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Proposal number: **101076459**

Proposal acronym: **EnergyEfficiency4SME**

Proposal title: **Accompanying SMEs in implementing energy efficiency measures**

Summary

D2.3 Selection of best practices suitable for transfer from large companies to SMEs

The selection of best practices to be transferred to SMEs in the three NACE sectors necessitated a rigorous and comprehensive process of comparison and validation. The input obtained from the questionnaire responses provided by companies was meticulously analysed, compared, and validated against relevant scientific literature and data derived from prominent EU platforms such as the European Energy Efficiency Platform, European Energy Efficiency Observatory, and European Energy Efficiency Best Practice Portal.

This demanding task was undertaken by Ph.D. Professor De Carli, along with the team of energy experts at FGEP. They conducted a thorough examination of the collected data and cross-referenced it with credible sources to ensure the accuracy and reliability of the identified best practices. Through this rigorous analysis, a set of indicators was established, delineating specific energy-efficient technologies and potential savings across the North, South, and Central regions of Europe.

This comprehensive approach, combining empirical data, expert knowledge, and scientific literature, ensures that the selected best practices are robust, well-founded, and applicable to SMEs operating in the designated sectors. By leveraging this wealth of information, the project aims to facilitate the effective transfer of energy efficiency measures, fostering sustainable practices and enabling SMEs to achieve tangible energy savings and operational improvements.

The working group identified and assessed a total of 26 energy efficiency measures, which have significant applicability across the three sectors: Accommodation and Food Service activities, Manufacturing - Agri-food, and Metal Work. The identification process involved extensive research, drawing from relevant literature and the collective experiences of the working group members. To provide a comprehensive overview and facilitate decision-making, two sets of indicators were developed. They effectively capture key parameters such as energy savings, associated costs, and the estimated payback time in three European macro regions: North, Centre, South.

The primary objective of these indicators is to equip project partners with a reliable toolset for identifying and implementing the most effective energy efficiency measures. By utilizing these indicators, project partners can support with informed decisions that align with the specific needs and conditions of SMEs within their respective regions.

Furthermore, the indicators play a strategic role in supporting the adoption of new practices and policies geared towards energy efficiency. By offering valuable insights into the potential benefits and feasibility of each measure, they empower project partners to guide SMEs in embracing sustainable energy practices. This proactive approach ensures that SMEs can effectively navigate the transition towards energy-efficient operations, thus fostering a more sustainable and environmentally responsible business landscape.

The energy efficiency measures have been subdivided into two sets of indicators that emphasize various parameters essential for facilitating constructive discussions between Chambers and Small and Medium Enterprises (SMEs) concerning the subject of energy efficiency.

These indicators encompass the percentage of energy saved in the European macro regions, specifically the Northern, Central, and Southern regions. These percentages are determined by considering the following energy consumption patterns:

For the accommodation sector and offices in warm climate areas, it has been estimated that energy consumption is approximately 70 kWh/(m^2 year) for heating and 60 kWh/(m^2 year) for cooling. In central Europe, the estimated consumption is 162 kWh/(m^2 year), and in colder regions, it rises to 226 kWh/(m^2 year).

An alternative methodology has been employed for assessing energy consumption in industrial buildings, taking into account the following consumption rates:

- Regions with Warm climate: A consumption rate of 105 kWh/(m^2 year) for heating and 60 kWh/(m^2 year) for cooling.
- Regions with continental climate: A standardized consumption rate of 150 kWh/(m^2 year).
- Regions with cold climate: A higher energy consumption rate of 210 kWh/(m^2 year).

The set of indicators empowers partners to introduce individual energy efficiency measures, along with the corresponding case studies that elucidate the technology involved and accentuate potential cost-benefit scenarios. For each specific measure, a comprehensive analysis is provided, including estimations of energy savings in terms of percentage and kWh, an assessment of feasibility, an average cost per square meter or per kilowatt, as well as a calculation of the payback period.

These indicators are combined with the minimum applicability criteria and operate synergistically with D5.2 One Stop Help Desk and the regional energy efficiency financing measures. This comprehensive approach serves as the initial step in engaging SMEs in the subsequent project phase, which will adopt a more technical and detailed approach that will be made possible through the assistance of energy experts who will conduct energy audits for the companies participating in project activities as outlined in D3.2.

The complete set of indicators can be downloaded at the following link:

https://www.fondazionefenice.it/wp-content/uploads/SET-OF-INDICATORS-EE4SME-.xlsx

NACE SECTOR		Energy Efficiency Measure	First Set of Indicators														
			% of saved energy in South Europe	% of saved energy in Central Europe	% of saved energy in North Europe	% saved energy - measures climate independent	implementability	Cost		Energy saving in South Europe	Energy saving in Central Europe	Energy saving in North Europe	Energy saving independent on climate	Payback time in South Europe	Payback time in Central Europe	Payback time in North Europe	Payback time independent climate
								[€/m2]	[€/kW]	[kWh/m2]	[kWh/m2]	[kWh/m2]	[kWh/kW]	Years	Years	Years	Years
All sectors		PV cells	50%	38%	30%		medium	132,0		168,0	126,0	102,0		3,5	4,7	5,8	
Accomodation		BMS	15%	15%	15%		medium	50,0		4,5	4,0	5,0		11,0	13,0	10,0	
All sectors	Office	Led	60%	60%	60%		easy	24,0		19,0	25,3	41,7		5,0	3,8	2,3	
Accomodation		Led	60%	60%	60%		easy	5,0		2,0	2,0	2,0		2,0	2,0	2,0	
All sectors	Production zone	Led	60%	60%	60%		easy	21,5		17,0	22,7	37,3		5,0	3,8	2,3	
All sectors	Productive zone	Roof and walls	35%	35%	35%		medium	90,0		36,8	52,5	73,5		20,0	14,0	10,0	
All sectors	Buliding	Roof and walls + windows	40%	40%	40%		high	110,0		42,0	60,0	84,0		22,0	15,0	10,7	
Accomodation		Windows	15%	15%	15%		medium	45,0		19,5	24,5	34,0		21,0	14,0	10,0	
All sectors		Opaque envelope	45%	45%	45%		medium	65,0		40,0	70,0	100,0		15,0	8,0	5,7	
All sectors		All envelope	60%	60%	60%		medium	110,0		59,5	94,5	134,0		17,0	9,6	6,8	
All sectors		Solar thermal collectors	50%	50%	50%		medium	1300,0		700,0	550,0	450,0		9,4	12,0	14,7	
All sectors	Productive zone	Hybrid boilers	67%	47%	26%		easy	175,0		70,0	70,8	55,1		20,0	20,0	20,0	
All sectors	Office	Hybrid boilers	67%	47%	26%		easy	75,0		46,7	76,3	59,4		12,0	8,0	9,0	
Accomodation		Hybrid boilers	67%	47%	26%		easy	75,0		46,7	76,3	59,4		12,0	8,0	9,0	
Metal Work/ Food Industry	Production sites	Direct evaporation heat pumps	68%	65%	56%		easy	25,0		120,0	115,0	100,0		1,5	5,0	15,0	
All sectors		Inverter pumps				25%	easy		250,0				480,0				1,5
All sectors		Inverter fans				25%	easy		250,0				480,0				1,5
All sectors	Production site	Inverter compressors				15%	easy		250,0				230,0				4,0
All sectors	Production site	Heat recovery compressors				50%	medium		200,0				750,0				2,0
Food industry		Chillers				30%	easy		700,0				1000,0				7,0
Food industry		Heat pump & chillers (heat recovery)				80%	medium		850,0				2250,0				3,0
All sectors		Heat recovery ventilation	85%	85%	85%		medium	40,0		11,0	25,0	35,0		30,0	12,0	9,0	
All sectors		Electric vehicles				77%	easy		970,0				550,0				11,0
All sectors	Production site	Cogeneration	50%	50%	50%		medium	90,0		35,0	80,0	115,0		30,0	20,0	15,0	
All sectors		Green electricity			100%	easy		0,0									1,0
All sectors		Cosfi	5%	5%	5%	easy		80,0					100,0				1,5

NACE SECTOR		Energy Efficiency Measure	Second set of indicators Minumum Applicability Criteria
All sectors		**PV cells**	in tilted roofs South orientation
Accomodation		**BMS**	Integrate energy control with management of the hotel
All sectors	**Office**	**Led**	applicable in all the context
Accomodation		**Led**	applicable in all the context
All sectors	**Production zone**	**Led**	check production activity while working at height
All sectors	**Productive zone**	**Roof and walls**	timing for the works, space to locate the materials
All sectors	**Buliding**	**Roof and walls + windows**	timing for the works, space to locate the materials, presence of single glazings
Accomodation		**Windows**	presence of single glazings
All sectors		**Opaque envelope**	timing for the works, space to locate the materials
All sectors		**All envelope**	timing for the works, space to locate the materials, presence of single glazings
All sectors		**Solar thermal collectors**	check the amount of energy need for sanitary hot water
All sectors	**Productive zone**	**Hybrid boilers**	check the noise of the air to water heat pump
All sectors	**Office**	**Hybrid boilers**	site to locate the air to water heat pump, check the noise of the air to water heat pump
Accomodation		**Hybrid boilers**	site to locate the air to water heat pump, check the noise of the air to water heat pump
Metal Work/ Food Industry	**Production sites**	**Direct evaporation heat pumps**	check the noise of the air to water heat pump
All sectors		**Inverter pumps**	no particular limitation
All sectors		**Inverter fans**	no particular limitation
All sectors	**Production site**	**Inverter compressors**	no particular limitation
All sectors	**Production site**	**Heat recovery compressors**	check how to recovery the heat
Food industry		**Chillers**	no particular limitation
Food industry		**Heat pump & chillers (heat recovery)**	proper selection of temperatures for heating and cooling
All sectors		**Heat recovery ventilation**	check the feasibility of the heat recovery unit
All sectors		**Electric vehicles**	
All sectors	**Production site**	**Cogeneration**	check prices of elecrricity and gas. It is useful when heating and electricity demands are quite constant alolng the whole year
All sectors		**Green electricity**	check the costs of electricity
All sectors		**Cosfi**	if inverters on machiunes are present this technical solution is not relevant anymore

Case studies

Energy efficiency measure 1 – Photovoltaic panels

Technology: Photovoltaic panels.
Sector: Measure identified in the food industry but applicable to all sectors.
Location: This energy efficiency measure has been implemented in several countries involved in the project, case study based in Estonia.
Implementation cost: € 373.000.

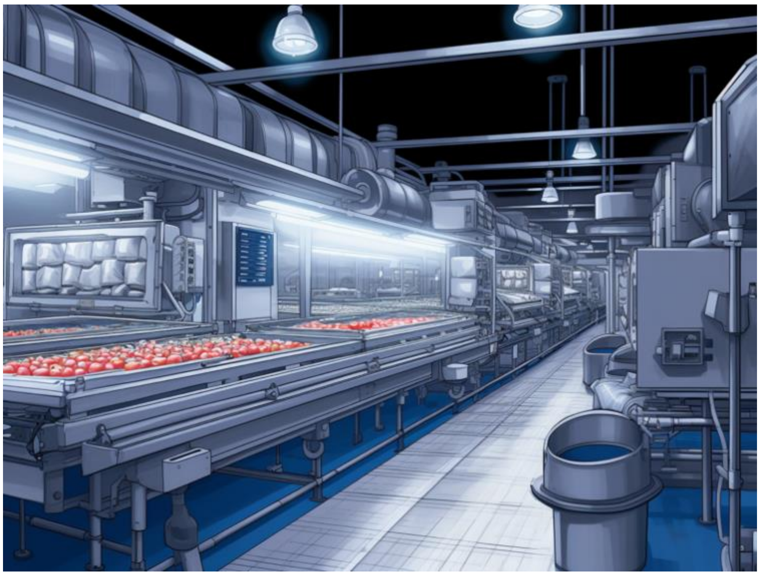
Technology
Solar Photovoltaic market is in strong expansion increasing of over 10% year by year. In 2022 in Europe have been installed 41,4 GW. The European policy REPowerEU in which the EU Solar Strategy is contained further speed up solar deployment. Within the best practices identified across the country participating to the interviews, a photovoltaic plant of 600 kWp has been selected. The photovoltaic plant is installed on the roofs of the company and parking areas. The photovoltaic plant utilizes monocrystalline panels known for their high efficiency in converting sunlight into electricity compared to polycrystalline panels. Monocrystalline panels have the capacity of converting solar energy into direct current (DC) electricity that will be then transformed by a high efficiency inverter into alternating current (AC) electricity. To date the efficiency of conversion of PV panel can reach up to 23% according to latitude, orientation and inclination. The photovoltaic system is equipped with a monitoring and control system integrated into the plant, allowing for real-time performance tracking and anomalies detection.

Benefits (energy created/saved/ CO_2 savings)
The carbon intensity of electricity generation in Estonia, as mentioned in the JRC report (2020), is 0.414 tCO_2 per MWh. To estimate the carbon emissions reduction, it has been multiplied the annual energy production by the carbon intensity factor: Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh)Carbon Emissions Reduction (tCO_2/year) ≈ 255 MWh/year × 0.414 tCO_2/MWh ≈ 105,6 tCO_2/year
The installation of the 600 kWp PV panels in Estonia is estimated to produce approximately 255 MWh/year of clean electricity and save approximately 105,6 tons of CO_2 emissions per year, considering the carbon intensity mentioned in the JRC report and a conversion factor of the panels of 23%. These calculations provide an approximate estimation, and actual results may vary based on specific local conditions and the efficiency of the PV system.

Energy efficiency measure 2 – LED lighting

Technology: LED lighting.
Sector: Measure identified in the food industry but applicable to all sectors.
Location: This measure has been implemented in all the countries involved in the project, case study based in Italy.
Implementation Cost: € 8.200.

Technology
LED (Light Emitting Diode) technology represents a paradigm shift in the illumination sector, providing a green, energy-efficient alternative to obsolete incandescent lighting systems.
LEDs operate on the principle of electroluminescence, emitting light when subjected to an electric current, a process vastly more efficient and yielding minimal heat dissipation compared to conventional incandescent and fluorescent technologies. The advantages of replacing old fluorescent lighting with LED lighting in works spaces are energy efficiency (savings up to 80% in electric power compared to classic lighting systems), longer lifetime, durability, instant start and dimming.



In addition, best practice can be performed through the combination of automation within indoor and outdoor illumination arrays facilitates an elevated level of energy optimization and user convenience. Embedded control mechanisms employ state-of-the-art technologies to modulate luminous flux, integrating sophisticated sensors and control modules capable of modulating light intensity and operational duration, responsive to occupant presence and user-defined parameters.
Relamping, are generally considered among the least expensive energy efficiency measures. On average, the return on investment (ROI) period for a relamping project with LED lamps typically ranges from 1 to 4 years according to the intensity of use. Anticipated price reductions in the coming years are poised to bring LEDs even closer in cost to fluorescent lamps.

Benefits (energy created/saved/ CO_2 savings)
The company with the introduction of this measure has been able to save around 29 MWh per year. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Italian Emission factor for electricity is 0,267 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 29MWh/year * 0,267 tCO_2/MWh ≈ 7,74 tCO_2/year.

Energy efficiency measure 3 – Sustainable energy procurement

Technology: Purchase of electricity from renewable sources.
Sector: Measure identified in the food industry but applicable to all sectors.
Location: Energy efficiency measure has been implemented in several countries involved in the project, case study based in Bulgaria.
Implementation Cost: € 0,00.

Technology

Purchase of green electricity typically refers to power derived from renewable resources such as wind, solar, geothermal, and hydropower, which have a minimal impact on the environment. When applied to any industry, the main aim is to reduce the carbon footprint and optimize energy consumption, thus contributing to sustainable development and offer to the customer added value services. In fact, sustainable energy procurement, especially when combined with co-financing measures available in Europe, holds significant advantages for companies. Firstly, it fosters long-term competitive advantages. By investing in eco-friendly products and practices, businesses reduce operational costs through energy efficiency and resource conservation. These savings translate into increased profitability and resilience in the face of fluctuating resource prices and regulatory changes. Moreover, green procurement enhances market positions. As sustainability gains momentum in consumer and B2B markets, companies that prioritize eco-friendly products and services gain a competitive edge. Customers increasingly favour environmentally responsible brands, boosting sales and brand reputation. In summary, purchase of electricity from renewable sources offers companies not only cost savings and regulatory compliance but also the strategic advantage of improved market positions, setting them on a path towards long-term success and growth.

Benefits (energy created/saved/ CO_2 savings)
This case study measure identified in the food industry but applicable to all the sectors has been identified in Bulgaria. As per the JRC GHG Emission Factors for Electricity Consumption (2020) this country emits approximately 0.528 tCO_2/MWh during electricity production. In the context of this case study, the company has made a conscious decision to exclusively procure electricity from sustainable sources. This choice has significantly decreased its carbon dioxide emissions. This strategic decision aligns with the company's ambitious goal of achieving net-zero emissions by 2030.

Energy efficiency measure 4 - Chillers

Technology: Chillers: Refrigeration Chiller.
Sector: Measure identified in the food industry but applicable to all sectors.
Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Malta.
Implementation Cost: € 400.000.

Technology
Chillers are an essential technology extensively utilized in multiple sectors to remove heat from a liquid via a vapor-compression or absorption refrigeration cycle. This liquid can subsequently be circulated through a heat exchanger to cool equipment or another process stream (such as air or process water). In this case, the technology in focus is a new 1000 kW refrigeration power chiller, identified primarily in the food industry but with important applicability in various domains tackled by the project, especially the Horeca value chain.

Modern industrial chillers incorporate cutting-edge technology, including variable speed compressors (for high performances at partial loads), advanced heat exchangers (maximizing the thermal efficiency thanks to large exchange surfaces at the evaporator and the condenser), and improved refrigerants.
In fact, embracing cutting-edge, high-efficiency products outfitted with low-Global Warming Potential refrigerants becomes imperative in EU market, this fact is also highlighted in the recent provisional agreement of European Council and Parliament that foresees a phase down for hydrofluorocarbons until 2036 and phase out by 2050.
The pursue to achieve a reduction in final energy consumption by 2030 is also included in the revised Energy Efficiency Directive, published on 20 September 2023. The new design of chillers with 30% lower refrigerant charge compared to conventional solutions perfectly aligns with the directive’s goals. These innovations drastically boost efficiency, resulting in significantly reduced energy consumption. Such efficiency gains directly translate into lower electricity bills, making them a financially sound investment. While the upfront cost of modern chillers can be higher, the long-term economic advantages are substantial. Reduced energy usage means lower operational expenses, which, over time, far outweigh the initial investment. Moreover, modern chillers typically have longer lifespans and require less maintenance, further contributing to cost savings.
Modern chillers often come equipped with smart features and remote monitoring capabilities. These enable real-time data collection, predictive maintenance, and precise control, ensuring optimal performance and minimizing downtime.

Benefits (energy created/saved/ CO_2 savings)

European Regulation 2016/2281 has implemented a minimum seasonal efficiency requirement for liquid chillers and heat pumps with capacities exceeding 400 kW. In this specific case in Malta, to achieve the same refrigeration power, an electric motor with an input power of approximately 300 kW is required, instead of the previously higher 409 kW. The average yearly hours for the chiller are 2190 hours. This would give an annual kWh saving of 238,710 kWh. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Emission factor in Malta for electricity is 0,349 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 239MWh/year * 0,349 tCO_2/MWh ≈ 83,41 tCO_2/year.

Energy efficiency measure 5 – Heat recovery ventilation

Technology: Heat recovery ventilation.

Sector: Measure identified in the food industry but applicable to all sectors.

Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Malta.

Implementation Cost: €150.000.

Technology

Heat recovery ventilation (HRV) technology has emerged as a pivotal solution to energy conservation challenges within various industrial sectors. This advanced ventilation system is crucial for maintaining a balanced and healthy indoor environment, especially in industrial setups, by ensuring a continuous supply of fresh air and eliminating pollutants.

This is achieved through the utilization of ventilation units, which comprise fans, motors, electronic controls, and additional components that are linked to buildings through air inlets, outlets, or ventilation conduits. HRV systems work on the principle of heat exchange. When a building's interior air is ventilated, the outgoing stale air contains heat energy. HRV units are designed to recover this heat before the air is expelled outside. The core of an HRV system is the heat exchanger, where the outgoing stale air transfers its heat to the incoming fresh air without the two airstreams mixing. This process maintains the indoor temperature and reduces the energy consumption associated with heating or cooling the building.

In the contemporary setting, European Regulations No 1253/2014 and No 1254/2014 delineate the specifications governing ventilation systems intended for application in both residential and industrial buildings. These regulations mandate that all Non-Residential Ventilation Units (NRVUs) must attain a minimum thermal efficiency rating of 73%. It is crucial to appropriately size the HRV system according to the unique requirements and attributes of the building to prevent inefficiencies and guarantee optimal energy recuperation.

Benefits (energy created/saved/ CO_2 savings)

In the case study taken as example for best practice transfer from big companies to SMEs, Heat recovery ventilation systems installation resulted in saving of 120 MWh per year. Thanks to the implementation of this measure the company reduced its footprint and avoid the emission of around 41,9 tCO_2/year considering of an Emission Factors for Electricity Consumption of 0,349 tCO_2/MWh.

Energy efficiency measure 6 – Building insulation

Technology: Building insulation - roof-walls – windows - envelops
Sector: Measure identified in the Accommodation, applicable to all the sectors.
Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Bulgaria.
Implementation Cost: € 432.800.

Technology

Building insulation is an essential component in modern construction, aiming to minimize and optimize energy consumption thus reducing environmental impacts, thanks to integration of materials designed to reduce heat transfer.
By implementing building renovation in roof, walls, windows, and building envelopes can also improve comfort and well-being of hotel guests maintaining a constant indoor temperature, as demonstrated in this project in Bulgaria.

In this case, a deep retrofitting has been performed focusing on multiple components of the building, all them crucial aspects for maintaining optimal indoor temperature: roof and floor thermal insulation, facade upgrade (very often the largest part of the surface of the building that physically separate the conditioned and the unconditioned environment of the construction), window and gap sealing at building nodes.
Particularly, insulated double glazed windows are instrumental to stop external air in reducing energy loss, controlling indoor climate, and minimizing external noise infiltration.
Combination of advanced heating, water heating, ventilation, and lighting measures, along with retrofitting of the building envelope are expected to lead to a massive reduction in heating demand near 90%, marking the path to the target of nearly-zero buildings (in line with goals of the Energy Performance of buildings Directive). The high upfront investment costs are rationalized by the substantial long-term benefits. This includes reducing the need for heating or cooling, resulting in savings on both maintenance of heating systems and indoor climate control. This is achieved by the potential use of a lower-capacity heat generator operating for a shorter duration.
Evidences shows that the thermal insulation made with modern technologies allows for an average savings of 40% in heating demand on today building stock, being the most significant energy retrofit implementation by far.

Benefits (energy created/saved/ CO_2 savings)

The retrofitting of the building envelops resulted in a decrease of energy consumption of 2852 MWh/year. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Emission factor in Bulgaria for electricity is 0,528 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 2852MWh/year * 0,528 tCO_2/MWh ≈ 1506 tCO_2/year.

Energy efficiency measure 7 – Solar thermal collectors

Technology: Solar thermal collectors.

Sector: Measure identified in the accommodation industry but applicable to all sectors.

Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Austria.

Implementation cost: € 55.000.

Technology

Solar thermal collectors, predominantly recognized for their capacity to convert sunlight into heat through a carrier fluid such as water, is used to meet the thermal energy and hot water for sanitary use demand of buildings.

In addition to the accommodation industry, they offer a highly efficient and sustainable alternative for energy generation, making them suitable for a wide range of sectors, including residential, commercial, and industrial settings. Furthermore, the versatility of this technology allows for its broad utilization across various industries.

Since the production of solar panels is strongly reduced by low sunlight intensity, occurring on winter days in cloudy or foggy regions such as Austria, it is necessary to complement the solar thermal system with supplementary heat generators such as boilers or heat pumps to ensure a continuous supply of heat.

Commonly, in the accommodation sector, solar thermal systems are typically designed with a varying number of solar collectors, ranging from approximately 5 to 25 (respectively for structures with 3 up to 20 rooms), along with storage tanks with a capacity up to 2000 or 3000 litres.

In accordance with each unique circumstance, generally an achievable target is to generate about 50% of the total annual hot water demand using solar panels.

The installation of the solar thermal system on the roof of the company was carried out by connecting the collectors, placed on the roof of the building, to a water storage system, allowing the production of hot water for production processes. The entire system was integrated with a circulation pump to ensure proper distribution of thermal energy within the facility.

Benefits (energy created/saved/ CO_2 savings)

The upfront cost of installing solar thermal collectors in Austria is approximately €55.000. The long-term gains and the environmental benefits outweigh the initial investment. The annual savings of around €10.000 imply that the system can pay back the initial investment in approximately 5 years. The solar thermal collector resulted in saving around 15 MWh/year that correspond of a Carbon Emissions Reduction of 2 tCO_2/year considering an Emission factor for electricity of 0,13 tCO_2/MWh.

Energy efficiency measure 8 – Heat recovery from air compressor

Technology: Heat recovery from air compressor.

Sector: Measure identified in the accommodation industry but applicable to all sectors.

Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in France.

Implementation Cost: € 50.000.

Technology

Heat recovery technology, especially when applied to air compressors, is a significant advancement in the drive towards energy efficiency. In production plants, where energy costs can significantly influence the bottom line, embracing such innovations can provide considerable financial savings while reducing the carbon footprint. This report examines the implementation and benefits of heat recovery technology on the air compressors, with a specific focus on its application in France's Auvergne-Rhône-Alpes region.

Air compressors, by nature, generate a significant amount of heat during its operation, as a by-product of compressed air production. In traditional systems, this heat is often vented away as waste. However, with heat recovery technology, it becomes possible to capture and reuse this otherwise wasted energy for other processes. Essentially, a heat recovery system on an air compressor captures the warm air and then transfers it to water, or air systems – or a factor mediating in heat exchange – which can be used for space heating or pre-heating domestic hot water, or other utilities in production plants. Depending on the compressor, it is possible to recover 70%-90% of the electric energy consumed, turning an energy-inefficient process into one that is both highly efficient and cost-effective. For this reason, recovering heat from air compressors proves highly advantageous in industrial settings, offering substantial benefits to companies reliant on compressed air by efficiently supplementing their heating systems. For the accommodation industry, especially hotels and resorts, there are continual requirements for hot water – be it for showers, swimming pools, or laundry operations. Using the heat generated by air compressors to supplement or even replace traditional water heating methods can provide significant energy savings.

Benefits (energy created/saved/ CO_2 savings)

Heat recovery from air compressors systems installation resulted in saving of 18 MWh per year. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that French Emission factor for electricity is 0,066 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 18MWh/year * 0,066 tCO_2/MWh ≈ 1,18 tCO_2/year.

Energy efficiency measure 9 – BMS Building Management System

Technology: BMS for monitoring energy consumption.

Sector: Measure identified in the accommodation industry but applicable to all sectors.

Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Malta.

Implementation cost: € 6.000.

Technology

Building Management System (BMS) technology is increasingly being recognized as a revolutionary tool in monitoring and optimizing energy consumption across various sectors. BMS integration is based on a network of on-site sensors, hardware and software components controlling the proper functionality of electrical and mechanical systems of the building; besides monitoring system energy efficiency this technology fulfil an in-depth analysis of the arising comfort conditions for the users community in diverse climates and operational settings.

BMS focuses on automation and control of building functions, taking into consideration heating, ventilation, air-conditioning (HVAC), lighting, and security.

This technology in a fully integrated environment is pivotal for industries aiming to reduce energy costs, enhance operational efficacy, and contribute to environmental sustainability. Malta, with its commitment to sustainable development, presents a compelling case study for BMS implementation. As regards energy efficiency of retrofitted buildings, collecting and storing interesting data is a core requirement in order to implement several best practices, involving comprehensively across all types of system facilities, to adapt efficiency standards on a case-by-case basis. Though BMS has been predominantly identified in the accommodation industry, it has broad applicability, including various sectors such as healthcare, education, retail, and manufacturing. Stakeholders gain advantages from a powerful tool that facilitates the shift toward designing innovative smart buildings.

Benefits (energy created/saved/ CO_2 savings)

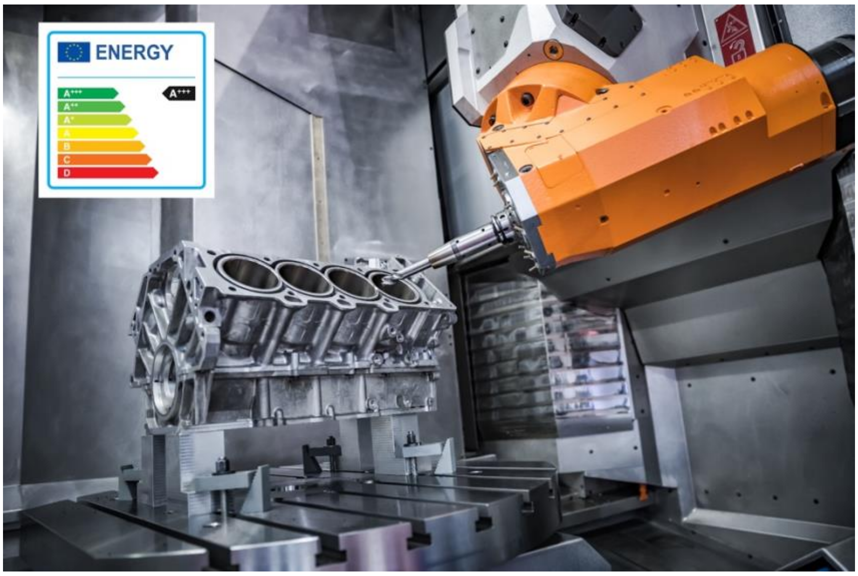
In Malta, the cost of implementing BMS technology is around € 6000. Notably, the system promises a remarkably swift payback period of six months. This quick return on investment is attributable to the significant reduction in energy consumption (about 2,4 MWh per year) and operational costs achieved through optimized energy management, especially in energy-intensive industries like accommodation services. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Emission factor in Malta for electricity is 0,349 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 2,4MWh/year * 0,349 tCO_2/MWh ≈ 0,837 tCO_2/year.

Energy efficiency measure 10 – New machineries with inverters

Technology: New energy efficient injection machine with inverters.
Sector: Measure identified in the metalwork industry but applicable to all sectors.
Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Italy.
Implementation cost: € 324.000.

Technology

The frequency inverters (variable speed drives) integrated into the machinery enable the conversion of incoming electrical power to optimize the performance of the motor, varying the frequency and the voltage depending on its use pattern. The optimal energy conversion and utilization by inverters subsequently minimize energy wastage, ensuring augmented energy efficiency and operational flexibility in several industrial processes characterized by a mix of activities, and hours of operation – running multiple shifts over workday. Running the motors at partial load permits reduction in energy consumption not only during peak hours, but also by addressing high out-of-hours electricity base load use in the industrial sector, whilst ensuring productivity. By minimizing wear and tear associated with abrupt starts and stops, these technologies reduce maintenance expenses and the frequency of motor replacements, providing long-term competitive advantage.



This technology, as implemented in Veneto region of Italy, illustrates substantial potential for scalable adoption across diverse sectors, optimizing the efficiency of entire systems and increasing machine durability. Considering EU's commitment to fostering a greener, more efficient industrial landscape, the EU Regulation on electric motors and variable speed drives (EU) 2019/1781 has played a strategic role in advancing this cause, imposing stringent efficiency requirements on both electric induction motors and variable speed drives, requiring for them to reach the IE2 level (International Energy efficiency classes) since 1 July 2021.

Benefits (energy created/saved/ CO_2 savings)

The financial outlay for each new machinery unit with inverters is approximately €324.000. The payback period, calculated on the basis of energy savings and operational benefits accrued, is estimated to be 6,9 years. This duration is a reflection of the technology's economic viability, considering the long-term savings and benefits post the payback period. Frequency inverters installation resulted in saving of 102 MWh per year. Thanks to the implementation of this measure the company reduced its footprint and avoid the emission of around 27,23 tCO_2/year considering of an Emission Factors for Electricity Consumption of 0,267 tCO_2/MWh.

Energy efficiency measure 11 – Heat Pump

Technology: Heat pump.

Sector: Measure identified in the accommodation industry but applicable to all sectors.

Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Italy.

Implementation Cost: € 200.000.

Technology

A heat pump is a device that transfers heat energy from a source to a heat sink, using electric power. It can either extract heat from a cooler place and release it to a warmer one (for heating purposes) or extract heat from a warmer place and release it to a cooler one (for cooling purposes). The heating or cooling efficiency of a heat pump is quantified through two parameters, respectively COP (coefficient of performance) and EER (energy efficiency ratio) typically ranging from 3 to 6, depending on the type of heat pump and operating temperature. Considering the new Ecodesign Directive 2009/125/EC, which envisions the gradual phasing out of fossil fuel boilers by 2029, at least 30 million more of these systems will be in operation by 2030 compared to 2020.

The energy and cost savings, coupled with the CO_2 reduction, make replacement of gas boilers with heat pump system an attractive solution for industries aiming for sustainability and operational efficiency with fast payback periods.

They can benefit from reduced operational costs due to energy savings, from 20% to 50% less than gas boiler, and less maintenance (avoiding gas combustion and flue gas produced by the boiler).

The adaptability and versatility of heat pump technology suggest a promising future in industrial and domestic applications.

Benefits (energy created/saved/ CO_2 savings)

In this particular case, the implementation of a heat pump has resulted in an impressive 6.5 tep or 34 MWh reduction in energy consumption.

Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Italian Emission factor for electricity is 0,267 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 34MWh/year * 0,267 tCO_2/MWh ≈ 9,08 tCO_2/year.

Energy efficiency measure 12 – Cogeneration systems

Technology: Cogeneration systems
Sector: Measure identified in the manufacturing industry but applicable to all sectors
Location: This energy efficiency measure has been implemented in several the countries involved in the project, case study based in Italy.
Implementation cost: € 355.000.

Technology
Combined Heat and Power Units (CHP) are a remarkable technology that harness primary energy sources to simultaneously generate two types of secondary energy: electrical and thermal output. At the core of these systems there is a combustion engine, which drives a synchronous generator to produce electricity. This is coupled with the recovery of waste heat to be used simultaneously for heating or various industrial processes. The key advantage of CHP lies in its ability to maximize energy efficiency by avoiding the dissipation of unused heat, a common occurrence in most industrial machinery applications. Instead, low-temperature heat is captured from lubricating oil, cooling water, and exhaust gases via heat exchangers and incorporated into the heating circuit.

In this way, the concept of decentralized energy production, tailored to the specific location and demand, minimizes losses during energy transfer. In contrast, conventional power stations typically exhibit an average efficiency of about 35%, squandering over 60% of energy input as wasted heat. Modern CHP systems, equipped with highly effective synchronous generators, can attain electrical efficiency levels that exceed 35% and thermal efficiency levels that go beyond 60%. This offers the potential to considerably boost the overall efficiency of conventional equipment utilized in medium-sized industrial settings, especially in instances where the electrical power demand is relatively low (below 1 MW), by more than 40%.
These units can be operated with natural gas, liquid gas, or even residuals from various processes as fuel, making them versatile and suitable for a range of applications. Additionally, in a future perspective, the incorporation of hydrogen as a fuel source into larger installations is becoming increasingly feasible, marking a noteworthy advancement in the progression of CHP technology.

Benefits (energy created/saved/ CO_2 savings)
The carbon intensity of electricity generation in Italy, as mentioned in the JRC report (2020), is 0,267 tCO_2 per MWh. The installation of combined heat and power units is estimated to produce approximately 393 MWh/year of electricity from low-temperature heat recovery and save approximately 104 tons of CO_2 emissions per year.

Energy efficiency measure 13 – Direct evaporation heat pumps

Technology: Direct evaporation heat pumps.
Sector: Measure identified in the manufacturing industry but applicable to all sectors
Location: Case study identified in Italy and Bulgaria.
Implementation Cost: € 92.000.

Technology

Direct evaporation system involves the direct cooling or heating of air using the evaporating refrigerant within the cooling coil, eliminating the need for an intermediate medium as water. As a result, it consumes less energy compared to equivalent chilled water systems. It functions as a heat pump air conditioning system, where a regenerating fluid carries the cooling or heating effect generated by the external unit to various room terminals through specially designed copper piping distributed throughout the building. Each terminal utilizes an electronic valve to control the flow of gas into the designated area, enabling the adjustment of cooling or heating levels as needed. One of the advantages of this system is its flexibility - the length of the pipes between the outdoor unit and the indoor unit can be up to 200 meters - and space efficiency. The installation options are highly adaptable, making this technology ideal for decentralized retrofitting into existing systems.

Direct evaporation heat pumps perform well in cooling or heating significant volumes of both fresh and recirculated air, making it particularly suitable for diverse thermal requirements in places where different zones of the building have distinct heating and cooling needs. Furthermore, the system can recover waste heat from cooled areas to heated zones, making it even more energy efficient. Multiple cooling coils in various ventilation units can also be connected to a common central direct evaporation system. By combining high coefficient of performance (COP) and energy efficiency ratio (EER) values (close to 5), alongside the typical rate of achieving the set point internal temperature, this system offers a broad operational range from up to 55°C in cooling to as low as -30°C in heating.

Benefits (energy created/saved/ CO_2 savings)

The company with the introduction of this measure has been able to save around 23 MWh per year. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh) and considering that Italian Emission factor for electricity is 0,267 tCO_2/MWh according to JRC, Carbon Emissions Reduction calculated in tCO_2/year can be estimated as follow: 23MWh/year * 0,267 tCO_2/MWh ≈ 6,14 tCO_2/year. These calculations provide an approximate estimation, and actual results may vary based on specific local set point temperature and system-specific requirements.

Energy efficiency measure 14 – Hybrid boilers

Technology: Hybrid boilers.
Sector: Measure identified in the accommodation industry but applicable to all sectors
Location: this measure has been implemented in various case studies located throughout Italy.
Implementation Cost: € 145.000.

Technology

These systems can be employed as replacements for conventional gas boilers and serve multiple purposes, including providing heating, meeting the demand for domestic hot water, and generating steam for a variety of industrial processes. Such functionality is achieved through the incorporation of an electrical heating element alongside the conventional burner, resulting in higher efficiency compared to models solely reliant on fossil fuels.

The operation of these systems can be configured to work either alternately (switching between the boiler and heat pump) or in parallel (simultaneous operation of the boiler and heat pump). The combinations of different heat generators are designed with the explicit aim of maximizing the share of renewable energy derived from heat pump operation. Particularly to optimize the startup process, electricity is utilized, and once the operating temperature is reached, the boiler switches to the primary fuel source. In a hybrid boiler system, the ratio between fossil fuel and electricity consumption is typically set at 25%. This means that 25% of the energy used for heating or steam generation is derived from electrical sources, while the remaining 75% comes from fossil fuels. Hybrid boiler systems are characterized by an extensive modulation range, making them suitable for variable heat demand scenarios - from residential complexes to industrial applications- and providing effective management during reduced heat requirements or electricity surplus situations (e.g. PV energy production). This approach allows self-generated excess electrical energy or grid peak production to be harnessed efficiently and ecologically, contributing to the reduction of fossil fuel consumption.

Benefits (energy created/saved/ CO_2 savings)

The replacement of pre-existing equipment resulted in decrease of electricity consumption by 41 MWh/year. Italy, as the JRC GHG Emission Factors for Electricity Consumption (2020), emits approximately 0,267 tCO_2/MWh during electricity production. Considering that Carbon Emissions Reduction (tCO_2/year) = Annual Energy Production (MWh/year) × Carbon Intensity (tCO_2/MWh), Carbon Emissions Reduction calculated in tCO2/year can be estimated as follow: 41 MWh/year * 0,267 tCO_2/MWh ≈ 10,94 tCO_2/year.