H2020 Work Programme

D6.3 – POLICY INSTRUMENTS TO PROMOTE INDUSTRIAL WH/C RECOVERY

LEAD CONTRACTOR: **FAEN**

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Contributing Author(s)	Andrea Díaz Barredo (Fundación Asturiana de la Energía), Paul Robbrecht (POM Antwerp), Stan Verdonck (POM Antwerp), Francisco Morentin (Cartif), Emanuel Sá (ADEP), Alberto Carrino (RINA), Arianna Matti (RINA), Elisa Crocco (RINA)
Reviewer(s)	Paul Robbrecht (POM Antwerp)
	Stan Verdonck (POM Antwerp)
	Francisco Morentin (Cartif)
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[1] PU = Public
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Abbreviations

SDS - Sustainable Development Scenario

RES: Renewable Energy Sources

IEA: International Energy Agency

PESTLE: Political, Economic, Social, Technological, Legal and Environmental analysis.

WH/C: Waste Heat/Cold

CHP: Combined Heat and Power

PV: Photovoltaic

NECP: National Energy and Climate Plan

EU ETS: Eurpean Union Emission Trading System

REC: Renewable Electricity Certificate

SEK: Code for the *Swedish krona*, the currency for Sweden.

DNH: District Heating Network

PNIEC: National Integrated Energy and Climate Plan (Spain)

SME: Small and Medium Enterprise

DHW: Domestic Hot Water

GHG: Green House Gas

ORC- Organic Rankine Cycle

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Executive summary

The objective of this report is the identification and assessment of the main policies existing for the promotion of recovery and re-use of industrial waste heat or cold in the European countries.

Policy measures are an interesting tool to help in the overcome of market failures, in the improvement of the resource allocation and an opportunity to unlock investments in industrial projects about waste heat/cold recovery and RES integration.

In the elaboration of the current report, four countries have collaborated for the identification of their national funding mechanisms. With the help of some components of their industrial ecosystems, considerations related to the suitability and effectiveness of public policies for the promotion of projects for the recovery and reuse of waste heat/cold, have been collected.

An overview of the main existing policy measures in Italy, Portugal, Sweden, Belgium and Spain has been carried out considering the identification and description of main tools, the target beneficiaries and an approximation of the public investment allocated to this activity at national level.

To improve the analysis, a series of 12 semi-structured interviews were conducted with the main industrial actors/sectors at regional level to catch their vision and experience with these policy instruments.

From the results of the interviews, it has been possible to verify that the main companies know the policy measures they can use for funding the projects of recovery waste heat/cold an integration with RES at industrial facilities.

However, not every company have used these tools for funding their projects and the set of the reasons is exposed. Companies have had the opportunity to express the issues and the barriers they found to submit a project to the calls for proposals launched in their countries.

A set of recommendations have been gathered, made by the industrial agents, in this report to serve as a guidance for the public entities in the designing process of policy tools for the recovery and harnessing of waste heat /cold.

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1 Introduction

The use of industrial residual heat is an important measure within the measures aimed at energy saving and improvement of energy efficiency in industrial processes.

Although energy saving and efficiency measures and the implementation of renewable energy sources have been gradually introduced in the industry, the industrial sector continues to be a big consumer of energy and a large user of fossil fuels.

The combination of the increase in energy consumption from renewable sources and the reduction of energy consumption through the implementation of more efficient technologies, can contribute to the reduction of the energy demand of the industry, which would decisively contribute to reduce its carbon footprint.

According to International Energy Agency (IEA), in the report *Tracking Industry 2020*[2], the industry sector accounted for 37% of total global final energy use in 2018. This represents a 0.9% annual increase in energy consumption since 2010, with 0.8% growth in 2018, following stronger growth of 1.6% the previous year. The European Commission data established that the industrial sector was responsible of the 24% of global emissions in 2018.

The industrial sector can be an important player in the decarbonisation process and a decisive contributor to the achievement of the energy transition goals. Following the Sustainable Development Scenario (SDS)[3] established by IEA, industry emissions must decrease by 1.2% annually to reach 7.4 $GtCO_2$ by 2030.

The industry sector's energy mix is very similar since 2010. The fossil fuel share of the energy mix decreased from 73% to 69%, while electricity rose from 18% to 21%, largely owing to increasing electricity use in non-energy-intensive industry.

In the Sustainable Development Scenario, growth in energy use needs to be limited to about 0.3% per year to 2030, despite expected growth in industrial production.

Energy mix changes, mainly shifting from coal towards natural gas, bioenergy and electricity, can contribute to a fall in the direct CO_2 emissions intensity of industrial energy use. While some energy sources like thermal and geothermal energy continue to expand, they cannot yet provide high-temperature heat on a large scale, and therefore are unable to replace a significant portion of industrial process heat.

Between 20% - 50% of the energy used in industrial processes is lost as hot exhaust gases, cooling water, and heat losses from equipment and products.

Policy makers can help to accelerate the implementation of technologies in key industrial sectors by providing funding for innovation, by introducing mandatory reduction of CO_2 emissions and by implementing policies for energy efficiency.

[2] https://www.iea.org/reports/tracking-industry-2020

[3] SDS - An integrated scenario specifying a pathway aiming at: ensuring universal access to affordable, reliable, sustainable and modern energy services by 2030; substantially reducing air pollution and taking effective action to combat climate change.

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1.1 Purpose and target group

The analysis of the existing policies in European countries participating in SO WHAT project is the aim of this deliverable.

To draw up the Deliverable 6.3, the participation of Italy, Portugal, Sweden, Belgium and Spain was considered and the main results collected in this document come from the partners from RINA, ADEP, IVL, POM and FAEN that give a sample of the main existing policies in European countries.

A compilation of the main policies: plans and strategies aimed at improving the energy efficiency and renewable energy implementation along with the main funding schemes in the involved countries.

In addition, a set of recommendations and lessons learnt based on industrial companies' experience has been gathered with the goal of encouraging the public administrations to design more effective policies and funding programmes.

1.1. Relationship with other activities in the Project

To maintain the coherence with other activities and documents carried out during the project, the PESTLE analysis carried out in the Deliverable D3.1 - Report on current barriers to industrial WH/C recovery and exploitation was a very valuable information in the first steps of this document.

This document has contributed to a better understanding of the general framework of the WH/C harnessing. This analysis enables us to not only take into account the technical barriers, but also the political, economic, social, legal and environmental barriers which are in close relation with the funding programs mechanisms. This knowledge has eased in finding solutions to design policies that encourage the WH/C recovery and harnessing.

In some cases, policy measures can be implemented to support activities to overcome these barriers. The main types of barriers identified in the Deliverable 3.1 are classified in two main types. The main barriers that may be overcome with the support of public policies are:

Barriers that hinder the business models

- Lack of existing infrastructure
- Current policy incentives promote other forms of heat supply
- Lack of financial funding
- Risk that the excess heat provider will terminate its industrial activities

Non-economic barriers

- Lack of trust between the stakeholders
- Different views of the value of the heat
- Lack of knowledge about the amount of excess heat
- Lack of knowledge about business arrangements

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Related to the PESTLE analysis, barriers have been extracted for Italy, Portugal, Sweden, Belgium and Spain to try to understand where the problems are and to try to propose solutions to overcome them:

Italy

- New policies proposed in the National Energy and Climate Plan targets:
    - biomass-fired,
    - individual heating systems to become more efficient
    - renovation of the building stock
    - solar thermal
    - district heating

- Different policies related to heating and cooling were developed, mainly incentivizing solar thermal, heat pumps, geothermal and biomass.

- Technologies such as CHP and district heating are covered by support schemes.

- RES are supported in the funding schemes but, in case of photovoltaics the initial national targets for PV are exempted[4].

- Waste thermal energy is not explicitly mentioned in policies.

Portugal

- No direct push for the recovery of industry excess heat and cold in the Portuguese energy policy.

- The focus is on electrification, solar thermal, heat pumps and biomass.

Belgium

-the introduction of RES and WH/C-recovery and district heating networks are supported, but there is a contingency of natural gas pipes that will have to be gradually replaced or inactivated. A long term vision and the implementation of specific policies and funding mechanisms will be needed to make this transition.

-setting up collaborations between different stakeholders to implement energy efficiency measures and collective investments takes time and has to be supported by public policies

Spain

- Electrification and RES in the thermal sector (mainly heat pumps) are considered key for decarbonisation and pushed for while residual heat and cold is mentioned but not explicitly pushed for.

- Support schemes exist for district heating and cooling on national, regional and local level.

[4] Mainly due to the initial national targets for PV plants were exceeded.

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Sweden

- Decarbonisation of the energy sector is being pushed by Swedish policies mainly with CO_2 taxation and a renewable electricity certificate scheme.

- The taxation on heating oil, individual oil boilers in single-family houses have been substituted by heat pumps and biofuels largely.

- The Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency contained an article (Article 14.5c) has been implemented for plants larger than 20 MW.

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2 Overview of existing policy measures for the promotion of WH/C recovery by country and region

In this section, a brief explanation about the main policy measures for the promotion of WH/C existing policies in the next countries and regions is done.

2.1 Italy

2.1.1 Identification of each existing policy measure

The main instruments used in Italy in the thermal sector are generally those applied in many other sectors in order to achieve energy efficiency objectives. Table 1 represents the instruments used in Italy in different sectors (residential, industrial, service and transport).

Table 1: Existing funding tools in Italy. Source: Integrated National Energy and Climate Plan

Type of measures	Measures denomination	Sectors			
		Residential	Service	Industry	Transport
Obligation scheme	White certificates				
Alternative measures	Tax deduction (house bonus + Ecobonus)				
	Thermal account				
	National Energy Efficiency Fund				
	Industry 4.0 national plan				
	Energy Requalification Program of the Central Public Administration (PREPAC)				
	Cohesion policies				
	Information and training plan				
	Vehicle fleet renewal TPL				
	Modal shift of goods				

Below, a short description of the instruments used in the industrial sector is described:

- **White certificates**: are negotiable certificates that certify an energy saving through energy efficiency projects. They are emitted for energy savings generated by renewables energy plants and plants connected to the district heating networks.

- **Transition 4.0** (ex. Industry 4.0 national plan):

  - **New Sabatini**: Support companies that require bank financing for investments in new capital goods, machinery, plants, factory equipment for productive use.

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- **Tax credit for investments in capital goods** (ex. super and hyper depreciation): incentivize companies that invest in new, material and intangible capital goods, functional to the transformation of production processes
- **Development contracts**: supports large-scale investments in the industrial, tourism and environmental protection sectors.

- Cohesion policy 2021 – 2027 (II.4 Energy) the objective of this policy is to evaluate and support pilot projects for the use of energy for industrial and civil heating.

2.1.2 Brief description of the policy measures

➢ White Certificates are negotiable certificates that verify the achievement of energy savings in energy end uses through interventions and projects to increase energy efficiency.

Using this mechanism, electricity and natural gas distributors must annually achieve primary energy saving targets, expressed in tons of oil equivalent saved. All activities carried out within the white certificate system, such as the management, evaluation and certification of savings related to energy efficiency projects, are delegated to the Energy Services Manager. As part of this mechanism, the implementation of projects involving the use of renewable sources for non-electric uses is also promoted, in relation to their ability to increase energy efficiency and generate non-renewable energy savings.

White Certificates are also issued for energy savings generated by high efficiency cogeneration plants, including renewable energy plants and plants connected to district heating networks. According to the integrated national plan for energy and climate (2019), with reference to CAR (high-efficiency cogeneration) plants, on average there is a volume of recovered useful heat that varies between 31 and 38 TWh per year, of which about 1.2 TWh per year are on average additional compared to the previous year.

Of this annual increase, a share ranging from 40 to 140 GWh is made up of renewable energy.

➢ Transition 4.0 (ex. Industry 4.0 National Plan) is designed for companies that want to seize the opportunities related to the fourth industrial revolution. The Plan provides for a set of organic and complementary measures able to encourage investments for innovation and competitiveness.

New Sabatini is a measure adopted by the Ministry of Economic Development with the aim of facilitating access to credit for companies. This measure finances plant and machinery, industrial and commercial equipment, other goods, software and digital technologies. This measure helps micro, small and medium sized enterprises to obtain a financing from banks or financial intermediaries. In addition, the measure also provides a contribution from the Ministry of Economic Development.

Investments must have the following requirements:

- Functional autonomy of the assets (the assets covered by the financing must be separable from the main asset to which they refer)
- Correlation of the goods covered by the measure to the productive activity of the company.

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The financing must have the following characteristics:

- Duration not exceeding 5 years
- Amount between 20.000 € and 4.000.000 €
- Must be used to pay the admissible investments

The contribution given by the Ministry of Economic Development is equal to the value of interest calculated on a financing with a duration of 5 years and with an amount equal to the investment, using an annual interest rate equal to:

- 2,75% for ordinary investments
- 3,575% for the investment in digital technology, tracking systems and waste weighting

- Tax credit for investments in capital goods is a measure that replaces the previous measures super and hyper depreciation. Investments in material capital goods included in previous measure "hyper depreciation" can have the following tax credit in 2022:

- 40% of the cost for the share of investments up to 2.5 million euros;
- 20% of the cost for the share of investments over 2,5 million euros within the maximum limit of 10 million euros of eligible costs;
- 10% of the cost for the share of investments up to 10 million euros within the maximum limit of 20 million euros of eligible costs.

Instead, investments in capital goods included in previous measure "super depreciation" can have a tax credit of 6% within the maximum limit of 2 million euros of eligible costs. The tax credit can be used only in compensation and in three annual shares with the same amount. For goods with a unit cost exceeding € 300.000, enterprises must produce a technical report issued by an engineer or an industrial expert or a certificate of conformity issued by an accredited certification entity showing that the goods can be included in this measure.

Development contracts are the main facilitative instruments dedicated to the support of large investment programme. With this instrument it is possible to finance the following programme:

- Industrial development programmes
- Development programmes for environmental protection
- Programmes for the development of tourist activities

The total amount of expenditure and costs admissible for the facilities shall not be less than 20.000.000€ and in addition the investment must have a significant environmental impact.

- Cohesion policies 2021 – 2027 aim to increase economic development and social opportunities to reduce the inequality between territories. Specifically, the thematic area "Energy" consists of interventions to increase energy efficiency. The priority for cohesion policies in energy context is to improve the performance of less efficient production facilities, to promote innovative offshore wind generation projects and to support clean technologies with high

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development potential. In addition, it is possible to evaluate and support pilot projects for the use of geothermal energy for industrial and civil heating.

2.1.3 Target beneficiaries and technologies funded

Table 2: Target beneficiaries

Policy	Target beneficiaries	Technologies funded
White certificate	Distributor of electricity and natural gas with more than 50.000 final client are obliged to save energy or to buy white certificate. Other entities that can participate are ESCO, EGE and other enterprises that want to realize interventions to reduce energy final consumption.	Energy efficiency interventions
New Sabatini	Micro, small and medium enterprises	Plant and machinery, industrial and commercial equipment, other goods, software and digital technologies.
Tax credit for investments in capital goods	All enterprises located in Italy	Capital goods
Development contracts	One or more enterprises, Italian or foreign, of any size (compatibility with the community regulations).	They are dedicated to the support of large investment programme
Cohesion policy	Enterprises (in particular small and medium-sized), public entities, associations or private individuals. The only condition is to submit a project in line with the selection criteria set by the managing authority of the programme.	Action to increase energy efficiency

2.1.4 Amount of public investment allocated to the promotion of WH/C recovery

Table 3: amount of public investment allocated

Policy	Amount of public investment
White certificate	**It is a market instrument, so the only amount of public investment allocated is related to the promotion of the interventions carry out (5,6 mld€)**
New Sabatini	**The total amount allocated for this measure as of 24 May 2022 was 3.282.953.065 €.**
Tax credit for investments in capital goods	**No public investment is allocated to this measure**
Development contracts	**The total amount allocated for this measure is 3.282.953.065 €**
Cohesion policy	**The amount allocated for development and cohesion fund for 2021 -2027 is 73,5 billion €**

*These data refer to the total amount allocated for these instruments because the specific amount assigned for each investment category is not available.

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2.2 Portugal

2.2.1 Identification of each existing policy measure

In general terms, there is no history of direct push for the recovery of industry excess heat and cold in the Portuguese energy policies. The main focus is on electrification, solar thermal, heat pumps and biomass.

The industry sector is made up of a wide diversity of activities and processes, including refining, pulp and paper production, glass, ceramics, cement and lime, iron and steel, industrial chemical, among other types of industry. Its emissions derive from the consumption of fossil fuels and, in some sectors, emissions from the chemical processes are involved. Industry emissions represented in 2015 about 19% of national emissions, of which 62% associated with burning of fossil fuels and 38% to process emissions[5].

There is a great need for innovation and creation of new business models in the industry. Reinforcing the perspectives of the circular economy and resource efficiency assume a decisive character on the path to be followed to identify and create innovative, efficient, green solutions with near zero emissions. The bet on industrial symbioses and the reuse of resources with greater incorporation of secondary materials and increased recyclability of the products produced can be an asset in the medium and long term.

2.2.2 Brief description of the policy measures

Recovery and Resilience Plan: Decarbonisation of Industry

This funding program is part of a set of measures that aim to contribute to the objective of carbon neutrality, promoting the energy transition through energy efficiency and support for renewable energies. It has a focus on the production of hydrogen and other gases from renewable sources with the support of digitalisation, introduction of new technologies or more sustainable and more energy efficient production processes, including circularity options, in order to decarbonise them.

The Recovery and Resilience Plan, with differentiated rates depending on the typology of investments, aims to contribute to the objective of carbon neutrality by promoting the energy transition through energy efficiency, support for renewable energies, focusing on the adoption of low-carbon processes and technologies in industry and the incorporation of renewable energy and energy storage.

Energy efficiency measures considered include "use of waste heat from nearby industries (in industrial symbiosis).

2.2.3 Target beneficiaries and technologies funded

The beneficiaries of the Recovery and Resilience Plan are companies of any size or legal form. The extractive and manufacturing industries are included. In addition, management entities of industrial parks, whose investments may directly affect the reduction of greenhouse gas

[5] Roadmap for Carbon Neutrality 2050 – Long-Term Strategy for Carbon Neutrality of the Portuguese Economy by 2050

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emissions in companies of the industry sector installed in the areas under their management can also benefit from this funding.
Consortia that translate industrial symbiosis in terms of proposed investments can also apply for these funds. If the application comes from a consortium, it is up to the lead entity to establish the agreements or contracts necessary for the implementation of the operation.
In terms of funding, the main targets are low carbon processes and technologies in the industry with the introduction of new processes, products and innovative business models or the change of processes aimed at their decarbonisation and digitization, including low carbon clean and innovative technologies and solutions that promote the efficient use of resources and their circularity, including:

- Industrial symbiosis (like waste heat recovery) enhancing the sustainability and resilience of value chains;

- Incorporation of new raw materials: fuels derived from waste, including biomass and biogas;

- Use of industrial symbioses and circular economy measures, incorporating innovation;

- Replacement and/or adaptation of equipment and processes for new sustainable technologies and renewable energy vectors;

- measures that aim at the adoption of fluorinated gases of reduced global warming potential.

2.2.4 Amount of public investment allocated to the promotion of WH/C recovery

For the particular case of the Resilience Plan, the total funding is 705 M€.

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2.3 Sweden

2.3.1 Identification of each existing policy measure

Swedish policy is pushing for a decarbonisation of the energy and industrial sector.

The goals and focus of the Swedish environmental and climate policies are defined within the Climate Policy Framework that was decided in 2017. The overarching goal is to reach net zero emissions by 2045. This framework consists of *Climate Law*, Climate Related Goals and *Climate Policy Council*[6].

The aim is to create consistent and clear climate policies to ensure sustainable long-term prerequisites for society and business.

To summarize, Swedish environmental and climate-related policies consist of three main components:

(1) rules and regulations to restrict or prohibit environmentally hazardous activities,

(2) investment support in sustainable technology and infrastructure and

(3) taxes and fees to create economic incentives for change.

There are no specific policy measures towards WH/C recovery but several different tools guide development in this direction. The following policy measures are the main tools for the transition:

- National Energy and Climate Plan (NECP)
- Taxation
  - CO_2 taxes
  - Energy taxes
- EU Emission Trading System (EU ETS)
- Renewable Electricity Certificate (REC)
- The environmental objectives system: 16 environmental quality objectives
- Klimatklivet (the Climate Leap initiative)
- Industriklivet (the Industrial Leap initiative)
- Renewable Electricity Certificate

2.3.2 Brief description of the policy measures

The Climate Policy Framework was decided upon by the Swedish government in 2017, together with a Climate Law. The framework has the same overarching goal as the NECP (see below) with net zero emissions by 2045 and thereafter negative emissions. The framework consists of climate related goals, a Climate Policy Council and a Climate Law. The law imposes a

[6] Naturvårdsverket. Sveriges klimatmål och klimatpolitiska ramverk. Cited 2022. Available from: https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/sveriges-klimatarbete/sveriges-klimatmal-och-klimatpolitiska-ramverk/

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responsibility on current and future governments to pursue politics that has its starting point in climate goals and to continuously report on progress[7].

Subsequently this framework has an impact on all climate related policies that are decided upon within Swedish politics.

National Energy and Climate Plan (NECP)

The final National Energy and Climate Plan was submitted to the EU in the beginning of 2020. The main objectives of the NCEP are [68][8]:

- Sweden will have net zero emissions by 2045 compared to 1990.
- Emission reduction of 40 % by 2020, 63 % by 2030 and 75 % by 2040 from sectors outside EU ETS compared to 1990.
- Emission reduction of 70 % in domestic transport by 2030 compared to 2010.
- Renewable energy share in gross final energy consumption will be 50 % by 2020.
- By year 2040 renewable electricity production will be 100 % by 2040. (This target is unrelated to decisions on nuclear power plants.)
- Energy use will be 50% more efficient than 2005 by 2030.

Carbon dioxide and energy taxes

The foundation of Swedish climate policy to reduce emissions is energy tax and carbon dioxide tax. Energy tax is a tax levied on the use of electricity, but the effect of this tax is difficult to quantify[9]. A consequence of energy taxation can be increased energy efficiency but this is also difficult to quantify[10]. The carbon dioxide tax was implemented in 1991 and aims to reduce the use of fossil energy. The level of tax is based on the carbon content and is applied on all motor fuels and fuels for heat production. Biofuels and peat are exempted from the tax[11].

The industry has been subject to some exemptions and reductions of energy and carbon dioxide tax through the years, due to the implications these costs might have on their ability to compete on a global market[12].

[7] Naturvårdsverket. Sveriges klimatmål och klimatpolitiska ramverk. Cited 2022. Available from: https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/sveriges-klimatarbete/sveriges-klimatmal-och-klimatpolitiska-ramverk/

[8] Sveriges integrerade nationella energi- och klimatplan. 2020.

[9] Energimyndigheten. *Ekonomiska styrmedel i energisektorn. En utvärdering av dess effekter på koldioxidutsläppen från 1990*. 2006.

[10] Industrins ekonomiska råd. *Svensk industry och EU:s nya industripolitik.* 2021. Available from: https://www.industriradet.se/wp-content/uploads/IER_2021.pdf

[11] Svebio, *Koldioxidskatt*. Cited 2022. Available from: https://www.svebio.se/vi-verkar-for/koldioxidskatt/

[12] Energimyndigheten. *Ekonomiska styrmedel i energisektorn. En utvärdering av dess effekter på koldioxidutsläppen från 1990*. 2006.

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Since 2005, when the EU ETS system was implemented, all the industries included in that system have been exempted for carbon dioxide tax, which is regulated through EU ETS instead. Some criticism has been raised on not including these industries with the largest emissions[13].

During the past ten years the taxation level for industries has changed. In May 2021 the Swedish government decided to remove the reduction of tax for industries on the use of fuel for heating or operation of stationary motors[14]. Previously the taxation level was reduced to 30% but this reduction was removed as of the 1st of January 2022. However, there is still an exemption for metallurgical processes, mineralogical processes, and the production of energy products. Manufacturing industries within EU ETS pay 30 % of energy tax and are entirely exempted from carbon dioxide tax[15].

EU Emission Trading System (EU ETS)

The EU ETS system was introduced in 2005 and the industries included in this system are exempted from carbon dioxide tax, in order to avoid double taxation. Due to the low prices of emission allowances the price on carbon dioxide is low. Emission-intensive industries are given a number of emission allowances in order to protect international competitiveness. Although, the system with distributing emission allowances for free is en-route to be phased out. In the reformation of the EU ETS system that was decided upon by the European parliament the 22nd of June 2022 these free allowances are to be phased out between 2027 and 2032. The linier reduction factor, that decides how many allowances that can be purchased, will also be reduced with 4.4 % from 2024, 4.5% from 2026 and 4.6 % from 2029[16]. The competitiveness will instead be protected by introducing a carbon dioxide toll. The toll is yet to be decided upon, and can therefore change along the way, but it would imply that import of products from countries with fewer emissions regulations will be subjected to a toll corresponding to the price on emissions for a European producer/industry[17].

The environmental objectives system

In 1999 the Swedish parliament decided upon 15 environmental objectives which intends to guide Swedish efforts to safeguard the environment. In 2005 another goal was added, resulting in the 16 environmental objectives that Sweden has today[18]. The climate change action is addressed with the Reduced Climate Impact goal, which is related to the objective of keeping the global average temperature increase below 2°C above pre-industrial levels and push for keeping it below 1.5°C. In the spring of 2022, the Environmental Objectives Committee submitted their report 'Sweden's global climate footprint' to the Swedish government. It suggests a strategy to reduce climate impact from consumption in a cost effective and socio-

[13] Energimyndigheten. *Ekonomiska styrmedel i energisektorn. En utvärdering av dess effekter på koldioxidutsläppen från 1990*. 2006.

[14] Regeringens proposition (2020). Slopad nedsättning av energiskatt på bränslen i vissa sektorer, Finansdepartementet, Sveriges riksdag, Regeringens proposition 2020/21:97.

[15] Industrins ekonomiska råd. Svensk industry och EU:s nya industripolitik. 2021. Available from: https://www.industriradet.se/wp-content/uploads/IER_2021.pdf

[16] Dagens Industri. EU-ja till snabbare utfasning av utsläppsrätter. Cited 2022. Available from: https://www.di.se/hallbart-naringsliv/eu-ja-till-snabbare-utfasning-av-utslappsratter/

[17] Industrins ekonomiska råd. Svensk industry och EU:s nya industripolitik. 2021. Available from: https://www.industriradet.se/wp-content/uploads/IER_2021.pdf

[18] Sveriges miljömål. Environmental Objectives. Cited 2022. Available from: https://www.sverigesmiljomal.se/environmental-objectives/

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economically effective manner[19], by for example complementing the Climate Policy Framework with goals on climate impact from consumption and climate benefits from export[20]. In addition, Energy Agreement in 2016 set the target for net zero emissions by 2045 compared to 1990[21]. To achieve this, one of the targets is 100% share of renewables in electricity generation by 2040.

Klimatklivet and Industriklivet

The Swedish government has introduced investment support schemes for measures and projects that reduce the emission of carbon dioxide; Klimatklivet (the Climate Leap initiative) and Industriklivet (the Industrial Leap initiative).

Klimatklivet was introduced 2015 and is estimated to reduce the emission of carbon dioxide with 1.5 million tons yearly[22]. Companies, municipalities, regions and organizations can all apply for projects within transport, charging infrastructure, energy and industry, agriculture, buildings etc. The applications are compared and valued based on the volume of reduced carbon dioxide per invested SEK and can receive up to 60% in support. As of March 2022, there have been 4 433 applications approved, corresponding to 1.9 million tons of carbon dioxide and 22,7 billion SEK.18 A difficulty for some of the industries within Klimatklivet is that companies that are included in the EU ETS system cannot apply for the support. But if the measure is outside of the scope of the environmental permit for the specific plant or is regarding the use of waste heat certain exemptions apply[23]. In the latest application round the Swedish Environmental Protection Agency specifically mentioned WH/C recovery projects as interesting[24].

Industriklivet is a similar funding where projects aiming to reduce emission of carbon dioxide can receive grants. This is applicable for industries included in the EU ETS system and stems from the goal of net zero emissions by 2045. Projects within this investment support must be innovative in another sense than projects within Klimatklivet. New technologies that can direct the industry toward more circular and biobased economy and which are yet to be commercialized are the aim of this support system. Projects can include pre-studies, research, pilot and demonstration projects as well as investments within the areas (1) greenhouse gas

[19] Regeringskansliet, Sveriges globala klimatavtryck, Cited 2022. Available from: https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2022/04/sou-202215/

[20] Regeringskansliet, Regeringen tar emot förslag om nya klimatmål för konsumtion och export, Cited 2022. Available from: https://www.regeringen.se/pressmeddelanden/2022/04/regeringen-tar-emot-forslag-om-nya-klimatmal-for-konsumtion-och-export/

[21] Energy Policies of IEA Countries: Sweden 2019 Review. 2019, IEA.

[22] Aktuell Hållbarhet, Klimatklivet gör nytta, Cited 2022. Available from: https://www.aktuellhallbarhet.se/miljo/klimat/klimatklivet-gor-nytta/

[23] Naturvårdsverket, Resultat för Klimatklivet, Cited 2022. Available from: https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/resultat-for-klimatklivet/

[24] Naturvårdsverket, Förutsättningar för stöd från Klimatklivet, Cited 2022. Available from: https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/forutsattningar-for-stod-fran-klimatklivet/

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emissions from the process industry, (2) negative emissions and (3) strategically important initiatives in the industry[25].

Renewable Electricity Certificate (REC)

The REC is a market-based support system to increase the amount of renewable electricity produced in Sweden[26]. Every producer of renewable energy receives a certificate for each MWh produced energy. The certificates can thereafter be purchased on an open market by stakeholders who are subject to quotas. These companies include electricity suppliers, electricity users who use the electricity produced by themselves, electricity users who import or buy electricity on the Nordic electricity exchange and by the Swedish Energy Agency registered electricity-intensive industries. These stakeholders are obliged to buy a certain share of electricity certificates which is determined in the Electricity Certificates Act. These levels are set until the year 2035[27]. The system is, since 2012, integrated with Norway. Energy sources that are qualified for REC are wind power, certain hydropower, certain biofuels, solar energy, geothermal energy, wave energy and peat in combined heat and power plants[28].

2.3.3 Target beneficiaries and technologies funded

The general aim of Swedish policy is to be technology neutral and let market-based mechanisms decide which technology that is most suitable and economically viable in order to reduce the emissions. There is thereby no specific support system for WH/C recovery.
Although *Klimatklivet* and *Industriklivet* are two support systems where this type of technology can be granted support, depending on the technology.

More information on these schemes in Table 4.

Table 4: Klimatklivet Aid program

Aid program for Klimatklivet	
Purpose	Klimatklivet grants financial support for investments that reduce emissions of carbon dioxide and other greenhouse gases.
Beneficiary	Companies, regions and county councils, municipalities and municipal companies, associations, tenant-owner associations and foundations. Industries within the EU ETS cannot receive a grant.
Eligible measures	Electricity production from biogas, physical investments, emissions reduction, measures with additional emissions reduction effect etc.
Managing body	Swedish Environmental Protection Agency

[25] Naturvårdsverket, Klimatklivet ger stöd till investeringar som tar hand om överskottsvärme, Cited 2022. Available from: https://www.naturvardsverket.se/om-oss/aktuellt/nyheter-och-pressmeddelanden/klimatklivet-ger-stod-till-investeringar-som-tar-hand-om-overskottsvarme/

[26] Energimyndigheten, Elcertifikatsystemet, Cited 2022. Available from: https://www.energimyndigheten.se/fornybart/elcertifikatsystemet/

[27] Energimyndigheten, Om elcertifikatsystemet, Cited 2022. Available from: https://www.energimyndigheten.se/fornybart/elcertifikatsystemet/om-elcertifikatsystemet/

[28] Energimyndigheten, Elcertifikatsystemet, Cited 2022. Available from: https://www.energimyndigheten.se/fornybart/elcertifikatsystemet/

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Eligible expenses	All expenses considered necessary to carry out the project are eligible expenses, ongoing costs cannot be included. Eligible expenses are: investments costs, leasing/rental of equipment, additional investment costs, personnel costs, travel and accommodation, premises, VAT, design, procurement, permit, final inspection, test operation, education and connection fees.
Maximum amount of the aid/grant	The amount of the subsidy can be up to maximum of 70% of the eligible expenditure.
More information	https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/

Table 5: Industriklivet Aid Program

Aid program for Industriklivet	
Purpose	Industriklivet is economic aid for industrial stakeholders to support projects that reduce the emissions of greenhouse gases.
Beneficiary	Industries such as iron- and steel industry, other metal-related industries such as mines, refineries and the chemical industry, mineral industry and forest industry. For support for bio-CCS/negative emissions, the electricity and heating sector is included.
Eligible measures	Pre-studies, research projects, pilot-plants and demonstration plants and investment within the following areas can receive grants: the process industries emission of greenhouse gases, negative emissions and strategically important projects within the industry.
Managing body	Swedish Energy Agency
Eligible expenses	Which costs that are eligible in a project and how large share of these costs that the beneficiary can receive depends on the basis of which the support has been granted. No indirect costs can be supported financially.
Maximum amount of the aid/grant	The amount of the subsidy will be up to 70% of the eligible expenditure depending on the size of the company. Stakeholders such as universities, municipalities and research institutes can receive support up to 100% of the eligible expenses.
More information	http://www.energimyndigheten.se/industriklivet

2.3.4 Amount of public investment allocated to the promotion of WH/C recovery

As previously mentioned all of the policies that are mentioned in this report are technology neutral and is thereby eligible to apply for many types of projects. The CO_2 taxation as well as EU ETS are systems that result in that emissions are associated with a cost. The potential to decrease costs are thereby how new technologies are supported. The Renewable Energy Certificates do not support a specific technology either but uses market mechanisms to steer development towards the most economically viable solution. NECP and the 16 environmental objectives map out the direction in which the transition should develop but they do not have any authorization to grant financial support to projects.

In *Klimatklivet* and *Industriklivet* projects can be funded with the potential to decrease emissions of greenhouse gases. *Industriklivet* requires a certain innovative technology but as long as that requirement is met the grant can be applied for. For 2022 *Klimatklivet* has 2.8 billion SEK

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available (approx. 280 MEUR), and from 2026 another 6 billion (approx. 600 MEUR) will be available[29]. *Industriklivet* comprises of 909 million SEK (approx. 90.9 MEUR) and has an authorization limit of 3 000 million SEK (approx. 300 MEUR)[30].

[29] Naturvårdsverket, Klimatklivet ger stöd till investeringar som tar hand om överskottsvärme, Cited 2022. Available from: https://www.naturvardsverket.se/om-oss/aktuellt/nyheter-och-pressmeddelanden/klimatklivet-ger-stod-till-investeringar-som-tar-hand-om-overskottsvarme/

[30] Regeringskansliet, Insatser genom Industriklivet, Cited 2022. Available from: https://www.regeringen.se/regeringens-politik/regeringens-insatser-av-betydelse-for-storre-foretagsetableringar-och--expansioner-i-norrbotten-och-vasterbotten/industriklivet/

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2.4 Belgium

2.4.1 Identification of each existing policy measure

At the end of 2019, following the European Regulation (EU) 2018/1999, Belgium submitted a definitive *National Energy and Climate Plan* for the period 2021-2030 to the European Commission.

The following strategic objectives are set in the Belgian energy and climate policy proposal, in accordance with the philosophy and the 4 pillars of the inter-federal energy pact:

- Guaranteeing secure, sustainable and affordable energy: an optimum is sought between environmental efficiency, economic efficiency and social efficiency.
- Putting citizens at the centre of the energy system: enabling citizens and businesses, to make the choices that will be most effective and efficient with a view to on the general objectives to be achieved together through participation and information.
- Keeping the costs of the system affordable for small and large consumers: at a global level, the energy transition entails costs, but doing nothing would be even more expensive. At the Belgian level, the transition will also offer economic opportunities. Specific attention is paid to the affordability and competitiveness of companies, as well as to vulnerable consumers.
- Ensure the involvement and coherence between the initiatives from all levels of government: Attention to consultation, coherence between the levels of competence, participation and communication to achieve a positive result.

This is translated into 5 dimensions stablished by the European Union as follows:

1. Decarbonisation dimension
   - Greenhouse gas emissions reductions
   - Renewable energy
2. Energy Efficiency dimension
3. Energy Security dimension
4. Internal Energy Market dimension
5. Research, Innovation and Competitiveness dimension

More info: https://www.nationalenergyclimateplan.be/en

2.4.2 Brief description of the policy measures

With a share of more than 50%, heat is the most important component of energy consumption in Flanders. For families, this even increases to three quarters of their energy consumption. 85% of the population heat their houses with fossil fuels. [31]

By 2050, nearly 100,000 households should make their heat supply more sustainable each year. That is one of the great challenges on which the Heat Plan 2025 focuses.

[31] Visienota Warmteplan 2025 – Vision to 2025 – Heat Plan 2025

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Flanders is responsible for most of the policies regarding WH/C recovery, and decided on the Heat Plan 2025 in December of 2021. The Heat Plan 2025 contains 26 measures to make the switch to sustainable heating and greening energy carriers.

An important role is assigned to the further development of heat networks in Flanders. Via the current heat networks are supplied approximately 560 GWh of heat per year. Based on the projects submitted in the various calls and with Strategic ecology support, a further growth of 1000 GWh extra by 2020 (250 GWh/year in the period 2017-2020) estimated. This growth will be extended to 2030.

The brief overview of specific policy measures towards WH/C recovery are the following:

Waste heat / cold recovery and DNH:

- Drawing up heat zoning plans / Municipal Energy Plans– Flanders supports local authorities in drawing up a heat plan.
  Citizens and companies can only make the right investment choice if sufficient information is available on the long-term strategy. The strategy is laid down in a heat zoning plan, based on data on, among other things, energy consumption and production, available or new residual heat sources, possibility of installing a heat network, possibility of new decentralised (and preferably renewable) heat production.
- Call Groene Warmte (Call Green Heat)
  The Flemish government launches an annual Green Heat call. Through this call, an investment subsidy is issued for investments in green heat, use of residual heat, a heat network or injection of biomethane. The costs charged are calculated as the additional investment costs of the installation and reference installation without the investment costs.

  Companies can benefit from support for investments in the following themes:
    - useful green heat installations (biomass >300 kWth large-scale solar boilers >425m2, borehole energy storage and cold heat storage (incl. heat pump), large-scale heat pumps, deep geothermal energy > 1MWth, connected district heating and cooling or organic rankine cycle ≥300kWe)
    - residual heat (use of residual heat, connected heat network or organic rankine cycle and for district heating and cooling)
    - energy-efficient heat networks
    - production (and injection) of biomethane

  The aid amounts to 30 to 65% of the additional ecological costs, depending on the theme and the size of the company.
- Connection subsidies
  The Flemish government is considering the introduction of connection subsidies for existing homes and compulsory connection for apartment buildings on heat networks. Some local authorities (e.g., Bruges) already give a subsidy of 2.000€.
- Ecologiepremie+ ("Ecology support +")
  The ecology subsidy is a support measure to make companies more sustainable, which is managed by the Flemish Agency for Innovation & Entrepreneurship (VLAIO). Small,

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medium and large companies that carry out certain ecological investments in the Flemish Region can benefit from ecology support. Ecological investments are investments in energy reduction, renewable energy, climate mitigation and climate adaptations and the environment and in the circular economy.

Through the ecology premium plus, companies can obtain investment support for investments that appear on the limitative technologies list (LTL). Eligible technologies are related to cooling, transport, lighting, heat, water and various. The aid amounts to 15 to 55% of the ecological additional costs of the essential investment components, depending on the technology and the size of the company. Only measures that are included in an exhaustive list are eligible for aid. This list is drawn up annually by ministerial decree. Examples of energy saving measures in the current list are: connection to existing heat networks, heat pump with residual heat as source, etc.

- Tax benefits

  To encourage major energy renovations (IER) and low-energy new construction in non-residential buildings, there are some tax benefits. These tax benefits translate into a discount on property tax for a period of five years. The amount of the reduction of the real estate tax depends on the height of the E-level of the building.

- Investeringsaftrek (Investment deduction)

  A company that carries out an investment upon incorporation or expansion can obtain an investment deduction under certain conditions. This is a tax benefit whereby a certain percentage of the acquisition or investment value of the investments made during the taxable period may be deducted from the taxable profit.

  For energy-saving investments in fixed assets in Belgium, there is the increased investment deduction of 13 to 15.5% depending on the tax year. These investments include assets for a more rational use of energy, cogeneration, renewable energy and transhipment infrastructure for rail and waterway transport. A tax certificate must be requested for this.

  Potentially eligible are:
  - improving efficiency of combustion, heating, air-conditioning and lighting equipment;
  - insulation of buildings, pipes, appliances and furnaces;
  - limitation of ventilation losses of buildings;
  - recovery of waste heat;
  - industrial production processes;
  - combined heat and power;
  - energy production based on renewable energy;
  - production and use of energy by converting biomass and/or waste;
  - Transhipment infrastructure transport by rail or waterway.

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Renewable Energy Sources

- Groene Stroom Certificaten (Green Current Certificates).
  A green energy certificate shows that a certain installation has generated an amount of electricity from a renewable energy source in the Flemish region. Owners of smaller (<25kW) green energy production installations can receive green energy certificates if they meet the conditions. New installations must take into account the banding factor (correction factor). In certain cases this is set at 0 (= no certificates).

- Call Groene Stroom (Call Green Elektricity)
  Owners of bigger (>25kW) green energy production installations can receive subsidies via a call for green electricity. This takes place via a competition formula in which the applicant submits a bid for a project. This bid reflects the ratio of the requested support to the expected energy yield and is ranked in relation to the other bids on the basis of cost-efficiency. The best-ranked bids will be paid out according to the budget.

- Warmte-kracht Certificaten (Cogeneration Certificates)
  Owners of a combined heat and power installation have the option of obtaining combined heat and power certificates. A cogeneration certificate shows that a certain production installation has achieved an amount of primary energy savings by using qualitative cogeneration compared to a reference plant and a reference boiler. These certificates have a value and can be sold to an energy supplier or the network operator. This support has introduced many cogeneration units in Belgium, but will be reduced in the future in favour of renewables.

Others:

- Participation of Society of Flanders
  Financing PMV companies in Flanders via, subordinated loans and capital investments. For capital investment in the context of energy efficiency, there is a budget of 20 million euros has been reserved and participations can be up to a maximum of 50 %. In this way, PMV wants to support our Flemish economy in making the Flemish, Belgian and European climate and energy targets.

- Green Deals
  Green Deals are already being used successfully as an innovative way of developing voluntary cooperation across the boundaries of companies, civil society and government. During the planning period we want to anchoring, expanding and deploying the operation to engage in energy and climate innovation.

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2.5 Spain

The so-called ***Strategic Framework for Energy, and Climate*** published in 2020 represents the transposition of the European Directives related to energy and climate to the Spanish policy framework.

This framework is composed mainly by a set of tools:

Law on Climate Change –which is the legal framework to facilitate the progressive adaptation to the demands of climate action. The text includes the institutional cooperation instruments, assessment and learning tools and an enabling framework for the energy transition with integration channels for the different sectors.

National Integrated Energy and Climate Plan (PNIEC) 2021-2030 - which defines the objectives of reducing greenhouse gas emissions, penetration of renewable energy and energy efficiency. It determines the lines of actions and the most appropriate and efficient path that is the most appropriate and efficient to, maximizing the opportunities and benefits for the economy, employment, health and the environment and to minimize costs for the most CO2-intensive sectors in the activities they must carry out to respect the energy transition rules.

Just Transition Strategy - which includes the instruments to optimize the employment opportunities of the transition through professional training frameworks, active employment policies, and support and accompaniment measures. Special attention is paid to strategic sectors and recovery plans of the territories that may be affected by this process so that "*no one is left behind*".

To reach the goals contained in the Framework, it is foreseen to work on the next global goals:

1. Public investment as a lever for private investment

The Framework provides certainty and confidence to all economic actors and seeks industrial modernization and job creation. It will be mobilized almost 240,000M€ of private, public investment and under public-private collaboration models.

2. Boosting Economic Growth

The planned investments and savings in the country's energy bill will allow an increase in Spain's GDP between 2021 and 2030 with a 1,8% increase in 2030.

3. Job creation engine

The measures of the Framework foresee the generation of between 250,000 and 364,000 new jobs between 2021 and 2030. These are jobs fundamentally linked to industry and the tertiary sector to improve efficiency, innovation and renewable energy implementation.

4. Renewable energy power

The framework foresees that more than 70% of electricity generation in Spain in 2030 will be renewable, compared to the current 40%; and that 100% will be reached by 2050, a goal that will allow the commitments of the Paris Agreement to be met. The Government will guarantee an adequate allowance for renewables, as well as a defined roadmap for the development of

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networks and storage and management systems. All of these actions will conduct to a proper integration of renewable energy technologies in the system.

5. Drive for innovation

The Framework provides an opportunity to innovate in the transition to a low-carbon economy. Spain has a high technological and industrial capacity in the generation and management of renewable energies as well as in energy efficiency.

New opportunities based on technology will improve the competitiveness of the industrial network and generate qualified quality employment in industries, universities and research centres.

6. Accompaniment to the industrial sector

The challenges of the industrial sector are fundamental and supporting ad-hoc measures are needed. A significant part of the mobilization of 240,000M€ in estimated investments will be oriented to the industrial sector which will allow an increase of between 48,000 and 53,000 jobs in manufacturing industries in 2030. Instruments will be created during this transition, supporting R&D&i activities and the adaptation of companies in the different economic sectors to the climate action needs.

2.5.1 Identification of existing policy measures

The main policy measures are contained in the reference documents:

- National Integrated Energy and Climate Plan (PNIEC) 2021 2030

This plan contains two main actions oriented to the promotion of the use of renewable energy in the industrial sector.

Measure 1.5. Incorporation of renewables in the industrial sector

Description: The introduction of renewable energy in industry contributes to moving towards the decarbonisation of the economy and the use of competitive energy alternatives.

According to "Energy in Spain 2016" [32] the final energy demand in the industrial sector reached around 24% in 2015. This demand was covered with 7% of renewable energy sources (mainly biomass). There is potential for both biomass and other renewable thermal energy sources (especially biogas and solar thermal), to contribute more significantly to the decarbonisation of the industrial sector.

As for the possibilities of electricity self-consumption in the industrial sector, although it has hardly been developed to date but there is also potential to take advantage of.

Within the mechanisms action, they are considered: the increase of renewable energies penetration in more subsectors since today there is a concentration of renewable energy consumption in four main subsectors: cement production, pulp and paper production, food, beverages and tobacco, and the wood industry and derived products).

[32] Published by the *State Secretariat for Energy* belonging to MITECO.

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Addressed objectives - Promote the decentralised generation of renewable energy and self-consumption in industry.

Mechanisms for the development of renewable energy in industry:

- Aid programs for the implementation of renewable energy in industrial processes. Actions to support industries or heat networks that supply them based on the potential, cost and characteristics of the technology together with the potential to improve their carbon footprint.
- Development of institutional capacities: it will be promoted the specific incorporation of the "energy criterion" in the industrial policy tools.
- Sectoral agreements: Voluntary agreements will be made with certain industrial subsectors to encourage increased consumption of renewable energy.
- Grants for carrying out studies, reports and energy audits that facilitate the transition to less carbon-intensive processes for industry. These studies must identify the different technological options based on the specific process heat requirements of each industrial subsector, the energy, technical and economic potential, and the identification of challenges and proposed measures.

Measure 1.6. Framework for the development of thermal renewable energy

Framework for the development of thermal renewable energies that includes mechanisms related to the promotion of heat and cold networks and the evaluation of the potential use of renewable energy and residual heat and cold in DH&C, lines of support for these installations or the evaluation of the potential of these systems in new urban developments.

Given the potential identified for the development of heating and cooling networks, PNIEC considers specific measures, both regulatory and economic support, so that heating and cooling networks with renewable fuels play a significant role in the year 2030.

Addressed objectives - Promotion of the penetration of renewable energy sources for thermal uses, and in particular in the building sector and with regard to heating and cooling networks.

Mechanisms related to the promotion of heating and cooling networks:

• Annual collection of necessary information to comply with the statistical obligations on heating and cooling networks, both existing and new, which will include at least the installed capacity, technology used, fuel used, energy produced.

• Establish mechanisms to ensure that final consumers are informed about energy efficiency and about the share of renewable energy in the heating/cooling networks to which they are connected.

• Evaluation of the potential of these networks in new urban developments.

• Development of renewable energy communities linked to air conditioning networks, including technical training at the local level.

• Guarantee the performance of a cost/benefit analysis in each new urban development.

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Additionally, to the above-mentioned documents, others also consider the importance of the industrial sector in the decarbonisation process:

- Decarbonisation Strategy to 2050

This strategy considers a sectoral decarbonisation to achieve a decarbonised economy in 2050.

To reach the goal of obtaining a competitive and sustainable industry in 2050, it will be needed the combination of the most advanced technologies, new energy vectors, as well as energy efficiency, to undertake this transformation, making the most of the opportunities.

From a technological point of view measures considered for the industrial sector are:

- Energy efficiency
- Carbon Capture and use
- Circular economy
- Renewable energies
- Decarbonised technologies
- Smart industrial policies
- Renewable energy vectors for electrification – renewable heat
- Renewable and very high efficiency cogeneration.

- Industry program

This is a program of aids aimed at energy saving and efficiency in SMEs and large companies in the industrial sector, co-financed by the European Regional Development Fund (ERDF), and managed by IDAE[33].

Within the *Industry III Program*, that is the current line in operation, it is expected to achieve a final energy saving of 500 ktoe/year. This represents 50% of the annual objective established by the PNIEC.

This aid program allows promoting a wide variety of actions to improve energy efficiency in industry, ranging from regular investments to new innovative processes.

Among them, the next actions have been covered:

- Renovation of the steam and hot water production system.
- Improved boiler performance by burner replacement and heat recovery.
- Recovery of waste heat.
- Energy optimization in the generation of industrial cold.

These actions to improve technology, industrial processes and the implementation of energy management systems, will allow companies to reduce consumptions and costs.

- Recovery, Transformation and Resilience Plan

Motivated by the economic and social crisis caused by COVID19, European funds for recovery are distributed in Spain through a plan with 4 transversal axes:

[33] Institute for Energy Diversification and Savings, IDAE

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- Ecological transition
- Digital transformation
- Social and territorial cohesion
- Gender equality.

Spain may receive up to 140,000 million euros for reforms and investments between 2021 and 2026. Of these, almost 70,000 correspond to non-reimbursable transfers, which will mostly be executed between 2021 and 2023. The rest corresponds to available credits.

For the period 2021-26: around 70,000 million euros will be available and distributed through 10 lever policies. For the purpose of this analysis, it is of interest, the most important policy levers are:

- Just and inclusive energy transition, consisting of the following components:

  - ✓ Component 7: Deployment and integration of renewable energy
  - ✓ Component 8: Electrical infrastructures, promotion of smart grids and deployment of flexibility and storage
  - ✓ Component 9: Renewable hydrogen roadmap and its sectoral integration
  - ✓ Component 10: Just Transition Strategy

  9.2% of the total funds are allocated to this leverage policy

- Modernization and digitalization of the industrial and SME fabric, tourism recovery and promotion of an entrepreneurial nation Spain, which consists of the following components:

  - ✓ Component 12: Industrial Policy Spain 2030
  - ✓ Component 13: Boosting SMEs
  - ✓ Component 14: Modernization and competitiveness plan for the tourism sector
  - ✓ Component 15: Digital Connectivity, promotion of cybersecurity and deployment of 5G

  23.1% is allocated to this leverage policy

Considering the most important components for both lever policies, it can be added:

Component 7: Deployment and integration of renewable energies

It is necessary to address the decarbonisation of the energy system and take advantage of the opportunity for economic growth and sustainable employment, with social and economic benefits that the promotion of renewable energy entails.

Some of the main investments of these components, which are aimed at the industrial sector, are:

- National Self-consumption Strategy to promote self-consumption facilities both in the industrial, service or agricultural sectors, as well as in the residential sector.

- Development of innovative renewable energy, integrated in the building and in production processes.

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Component 12: Industrial Policy Spain 2030

The manufacturing industry (excluding the energy sector) represents 12.3% of the Gross Value Added of the Spanish economy[34], a percentage lower than in neighbouring countries.

One of the main challenges facing the industry is the improvement in efficiency in water management, waste, energy and resources, emissions and renewable energy in the circular economy framework.

Some of the main investments of this component, are:

- Program to promote competitiveness and industrial sustainability in which a line of support will be opened for innovation and sustainability plans to finance individual innovation and sustainability projects in key areas in the industrial transition such as energy efficiency, decarbonisation and new sustainable energy sources.

2.5.2 Brief description of the policy measures funded

The next list is a compilation of the policy measures that have been granted through the implementation of national and regional programs aimed at improving the energy efficiency:

- Aid program for the Promotion of energy saving and efficiency – Heating and cooling networks
- Aid program for energy efficiency in SMEs and large companies in the industrial sector
- Aid incentive program for thermal renewable energy installations.
- Aid for the execution of incentive programs for the implementation of thermal renewable energy facilities in different sectors of the economy
- Aids for investments aimed at companies to support the transition of industrial activity towards a circular economy

2.5.3 Target beneficiaries and technologies

From the different national plans and strategies mentioned above, aid programs arise to finance investments in heat utilization systems and implementation of renewables.

Also, some regional administrations, launch their own programs aimed at energy saving and energy efficiency and the implementation of renewables. The aids programs published by the regional government of Asturias are gathered. It is very common that the rest of Spanish regions, launch similar calls with similar topics so the case of Asturias should serve as an example of the aid programs put at company's disposal to improve the industry efficiency or renewable energy implementation.

In some cases, there is a transfer of management from the national administration to the regional administration, as indicated in some of the aids mentioned below.

[34] Recovery, Transformation and Resilience Plan. Component 12

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The next tables include a summary of the most important ones:

Regional aid programs:

Table 6: Aid program for the Promotion of energy saving and efficiency. Heating and cooling networks

Aid program for the Promotion of energy saving and efficiency – Heating and cooling networks	
Purpose	Economic aid for new heat networks (District Heating) and the expansion of existing ones
Beneficiary	Private companies and communities of owners
Eligible measures	Construction of new heat networks (District Heating) and the expansion of existing ones to new users (although thermal generation power remains unchanged).
Managing body	Regional Ministry of Industry, Employment and Economic Promotion. Renewable Energy and Energy Efficiency Service
Maximum amount of the aid/grant	The amount of the subsidy will be up to 30% of the eligible expenditure.
More info	Más Info: AYUD0004T06 - Subvención para la construcción y ampliación de redes de calor o frío - Sede Electrónica (asturias.es)
Publication	Publicación BOPA: https://sede.asturias.es/bopa/2021/01/19/2021-00149.pdf

Table 7: Aid program for the Promotion of energy saving and efficiency - Public Aid for Industries

Aid program for the Promotion of energy saving and efficiency - Public Aid for Industries	
Purpose	Economic aid for private companies for the replacement of energy-consuming equipment and installations
Beneficiary	Private companies whose activity is included in any of the classes belonging to section C "manufacturing industry", of the national classification of economic activities (CNAE)
Eligible measures	Substitution of energy-consuming equipment and installations for other equipment and installations that use high-efficiency technologies or the best available technology, provided that it allows the company's energy consumption to be reduced.
Managing body	Regional Ministry of Industry, Employment and Economic Promotion. Renewable Energy and Energy Efficiency Service
Eligible expenses	· The acquisition costs of equipment, facilities and systems that transform or consume energy in the production process, as well as the auxiliary systems necessary for its operation. · The costs related to the associated engineering project · The costs related to the civil works for the implementation of said equipment, and its assembly and start-up.
Maximum amount of the aid/grant	The amount of the subsidy will be up to 22% of the eligible expenditure, and in no case will it exceed the maximum amount established in each call.
More information	AYUD0004T08 - Subvención para la sustitución de equipos e instalaciones consumidores de energía en la industria - Sede Electrónica (asturias.es)
Publication	Publicación BOPA: https://sede.asturias.es/bopa/2021/01/19/2021-00149.pdf

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Table 8: Aid program for thermal renewable energy installations

Aid program for thermal renewable energy installations	
Purpose	To encourage and promote actions in the industrial sector that reduce carbon dioxide emissions by improving energy efficiency, thereby helping to achieve the goals of reducing final energy consumption.
Beneficiary	Companies considered SMEs and large companies in the industrial sector whose CNAE 2009 are: 07-11 and 13-39
Eligible measures	Actions must achieve a reduction in carbon dioxide emissions and final energy consumption, by improving energy efficiency with respect to their starting situation the energy savings and the reduction of CO_2 emissions. 1) Improvement of technology in equipment and industrial processes. 2) Implementation of energy management systems.
Managing body	Regional Ministry of Industry, Employment and Economic Promotion. Renewable Energy and Energy Efficiency Service Financed with "Next Generation EU" Funds through the Recovery, Transformation and Resilience Plan
Eligible expenses	Investments to replace equipment and installations, as well as auxiliary energy-consuming systems for others that use high energy efficiency technologies or the best available technology in order to reduce final energy consumption and CO_2 emissions.
Maximum amount of the aid/grant	The maximum amount of aid will be for each of the actions, the least of the following three: a) 30% of the eligible investment of the project, and with the particular limits that for each type of action are indicated in annex IV of these bases. b) The maximum amount that, depending on the region where the project is located and the type of promoter company, is established for energy efficiency actions in article 38 of Regulation (EU) No. 651/2014, of June 17, 2014. c) The maximum amount of aid per application that will be set by the autonomous communities and cities of Ceuta and Melilla in their respective calls based on their budget.
More info	Aid for energy efficiency actions in SMEs and large companies in the industrial sector - https://www.pap.hacienda.gob.es/bdnstrans/GE/es/convocatoria/474185
Publication	Royal Decree 263/2019, of April 12, which regulates the Aid Program for energy efficiency actions in SMEs and large companies in the industrial sector: https://www.boe.es/diario_boe/txt.php?id=BOE-A-2019-5570

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Table 9: Grants of investment aimed at companies to support the transition of industrial activity towards a circular economy

Bases approval: Grants of investment aimed at companies to support the transition of industrial activity towards a circular economy	
Purpose	Granting of subsidies under a competitive system, for the execution of investment projects that facilitate the transition of industrial activity towards a circular and decarbonized economy, through measures of efficiency in the use of resources and energy efficiency in competitive conditions, with special attention to initiatives resulting from collaborative models of industrial symbiosis or urban industrial symbiosis.
Beneficiary	SMEs as well as Large Companies with their own legal personality that have a production establishment located in Asturias.
Eligible measures	The eligible actions must have a substantial contribution to the transition of the industry towards a circular economy and respond to one of the following types of projects: - Type A Projects for the use of waste streams to promote industrial symbiosis or urban industrial symbiosis. - Type B: Projects for the decarbonization of industry. Investments aimed at energy efficiency measures using residual heat in industry.
Managing body	IDEPA – Economic Development Agency of the Government of Asturias
Eligible expenses	The eligible concepts will correspond to the acquisition of tangible and intangible assets that facilitate the transition to the circular economy, in accordance with the following descriptions: Tangible assets: - Equipment complementary to those of the existing processes. - Adequacy of warehouses and production facilities. - Singular elements of internal transport. Intangible assets: - Linked to the transfer of technology such as the acquisition of patent rights, licenses, know-how or non-patented technical knowledge. - Design and redesign of processes to facilitate the reuse and recycling of waste or increase energy efficiency in existing processes. - Facultative direction of the project.
Maximum amount of the aid/grant	Not define yet. It will be defined when the Call for projects opens
More info	https://www.idepa.es/documents/20147/1985025/Propuesta_BBRR_Circularidad.pdf/b3d3dbd9-56a3-b452-4f0c-f336bc02dd05
Publication	www.idepa.es https://www.idepa.es/innovacion/financiacion

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Table 10: Aid program for industrial research, development and innovation projects in the field of the manufacturing industry

Aid program for industrial research, development and innovation projects in the field of the manufacturing industry	
Purpose	Subsidies for the use of renewable energies and energy saving and efficiency actions
Beneficiary	Private companies, self-employed workers, individuals, non-profit entities and communities of owners
Eligible measures	PROMOTION OF THE USE OF RENEWABLE ENERGY. - Facilities for energy use of biogas - Production of electrical energy through mini-hydraulic turbines or through wind turbines - Isolated photovoltaic solar energy. - Use of biomass as fuel for the production of thermal energy. - Geothermal systems for the production of thermal energy (heat and/or cold). PROMOTION OF ENERGY SAVING AND EFFICIENCY - Heat/cold networks - construction of new heat networks (district heating) and the expansion of existing ones to new users (although thermal generation power remains unchanged). - Public aid program for industries - This subsidy line includes the replacement of energy-consuming equipment and installations with other equipment and installations that use technology
Managing body	Regional Ministry of Industry, employment and economic promotion
Eligible expenses	Depending on the main line, different eligible expenses are considered.
Maximum amount of the aid/grant	The amount of the aid will be up to 25% of the eligible cost.
More info	
Publication	https://sede.asturias.es/bopa/2022/07/12/2022-05326.pdf

National aid programs:

Table 11: Aid program for the implementation of thermal renewable energy facilities in different sectors of the economy

Aid program for the implementation of thermal renewable energy facilities in different sectors of the economy	
Purpose	It will promote installations in industry, the agricultural sector, the service sector and the public sector
Beneficiary	The aid will be implemented through two incentive programs: - the first - aimed at sectors of the economy - the second, to the public sector it will allow the start-up of solar thermal, geothermal, ambient energy (aerothermal and hydrothermal), biomass or heating and cooling microgrids of less than 1 MW of power.

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Eligible measures	Among the eligible actions are applications for the production of cold and/or heat in buildings (sanitary hot water and air conditioning) or in industrial processes (cleaning, drying, thermal baths for surface treatment, laundry services, vehicle washing, pasteurization and conservation of perishable products, air conditioning of warehouses for industrial use, livestock and greenhouses, etc).
Managing body	IDAE through the Regional Governments
Eligible expenses	Investment in equipment and materials, the costs of executing the works or the control and monitoring systems for both the production and the demand for thermal energy, as well as the civil works necessary for the execution of the projects.
Maximum amount of the aid/grant	Up to 45% in the case of small businesses, and in both areas it will increase by 5% in areas of demographic challenge: municipalities with up to 5,000 inhabitants and non-urban municipalities with up to 20,000 inhabitants with population centres of less than 5,000 inhabitants.
More info	https://www.idae.es/noticias/el-gobierno-aprueba-una-linea-de-ayudas-para-la-implantacion-de-renovables-termicas-en#:~:text=Renovables%20t%C3%A9rmicas%20en%20el%20Plan%20de%20Recuperaci%C3%B3n&text=Este%20programa%20de%20incentivos%20complementa,energ%C3%ADa%20del%20Plan%20de%20Recuperaci%C3%B3n.
Publication	https://www.boe.es/boe/dias/2021/12/22/pdfs/BOE-A-2021-21106.pdf

Table 12: Aid program for industrial research, development and innovation projects in the field of the manufacturing industry

Aid program for industrial research, development and innovation projects in the field of the manufacturing industry	
Purpose	Support industrial companies in the execution of industrial research projects, technological development, process and organizational innovation, as well as investments focused on sustainability through the improvement of energy efficiency and environmental protection beyond the standards of the European Union
Beneficiary	Companies, regardless of their size, that develop an industrial activity.
Eligible measures	In the funding line aimed at "Innovation in Sustainability and Energy Efficiency": - Innovative investments aimed at protecting the environment - Innovative investments in energy saving measures or renewable energies. Those investments aimed at improvements that allow achieving a higher level of energy efficiency in the production processes or replacement of fossil energy sources with renewable ones will be considered.
Managing body	MINCOTUR – Ministry of Industry, Commerce and Tourism
Eligible expenses	Innovative investments in energy saving measures or renewable energies. Those investments aimed at improvements that allow achieving a higher level of energy efficiency in the production processes or replacement of fossil energy sources with renewable ones will be considered.
Maximum amount of the aid/grant	The maximum amount of subsidy to be received in this call will be limited to 4,000,000 euros. Part of the aid will be granted as grant and the other part as a loan.

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More info	https://www.mincotur.gob.es/PortalAyudas/ayudas-IDI/Descripcion/Paginas/Descripcion.aspx
Publication	https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-12379

2.5.4 Amount of public investment allocated to the promotion of WH/C recovery

To give a general idea of the funds allocated to the promotion of renewable energy and energy saving and efficiency. Between 2021 and 2030 it can be mentioned that the PNIEC establishes the following figures for this type of measures:

- Investments in Energy Saving and Efficiency Measures for the Industrial Sector - €7,750M.
- Investments in renewables in the electricity sector 2021-2030 for the Target Scenario €91,108M.

Furthermore, for the two main components of the policy leverages, amount of inversion will be:

- Component 7: 3.165.000,00€
- Component 9: 3.782 000€

Amount of grants for the finance of the mentioned calls:

- Aid program for the Promotion of energy saving and efficiency – Heating and cooling networks – 1.500.000€.
- Aid program for the Promotion of energy saving and efficiency - Public Aid for Industries - 1.500.000€.
- Aid program for thermal renewable energy installations - 4.779.747,67 €
- Aid program for the implementation of thermal renewable energy facilities in different sectors of the economy - 150,000,000.00€ (up to €500,000,000 if needed).

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3 Consultation to main industrial agents

Within the context of the task 6.3, a consultation to some industrial agents with the capacity in the recovery and harnessing of waste heat/cold was carried out by the partners.

This consultation was conducted to companies from Italy, Sweden, Portugal and Spain. Some companies are multinational companies and others are SME's but all of them have waste heat/cold and the potential to implement technologies for its re-use.

3.1 Identification of companies involved

The selection of companies was carried out by the partners, as indicated in the Table 13:

Table 13: Participant companies

COUNTRY	PARTNER	SELECTED COMPANY	Sector
Italy	RINA/ENVI	FONDERIA DI TORBE SRL	Automotive industry
		IREN ENERGIA	Energy
		MARTINI & ROSSI	Food and Beverages
Sweden	IVL	BOLIDEN GROUP	Mining
		SANDVIK AB	Mining
Portugal	ADEP	THE NAVIGATOR COMPANY	Pulp Industry
Spain	CARTIF	SAETA DIE CASTING	Metal Industry (Aluminium)
		PROSOL – PRODUCTOS SOLUBLES	Food and Beverage
		GALLETAS GULLÓN	Food and Beverages
	FAEN	ARCICHAMOTAS	Refractory materials
		CERÁMICA DEL NALÓN	Refractory materials
		TUDELA VEGUIN	Cements
		CAFENTO	Food and Beverages

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3.2 Methodology

The consultation consisted of a questionnaire that was replied by 12 companies identified by the partners. The main goal was to obtain information about the experience of some representatives of the industrial sector in harnessing the heat/cold surplus and the implementation of renewable energy systems in their facilities.

The questions contained in the questionnaire were devoted to obtain information about the knowledge and experience on existing public funding mechanisms for the support of actions for recovery of waste heat/cold and related to the aids to support investments.

Also, some questions were related to the public aid programs for the implementation of renewable energy technologies.

The selected companies come from different sectors of the industry, the main results of the consultation will give an idea about the sectors where the public policies are being more effective and to know if there is room for the improvement of public policies.

The companies were selected trying to choose at least:

- One company that is already recovering and using their waste heat/cold – this would allow to know which public programs they used to do it.

- One company that has potential to do it but is not doing it yet – this would allow understanding the existence of possible difficulties in accessing the public funds.

- Another one in any of two cases – which will enrich the information gathered.

Depending on the knowledge of the public programs and if they had implemented any technology or system for recovering the waste heat/cold, the answers were redirected to finally obtain the most important information of the existing installations.

The template used in the interviews can be seen in the Appendix A.

3.3 Main results

Twelve companies from Italy, Sweden, Portugal and Spain replied to the questionnaires providing valuable information about the current situation of waste heat/cold recovery in their facilities and about the implementation of renewable energy technologies.

The next main results can summarize the main information gathered in this process.

- Implementation of systems/ technologies for the recovery of waste heat/cold

Eight of the companies have implemented any type of technology for the recovery of the heat/cold surplus and are using it in different process.

The companies, which are already harnessing part of the waste heat/cold, are:

- Fonderia di Torbe
- IREN Energia,

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- Martini & Rossi
- Boliden Group
- Prosol
- Galletas Gullón
- Cerámica del Nalón
- Tudela Veguín

The other companies stated that they have analysed their technical and economical capacities to recove and harness the waste heat/cold but for reasons related to both aspects they have not implemented any system yet.

In case of Sandvick, an internal heat recovery system at the industrial site is currently under construction. The short-term plan only establishes heat recovery systems at two of the main production sites, but the final goal is to replace all heating system in buildings with waste heat from the site.

Other companies have confirmed their aim to enlarge their current recovery systems. Boliden Group is planning to take the Final Investment Decision during the fall of 2022, the construction of the recovery plant could start in 2023. Boliden is delivering 35-40 GWh annually to the nearby harbour and city district, but this will be increased with about 100 GWh to reach around 140 GWh annually.

It must be mentioned that one of the companies, IREN Energía, is an Energy Producer and acts as a Distribution System Operator. In this sense, IREN Energía is in charge of three District Heating Networks in their area. All the district heating networks mentioned consisted on waste - to- heat plants that feed the network in urban areas like:

- Turin district heating network
- Piacenza district heating network
- Parma district heating network, which is under construction.

Some companies started the recovery many years ago:

- Fonderia di Torbe started this recovery in 1990. In 2004 they decommissioned the installation, they installed a new system in 2018.

- Martini and Rossi started this process in the period 1990-2000 and after that first experience, continued increasing the recovery systems in the 2000 decade, and in 2018.

- Prosol installed the first systems before 2000 and made a retrofitting in 2018.

- In case of Cerámica del Nalón, the company installed the systems in 2007

- Tudela Veguín in 2010 and Galletas Gullón in 2016.

- Process where the waste heat/cold recovery is implemented

As expected, the industrial processes in which these companies have implemented heat recovery systems are closely related to the processes they carry out.

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In the Table 14 the main processes used by each company are shown:

Table 14: Proccess involved

FONDERIA DI TORBE SRL	Heat recovery from the diathermic oil of the hot wind cupola oven
MARTINI & ROSSI	- Process 1 - Cold recovery - Pre - Cooling of products - Process 2 - In a cogeneration where it is re-used the heat of the flue gas produced
IREN Energia	- Turin district heating network - TRM waste-to-energy plant; Piacenza waste-to-energy plant that is connected to Piacenza DH network; Parma waste-to-energy plant that will be connected to Parma DH network.
BOLIDEN GROUP	Heat recovered from: - Lead operations - Recycling of electronics - Smelting operations - Fuming furnace - Fuming boiler
PROSOL	Heat Recovery from coffee extraction and coffee concentration and from a steam boiler
GALLETAS GULLÓN	Heat recovery from the hot water boilers and ovens.
CERÁMICA DEL NALÓN	Recovery of waste heat from the gases of the firing tunnel kiln.
TUDELA VEGUIN	Manufacture of cement and its additions

- Technologies used for the waste heat/cold recovery

Each company utilises different technologies to recover waste heat/cold from different processes.

A summary of the main technologies used is shown in the Table 15

Table 15: Technologies used in the WH/C recovery

FONDERIA DI TORBE SRL	ORC- Organic Rankine Cycle
IREN Energia	Intermediate substations with heat exchangers provide the waste heat to the DH networks
MARTINI & ROSSI	Heat exchangers
BOLIDEN GROUP	District heating accumulator tank and pumps, heat-exchangers and condenser
PROSOL	Vacuum evaporators and steam boiler
GALLETAS GULLON	Air-air heat exchangers

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CERÁMICA DEL NALÓN	Heat exchanger boiler
TUDELA VEGUIN	CHP plant of 10MW that uses the exhaust gases of the mill

- Application of the waste heat/cold recovered

Only in two cases the recovered heat is exported from the facilities of each company to another facility. This is the case of Boliden, which gives the heat to the harbour located next to the Rönnskär industrial site and to the city district network of Ursviken. When the expansion is done, the heat will be exported to the city of Skellefteå.

In case of Sandvick, the harnessing will be done in two steps. First step will be to the waste Heat /Cold recovery internally with the selling of small amounts of heat via a local energy company. Exporting heat to the district heating system is a future project. The interconnection of the industrial site and the local district heating system has been prepared, pipelines are already installed, although the connection have not been made yet.

In case of IREN Energia, as said before, the heat is exported to three District Heating Networks from the waste - to - heat plants in Turin Piacenza and Parma (work in progress).

In the rest of production plants, the heat is used in other industrial processes or even used in the same process where the waste heat/cold was extracted.

In this sense, the information gathered is shown in the Table 16:

Table 16: Application of the WH/C recovered

FONDERIA DI TORBE SRL	Reused in the same plant
MARTINI & ROSSI	Process 1 - Recovered energy is reused in the same process. Process 2 - Heat recovery is exported to other process but in the same production plant
PROSOL	In boiler and extraction batteries the recovered heat is used in the same machinery that originates the waste heat. In the concentrators, the recovered heat (and water) is used in other processes within the factory.
GALLETAS GULLÓN	Waste heat is used directly in the same system that generates it
CERÁMICA DEL NALÓN	The waste heat is used in heating water for heating the office and for DHW.
TUDELA VEGUIN	The waste heat is used in the same factory to dry the materials (clinker).

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- Renewable technology implemented or planned

Table 17: Renewable energy sorurces

FONDERIA DI TORBE SRL	Planned: Photovoltaic plant
MARTINI & ROSSI	Implemented: High Vacuum solar panels for heat production.
IREN Energía	They produce and distribute energy. The Group's power production plants consist mainly of hydroelectric and photovoltaic plants
BOLIDEN GROUP	Solar pannels in recycling batteries plant
THE NAVIGATOR COMPANY	Implemented: Production of thermal energy and electricity through biomass and 'black liquor' resulting from the treatment of wood. Photovoltaic in self-consumption regime with a total power of 7 MWp. Planned: Expansion of the photovoltaic system to around 28 MWp.
SAETA DIE CASTING	In implementation: Photovoltaic system on the factory roof
PROSOL	Planned: Photovoltaic (PV) on the roof and biomass boiler (ground coffee and wood chips)
TUDELA VEGUIN	Implemented: Solar photovoltaic plant for self-consumption Total power: 3MWp. Production: 4,4 GWh per year Planned: extension of the PV plant

- Public funding use for renewable energy technologies implementation

It must be mentioned that the most of companies that have installed any type or renewable energy facility used their own resources to fund the investments.

There is an exception with Martini & Rossi, which used funds from the SHIP2FAIR (S2F) program (H2020) to fund the vacuum solar panels.

In the case of Saeta die Casting, they used their own resources at the first stage but now they have the possibility to apply for the *Recuperation, Transformation and Resilience Plan* (RTSP) funds.

- Issues related to use of the public funding programs

Companies, not only which are actually recovering and using the waste heat/cold, provided information in this sense but companies that does not have implemented any system, also experienced some problems in the public programs. In some cases, these problems were the reason why they had not yet installed any waste heat/cold recovery system.

The main issues mentioned are:

✓ Lack of public mechanisms for waste heat recovery: in some countries, there are no specific public mechanisms for waste/heat recovery.

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- ✓ Complexity of the funding mechanisms and tools. Complexity in the administrative process and in the subsidy calculation procedure. Also, calculations of the energy savings of some funding programs asks for additional investments, e.g. monitoring campaigns. This introduces an extra effort that will not be compensated by the maximum subsidy that can be received.
- ✓ Financial conditions that do not appeal companies due to the fact that the investments are usually high and the grants covers a percentage. Typically, 30% for large companies, 40% for medium-sized companies and 50% for small companies. Heat recovery systems consisting on the whole replacement of production machinery by new and more efficient equipment implies highly intensive capital investments and aids cover only a small percentage of the required investments.
- ✓ Companies subject to the CO_2 Emission Rights Trading Regime are excluded in some calls for projects as potential beneficiaries. When companies are not excluded, other type of investments may be more cost-effective than the installation of waste heat/cold recovery systems due to the big investments needed and the long payback associated.
- ✓ National/regional funding programs usually are very rigid. Some European programs allow higher direct subsidy percentages than national public programs and allow greater flexibility in the execution periods.
- ✓ In some cases, the aid programs are launched within innovation-based programs. These are not the most appropriate programs as this type of projects often do not fulfil the innovation programs requirements.
- ✓ In some cases, grants penalize any increase in production capacity associated with the investment, e.g. the replacement of an equipment can only be funded if the new one has a production capacity equal or less than the original. This is a critical limitation regarding the future expansion of the production capacity of the companies.
- ✓ The deadlines for requesting, executing and justifying expenses may be incompatible with the company's annual or biannual planning with regard to its investments. In the case of large subsidies, to apply for these aids it is required a specific paperwork, both technical and administrative, which cannot always be carried out by the factory staff.
- ✓ In some occasions, companies must anticipate the investment with a long-time difference with respect to the payment of the aid. Mechanisms of "advance payments" or "partial advanced payments" are not well implemented in the programs so in the most of cases are denied. These causes financial problems to the companies.
- ✓ Every change at the industrial plant requires an adjustment of administration and eventually in environmental permits. If the facility requires a substantial modification of the environmental impact study, it could be one of the factors that will contribute most to delay and to a possible rejection of the project. Any changes in the environmental permit may be lifted to different administration level which implies more administrative complexity and important delays.

Some of these reasons contributed to the fact that companies had used their own economic resources rather than public programs.

It is worthy to mention some exceptions like Prosol or Galletas Gullón.

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Galletas Gullón used a grant from the FP7 European public R&D program – REEMAIN Research Program.

In the case of both Boliden and Sanvick, their first steps were done using their own resources but with the extension in Boliden's plant and the installation in Sandvick, they are applying to the Swedish Klimatklivet support program.

It must be mentioned that in the first time, Klimatklivet did not consider this type of companies/investments as eligible but the program is being modified to include an exception for projects concerned waste heat recovery and to enable waste heat/cold recovery installations.

In addition, some companies also referred to the barriers experienced during the decision process of installing a waste heat/cold recovery system and while trying to apply for a grant.

The most important ones are related to:

Technical barriers

- Some companies referred the fact that to install a heat/cold recovery system it is needed to replace the complete equipment by another one with better efficiency conditions.

- In some facilities, several sources of waste heat/cold generation are distributed among a relatively large number of independent and separate systems, which increase the difficulties to recover it. In these types of facilities, higher investments are needed, with long amortization periods. This situation, along with a complex and volatile market in a changing regulatory environment, make it a high-risk operation.

-The replacement of equipment and the option to recover and reuse the waste heat/cold is mostly done when the end of the life cycle of the equipment is approaching. At this moment it may be not a public funding program avaible to apply for.

- In some cases, technical complexity required to install waste heat recovery systems is not compensated by the economic benefits. This complexity and the uncertain economic benefits makes it more difficult for companies to consider waste heat recovery in their investments programs.

- Problems related with the lack of demand have been appointed as some companies are located in isolated areas. They do not have any potential user of the heat in a reasonably close area so, the costs of the infrastructure to transport the heat/cold is not economically feasible. Also, in some cases, high temperatures and temperature fluctuations make it difficult to manage and this make it difficult to match the offer and the demand of heat.

- Waste heat/cold recovery introduces more equipment and bigger complexity in the production plants, which lead to increase the needs in maintenance tasks and risks of fails. Some companies pointed issues regarding the increase in the maintenance needs and in the complexity of maintenance process. It may be needed to hire more personnel/external companies and the costs of maintenance increases.

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- Furthermore, companies would need to hire new personnel and train them, also the former one, in new capabilities related to the operation of the plant so the costs of operation also increase.

- Related to the renewable energy implementation, it is commented that in some cases, the size needed of some renewable energy technologies, e.g. solar power facilities, would disqualify it from investments support.

✓ Administrative barriers

- Waste/heat recovery systems do not directly affect to the production process of companies so resources are not clearly assigned to it. Depending on the business focus, companies may prioritise in the new products/lines more than in improving the energy efficiency. This type of investments are not considered due to the fact that the effects, economic and environmental, will only be perceived in long term.
- Some industries in some countries, e.g. metallurgy in Sweden, are exempted from energy taxes so the investment would not pay off.
- The authorization procedures are very long and the documentation to complete the electrical connection phase is considerable.

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4 Recommendations and lessons learnt

Considering the differences existing in the different countries and the differences between the companies and sectors analysed, it is easy to understand that recommendations can be different in each sector and country.

Nevertheless, there are common considerations that can be highlighted to contribute to the improvement of public tools aimed at supporting the recovery and re-use waste heat/cold and for the implementation of renewable energy sources in industrial facilities.

One important common consideration for WH/C recovery is that the European policies must intensify the promotion of waste heat and cold recovery. In this way, the national and regional policies will have to align with the European ones to become more effective.

A mechanism that could help in reaching this effectiveness would be the classification of WH/C technologies as renewable technology, making them visible in the EU Taxonomy. This measure would facilitate to unlock investments, help in reaching the goals of the European Green Deal, and contribute to the energy transition.

Following, we provide a summary of the main recommendations given by the industrial sector in each country related to their experience in recovering and harnessing waste heat/cold.

Sweden

The different policy measures impact the financial outcome of investing in WH/C recovery systems, unrelated to if they steer by giving investment support or steer by introducing a cost for polluting or inefficient use of energy.

Companies who are not subjected to carbon dioxide taxes for example are protected when it comes to international competitiveness but do not have the same motivation to reduce emissions since they are not subject to a tax. To find a balanced point of interaction between these motivational points is therefore necessary.

The taxation system in Sweden defines levels of taxation for companies in these types of categories, considering that they are players on a global market and that high taxation levels can have an impact on competitiveness. In some cases, this affects the possibilities to invest in some types of technologies. For example, an investment in solar panels may not be profitable when the company has zero taxation on energy use. Thereby there won't be any economic benefit from the establishment and thereby not that much to gain from an economical perspective.

From the interviews with the Swedish industrial actors, we can add some recommendations for the establishment of WH/C systems.

- The collaboration with the local energy company is key in order for the establishment to come into place. A long-going, well-established dialogue and mutual trust as well as finding a business model where both parties can benefit from the establishment is important.

- *Klimatklivet* is now a possibility for these types of projects, although some specific rules apply for EU ETS companies since these cannot receive state funds for projects that reduce their climate gas emissions. From an industrial point of view these funds are seen as "square" and

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inflexible, although the experience from discussing with the Swedish Environmental Protection Agency is that they are solution oriented and accommodating.

- *Industriklivet* is another similar possibility, which is open for EU ETS-connected industries, but these funds are only applicable for new technology, where WH/C do not qualify.

Portugal

Policies for the promotion of the recovery and use of waste heat/cold are mainly under the framework of the *Recovery and Resilience Plan* and as commented before, there is no historical instruments for the promotion of the recovery of industrial excess of heat and cold.

One consideration that may be done is that the most important effort in the energy mix has been done so far on electrification, in the use of solar thermal technologies, in the use of heat pumps and in the introduction of biomass as fuel.

- Gas, coal and oil dominate the heating and cooling supply in Portugal and process heating contributes to the largest demand.

- Demand for space heating and cooling is in general low thanks to Portugal's mild climate.

- From a technology standpoint, Portugal has a large RES potential, especially heat from cogeneration with renewable origin. Biomass could contribute largely to making the heating sector more sustainable.

- The building sector is pushing for solar thermal for heating domestic water, rather than district heating and excess heat recovery.

- The share of district heating is very low, and the potential is also restricted due to low demand. There is some potential for waste heat and cold recovery, mainly from industrial sites and thermal plants.

The industrial activities, that represent an important share of the total emissions at national levels, would need incentives to change the main energy sources (oil, gas and coal) and to transform to a low carbon emissions industry. The industrial sector in Portugal has an opportunity to be an important part of the energy transition and needs innovative funding mechanisms to play its role in this process.

Heat/cold recovery along with other efficiency measures can play an important role in the energy transition and it may be needed to develop a portfolio of funding programs for the promotion of the recovery and use of waste heat/cold.

From the interviews with the Portuguese industrial actors, we can add some recommendations for the establishment of WH/C systems.

- Due to the big investments, with long payback (investments longer than 3 years are usually disregarded) incentives are crucial to make the use of waste heat/cold more viable by considering the production of GHG emission credits.

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- In industries subject to trading in emission rights there is an incentive to consider energy efficiency or emission reduction measures whose cost/effectiveness is lower than the acquisition of a GHG emission license on the market.

- It could be positive if the environmental impact factor could be considered and the waste heat/cold recovery could be accounted for avoided or reduced GHG emissions, e.g. the heat recovery converted to a fossil fuel emissions equivalent reduction. This could be an incentive mechanism for waste heat recovery.

Spain

There are different funding mechanisms both at national and regional level aimed at facilitating the improvement of energy efficiency and the implementation of renewable energy sources.

Some advances have been done in recovery and re-use of heat in the industrial sector. Technologies for recovery and re-use of the waste heat/cold have been installed in several companies and the waste energy are being re-used in the industrial processes or is used to the production of DHW or heat and cooling system in the facility.

Although there are public funds for the implementation of district heating networks, this activity has its own difficulties. In some cases, the potential demanding sites are far from the industrial site and incentives are not high enough to reach a positive investment decision.

From the interviews with the Spanish industrial actors, we can add some recommendations for the establishment of WH/C systems.

- In some occasions, investments in waste heat/cold recovery have been discarded due to the prioritisation of other investments more related to the core business of the companies or because they have better profitability for the company.

There are several reasons related with technical, economical and infrastructure-related issues:

- No clear inner optimal use for the recovered heat or difficulties to implement solutions to re-use it due to high investments, big modifications of the plant lay-out …
- No feasible user around that is able to use it. Companies could be interested in selling the recovered heat/cold to a potential user but there is no infrastructure to conduct the heat/cold or no district heating network are built.
- Low incentives and/or bad financial conditions

Some considerations for the improvement of the policy programs are done around these topics:

- It could be positive to promote district heating networks, with special efforts in locations where the heat/cold is produced and where potential demand is close.

When the companies are located in an industrial site or in a technological park, where several companies are located, a good incentive would be to promote the construction of district heating networks in these industrial areas or business centres as the recovered heat will have a direct application with an economical profit for the industry.

- Related to administrative issues during the application process, it could be very positive to simplify some parts (calculations of savings, justifying of expenditures…), to make it more

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flexible in terms of eligibility of technologies and systems and to enlarge the deadlines to allow the companies to be able to accommodate internally with the planning of its own investments.

Italy

Different instruments are implemented in Italy for funding energy savings and efficiency. Three main tools are available to the industrial sector: *White certificates*, *Transition 4.0 (ex. industry 4.0 National Plan)* and *Cohesion policies*. Projects for harnessing waste/heat recovery can be funded using these programs.

It must be mentioned that *White Certificates* are aimed at big companies and is oriented to the implementation of energy efficiency measures. *New Sabatini* and *Cohesion Policy* are aimed at micro, small and medium enterprises also to implement energy efficiency systems.

From the interviews with the Italian industrial actors, we can add some recommendations for the establishment of WH/C systems.

- Considerations have been made regarding the lack of specificity of the aid programs, so it can be understood that the aid available was not specifically intended for the recovery and use of residual heat/cold.

- It seems that the aid programs for renewables have been more successful, so it is considered that the main characteristics of the aid programs for renewables could be replicated and adapted to programs for the recovery and use of heat.

Some general recommendations, can be mentioned:

- The design of specific policy measures for the recovery of waste heat/cold in the industrial sector by considering specific conditions of industrial activity and sectorial characteristics.

In this sense, considerations about technologies and equipment along with funding rates should be considered as the complexity of projects make it needed to implement complex equipment and, in some cases, important modifications of the layout of the plant.

- Eliminate administrative barriers through the reduction of the complexity of the administrative process in terms of flexibility, eligibility, beneficiaries and financial conditions.

- Establishing mechanisms that facilitate the transfer/sale of heat/cold among companies. These can be done through the implementation of support programs for the installation of district heating networks/infrastructures in areas where there is a concentration of companies, industries, e.g. Industrial sites, technology parks, industrial poles…

- Simplification of the environmental procedures to be followed when a waste heat/cold recovery project is going to be implemented.

Belgium

The sector association for heat networks (WNVL), ODE's technology platform for heat networks, has the objective to stimulate a supported development of sustainable heating and cooling networks. The organisation published a guidance for the development of the regulatory framework for heat networks in Flanders. The main conclusions were:

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At a Federal level:

1. Social tariffs
Within the federal competence over energy tariffs, elaborate the social tariffs for heat supplied by heat networks, financed from public service obligations in the natural gas tariffs.

2. CO_2 tax on fossil fuels and electricity
Introduce a CO_2 tax on fossil fuels and electricity, with an increasing trajectory towards 2030, in line with the conclusions of the National Debate on Carbon Tariffs; provide the necessary flanking measures for energy renovation and the prevention of energy poverty.

3. Flexible capacity via CHP and heat networks
In the compensation for flexible capacity (CRM), give priority to decentralized cogeneration units with a mandatory decoupling of useful heat to heat networks near densely built-up cores. This choice promotes both the energy efficiency of power production and the development of heat networks.

At the Flemish (regional) level:

1. Correct EPB calculation for heat networks
Adjust the EPB regulations for the correct calculation of heat from external heat supply (adjustment of primary energy factors, overarching parameter for heat network). Harmonize the EPB regulations in the three regions.

2. Stimulate residual heat for heat networks
Stimulate the recovery of residual heat from industry and from unconventional low-temperature residual heat sources (data centres, sewage treatment, cooling installations, etc.): a policy instrument for this purpose is the introduction of a levy on the discharge of unused residual heat.

3. Supporting local authorities' heat strategy
Provide financial and organizational support for local authorities when developing a local heat zoning plan and a heat policy vision.

4. Connection premiums for heat networks in existing buildings
Encourage the connection of existing buildings to heat networks by introducing a premium for individual connections; this is necessary to promote the replacement of fossil individual installations by collective sustainable heat. Develop effective support for the collective renovation of existing homes, both through financial incentives and substantive support.

5. Shift taxes from electricity to gas and fuel oil
Carry out an energy tax shift in the distribution rates for electricity and gas: shift a number of taxes from the electricity tariff to the gas tariff, so that lower electricity tariffs stimulate the growth of heat pumps and higher gas tariffs make heat networks more feasible. Combine this with the federal CO_2 tax (see above).

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6. Underpin the policy with a heat knowledge centre
Make people and resources available for a green heat knowledge platform, for substantive support and policy translation of the transition in the heat sector. Provide operational resources for the contribution of expertise from the relevant sector organisations.

7. No obligation for a split market model
In the discussion about the regulation of heat networks, parallels are often drawn with the liberalized market model of the electricity and gas market. There is a strict separation ("unbundling") of the various tasks of energy production, transport, supply and distribution (by network operators). In our opinion, the disadvantages of unbundling for heat networks outweigh the possible advantages.

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6 Appendix A – Templates used in the interviews with the industry.

6.1 Questions directed to industrial actors

- Name of the company

- Brief description of the company (activity, sector, location…).

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

- In what processes is the system implemented?

- What technologies have been implemented to recovery the WH/C?

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

- What would your company need to overcome these barriers?

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

- What processes in your company would be likely to incorporate WH/C recovery systems?

In case your company does not know them:

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- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

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7 Appendix B – Replies from the main regional industrial agents.

7.1 Participant companies:

7.1.1 IREN ENERGÍA

7.1.2 Fonderia di Torbole SRL

7.1.3 Martini & Rossi

7.1.4 The Navigator Company

7.1.5 Boliden Group

7.1.6 Sandvik AB

7.1.7 Arcillas y Chamotas Asturianas, S.L.

7.1.8 Cerámica del Nalón, S.L.

7.1.9 Cementos Tudela Veguín, S.A.

7.1.10 Galletas Gullon

7.1.11 PROSOL – Productos Solubles

7.1.12 Saeta Die Casting

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1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company

IREN ENERGIA

- Brief description of the company (activity, sector, location…).

Production of electricity and thermal energy, distribution and sale of electricity, and heat (district heating)

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

Currently on the Turin district heating network the only "proper" waste heat recovery system is the TRM waste-to-energy plant.

As for the other DH networks, IREN Energia has 2 more waste-to-energy plants:

- Piacenza waste-to-energy plant that is connected to Piacenza DH network;
- Parma waste-to-energy plant that will be connected to Parma DH network.

- In what processes is the system implemented?

DH networks

- What technologies have been implemented to recovery the WH/C?

Intermediate substations with heat exchangers provide the waste heat to the DH networks

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

Thanks to these connections it was increased the inhabitants connected to the DH networks served without the construction of new plants.

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

The several possibilities for implementing waste heat defined in Europe as fourth generation DH are being evaluated. Some preliminary studies have been made to use waste heat from industries (mainly foundries) and data centres.

At the same time is being evaluated the option of new DH networks with lower temperatures.

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

Beyond that the "geographical location" of the industrial plants (normally located in detached areas from the inhabited residential city districts) and therefore it is not always possible to allocate waste heat to residential and / or commercial users, one of the main barrier to waste-heat-systems implementation is the difficulty in being commercially competitive because of large costs to be incurred for investments in the construction of the systems (technology for heat recovery and construction of the network).

- What would your company need to overcome these barriers?

It would be central to have access to an incentive system alike as for other renewable sources

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

- What processes in your company would be likely to incorporate WH/C recovery systems?

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

The Group's power production plants consist mainly of hydroelectric and photovoltaic plants that use renewable sources and cogeneration thermoelectric plants that produce energy via combined cycles, which are some of the most efficient technologies currently available on the market. Furthermore, cogeneration is connected to the urban district heating network, which, compared to traditional heating systems, allows for reductions in energy consumption and improves environmental performance.

In 2020, Iren Group produced 10,110 GWh of electricity, more than 73% from renewable sources (water, solar, biomass or waste) and high - efficiency cogeneration.

3 waste-to-energy plants produced 598 GWh of electricity, in line with the previous year, as was the quantity of waste treated; the significant change compared to 2019 is in the production of thermal energy, which, thanks to the connection of the Turin waste-to-energy plant to the district heating network, increased by over 27%.

Hydroelectric production (30 hydroelectric plants) in 2020 amounted to approximately 1,295 GWh and 95 photovoltaic systems produced 21,076 MWh of electricity in 2020

Electricity produced by plants fuelled by eco - friendly sources (renewable or high efficiency cogeneration), which account for 70% of the Group's plant portfolio, accounts for more than 73% of all production.

Beside there are projects to use battery storage systems and to construct some Eolic plants.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

The authorization procedures are very long and the documentation to be attached to complete the connection phase is considerable. Furthermore, the absence of an authorization often compromises the ability to continue subsequent activities, so the times get longer.

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company

Fonderia di Torbole SRL

- Brief description of the company (activity, sector, location...).

Fonderia di Torbole has Headquarters in Torbole Casaglia (Brescia-Italia) is a leading company in the production of brake discs and drums for the automotive market

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

Installed in 1990 then decommissioned in 2004 and installed a new system in 2018

- In what processes is the system implemented?

Heat recovery from the diathermic oil of the hot wind cupola oven

- What technologies have been implemented to recovery the WH/C?

ORC- Organic Rankine Cycle

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

They are reused in the same plant

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

Own resources

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

No public program

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

No know technology

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

- What would your company need to overcome these barriers?

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

- What processes in your company would be likely to incorporate WH/C recovery systems?

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

At the moment no one, but photovoltaics are planned

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company. Martini & Rossi

- Brief description of the company (activity, sector, location…).
Martini & Rossi is the Italian company of the Bacardi Group. It is located in Pessione of Chieri (TO) since 1863. Pessione plant is the historical site where all our products in all the receipts are produced: Martini, Sparkling Wines and Liquors and starting from 31st of January 2017 also Bacardi Rum.
The plant owns the entire process from must and wine acceptance to the finished goods deliveries to the markets. The site host also a R&D Dept. dedicated to wine based products.
With the start of the Rum production Pessione became the largest Operation Centre (the definition of a Bacardi production Hub) for the Bacardi Group.

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented? The three most important energy recovery systems were implemented in the 1990s, in the early 2000s and the last one in 2018

- In what processes is the system implemented? Two of these systems involved the production department, i.e. the cellars reusing part of the cold wine already processed in the pre-cooling of the wine to be processed. The other involved the cogeneration process by reusing the heat of the flue gas produced.

- What technologies have been implemented to recovery the WH/C? In all cases the technology used was the heat exchanger.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant? In the case of cold recovery, the recovered energy is reused in the same process. While for heat recovery, other utilities are supplied. But all within the Pessione production plant

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so? All these systems were implemented by using own resources.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

- What would your company need to overcome these barriers?

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C? There are not specific public mechanism for these type of activities.

- What processes in your company would be likely to incorporate WH/C recovery systems? The production process of Asti Spumante, a product that needs both heat and cold at different stages of its process. The refrigeration and distillation unit process.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented? High Vacuum solar panels for heat production.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company... Peak Power of 329 kW. The solar field produces hot water in winter and 3.5 bat saturated steam in summer. The hot water is used for environment heating, while the steam is mainly used in distillation process.

- How did your company managed the implementation of these systems, with its own resources or did it use a public program to do so? Martini & Rossi applied to the SHIP2FAIR (S2F) program, an EU initiative that foster the integration of solar heat in the industrial processes of the agro–food industry. S2F is part of H2020 program

- What difficulties/barriers have been the most difficult for your company to overcome in the process? Most of the problems faced in the implementation of this project were of a technical nature. Plant engineering with regard to components subject to high temperatures and temperature fluctuations. And IT for data collection and transmission.

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants? From a regulatory point of view, there is still no specific regulation for installations such as the solar field implemented.

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

2 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company

The Navigator Company (Portugal)

- Brief description of the company (activity, sector, location…).

Navigator is an integrated forest producer, whose end products are pulp & paper, tissue, and energy. Its operations are based at modern, large-scale industrial units that use state-of-the-art technology and are a benchmark for quality in the sector.

Its the third largest exporter and also the largest national added value generator, accounting for approximately 1% of GDP, about 3%% of all Portuguese exports of goods and near 6% Portuguese containerized cargo.

Currently, our total annual production capacity is near to 1.6 million tons of paper, 1.5 million tons of pulp each year, of which roughly 80% is integrated into paper production, 130 thousands of Tissue and 2.5 TWh of electricity per annum (roughly 5% of the total electricity use annually in Portugal.).

The energy flow process begins with the burning of biomass to produce superheated steam, which is later expanded in a turbine to produce electricity. At the end of this expansion cycle, the steam is at a pressure of about 3.5 bar and a temperature of 155°C. This flow is destined to feed the industrial process.

- Does your company have implemented systems for the recovery and use of waste heat?

In this pulp industry, there are some waste heat utilizations that are almost inherent to the process itself. In the paper steam cycles, we have some cycles that are almost a "reboiler" of hot water to regenerate steam and it continues the flow through the cylinders, and this is something almost inherent to this kind industry. However, we think this is not considered to be the use of waste heat within the scope of this project (SoWhat). From what is understood and from what was learned from the project, it has more to do with the recovery of gaseous emissions from chimneys, or with hot waste water currents such as, for example, those we have and which we have not yet taken advantage of. We have done some research on this case, to use our hot effluent, but in general terms, there is still no effective residual heat recovery. We have some recoveries inherent to the paper pulp process, but we do not have these more "traditional" ones. It is an area that we have been trying to investigate and find solutions, but we still don't have any intervention that we can highlight about, for example, the use of heat from our effluent.

There is effectively knowledge that there is a hot stream with potential for exploitation, but for which there is still no solution or project for this purpose.

This effluent could be used to produce electricity through ORC (Organic Rankine Cycle), heat pump cycles, among other possibilities. The temperature of this effluent is around 50ºC.

There are many circuits mapped in the plant in terms of enthalpy, flow rates and temperatures among other characteristics such as pH.

In short, there is use of heat inherent to the process, but for other streams, such as the water itself that is returned to a cooling tower, there is still no use. These are large currents, but low enthalpy. It is recognized that there is this source, which has a lot of energy (with many MW available), but with little enthalpy, which corresponds to a lower potential for exploitation.

Barriers: Due to the type of process, there are many sources of heat. For example, a lot of tepid water is already used, which is around 45/50ºC. There is a lot of water at this temperature, as said earlier. There are fewer warmer waters and, of course, the enthalpy is lacking to be able to do something more with this heat. Even for the ORC, 50ºC is a very low temperature to be effective. To be more viable it would be necessary to have a temperature rise using, for example, a heat pump. Additionally, these effluents have very high (or very low) pHs, which conditions the technology (and materials) to be used in heat exchangers. Waste heat recovery is not yet a very "traditional" thing, nor is it a very evolved process. The companies themselves commercially have this concept very little developed. The barrier, currently, is more related to technical issues. Of course, the financial component is what makes it all viable.

Navigator surroundings: additionally, another barrier is related to the existence of few industries and little housing in the vicinity of the company, which makes the feasibility process of an eventual heat distribution to the neighbourhood a little more uninteresting. The company is also not integrated in a logistics/industrial zone as are others in Portugal. We (Navigator) are a big company, but with little industry around us. There are not exactly neighbourhoods around to even consider the construction of a heat distribution network. The houses themselves in Portugal do not have relevant heating systems (nor heating needs comparable to northern European countries).

- Does your company know the public mechanisms designed for the use of WH/C?

In Portugal, under the existing legislation applicable to energy intensive industries, companies are obliged to carry out periodic energy audits. These audits may eventually detect some measure that is economically rational. But in the industrial context, everything with a payback period of less than 3 years is viable, the rest is mostly disregarded. This can be somehow indirectly seen as a public incentive mechanism.

Take, for example, Organic Rankine Cycle (ORC), which is a technology currently under consideration at Navigator, but is something that is not yet seen as having paybacks of this order of magnitude.

To evaluate the implementation of recovery technologies, the environmental impact factor could be considered if the heat recovery could be accounted for avoided or reduced GHG emissions, for example, the heat recovery converted to a fossil fuel emissions equivalent reduction. This could be an incentive mechanism for waste heat recovery.

Navigator is already obliged to buy emission allowances. Therefore, we already have this incentive to consider energy efficiency or emission reduction measures whose cost/effectiveness is lower than the acquisition of a GHG emission license on the market. Therefore, if it were possible to reduce emissions, the amount of GHG licenses needed would be smaller.

- Does your company have any type of renewable energy facility?

There is production of energy (thermal and electrical) through biomass and 'black liquor' (fuel) resulting from the treatment of wood.

There is solar photovoltaic in self-consumption regime with a total power of 7 MWp. All electricity production is used for self-consumption for 5 installations. The investment for the installation comes entirely from the company's own funds.

In the short term, an expansion of the photovoltaic system to around 28 MWp is planned. In this case, the business model will be different. There will be long-term acquisition agreements and CAPEX will come from an outside entity. Therefore, it's no long an investment of own funds and becomes a distinct model. Almost all of the electricity production will be for the company's demand, there may be a small residual income from sales of electricity to the grid under certain conditions. There is an immense need for electricity for own consumption, so the entire photovoltaic production is absorbed.

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

In terms of implementation for both the use of solar PV energy and biomass for cogeneration, there were no administrative, legal, or environmental difficulties that created any obstacles.

Regarding the photovoltaic system, it's a self-consumption regime without injection into the grid. This is, therefore, the simplest situation regarding the production of solar photovoltaic energy.

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

Incentives are fundamental to make the use of waste heat more viable by considering, for example, once again, the production of GHG emission credits. This incentive would be of an environmental, but also financial, nature. Environmental because it will be introducing a contribution for the country's sustainability goals (and the world). In particular for reducing GHG emissions. In the past, other less competitive technologies already benefited from this type of incentives so that their use was viable. For this reason, it could also be considered something similar for the use of waste heat.

It would also be interesting to understand how incentive schemes work in other countries where there are fully mature markets. It would be interesting to understand if the Nordic market of waste heat recovery exists only for climatic reasons or because there are other types of incentives. There could be a comparative analysis in terms of regimes. Or even comparison with other Mediterranean countries such as Italy or Spain, to understand how Portugal is doing in terms of the regulatory framework in this area.

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

1.1 BOLIDEN

- Name of the company: Boliden Group

- Brief description of the company (activity, sector, location…).

Boliden is a highly technological metal company with three main focus areas: exploration of new mineral deposits, mines and smelters. Boliden is located in northern Sweden and has about 6 000 employees. Operations are located in Sweden, Finland, Norway and Ireland. Products include zinc and lead ingots, copper cathodes, gold bars and silver granules. The main customers are industries throughout Europe for example construction and automotive industries.

Boliden Rönnskär is one of the sites at Boliden and is located in the harbor in Skellefteå. It is one of the world's most efficient copper smelters. The site handles copper and lead concentrates from Bolidens own mines, but also from external suppliers. After investments and development of the technique the smelters are now world-leading in recycling of electronics. Mainly copper, gold and silver can be derived from these materials. Rönnskär is the single largest site at Boliden AB and the largest private employer in the region.

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

A pre-study is currently running which will give the basis for final investment decision which will be taken during the fall of 2022. The detailed design will be finalized during winter/spring with construction commencing during 2023.

- In what processes is the system implemented?

The heat is collected from lead operations, recycling of electronics operations, smelting operations (flash furnace, copper converters) and fuming furnace and fuming boiler (here both the cooling of the slag has steam and the other is steam-based, so the steam condenses down to hot water). Today 35-40 GWh is delivered annually to the nearby harbour and city district, but this will be increased with about 100 GWh to around 140 GWh annually.

- What technologies have been implemented to recovery the WH/C?

District heating accumulator tank and pumps, possibly heat-exchangers, condenser in order to be able to deliver the right temperature.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

The WH/C is already exported to the harbour and the close by city district of Ursviken but with this expansion it can also be exported to the entire city of Skellefteå.

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

The implementation will be established using own financial resources combined with a grant.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

A Klimatklivet-grant was used. It would be easier if this financial instrument was more flexible but there is an understanding as to why these grants are constructed in the way that they are, with limited flexibility.

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

Not applicable.

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

Not applicable.

- What would your company need to overcome these barriers?

Not applicable.

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

Industriklivet is another financial instrument that can aid the establishment of heat recovery but it requires a high level of innovation which is not fulfilled in these types of projects.

- What processes in your company would be likely to incorporate WH/C recovery systems?

The heat is collected from lead operations, recycling of electronics operations, smelting operations (flash furnace, copper converters) and fuming furnace and fuming boiler. Today 35-40 GWh is delivered annually to the nearby harbour and city district, but this will be increased with about 100 GWh to around 140 GWh annually.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

Not applicable.

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

Not applicable.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

Not applicable.

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

Not applicable.

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

Not applicable.

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

Not applicable.

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

Solar cells, but not at Boliden Rönnskär. Boliden Bergsö (plant for recycling of batteries) in Landskrona has solar panels but not in Skellefteå.

- What renewable technologies would be the best adapted to the conditions in your area?

Solar panels would be most suitable. Power Purchase Agreements (PPA's) for renewable energy has been signed but no production units in-house have been established.

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

No comment.

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

The processes have not been experienced as complicated.

- Which what level of the administration have you found more difficulties?

The county-level is the level with whom we have the most contact, but we have not experienced many difficulties in this communication.

- Which process took the most time?

Not applicable.

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

Not applicable.

- Did the public program provide for the expenses that had to be deal with?

Not applicable.

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

The increased prices for material is the largest question mark at the moment. After we received that grant the prices increased with around 30-35% which led to that half of the grant was "eaten up" by increased costs. We were able to find a relatively flexible solution where we could make a complementary application and increase the granted amount.

From a tax perspective the heating that is delivered is subject to taxation. From a financial perspective this affects the business case negatively. To reward these solutions a different taxation level where recovered heat is treated differently would be preferred.

A good cooperation and dialogue with the energy company is a key for these projects in order for them to succeed.

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

1.1 SANDVIK AB

- Name of the company: Sandvik AB

- Brief description of the company (activity, sector, location…). Sandvik is a global high-technological industrial group with sales in around 150 countries. Globally around 44 000 people are employed at Sandvik. Their products are oriented around expertise and solutions for production-, mining and infrastructure industries. These include:

- Tools for advanced cutting metal processing,
- Machines, tools, service and digital solutions for mining and infrastructure-industries
- Advanced stainless steel and special alloys, as well as products for industrial heating

Sandviken is located about 200 km north of Stockholm. At the production site in Sandviken there is pipe production. The steelworks are the largest consumer of energy on the site. There is also processing of material into drill steel and steel strips. Located here is also a research facility.

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

An internal heat recovery system at the industrial site is under construction. 2015 a new energy central was established in Götvalvsverket, one of many buildings at the site.

- In what processes is the system implemented?

So far the WH/C recovery has only been established at two of the main production sites but the aim is to replace all heating in buildings with waste heat from the site.

- What technologies have been implemented to recovery the WH/C?

No innovative technologies have been used in the system, only heat exchangers and heat pumps.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

The initial step is to establish WH/C recovery internally at the site. Smaller amounts of heating are being sold, via the local energy company Sandviken Energi, to a few buildings nearby, for example Göranssonska skolan (a school). But a larger integration in the local heating system has not been established. When the internal project is finalized the question of exporting heat to the district heating system will be discussed again. The interconnection of the industrial site and the local district heating system has been prepared with pipelines but have not been connected yet.

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

The investment was made with company resources. Klimatklivet investment supports was applied for but not granted. A new application was sent in during 2022 after discussions with the Swedish Environmental Protection Agency.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

Sandvik was not granted the investment support but a simpler application process would be desirable.

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

Sandvik is yet to integrate with the local district heating system in Sandviken. The possibility of a collaboration has been discussed since the 1950's but has not yet been established. The discussion is on-going, although at a low intensity.

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

Uncertainty concerning the remaining amount of excess heat is one barrier at the moment. When the on-site use of recovery heat is finalized, and all of the buildings at the industrial plant have been connected to the system, the discussion can be re-established. By then it will be clear what the remaining potential of recovery heat is and if it can be utilized in the district heating system. The district heating system in Sandviken will be interconnected the coming years with the DHS in Gävle, a nearby larger city. In Gävle a few larger industries are already exporting or have plans to export excess heat to the DHS, leading to an uncertainty concerning the amount of heat that will be required by the local markets.

- What would your company need to overcome these barriers?

At the moment the only thing necessary is time to finalize the internal project and gather experience of operating the system. In combination with experiences from the interconnection of the grids between Sandviken and Gävle, this will give a clearer image of what can be possible in the future.

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

Since Sandvik is a part of EU ETS Klimatklivet is not open for these types of industries. Although there is a now an exception for projects concerning waste heat recovery and this possibility has thereby opened up now.

- What processes in your company would be likely to incorporate WH/C recovery systems?

The two larger steelworks at the site are the processes at which the WH/C recovery will be implemented.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

Not applicable.

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

Not applicable.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

Not applicable.

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

Not applicable.

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

Not applicable.

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

Not applicable.

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

Yes.

- What renewable technologies would be the best adapted to the conditions in your area?

Wind power and solar power plants.

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

The investment of wind power is not considered interesting now. A solar power plant would be more within reach. The size of the solar power plants would disqualify it from investments supports. In combination with the fact that industries within metallurgy are exempted from

energy taxes in Sweden the investment would not pay off and is therefor not a possibility at the moment.

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

Sandvik is conducting environmentally hazardous activities which requires a permit. Every change at the production site thereby requires an adjustment of the permit. This is the largest procedure that comes into play in these types of actions.

Any changes in the environmental permit has to be lifted to the regional entity, the County Administrative Board, that can then state the conditions or say what Sandvik may or may not do.

- Which what level of the administration have you found more difficulties?

The processes have not been experienced as complicated.

- Which process took the most time?

Not applicable.

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

Not applicable.

- Did the public program provide for the expenses that had to be deal with?

Not applicable.

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

The main comment would be to simplify the application processes and expand the scope of application in Klimatklivet. Sandvik is now excluded due to EU ETS, a grant would mean that the industry would receive double support. Although a resent decision has resulted in that there is an exception for projects within the usage of residual heat.

TASK 6.3. - ENHANCING SO WHAT IMPACT THROUGH POLICY INSTRUMENTS

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company

Arcillas y Chamotas Asturianas, S.L.

- Brief description of the company (activity, sector, location…).

We have a rotary kiln and calcine Caolin to Chamotte, our sector is the raw materials for refractories. We are in Polígono de Silvota (Llanera-Asturias).

- Does your company have implemented systems for the recovery and use of waste heat?

No we don´t

If so:

- When was the WH/C system implemented?

- In what processes is the system implemented?

- What technologies have been implemented to recovery the WH/C?

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

Yes we have WH and we are interested in the recovering.

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

High cost

- What would your company need to overcome these barriers?

Financial Aid

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

Bad financial conditions

- What processes in your company would be likely to incorporate WH/C recovery systems?

Residual heat in the outlet product

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

No we don´t

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

TASK 6.3. - ENHANCING SO WHAT IMPACT THROUGH POLICY INSTRUMENTS

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company – Cerámica del Nalón

- Brief description of the company (activity, sector, location…) – Company created in 1920 in the town of Lada (Langreo) dedicated to the manufacture of refractory ceramic products for industry (steel, cement, lime,…).

- Does your company have implemented systems for the recovery and use of waste heat?

Yes, the company does

If so:

- When was the WH/C system implemented?

The system was implemented 15 years ago.

- In what processes is the system implemented?

It is implemented in the recovery of waste heat from the gases of the firing tunnel kiln. The waste heat is used in heating water for heating the office and for ACS water.

- What technologies have been implemented to recovery the WH/C?

Heat exchanger boiler

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

The heat is used in the own facilities.

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

The company used its own resources.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

N/A

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

- What would your company need to overcome these barriers?

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

- What processes in your company would be likely to incorporate WH/C recovery systems?

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

It would be needed quickness in the granting of aids. Also, payment in advance could be good because of the same reason. These measures could speed up the implementation of recovery technologies.

In many cases, W/H recovery systems does not directly affect to the production process of companies so resources are not clearly assigned, despite the fact that in the long term they may lead to both economic and environmental improvements.

- Does your company have any type of renewable energy facility?

No.

If so:

- What renewable technology have your company implemented?

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

The company has not studied the public programs for this type of implementation; it has directly held meetings with several installation and operation of renewable energy companies.

Yes, the company does.

- What renewable technologies would be the best adapted to the conditions in your area?

Solar panels installed on the roof of the company facilities.

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

N/A

- Which what level of the administration have you found more difficulties?

N/A

- Which process took the most time?

N/A

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

The WH system was installed using own economical resources. It was not asked public funding.

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

N/A.

QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Company: Cementos Tudela Veguín SA

- Brief description of the company (activity, sector, location…):

- Production of cement and lime.

- Sector: Mineral Industries

- Location: the company has three different plants:

Asturias: Aboño (Gijón, Asturias) and Tudela Veguín (Oviedo)

León: La Robla

- Does your company have implemented systems for the recovery and use of waste heat?

Yes, Tudela Veguin has a plant for producing cement in Aboño, Gijón, where it is installed a CHP (Combined Heat and Power) plant of 10MW.

If so:

- When was the WH/C system implemented?

This plant was installed in 2010.

- **In what processes is the system implemented?**

Manufacture of cement and its additions.

- What technologies have been implemented to recovery the WH/C?

The CHP consists on a generator that uses the exhaust gases of the mill.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

The waste heat is used in the same factory to dry the materials (clinker).

- How did your company faces the implementation of these systems, with its own resources or did it use a public incentive program to do so?

It was installed using the company's own resources.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

Yes, the company is very interested in installing WH/C technologies different to the current CHP.

- What reasons/barriers are responsible of the fact that no WH/C recovery system has been implemented yet?

To address these type of facilities, it is needed high investments with a long amortization period. This situation, along with a complex and volatile market in changing regulatory system, make it a high-risk operation.

- What would your company need to overcome these barriers?

It would be needed some type of public aid or incentive policies that allow the reduction of part of the risk.

- Does your company know the public mechanisms designed for the use of WH/C?

Yes, several times Tudela Veguin analyzed and looked for aid programs that could be available.

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

- It is more related to a deficient design in the mechanisms as the public programs only award the reduction in the primary energy consumption but the company would get a reduction in the fuel input to the installation and a reduction in the global energy demand of the plant.

- Additionally, Tudela Veguin is a company subject to the CO_2 Emission Rights Trading Regime and this type of companies are excluded as potential beneficiaries of public aids.

- What processes in your company would be likely to incorporate WH/C recovery systems?

Two process are the most likely to incorporate recovery systems:

- First process: clinker cooler in La Robla and Aboño.

- Second process: furnace exhaust gases.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- It is needed the identification of this process (the reutilization of waste heat) as an energetic reduction measure that will contribute to the reduction of the global energy consumption and include this kind of process/technologies in the aid programs.

Also, it would be interesting not to exclude the companies subject to the CO_2 Emission Rights Trading Regime to the aids programs.

- Does your company have any type of renewable energy facility?

Yes, Tudela Veguin owns a PV plant in Leon.

If so:

- What renewable technology have your company implemented?

Solar photovoltaic plant for self-consumption.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- ✓ Total power: 3MWp for self-consumption.
- ✓ Production: 4,4 GWh per year

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

The PV plant was installed using company's own economic resources.

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

For Tudela Veguin, which is a company that dedicates to other matters, the most difficult part consisted on the newness of the project and the lack of knowledge of this type of installation.

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

The PV plant was installed in the roof of one of the facilities of the factory so the procedure to install was not very complex.

- Which what level of the administration have you found more difficulties?

The contacts were done with the local and regional administration and no difficulties were found.

- Which process took the most time?

If the facility required a substantial modification of the environmental impact study, it could be one of the factors that will contribute most to delay the project.

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

The usual costs of this type of facility. No significant deviations.

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

As previously said, adapt the public funding mechanisms to other types of systems and technologies to include in the beneficiaries, not only the reduction in thermal energy but other types of process which contribute to the general reduction of the energy demand and the energy efficiency of the plant.

TASK 6.3. - ENHANCING SO WHAT IMPACT THROUGH POLICY INSTRUMENTS

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company GALLETAS GULLON

- Brief description of the company (activity, sector, location…).

The Spanish family-owned company Galletas GULLÓN has 130 years of history in the manufacture of cookies, always located in Aguilar de Campoo (North of Palencia, Spain). This town is where its two production plants, GULLÓN and VIDA, are located, which together generate 1,700 direct jobs.

Like all large industrial bakery factories, both factories are organized around different independent production lines specialized in producing one type of biscuit (or two relatively similar types). Each line is equipped with its own mixing and kneading machinery, its forming machinery, its cooking oven, its cooling systems for baked biscuits, its systems for filling cream or chocolate coating (if they are not dry-type biscuits) and finally its packaging systems (primary, secondary and palletizing). Some types of cookies can be packaged in dozens of variations of packaging formats, giving rise to a combinational explosion in the number of possible references. More than 700 different references are produced.

Adding both factories (GULLÓN and VIDA) there are more than 40 production lines, which means that all the previous production elements (kneaders, formers, ovens, packaging machines,…) must be multiplied by 40. Considering both factories jointly (which are separated by 300 meters), this facility is the largest biscuit factory in Europe.

According to 2020 data (GULLON 2020 Public Sustainability Report[1]) the company emitted 23,851 tons of CO_2 in the combustion of fixed sources. These are equivalent to 118,074 MWh of natural gas according to the emission factor provided by Spanish Government[2] for 2020 of 0.202 t CO_2/MWh (56.13 kg CO_2/GJ_{PCI}).

The vast majority of gas consumption occurs in ovens, since the rest of the cookie-making steps do not require intense heat like baking does. There are certain production processes such as the handling and preparation of viscous ingredients such as oils, creams and chocolates that require the use of hot water. This hot water is generated by natural gas boilers. The gas consumption of these boilers (which are also used for space heating of the offices and the changing rooms as well as for the generation of DHW) is substantially less than the gas consumption of the factory's ovens (one oven for each production line).

[1] https://gullon.es/wp-content/uploads/memoria-de-sostenibilidad_cuadriptico-gullon-2020.pdf
[2] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/factoresemision_tcm30-479095.pdf

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

The heat recovery system was implemented in 2016 within the FP7 REEMAIN[3] research program that ran from 2013 to 2017.

- In what processes is the system implemented?

The heat recovery process was implemented in the biscuit baking process. That is, in natural gas ovens and in this case in one of the ovens. As previously mentioned, the ovens are by far the main consumers of natural gas in the factory and the largest sources of waste heat in the biscuit manufacturing process.

Industrial bakery ovens are several tens of meters long made up of several chambers and equipped with a metal conveyor belt that runs through its entire interior transporting the cookies. The different chambers are equipped with their own burner (or multiple direct flame burners) and the temperature in each chamber is controlled independently. Normally gas ovens can use up to three possible mechanisms: direct flame, indirect radiation and direct convection.

- What technologies have been implemented to recovery the WH/C?

Academic literature typically splits the thermal energy consumed in an oven among the following contributions: (i) the heat absorbed by the cookies inside the oven (which is indeed the real objective), (ii) the losses due to the metal conveyor belt (in the new ovens the conveyor belt does not return outside of the lower part of the oven but returns back through the oven inside, reducing losses), (iii) losses through the walls of the oven (which are reduced by using materials with better thermal insulation), and (iv) heat losses through the chimney.

Losses through the chimney are unavoidable since it is necessary to evacuate the combustion gases from the interior of the furnace. Air-air heat exchangers have been installed in such a way that the waste heat of the combustion gases (just before exiting through the chimney) is used to preheat the fresh air that is introduced into the burner, thus increasing its efficiency.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

The recovered waste heat is used directly in the same system that generates it. In fact, each chamber of the oven is equipped with its own heat recovery unit so that the waste heat of each chamber is recovered to be used only in the burner of that chamber. This is due, in the first place, to the great distances between the chimneys of the different chambers. And also to the fact that the temperature control of the different chambers requires a very precise control of the burner since all the chambers of the oven (even those that work with indirect radiation systems) must be equipped with a system that continuously renews the air inside the ovens to favour the reduction of the humidity contained in the biscuits.

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[3] https://cordis.europa.eu/project/id/608977/reporting

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

The main barrier for these systems is the fact that its implementation on an existing oven is usually not feasible (at least in an easy and non-problematic way). The chamber temperature control system (through the burners regulation) is designed to work with burner inlet air at room temperature. By replacing this room temperature air with preheated air while at the same time forcing the fume extraction to pass through the exchanger, it is likely that the control system stops working properly. In addition, the control system is usually a closed system developed by the furnace manufacturer.

This measure can only be considered when installing a new oven or replacing an existing oven when it has already reached the end of its useful life. In this situation, a decision must be made between installing a conventional oven (less efficient but cheaper) or installing an oven equipped with heat recovery mechanisms (more efficient but more expensive). In the specific case described, part of the economic resources provided by the REEMAIN project were used to finance the extra cost (exchangers) of an oven equipped with heat recovery mechanisms compared to an oven that does not incorporate such mechanisms.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

In this case, a FP7 European public R&D program was used, which allows a higher direct subsidy percentage than national public programs and also allows greater flexibility in the execution periods within the 4-year duration of the project.

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

- What would your company need to overcome these barriers?

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

In general, public grant programs are known that would be compatible with WH/C recovery measures, such as the AID PROGRAM FOR ENERGY EFFICIENCY ACTIONS IN SMEs AND LARGE COMPANIES IN THE INDUSTRIAL SECTOR[4]. This program establishes subsidies for investments to replace equipment, installations, or auxiliary energy consuming systems, with others that use high energy efficiency technologies or the best available technology in order to reduce final energy consumption and greenhouse gas emissions. CO_2. The maximum aid is capped at €1M per action and the subsidized percentage (once all the non-eligible costs have

[4] https://www.idae.es/en/node/12854

been discarded) may not exceed 30% for large companies, 40% for medium-sized companies and 50% for large companies. This aid heavily penalizes any increase in production capacity associated with the investment, so a measure such as the one described above that requires the replacement of the furnace could only be financed if the new furnace had a production capacity equal or less than that of the replaced furnace. This is a critical limitation regarding the future expansion of the production capacity of the line.

- What processes in your company would be likely to incorporate WH/C recovery systems?

As already explained there are only two processes that consume natural gas: hot water boilers and ovens. The consumption of the boilers is almost negligible versus the ovens consumption. Other possible machines or processes where waste heat recovery could be implemented would be the electric chillers and the air compressors. But in both cases the hypothetical figures of energy recovered would be much lower than the figures involved in recovering waste heat from the ovens. Additionally the recovered energy would be in form of low enthalpy (low temperature) heat streams only suitable to be used in some minor processes requiring medium (50-60ºC) or low temperatures (30-50ºC).

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manged the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

In the past, the company evaluated the installation of renewable energy systems for both the thermal energy and the electrical energy. It is important to note that, like most industrial bakery facilities, the factory operates mostly on a 24x5 basis, to avoid the daily process of turning the ovens on and off. Therefore, the biscuit production figures of the night shift

(without any type of solar radiation) are comparable to the production figures of the morning and afternoon shifts.

- What renewable technologies would be the best adapted to the conditions in your area?

Solar thermal systems intended to generate (or partially support) the hot water service, currently generated with the boilers, were discarded due to their high return on investment values. This is caused by two reasons (i) the north of Spain does not have as many hours of direct solar radiation as the rest of the country, (ii) given the high gas consumption of the ovens, the price of gas is more optimized than in a small gas consumer.

The use of biomass would be the only fully manageable renewable energy that would replace the natural gas consumed in the boilers. However, the production ovens would continue to be gas-fired and the reduction in gas consumption would be very small, not compensating for the effort required to install the biomass supply systems.

Photovoltaic solar systems would be better adapted to the conditions of the area and the process since their integration is carried out without any type of affectation on the production systems. However, the power supply to the factory (due to its three production shifts) should remain unchanged. Not all factory roofs are suitable for the installation of photovoltaic panels and, similarly as the biomass option for boilers, only a small fraction of the electricity consumed annually could be produced by a photovoltaic installation, so for the moment it was not considered a priority action.

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

Speaking in general terms, public aid programs have several limitations that, depending on the circumstances, may prevent factory responsible from deciding to count on or request such aids. Among others, the percentages of subsidies are not always high enough. The deadlines for requesting, executing and justifying expenses may be incompatible with the company's annual or biannual planning with regard to its investments. And lastly, (especially in the case of large subsidies), to apply for this aids it is required a specific paperwork, both technical and administrative, which cannot always be carried out by the factory staff. And therefore it ends up requiring the collaboration of an external consultant.

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

Heat recovery systems require an initial economic investment and in return they provide the advantage of better energy efficiency and therefore lower energy consumption and a reduction in the associated operation economic costs. But they inevitably add more complexity to industrial facilities, which in turn is a natural cause of potential maintenance problems. The installation now has more components to maintain and more items likely to fail. In the worst case scenarios, a breakdown in the heat recovery system could cause the production system to also stop and, like any unforeseen production stoppage, lead to a certain production cost.

For this reason, in general, production and maintenance departments always prioritize compliance with planning and maintainability over energy efficiency. The economical preliminary calculations about implementing WH/C recovery measures usually does not take into account this higher risk in terms of facility reliability.

Depending on the energy savings provided by the measure, the cost that the energy represents within the production costs and the possible perceived risk, a cost-benefit analysis is carried out of the possible implementation of heat recovery systems. Within this study, one of the most difficult difficulties to quantify is the internal resistance to modifying existing installations and therefore risking causing possible punctual degradation of their operation.

Additionally, the company's production figures have not stopped growing in the last twenty years. The company is clearly in an expansion phase and this means that all efforts are focused on completing the scheduled growth. That is, expand market share, acquire and deploy the new production lines required for it, and hire and train the necessary additional staff. As well as ensuring the required raw materials supply in the right quantity and cost. Probably, when the factory enters the production plateau phase, it will be possible to devote more efforts to optimizing the energy consumption of the existing facilities through the implementation of heat recovery systems or the RES introduction.

Another important comment is the fact that in industrial bakery factories the waste heat generation is distributed among a relatively large number of independent and separate systems. Unlike other productive activities, such as foundries, where most of the waste heat is generated in a single production machine or system.

TASK 6.3. - ENHANCING SO WHAT IMPACT THROUGH POLICY INSTRUMENTS

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company PROSOL – PRODUCTOS SOLUBLES[1]

- Brief description of the company (activity, sector, location…).

Since 1998 PROSOL has had as its mission to be the best alternative with its products and services for its customers' brand and consumers' preferred option. Today they manufacture more than thirteen million cups of coffee and coffee products a day and export them to more than 30 countries. From their production facilities in Palencia (Spain) and with the support of the offices in Madrid and Sao Paulo.

The company PROSOL is dedicated to the manufacture[2] of **instant coffee**[3] in glass jars, PET jars, cardboard-metal cans, sticks, sachets and bags. Since 2013, there is also a second product line of capsules[4] compatible with Nespresso machines. They can be produced in 3 different technologies: Aluminium, Home Compostable and Plastic. As in the case of the instant coffee, the product is usually full customized to the client requirements in terms of recipe (combination of different varieties) and packaging options (consumer unit and also primary and secondary packaging requirements).

Instant (or soluble) coffee is made from coffee beans that have been roasted and ground. The ground beans are then extracted with hot water to recover the coffee flavour and aroma. The process is similar to using a coffee percolator at home. The industrial manufacturing of instant coffee can be summarized in the next steps:

1) Delivery

Raw, green coffee beans enter the factory by lorry packaged in big-bags. These big-bags are unloaded to be sieved and cleaned by machine to remove any unwanted debris that may have found its way into the batch of beans. It is stored in different silos classified by variety and quality.

2) Roasting

Next comes the roasting of the beans to turn them from their original green colour to the more familiar brown. According to the specific recipe, different amounts of the selected varieties are dumped from the silos to be transferred and mixed in the roaster. The beans are heated to

[1] https://www.prosol.coffee/en/index
[2] https://www.prosol.coffee/UploadsMedia/Historia/2019_PROSOL_VideoCorp_Corto_ENG.mp4
[3] https://www.prosol.coffee/en/supplier-manufacturer-instant-coffee-and-coffee-drinks
[4] https://www.prosol.coffee/en/supplier-manufacturer-compatible-capsules

temperatures among 200 and 300°C for a variable time depending on the specific recipe. The roaster uses natural gas to provide the required heating.

3) Grinding

The roasted coffee beans are now sent to be ground in an electric industrial roller-mill grinder. When coffee is ground, a lot of the aromas are lost into thin air. To minimize the loss, the aromas are collected by pumping nitrogen gas through the grounds, capturing the aromas on its way through. The vapour is then stored in a tank to be added later on.

4) Brewing

The ground coffee is now mixed with pressurized water to brew in a device called Instant Coffee **Extractor** or Battery Extractor, similarly like a French press but in this case hundreds of litres are prepared in each batch. The infused pressurized water is heated to between 150 and 200°C depending on the specific recipe. Analogously, extraction time can range between 100 and 200 minutes. Steam-water heat exchangers are used to produce the required temperature. Once the infusion has finished, the obtained liquid coffee is sucked from the cylinders and hot water and steam is used to remove the spent coffee grounds and clean the system for the next batch.

5) Evaporation/Concentrating

The brewed and filtered coffee is sent to a giant evaporation tank where partial vacuum is applied in order to reduce the evaporation temperature to 70°C. The water evaporates and is siphoned off and it condenses into hot liquid water. The liquid coffee is reduced by 50% to produce a thick, syrupy coffee extract. As the liquid stock is heated, it reduces and intensifies in flavour. Usually there are several tanks connected in series producing consecutive evaporations and reductions of the water content of the syrupy. The machines are usually called Evaporators or **Concentrators** since the increase the concentration of the coffee extract through partial evaporation processes. The heating required for boiling the coffee extract is produced by steam coming from the factory steam boilers.

6) Spray drying

The drying of the product happens in a **spray drying tower** where the coffee extract is sprayed into a stream of hot air (around 250°C) at the top of a tall cylindrical tower. These fine droplets on contact with heated air they dry up until they reach the tower bottom with a humidity lower than 5%. After a certain time cooled these particles are already suitable for packaging or for the agglomeration process. The required heated air, constantly injected into the tower, is produced by natural gas direct flame burners.

7) Agglomeration

This optional process (not used for powder instant coffee references) happens in machines called **Agglomerators** where basically the coffee powder coming from the spray drying tower is mixed with steam in order to facilitate the creation of bigger size particles. The resulting bigger particles are then passed through mechanical sieves in order to select the granules with the desired size to facilitate dosage and dissolution. Steam is consumed in this process.

8) Packaging

Finally, the granules are sent to the packaging section where automatic weight and dosage systems fill the different jars, cans, sticks, sachets and bags. After that, automatic machines

label the different filled containers and the consumer units are grouped into primary packaging and palletized to be sent to the end product warehouse. No thermal energy is required in this process.

The manufacturing of compatible capsules shares the initial steps: delivery, roasting and grinding. And after that, the ground coffee is directly sent to the capsules packaging section where it is automatically dosed into capsules packaging machines. As in the case of instant coffee packaging, capsules, covers, plastic bags and carboard boxes are provided by external suppliers.

It is important to remark the importance of the steam production in this manufacturing process. First, all the heating is provided by steam-water heat exchangers. In this case, the used steam condensates and it is returned back to the system. Second, there are process like the cleaning of the extractors and the agglomeration machines that require the supply of steam without returning it to the boiler water feed-in system. This means these processes have associated important impact in the production of osmotized water required for the boiler feed-in system.

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

Two of the Waste Heat Recovery systems (Extractors and Concentrators) were implemented at the same time as the extraction batteries and the concentrators production machines so, before 2000. The third and last waste heat recovery was a retrofitting of the existing steam boiler and was implemented in 2018.

- In what processes is the system implemented?

Three different processes or machineries have been implemented with Waste Heat Recovery mechanisms:

1) The coffee extractors are responsible for obtaining liquid coffee by passing pressurized water at 180ºC through previously roasted and ground coffee powder. The liquid coffee obtained at the end of the process is very hot and is passed through a heat exchanger to preheat the fresh water that will be used in the next manufacturing batch. This way, the heating of the water is carried out in two steps. One first step from room temperature to 70ºC (which is precisely the heating produced by heat recovery). And then, steam is used (with a steam-water exchanger) to carry out the final heating from 70ºC to 180ºC.

2) Concentrators are basically vacuum evaporators used to concentrate the coffee obtained in the extraction batteries. The coffee goes through different stages where it is heated in tanks subjected to a partial vacuum to produce its partial evaporation and therefore increase the percentage of dry extract of the coffee. The water vapor generated by the process itself is condensed (in the form of water at 60ºC). The old machines discarded this condensed water, but the new installations completely reuse this condensed water in other parts of the production process. This way, not only there is heat recovered (the water is at 60ºC) but it also represents a significant saving in osmosis water (the recovered water is basically condensed steam and therefore has hardly any mineral salt content)

3) The factory's main steam boiler has a capacity of 10 tons/hour and was not equipped with any heat recovery mechanism. A boiler economizer was installed into the exhaust stream of the boiler. Exhaust waste heat is recovered by industrial finned tube that lines the inside of the economizer. The heat is transferred to boiler feedwater. The economizer reduces the overall fuel needed by the boiler for steam production and the resulting pollution.

- What technologies have been implemented to recovery the WH/C?

In the recovery implemented in the concentrators (vacuum evaporators), no specific heat recovery technology was used, but rather a modification of other production processes so that the hot and condensed water from the concentrators could be incorporated. The only necessary modification was the installation of colorimeters (automatic color sensors) to control the color of the recovered water in real time and discard it automatically if, due to a fault in the concentrators, the recovered water began to contain an excessive value of coffee or other dissolved solids.

In the implemented heat recovery of the coffee extractors, it was necessary to install a water-water exchanger as well as the corresponding pump and temperature control system.

In the recovery of the boiler (economizer), a commercial air-water exchanger was used, one of those normally used (and certified) in steam boilers.

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

Both in the implementation of the boiler and the extraction batteries, the recovered heat is used in the same machinery that originates the waste heat. In the case of the WH recovery implementation in the concentrators, the recovered heat (and water) is used in other processes, but always within the factory.

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

In the case of the recovery in the extractors, the measure was already incorporated in the design of the machinery and was already incorporated in the equipment. The additional cost was assumed within the planned investment for the complete installation.

In the case of the recovery in the concentrators, the extra cost was basically associated with the color detection system and the new working mode of the factory systems that now receive the recovered hot water. And the cost was assumed within the investment costs foreseen for the factory.

In the case of the boiler economizer, both the cost of the exchanger and the installation works were assumed with the company's own resources.

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

No public aids were requested.

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

The installation of an economizer in the factory's second steam boiler has also been considered. The second boiler is smaller (5 tons/hour), but the measure would basically consist of replicating the installation made in the other boiler, but obviously with a smaller heat exchanger.

Another heat recovery measure that has been considered is the heat recovery from the factory's air compressors. The approach of the measure considered was to conduct the hot air outlet flow from the compressors as the air inlet of the boiler burner. In other words, the boiler burner, instead of being fed with air at room temperature, would be fed with hot air obtained by recovering waste heat from the compressors.

Finally, the spray drying tower is the machine where concentrated coffee extract is sprayed in a small droplet in a vertical cylindrical enclosure. In contact with a hot air flow, the water evaporates from initial product to become product powder. The substance is then filtered to retain powder and let air free. The system is continuously injecting a dry hot air flow and removing an outlet air flow with higher humidity and medium temperature. In the academic world there are plenty of research papers[5] proposing heat recovery among the medium-temperature high-humidity outlet flow and the fresh cold air inlet (before being heated). However, the outlet flow has an important dust content (fouling problem) and no turnkey heat exchangers are commercially available.

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

The main reason why an economizer has not been implemented in the second boiler is due to lack of economic profitability. Unlike the main boiler, this second boiler works most of the time below 50% of its nominal power. The main boiler is responsible for covering the base load of the demand, while the second boiler only works to cover the demand peaks. Therefore, due to its lower level of use, the savings produced would be lower and therefore the returns on investment obtained are not considered acceptable.

Regarding the recovery of heat in the compressors, it was ruled out due to two technical problems: (i) Undesired modification of the combustion curve of the burner due to pressurization and depressurization in the air intake of the burner compared to the start-stop of the compressor fans, (ii) Undesired modification of the load curve of the compressor heat evacuation system.

It is important to note that the typical measure of heat recovery in compressors is usually thought to generate hot water at a temperature between 50 and 60ºC. However, except for generating DHW, this temperature is not useful enough, as factory process temperatures are substantially higher. For this, a steam boiler is used. Additionally, the demand for DHW is relatively small.

Finally, regarding heat recovery in the spray drying tower, the main barrier is the lack of reliable manufacturers that offer a turnkey and guaranteed solution. As explained above, the outlet stream has a high dust and moisture content and this is a major impediment to the reliability of the heat recovery system.

[5] https://www.sciencedirect.com/science/article/abs/pii/S0196890419302560
https://www.sciencedirect.com/science/article/abs/pii/S1359431116305968

- What would your company need to overcome these barriers?

There are really no external barriers preventing the implementation of the studied but currently discarded heat recovery measures. The reasons are basically a techno-economic combination.

The economic cost and technical complexity required do not compensate for the economic savings that they would produce. In the future, if new technologies could make it possible to simplify and reduce the costs of implementation, it could be considered again.

Another possible option would be that the cost of energy, especially natural gas, would increase so much that, even if the savings were small in energy terms, it would lead to greater savings in economic terms. But possibly, in such a scenario of astronomical cost of gas, either an attempt would be made to replace gas with another fuel, or the very viability of the factory could be in danger.

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

Of the three heat recovery implementations considered, only one, the boiler economizer, was considered initially to request some public aids in this regard, within the aid programs available in 2018.

More specifically, it was considered to apply for the **Aid program for energy efficiency actions in SMEs and large companies in the industrial sector**[6] that closed the 31th December 2018. This Spanish national aid program had a total Budget of 168M€ coming from the National Energy Efficiency Fund. 40% of the mentioned budget (67M€) was reserved for SMEs projects.

This action was intended to promote investments in the replacement of equipment and installations, as well as auxiliary energy-consuming systems, for others that use highly energy-efficient technologies or the best available technology in order to reduce energy consumption and CO_2 emissions.

The requirements of the program established a maximum economic-energy ratio of 14,379€ (eligible investment)/toe (final energy savings). The measurement of energy savings obtained by the application of this Program should be calculated following the calculation methodology indicated in Annex V of Directive 2012/27/EU.

Only actions whose eligible investment was equal to or greater than 75,000€ were eligible for this Program. Likewise, a maximum amount of eligible investment in the program per request of €50M was established.

[6] https://www.idae.es/ayudas-y-financiacion/para-eficiencia-energetica-en-la-industria/convocatorias-cerradas/segunda-convocatoria-ayudas-pyme-fnee

The aid was established under the modality of monetary direct subsidy without return, with a subsidy amount that was 30% of the eligible investment for large companies, 40% for medium-sized companies and 50% for small companies.

Finally, it was decided not to apply for this subsidy because the justification of the possible energy savings was not easy since it was required additional investments in monitoring campaigns. This extra effort did not compensate for the possible 30% subsidy received.

- What processes in your company would be likely to incorporate WH/C recovery systems?

As already mentioned, installing a similar economizer on the second steam boiler has been considered but it has not passed the economic feasibility study. Also waste heat recovery from the compressors have been also studied and discarded. And finally, the thermal dewatering using spray dryers is an energy-intensive process and the eternal theoretical candidate for waste heat recovery.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

Instant coffee manufacturing industry uses turnkey machinery designed by specialized suppliers. It is not always possible to modify existing systems to introduce heat recovery mechanisms without affecting their performance. For this reason, in many cases, possible heat recovery mechanisms must be incorporated in the design phase of the facility. In other words, the heat recovery mechanism is already included by the supplier with the original production machinery. Then, it makes impossible to define the technical and economic boundaries between the heat recovery system and the original installation. This makes it very difficult to apply for specific public aids for these waste heat recovery installations.

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

- How did your company manage the implementation of these systems, with its own resources or did it use a public program to do so?

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

Two projects are currently being studied: photovoltaic (PV) on the roof and biomass boiler (spent ground coffee and wood chips)

a) Installation of Photovoltaic (FV) on the roof of the factory.

It is currently being considered the installation of a self-consumption PV plant to cover around 7-8% of the current electrical power. The project is in the feasibility verification phase.

The feasibility calculations are being made on the assumption of completely own resources in regards to the initial investment or CAPEX. The PV installation will be owned by the factory without any type of PPA with other possible ESCO. The corrective maintenance and periodic revisions of the installation would be outsourced to an external company.

b) Installation of a biomass steam boiler to burn the spent coffee grounds generated along with wood chips.

Currently, the used grounds are discarded as waste, but in other similar industries spent coffee grounds are dried and burned in the boilers to power the factory, since it has a high calorific value[7] of around 18.8 MJ/Kg (4500 kcal/kg at water content 10%). For instance, hard black coal is considered to have a calorific value of 23.9 MJ/Kg.

Once dried, the produced spent grounds would not be enough to cover the factory steam demand. For this reason, it has been considered to complement the available coffee grounds with wood chips and thus increase the steam production capacity until it equals the demand of the factory. In principle, the vast majority of the factory's steam demand would be produced by the biomass boiler, although the existing natural gas boilers will continue to operate to supplement in cases of specific peaks in demand. Biomass boilers have a very large thermal inertia.

In the case of the new biomass boiler, it is not discarded to arrange some kind of PPA with some possible ESCO so the initial investment, the maintenance and the wood chip supply were in charge of a possible Energy Service Company who would be payed by the coffee factory according to the values of supplied steam. But it is not decided yet. Financing the investment with their own resources is still a considered option.

- What renewable technologies would be the best adapted to the conditions in your area?

Photo-voltaic generation seems better than solar thermal technologies since most of the factory heat demand is at high temperatures and therefore requires steam as heat carrier and also as ingredient to be consumed in the process. So flat solar thermal panels would not be suitable for the heating requirements. Other solar thermal technologies like Concentrating Solar Power (CSP), capable of producing steam could be considered, but these technologies are

[7] https://www.sciencedirect.com/science/article/abs/pii/S0960148117305967?via%3Dihub

more expensive and complex and usually require more skilled maintenance workers. Additionally, the factory operates in 24x5 operation mode and this means, it is still required to produce steam during the night.

Biomass steam boiler seems also a good candidate for 24x5 operation. Additionally, the presence of spent ground coffee as waste, represents an opportunity to turn a waste into an useful input.

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

As mentioned, the two possible renewable projects are still under early verification of their technical and economic feasibility. However, since these two possible projects will require big economic investments, it has already been identified some possible public programs that could be considered.

Regarding the PV plant, two possible public aids are being considered:

"Sub-measure 4.2 – Support for investments in transformation/marketing and/or development of agricultural products[8]" of the Castilla y León Rural Development Program 2014-2020 co-financed by the European Regional Development Fund (ERDF) for line NC1.

Targets companies engaged in the transformation and/or marketing of agricultural products and provides a maximum aid percentage of 40%

Possible aid requests will be prioritized according to the order resulting from the score obtained in the selection process, in such a way that those with the highest score will be given priority. Score is based on several criteria like sustainability, female or youth job creation, rural population fixation. Also the score is increased, if the factory invest in different production aspects in order to improve the company competitiveness. The possible considered scorable types are the next ones:

- Investments in equipment and facilities for the collection and treatment of waste
- Investments in equipment and facilities for the recovery and use of by-products
- Investments in equipment and facilities for packaging and/or packaging with biodegradable and/or recyclable materials
- Investments in equipment and facilities for the generation of renewable energy
- Investments in robotic equipment and facilities
- Investments in sensorization and connectivity equipment and installations, as well as in other equipment and installations related to digitization.

Since it is foreseen to make some investment in automatization, robotization and digitalization of the compatible capsules production lines, including also the generation of renewable energies (through the PV plant) could also increase the scoring and facilitate its approval.

8 https://www.tramitacastillayleon.jcyl.es/web/jcyl/AdministracionElectronica/es/Plantilla100Detalle/1251181050732/Ayuda012/1285123885747/Propuesta

Aid program for self-consumption, storage, photovoltaic and wind power. Recovery, transformation and resilience plan (Ministry of Economy and Finance and Regional Public Energy Entity of Castilla y León (EREN)[9]

Within the Incentive Program 2: Implementation of self-consumption facilities, with renewable energy sources, in other productive sectors of the economy, with or without storage. Grants of between 15% are contemplated (typically, although in some cases the percentage can be increased to 45%). Grants are awarded in order of application. Funds are depleted but there is public anticipation of raising additional funds.

And regarding the biomass boiler, the considered public program is the **Incentive program for the implementation of thermal renewable energy facilities in different sectors of the economy, within the framework of the Recovery, Transformation and Resilience Plan (PRTR)[10]**

The granting of direct economic aid for the implementation of thermal renewable energy installations in different sectors of the economy. These grants, which will be awarded on a simple concurrence basis, will be in force until the end of 2023, and are endowed with an initial amount of €150M distributed among the different regions. The region of Castilla y León (where PROSOL is located) has an allocated budget of €8,4M.

The aid is executed through two incentive programs: the first, aimed at sectors of the economy (industry); and the second, to the public sector. It allows the start-up of solar thermal, geothermal, ambient energy (aerothermal and hydrothermal), biomass or heating and cooling microgrids of less than 1 MW of power.

Among the eligible actions are applications for the production of cold and/or heat in buildings (sanitary hot water and air conditioning) or in industrial processes (cleaning, drying, thermal baths for surface treatment, laundry services, vehicle washing, pasteurization and conservation of perishable products, air conditioning of warehouses for industrial use, livestock and greenhouses).

The aid granted will cover 70% of these costs in the public sector and up to 45% in the case of small businesses. (40% in medium-sized companies and 35% for large companies). The aid program regulation contemplates a maximum unit eligible cost of €430/kW for biomass boilers as long as the fuel will be 100% renewable and the use of fuels from wood that has been chemically treated will not be allowed.

In the case of the region of Castilla y León, only the call for Incentive Program 2 (residential) has been published on January 2022. However, Incentive Program 1, indicated for industry, has not been published yet.

[9] https://www.tramitacastillayleon.jcyl.es/web/jcyl/AdministracionElectronica/es/Plantilla100Detalle/1251181050732/Ayuda012/1285096261830/Propuesta

[10] https://www.idae.es/noticias/el-gobierno-aprueba-una-linea-de-ayudas-para-la-implantacion-de-renovables-termicas-en

In other communities such as the Basque Country[11], the incentive program for industry has entered into force on March 2022. Andalusia[12] activated the call on May 2022.

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

One of the identified barriers related with the processing of public aids is the fact that, as it is the responsibility of the regional governments, not all the regions open the calls at the same time. And in some cases, as occurs with subsidies for thermal renewables in industry, the PROSOL region is one of the last to open the call. The deadline for closing the call is set by national regulations. Therefore, a delay in the opening of the call means less time to plan and execute the installation.

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

The company does not have specialized personnel neither in the search for subsidies nor in their subsequent administrative processing. For this, the services of a specialized consulting firm with which they work on a regular basis are outsourced. This consultancy firm is responsible for monitoring the possible subsidies appropriate to the planned investments. And in case of deciding to apply for those aids, it is also in charge of all the associated administrative management. This methodology is applied both to investment support programs and R&D&I project support programs.

This is not considered to be a disadvantage, but rather an advantage. Since this way, the company's personnel can dedicate themselves and specialize in those activities related to the manufacturing business that are critical activities.

[11] https://www.euskadi.eus/y22-bopv/es/bopv2/datos/2022/03/2201320a.pdf

[12] https://www.agenciaandaluzadelaenergia.es/sites/default/files/Documentos/Incentivos/02_termicas_convocatoria_16.03.2022.pdf

TASK 6.3. - ENHANCING SO WHAT IMPACT THROUGH POLICY INSTRUMENTS

1 QUESTIONS DIRECTED TO INDUSTRIAL ACTORS

- Name of the company SAETA DIE CASTING[1]

- Brief description of the company (activity, sector, location…).

The company SAETA DIE CASTING is dedicated to the manufacture of high pressure die-cast aluminium parts (HDPC[2]). It belongs to the SIGNIFY group (PHILIPS lighting; world leaders in lighting). That is why the vast majority of its activity is devoted to produce aluminium mechanical components and luminaires for indoor and street lighting, although it also produces aluminium parts for external customers in the automotive, furniture and construction machinery sectors. Their facilities occupy 8,500 m2 (the factory is surrounded by other industries and cannot be expanded) and is located in Valladolid (Spain). It employs 135 workers split over three production shifts. 70% of its production is exported abroad.

The production process (creation of aluminium parts by high pressure injection) can be summarized in the three following processes[3]:

1.Melting of aluminium ingots. It is carried out in the melting towers where the aluminium is dumped at room temperature in the form of ingots together with the "filling channels" recycled from previous manufacturing batches. There are 3 melting towers, one for each of the three aluminium alloys used in the factory. The required heat in the melting towers is provided by natural gas. The molten aluminium comes out of the towers and is dumped into ladles to be transferred with forklifts to the different injection machines.

2. Aluminium injection. These machines are responsible for injecting the molten aluminium into the corresponding shaping moulds, forming the piece, removing it and cooling it. There are 9 injection cells, each prepared to produce different sizes of products. Their consumption is fundamentally electrical and they are made up of 6 clearly differentiated components: an electric induction waiting furnace, the pressure injection machine, the molten aluminium feeding system (by robotic ladle or by pneumatic pumping), the robotic produced-part extracting system, the temperature control system for the moulds and the cooling system for the produced parts (by air tunnel or cold water pool).

3. Machining processes. These processes include burr removal stages (robotic and also manual stations), machining on CNC machines (smoothing, drilling, threading…). Specific polishing stages/machines are also included (by shot blasting and by immersion in polishing stones).

[1] https://saetadiecasting.com/en/home/

[2] https://www.italpressegauss.com/en-gb/my-application-and-industry/application-by-process/what-is-high-pressure-die-casting

[3] https://www.youtube.com/watch?v=fpQ5fvGrzVE

Finally, there are also washing stages (washers) and subsequent drying by hot air. All the energy consumption of the machining processes is electrical.

All the machines cooling (those that require it) is done through a 20ºC water closed circuit based on an external cooling tower (evaporation). Even in the summer, this cooling tower is capable of providing the necessary cooling without the need for compressor chillers.

The air conditioning of the factory building is based on hot water fan coil units (for space heating in winter), evaporative coolers in the area of the CNC machines and forced ventilation systems (with extraction through the roof) in the injection machines area. The heating fan coil units are only used a few days in the winter, especially on Mondays, since the heat dissipated from the injection machines progressively increases the temperature inside the workshop. The warehouses (raw material, intermediate and finished product) do not require any type of specific air conditioning. The offices are heated by radiators. There is a small natural gas boiler to generate the necessary hot water for the workshop fun coil units, the office radiators and the DHW used in the toilets and the locker rooms of the factory.

The factory works three shifts from Monday to Friday, resting on weekends. The melting towers and the waiting furnaces in the injection cells require several days to achieve their operation temperature after a full cold start. Because of it, these systems continue to run even on weekends, to maintain the contained aluminium in liquid state. They are only turned off for 15 days in the summer for maintenance during the summer vacation shutdown.

- Does your company have implemented systems for the recovery and use of waste heat?

If so:

- When was the WH/C system implemented?

- In what processes is the system implemented?

- What technologies have been implemented to recovery the WH/C?

- Are the WH/C reused in the same plant or exported to be used in other sectors/plants? Which sectors? Which type of plant?

- How did your company face the implementation of these systems, with its own resources or did it use a public incentive program to do so?

- In case of having used public programs, which ones? What aspects would you improve in them in order to facilitate greater deployment of these systems?

If not:

- Does your company evaluate the implementation of systems for the recovery and/or use the WH/C?

The installation of waste heat recovery systems in the melting towers has been evaluated (and ultimately discarded) in the past. These towers work with natural gas and have a chimney through which the combustion gases are evacuated. This hot air stream is a possible waste heat source. The waiting ovens of the injection machines are electric. Its function is to maintain the already molten aluminium in a liquid state and

do not require the evacuation of hot gases. They can not be considered as a feasible source of waste heat.

Regarding heat recovery in the melting towers, two options were contemplated:

(i) Heat recovery to preheat ingots

The first option considers using the recovered heat to preheat the aluminium ingots before being introduced into the melting tower by using a system called PHC (Pre Heating Chamber). It is basically a pre-heating box, powered exclusively by the exhaust gases of a melting furnace. Depending on the type, it contains 2.4 or 8 ingot packages. The door is secured by two anti-fall devices. This purely mechanical and works much like in elevator. The preheating chamber raises the internal temperature below the melting point of aluminium. So the ingot packages in the chamber can reach even faster to desired temperature of 400 ºC. Without melting the inside aluminium of course.

In this way, the ingots would enter the melting furnace at a temperature close to 400ºC instead of at room temperature (the melting of aluminium takes place at a temperature of around 700ºC) and therefore the gas consumption in the melting towers would be partially reduced. There is no saving of electrical energy. Increasing the temperature of 1 Kg of aluminium from 0ºC to 700ºC requires 627'9 KJ (Aluminium heat capacity is 897 J/KgºC), and this system would save 4/7 of this energy. However, melting one kilogram of aluminium requires 397 KJ and this latent heat energy keeps being fully supplied by the gas melting tower.

(i) Example of heat recovery system to preheat ingots

(ii) Example of a heat recovery system with air-water heat exchanger

(ii) Heat recovery to generate superheated water

In this case, it was considered to take advantage of the waste heat of the melting tower, which currently escapes to the outside to conduct it through an air-water heat exchanger and generate hot water (superheated and pressurized) that would be used in other stages of the production process.

The only possible internal receptors of this recovered heat would be the mould temperature control systems of the 9 high-pressure injection machines. The temperature of the moulds ranges between 120 and 140ºC, that is why pressurized water is required. Current tempering systems are autonomous equipment that automatically heat or chill the moulds by circulating water through the specific jackets of the injection machines.

The space heating of the workhouses (they only work a few hours a year) and of the offices (all winter) represents a very small load compared to the possible values of recovered energy.

There are no possible external receivers to which this hypothetical recovered heat can be transferred (there is no district heating in the industrial park)

- What reasons/barriers are responsible for the fact that no WH/C recovery system has yet been implemented?

Regarding the first option (Heat recovery to preheat ingots), the measure was discarded basically because the inconveniences it might cause did not compensate for the possible produced economic savings, at least when the price of natural gas was lower than nowadays. The main drawbacks of this measure were the lack of space for the installation of the new ingot preheating space and the additional health and safety requirements. Since now the load of ingots to the melting furnace will not be at room temperature but at temperatures close to 400ºC and therefore the necessary protection and safety mechanisms will have to be ensured.

Regarding the second option (Heat recovery to generate superheated water), in this case there were not space availability problems since the air-water heat exchanger would have been located on the roof next to the chimney outlet. The insurmountable drawback of this possible heat recovery is the lack of a suitable internal receiver for the recovered heat (pressurized water). The moulds tempering systems do not admit such external heat supply and, furthermore, the moulds only require heating when they start operating after a production stoppage. During the continuous production operation, the moulds usually require cooling to evacuate the heat transmitted by the injected liquid aluminium at 700ºC.

There are no possible external receivers of this possible recovered heat since there is no hypothetical district network that could accept the recovered heat and the adjacent businesses do not require heat beyond what is necessary for their offices.

- What would your company need to overcome these barriers?

The first option was discarded due to lack of economic profitability (excessive payback) compared to the current costs of natural gas. It could be reconsidered if natural gas prices continue with high values like the current ones although the lack of available space inside the workshop keeps being a problem.

The second option could easily be considered if there were a possible external receiver of the recovered heat. Preferably a district network that would demand thermal energy all year round (since the melting towers are only turned off for 15 days in summer). In this case, the company would be willing to study the sale of this residual heat if the economic conditions were adequate, fundamentally the required investment was

affordable and the expected payback was below the values required by the parent company.

- Does your company know the public mechanisms designed for the use of WH/C?

In case your company know them:

- Which is the barrier or deficiency that your company found in these mechanisms for which it has not decided to use them to implement systems for recovery the WH/C?

The aid programs for industry energy efficiency improvement equally considers heat recovery retrofitting as the whole replacement of installed production machinery with new and more efficient machinery.

For example, the Spanish National Program to Improve Energy Efficiency in Industries[4]

This program is endowed by the European Regional Development Fund (ERDF) with 478 M€ until June 2023 and allows actions to be promoted to improve energy efficiency in the industrial sector, ranging from regular investments to new processes with a markedly innovative nature. Among them, improvements such as the following are financed:

- Renovation of the steam and hot water production system.
- Regulation of motors by means of electronic speed variators.
- Replacement of the lighting system with high energy efficiency LEDs.
- Improved boiler performance by burner replacement and heat recovery.
- Waste heat recovery.
- Replacement of plastic injection machines for more efficient ones.
- Energy optimization in the generation of industrial cold.
- Improvement of energy efficiency in the textile finishing process.
- Substitution of air compressors for high efficiency equipment.

And in any case, the aid only covers a small percentage of the required investments. Typically 30% for large companies, 40% for medium-sized companies and 50% for small companies. And always considering the concept of eligible investment where certain expenses (such as taxes and personal expenses) are eliminated from the calculation of the subsidy.

For this reason, it has been decided to prioritize investments and apply for this aid to renew the oldest injection machines as well as the oldest CNCs for new, more efficient production machines. Therefore, it can be said that the measure has been temporarily ruled out compared to other higher priority investments. Melting towers, even when they do not have a heat recovery mechanism, are not relatively inefficient machines compared to more modern melting towers.

[4] https://www.idae.es/noticias/idae-amplia-las-ayudas-de-eficiencia-energetica-para-empresas-industriales-hasta-rozar-los

- What processes in your company would be likely to incorporate WH/C recovery systems?

As already mentioned, only the melting towers are good candidates to implement heat recovery mechanisms, since how they work with natural gas they must necessarily evacuate the combustion gases and they also work 24 hour during 350 days a year.

In case your company does not know them:

- In your opinion, what factors would be decisive for your company, within the public programs, to assess the implementation of recovery technologies?

- Does your company have any type of renewable energy facility?

If so:

- What renewable technology have your company implemented?

The company has just received authorization (from the head quarter company) for the installation of a photovoltaic system on the factory roof. It has not yet been installed, but the final project is already validated, as well as the approval for the corresponding financial budget. It will be installed during the factory summer shutdown.

- Which are the main characteristics of the facility: total power, production, application of the energy produced, and share of participation in the global electricity consumption of the company…

The photovoltaic installation will occupy the entire roof surface and will have a nominal power of 460 kW with an estimated annual production of 600,000 kWh, which represents 10% of the factory's annual electricity consumption. The installation will be used completely for self-consumption without the possibility of dumping the surplus electricity production into the grid. That is, the system will be equipped with a zero-injection mechanism that automatically reduces the production of the photovoltaic inverters when the photovoltaic production exceeds the electricity demand of the factory. Therefore, the production of surpluses and their grid dumpling is prevented. This is a requirement of the Spanish regulations that simplifies the administrative procedures to obtain authorization from the electricity distribution company at the cost of reducing the annual efficiency of the photovoltaic system. Since the furnaces remain on during the weekends (to maintain the temperature of the furnace and the material), the zero-injection mechanism is not expected to act except during the 15 days of maintenance shutdown in summer.

- How did your company manage the implementation of these systems, with its own resources or did it use a public program to do so?

It should be clarified that the SIGNIFY-SPAIN group has two factories in Valladolid, the SAETA DIE CASTING aluminium injection foundry and the SIGNIFY-PHILIPS factory dedicated to the complete manufacture of lighting fixtures.

The company has jointly managed the investment in the photovoltaic plants through the parent company SIGNIFY-SPAIN for the two factories in Valladolid. In other words, both factories are going to install a photovoltaic plant on their roof.

The required funds are initially their own funds, but a possible subsequent economic subsidy d from the Recovery, Transformation and Resilience Plan[5] has also been considered. This national Program includes aid for the purchase and deployment of self-consumption installations, with renewable energy sources, in other productive sectors of the economy, with or without energy storage. (Incentive Program 2).

In this case, the aid requested is 40,000€, which corresponds to approximately 15% of the planned investment. Therefore, even though it is not a negligible amount, the aid requested has not played a critical role in decision-making. Possibly the payback of this measure would have been low enough without the aid to be approved by the parent company

- What difficulties/barriers have been the most difficult for your company to overcome in the process?

The biggest restriction in this process is the lack of available surface on the roofs of the factory. If more roof surface had been available, more PV panels capable of covering more than 10% of the factory's electricity demand would have been installed for sure.

- If your company used public programs, which one(s)? What aspects should be improved in public programs with the aim of facilitating a greater deployment of renewable energies in industrial plants?

The economic aid has been requested but has not yet been justified and therefore the payment has not yet been collected, although the approval notification has been received. The aid program contemplates the possibility of requesting a pre-financing advance but a bank guarantee is required in exchange. It is unknown if the advance has been requested.

One complaint in this regard is the cumbersome administrative process, especially the subsidy calculation procedure.

If not:

- Does your company assess the implementation of renewable energy systems for own energy supply?

- What renewable technologies would be the best adapted to the conditions in your area?

- Which factors should be improved within the public programs to facilitate the implementation of renewable technologies in the industry?

- Different levels of the public administration come into play in this type of actions (WH/C implementation and RES implementation), from local, to regional and to national level.

- What type of procedure has been the most complex?

[5] https://www.idae.es/ayudas-y-financiacion/para-energias-renovables-en-autoconsumo-almacenamiento-y-termicas-sector

- Which what level of the administration have you found more difficulties?

- Which process took the most time?

- Did you have to assume significant costs (legal advice, consultancy…) for the installation of RES systems?

- Did the public program provide for the expenses that had to be deal with?

In this case, the only aid requested has been done jointly for the two factories with the administrative and financial support of the parent company. Therefore, by having personnel specialized in these subsidies, the bureaucratic effort has been lower for the factory personnel. The possible extra cost (legal advice, financial reporting, technical consultancy…) has been supported by the head quarter company.

- Any other comments or remarks from the industry that should be taken into account in the recommendations and best practices in the promotion of WH/C recovery policies.

The fact that heat recovery measures from the three melting towers have been discarded in the past is fundamentally due to two causes: the lack of optimal use for the recovered heat and the prioritization of investments.

However, the parent company encourages the group's factories to implement environmental sustainability measures as long as there is also a certain economic sustainability. This environmental sustainability is considered globally, both in terms of waste reduction and the reduction of energy consumption and emissions.

On the other hand, the company would be interested in selling the possible recovered heat to a hypothetical district network. In fact, the company is located[6] in an industrial park that is highly occupied by companies that, to a greater or lesser extent, have a demand for heat, both for space heating and DHW in the offices and, in some cases, for their own production process. With the help of local and regional governments, it would be a good idea for industrial parks to be equipped with district networks where companies with surplus waste heat could discharge any recovered heat for a fee.

[6] https://goo.gl/maps/fuj3UQM4qjWc38rm6