150 W/m^2	3.000 W/m^2	6%	321 W/m^2
high temp.	150 W/m^2	10.000 W/m^2	2%	347 W/m^2

Table 9: The average density of the heat flow rate (W/m^2) of the current insulation practice

Considering the share (10% / 6% / 2%) of equipment per temperature level, which is not insulated at all or which has damaged insulation, the average densities of the heat flow rates were calculated: 190 W/m^2 for low temperatures, 321 W/m^2 for middle temperatures and 347 W/m^2 for high temperatures.

In step two, the current average density of the heat flow rates for the three temperature ranges were compared with the density of the heat flow rates defined by the VDI 4610 energy class C.

Comparison current insulation performance vs. insulation performance according to VDI 4610 energy class C			
Temperature level	**Current practice**	**VDI 4610 energy class C**	**Reduction of energy loss in %**
low temp.	190 W/m^2	22 W/m^2	**88%**
middle temp.	321 W/m^2	40 W/m^2	**88%**
high temp.	347 W/m^2	75 W/m^2	**78%**

Table 10: Current insulation performance vs. insulation performance according to VDI 4610 energy class C

For low-temperature and middle-temperature processes the comparison identifies an 88% lower density of the heat flow rate for the VDI 4610 energy class C: 22 W/m^2 instead of 190 W/m^2 and 40 W/m^2 instead of 321 W/m^2.

Applying the energy class C in low and middle-temperature levels would therefore reduce heat and energy losses by 88%. In high-temperature processes, the density of the heat flow rate would have to be reduced from 347 W/m^2 to 75 W/m^2, resulting in a reduction of heat and energy losses of 78%.

Based on this analysis, we estimate that 88% of the energy loss can be reduced in the low-temperature and in the middle-temperature levels and 78% in the high-temperature level if VDI 4610 energy class C is applied.

According to our conservative estimate and precise analysis, applying these reduction potentials and taking the different industrial processes as well as country-specific factors in the energy supply into consideration, **industrial insulation will deliver annual energy savings of 14 Mtoe. This amount is equivalent to the annual energy consumption of 10 million European households.** The number of households is calculated based on the Odyssee-Mure EU project, with an average energy consumption of a European household of 1,36 toe.

The annual energy savings potential of 14 Mtoe could be realised if all equipment in EU's industry which can be insulated were insulated consistently with systems performing at VDI 4610 energy class C level.

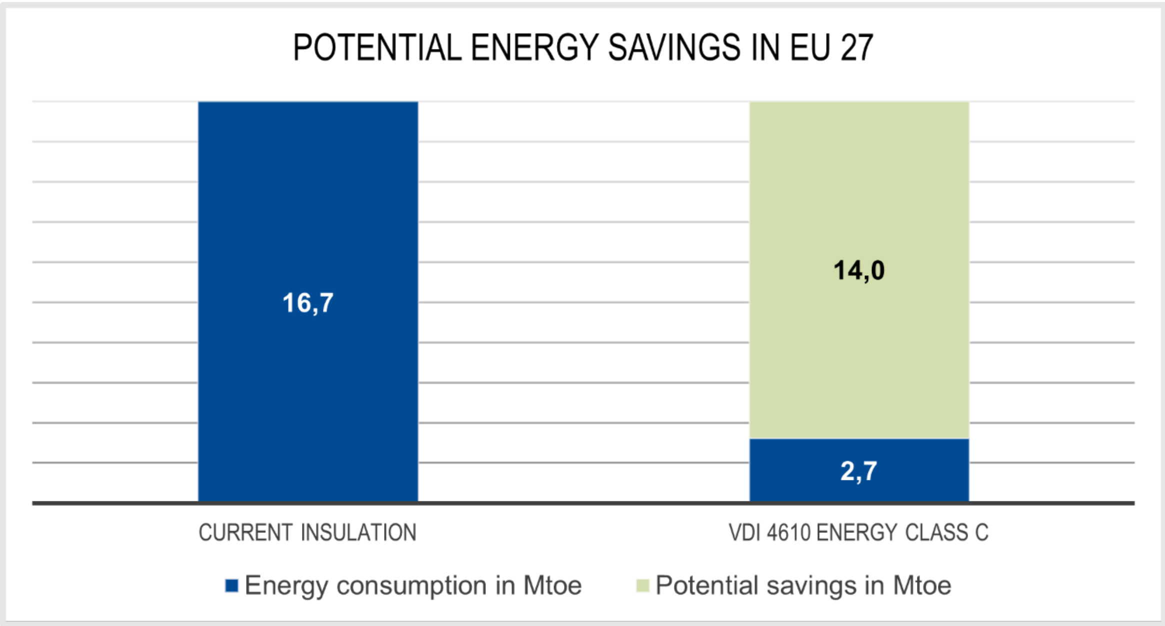


Figure 14: Comparing the potential energy savings in EU 27 – the situation today vs. the VDI 4610 energy class C scenario

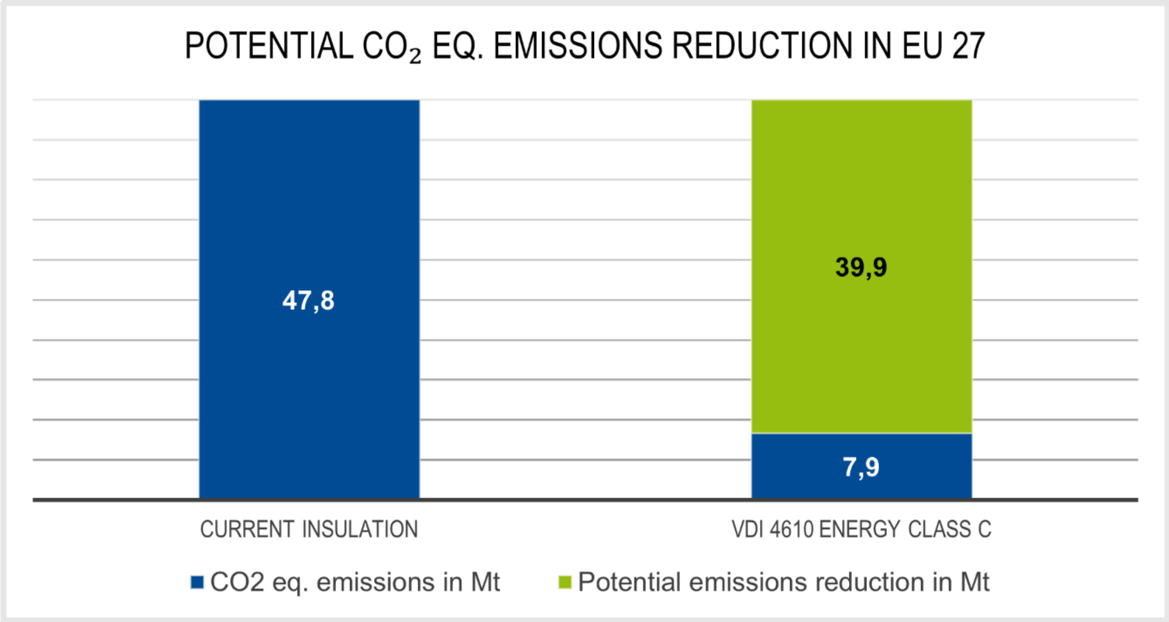


Figure 15: Comparing the potential CO_2 eq. emissions reduction in EU 27 – the situation today vs. the VDI 4610 energy class C scenario

On the following pages, the figures show the energy savings and CO_2 equivalent emissions reduction potential for all energy classes as well as cost-effective insulation solutions in comparison to the current situation.

It can be assumed that with increasing carbon and energy costs for industry, the cost-effective insulation solutions of today, ranging between energy class D and C will move further to the right towards energy class C and B levels. This is directly dependent on how much future energy prices, including future carbon taxes, will increase.

Companies who have already chosen to implement at least energy class C solutions will see a reduction in their energy consumption and greenhouse gas emissions and are well prepared for the future.

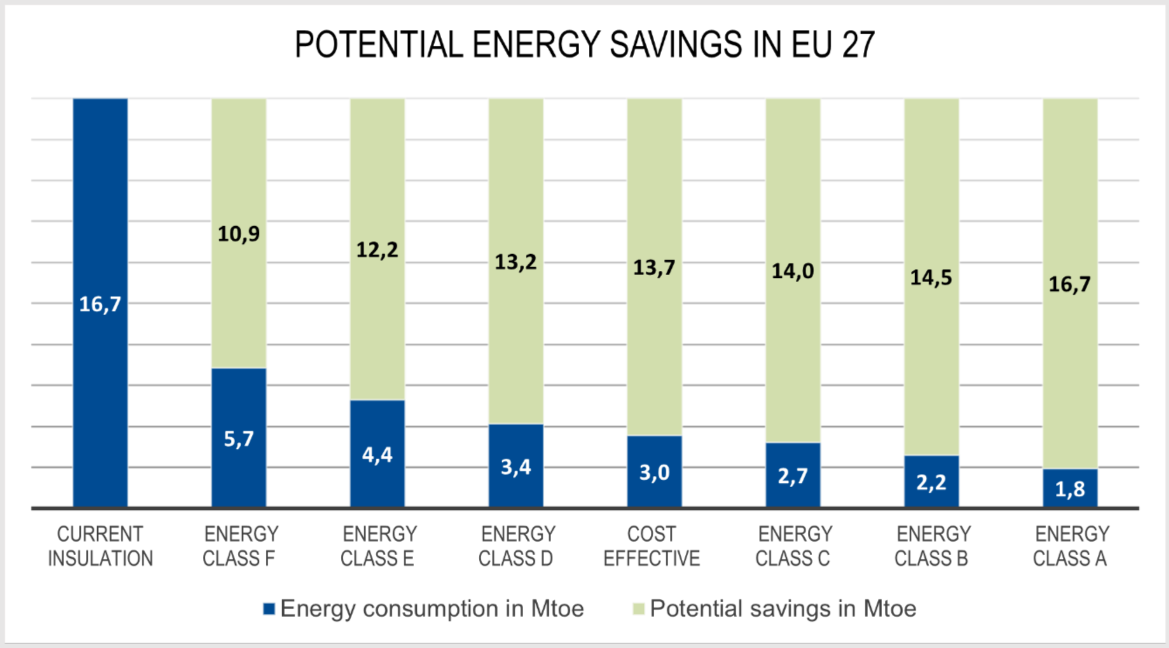


Figure 16: Potential energy savings in EU 27 by VDI 4610 energy classes and cost-effectiveness

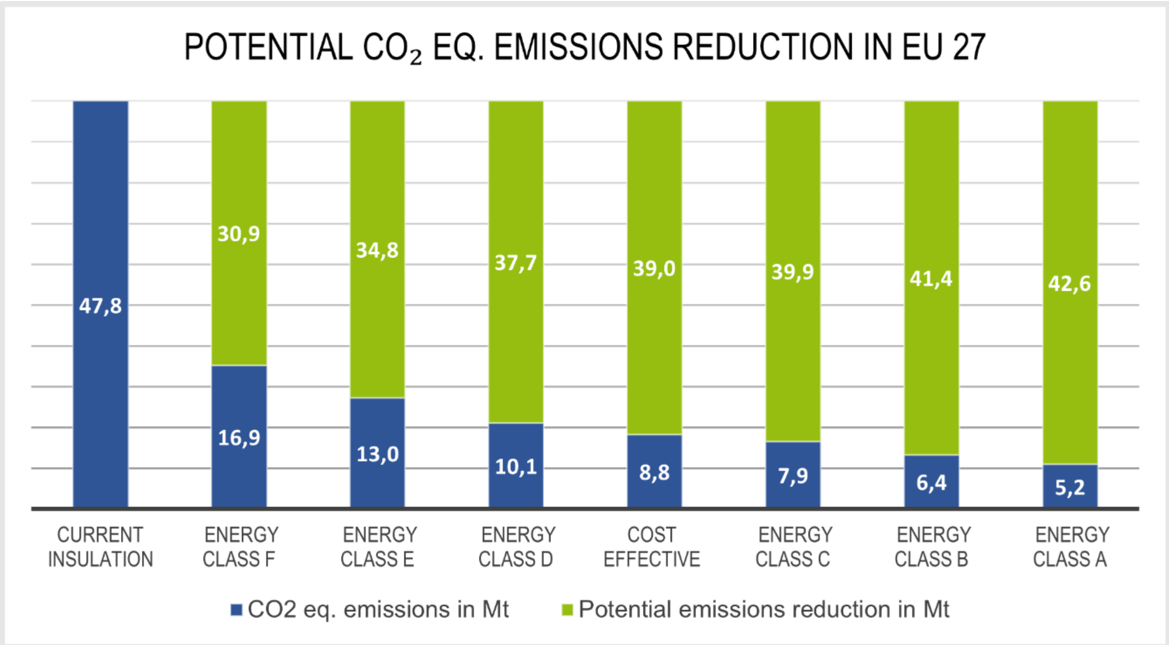


Figure 17: Potential CO_2 eq. emissions reduction in EU 27 by VDI 4610 energy classes and cost-effectiveness

The savings potential was found to exist across all regions, sectors and equipment and at all operating temperatures. The potential varies between regions and sectors, due to differences in energy use, temperature profiles and energy sources. However, to evaluate the savings potential of industrial insulation this study analysed the energy savings potential of insulation systems operating above ambient temperatures only.

For the electricity sector, EiiF exclusively considered gas, coal, oil and biomass technologies in its study. However, insulation energy efficiency potential also exists also in carbon-free technologies such as nuclear and some renewables.

The following examples show the full process and methodology of the energy and emissions savings analysis for the refinery sector in Germany and for the chemical sector in France.

Energy analysis of the German refinery sector

For the energy analysis, the total energy consumption of the German refinery sector was taken from the Enerdata Odyssee-Mure EU project database. As a next step, the amount of energy was adjusted to the amount of energy which is used in thermal processes.

Total energy consumption (Enerdata database)		Thermal energy consumption (EiiF estimate)
7.162 ktoe	→	6.637 ktoe

Table 11: Thermal energy consumption per sector in German refineries (EiiF estimate)

EiiF estimates that about 6.637 ktoe out of the total energy consumption of 7.162 ktoe (Enerdata) is the amount of energy that is linked to thermal energy use in German refineries which can be influenced by insulation. The thermal energy consumption of 6.637 ktoe was then split over the different temperature levels. The percentage of energy use at the different temperature levels varies from sector to sector as it is dependent on specific production parameters.

Thermal energy consumption (EiiF estimate)	Share of thermal energy consumption	Thermal energy consumption per temp. level	
6.637 ktoe	10%	664 ktoe	low temp.
	10%	664 ktoe	middle temp.
	80%	5.309 ktoe	high temp.

Table 12: Thermal energy consumption per temperature level in the German refinery sector

In the German refinery sector, about 10% of the thermal energy used (664 ktoe) is consumed by temperature processes at the low temperature level below 100 °C. An additional 10% (664 ktoe) is consumed by temperature processes in the middle-temperature range of 100 °C to 300 °C. About 80% (5.309 ktoe) of the energy is consumed at high temperature levels above 300 °C.

According to the Ecofys methodology (see Chapter 2), the share of energy input which is currently lost over surfaces was analysed to be 9,6% for low temperatures, 6,7% for middle temperatures and 5,0% for high temperatures.

Thermal energy consumption per temp. level		Share of thermal energy loss over surfaces which can be influenced by insulation	
low temp.	664 ktoe	9,6%	64 ktoe
middle temp.	664 ktoe	6,7%	44 ktoe
high temp.	5.309 ktoe	5,0%	265 ktoe

Table 13: Share of thermal energy loss over surfaces which can be influenced by insulation in the German refinery sector

According to the analysis, about 64 ktoe (9,6% of 664 ktoe) in low-temperature processes about 44 ktoe (6,7% of 664 ktoe) in middle-temperature processes and 265 ktoe (5,0% of 5.309 ktoe) in high-temperature processes are currently lost over surfaces which can be influenced by insulation.

Based on these energy figures, the savings potential was evaluated if VDI 4610 energy class C was applied.

Evaluation of the savings potential if VDI 4610 energy class C was applied				
Temperature level	**Share of thermal energy loss over surfaces which can be influenced by insulation**	**Reduction of thermal energy loss in % if energy class C was applied**	**Remaining thermal energy loss over surfaces**	**Energy savings if energy class C was applied**
low temp.	**64 ktoe**	**-88%**	**8 ktoe**	**56 ktoe**
middle temp.	**44 ktoe**	**-88%**	**5 ktoe**	**39 ktoe**
high temp.	**265 ktoe**	**-78%**	**57 ktoe**	**208 ktoe**

Table 14: Evaluation of the savings potential if VDI 4610 energy class C was consistently applied in the German refinery sector

For the German refinery example, the calculation results in energy savings of 56 ktoe (88% of 64 ktoe) from low-temperature processes, 39 ktoe (88% of 44 ktoe) from middle-temperature processes and 208 ktoe (78% of 265 ktoe) from high-temperature processes.

Finally, the total energy savings potential was calculated by adding up the three temperature level results: 56 ktoe + 39 ktoe + 208 ktoe = 303 ktoe.

The analysis of the greenhouse gas emissions reduction potential was based on the energy figures and considering the differences in the energy mix per country and sector. In the German refinery example, the greenhouse gas emissions reduction potential was estimated to be 1.044 kt.

Total energy & greenhouse gas emissions savings potential
303 ktoe
1.044 kt CO_2 eq.

Table 15: Total energy & greenhouse gas emissions savings potential for the German refinery sector

Energy analysis of the French chemical sector

Like in the example before the energy consumption of the chemical sector in France was taken from the Enerdata Odyssee-Mure EU project database.

As the next step the amount of energy was adjusted to the amount of energy which is used in thermal processes.

Total energy consumption (Enerdata database)		Thermal energy consumption (EiiF estimate)
4.152 ktoe	→	**2.437 ktoe**

Table 16: Thermal energy consumption per sector in the French chemical sector (EiiF estimate)

EiiF estimates that about 2.437 ktoe out of the total energy consumption of 4.152 ktoe (Enerdata) is the amount of energy that is linked to thermal energy use which can be influenced by insulation in the French chemical sector.

The thermal energy consumption of 2.437 ktoe was then split over the different temperature levels. The percentage of energy use at the different temperature levels varies from sector to sector as it is dependent on specific production parameters.

Thermal energy consumption (EiiF estimate)	Share of thermal energy consumption	Thermal energy consumption per temp. level	
2.437 ktoe	30%	731 ktoe	low temp.
	40%	975 ktoe	middle temp.
	30%	731 ktoe	high temp.

Table 17: Thermal energy consumption per temperature level in the French chemical sector

In the French chemical sector, about 30% of the energy used (731 ktoe) is consumed by temperature processes at the low temperature level below 100 °C. An additional 40% (975 ktoe) is consumed by temperature processes in the middle-temperature range of 100 °C to 300 °C. About 30% (731 ktoe) of the energy is consumed at high temperature levels above 300 °C.

According to the Ecofys methodology (see Chapter 2), the share of energy input which is currently lost over surfaces was analysed to be 9,6% for low temperatures, 6,7% for middle temperatures and 5.0% for high temperatures.

Thermal energy consumption per temp. level		Share of thermal energy loss over surfaces which can be influenced by insulation	
low temp.	731 ktoe	9,6%	70 ktoe
middle temp.	975 ktoe	6,7%	65 ktoe
high temp.	731 ktoe	5,0%	37 ktoe

Table 18: Share of thermal energy loss over surfaces which can be influenced by insulation in the French chemical sector

According to this analysis about 70 ktoe (9,6% of 731 ktoe) in low-temperature processes, about 65 ktoe (6,7% of 975 ktoe) in middle-temperature processes and 37 ktoe (5,0% of 731 ktoe) in high-temperature processes are currently lost over surfaces which can be influenced by insulation.

Based on these energy figures, the savings potential was evaluated if VDI 4610 energy class C was applied:

Evaluation of the savings potential if VDI 4610 energy class C was applied				
Temperature level	**Share of thermal energy loss over surfaces which can be influenced by insulation**	**Reduction of thermal energy loss in % if energy class C was applied**	**Remaining thermal energy loss**	**Thermal energy savings if energy class C was applied**
low temp.	**70 ktoe**	**88%**	**8 ktoe**	**62 ktoe**
middle temp.	**65 ktoe**	**88%**	**8 ktoe**	**57 ktoe**
high temp.	**37 ktoe**	**78%**	**8 ktoe**	**29 ktoe**

Table 19: Evaluation of the savings potential if VDI 4610 energy class C was consistently applied in the French chemical sector

In the French chemical sector example, the calculation results in energy savings of 62 ktoe (88% of 70 ktoe) from low-temperature processes, 57 ktoe (88% of 65 ktoe) from middle-temperature processes and 29 ktoe (78% of 37 ktoe) from high-temperature processes.

Finally, the total energy savings potential was calculated by adding up the three temperature level results: 62 ktoe + 57 ktoe + 29 ktoe = 148 ktoe.

The analysis of the greenhouse gas emissions reduction potential was based on the energy figures and considering the differences in the energy mix per country and sector. In the French chemical sector example, the greenhouse gas emissions reduction potential was estimated to be 440 kt.

Total energy & greenhouse gas emissions savings potential
148 ktoe
440 kt CO_2 eq.

Table 20: Total energy & greenhouse gas emissions savings potential for the French chemical sector

6. The EU's challenge to decarbonise industry by 2050

The European Union has set itself an ambitious goal: to be climate neutral by 2050, with net-zero CO_2 eq. emissions. Decarbonising EU industry is one of the major challenges of reaching this target. Considering the current annual level of CO_2 equivalent emissions in EU 27 (EEA 2017: 3.853 Mt), it is clear that this goal can only be achieved with the support and participation of all key sectors including the EU's industry and energy supply, which accounts for 49% (EEA 2017) of the EU's emissions.

On 11 December 2020, the EU Council endorsed the proposal by the European Commission to reduce emissions by at least 55% by 2030. In her speech at the Climate Ambition Summit on 12 December 2020, European Commission President Ursula von der Leyen said: "It is about a new circular economy that creates jobs and prosperity while preserving nature.

Many things have to change, so that our planet can remain the same for the next generation. 55% is Europe's contribution on the road to Glasgow. Let us walk this road together!"

Having agreed on a more ambitious greenhouse gas target, the EU now needs to adjust and define the new energy efficiency target. The European Commission estimates that this will have to increase from the existing 32,5% to more than 36%.

The European Commission states very clearly in its fact sheet National Energy and Climate Plans: Member State contributions to the EU's 2030 climate ambition (EC, 2020) that energy efficiency has to be "the first priority for the clean energy transition," and that today "the current national plans show an ambition gap: 2.8 percentage points for primary energy consumption and 3.1 percentage points for final energy consumption in the EU."

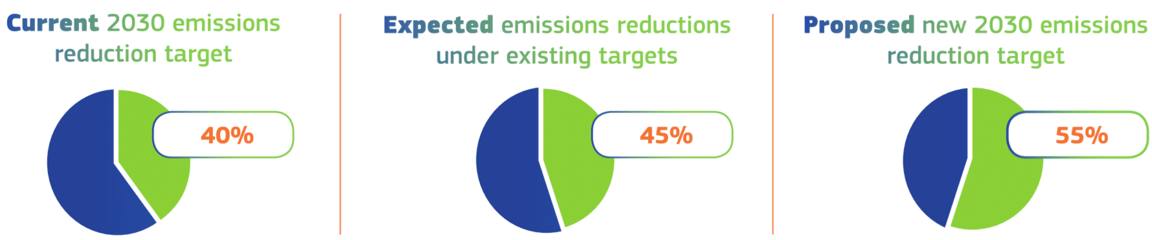


Figure 18: Improvement in energy efficiency needed to achieve the 55% emissions reduction target in 2030. Source: European Commission

Against this backdrop, and the fact that already the "old 2030 energy efficiency target of 32,5%" will not be met by the current National Energy and Climate Plans (see Figure 18), the European Commission states in its fact sheet that there is additional work to be done and that new initiatives are needed to accelerate efforts. As a consequence, all member states will have to further improve and upgrade their National Energy and Climate Plans.

This European study highlights the existing potential of industrial insulation, proving that in addition to the EU focus areas of buildings, transport and agriculture, industry also has opportunities to contribute. In the National Fact Sheets (Annex A), EiiF analyses the industrial insulation potential by energy source and industry sector for each EU member state as well as four non-EU countries (Norway, Serbia, Switzerland and UK).

For example, Germany's industry could reduce by almost 10.000 kt of CO_2 eq. emissions and annually save almost 3.500 ktoe of energy by upgrading industrial insulation systems to VDI 4610 energy class C. Sweden's paper industry alone has the potential to reduce by 570 kt of CO_2 eq. emissions every year and to annually save about 250 ktoe of energy by simply insulating its national paper production consistently and in compliance with the VDI 4610 energy class C. For detailed information, please see the EiiF National Fact Sheets in Annex A.

7. EiiF recommendation

Our recommendation based on the results of this study is to introduce energy-efficient insulation standards and to significantly increase the number of insulation inspections to quickly tap existing potential.

We believe and are backed up by the analysis of this study that the fastest and easiest way would be to introduce energy-efficient insulation standards based on the VDI 4610 energy classes and to make them mandatory for any newly built plant in Europe, and to make repairs and upgrades of existing insulation systems attractive by, for example, introducing subsidies in the framework of the individual National Energy and Climate Plans.

Furthermore, thermal energy audits like EiiF's TIPCHECK Programme could be included in the National Energy and Climate Plans.

In addition, extending Article 8 of the Energy Efficiency Directive to also include small and medium-sized businesses with a defined energy consumption and promoting the implementation of the ISO 50001 energy management standard in industry will have a positive impact on the uptake of energy-efficient insulation solutions in industry.

Looking at the Industrial Emissions Directive, EiiF believes that energy-efficient techniques like industrial insulation have to be included more prominently in all BREF-documents (Best Available Technique Reference Document) and CO_2 has to be integrated as a pollutant. Furthermore, our experience shows that the horizontal Energy Efficiency BREF needs to be updated.

In conclusion, we would like to summarise the multiple benefits the EU can count on if our recommendations are acted on.

For the climate

- Cutting annual CO_2 eq. emissions by 40 Mt
- Reducing energy consumption in industry by 14 Mtoe every year – equivalent to the energy consumption of 10 million households

For Europe

- Contributing towards net zero in 2050 (Green Deal)
- Creating and saving jobs in Europe (Green Recovery)

For industry

- Increasing competitiveness (reducing production costs)
- Offering smart investment opportunities with rapid payback
- Creating safer, better working conditions

Increased activity in the field of industrial insulation will contribute in a financially attractive way to decarbonising industry and providing and saving jobs in Europe.
The installation of new and better performing insulation solutions as well as the repair work will have to be done here in Europe by European insulation workers. Most insulation materials used in industry are produced in Europe.

The EiiF community, comprised of the leading industrial insulation companies, offers with this EiiF Study 2021 a very solid and fact-based analysis and a good foundation for further discussion of how to tap the industrial insulation energy efficiency potential which is financially attractive and immediate.

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XIV. VDI 4610 Part 1: Energy efficiency of industrial installations – Thermal insulation, 2018

Annex A – Breakdown of potential by country and sector: National Fact Sheets

Contents

1. Austria

Download the EiiF Fact Sheet for Austria from www.eiif.org/publications

AUSTRIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 343 ktoe

Emissions reduction potential: 885 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 20,6**
- **GAS: 168,6**
- **ELECTRICITY: 1,4**
- **OIL: 25,1**
- **HEAT: 18,0**
- **BIOMASS: 109,4**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Austria	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	47	135
Chemical industry	42	103
Refineries	17	59
Paper & Pulp	73	184
Food industry	25	64
Non-metallic minerals	34	92
Steel industry	25	71
Machinery	17	44
Wood industry	42	87
Non-ferrous metal	6	15
Transport equipment	5	11
Textile	3	8
All other sectors	5	13
TOTAL	**343**	**885**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **186.000 HOUSEHOLDS**

OR

MORE THAN **517.000 CARS**

2. Belgium

Download the EiiF Fact Sheet for Belgium from www.eiif.org/publications

BELGIUM

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 554 ktoe

Emissions reduction potential: 1.581 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 30,2**
- **GAS: 290,6**
- **ELECTRICITY: 2,6**
- **OIL: 142,00**
- **HEAT: 21,5**
- **BIOMASS: 66,9**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Belgium	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	57	152
Chemical industry	170	484
Refineries	59	213
Paper & Pulp	29	68
Food industry	75	195
Non-metallic minerals	50	154
Steel industry	47	134
Machinery	12	33
Wood industry	17	40
Non-ferrous metal	7	17
Transport equipment	4	12
Textile	8	21
All other sectors	19	59
TOTAL	**554**	**1.581**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **316.000** HOUSEHOLDS

OR

MORE THAN **834.000** CARS

3. Bulgaria

Download the EiiF Fact Sheet for Bulgaria from www.eiif.org/publications

BULGARIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 191 ktoe

Emissions reduction potential: 618 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 65,5**
- **GAS: 58,8**
- **ELECTRICITY: 0,7**
- **OIL: 37,3**
- **HEAT: 12,1**
- **BIOMASS: 16,8**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Bulgaria	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	62	257
Chemical industry	47	129
Refineries	21	74
Paper & Pulp	10	24
Food industry	9	22
Non-metallic minerals	22	66
Steel industry	3	6
Machinery	4	12
Wood industry	4	8
Non-ferrous metal	4	7
Transport equipment	1	2
Textile	3	6
All other sectors	2	4
TOTAL	**191**	**618**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **251.000** HOUSEHOLDS

OR

MORE THAN **288.000** CARS

4. Croatia

Download the EiiF Fact Sheet for Croatia from www.eiif.org/publications

CROATIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 78 ktoe

Emissions reduction potential: 229 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 6,9**
- **GAS: 34,5**
- **ELECTRICITY: 0,1**
- **OIL: 26,0**
- **HEAT: 5,5**
- **BIOMASS: 4,7**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Croatia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	12	36
Chemical industry	8	21
Refineries	20	67
Paper & Pulp	2	6
Food industry	10	28
Non-metallic minerals	14	49
Steel industry	0	0
Machinery	3	7
Wood industry	4	5
Non-ferrous metal	0	1
Transport equipment	0	1
Textile	1	3
All other sectors	2	4
TOTAL	**78**	**229**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **48.000** **HOUSEHOLDS**

OR

MORE THAN **116.000** **CARS**

5. Cyprus

Download the EiiF Fact Sheet for Cyprus from www.eiif.org/publications

CYPRUS

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 16 ktoe

Emissions reduction potential: 58 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 0,1**
- **GAS: 0,0**
- **ELECTRICITY: 0,0**
- **OIL: 16,0**
- **HEAT: 0,0**
- **BIOMASS: 0,2**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Cyprus	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	10	35
Chemical industry	0	0
Refineries	0	0
Paper & Pulp	0	0
Food industry	2	5
Non-metallic minerals	5	16
Steel industry	0	0
Machinery	0	1
Wood industry	0	0
Non-ferrous metal	0	0
Transport equipment	0	0
Textile	0	0
All other sectors	0	0
TOTAL	**16**	**58**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **17.000 HOUSEHOLDS** OR MORE THAN **24.000 CARS**

6. Czech Republic

Download the EiiF Fact Sheet for Czech Republic from www.eiif.org/publications

CZECH REPUBLIC

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 414 ktoe

Emissions reduction potential: 1.278 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 158,1**
- **GAS: 159,2**
- **ELECTRICITY: 1,1**
- **OIL: 16,2**
- **HEAT: 38,1**
- **BIOMASS: 41,3**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector Czech Republic	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	134	537
Chemical industry	46	130
Refineries	15	49
Paper & Pulp	25	58
Food industry	32	80
Non-metallic minerals	43	143
Steel industry	34	88
Machinery	30	68
Wood industry	14	32
Non-ferrous metal	3	7
Transport equipment	18	41
Textile	6	14
All other sectors	15	31
TOTAL	**414**	**1.278**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **245.000 HOUSEHOLDS**

OR

MORE THAN **623.000 CARS**

7. Denmark

Download the EiiF Fact Sheet for Denmark from www.eiif.org/publications

DENMARK

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 139 ktoe

Emissions reduction potential: 423 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 29,8**
- **GAS: 42,4**
- **ELECTRICITY: 0,2**
- **OIL: 31,6**
- **HEAT: 6,1**
- **BIOMASS: 28,8**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Denmark	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	42	127
Chemical industry	10	26
Refineries	16	57
Paper & Pulp	2	4
Food industry	26	75
Non-metallic minerals	17	56
Steel industry	2	6
Machinery	13	34
Wood industry	6	23
Non-ferrous metal	0	0
Transport equipment	1	2
Textile	2	6
All other sectors	3	10
TOTAL	**139**	**423**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **83.000 HOUSEHOLDS** OR MORE THAN **209.000 CARS**

8. Estonia

Download the EiiF Fact Sheet for Estonia from www.eiif.org/publications

ESTONIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 42 ktoe

Emissions reduction potential: 149 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 25,8**
- **GAS: 7,1**
- **ELECTRICITY: 0,0**
- **OIL: 1,5**
- **HEAT: 2,4**
- **BIOMASS: 5,5**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Estonia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	29	116
Chemical industry	2	2
Refineries	0	0
Paper & Pulp	2	4
Food industry	2	6
Non-metallic minerals	3	11
Steel industry	0	0
Machinery	1	2
Wood industry	2	5
Non-ferrous metal	0	0
Transport equipment	0	1
Textile	0	1
All other sectors	1	2
TOTAL	**42**	**149**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **27.000 HOUSEHOLDS** OR MORE THAN **63.000 CARS**

9. Finland

Download the EiiF Fact Sheet for Finland from www.eiif.org/publications

FINLAND

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 510 ktoe

Emissions reduction potential: 1.206 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 40,2**
- **GAS: 47,1**
- **ELECTRICITY: 2,4**
- **OIL: 83,4**
- **HEAT: 82,7**
- **BIOMASS: 254,1**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Finland	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	61	192
Chemical industry	37	78
Refineries	33	117
Paper & Pulp	261	595
Food industry	18	25
Non-metallic minerals	12	36
Steel industry	20	47
Machinery	10	14
Wood industry	38	56
Non-ferrous metal	4	6
Transport equipment	3	4
Textile	1	2
All other sectors	13	33
TOTAL	**510**	**1.206**

*Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **281.000 HOUSEHOLDS** OR MORE THAN **768.000 CARS**

10. France

Download the EiiF Fact Sheet for France from www.eiif.org/publications

FRANCE

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 1.288 ktoe

Emissions reduction potential: 3.423 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 106,7**
- **GAS: 729,2**
- **ELECTRICITY: 8,1**
- **OIL: 173,5**
- **HEAT: 125,0**
- **BIOMASS: 145,5**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in France	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	156	471
Chemical industry	148	440
Refineries	121	397
Paper & Pulp	97	242
Food industry	222	637
Non-metallic minerals	122	366
Steel industry	90	256
Machinery	64	184
Wood industry	34	82
Non-ferrous metal	19	43
Transport equipment	40	108
Textile	16	43
All other sectors	158	154
TOTAL	**1.288**	**3.423**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **900.000** HOUSEHOLDS

OR

MORE THAN **1,9 MILLION** CARS

11. Germany

Download the EiiF Fact Sheet for Germany from www.eiif.org/publications

GERMANY

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 3.466 ktoe

Emissions reduction potential: 9.981 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 737,4**
- **GAS: 1.571,9**
- **ELECTRICITY: 16,8**
- **OIL: 394,8**
- **HEAT: 283,5**
- **BIOMASS: 461,6**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector Germany	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	836	3.071
Chemical industry	648	1.484
Refineries	303	1.044
Paper & Pulp	219	524
Food industry	261	689
Non-metallic minerals	265	814
Steel industry	247	699
Machinery	181	469
Wood industry	167	373
Non-ferrous metal	54	133
Transport equipment	128	303
Textile	26	69
All other sectors	132	309
TOTAL	**3.466**	**9.981**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **2,1 MILLION HOUSEHOLDS** OR MORE THAN **5,2 MILLION CARS**

12. Greece

Download the EiiF Fact Sheet for Greece from www.eiif.org/publications

GREECE

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 251 ktoe

Emissions reduction potential: 847 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 46,1**
- **GAS: 72,4**
- **ELECTRICITY: 2,2**
- **OIL: 119,2**
- **HEAT: 0,0**
- **BIOMASS: 10,7**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Greece	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	83	306
Chemical industry	4	11
Refineries	67	240
Paper & Pulp	2	5
Food industry	24	67
Non-metallic minerals	27	98
Steel industry	2	5
Machinery	1	4
Wood industry	2	4
Non-ferrous metal	17	43
Transport equipment	1	4
Textile	2	4
All other sectors	19	55
TOTAL	**251**	**847**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **245.000 HOUSEHOLDS**

OR

MORE THAN **377.000 CARS**

13. Hungary

Download the EiiF Fact Sheet for Hungary from www.eiif.org/publications

HUNGARY

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 226 ktoe

Emissions reduction potential: 620 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 19,7**
- **GAS: 116,0**
- **ELECTRICITY: 0,4**
- **OIL: 45,7**
- **HEAT: 22,1**
- **BIOMASS: 22,3**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Hungary	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	34	110
Chemical industry	52	127
Refineries	24	79
Paper & Pulp	9	27
Food industry	29	72
Non-metallic minerals	19	56
Steel industry	13	34
Machinery	17	45
Wood industry	5	13
Non-ferrous metal	4	11
Transport equipment	8	18
Textile	2	5
All other sectors	10	24
TOTAL	**226**	**620**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **140.000** **HOUSEHOLDS**

OR

MORE THAN **340.000** **CARS**

14. Ireland

Download the EiiF Fact Sheet for Ireland from www.eiif.org/publications

IRELAND

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 139 ktoe

Emissions reduction potential: 425 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 18,3**
- **GAS: 67,0**
- **ELECTRICITY: 0,3**
- **OIL: 34,4**
- **HEAT: 0,0**
- **BIOMASS: 19,2**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Ireland	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	39	125
Chemical industry	6	16
Refineries	6	21
Paper & Pulp	0	1
Food industry	20	63
Non-metallic minerals	17	58
Steel industry	20	53
Machinery	15	44
Wood industry	11	25
Non-ferrous metal	0	0
Transport equipment	1	2
Textile	0	1
All other sectors	5	17
TOTAL	**139**	**425**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **94.000 HOUSEHOLDS** OR MORE THAN **209.000 CARS**

15. Italy

Download the EiiF Fact Sheet for Italy from www.eiif.org/publications

ITALY

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 1.458 ktoe

Emissions reduction potential: 3.861 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 90,3**
- **GAS: 790,6**
- **ELECTRICITY: 8,4**
- **OIL: 290,3**
- **HEAT: 178,0**
- **BIOMASS: 100,6**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Italy	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	416	1.251
Chemical industry	147	270
Refineries	155	545
Paper & Pulp	86	130
Food industry	128	294
Non-metallic minerals	157	450
Steel industry	90	220
Machinery	154	406
Wood industry	0	0
Non-ferrous metal	23	60
Transport equipment	0	0
Textile	61	162
All other sectors	41	72
TOTAL	**1.458**	**3.861**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **1 MILLION** HOUSEHOLDS

OR

MORE THAN **2,1 MILLION** CARS

16. Latvia

Download the EiiF Fact Sheet for Latvia from www.eiif.org/publications

LATVIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 54 ktoe

Emissions reduction potential: 119 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 1,1**
- **GAS: 10,6**
- **ELECTRICITY: 0,0**
- **OIL: 2,3**
- **HEAT: 6,5**
- **BIOMASS: 33,0**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Latvia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	7	18
Chemical industry	1	3
Refineries	0	0
Paper & Pulp	0	0
Food industry	4	10
Non-metallic minerals	5	14
Steel industry	0	0
Machinery	1	2
Wood industry	34	68
Non-ferrous metal	0	0
Transport equipment	0	1
Textile	0	1
All other sectors	1	1
TOTAL	**54**	**119**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **35.000 HOUSEHOLDS**

OR

MORE THAN **80.000 CARS**

17. Lithuania

Download the EiiF Fact Sheet for Lithuania from www.eiif.org/publications

LITHUANIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 76 ktoe

Emissions reduction potential: 199 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- COAL: 4,1
- GAS: 21,0
- ELECTRICITY: 0,0
- OIL: 26,8
- HEAT: 14,8
- BIOMASS: 9,7

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Lithuania	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	5	13
Chemical industry	21	27
Refineries	25	89
Paper & Pulp	1	3
Food industry	9	24
Non-metallic minerals	5	20
Steel industry	0	0
Machinery	1	2
Wood industry	5	12
Non-ferrous metal	0	0
Transport equipment	0	0
Textile	2	4
All other sectors	2	4
TOTAL	**76**	**199**

*Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **73.000** HOUSEHOLDS

OR

MORE THAN **115.000** CARS

18. Luxembourg

Download the EiiF Fact Sheet for Luxembourg from www.eiif.org/publications

LUXEMBOURG

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 21 ktoe

Emissions reduction potential: 56 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 1,7**
- **GAS: 14,8**
- **ELECTRICITY: 0,7**
- **OIL: 0,5**
- **HEAT: 0,0**
- **BIOMASS: 3,1**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Luxembourg	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	1	3
Chemical industry	1	3
Refineries	0	0
Paper & Pulp	0	0
Food industry	1	2
Non-metallic minerals	6	18
Steel industry	7	17
Machinery	0	1
Wood industry	2	4
Non-ferrous metal	0	0
Transport equipment	0	0
Textile	2	6
All other sectors	1	2
TOTAL	**21**	**56**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **9.000 HOUSEHOLDS** OR MORE THAN **31.000 CARS**

19. Malta

Download the EiiF Fact Sheet for Malta from www.eiif.org/publications

MALTA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 4 ktoe

Emissions reduction potential: 12 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 0,0**
- **GAS: 2,2**
- **ELECTRICITY: 0,0**
- **OIL: 1,7**
- **HEAT: 0,0**
- **BIOMASS: 0,0**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Malta	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	3	8
Chemical industry	0	0
Refineries	0	0
Paper & Pulp	0	0
Food industry	0	0
Non-metallic minerals	0	0
Steel industry	0	0
Machinery	0	0
Wood industry	0	0
Non-ferrous metal	0	0
Transport equipment	0	0
Textile	0	0
All other sectors	1	4
TOTAL	**4**	**12**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **7.000 HOUSEHOLDS**

OR

MORE THAN **5.000 CARS**

20. Netherlands

Download the EiiF Fact Sheet for the Netherlands from www.eiif.org/publications

NETHERLANDS

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 956 ktoe

Emissions reduction potential: 2.720 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 77,1**
- **GAS: 475,0**
- **ELECTRICITY: 1,8**
- **OIL: 277,1**
- **HEAT: 92,2**
- **BIOMASS: 33,0**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in The Netherlands	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	183	589
Chemical industry	377	988
Refineries	139	470
Paper & Pulp	21	50
Food industry	110	279
Non-metallic minerals	22	63
Steel industry	43	124
Machinery	23	61
Wood industry	3	8
Non-ferrous metal	5	10
Transport equipment	5	13
Textile	6	14
All other sectors	20	52
TOTAL	**956**	**2.720**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **708.000 HOUSEHOLDS** OR MORE THAN **1,4 MILLION CARS**

21. Norway

Download the EiiF Fact Sheet for Norway from www.eiif.org/publications

NORWAY

The total energy savings and emissions reduction potential by improving insulation solutions in Norway's industry

Energy savings potential: 134 ktoe

Emissions reduction potential: 405 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 19,7**
- **GAS: 21,4**
- **ELECTRICITY: 10,2**
- **OIL: 59,8**
- **HEAT: 1,8**
- **BIOMASS: 20,6**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Norway	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	6	16
Chemical industry	5	10
Refineries	26	93
Paper & Pulp	46	164
Food industry	11	37
Non-metallic minerals	7	16
Steel industry	11	33
Machinery	8	18
Wood industry	1	3
Non-ferrous metal	11	8
Transport equipment	1	2
Textile	0	0
All other sectors	2	5
TOTAL	**134**	**405**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **78.000** HOUSEHOLDS

OR

MORE THAN **201.000** CARS

22. Poland

Download the EiiF Fact Sheet for Poland from www.eiif.org/publications

POLAND

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 1.070 ktoe

Emissions reduction potential: 3.545 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

COAL: 479,5

GAS: 300,7

ELECTRICITY: 3,6

OIL: 77,1

HEAT: 42,8

BIOMASS: 166,3

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Poland	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	352	1.455
Chemical industry	117	426
Refineries	82	250
Paper & Pulp	75	193
Food industry	107	349
Non-metallic minerals	117	347
Steel industry	53	128
Machinery	31	78
Wood industry	71	160
Non-ferrous metal	13	30
Transport equipment	15	34
Textile	6	15
All other sectors	30	80
TOTAL	**1.070**	**3.545**

*Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **703.000** HOUSEHOLDS

OR

MORE THAN **1,6 MILLION** CARS

23. Portugal

Download the EiiF Fact Sheet for Portugal from www.eiif.org/publications

PORTUGAL

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 291 ktoe

Emissions reduction potential: 735 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 31,4**
- **GAS: 107,4**
- **ELECTRICITY: 0,7**
- **OIL: 63,8**
- **HEAT: 63,5**
- **BIOMASS: 23,9**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Portugal	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	75	250
Chemical industry	14	29
Refineries	40	138
Paper & Pulp	62	54
Food industry	21	54
Non-metallic minerals	43	124
Steel industry	3	5
Machinery	7	20
Wood industry	4	8
Non-ferrous metal	1	3
Transport equipment	0	0
Textile	16	37
All other sectors	5	12
TOTAL	**291**	**735**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **447.000 HOUSEHOLDS**

OR

MORE THAN **437.000 CARS**

24. Romania

Download the EiiF Fact Sheet for Romania from www.eiif.org/publications

ROMANIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 340 ktoe

Emissions reduction potential: 998 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 51,2**
- **GAS: 168,5**
- **ELECTRICITY: 2,3**
- **OIL: 69,7**
- **HEAT: 18,9**
- **BIOMASS: 29,3**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Romania	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	73	269
Chemical industry	60	157
Refineries	39	132
Paper & Pulp	5	14
Food industry	30	78
Non-metallic minerals	36	113
Steel industry	36	92
Machinery	16	40
Wood industry	20	43
Non-ferrous metal	0	0
Transport equipment	10	24
Textile	9	23
All other sectors	6	14
TOTAL	**340**	**998**

*Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **330.000 HOUSEHOLDS** OR MORE THAN **512.000 CARS**

25. Serbia

Download the EiiF Fact Sheet for Serbia from www.eiif.org/publications

SERBIA

The total energy savings and emissions reduction potential by improving insulation solutions in Serbia's industry

Energy savings potential: 173 ktoe

Emissions reduction potential: 576 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 78,7**
- **GAS: 42,9**
- **ELECTRICITY: 0,5**
- **OIL: 22,9**
- **HEAT: 13,9**
- **BIOMASS: 14,4**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Serbia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	68	290
Chemical industry	11	28
Refineries	9	28
Paper & Pulp	22	57
Food industry	14	50
Non-metallic minerals	4	10
Steel industry	20	47
Machinery	2	4
Wood industry	7	21
Non-ferrous metal	2	4
Transport equipment	3	8
Textile	4	11
All other sectors	9	19
TOTAL	**173**	**576**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **135.000 HOUSEHOLDS**

OR

MORE THAN **261.000 CARS**

26. Slovakia

Download the EiiF Fact Sheet for Slovakia from www.eiif.org/publications

SLOVAKIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 189 ktoe

Emissions reduction potential: 531 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 18,4**
- **GAS: 90,2**
- **ELECTRICITY: 2,1**
- **OIL: 36,2**
- **HEAT: 8,4**
- **BIOMASS: 33,8**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Slovakia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	21	72
Chemical industry	17	39
Refineries	30	106
Paper & Pulp	23	47
Food industry	7	20
Non-metallic minerals	19	53
Steel industry	45	125
Machinery	9	25
Wood industry	3	6
Non-ferrous metal	3	5
Transport equipment	6	17
Textile	1	3
All other sectors	5	13
TOTAL	**189**	**531**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **153.000 HOUSEHOLDS**

OR

MORE THAN **284.000 CARS**

27. Slovenia

Download the EiiF Fact Sheet for Slovenia from www.eiif.org/publications

SLOVENIA

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 55 ktoe

Emissions reduction potential: 157 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 12,1**
- **GAS: 25,9**
- **ELECTRICITY: 0,9**
- **OIL: 4,4**
- **HEAT: 3,5**
- **BIOMASS: 8,1**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Slovenia	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	12	49
Chemical industry	6	13
Refineries	0	0
Paper & Pulp	6	18
Food industry	3	8
Non-metallic minerals	7	21
Steel industry	4	10
Machinery	5	12
Wood industry	3	6
Non-ferrous metal	3	7
Transport equipment	1	3
Textile	1	2
All other sectors	3	7
TOTAL	**55**	**157**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **36.000 HOUSEHOLDS** OR MORE THAN **82.000 CARS**

28. Spain

Download the EiiF Fact Sheet for Spain from www.eiif.org/publications

SPAIN

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 1.280 ktoe

Emissions reduction potential: 3.880 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 117,4**
- **GAS: 626,4**
- **ELECTRICITY: 9,9**
- **OIL: 378,8**
- **HEAT: 0,0**
- **BIOMASS: 147,4**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Spain	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	248	853
Chemical industry	130	366
Refineries	355	1.157
Paper & Pulp	70	177
Food industry	118	332
Non-metallic minerals	129	400
Steel industry	55	140
Machinery	28	82
Wood industry	42	102
Non-ferrous metal	16	36
Transport equipment	17	47
Textile	13	37
All other sectors	60	150
TOTAL	**1.280**	**3.880**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **1,4 MILLION HOUSEHOLDS**

OR

MORE THAN **1,9 MILLION CARS**

29. Sweden

Download the EiiF Fact Sheet for Sweden from www.eiif.org/publications

SWEDEN

The total energy savings and emissions reduction potential by improving insulation solutions in industry

Energy savings potential: 513 ktoe

Emissions reduction potential: 1.323 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 45,7**
- **GAS: 30,2**
- **ELECTRICITY: 3,0**
- **OIL: 83,1**
- **HEAT: 21,7**
- **BIOMASS: 329,0**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Sweden	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	54	132
Chemical industry	37	140
Refineries	44	156
Paper & Pulp	250	573
Food industry	15	37
Non-metallic minerals	18	67
Steel industry	26	78
Machinery	11	18
Wood industry	44	90
Non-ferrous metal	3	7
Transport equipment	7	14
Textile	1	2
All other sectors	4	8
TOTAL	**513**	**1.323**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **308.000 HOUSEHOLDS** OR MORE THAN **772.000 CARS**

30. Switzerland

Download the EiiF Fact Sheet for Switzerland from www.eiif.org/publications

SWITZERLAND

The total energy savings and emissions reduction potential by improving insulation solutions in Switzerland's industry

Energy savings potential: 123 ktoe

Emissions reduction potential: 325 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 5,1**
- **GAS: 55,0**
- **ELECTRICITY: 0,6**
- **OIL: 21,5**
- **HEAT: 7,2**
- **BIOMASS: 33,4**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in Switzerland	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	14	32
Chemical industry	4	10
Refineries	7	24
Paper & Pulp	26	64
Food industry	16	48
Non-metallic minerals	9	15
Steel industry	17	48
Machinery	0	0
Wood industry	15	44
Non-ferrous metal	2	4
Transport equipment	0	0
Textile	2	6
All other sectors	11	29
TOTAL	**123**	**325**

**Gas, Coal, Oil, Biomass Technologies*

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **86.000** **HOUSEHOLDS**

OR

MORE THAN **184.000** **CARS**

31. United Kingdom

Download the EiiF Fact Sheet for the United Kingdom from www.eiif.org/publications

UNITED KINGDOM

The total energy savings and emissions reduction potential by improving insulation solutions in the UK's industry

Energy savings potential: 1.183 ktoe

Emissions reduction potential: 3.480 kt

The industrial insulation energy savings potential by different energy sources (in ktoe):

- **COAL: 127,0**
- **GAS: 709,5**
- **ELECTRICITY: 2,8**
- **OIL: 213,0**
- **HEAT: 16,9**
- **BIOMASS: 113,9**

The industrial insulation potential to reduce the energy consumption and carbon emissions by industry sector:

Potential by sector in United Kingdom	Energy savings (ktoe)	CO_2 eq. emissions reduction (kt)
Electricity sector*	345	983
Chemical industry	27	82
Refineries	163	584
Paper & Pulp	128	315
Food industry	91	279
Non-metallic minerals	47	124
Steel industry	125	346
Machinery	12	34
Wood industry	76	205
Non-ferrous metal	13	31
Transport equipment	56	169
Textile	27	82
All other sectors	73	249
TOTAL	**1.183**	**3.480**

Gas, Coal, Oil, Biomass Technologies

The national insulation savings potential is equivalent to the annual energy consumption of:

The calculation is based on the national average energy consumption provided by the Odyssee-Mure EU project (www.odyssee-mure.eu)

MORE THAN **863.000** HOUSEHOLDS

OR

MORE THAN **1,7 MILLION** CARS

Annex B - Insulation energy audit: The TIPCHECK Programme

Contents

1. The TIPCHECK Programme

The TIPCHECK Programme was implemented by the European Industrial Insulation Foundation (EiiF) with the aim of providing industry with tools and solutions to save energy and to reduce CO_2 eq. emissions by improving their technical insulation systems.

Within the framework of the TIPCHECK Programme, EiiF offers TIPCHECK energy audits and TIPCHECK trainings qualifying insulation experts to run standardised thermal energy audits.

2. TIPCHECK ENERGY AUDITS

The TIPCHECK energy audit is a **standardised thermal energy auditing tool**, in line with EN 16247 and ISO 50002, for evaluating the performance of industrial insulation systems. TIPCHECK stands for **T**echnical **I**nsulation **P**erformance **Check**.

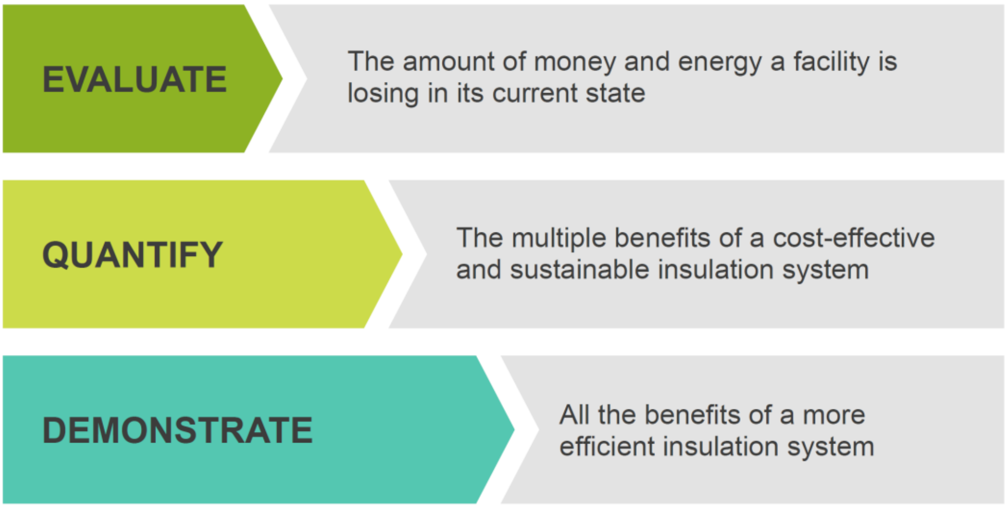
TIPCHECKs evaluate insulation systems of existing facilities, planned projects or retrofits and demonstrate how more efficient insulation could:

- save energy
- save money
- contribute to a cleaner environment through reduced CO_2 eq. emissions

TIPCHECKs contribute to energy management systems such as ISO 50001 and in addition to energy efficiency potentials, TIPCHECKs can help to identify:

- process efficiency improvements
- safety risks to personnel and equipment

TIPCHECKs identify the spots bearing the highest energy saving potential, offering a rapid payback time of two years on average or even less. The scope of a typical TIPCHECK usually includes uninsulated lines, lines with damaged insulation and insulated lines.



TIPCHECKs are carried out by EiiF directly and by EiiF certified **TIPCHECK engineers**.

3. TIPCHECK TRAININGS

Every year EiiF organises qualified trainings for insulation engineers, asset owners, energy auditors, energy managers and consultants to train them to perform standardised high-quality thermal energy audits, so-called TIPCHECKs.

The engineers passing the course get their TIPCHECK engineer certification and become TIPCHECK engineers.

Four times per year EiiF organises TIPCHECK Refresher trainings. Led by the EiiF staff and with the support of invited external experts, active TIPCHECK engineers learn about the latest tools and the political developments relevant for them and their thermal energy auditing services and are invited to share their knowledge and experience in interactive sessions with their TIPCHECK colleagues from all over the world.

The dates of the next TIPCHECK training courses can be found online: www.eiif.org/agenda

4. TIPCHECK IMPACT & SUCCESS

The TIPCHECK Programme is a non-invasive investigative tool that delivers multiple energy and non-energy benefits to the energy user, the supply system and the economy.

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to assess the manageability of the cost or the potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction.

However, clients are not necessarily and not always aware how much energy they are wasting, as they may not realise how easy and quick it is to stop the energy waste with properly insulated systems/installations.

Since 2010, about 2.500 TIPCHECKs have been carried out and evaluated by EiiF. The impact and the success of the TIPCHECK Programme can be summarised as follows:

- The TIPCHECK Programme has already resulted in EU-wide annual energy savings of more than 70 ktoe or 814.000 MWh - equivalent of the energy consumption of more than 50.000 European households*
- 75% of TIPCHECKs lead to insulation investments
- The payback periods for the initiated TIPCHECK insulation projects were in most cases 2 years or even less
- ~50 million EUR was the total insulation contract volume generated
- See the list of EiiF-certified TIPCHECK engineers here: www.eiif.org/tipcheck/certified-engineers

**1,36 toe/household average energy consumption in the EU. Source: www.odyssee-mure.eu*

5. TIPCHECK CASE STUDIES

Case Study 1 - Oil Storage Tank Roof

SUMMARY

At an oil refinery, the roof on a large oil storage tank needed replacement due, in part, to damage from corrosion under damaged insulation. The owner was considering installing the new roof without insulation, and accepting the resulting heat losses, in order to alleviate future problems with corrosion.

A TIPCHECK audit revealed the magnitude and cost of the heat losses, and the insulation firm that performed the audit was able to recommend a technical solution that allowed the new roof to be insulated without a recurrence of the corrosion problems.

BEFORE: An aged oil storage tank in a refinery had a heavily corroded roof and urgently needed repair

PROJECT INFORMATION

Client Details

Company: Confidential/Not disclosed

Facility Purpose and Location: Refinery, Italy

Project Contact (Role): Confidential/Not disclosed

CASE DETAILS

Key Facts and Challenges

- The operating temperature of the tank was 60 °C
- The roof of the oil storage tank was equipped with very old and damaged insulation, and the sheet of the roof was heavily corroded
- The status of the roof required that it must be demolished and fully replaced
- In order to avoid corrosion problems in the future, the owner was considering replacing the roof without insulation accepting the heat loss

Key Findings

- The TIPCHECK audit found out that without insulation the energy loss would have been approximately **9.500 MWh/year** resulting in annual financial losses of almost **240.000 € per year** if an energy price of 25 €/MWh was assumed

- An insulation of only 30 mm thickness on the roof, applied with a technical solution to avoid future corrosion under insulation (CUI) problems, could reduce the energy loss by 80%

Results

The owner decided to insulate the new roof and the installed 30 mm insulation system equivalent to the VDI 4610 energy class G saves him every year (rounded figures):

- CO_2 eq. emissions: -1.500 t
- Energy: -7.500 MWh
- Financial savings (25 €/MWh): -185.000 €
- Investment (approx.): 400.000 €
- Payback time: 2,2 years

AFTER: The tank roof newly insulated with a 30 mm insulation solution and long-lasting corrosion protection

Case Study 2 - Chemical Plant

SUMMARY

A large chemical plant in Italy contained hundreds of uninsulated or under-insulated parts, such as valves and flanges, which needed to be evaluated individually in order to assess the associated heat losses. The standardised TIPCHECK methodology revealed in detail the amount of heat lost from each instance of missing or damaged insulation and allowed the TIPCHECK auditor to present specific remediation recommendations and their projected results. In response to the TIPCHECK results, the client acted immediately to implement recommended measures.

PROJECT INFORMATION

Client Details

Company: Confidential/Not disclosed
Facility Purpose and Location: Chemical plant, Italy
Project Contact (Role): Confidential/Not disclosed

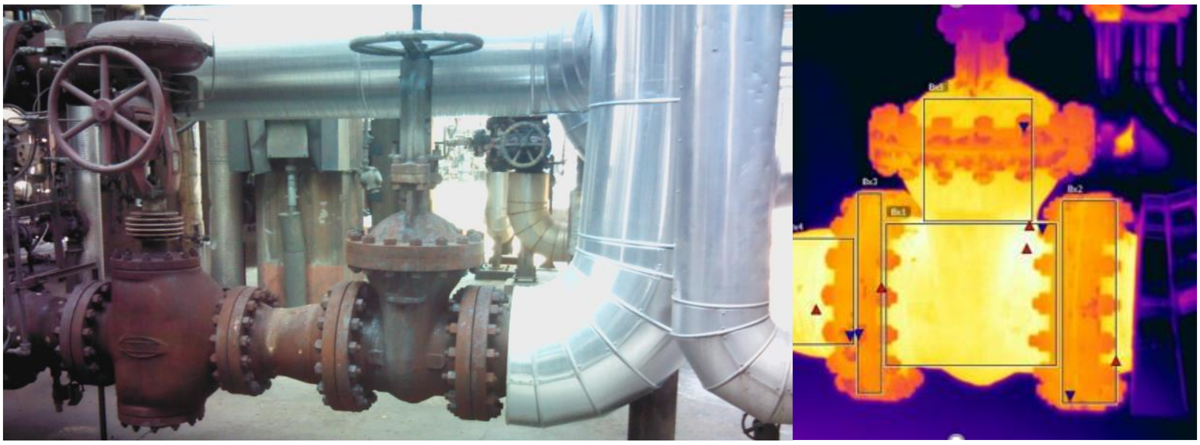
CASE DETAILS

Key Facts and Challenges

- Flanges and valves are very often uninsulated, mainly for operational and maintenance reasons. Like many other plants in Europe, this chemical plant also had a large number of uninsulated flanges and valves and several parts of the equipment was only partly insulated and/or covered with old and damaged insulation
- The process temperature range of the identified equipment lacking insulation was from 75 °C to 150 °C
- An energy price of only 20 €/MWh was assumed to conservatively estimate the potential financial savings
- The large number of single items to be inspected and the evaluation of the savings potential of equipment with old insulation and/or uninsulated parts presented a great challenge due to the number of components and various different situations

Key Findings

- 650 m of piping was uninsulated or covered with damaged insulation
- 300 flanges, 160 valves, and 3 tanks were uninsulated



Insulating one DN 300 valve with a surface temperature of 150 °C and operating all year can save annually 15 MWh and 3 t of CO_2 eq. emissions. Calculated with an energy price of 20 €/MWh this saves 300 € per year. The insulation investment offers a payback time of less than two years.

Results

Based on the TIPCHECK report and the energy, cost and CO_2 eq. emissions savings potential, the client decided to proceed with the full implementation of the TIPCHECK recommendations. The client recognised that new insulation techniques allow to insulate while fulfilling operational and maintenance needs presenting a great opportunity to save energy and by this reduce his production costs.

- CO_2 eq. emissions: -2.240 t
- Energy: -11.100 MWh
- Financial savings (20 €/MWh): - 220.000 €
- Investment (approx.): 200.000 €
- Payback time: <1 year

Responsible TIPCHECK engineer Case Studies 1 + 2:

Name (Role): Michele Mannucci, General Manager

TIPCHECK Certification: Senior TIPCHECK engineer, Level 2 Certified Thermographer

Company: Termisol Termica S.r.l.

Personal experience Case Study 1:

“The surface of the roof of the tank was as big as a football pitch and the temperature inside was 60 °C. The challenge was to find the right technical solution to insulate and avoid returning CUI problems which had damaged the roof before. We found the right balance helping the client to save energy and money and preserve the newly refurbished roof of the tank.”

Personal experience Case Study 2:

“The complexity of this project was due to the size of the plant and the need to assess the status of the insulation in hundreds of single parts. The TIPCHECK standardised methodology helped us to do this precisely and effectively. Our client was very positively surprised when we presented the audit results highlighting his saving potential and the short payback time and he decided to proceed without further delays.”

Case Study 3 - Fibreglass Plant

SUMMARY

At a fibreglass plant in Oschatz, Germany, a continuous furnace uses hot air to melt glass in order to create a solid mat composite that is used in automotive and marine construction and to make glass fibre complexes and fabrics.

Increasing energy expenditures prompted the plant management to commission a TIPCHECK audit. The audit revealed that oil in the air had penetrated and deteriorated the roof insulation, leading to the increasing energy losses, and that insulation between elements of the steel framework had deteriorated. In addition, the framework itself had never been insulated, contributing to the high heat losses.

Implementation of recommendations in the TIPCHECK report resulted in energy savings even higher than those estimated in the report.

PROJECT INFORMATION

Client Details

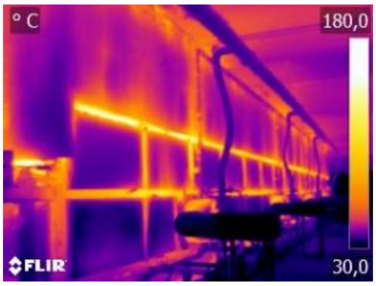
- Company: P-D Glasseiden GmbH
- Facility Purpose and Location: Fibreglass plant, Oschatz, Germany
- Project Contact (Role): Mathias Winkler (Energy Manager)

CASE DETAILS

Key Facts and Challenges

- Energy costs for the melting process in the ovens with a temperature of 180 °C were greatly increasing
- The roof insulation had deteriorated and its cover was damaged
- The steel framework in the vicinity of the melting operation had never been insulated

Key Findings



- The roof insulation had been penetrated and damaged by oil in the plant air, resulting in a deterioration of its effectiveness by a factor or two
- The cassette insulation between elements of the steel framework had deteriorated due to direct thermal load

Results

Based on the recommendations of the TIPCHECK report, the client replaced the roof insulation and installed and sealed a new cover seam. He also ordered the insulation of the steel framework and application of an additional layer of insulation to the cassettes between the steel frames.

Subsequent calculations of energy savings by the client confirmed those estimated in the TIPCHECK report of approximately 440 MWh for an area of 200 m^2 and showed even higher results.

The fuel mix used in the plant and the energy price are confidential and cannot be published in this study. But calculating the findings of this TIPCHECK Case Study 3 with standard solutions and rounded values leads to the following results which are realistic but not exactly the ones of the P-D Glasseiden GmbH:

- CO_2 eq. emissions (Fuel mix [250 gr CO_2/kWh]): -110 t
- Energy savings: -440 MWh
- Possible financial savings (30 €/MWh): -13.200 €
- Investment needed: 20.000 €
- Calculated payback time: 1,5 years

Responsible TIPCHECK engineer Case Study 3:

Name (Role): Tino Leonhardt (Project Engineer)
TIPCHECK Certification: Senior TIPCHECK engineer, Thermographer
Company: G+H Isolierung GmbH

Personal experience Case Study 3:

"The Energy Manager, Mathias Winkler, asked us to perform a TIPCHECK audit on the fibre glass ovens, because they operate at a relatively high temperature (180 °C). We found high temperatures and associated heat losses on some surfaces and outer parts, where the insulation was either damaged or missing. Our tailormade insulation solution was able to reduce the identified heat losses to an acceptable minimum."

Case Study 4 - Meat Processing Plant

SUMMARY

At a meat processing plant in Germany, plant management commissioned a TIPCHECK audit to determine the potential energy savings that might result from insulating lines conveying hot media throughout the plant. The TIPCHECK report concluded that insulating the lines to meet an applicable energy savings ordinance could pay back in less than two years.

PROJECT INFORMATION

Client Details

Company: Confidential / Not disclosed
Facility Purpose and Location: Meat processing plant, Germany

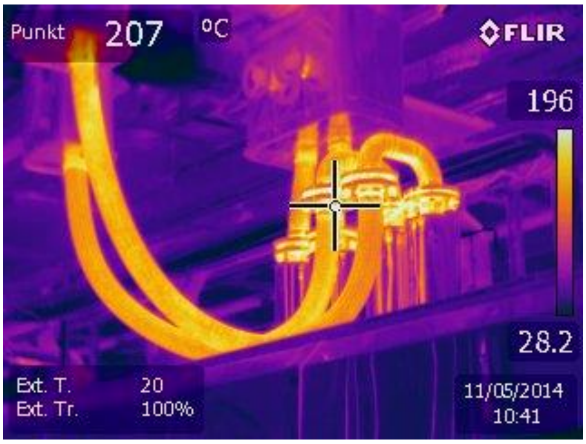
CASE DETAILS

Key Facts and Challenges

- Plant operations take place indoors, with a reasonably steady mean ambient operating temperature of 18 °C and relative humidity of approximately 40%
- Hot media processing temperatures range from 75 °C to 175 °C
- Only uninsulated components were included in the TIPCHECK audit

Key Findings

- Insulating uninsulated hot media lines to a thickness that satisfies the applicable Energy Saving Ordinance ENEV 2014 results in annual fuel cost savings of nearly 9.000 €
- The investment needed to insulate the lines is slightly over 16.000 € offering a payback time of less than two years



Uninsulated lines with a surface temperature above 200 °C were identified during the TIPCHECK.

Results

The client decided to proceed with the recommended implementation of the tailored insulation solutions following the TIPCHECK findings and similar TIPCHECK and remediation projects were carried out subsequently at all of the company's German sites.

The fuel mix used in the plant and the energy price are confidential and cannot be published in this study. But calculating how the identified potentials of this TIPCHECK Case Study 4 could be realised with standard solutions and rounded values leads to the following results:

CO_2 eq. emissions (Fuel mix [250 gr CO_2/kWh]):	-75 t
Energy savings:	-300 MWh
Possible financial savings (30 €/MWh):	-9.000 €
Investment needed:	16.000 €
Calculated payback time:	1,8 years

Responsible TIPCHECK engineer Case Study 4:

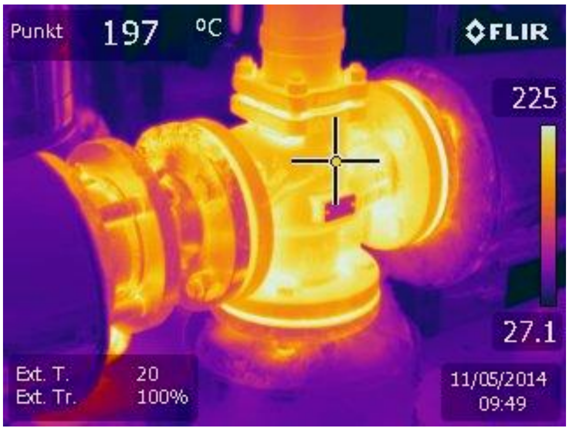
Name (Role): Holger Fürst (Project Leader)

TIPCHECK Certification: Senior TIPCHECK engineer, Thermographer

Company: KAEFER Isoliertechnik GmbH

Personal experience Case Study 4:

"The Energy Manager asked us to perform a TIPCHECK audit. We started with one plant and found very cost-attractive energy saving potentials for uninsulated flanges, valves, and manholes in the vessel park. Similar TIPCHECK projects were carried out subsequently at all of their production sites in Germany. In addition to the TIPCHECK audits, our thermographic studies of already insulated and covered surfaces helped the client to fulfill their safety requirements of limited surface temperatures."



Thermographic inspections identify dangerously high surface temperatures on insulated and uninsulated equipment like on this uninsulated valve and the connected flanges.

Annex C – Examples of ice formation in cold insulation systems and condensation on uninsulated parts

As stated in Chapter 2.4, in applications with temperatures below the ambient level, insulation has additional demands besides limiting the loss of energy. Below are some examples of cases where several problems occurred. These problems were caused by either not insulating some parts, insufficient insulation (causing dew point problems) or damaged vapour barriers and/or insulation.

Pump fully covered with ice breaks down

Valve fully covered with ice can no longer be operated

Water vapour is always present in the air and when it comes close to colder surfaces, it condensates. This condensation could take place either on uninsulated parts or inside the insulation layer. A good vapour barrier outside the insulation layer is therefore important.

If condensation is allowed to take place, the water (or ice) will:

• Increase energy losses
  - Water has a 20 times higher thermal conductivity than air
  - Ice has a 100 times higher thermal conductivity than air
• Cause damage to the insulation material
• Cause corrosion to pipes, vessels and cladding (CUI)
• Cause structural problems for the installation (due to the extra weight)
• Cause inoperable valves, engines, pumps (due to ice formation)
• Cause electrical shortcuts and make control panels break down

Broken vapour barriers and insufficient insulation caused ice to form around these pipes causing both process control and structural problems

Control panel "protected" with plastic sheeting from the dripping condensation water. Extensive ice formation on pipes and valves

In general, cold insulations have a limited service life expectancy as they are unstable systems and sensitive to damage. They must be regularly maintained, including routinely checking sealings and interruptions. This is not only needed in order to save energy but also to keep industrial processes running.

EiiF therefore recommends to regularly inspect cold insulation systems and to combine the regular inspections with an energy analysis of the current insulation system.

The European Union has set itself an ambitious goal: to be climate-neutral by 2050, with net-zero greenhouse gas emissions.

Considering the current annual level of CO_2 equivalent emissions in EU 27 (EEA 2017: 3.853 Mt), it is clear that this goal can only be achieved with the support and participation of all key sectors, including the EU's industry and energy supply, accounting for 49% (EEA 2017) of the EU's emissions.

Against this backdrop, EiiF analysed 2.500 thermal energy audits (TIPCHECKs) and Enerdata's detailed industrial energy data about EU 27 (Odyssee-Mure EU project), to evaluate how industrial insulation can support the decarbonisation of industry. The main finding of this EiiF Study 2021 is that industrial insulation is ready to deliver 14 Mtoe of energy savings, consequently reducing the EU's annual CO_2 equivalent emissions by 40 Mt.

European Industrial Insulation Foundation (EiiF), as a neutral and non-profit institution, promotes insulation as a top-of-mind method for enhancing sustainability and profitability. Since its foundation, EiiF has established itself as a resource for industries that need to reduce CO_2 equivalent emissions and save energy. Its programme raises awareness of the multiple benefits of industrial insulation.
EiiF was established in 2009 by 12 Founding Partners. Nowadays, it comprises more than 50 leading industrial insulation companies from global player size to small and medium-sized companies.

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