H2020 Work Programme

D2.1 – REPORT ON END-USERS' CURRENT STATUS, PRACTICES AND NEEDS IN WASTE H/C RECOVERY AND RES INTEGRATION
LEAD PARTNER: CAR

Date: January 20th, 2020

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Abbreviations

°C: Celsius degrees

B2B: Business to Business

B2C: Business to Consumer

CAPEX: CAPital EXpenditure

CHP: Combined Heat and Power

COP: Coefficient of Performance

DH: District Heating

DHCN: District Heating and Cooling Networks

EII: Energy Intensive Industries

ESCO: Energy Service COmpany

EU: European Union

GHG: Greenhouse Gas

GIS: **G**eographic Information System

GM: General Manager

HP: Heat Pump

IPCC: Intergovernmental Panel on Climate Change

KPI: Key Performance Indicator

OPEX: OPerating EXpense

PD: Participatory Design

PPA: Power Purchase Agreement

R&D: Research and Development

RES: Renewable Energy Sources

ROI: Return On Investment

SHIP: Solar Heat for Industrial Processes

SME: Small and Medium Enterprises

UI: User Interface

UX: User eXperience

WH/C: Waste Heat/Cold

WHR: Waste Heat Recovery

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Executive summary

This document represents the Deliverable D2.1 "Report on end-users' current status, practices and needs in waste H/C recovery and RES integration", developed within T2.1 (WP2). It provides a description of the participatory approach defined to guide the user requirements specification process.

Validation industrial sites involved in the related task and additional stakeholders has been directly interrogated about their specific needs regarding the software tools to be developed in the scope of the SO WHAT project.

To increase the number of interviewed stakeholders, two approaches have been defined:

- Design-thinking workshop (held in December, 10th), to bring together European players active in the energy and industrial sectors, public authorities, ESCOs and energy agencies so that they may exchange best practices and provide ideas and concepts in order to define the tool requirements via a participatory approach.
- Online survey (available at https://es.surveymonkey.com/r/N8D7GFR), to give the possibility of "giving answers" to people not attending the workshop.

To try to involve the maximum number of stakeholders, all the information concerning the survey and the questionnaire has been published in social media (project website, LinkedIn, Twitter, ...).

As SO WHAT Tool end-users are not the general audience, a first section describing the global concept overview is included. After this general concept overview, a summary of the literature review concerning participatory methods and the approach to be used in the scope of this task is presented in section 3. Section 4 describes the considered roles, and the following section includes the questionnaire definition. Section 6 summarizes the information gathered from the online survey, the co-creation workshop and the face-to-face meetings with internal stakeholders, and section 7 presents the list of technical requirements derived from the information gathered from the end-users. Finally, the main conclusions are described.

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1 Introduction

1.1 Purpose and target group

The task linked to this deliverable (T2.1) is devoted to the definition of end-users' requirements, but following a participatory approach in order to provide a tool coherent with the users' needs.

Validation industrial sites and additional interested stakeholders have been asked about their specific needs for the recovery potential of industrial WH/C as well as about the desiderata of the dedicate techno-economic assessment tool that will be developed in the scope of the SO WHAT project.

One online survey and a dedicated event (workshop hold on December, 10th in Antwerp) has been held to give the possibility of explaining their needs to the maximum number of involved stakeholders.

All the information gathered from the surveys, the workshop and from multiple conversations with people from the validation industrial sites of the SO WHAT project have been summarized in this deliverable, and a preliminary list of technical requirements have been generated using all the information collected.

1.2 Relation with other activities of the project

The following tables described the step defined to guide the user requirements definition - Table 1 - and how this process will be performed along all the activities within Work Package 2 - Table 2 -.

Table 1 User requirements definition steps (T2.1)

Step description
Research into participatory methods and agreement on how they will be applied in this task
Definition and classification of possible end-user roles and the list of possible entities to be interviewed
Definition of the list of most relevant questions to be made
Preparation and realisation of a co-creation workshop to gather as much information as possible about the needs of the stakeholders regarding tools like SO WHAT ones
Generation of a Survey Monkey questionnaire to be sent to people not attending the workshop
Summary of the requirements drawn from the workshop and the questionnaire
Description of the technical requirements derived from the information gather from the online questionnaire and the workshop

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Table 2 Tasks with needs regarding user requirements

Description	Task
Modules specifications and update of existing tools.	T2.2
Transfer of technical requirements into IT framework and architecture definition	T2.3
Definition and selection of scenarios to be implemented regarding each use case	T2.4
So WHAT Simple Tool definition and development	T4.1
SO WHAT Software development	T4.2
UX and UI and final dashboard for non-technical staff of the simulation software	T4.5
Monitoring programme for demo cases	T5.1

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2 Global concept overview

This section contains information that can be useful to understand the context and the problems to be addressed by SO WHAT Tool. A preliminary general description of SO WHAT Tool is presented to give an overview of the initial scope identified for the software to be developed, and then an introduction to WH/C recovery and RES integration has been included. SO WHAT end-users are specific users directly related with WHR and RES and because of that this initial chapter is devoted to contextualize both concepts of waste heat recovery and renewables integration. All this information is crucial to comprehend the requirements that have been described in section 7.

Once the context and the problems to be solved were correctly understood, five groups of stakeholders have been identified as the most important end users to be addressed by the SO WHAT Tool:

- Industrial Facility: industries interested in selling waste energy, in internally reuse waste heat energy, in purchasing external waste heat energy, etc.
- Municipality / Regional Energy Agency /Public Authority
- Provider of equipment/services
- User/Operator of Waste Heat/Cold
- Academia, Associations and Research

2.1 General description of the purpose of SO WHAT Tool

Due to the nature of the SO WHAT Tool, there will be a modular approach to software development and the mandatory presence of several actors involved, a preliminary overview of the SO WHAT components is found in this sections. The SO WHAT Tool must perform the following functions:

- Model an industrial facility and identify potential with respect to waste heat, cool (H/C) and surplus RES
- Model the community and its assets (e.g. local RES, storage, flexible loads etc.) to understand the demand profile of the community, which can utilise the waste H/C and RES
- Identify the delivery mechanism(s) for how waste H/C and surplus RES can be provided to the Community and/or other industries and the technical, commercial, legal and financial incentives for doing so

The Tool will be available as a free and commercial version, the definitions of which are yet to be defined, however the workflow in Figure 1 below shows how the modular but integrated design of SO WHAT Tool will bring together different software presented as one user interface to offer the user a guided, intuitive and accurate platform that is above what is already available. The blue boxes in the diagram below are directly developed from IES software whereas the red boxes will be developed with the support of other partners.

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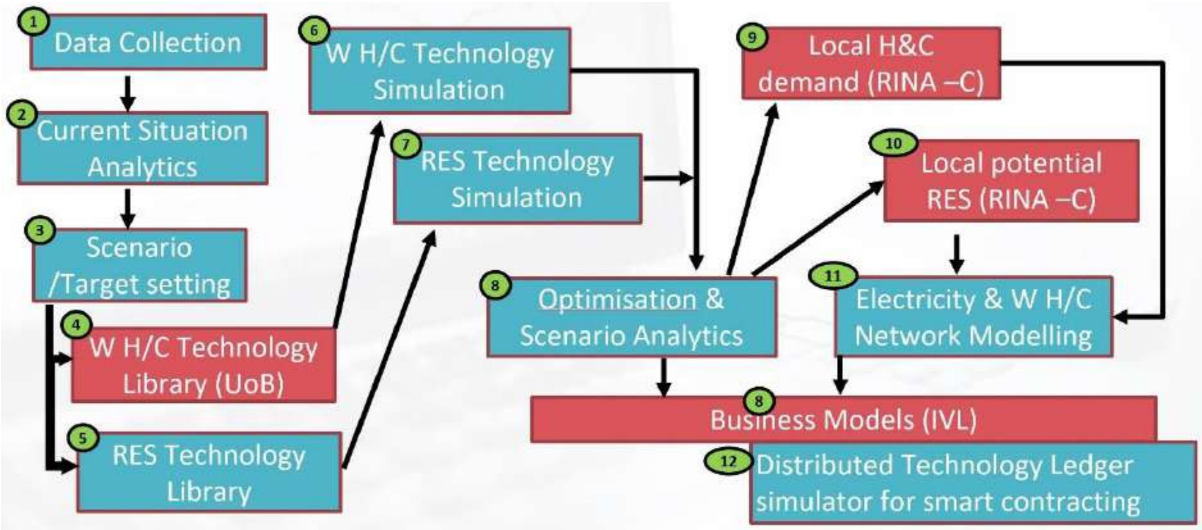

Figure 1 Proposed high level SO WHAT workflow

2.2 Preliminary description of WH/C recovery

All the thermal and mechanical processes always produce waste heat (WH). The biggest amounts of waste heat are lost in the industry and in the power generation processes. It is not easy to determine the exact figure of WH in the industry, but according to previous studies [1], it is estimated that between 20 and 50% of the industry energy consumption finally ends as waste heat. And it is also estimated that between 18 and 30% of this waste heat could be used.

On the other hand, sanitary hot water, space heating and other ways of process heating account for more than 50% of the energy use in the European Union. According to the European Commission data [2], the 70% of the energy used in the European industry is used for space and industrial process heating (193.6 Mtoe). In EU households, heating and hot water alone account for 79% of total final energy use (192.5 Mtoe). Therefore, as long as its recovery and use become technically and economically feasible, the waste heat may represent an important source of possible energy.

Previously in the Work Package 1 activities, a complete review of the possible estimations of waste heat potential in the EU has been made. Reported in the Deliverable 1.2 – "First release of SO WHAT industrial sectors WH/C recovery potential", there is a description of the two methods for estimating the waste heat potential across the EU found in the literature. The recoverable waste heat potential is calculated to be 187TWh per year by method 1 and 167TWh per year by method 2.

As can be seen in Figure 2, three main components are required to accomplish waste heat recovery (WHR): 1) a source of waste heat, 2) a recovery technology, and 3) an end use for the recovered energy.

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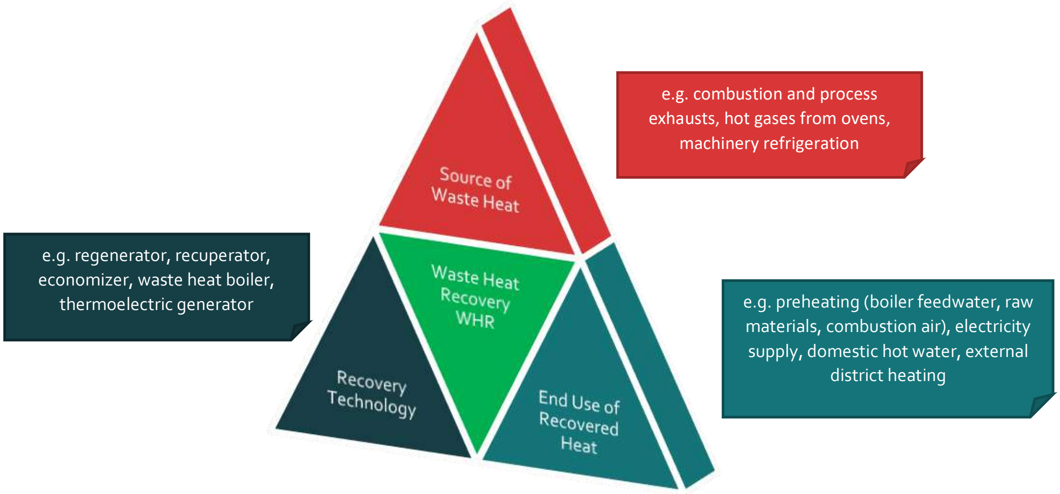

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Figure 2 Essential components for Waste Heat Recovery (WHR)

2.2.1 Sources of Waste Heat

Waste heat is generated along the industrial processes as a by-product in different forms like: combustion gases released into the atmosphere, heated water discharged into the environment, heated products at the industrial processes output and also heat transfer through the hot surfaces of the factories equipment and machinery. Therefore, the sources of residual heat differ among themselves in the physical state (mainly fluids or gaseous), the temperature ranges, their type of occurrence (constant or periodic based on manufacturing batches or seasonality) and of course the power thermal available.

Traditionally, three stages are considered within the energy cycle: energy conversion, energy distribution and energy use, where conversion losses and end-user losses represent possible sources of waste heat. Distribution losses are not usually considered as sources of waste heat but non-usable system inefficiencies. In this type of loss, improving the insulation is generally the cheapest and simplest way to recover heat. One possible example of conversion losses would be all the possible waste heat that is produced in steam boilers, air compressors or water chillers. Other example of end-user losses would be all the different types of waste heat that are produced in manufacturing furnaces.

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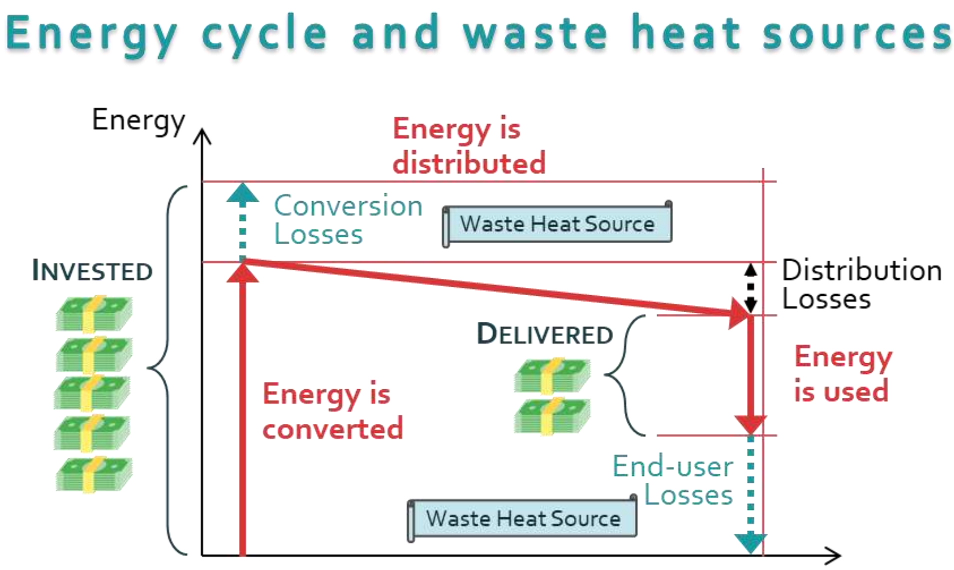

Figure 3 Industrial processes energy cycle

Most waste heat recovery devices transfer heat from a higher temperature effluent stream to another lower temperature inlet stream. It is possible to both increase the temperature of the inlet flow and also to transform the state of the inlet flow from liquid to steam, as in a boiler. These devices can be broadly named as heat exchangers. On the other hand, waste heat can be used by passing hot gases or steam through a turbine to generate electricity. Therefore, as a general rule, it can be considered that the "utility" of a waste heat will be determined by its temperature; the higher its temperature value, the higher its quality value.

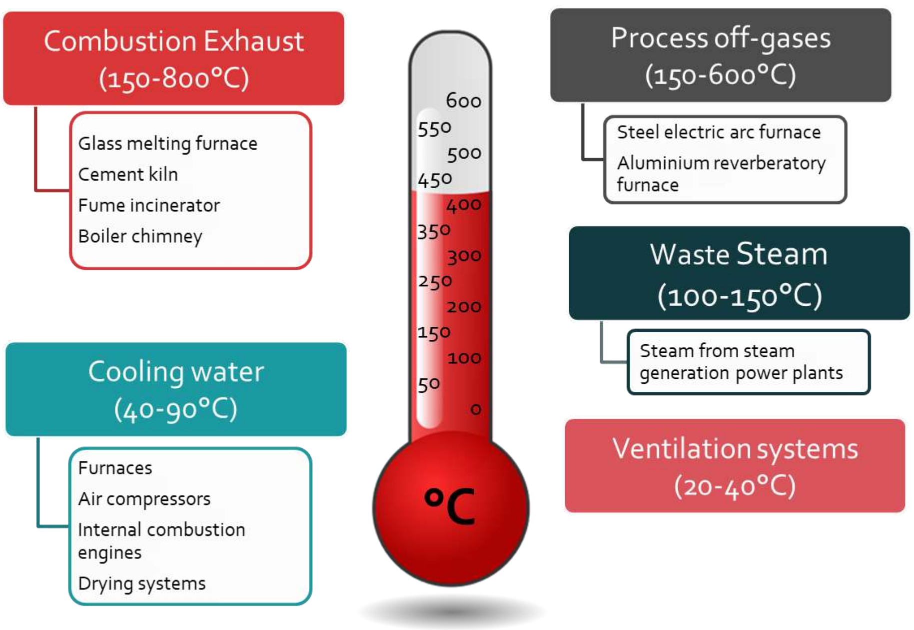

Figure 4 Industrial waste heat sources

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2.3 Recovery technologies

The equipment used for waste heat recovery must take into account parameters such as pressure and temperature operation ranges, waste heat source size (i.e. kW, MW), waste heat intermittency (i.e. batch process or continuous process). Additional aspects, such as the waste heat carrier (i.e. gas, liquid or solid) and the purity and corrosiveness and of the waste heat streams are interesting to be considered. The existence of impure and/or corrosive products or materials that could lead to phenomena such as fouling, chemical degradation and gradual wear&tear of the heat exchanger surfaces, pipes and auxiliary components (e.g. pumps). The presence of extreme values in any of the above parameters will probably mean the mandatory use of special design and materials and therefore higher implementation costs. In the market, there are different technologies available depending on the type and power of the waste heat source, the temperature ranges and the final use of the energy. Figure 5 shows the main technologies for using waste heat for various ranges of temperature and thermal power.

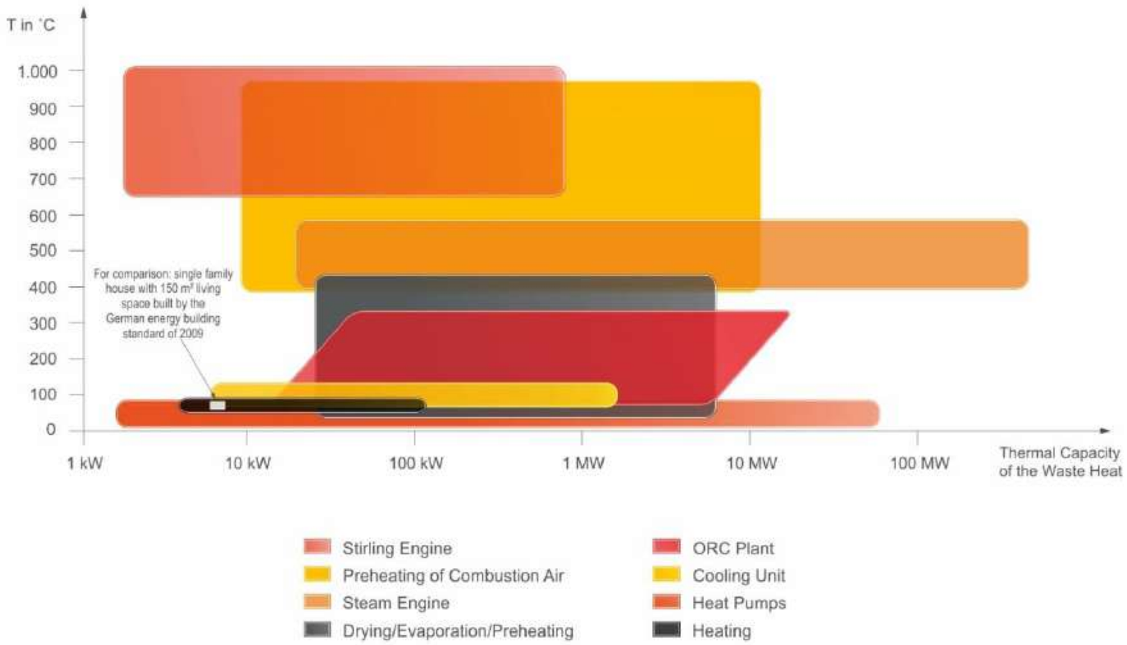

Figure 5 Categorization of waste heat utilization technologies (SOURCE: Sächsische Energieagentur GmbH)

As a first classification step, recovery technologies can be divided into electrical and thermal, depending on whether there is a conversion of energy types.

Generally speaking, the most flexible form of energy conversion seems to be electricity, which is easily transportable or can be exported to the electricity grid. However, low efficiency (especially at low temperatures) in the generation of electricity from waste heat remains a barrier that must be taken into account. The electrical conversion when the waste heat source has a temperature higher than 400°C is carried out with Steam Engines and Stirling Engines with a conversion performance usually ranging between 20 and 40%. On the other hand, with lower temperatures of the WH source

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(values between 80 and 250°C), it is possible to perform an electrical conversion with ORC (Organic Rankine Cycle) equipment, but in these cases the low conversion yields will oscillate around 10%.

Regarding thermal technologies, the Preheating of Combustion Air allows a very wide temperatures range for its applicability with very different performances depending on the possible cases. Analogous considerations can be done for the Drying / Evaporating / Preheating but with lower temperature ranges of waste heat.

When the temperature of waste heat stream is between 80 and 100°C there is the option of recovering the WH in the form of hot water at the temperatures necessary for space heating and DHW. The mechanism uses heat exchangers with nominal performances values ranging from 90%.

When the waste heat temperatures ranges between 80 and 200°C, it is also possible to recover energy for cold transformation using absorption cooling units. The conversion performance of this equipment depends on the waste heat stream temperature, the cold temperature that is required to be produced, and as well also the intermediate temperature of the corresponding cooling tower. Nominal Coefficient of Performance (COP) of these sorption chillers ranges from 0.5 in the case of simple effect chillers to 1.2 in the case of multiple effect chillers.

Finally, for the lowest values of the waste heat temperature, the possible option would be its recovery and valorisation through the use of Heat Pumps (to use the low temperature WH as a cold focus to generate a second stream of higher temperature through a Heat Pump (and its corresponding electrical input)). Like all HP, the electrical-thermal conversion efficiency is around 300%. Besides, it is important to emphasize that it will be required an electrical power (and therefore a consumption) of one third of the thermal capacity of the generated high temperature stream. It will not be a "free" recovery in terms of electricity consumption.

That taken into account, a specific module/database of relevant technologies will be included in the SO WHAT Tool, as its need has been highlighted.

2.3.1 End use of the recovered heat

Regarding the final use of recovered industrial heat, its use can be classified in two possible ways: internal use or external use.

When the internal use is considered, the industrial facility itself where the waste heat is recovered will transform and consume the recovered energy, whether it is in the form of heat or if it is transformed into other forms such as refrigeration or even electrical energy.

Additionally, the internal use can also be split in two possibilities of WH recovery: direct recovery to the original process or recovery with transfer to a second process within the original production facility. The first case would include the installation of economizers in steam boilers (feedwater economizers) or heat recovery exchangers to preheat the intake air to the furnace burners. The second case would include heat recovery in the compressors as well as any other heat recovery to be transformed into another form of energy such as electricity or cooling.

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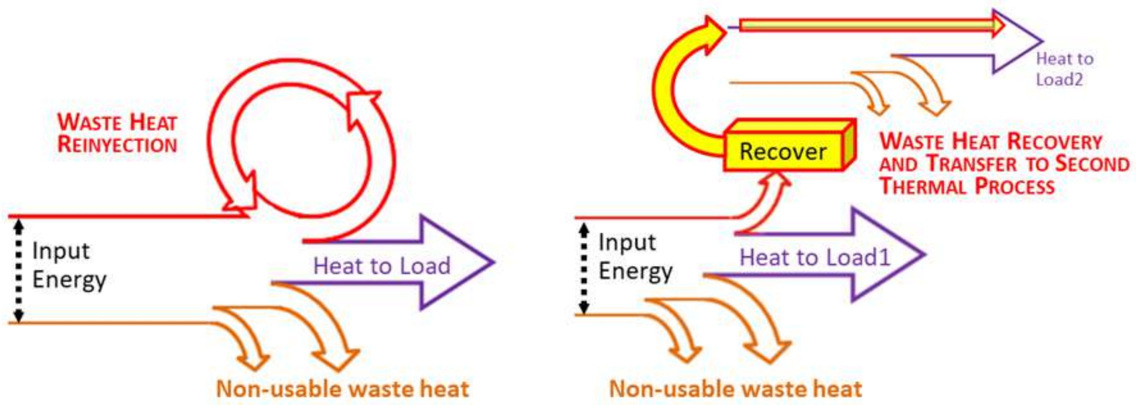

Figure 6 Schematic representation of direct WHR (left) and inter-process WHR (right)

The main advantage of the direct WHR is that the temporal synchronization (matching) between the production of waste heat and its reuse is naturally guaranteed. Whereas in the reuse in another process of the factory a certain simultaneity of both processes must be ensured previously throughout the production calendar.

In the external use – represented in Figure 7 -, which is often explored when the waste heat cannot be used internally in the origin facilities, the waste heat can be used by third parties such as administrative, commercial or residential buildings or even other industries. In this case, the first challenge is the adjustment or synchronization of the potential waste heat and the demand of third parties, since both will not always be time-matched. This scenario usually appears in those processes of EII (Energy Intensive Industries) industries (food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminium), and non-metallic minerals (primarily cement)) where are required huge quantities of high-temperature thermal energy and therefore the amount of waste heat exceeds the needs of this type of heat of the factory itself.

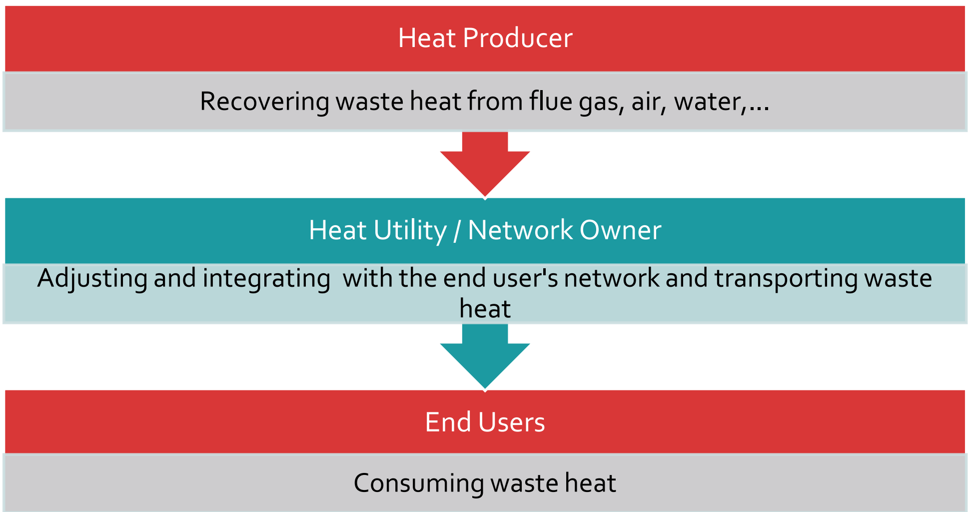

Figure 7 Schematic representation of an external use of WH recovery case.

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In addition, in this external use case there is the possibility of introducing intermediate actors (ESCOs) between heat producers and end users of the recovered waste heat. As an example, Figure 8 illustrates a situation in which an intermediate ESCO finances the installation of heat recovery systems in the factory and remunerates the heat producer for the recovered heat which is supplied to the heat utility or the owner of the heat network, which pays to the ESCO for the corresponding energy supply. Both the heat producer and the owner of the heat network do not make any initial economic investment, only receive an income (heat producer) or provide a payment (heat utility) based on the energy values provided or consumed. It is the ESCO that makes all the initial economic investments and recovers its investment based on the difference between the purchase price from the heat producer versus the sale price from the Network Utility.

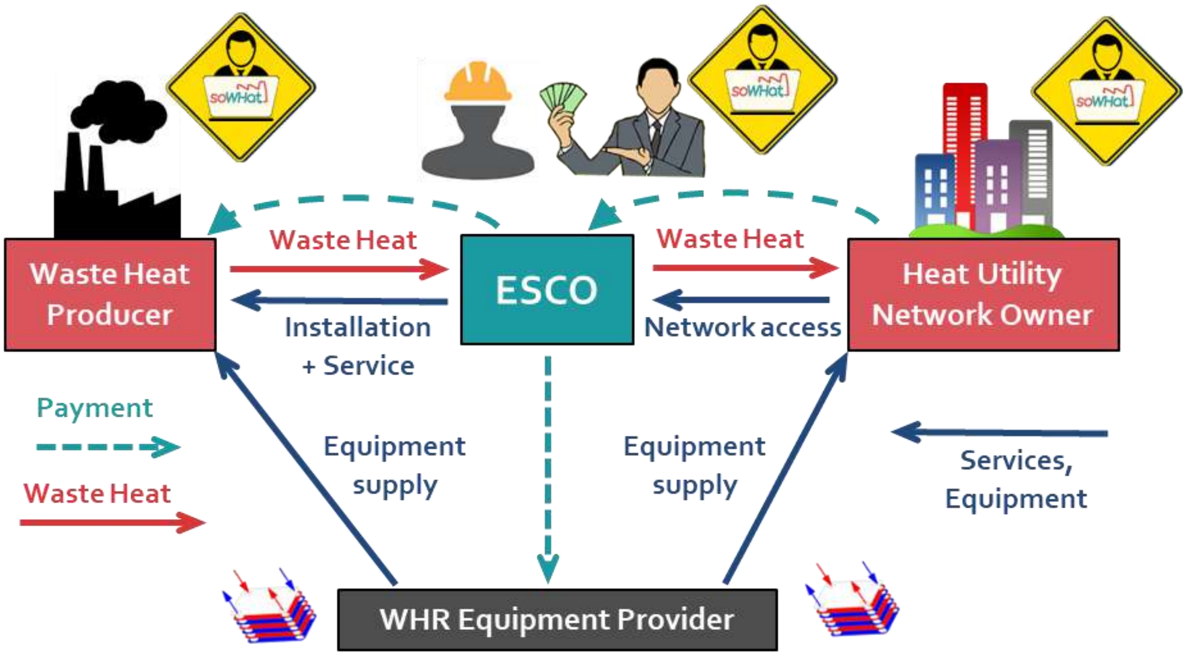

Figure 8 Schematic representation of a business model of a case of ESCO as an intermediary in an external use of WH recovery

Obviously, there are other possible business models where the ESCO company is dependent (belongs) on the heat producer or is dependent on the Heat Utility. In these cases, the heat producer or the heat utility partially or totally assumes the corresponding initial investments.

2.3.2 Practical aspects

Once ended the explanation of the waste heat recovery triangle and the corresponding three main components necessary for heat recovery, it is only worth mentioning that, from a practical point of view, the greatest challenge to implement a WHR is not to identify a source of heat, but to find the appropriate "heat sink" for it. In other words, finding the "end use" for the recovered heat.

Some of the questions that must always be asked before considering the design of a WHR project could be the following: Where will you use the recovered heat?, Is the heat sink close or far from the waste heat source?, Is the heat sink appropriate for the heat source temperature?, Will heat sink and heat source operate at the same time, all the time?, Will its volume vary considerably, and often?

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And, specifically for the case where the waste heat source is an exhaust stream, some additional questions must also be prompted: What is your exhaust?, Does your exhaust contains particles that can accumulate inside the heat exchanger? Or anything corrosive?, Will the heat sink cool the exhaust below dew-point?

The question to solve is not whether Waste Heat Recovery is a good or bad thing, the question should be: What waste heat is worth recovering?

These are the questions that the Tool is aiming to solve and the various aspects to be considered in the software development phase.

2.4 Preliminary description of Local RES integration

According to the IPCC 5th assessment report [3], the industrial sector is one of the biggest energy consumers (28%) and greenhouse gas (GHG) emissions contributor worldwide (30%). Industry must play a very important role in the GHG emission reduction through the reduction of its energy consumption and it carbon footprint. The integration of renewable energy systems in the industry facilities is one way to achieve the desired reductions.

RES integration in industrial asset brings different benefits to the industrial players, beyond what could be expected from the simple purchase of renewable power. The motivation of the industrial players vary widely depending on multiple factors like location, energy needs, type of company and external regulation. For instance, in integration of RES in B2C industries is more often boosted by drivers like corporate image or long-term sustainability business than in the case of B2B industries. Companies developing RES projects on off-grid industrial sites are usually driven by the reliability and the cost of their fuel supply to be replaced with the RES system.

2.4.1 Renewable Energy Technologies

Within the activities of the WP1 (Industrial sites assessment and technology database) it is being performed a detailed assessment of the potential for local renewable energy source (RES) generation and integration, for both heat supply and electricity generation, at the industrial plant sites. All the information collected in the aforementioned activities will be collected in Deliverable D1.6, but a preliminary list of sources and technologies for which it will be possible to estimate potential using SO WHAT Tool has been included here in order to provide some kind of previous contextualization.

As shown in Table 1, renewable energy technologies can be classified in three-generation clusters depending if they are used for electricity generation, heat generation or cold generation. The most frequent use is usually electricity or heat generation, while cold generation was traditionally achieved through the joint utilization of solar thermal panels and sorption chillers. In the last years, due to the huge decrease of the PV panels price, it is also being considered the joint use of PV panels with electric compressor chillers as a renewable cold generation system.

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Table 1 RES Technologies classification

Electricity	Heat	Cold
Photovoltaic	Solar process heat	Solar thermal cooling
Concentrate Solar Power	Solar thermal collectors	Solar electric cooling
Wind turbines	Solar concentrators	
Hydro Electricity	Air collectors	
	Geothermal	
	Biomass	
Hybrid solar panels (PVT)		
Cogeneration with biogas (CHP)		
Solid cogeneration (Pellets, Wood, chips, Urban Waste)		

The renewability impact depends on the renewable energy potentials and energy prices of a specific location. With the exception of biomass, that could be exported and imported from other regions or even other countries, the renewable energy potential will depend basically on the specific climate conditions. The analysis of weather data like temperature, humidity, solar radiation and wind conditions will provide an assessment of the feasibility and impact of various possible renewable energy sources.

The introduction of electricity generation RES in industrial facilities is constantly increasing, especially through the installation of PV panels on top of the factory roofs. The main advantage of these RES assets is the non-practical dependence on the particularities of the manufacturing industrial processes. In other words, the most relevant parameters to be consider in the global feasibility study are: available roof surface, grid connection normative, surplus energy trading regulations, investment and payback restrictions, insurances, etc. Other parameters like factory energy consumption, energy demand curves, production calendars and so on will affect the economic feasibility but not the technical feasibility.

The rooftop PV plant will produce energy, depending on the solar radiation climatic values and the produced electricity will be self-consumed by the factory or exported to the national grid with some kind of economic revenue like feed-in tariff or later compensation. The above mentioned relevant parameters will affect the profitability of the RES implementation but, in general terms, the technical specifications of the manufacturing processes will not be determinant. In one phrase: the specific processes (electric) under the factory rooftop do not determine the technical feasibility of the renewable electric system (as long as selling electricity to the grid is allowed).

However, regarding the use of solar thermal RES things will be completely different since all the renewable thermal energy generated cannot be "sold to grid" and therefore it must be consumed by the industrial facility, with the exception of rare cases. This means the renewable thermal energy generation must be fully adapted to the industrial facility thermal energy requirements in terms of quantity, in terms of quality (temperature) and also in terms of its availability distribution along the

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time. In this case, the specific processes (temperature requirements) under the factory rooftop determine the technical feasibility of the renewable thermal system.

As explained before, due to the universal exchange capacity of the electricity versus the quality (temperature) specificity of the thermal energy, the integration of renewable heat into the core industrial process is more complex than the renewable electricity integration. Heat projects require advanced feasibility studies to design and size the connection between the heat generation asset and the production process.

Based on International Energy Agency (IEA) in task 49 [4] about Solar Heat for Industrial Processes (SHIP), it says 120 operating solar thermal systems for process heat are reported worldwide, with a total capacity of about 88 MW_{th} (125,000 m^2). There is great potential for market and technological developments, as 28% of the overall energy demand in the EU27 countries originates in the industrial sector, majority of this is heat of below 250°C.

According to a study found in [5], around 30% of the total industrial heat demand is required at temperatures below 100°C and 57% of this demand is required at temperatures below 400°C. The heat demand below 100°C could theoretically be met with solar thermal systems using current technologies, if suitable integration of the solar thermal system can be identified. With technological development, more and more medium temperature applications, up to 400°C, will also become market feasible.

Finally, biomass is derived from organic material such as trees, plants, and agricultural and urban waste. It can be used for heating, electricity generation, and transport fuels (like bio-ethanol). Biomass is the most stable and the only manageable renewable energy, without depending on variable factors such as wind or water.

Biomass is considered a renewable energy source because its inherent energy comes from the sun and because it can regrow in a relatively short time. Trees take in CO_2 from the atmosphere and convert it into biomass and when they die, it is released back into the atmosphere. Whether trees are burned or whether they decompose naturally, they release the same amount of CO_2. The idea is that if trees harvested as biomass are replanted as fast as the wood is burned, new trees take up the carbon produced by the combustion, the carbon cycle theoretically remains in balance, and no extra carbon is added to the atmospheric balance sheet - so biomass is arguably considered "carbon neutral." Since nothing offsets the CO_2 that fossil fuel burning produces, replacing fossil fuels with biomass theoretically results in reduced carbon emissions, as shown in Figure 9.

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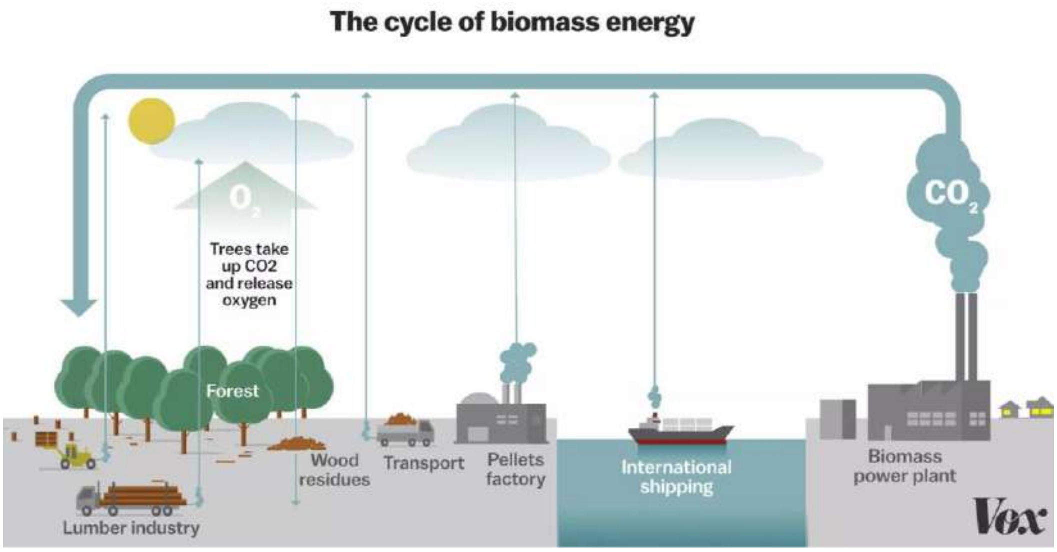

Figure 9 The cycle of biomass energy and CO2 (Source: VOX)

However, for biomass to be effective at reducing greenhouse gas emissions, it must be produced in a sustainable way. Biomass production involves a chain of activities ranging from the growing of feedstock to final energy conversion. Each step along the way can pose different sustainability challenges that need to be managed. Currently there is a lot of ongoing debate and controversy about the real future sustainability of the biomass energy.

2.4.2 RES Integration schemes

The review of examples of existing RES integration projects reveals a wide array of integration schemes, from simple and investment-light projects to more complex mixed projects performing bigger reductions in terms of energy consumption and emissions, that will be further analysed in T3.1.

· *Green power procurement with a third party power producer on the industrial factory premises.*

The industrial actor is freed from any responsibility regarding the initial investment, building and operation of the RES asset. It is a third party the one that takes that responsibility through a long-term power purchase agreement (PPA) between the third party and the industrial actor. The industrial player does not require hiring expertise personnel with knowledge in designing, building and operating RES facilities.

· *On-site installation of fully owned and operated renewable power generation system*

The renewable asset is fully owned and operated by the industrial actor. This way the integration level is increased since all the risks are taken over by the industrial actor and no kind of complex negotiation with external parties are required. The biggest disadvantages of this case are the high upfront investment cost, the impact on the company's net revenues and the mandatory need for technical skills (additional personnel) to design, build and operate the new RES facility.

· *On-site installation of RES production system and factory process adaptation*

The biggest share of the total final consumption in the manufacturing industry comes from the process energy and not from the auxiliary services. Therefore, in order to have a significant impact in

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the GHG emissions, it is needed to integrate the RES assets with the industrial core processes and have them both adapt to each other. Modifying the production assets requires more expert operational skills in order to improve the feed between the RES assets and the production assets. The most typical example is the replacement of the factory steam heating systems with hot water heating systems in order integrate solar thermal plants into the core production processes.

· *Circular economy Paradigm: renewable raw materials and energy and by-products valorisation.*

This is probably the highest level of integration of renewables in an industrial factory. In this case, not only the RES is integrated into the production processes – as in the previous case-, but is also considered the whole product value chain. The use of renewable raw materials is included in the products and the possible process by-products are further used for secondary energy like, for example, woodchips by-products, solid biowaste or biogas generated from the facility production by-products.

Figure 10 shows a schematic representation of how the complexity is increased in the evolved models versus the simplest models.

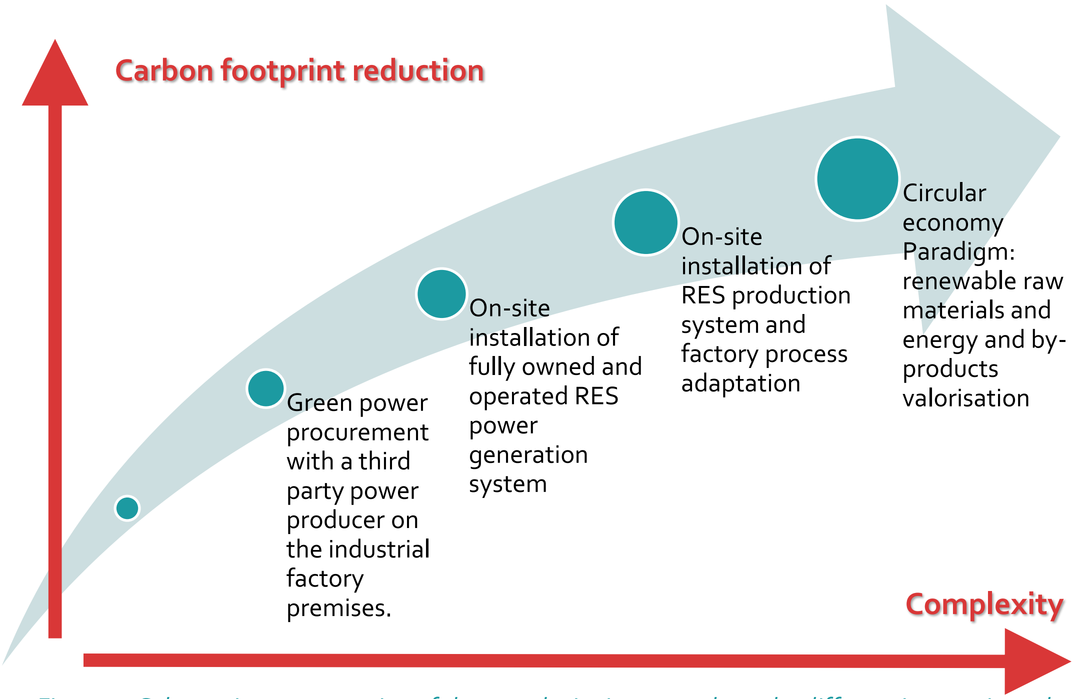

Figure 10 Schematic representation of the complexity increase along the different integration schemes

2.4.3 Main barriers for integration of RES on industrial sites

Nowadays Europe is leading the economy decarbonisation policies and pushing for a deeper penetration of the renewable power generation inside the European energy mix and also some adaptation of the demand curves to this new energy generation status. The massive introduction of renewable assets into the industry sector is also desired, but in this case some different barriers and issues that hinder the RES deployment have been identified. Obviously, the double diversity in terms of both national-situations and industrial sectors-sizes produces multiple barriers that do not affect simultaneously to all the possible industrial actors. The most general barriers are detailed next: It is

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important to remark that the list of barriers presented next is a preliminary list used for contextualization purposes while Deliverable 3.2 will provide a more detailed and rigorous study of the barriers but also technical feasibility and profitability of the RES integration in industrial environment.

· *Low energy density*

Except biomass, renewable energies in general require big areas to produce large power levels. On the other hand, big industrial plants occupy big land surfaces, but not always the occupied area is suitable to receive renewable installations. Restrictions like lack of physical access, weight load limitations of the rooftops, presence of oxidative/reactive chemical products in the air, shadows or other physical or legal restrictions will reduce the real effective surface available for deploying renewable generation systems.

In the case of energy intensive factories, the use of all the available surface will only provide a small amount of the factory energy consumption. However, in the case of manufacturing companies with big and extended buildings devoted to the raw material and end-product storage, this restriction might be less important.

· *Energy production regulatory regime*

The regulatory regime must allow the production of electricity or heat by independent players. This authorization could be only theoretical if the administrative and normative complexity impede (*in real life)* industrial actors from producing their own renewable energy.

Once the authorisation for (electric) energy production has been achieved, the surplus energy trading rules will affect the profitability of the RES asset. For instance, when normative complexity limits the ability to sell the extra energy and improve the RES return on investment. Alternatively, in the case of self-consumption installations, the mandatory installation of zero-injection systems instead of net balance metering systems will also reduce the ROI.

These regulative restrictions will affect much more to the SMEs than the big industrial companies since the ability of a company to participate in the power trading will usually depend on its size as will require, for sure, having a dedicated energy department and the internal adequate skills.

· *Operability and Integration*

The operation of an energy producing facility will be quite different from the traditional activities of the manufacturing plant, so industrial actors will need to recruit new specific profiles with skills and experience in the energy generation business. Again, this human resources strategy might be quite expensive for SMEs and only big industrial players with large scale RES projects might afford it.

Industrial installations and industrial processes could require important modifications in order to integrate RES assets. Especially in the case of renewable heat, it might require to be able to respond steadily to heat demands. In addition, it will probably require a backup heat delivery and some kind of thermal storage plan.

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The addition of the new RES asset, while maintaining the previous fossil fuel energy production adds complexity and cost in terms of operation and maintenance.

· *Investment*

RES integration projects increase capital expenditure (CAPEX) versus to power purchase and therefore require higher up-front investment costs than traditional fossil fuel generation units or direct and simple electricity grid connection.

Industrial financial managers might lack the equity capital needed to invest in the RES production asset, or even in case of having such investment capability, they do not authorize it since it would negatively affect the company financial ratio.

A possible solution to this problem is the introduction of a third party power producer. This way, the factory CAPEX will be transformed into operation and maintenance cost (OPEX) through the third party investment mechanism. This way, the high amount of investment is transferred to the third party.

· *Return on investment*

The usual specificity of RES projects is their high CAPEX, low OPEX and long lifetime, which logically returns paybacks (longer than 5 years) that are far much longer than the usual return on invested capital of production assets.

If the non-financial benefits (like improvement of the company environmental public image or GHG reduction taxes decrease) of deploying the RES asset does not compensate the "perceived" lack of competitiveness, industrial companies will probably not authorise such investment.

Again, the introduction of a third party power producer allows to transform CAPEX into OPEX and therefore reducing the payback time.

In most cases, larger installations benefit from "scale economy" and offer better economics than smaller installations. Again, this is a disadvantage of SMEs versus big industrial installations.

· *Risk and Insurance*

The assurance of the energy supply continuity is a key element for most industrial actors. The additional costs of restarting production due to an energy supply interruption can frustrate the benefits from energy savings of the RES deployment.

Companies may consider a risk in implementing intermittent energy sources that require back-up solutions such as diesel generators add an extra layer of complexity to energy management of the facility.

RE assets have a long time horizon of more than 20 years whereas industrial production facilities can be downsized, shut down or relocated much faster if the evolution of the political situation or the market cycles requires it.

· *Contractual scheme complexity*

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Contractual complexity regarding grid connection can prevent industrial partners considering direct implementations. On the other hand, there is also specific contractual complexity between the industrial prosumer and the third party power producer and the utility. Again, this layer of complexity will affect much more to the Small and Medium Enterprises (SMEs) than to the big companies that might already have an in-house legal department capable of dealing with this extra task.

For heat in particular, there are currently no standard contracts for heat purchase since heat is not a standardized commodity like electricity (its quality depends on pressure and temperature).

· *Technology maturity*

Dominant RE technologies (solar, wind, geothermal, biomass…) are now mature and considered as such by industrial managers and investors. However, other technologies still require development (power to gas and tri generation). Investing in non-mature renewable technologies carries specific risks that industrial players are probably not willing to take.

Although innovation is widely regarded as a positive value for companies, investing in non-mature technologies can hurt one's public image. When the required research & development programs come at a very high cost, this can be seen negatively by shareholders and financers as it reduces short term gains and increases long term risk in the case of failure. For instance, due to the current controversy about biomass, companies investing in biomass RES assets might be affected their public image in the future.

· *Awareness*

Industrial companies lack awareness regarding support mechanisms (like incentives or guarantees), costs and best practices, which appears to be crucial in filling the gap between simple knowledge of the subject and engaging in concrete implementation on the ground of RES projects. Banks and insurers also require this cost and risks information for financing and insurance.

Talking about project implementation, the diffusion of feedback regarding decision progress, RES asset integration and project management would be a great help to facilitate future RES projects. However, this knowledge of design and operation best practices information is hardly ever communicated between industrial actors. Awareness issues cannot be addressed without sharing knowledge.

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3 Definition of Participatory methods

3.1 Summary Literature Review

A brief literature review has been carried out to count with enough information to properly guide the activities to be accomplished in the scope of T2.1. Information about co-creation, workshops leadership and online surveys definition has been gathered to guarantee that all the activities have been developed the correct way.

As stated in [6], the beginnings of contemporary Participatory Design lie in the restless days of the various social, political and civil rights movements in the 1960s and 1970s, when people demanded an increased say in important decisions. At this time too, the Participatory Design of information technology was created in Europe, and especially in Scandinavia as part of the named "workplace democracy movement". The active involvement of the future end-users' was central to define the technology to be developed.

Participatory design (PD) is an approach to the design where the designers invite future end-users' to participate in all phases of the design process [6]. Participatory design is different from user-centred design, because in user-centred design the user is not really part of the design team, while in participatory design the user becomes a critical part of this process. The words wrote by Robert Jungk in the closing comments of the resulting publication of the conference held in 1971 by the Desing Research Society give an idea of the potential of participatory design: 'we could talk not (only) about participation at the moment of decision, but about participation at the moment of idea generation' [8].

As participatory design allow end-users' to play an active role in the design process, end-users' move from being passive informants to having an active role (very valuable and acknowledged by the rest of the stakeholders) [9]. That way, participatory design is a win-win process of mutual learning for both designers and users. On the one hand, it gives the ones that will use one technology the opportunity of having a voice in its design and, on the other hand, it allows design professionals to help people without technical knowledge in defining what they want from the design process and understanding what is technically feasible [9]. 'Participatory design is driven by social interaction as users and designers learn together to create, develop, express and evaluate their ideas and visions' [9]. In the scope of SO WHAT project, it is extremely important to define and develop viable and usable software tools, totally aligned with the main aims of the most involved stakeholders, and that is why participatory design plays a key role to define the main requirements for the SO WHAT Tool.

In this deliverable, we explain the activities done regarding end-users' involvement in the requirements specification of the tools to be developed in the scope of the SO WHAT project. As explained in [9] [11], participation is a wide variety of methods and techniques focused on including users and stakeholders in the design process of a project.

3.2 Approach used for this task

As stated before, a workshop has been held and an online survey has been sent and made available through the website to related stakeholders not attending the workshop to try to obtain as much information as possible.

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First, a list of relevant roles to be considered in the scope of this task was generated and then, all the partners involved in T2.1 were encouraged to send the online survey to their main contacts concerning the defined "interesting roles" and to send invitations to the workshop to stakeholders near Antwerp.

Then, the main partners involved in T2.1 carried out a collaborative work to define the list of questions to be included in the survey. A first "brainstorming" online session was organized to obtain a first list of all the suggested questions. Then, this initial list of questions was refined (collaborative work again) to delete "not needed" queries. Both technical and non-technical people (including people from SIE, to have the point of view of "dissemination experts") were involved in this process to try to consider as much points of view as possible.

Later on, the co-creation workshop was defined based on the aforementioned literature review and the contributions from the main partners involved in T2.1. In order to ensure that the people attending the workshop were able to understand both the objectives of the session and the contribution required, a PowerPoint presentation was generated and used to introduce the workshop to its attendees, explaining the scope of it and the activities to be carried out during the workshop.

Other important issues to be taken into account when setting up a workshop are the following:

- To ensure that there is access, space and facilities to suit everyone who is going to be attending
- To lay out the seating in such a way that people can work in small groups but also easily communicate with the whole group
- To ensure that there is somewhere to attach all the copious number of sticky notes that will capture every contribution from the attendees

Therefore, smaller working groups has been organised in order to give everyone the opportunity to discuss and let hear his/her voice. Once the brainstorming sessions were held and all the information was been collected, the leaders of the different groups prepared a presentation with the most important outcomes. Then, they presented the outcomes to all the attendees, and everyone had the opportunity of adding something, change "misunderstandings" and so on. Last, a final/voting process was held to find out the most important requirements.

Concerning the online survey, it is important to be sure that it is correctly defined, because asking the wrong questions or sending a too long survey will generate limited or not useful results.

Before starting to define an online questionnaire, it is important to define what the objective or goal of the survey is. Another important (very, very important) issue is to keep the questionnaire as short and interesting as possible. Besides, it is key to avoid intricate questions, and to try to incorporate a few questions that require an open-text answer. Leading questions have to be avoided, because it is not a good idea to direct the responders in any way.

Using an online questionnaire creator is the best way to create an online survey because it is easy to use, it is inexpensive, it supports a variety of question types, it provides valuable insights (most online questionnaire creators both store and tabulate the response data automatically) and it reduces the possibility of human error.

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3.2.1 Workshop

Based on literature review, the participatory approach defined for the workshop was based on "putting people in the shoes of different roles".

People attending the workshop were divided into groups. Each group worked "alone" on giving answers to the list of questions, and then, group leaders gave a summary of the information obtained within each group.

During this "work in groups" process, some materials were available to be used:

- Sticky notes (answers/requirements were written on them and then each sticky note was put in each "place" as "essential", "important" o "additional" requirement). A5 tables (see Figure 11) were designed and printed to be used to place the sticky-notes-requirements on them.

essential	important	additional

Figure 11 Requirements table used during the workshop

- Pens and pencils
- Tables and chairs placed in groups
- Stickers with everyone's name

Below - Figure 12 - some images from the workshop can be found, showing firstly the general presentation and after the working groups during the discussion.

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Figure 12 Pictures from the co-creation workshop

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3.2.2 Interviews to be sent by e-mail

Once the final list of questions was designed, it has been decided to send them using an online survey tool (SurveyMonkey[2] in this case). SurveyMonkey is an online survey software that helps to create and run professional online surveys. It is a very powerful and well known online application.

SurveyMonkey presents all the tools necessary to create strong and professional surveys easily. The free pricing plan gives access to the basic tools needed to create surveys, and that was the one used to create the online survey in the scope of T2.1.

The basic plan allows the user to have 10 questions per survey (enough in our case) with a maximum of 100 responses per survey. Using the web interface, users can choose from 31 survey templates and 15 types of questions.

The survey can be administered and sent to users via a number of ways (a link was used in this case, sent in an e-mail). Analysis of the answers happens in real time, and results are viewed as respondents complete their surveys.

[2] https://es.surveymonkey.com

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4 Description of the considered roles

As stated before, the identified roles that might become SO WHAT Tool users have been clustered in the following five types:

- Industrial Facilities
  - Industrial Facilities (interested in sell waste heat energy)
  - Industrial Facilities (interested in internally reuse waste heat energy and renewable energy)
  - Industrial Facilities (interested in purchase external waste heat energy and renewable energy)
- Municipalities / Regional Energy Agencies /Public Authorities
- Providers of equipment/services (without risks associated to final energy savings; they only sell the design project or the machinery)
  - Energy Audits Companies
  - RES equipment sellers
  - WH/C recovery equipment sellers
  - Industrial Integrating Engineering Companies (Consulting firms)
- Users/Operators of the Waste Heat (with risks related with the behaviour of the energy savings. Make initial investment and have their payment (ROI, Turnover) associated to energy consumption or energy savings or both...)
  - DH Operators
  - ESCOs
  - Investors
- Academia, Associations and Research
  - Universities
  - Associations
  - EU projects

Those are the roles considered in the scope of the online survey, but they have been reduced to the three most important ones in the scope of the co-creation workshop (otherwise, there would not have had enough time to carry out the co-creation workshop as it has been defined).

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5 Questionnaire definition

This chapter includes the final list of questions that have been created after a continuous improvement process carried out by RINA-C, IESRD and CAR. Although those questions are just a guide of the information to be gathered during the co-creation workshop, an online survey has been generated to gather information from stakeholders not attending the workshop, so all the information given in [6] has been used to create a questionnaire "easy to fill-in" and to try to receive as much answers as possible.

Long lists of questions have to be avoided when talking about online surveys and, often, a short questionnaire with carefully thought out questions will get high response rates and provide better quality data. In addition to thinking about the questions, issues regarding how to analyse and stratify the results have to be taken into account. Besides, a big important issue to be considered is not to compromise responders' confidentiality and sensitive data were not required.

As stated in and [7] and [10], the key design principles to create a questionnaire are the following:

- Keep the questionnaire concise and focussed on the main objectives that have been identified.
- Make the questions "easy to be answered" (clear and unambiguous)
- Ask the right types of questions

Besides, it is important to give the user information about the questionnaire itself (a paragraph has been included in the online questionnaire explaining about these issues):

- The purpose of the survey
- What are the results going to be used for?
- How to deal with confidentiality

The final list of questions included in the online survey is the following one:

1. What kind of entity are you part of?
    a. Industrial Facility
    b. Municipality / Regional Energy Agency /Public Authority
    c. Provider of equipment/services
    d. User/Operator of Waste Heat/Cold
    e. Academia, Associations and Research

    Please, specify your role in this entity:

2. How aware are you about Waste Heat and Waste Cold (WH/C)?
    a. I have no idea about WH/C
    b. I have a vague idea about WH/C, where there might be a potential but not how to exploit it
    c. I am aware of WH/C, but I am not so familiar with the ways to exploit it.
    d. It is a focus of the company/institution I am working on, and I am aware about the potential of these two flows and ways to exploit it.

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3. Have you ever performed an analysis of the feasibility of including a kind of Waste Heat and Waste Cold exploitation technologies? If so, what kind of activities did you do? What indicators did you use to evaluate the different possibilities?
4. Ignoring economic issues, what might be you main technical considerations for introducing in a company/city/facilities external recovered WH (or renewable energy sources - RES)?
5. SO WHAT main objective is to develop and demonstrate an integrated and easy-to-use tool which will support industries, energy utilities, municipalities and other stakeholders in selecting, simulating and comparing alternative Waste Heat and Waste Cold exploitation technologies that could cost-effectively balance the local forecasted H&C demand also via Renewable Energy Systems (RES) integration.

   Have you ever used a software tool similar to the aforementioned one? If so, what are the most interesting functionalities of this tool you used? Did you miss any functionality?

6. What would you expect from a kind of software tool as the one mentioned in the previous questions?
7. In your opinion, what kind of roles of your organization would be interested in this kind of software tools?
   a. Managers group / Decision-makers
   b. Energy management department / higher level technics
   c. Maintenance team / technics
   d. R&D?
8. What kind of information would you be willing and able to provide about the company/city/facilities to feed the software tool and let it provide you with its functionalities?
   a. Building layouts / factory geometry
   b. Manufacturing process
   c. General energy flows
   d. Detailed energy flows
   e. Energy bills
   f. Production Schedules
   g. Monitoring data
   h. GIS based datasets
   i. Energy consumption data apart from the industry
   j. Others
9. What are your expectations regarding documentation, training lessons and training material?
   a. It will be enough with a user manual.
   b. Online training material (manual, tutorial, webinars, etc.)
   c. Face to face training lessons
   d. Other
10. What would be the boundary of your analysis
    a. Few processes/part of the company/institution under analysis
    b. The entire premises of the company/institution under analysis
    c. The company/institution under analysis and neighbouring ones
    d. The company/institution under analysis and larger surrounding area

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e. Other

Once the set of questions to be included in the survey have been designed, a Survey Monkey questionnaire has been created (available at https://es.surveymonkey.com/r/N8D7GFR).

Although the online questionnaire has been designed to be as brief as possible, a "long" list of questions have been generated to try to cover more issues when using these questions during the workshop or face-to-face meetings with internal stakeholders (partners of the project).

1. How aware are you about Waste Heat and Waste Cold (WH/C)?
    a. I have no idea about WH/C
    b. I have a vague idea about WH/C, where there might be a potential but not how to exploit it
    c. I am aware of WH/C, but I am not so familiar with the ways to exploit it.
    d. It is a focus of the company/institution I am working on, and I am aware about the potential of these two flows and ways to exploit it.
2. Have you ever performed an analysis of the feasibility of including a kind of Waste Heat and Waste Cold exploitation technologies? If so, what kind of activities did you do? What indicators did you use to evaluate the different possibilities?
3. Do you have any RES installed and/or have you considered to analyse such investment? In which stage of the analysis you might have benefit a tool?
4. Ignoring economic issues, what might be you main technical considerations for introducing in a company/city/facilities external recovered WH (or renewable energy sources - RES)?
5. SO WHAT main objective is to develop and demonstrate an integrated and easy-to-use tool which will support industries, energy utilities, municipalities and other stakeholders in selecting, simulating and comparing alternative Waste Heat and Waste Cold exploitation technologies that could cost-effectively balance the local forecasted H&C demand also via Renewable Energy Systems (RES) integration.

    Have you ever used a software tool similar to the aforementioned one? If so, what are the most interesting functionalities of this tool you used? Did you miss any functionality?

6. What would you expect from a kind of software tool as the one mentioned in the previous questions?
7. How do you think an integrated simulation tool like SO WHAT could help to increase your benefits (concerning sales of your products/services, benefits for your city, cost reduction in your company, ...)?
8. In your opinion, what kind of roles of your organization would be interested in this kind of software tools?
    a. Managers group / Decision-makers
    b. Energy management department / higher level technics
    c. Maintenance team / technics
    d. R&D?
9. What kind of information would you be willing and able to provide about the company/city/facilities to feed the software tool and let it provide you with its functionalities?
    a. Building layouts / factory geometry

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   b. Manufacturing process
   c. General energy flows
   d. Detailed energy flows
   e. Energy bills
   f. Production Schedules
   g. Monitoring data
   h. GIS based datasets
   i. Energy consumption data apart from the industry
   j. Others
10. What are your expectations regarding documentation, training lessons and training material?
    a. It will be enough with a user manual.
    b. Online training material (manual, tutorial, webinars, etc.)
    c. Face to face training lessons
    d. Other
11. What would be the boundary of your analysis
    a. Few processes/part of the company/institution under analysis
    b. The entire premises of the company/institution under analysis
    c. The company/institution under analysis and neighbouring ones
    d. The company/institution under analysis and larger surrounding area
    e. Other
12. What level of sophistication do you expect (you can handle) without the intervention of experts and consultants?
13. Please, try to describe how do you think it would be a "usual use case / usual sequence of use" of the software tool?
14. Do you think the inclusion of detailed examples of successful implementation of WHR or RES in the tool would help your organization in the decision making process? Would your organization will to collaborate by providing such detailed information?

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6 Summary of the information gathered from the survey, the co-creation workshop and the face-to-face meetings with some internal stakeholders

6.1 Summary of the information gathered from the answers online survey

The survey has received 35 answers, which contents were summarized below.

1. What kind of entity are you part of?
    a. Industrial Facility
    b. Municipality / Regional Energy Agency /Public Authority
    c. Provider of equipment/services
    d. User/Operator of Waste Heat/Cold
    e. Academia, Associations and Research

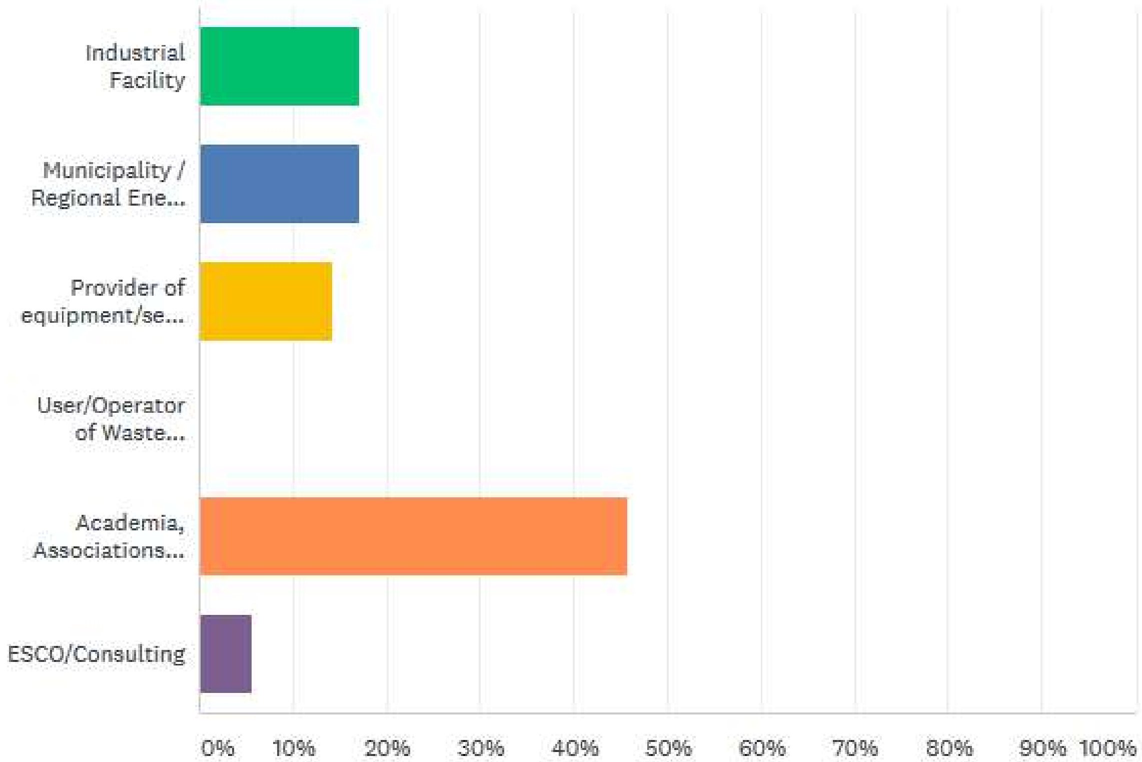

Figure 13 Answers to question 1 - What kind of entity are you part of?

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Table 2 Answers to question 1 - What kind of entity are you part of?

What kind of entity are you part of?		
Industrial facility	18%	6
Municipality/Regional Energy Agency / Public Authority	18%	6
Provider of equipment/services	15%	5
User/Operator of Waste Heat/Cold	0,00%	0
Academia, Associations and Research	43%	16
ESCO/Consulting	6%	2

Please, specify your role in this entity:

Table 3 Answers to question 1 - Please specify your role

Please specify your role		
Project manager	30%	7
GM	4%	1
Consultant	4%	1
Researcher	13%	3
Engineer	26%	6
Professor	4%	1
Waste manager	8%	2
Technician	8%	2
Student	4%	1

2. How aware are you about Waste Heat and Waste Cold (WH/C)?
    a. I have no idea about WH/C
    b. I have a vague idea about WH/C, where there might be a potential but not how to exploit it
    c. I am aware of WH/C, but I am not so familiar with the ways to exploit it.
    d. It is a focus of the company/institution I am working on, and I am aware about the potential of these two flows and ways to exploit it.

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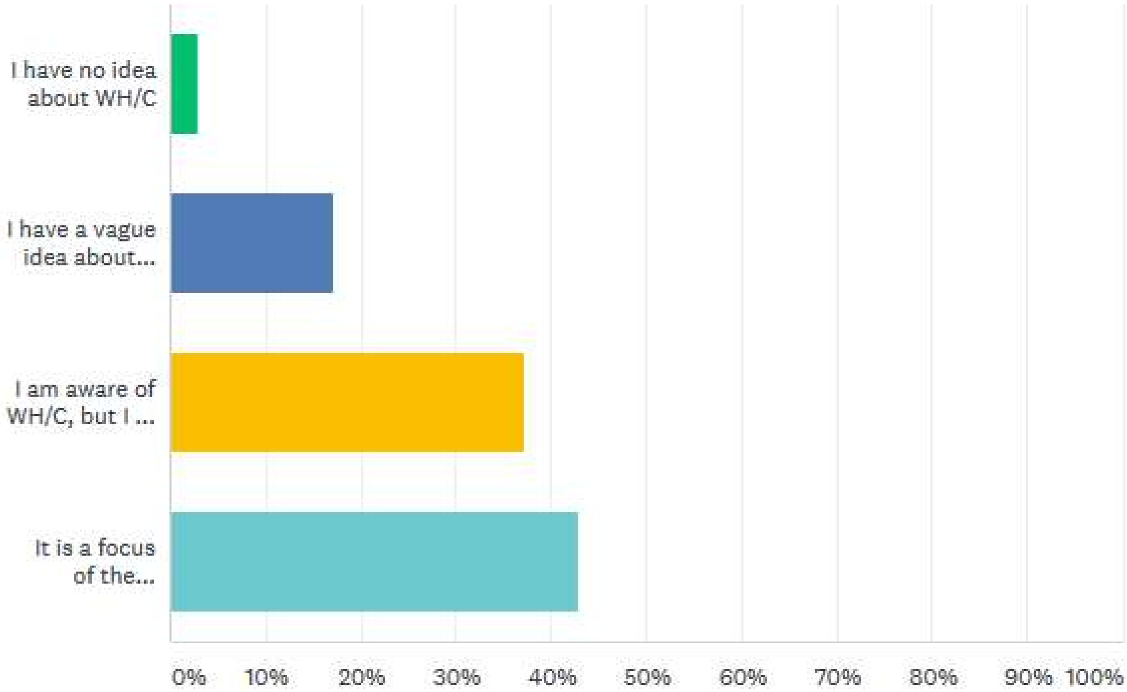

Figure 14 Answers to question 2 – Awareness about WH/C

Table 4 Answers to question 2 - Awareness about WH/C

Awareness about WH/C		
I have no idea about WH/C	3%	1
I have a vague idea about WH/C, where there might be a potential but not how to exploit it	17%	6
I am aware of WH/C, but I am not so familiar with the ways to exploit it	37%	13
It is a focus of the company/institution I am working on, and I am aware about the potential of these two flows and ways to exploit it	43%	15

3. Have you ever performed an analysis of the feasibility of including a kind of Waste Heat and Waste Cold exploitation technologies? If so, what kind of activities did you do? What indicators did you use to evaluate the different possibilities?

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Table 5 Answers to question 3 - Have you ever performed an analysis of the feasibility of including a kind of WH/C exploitation technologies

Have you ever performed an analysis of the feasibility of including a kind of WH/C exploitation technologies?		
Yes	54%	19
No	46%	16

4. What would be the boundary of your analysis?
   a. Few processes/part of the company/institution under analysis
   b. The entire premises of the company/institution under analysis
   c. The company/institution under analysis and neighbouring ones
   d. The company/institution under analysis and larger surrounding area
   e. Other

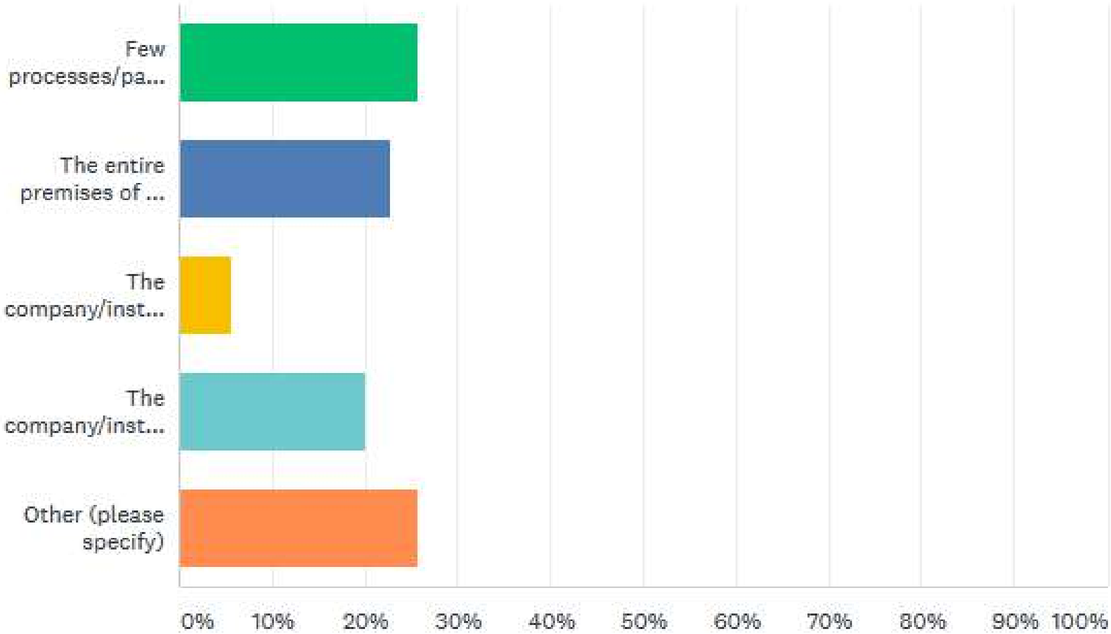

Figure 15 Answers to question 4 - What would be the boundary of your analysis?

Table 6 Answers to question 4 - What would be the boundary of your analysis?

What would be the boundary of your analysis?		
Few processes/part of the company/institution under analysis	26%	9
The entire premises of the company/institution under analysis	23%	8
The company/institution under analysis and neighbouring ones	6%	2

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The company/institution under analysis and larger surrounding area	20%	7
Other	26%	9

Comments regarding "others" were regarding a country/municipality or region analysis.

5. Ignoring economic issues, what might be you main technical considerations for introducing in a company/city/facilities external recovered WH (or renewable energy sources - RES)?

The main considerations regarding the answers given are the following:

- Time matching between the WH/C available and the "receiver"
- Stability and predictability
- Temperature levels source
- Easy maintenance and operation
- Environmental impact
- Lack of knowledge/training

Other issues that have been mentioned in the answers: sustainability, have an appropriate technological system, high efficiency, marketing and infrastructure.

6. SO WHAT main objective is to develop and demonstrate an integrated and easy-to-use tool which will support industries, energy utilities, municipalities and other stakeholders in selecting, simulating and comparing alternative Waste Heat and Waste Cold exploitation technologies that could cost-effectively balance the local forecasted H&C demand also via Renewable Energy Systems (RES) integration.

   Have you ever used a software tool similar to the aforementioned one? If so, what are the most interesting functionalities of this tool you used? Did you miss any functionality?

Table 7 Answers to question 6 – Use of similar software tools

Have you ever used a software tool similar to the ones to be developed in the scope of the SO WHAT project?		
Yes	17 %	5
No	83%	28

Similar tools that have been used by the responders: Cyclo tempo, Fluent, Homer, Excel calculations developed "ad hoc", Simulink,

Comments regarding the more interesting functionalities are the following ones

- Getting hourly balance with a certain size of storages

Other issues mentioned by the responders:

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- The main shortcoming of simulation tools is the weak handling of up and down ramping properties of power plants as parts of the system.
- Heat pump COP has to be taken into account as a function of fluctuating temperatures
- It is difficult to consider the fluctuations of the amount of accessible waste heat (also temperature fluctuations)

7. What would you expect from a kind of software tool as the one mentioned in the previous questions?

The main expectations where the ones above:

- Free to use, even with reduced functionalities
- Pre-set equipment alternatives available
- Possibility of testing one design with different changes in the parameters/technologies to be used
- Easy to use, with a clear and understandable GUI

Other issues that people mentioned in their answers:

- Support the identification of WH sources (quantity and quality)
- Identify the best technology in each situation
- Pay-back calculation
- Energy auditing
- Monitoring and control (optional)
- Hourly balancing optimization depending on different parameters (price of heat and electricity, storage use option, HP COP setting as a function of varying temperatures)
- Power plant (CHP) ramping speed consideration
- General overview and specific in depth analysis
- Energy availability prediction
- Possibility to create cascade systems
- To be as fast/easy/simple as possible but, at the same time, to be precise/correct/appropriate for the specific case
- Technical and economic assessment
- Translated to local language
- To provide the optimized options with minimum life cycle cost and maximum annual energy cost/cCO_2 savings
- Capability to find out new solutions to recover WH from facilities/services managed by the user/entity
- The speed of the calculation is not a big issue, but it should be reasonable

8. In your opinion, what kind of roles of your organization would be interested in this kind of software tools?
    a. Managers group / Decision-makers
    b. Energy management department / higher level technics

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c. Maintenance team / technics
d. R&D?

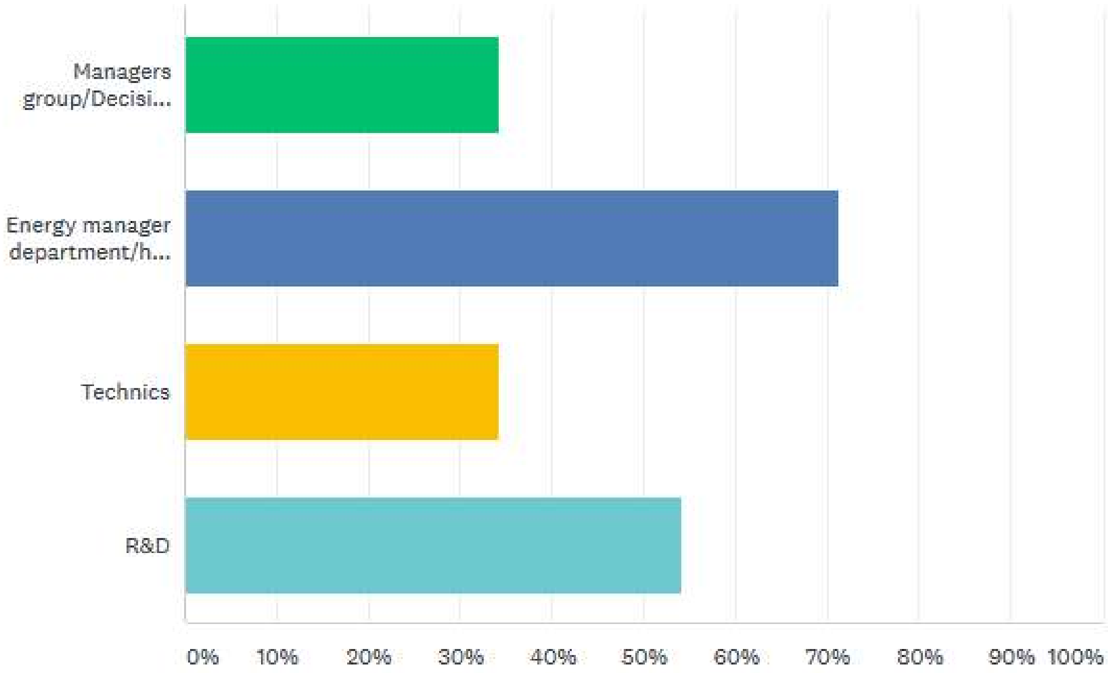

Figure 16 Answers to question8 - What kind of roles of your organization would be interested in this kind of software tools?

Table 8 Answers to question 8 – Interested roles

Interested roles		
Managers group/Decision makers	34%	12
Energy manager department / high level technics	71%	25
Technics	34 %	12
R&D	54%	19

9. What kind of information would you be willing and able to provide about the company/city/facilities to feed the software tool and let it provide you with its functionalities?
    a. Building layouts / factory geometry
    b. Manufacturing process
    c. General energy flows
    d. Detailed energy flows
    e. Energy bills
    f. Production Schedules
    g. Monitoring data
    h. GIS based datasets
    i. Energy consumption data apart from the industry

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j. Others

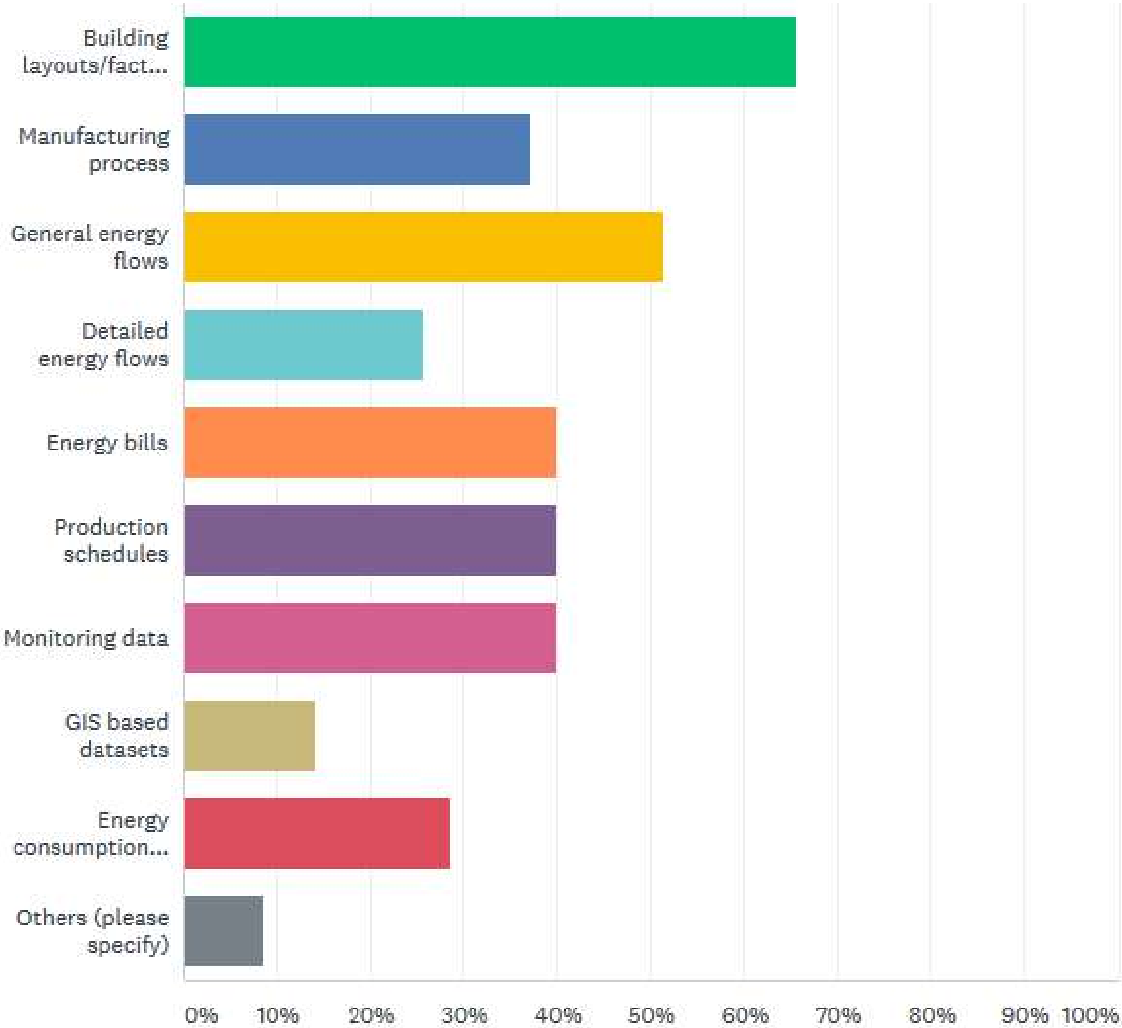

Figure 17 Answers to question9 - What kind of information would you be willing and able to provide about the company/facilities/city to feed the software tool?

Table 9 Answers to question9 - What kind of information would you be willing and able to provide about the company/facilities/city to feed the software tool?

What kind of information would you be willing and able to provide about the company/facilities/city to feed the software tool?		
Building layouts/factory geometry	66%	23
Manufacturing process	37 %	13
General energy flows	51 %	18

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Detailed energy flows	26%	9
Energy bills	40 %	14
Production schedules	40%	14
Monitoring data	40%	14
GIS based datasets	14%	5
Energy consumption data apart from the industry	29%	10
Others	9%	3

One person specified "none" in the "others" answer, and another one said that the information he/she would be willing to provide depends on the degree of cooperation between the software provider and the company.

10. What are your expectations regarding documentation, training lessons and training material?
    a. It will be enough with a user manual.
    b. Online training material (manual, tutorial, webinars, etc.)
    c. Face to face training lessons
    d. Other

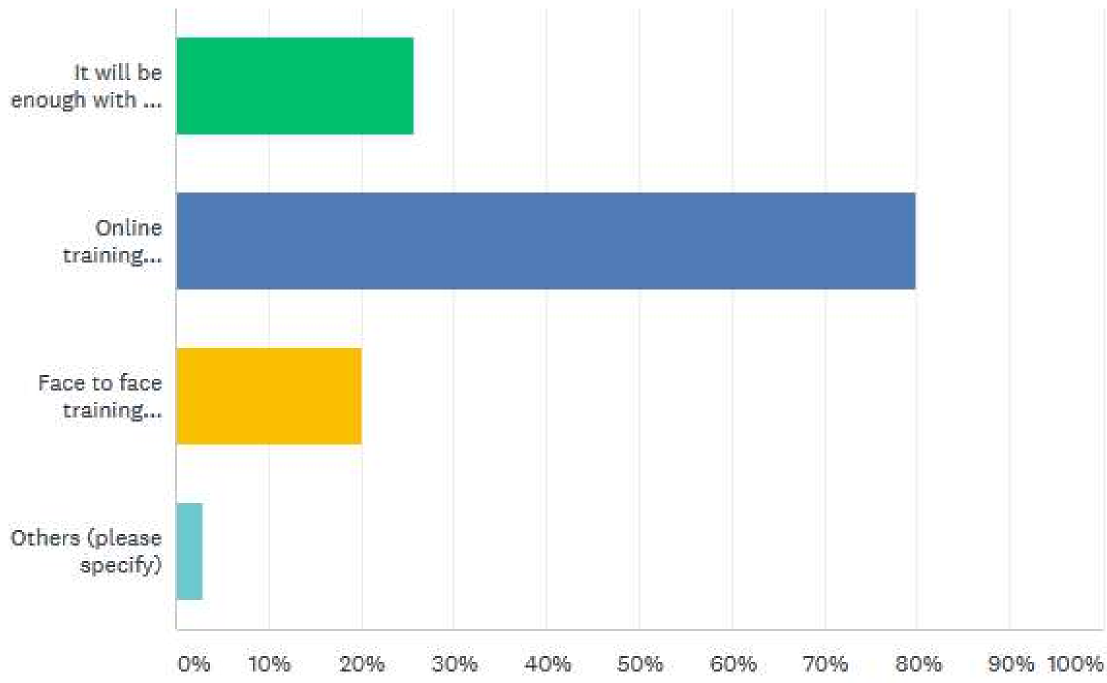

Figure 18 Answers to question 10 - Expectations concerning documentation and training material

Table 10 Answers to question 10 - Expectations regarding documentation and training material

Expectations about training material		
It will be enough with a user manual	26%	9
Online training material (manual, tutorial, webinars, etc.)	80%	28

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Face to face training lessons	20%	7
Others	3%	1

The only answer in "others" was "Good documentation please".

6.2 Summary of the information gathered from the co-creation workshop and the face-to-face meetings with some internal stakeholders

The results obtained from the co-creation workshop were summarized in this section. The number of attendees to the workshop was 36 (most of people were from the SO WHAT consortium, but it was also open to externals). People were divided into three groups, and all the attendees have given their feedback concerning ESCO, Municipality/Energy Agency and Industry roles.

6.2.1 ESCO role

Main KPIs/Information to be provided by the software tools to be developed in the scope of the SO WHAT project:

- Payback/Cost-pricing analysis/return of investment
- Maintenance costs
- Estimation of investment
- CO_2 footprint (it is important not to avoid environmental information)
- Optimal distance between source and sink
- Best tariff to be offered to the user
- Amount (and quality → exergy calculation) of waste energy available (amount and distribution over the year/day)
- Sensitive analysis

Figure 19 shows a summary of the user needs gathered during the three working tables regarding ESCOs.

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essential	Important	additional
• Provide useful information but on a user-friendly way • Cost-benefit analysis about the investment • Cost-benefit analysis about investing in the tool • Different alternatives using different objective functions / Comparison of scenarios • The tool has to be a step change for the ESCO • Provide a clear business case definition • Standardized format for inputs • Accurate calculations • Life Cycle Analysis calculations	• Estimation of operational and maintenance costs • Identify the main inefficiencies of the processes • Comparison of different technologies to be applied • Illustrate environmental benefits • Facilitate discussion with decision makers • Time series information (heat demand of clients would change along time) • Comprehensive assessment of WH recovery opportunities in the site • "Emergy" calculation of RES alternatives	• Calculation of RES alternatives • Examples of similar already implemented solutions

Figure 19 Requirements gathered concerning ESCOs role (co-creation workshop)

As written in Figure 19, most of the user-needs have been classified as essential or important by the end-users. Although this is not surprising (everyone thinks that their needs are the most important and needed ones), it has to be reviewed to generate the final list of requirements.

Emergy analysis was also mentioned as shown in Figure 19. The Emergy methodology [12] is based on the systems ecology field. Emergy is usually defined as the amount of available energy of one type (usually solar) that is directly or indirectly required to generate a given output flow or storage of energy or matter. The unit of emergy is the emjoule or emergy joule. Using emergy, sunlight, fuel, electricity, and human service can be put on a common basis by expressing each of them in the emjoules of solar energy that is required to produce them.

One of the most demanded functionality is about *scenarios/objective functions comparison*. The idea is that, once the user has specified all the information given by the tool, it would be so useful for the user to have the possibility of select different scenarios and compare them using some "key indicators", and something similar but using different objective functions.

The sentence "*the tool has to be a step change for the ESCO*" means that ESCOs will be interested in SO WHAT Tool if it offer them something very different and with a lot of "added value". If SO WHAT Tool offer functionalities that are already (more or less) covered by the ESCOs (even if they are covered in a "primitive" way), ESCOs will be not so much interested in those tools.

Another demanded functionality is about time series information. It would be desirable that the software provides time series information about the moments in which heat/cold are going to be available, and about the moments in which this heat/cold are going to be needed (if those moments of time does not match, additional issues have to be taken into account). That way, the matching between demand and supply could be done.

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Besides, and to *facilitate the discussion with the decision makers*, some "non-technical" reports should be offered containing a summary of the information and conclusions generated by the software tools.

If some information about *similar already implemented solutions* is given by the SO WHAT Tool, then users will have more information to convince decision-makers.

Information about *dysfunctionalities to be avoided* is also important, so we discussed a bit about it during the co-creation workshop. The main dysfunctionalities mentioned were the following:

- Too technical information for non-technical people: If too technical information is offered to non-technical people, they will probably get confused
- Really simple output (specially for non-technical users)
- Not correct information
- Overestimations

Some of the attendees to the workshop specified that there are some information that probably will not be given by ESCOs:

- Price of the energy sources
- Contractual arrangements

6.2.2 Municipality/Energy Agency role

On the one hand, and when in the shoes of Municipalities and Energy Agencies, the attendees to the workshop gave the following ideas about *the outputs to be offered* by SO WHAT Tool:

- Maps of current situations in terms of technologies/sources/demand
- Visualize results on scenarios assessment on maps easily interpretable by non-technical people
- Maps showing CO_2 emissions in the different district
- Assess multiple scenarios in terms of technical/economic/environmental feasibility
- Benchmarks at regional/national/international level
- Indications about contractual arrangements
- Relevant indicators:
- CO_2 emissions savings
- CO_2 emissions savings/investment
- Cost of heat (important for citizens perspective)
- Total costs for DHN (energy + development costs)
- Security of supply
- Pollution
- Job security

On the other hand, those are the inputs that people from Municipalities and Energy Agencies could be able to provide:

- Audit from industries are confidentiality → Alternatives data sources should be found
- Buildings energy consumption (not always available for municipalities; for some other real time measurements are available)

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- Buildings energy certificates
- GIS data set could be useful but not always available

Main functionalities (there were no time to classify functionalities between essential, important and additional) agreed by the attendees when in the scope of Municipalities and Energy Agencies:

- Plan new DHCN
- Match demand and supply
- Assess cost effective solutions for H&C sector
- Valorise WH/WC recovery considering socio-economic impact
- Facilitate collaboration with industrial sector
- Identify who needs the heat and where there is heat available
- Cities as buildings owner could assess impact of future H&C sustainable scenarios for their buildings
- Support policies development

All those functionalities should be given in the scope of three spatial scales: district level, street level and building level, and considering short, medium and long term H&C scenarios.

In the opinion of the attendees to the workshop, *SO WHAT Tool should be delivered in two ways*:

- Free tool for municipalities to use autonomously to identify priority of interventions
- Detailed tool to be used with the support of consultants

Last but not least, the main *dysfunctionality to be avoided* in this case is the too heavy pre-processing of input data.

6.2.3 Industry role

Those are the main KPIs/Information that should be provided by the software tools to be developed in the scope of the SO WHAT project when talking about industries:

- Payback
- Money saved
- Costs
- LCA
- CO_2 saved

As it has been included in the section devoted to ESCOs, industries role also consider as key the information about the available amount, quality and reliability of waste heat and cold.

Figure 20 gives a summary of the user needs gathered during the three working tables regarding industries. During the workshop, people only had time to classify their needs between "essential" and "less essential".

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essential	less essential
• Data input needs to be as simple and quick as possible and have the ability to be uploaded from documents already created (e.g. xls) • Ability to show the amount of waste heat • Ability to show the quality of waste heat • Ability to show the reliability of heat supply • Give information on technical solutions • Show what the market (demand/supply of heat) is like around me/in the local community • Exergy Analysis • Optimisation • Ensure the continued efficiency of operations and tell me whether disruption to my processes will be caused by using the tool or installing technical solution that it recommends.	• Technical solutions should be updated and have with costs • Guidance on how to get funding – grants available for technologies etc. , co-funding, business models • Tell me if the solutions will put future limits on any process • Allow me to prioritise depending on targets • Consider feed in tariffs

Figure 20 Requirements gathered concerning Industry role (co-creation workshop)

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7 Technical requirements derived from users needs

The input from the interview, questionnaires and workshop responses has been analysed and grouped in to technical requirements from a user perspective. The below shows areas that are common to all users and then areas that are specific to 1 type of user that the tool should be tailored for.

It should be noted that as nearly all responses regarded functions as essential or important, all of these have been grouped together and will be assessed within WP2 next activities on the basis of:

a. whether they are in scope of the project according to the Grant Agreement
b. whether they can be implemented given the time and resource constraints of the project

Only ESCO users mentioned items that were considered as 'Additional', and as these are part of the project according to the Grant Agreement, they have been included with the lists below.

All requirements requested from the ESCO user's point of view are in line with the other users, so a separate section for ESCO specific functions is not required, whereas for industry and Municipality/ Energy Agency Users, there were additional requirements that means the tool will need to be tailored in some way to meet these needs specific to the user.

It should be noted that this is the beginning of the specification of the SO WHAT Tool, and a more detailed speciation will be produced with all requirements considered which will occur in the following deliverables D2.2 and D2.3.

7.1 Requirements Common to All Users

Usability of Tool

- Reliable, accurate, trustworthy, transparent
- Validated by case studies
- Easy to use for non-technical people

Functions of the tool that are common to all users:

- Simple and quick as possible data input
- Ability for data input to be uploaded from documents already created (e.g. xls)
- Tool should provide the ability to quantify the following from the facility/area:
    - amount of waste heat
    - quality of waste heat (exergy)
    - reliability of waste heat supply
- The above should be available to the lowest time step possible and summed up by hour/ day/month/year
- Provide potential technical solutions for waste heat/cooling recovery as well as technical and cost details for these.
- Provide examples of similar already implemented solutions

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- Optimisation for the use of technical solutions
- Exergy Analysis
- Show the local community market for the supply of heat - visualise on maps
- Show the local community market for the demand for heat - visualise on maps
- Show how the industrial facility can complement/balance the demand/supply of heat market
- Map the current situations in terms of technologies used
- Ensure the continued efficiency of operations and identify whether disruption to industrial processes will be caused by installing technical solution that it recommends.
- Show the optimal distance between source and destiny
- *Have the ability to set KPI targets and to select scenarios to help achieve the targets*
- Show tariffs to be offered to the user
- Facilitate the discussion with the decision makers
- "Non-technical" reports should be offered containing a summary of the information and conclusions generated by the software tools.
- Calculation of RES alternatives.

KPIs the Tool should show that are common to all users:

- Payback
- Return of investment
- Maintenance costs
- Investment cost
- Money saved
- Costs
- LCA
- CO2 saved

7.2 Requirement Specific to Municipality/Energy Agency Users

Functions specific to Municipality/Energy Agency User:

- All function to be at scope of three spatial scales: district level, street level and building level
- All functions to consider short, medium and long term H&C scenarios.
- Free tool for municipalities to use autonomously to identify priority of interventions
- Detailed tool to be used with the support of consultants
- Plan new DHCN
- Match demand and supply
- Assess cost effective solutions for H&C sector
- Valorise WH/WC recovery considering socio-economic impact
- Facilitate collaboration with industrial sector
- Cities as building's owner could assess impact of future H&C sustainable scenarios for their buildings
- Support policies development
- Visualize results on scenarios assessment on maps easily interpretable by non-technical people

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- Maps showing CO_2 emissions in the different district
- Assess multiple scenarios in terms of technical/economic/environmental feasibility
- Benchmarks at regional/national/international level
- Indications about contractual arrangements

KPIs specific to Municipality/Energy Agency User:

- Cost of heat (important for citizens perspective)
- Total costs for DNH (energy + development costs

7.3 Requirements Specific to Industry Users

- Technical solutions should be updated and have with costs
- Guidance on how to get funding – grants available for technologies etc., co-funding, business models
- Connection to technology provider – via tool
- Compare cost of solutions to standard supply
- Tell me if the solutions will put future limits on any process
- Allow me to prioritise depending on targets
- Consider feed in tariffs

7.4 Requirements where more clarity is needed

It should be noted that from analysing the responses to the surveys, the only requirements that are not included in the below sections are as follows:

- Possibility to create cascade systems
- Translated to local language

It needs to be assessed precisely what is involved in delivering these and whether they can be done in the scope/constraints of the project.

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8 Conclusions

This deliverable describes the participatory approach defined to guide the user requirements specification process, and all the activities carried out in the scope of the SO WHAT project concerning this issue.

Nowadays, innovative collaboratively with involved stakeholders has become the new business imperative. When developing software, having a main line into what end users are thinking is critical. Employing co-creation early in the software development process reduces potential of investing in a product concept that is ultimately going to fail by the time that it gets to market. This is key in the scope of the SO WHAT project, because it is extremely important to define and develop viable and usable software tools, totally aligned with the main needs of the most involved stakeholders.

It is important to have in mind that the software tool to be developed in the scope of the SO WHAT project is not devoted to the general public, so it is important to correctly identify the possible end-users to be sure that requirements are extracted from the suitable stakeholders. Besides, and in the scope of WH/C recovery, at least two roles are needed: the heat/cold producer and the heat/cold consumer (who can be the same at the producer or not), but sometimes the collaboration is not feasible without the participation of a "third party" (ESCO, Municipality, etc), and those stakeholders have to be also considered.

The literature review that has been done and the training concerning co-creation, workshop leadership and so on have given us all the tools needed to develop all the activities to be done in the scope of T2.1 in a successful way, obtaining the information needed to start the definition of the SO WHAT software tool.

The online survey has given us precise information from the point of view of a set of stakeholders, and this is so valuable. Besides, the co-creation workshop has given us the opportunity of exchanging views with a considerable group of end users and we have given them the possibility of specifying their main aims concerning the software tools to be developed in the scope of the project.

The interviews done to some internal stakeholders has obtained a lot of valuable information too and, as those interviews where done just to one or two people from the same entity, they have bring us the opportunity of asking "everything" we had in mind.

Concerning the information gathered, the following are the most demanded needs (most of them have been mentioned both in the online survey and during the co-creation workshop):

- Simple and standardized input formats
- Ability to show the amount, quality and reliability of waste heat/cold
- Exergy analysis
- Cost benefit and life cycle analysis
- Environmental benefits calculation (CO_2)
- User-friendliness
- Demand and supply matching

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With regard to the information given by the online survey responders, just a few people have used software tools similar to the ones to be developed in the scope of the SO WHAT project, but everyone is so interested in using them. At the moment, it seems (according to the answers to the survey) that, when needed, people use "ad-hoc" excel sheets to calculate the information needed.

Regarding documentation and training, most of people (80% of the responders to the online survey) have specified that it would be enough with online training.

The list of requirements obtained from all the information gathered along the different activities carried out in the scope of T2.1 is so valuable, because those requirements come directly from people who perfectly know the context of WHR and RES integration and that would probably use SO WHAT software tools if they were available at this moment.

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References

[1] Waste heat recovery: Technology and Opportunities in U.S. Industry (https://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf)

[2] European Commission- Heating and cooling (https://ec.europa.eu/energy/en/topics/energy-efficiency/heating-and-cooling)

[3] IPCC, "Climate Change 2014: Mitigation of Climate Change. Contribution of working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," 2014.

[4] Solar Heat Integration in Industrial Processes (http://task49.iea-shc.org/description)

[5] Euroheat & Power: international network for district energy, promoting sustainable heating and cooling in Europe and beyond (https://www.euroheat.org)

[6] Robertson, Toni & Simonsen, Jesper. (2012). Challenges and Opportunities in Contemporary Participatory Design. Design Issues. 28. 10.1162/DESI_a_00157.

[7] Bratteteig, Tone & Wagner, Ina. (2016). Unpacking the Notion of Participation in Participatory Design. Computer Supported Cooperative Work (CSCW). 10.1007/s10606-016-9259-4.

[8] Sanders, E.B.N. and Stappers, P.J. (2008) Co-Creation and the New Landscapes of Design. Co-Design, 4, 5-18. http://dx.doi.org/10.1080/15710880701875068

[9] Robertson, T., & Simonsen, J. (2013). Participatory Design: an Introduction. In J. Simonsen & T. Robertson (Eds.), Routledge International Handbook of Participatory Design (pp. 1–18). New York and London: Routledge.

[10] Improvement Skills Consulting Ltd. (2009). Data Collection Questionnaires – A Quick Guide. Available online: https://ianjseath.files.wordpress.com/2009/07/questionnaires-quick-guide.pdf

[11] Lars Bo Andersen, Peter Danholt, Kim Halskov, Nicolai Brodersen Hansen& Peter Lauritsen (2015) Participation as a matter of concern in participatory design, CoDesign,11:3-4, 250-261, DOI: 10.1080/15710882.2015.1081246

[12] Odum, H.T., 1995. Self organization and maximum power. Chapter 28, pp. 311-364 in Maximum Power, Ed. by C .A. S. Hall, University Press of Colorado, Niwot.

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