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H2020 Work Programme

D5.5 - REPLICATION STRATEGY OF SO WHAT

Lead Contractor: **RINA-C**

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Executive Summary

The present report, SO WHAT D5.5, entitled "Replication Strategy of SO WHAT" aims to describe the comprehensive techno-economic replication study of three different industrial cases.

To promote the replication of SO WHAT demonstrators, a twofold strategy has been followed:

- Replication within the consortium: to encourage the replication of business cases;
- Replication outside the consortium: through external companies that are evaluating the possibility of making a new investment for industrial waste heat/cold recovery and/or RES installation.

New potential projects have been characterised in terms of energy demand, boundary conditions, end-users' requirements.

The deliverable is articulated into the following sections:

- Chapter 1 gives an introduction to the report and the methodology used;
- Chapter 2 describes two replication studies within the consortium. The first one is configured as a complementary scenario of the LIPOR demo site, where the heat recovered from the latter is also used for other users (one business hub and one beer factory). The second case analyses the possibility of using RES for a Martini & Rossi production plant;
- Chapter 3 focuses on a replication study outside the consortium where a steel mill has been involved. The study includes the possible installation of an ORC turbine for electricity production from the thermal recovery of exhausted gases from the stack of the reheat furnace;
- Chapter 4 presents the conclusions of the study.

Abbreviations

EE: Electric energy

GHG: Greenhouse Gases

HVAC: Heating, Ventilation and Air Conditioning

O&M: Operations and Maintenance

ORC: Organic Rankin Cycle

PV: Photovoltaic

RES: Renewable Energy Source

WHC: Waste Cold Recovery

WHR: Waste Heat Recovery

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1 Introduction

With the aim of defining a replication strategy and of supporting the evaluation of new investments for industrial waste heat/cold recovery and/or RES installations, three replication studies are analysed using the SO WHAT tool.

In this report, three different industrial cases are presented. For each replication study, the following inputs are considered:

- data availability;
- production process and operating hours;
- characteristics of buildings and orientation;
- energy carriers and fuels used;
- monitored and/or estimated consumption;
- geographical context;
- pre-existence of technologies for industrial waste heat/cold recovery and/or RES use
- energy prices and GHG emission factors.

After analysing the available data, the SO WHAT "advanced tool" has been used. Most of the analyses have been carried out using the tools: iSCAN, iCD, iCIM, iVN and the SO WHAT "online tool" for economic feasibility studies. In addition, in some cases, the SO WHAT "online tool" has also been used to have a first view of the potential of heat/cold recovery.

For each replication study, the production process and consumption of the main energy carriers are described, focusing on the annual trend. Having identified potential RES solutions or heat recovery technologies, technical feasibility analyses have been carried out, identifying the potential energy savings and the potential GHG emissions reduction achieved. Depending on the needs, sections of the SO WHAT "advanced tool" have been used or not.

Once the technical and economic parameters have been identified, economic feasibility and risk assessment analyses have been conducted to evaluate the identified technological solution and the investment to be supported.

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2 Replication studies within the consortium

3 LIPOR – new complementary scenario

3.1.1 Description of the site

This replication case study focuses on an existing industrial area in the vicinity of the LIPOR's demo site, in which various economic activities are carried out, mainly industrial, but also trade and services. Based on the existing knowledge of the area, two buildings were selected, corresponding to industrial activity and a business centre.

- **The Business Hub**

The "Business Hub" is a business centre that includes several service buildings, warehouses, and restaurants, among other typologies. The building is in the north of Portugal, in Porto's metropolitan area. It currently comprises around 100 companies, making up a useful working area of approximately 55,000 m^2. The building is powered by two energy vectors: electricity and propane gas. Electricity fully serves all spaces, with various purposes such as artificial lighting, equipment, Heating, Ventilation and Air Conditioning (HVAC) systems, among others. Propane gas has a residual use and is only used in one of the existing restaurants and for heating the common outdoor areas.

Electricity is the dominant vector and, therefore, is the focus of this study. Annually, the Business Hub has a total electricity consumption of 4.14 GWh, resulting in a total emission of 1,480 tCO_{2eq}.

Energy for heating and cooling is responsible for about 30% of the annual final electricity use, totalling about 1.2 GWh/year of final energy. The heating and cooling need amount to around 3.7 GWh/year. Most of the needs are related to heating, given the deficit in the thermal behaviour of the building envelope. The HVAC systems in the spaces are generally of the heat pump type and serve for the purposes of heating and cooling spaces.

- **Beer factory**

Next to the Business Hub, there is one of the largest beer producers nationwide. The production of beer requires a large amount of thermal energy for the various processes and steps necessary for the manufacture of this product. As part of the mapping of potential users of residual thermal energy near LIPOR's demo site, contact has been made with this company that expressed interest in acquiring residual thermal energy if the construction of a heat network would be feasible.

The thermal energy consumption for the manufacturing process is about 63 GWh/year, and it is assumed that 30% of this energy (18.9 GWh) could come from a heat network.

Currently, the thermal energy used in this installation comes from natural gas cogeneration, it is estimated that GHG emissions associated with the heat component amount to around 3,800 tCO_2.

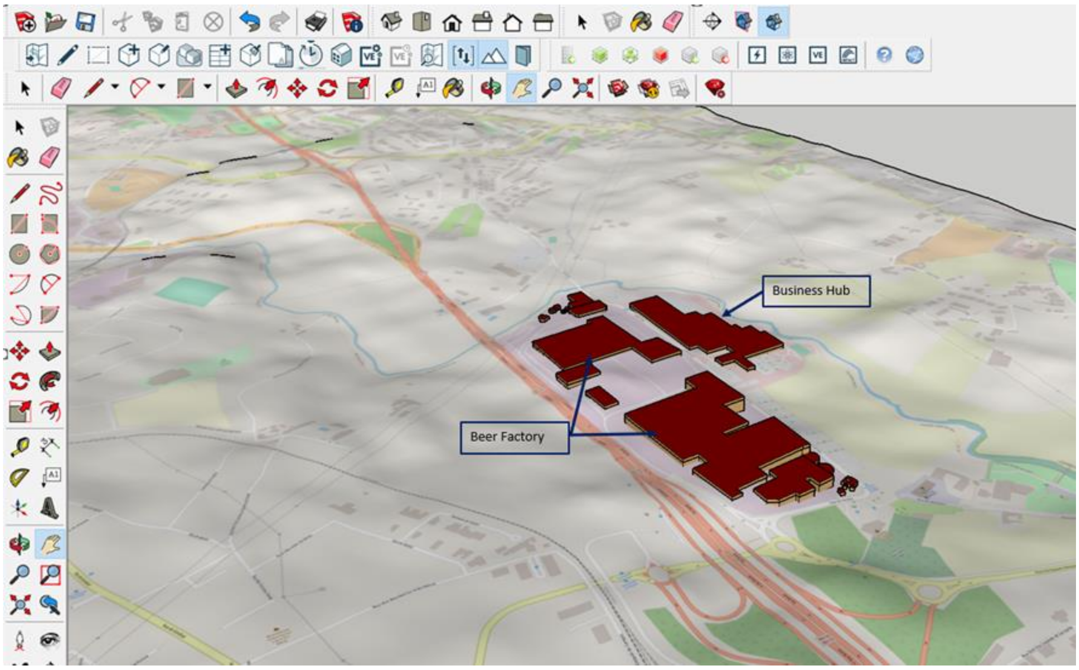

Figure 2.1: SO WHAT tool (iCD) modelling image of the two sites considered.

Since the buildings are very close, it is considered that the same branch of the heat network can supply both. Since there is a huge availability of waste heat coming from the energy recovery plant, for this purpose, it is considered that the heat is distributed under conditions like those considered for the airport supply base scenario.

3.1.2 Analysis of energy consumption of the site

In the case of the Business Hub building, energy consumption follows a seasonal profile with the highest heating needs occurring in the winter months and the peak demand for cooling occurring in the summer. Previous studies and visits to the spaces show that the building has high heat needs since its surroundings are poorly insulated, given that it is an old building and not initially intended for the current activity. It is also verified that, at the same time, there is always a demand for the cold to cool the existing data centres in the different spaces.

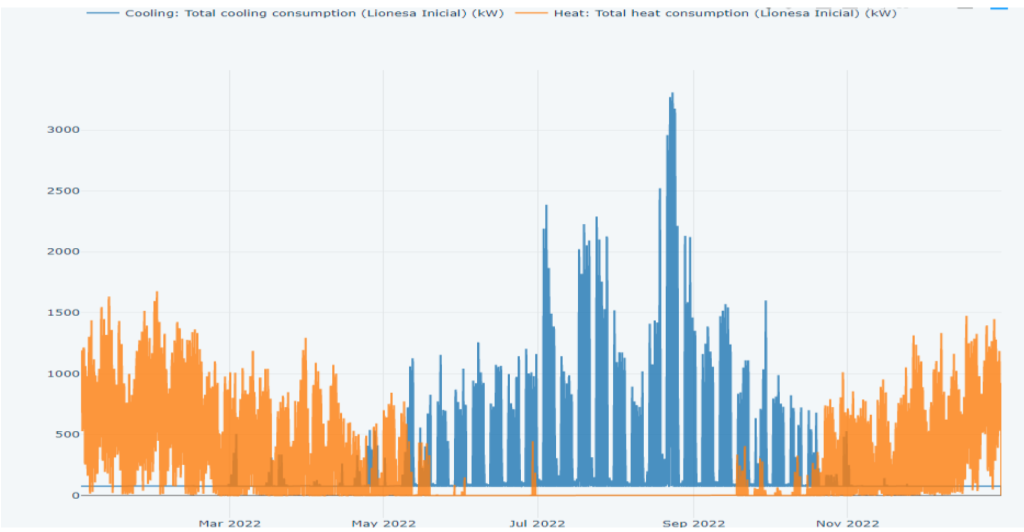

Figure 2.2: SO WHAT tool (iVN) output graph of the heating and cooling demand for the Business Hub.

As previously mentioned, the existing air conditioning systems are based on air-to-air heat pumps in a decentralised configuration, with individual equipment for each independent space. The GHG emissions resulting from the energy used for air conditioning also follow a seasonal profile, totalling 250 tCO_{2eq}/year.

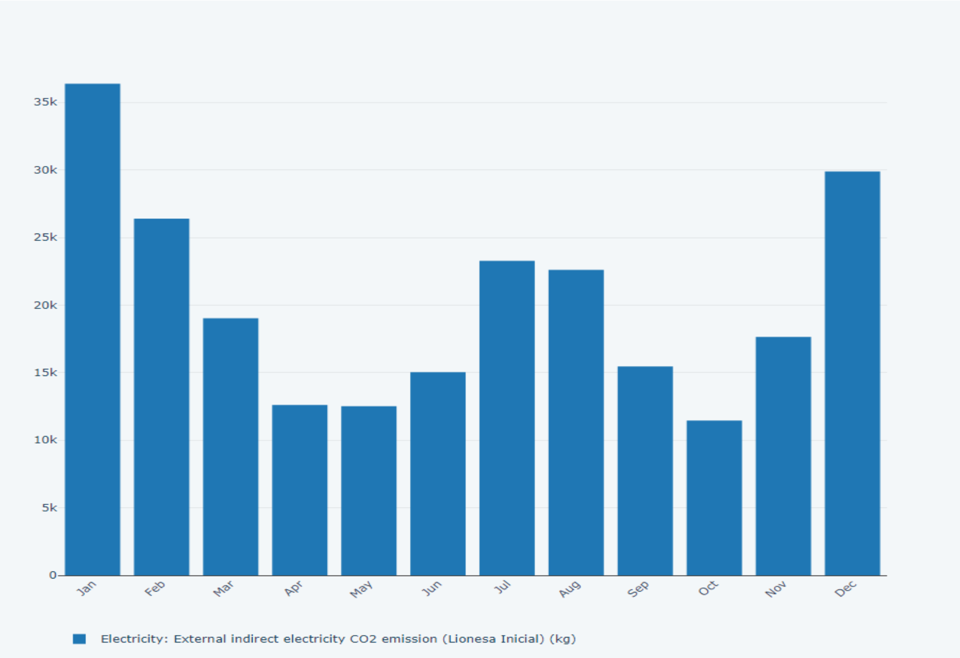

Figure 2.3: SO WHAT tool (iVN) output graph of the GHG emissions resulting from the energy used for heating and cooling in the Business Hub.

For the beer factory the heat demand profile is much simpler since, for simplification, it is considered to be constant. The total thermal energy needs are 18,9 GWh/year resulting in an estimated 2,900 tCO_{2eq}/year. In the current system, thermal energy is produced using natural gas combined with some heat recovered from cogeneration.

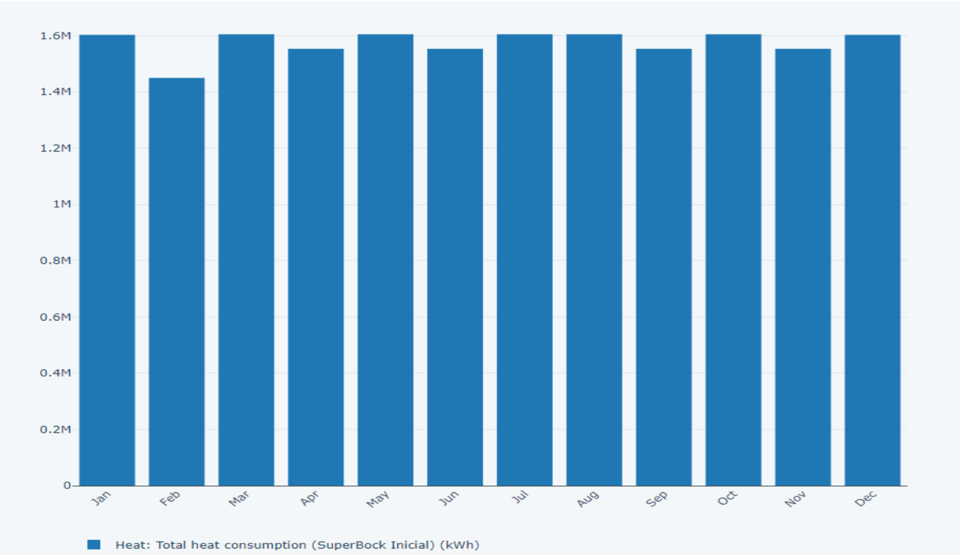

Figure 2.4: SO WHAT tool (iVN) output graph of monthly heating energy demand for the beer factory.

3.1.3 Identification of potential WHR/WCR or RES Opportunities

Since these examples are two installations with very significant demand for thermal energy at low temperatures, this group of buildings is an excellent opportunity to use the residual heat from the neighbourhood.

Additionally, these two anchor buildings are in an industrial and service area with several other facilities nearby that can benefit from a heat distribution network. As the waste heat comes from a nearby waste-burning plant with constant operation throughout the year, the amount of available thermal energy is quite significant and with a very stable supply profile.

The following figure illustrates the annual profile of residual heat available for supply, based on real data for a complete year. The total annual thermal energy available amounts to about 500 GWh.

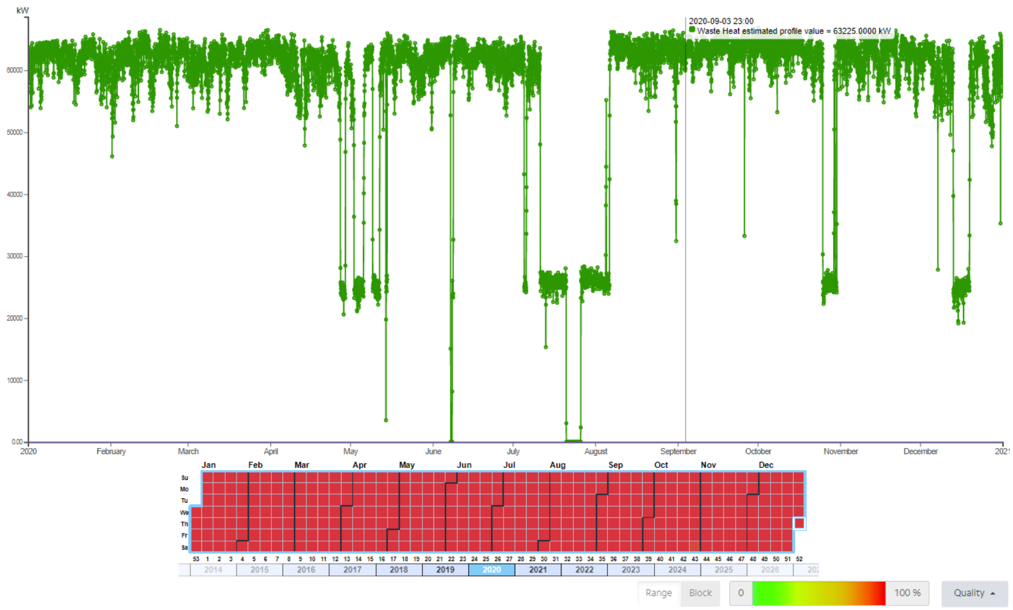

Figure 2.5: SO WHAT tool (iSCAN) output graph for the estimation of waste heat annual profile.

3.1.4 Evaluation of energy savings and avoided GHG Emissions

The residual heat to be supplied to the two new facilities is recovered at the source at a temperature of 55 ºC. To optimise use and profitability, this heat carrier is brought to a temperature of 95ºC by using a heat pump. Through the construction of the thermal network, it will be possible to provide heat to the two new users considered. In addition, the heat will also be used as a heat source for an absorption chiller to be installed in the Business Hub to meet the cooling needs of the spaces.

For the assessment of energy savings and reduction of GHG emissions, the iVN tool developed for the SO WHAT project has been used, combining the technologies described above with the source of residual heat from the waste treatment and recovery station.

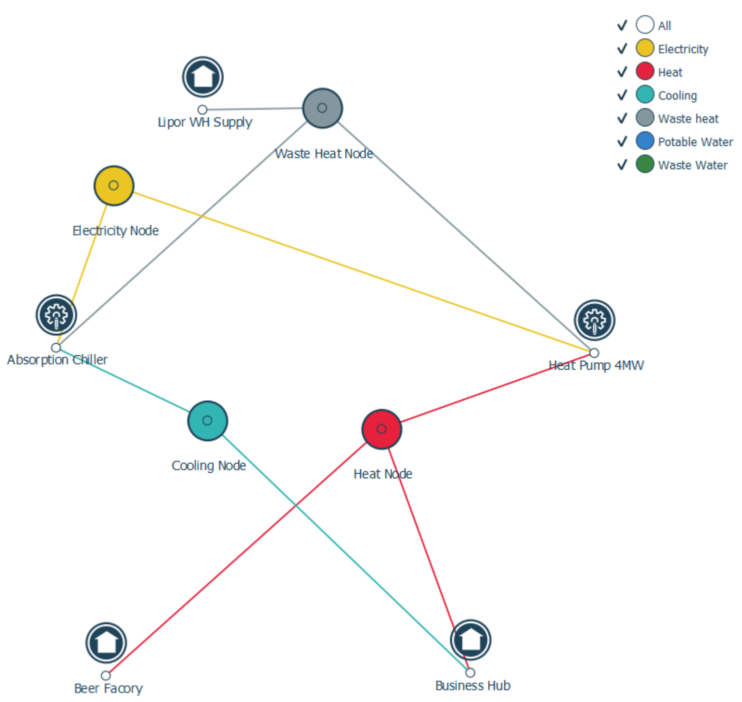

Figure 2.6: SO WHAT tool (iVN) Complementary scenario network modelling.

In this case, there is no reduction in energy consumption, as it is a replacement of thermal energy consumption with the use of waste heat. However, there is a reduction in primary energy consumption, GHG emissions and economic savings in bills. The following figure summarises the estimated impact in terms of GHG emissions of the replacement of the conventional systems of the two facilities under study, by systems that use the residual heat.

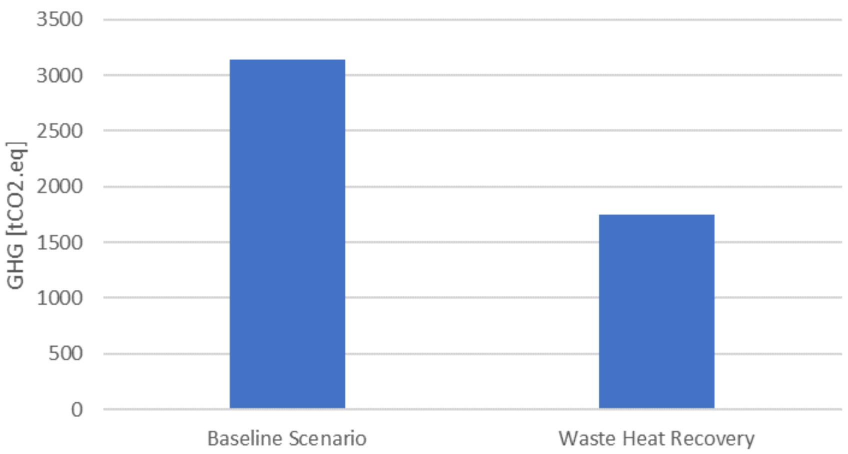

Figure 2.7: GHG emissions reduction for the business centre and beer factory.

With the use of waste heat recovery and recovery technologies, it is possible to reduce GHG emissions associated with heat purposes by around 45%. In addition to the reduction in emissions, a significant decrease in operating costs is also expected. It should be noted that a value of residual emissions associated with the kWh of residual heat has been considered, as its recovery is not completely free from environmental impact. However, the double counting of carbon emissions associated with production and demand should be taken care of.

3.1.5 Cost-benefit Analysis

This exercise of cost-benefit analysis seeks to estimate the potential rewards expected from a situation or action and, by subtracting the total costs associated with this action, based on some known values resulting from the detailed analysis carried out on LIPOR's base case study.

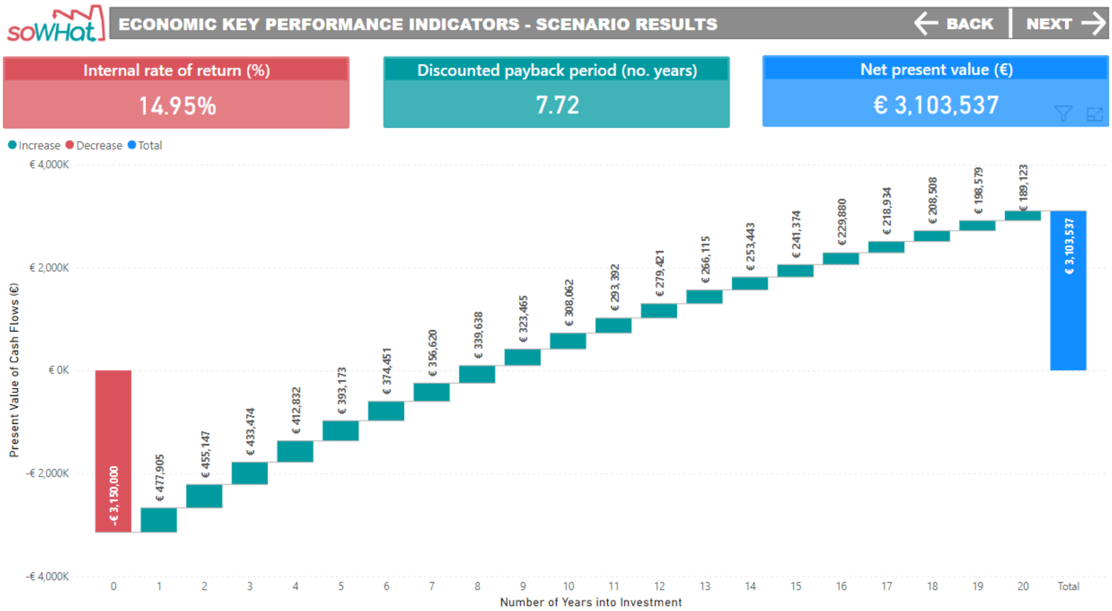

Figure 2.8: SO WHAT tool (online) economic feasibility analysis

The economic analysis has been carried out considering the case of waste heat reuse (coming from LIPOR) within a new district heating network to supply the two new nearby utilities (Business hub and beer factory). After a first simulation, the result obtained highlights that to justify the new investment it is necessary to distribute more waste heat than what will be used by the Business hub and the beer factory. As shown in Figure 2.8, the investment shows positive financial parameters, only considering a waste heat recovery and supply of over 140 GWh/year. This quantity is currently more than double what is estimated for the two new users.

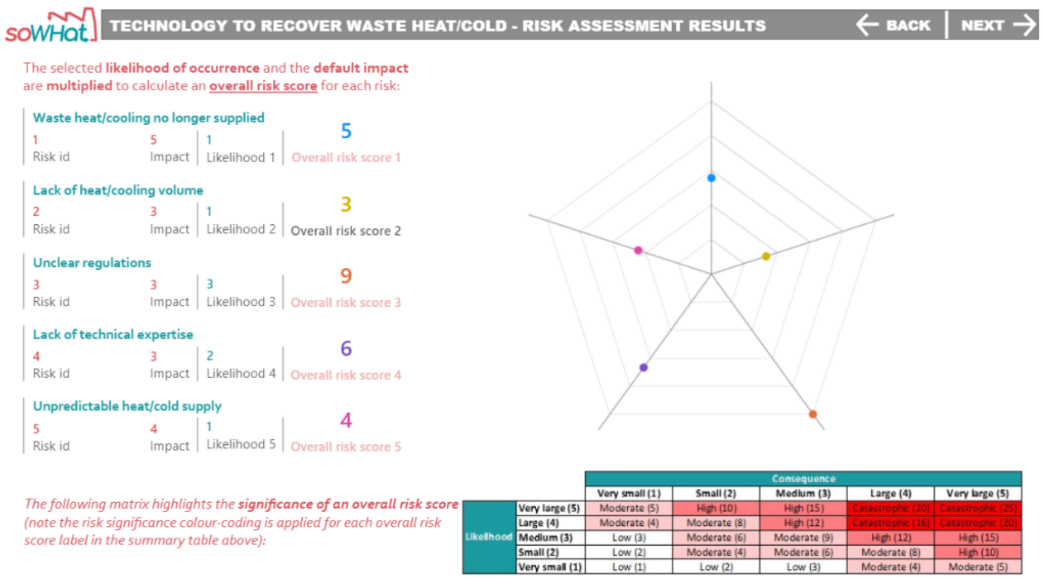

Figure 2.9: SO WHAT tool (online) Risk assessment results.

Through the SO WHAT tool, it has been possible to conduct a risk assessment of the investment, shown in Figure 2.9. As regards the waste heat availability and the risk of lack of heat volume, as described above, the availability of the waste heat resource, quantified in detail in Figure 2.5, amounts to about 500 GWh/year from the combustion of waste at LIPOR. This availability of energy is constant and depends only on the future availability of waste. Temporary unavailability occurs in very defined, short and foreseeable periods.

As far as specific regulation is concerned, there is a lack and absence of comparable situations. In fact, in Portugal, there is no history of using district heating networks. The only existing example of a district heating network was built in Lisbon during a city renovation to host the international exhibition "Expo 98".

With the growing ambition to decarbonisation, resilience and reduce dependence on fossil fuels, there is growing interest in re-using waste heat in conjunction with industry, but there is still much to be done at the national and regulatory levels.

4 Martini & Rossi – Santo Stefano Belbo Plant

4.1.1 Description of the Site

With the aim of involving internal partners in the consortium to encourage replication, the case of the Santo Stefano Belbo plant of Martini & Rossi has been investigated.

The industrial process carried out inside the Santo Stefano Belbo site represents the first step of the Martini Asti production chain. The main activities are carried out during the harvest season (late August-early October), while during the rest of the year the main activity concerns the storage and maintenance of the must at a temperature of 0 °C in order to prevent fermentation.

For the storage and maintenance of the must at temperature there are 7 cooling cells, each of 8,000 hl, powered by electric refrigeration units.

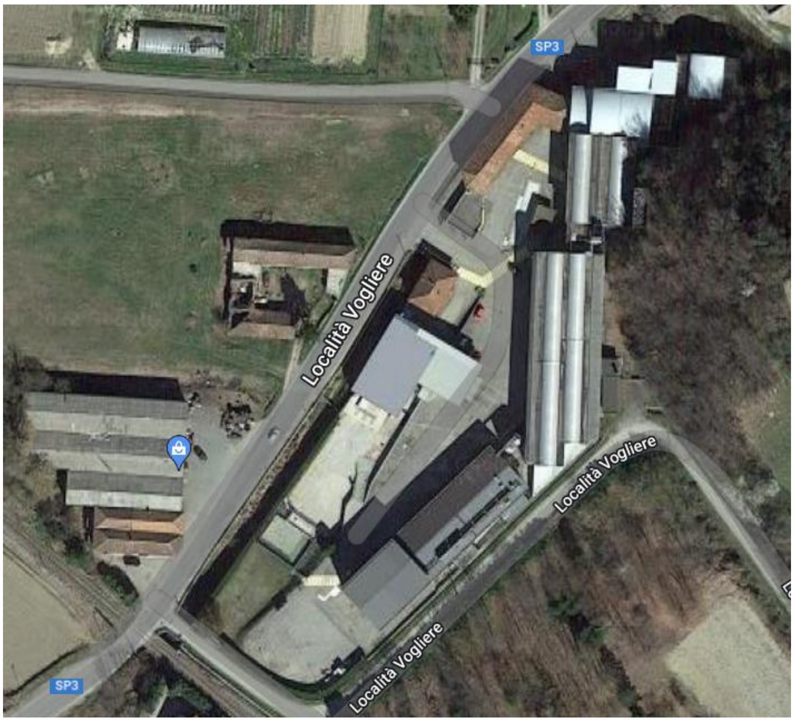

Figure 2.10: Santo Stefano Belbo plant.

The plant does not have natural gas consumption, but only electricity. The annual electric demand is 1 GWh/year, equal to about 250 tCO_{2eq} emission/year.

As described in the following sections, the opportunity to reuse the waste cold has not been analysed in this replication case. Both because of the low amount of recoverable energy and the absence of new users for the reuse of waste cold.

Alternatively, the SO WHAT tool has been used to evaluate the possible installation of a photovoltaic system, in order to reduce emissions and use RES.

It should be noted that in the case of this industrial plant, the processing of the must does not involve evaporation of an alcoholic type. This case does not make the area at risk of explosion and therefore makes it feasible to install a photovoltaic system in this plant rather than in other sites of the Company.

4.1.2 Analysis of energy consumption of the site

The hourly data monitoring of electricity consumption has been imported on iSCAN. Figure 2.11 shows the annual trend and it is noted that the consumption peaks are present especially during the harvest season. During the rest of the year, the electricity is used to keep the must at temperature. Most of the electricity consumption is used by the cooling cells.

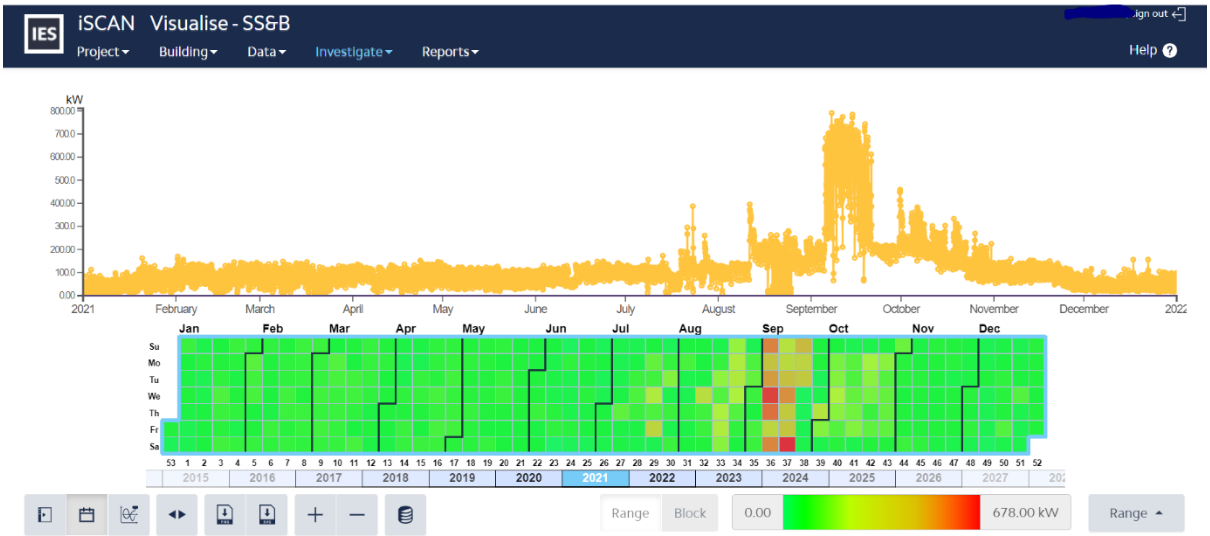

Figure 2.11: SO WHAT tool (iSCAN) annual electricity demand of Santo Stefano Belbo plant.

Using iCD has been possible to import in Sketch-Up the model of the area affected by the plant and its buildings (Figure 2.12). This step is fundamental in the case of energy simulation of buildings. In this case, the energy simulation of the building has not been carried out as it was not necessary for this replication study since most of the consumption concerns the production process and not the air conditioning/heating of the rooms.

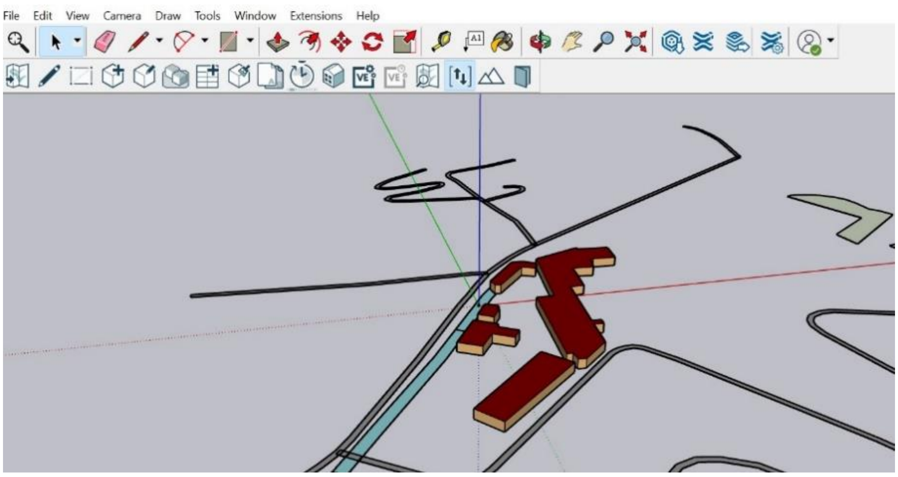

Figure 2.12: SO WHAT tool (iCD) modelling image of the considered site.

Through iCD, the synchronisation of the model with iCIM has been carried out, and such passage has turned out useful to be able to import the model already created inside iVN, as shown in the figure below.

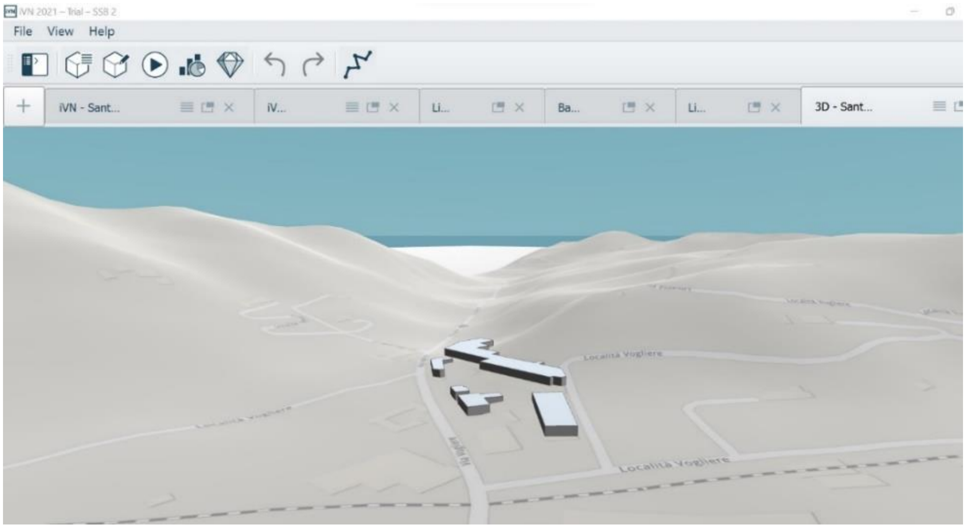

Figure 2.13: SO WHAT tool (iVN) imported model from iCD through iCIM link.

Once the model is imported into iVN, the network modelling has been carried out through the iVN items. This function made it possible to define the energy carriers involved and whether each item is a consumer ("As a Sink") or a producer ("As a Source"). Figure 2.14 shows the network model of the baseline scenario.

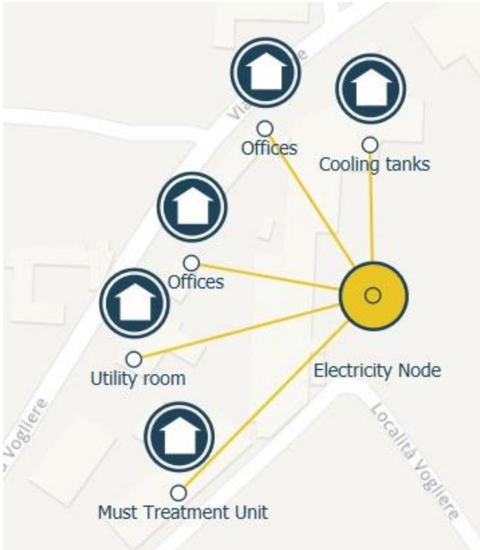

Figure 2.14: SO WHAT tool (iVN) network modelling (Baseline scenario).

Also, electricity consumption has been imported to iVN from iSCAN. Currently, the plant does not monitor the individual users and therefore the correct distribution of electricity consumption is not known. In iVN, it has been possible to add a multiplicative factor to assume a consumption distribution and to obtain the monthly trend as reported in Figure 2.15.

Figure 2.15: SO WHAT tool (iVN) output graph of monthly electricity demand for the main areas of the plant.

4.1.3 Identification of potential WHR/WCR or RES opportunities

After analysing the energy carriers used within the plant and their distribution, the online SO WHAT tool has been used to get a first indication of the potential WHR/WCR or RES opportunities.

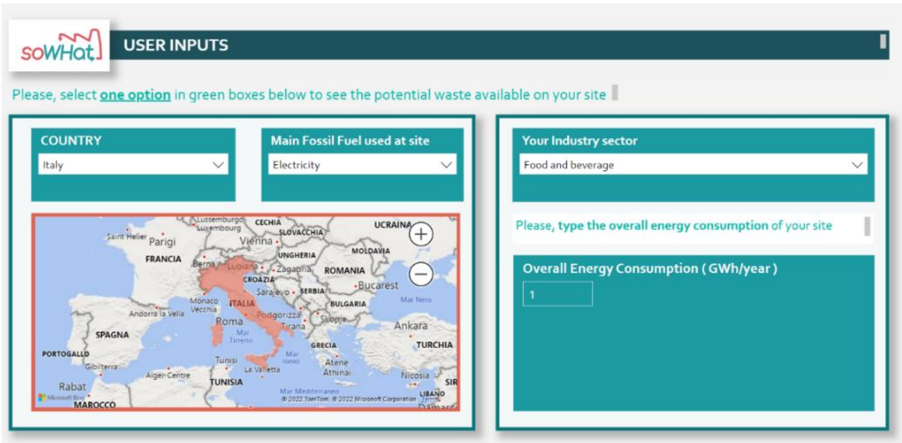

Figure 2.16: SO WHAT tool (online) inputs dashboard.

Through the inclusion of geographical location, energy consumption and the industrial sector it is possible to obtain a rapid definition of waste heat potential, based on GW/year of waste heat recoverable and the reference temperature range.

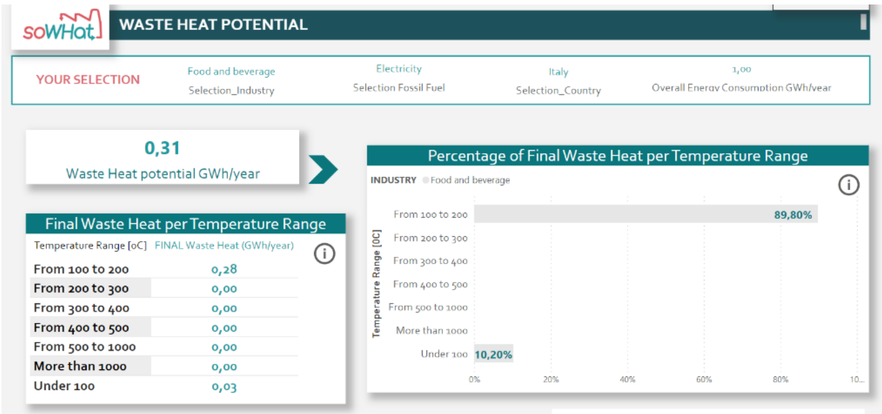

Figure 2.17: SO WHAT tool (online) potential waste heat to recover.

As described above, the activities carried out at the Santo Stefano Belbo plant mainly concern the maintenance of the must at a temperature of 0 ºC. Figure 2.17 shows that for temperatures below 100ºC, the amount of energy that could be recovered is low. Moreover, by analysing the cold network of the plant system, no waste cold sources that could be useful were found.

So, in this case, recovery from cold cannot be carried out. But in order to reduce energy consumption and GHG emissions, the installation of a photovoltaic system has been evaluated.

Through iVN, a new scenario of the network that connects a new iVN asset (PV array) to the electricity node has been created, shown in Figure 2.18.

To define the size of the photovoltaic system is it possible to operate in two ways:

- Entering the available surface
- Entering the implant size in kW

Following both choices, it is possible to evaluate the optimal size of the plant by analysing the results obtained from iVN simulation. In this case, considering the available area, a size of 150 kW has been chosen, with the aim of maximising self-consumption and reducinge input into the network. The tool also allows you to set the inclination and orientation of the panels.

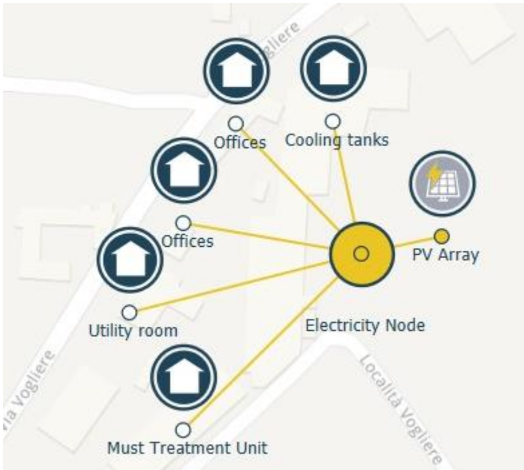

Figure 2.18: SO WHAT tool (iVN) Network modelling with RES (new scenario).

Figure 2.19 shows the hourly electricity production trend of the simulated photovoltaic system (150 kW).

Figure 2.19: SO WHAT tool (iVN) output graph of hourly electricity generation of the PV plant.

4.1.4 Evaluation of energy savings and avoided GHG emissions

The estimated electricity production of the 150-kW photovoltaic system is 158 MWh/year. With a self-consumption value of 92%, it is possible to reduce the electricity taken from the grid by 14%. This solution would allow reducing the CO_{2eq} emission of the site by about 36 tons.

In addition, through iVN, it is possible to compare the trend of the baseline scenario with the new scenario.

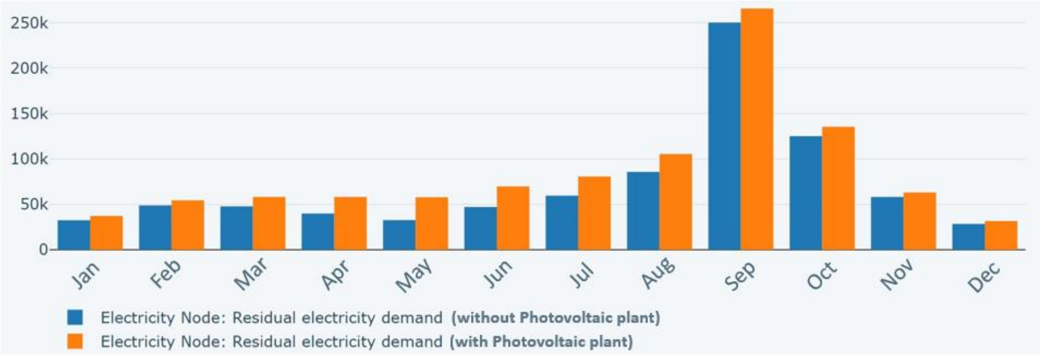

Figure 2.20: SO WHAT tool (iVN) comparison chart of monthly electricity demand (Base scenario vs new scenario)

Through the tool, it is also possible to analyse, with hourly detail, the withdrawal curves. Figure 2.21 points out that the new scenario electricity supply from the grid (in blue) is drastically reduced during daylight hours.

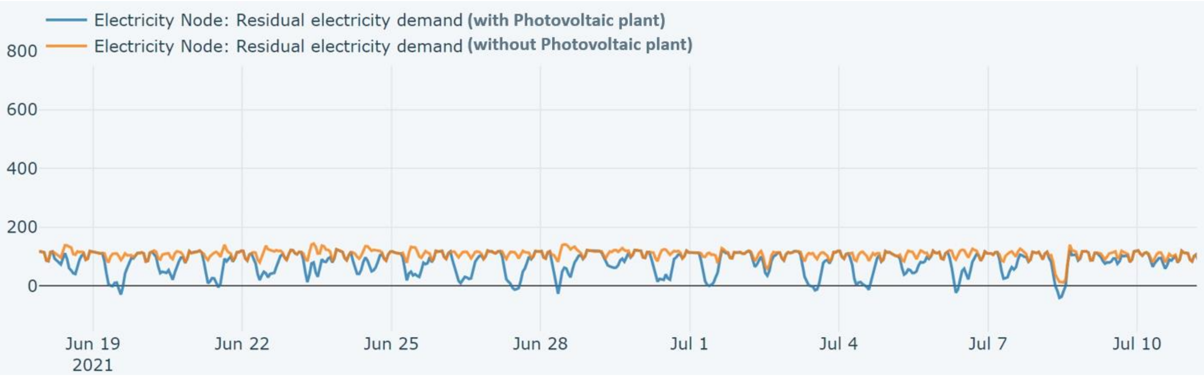

Figure 2.21: SO WHAT tool (iVN) comparison chart of hourly electricity demand (Base scenario vs new scenario).

4.1.5 Cost-benefit analysis

Once the investment has been technically evaluated, the economic feasibility analysis can be carried out using the SoWhat online tool. The data to be defined before the analysis are as follows:

- Electricity price: estimated in this case at 0.400 €/kWh, based on the analysis carried out by the production plant;
- Baseline O&M costs: in this case related to the cost of electricity supply from the grid of about 58,000 €/year (calculated through iVN);
- New scenario O&M costs: in this case related to the cost of maintenance of the photovoltaic system;
- Useful life of the investment: for a photovoltaic system equal to about 30 years.

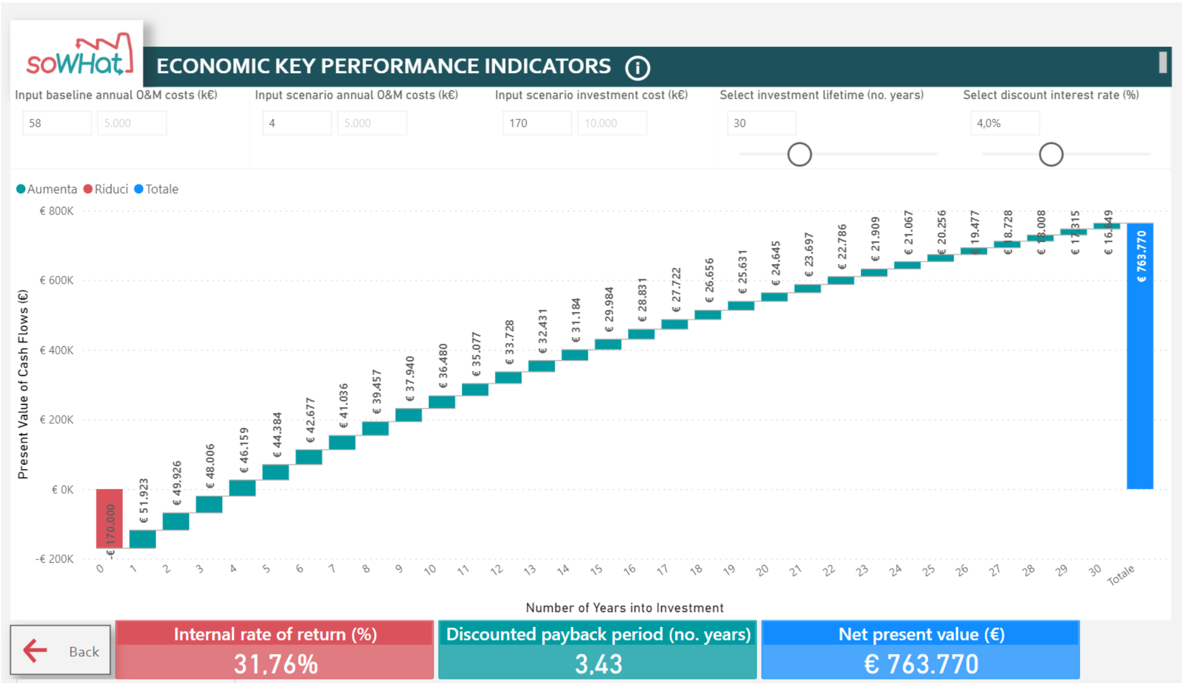

Figure 2.22: SO WHAT tool (online) economic feasibility analysis.

Figure 2.22 shows the following financial parameters, obtained from an investment of 170,000€:

- Internal rate of return: 31.76%;
- Discounted payback period: 3.43 years;
- Net present value: 763,770 €.

Photovoltaics is a mature technology. The possible risk of not drawing energy from the plant does not involve any danger because the electricity produced will be fed into the national grid and sold at an agreed price.

In addition, since the current price of energy is constantly changing, with it the financial parameters of an investment could also quickly vary. Through this tool, it is possible to compare different scenarios and evaluate the economic feasibility of the investment under different economic conditions.

5 Replication studies outside the consortium

6 Steel mill in the UK[2]

6.1.1 Description of the site

In order to test the replicability through the use of the SO WHAT tool also outside the consortium, a steel mill in the UK has been involved in this replication study. One of the first difficulties in engaging external companies was data sharing. For this specific case, only temperature and fuel consumption information were available. To conduct the simulation in the most complete way possible, some data such as the trend of electricity supply, gas consumption and waste heat recoverable have been assumed.

The most energy-consuming plant of this industrial site is the steel reheat furnace. Reheating furnaces are used in steel mills' hot rolling mills to raise the temperature of the steel stock (billets, blooms, or slabs) up to ,1200 °C, which is appropriate for plastic deformation of the metal and, consequently, for rolling in the mill. The steel stock is charged at the furnace entrance, heated in the furnace, and discharged at the furnace exit during the continuous heating process in a reheating furnace. During the steel stock's passage through the furnace, heat is mostly delivered to it by means of convection and radiation from the burner gases and the furnace walls.

Figure 5.1 describes the current scheme of the reheat furnace. Inside the furnace, there are 6 direct burners, and a heat recovery unit is already installed. This recuperator recovers heat from the exhaust gases and uses it to preheat the combustion air inlet to the burners. The temperature of the exhaust gases downstream of the recuperator varies between 325 and 350 °C.

The furnace burners are fired with natural gas, for an estimated annual consumption of 310 GWh/year equal to 62,930 tCO_{2eq}. The electricity consumption of the entire site is estimated to be 51 GWh/year equal to 10,812 tCO_{2eq}.

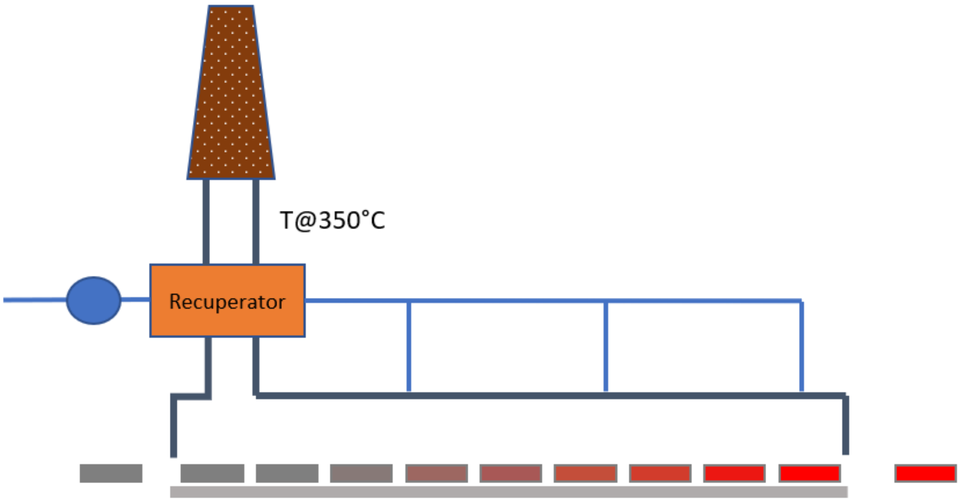

Figure 5.1: Reheat furnace scheme (baseline scenario)

[2] The name of the company for privacy reasons cannot be disclosed

6.1.2 Analysis of energy consumption of the site

As mentioned before, the consumption profiles have been estimated on the basis of the data that the company has made available. Once get the hourly profiles, these have been imported into iSCAN. As you can see in Figure 5.2 and Figure 5.3 the trend of consumption follows a constant cycle, stopping only once a week.

About the profile of electricity needs, it is noted the baseline consumption of about 3-4 MW.

Figure 5.2: SO WHAT tool (iSCAN) estimated annual electricity demand of the plant.

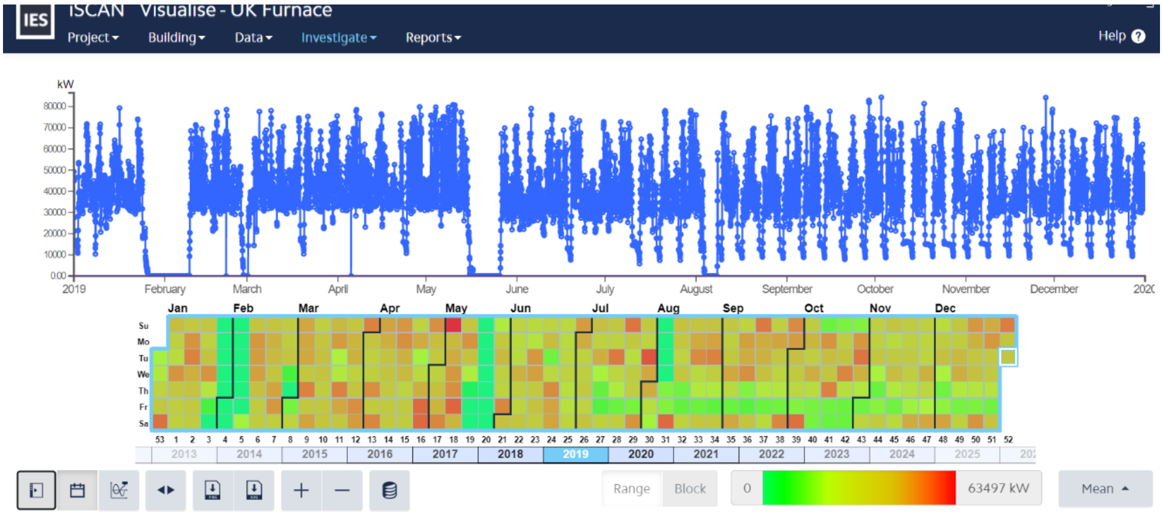

Figure 5.3: SO WHAT tool (iSCAN) estimated annual natural gas demand of the plant.

The imported iSCAN data has been imported into the iVN also, where the base scenario network has been modelled. The modelling involved the insertion of three fundamental nodes related to electrical consumption, thermal and especially waste heat, as shown in Figure 5.4.

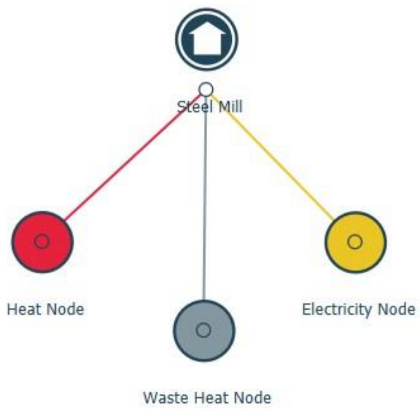

Figure 5.4: SO WHAT tool (iVN) Network modelling (baseline scenario).

Starting from the available data (temperature and flow) of the exhausted gases at the stack, the potential thermal power recoverable, about 14 MW, and its trend have been calculated. Also, this data has been imported into iSCAN and is represented in Figure 5.5.

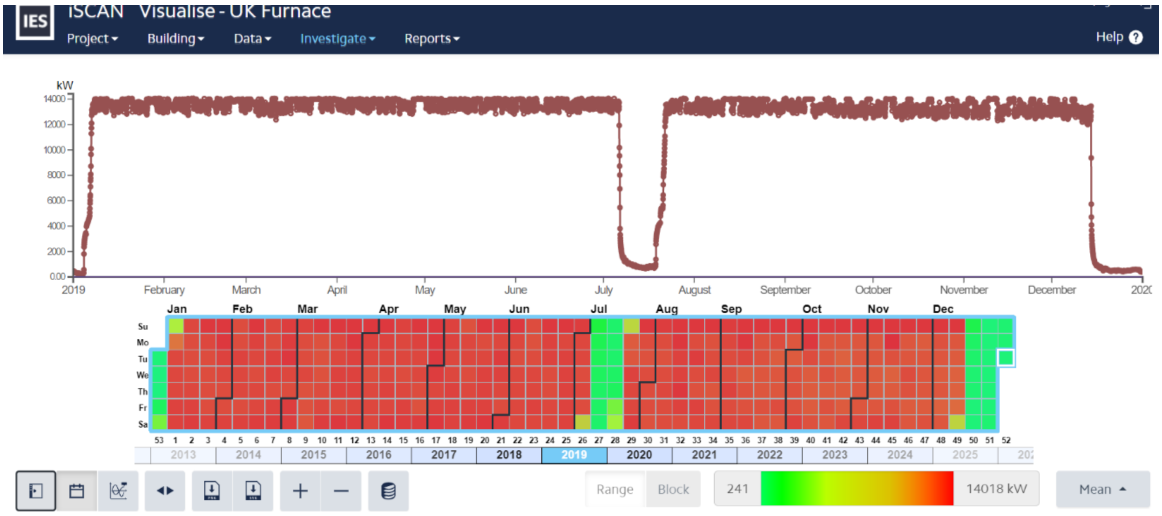

Figure 5.5: SO WHAT tool (iSCAN) estimated potential waste heat to recover.

6.1.3 Identification of potential WHR/WCR or RES opportunities

In order to maximise the benefits to be obtained from the reuse of waste heat at 350 °C, the possibility of installing an ORC turbine has been considered. This solution allows to reduce the temperature of the exhausted gases up to 135 °C (minimum temperature to be kept inside the furnace stack to prevent the risk of condensation in the stack) and to produce electricity that will be self-consumed for 100% by the steel mill. In Figure 5.6 the scheme of the new scenario is described.

To correctly simulate the operation of the ORC module according to the load profiles imported by iSCAN, specific parameters, related to the new heat source, have been inserted into a new Script Python. These specific parameters concern:

- Heat source mass flow rate;
- Heat source-specific heat capacity;
- Heat source inlet and minimum allowed outlet temperature.

Figure 5.7 reportsthe new Script Python uploaded to iVN before the simulation, and Figure 5.8 shows the new network model that connects the ORC module to the electrical and waste heat node and waste heat nodes

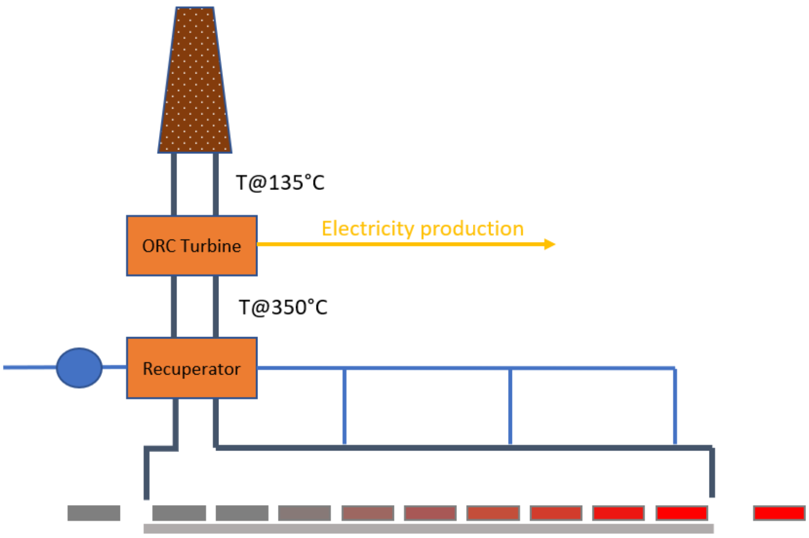

Figure 5.6: Reheat furnace scheme (New scenario)

```
import numpy as np

#def ORC(INPUTS):

    # Organic rankine cycle (ORC) installation input parameters
    #if INPUTS == []:
m_hs = 60.0           # Heat source mass flow rate [kg/s]
Cp_hs = 1.1          # Heat source specific heat capacity [KJ/(kg.K)]
#T0 = 25               # Reference ambient air temperature [°C]
T_hsin = 350          # Heat source inlet temperature [°C]
T_hsoutlim = 135      # Heat source minimum allowed outlet temperature [°C]

    #else:
        #pass

#print('Q T_hsout T_hsin epsLim, eps, etha, Win, Wnet')
#print(ORC([]))
```

Figure 5.7: Script Python for ORC module.

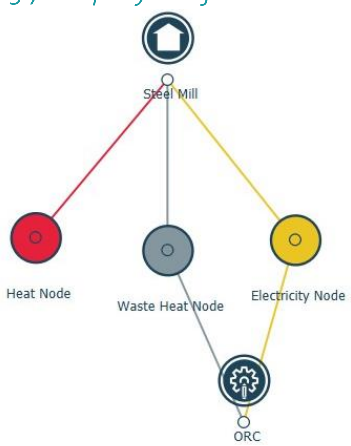

Figure 5.8: SO WHAT tool (iVN) Network modelling (New scenario).

The iVN simulation allows obtaining the waste heat removal profile, as reported in Figure 5.9. It is noticed that the trend is different regarding the diagram drawn in figure 3.5. The diagram of figure 3.5 describes the potential waste heat that could be recovered, and it is related to the furnace operation. On the other hand, the trend shown in Figure 5.9 the result of the iVN simulation, relates the waste heat available, consumption of electricity, minimum percentage of load and environmental conditions.

So, it should be noted that for simulations involving complex systems such as turbines or combustion engines, the results of simulations could be varied, since these depend on multiple external factors with different variables.

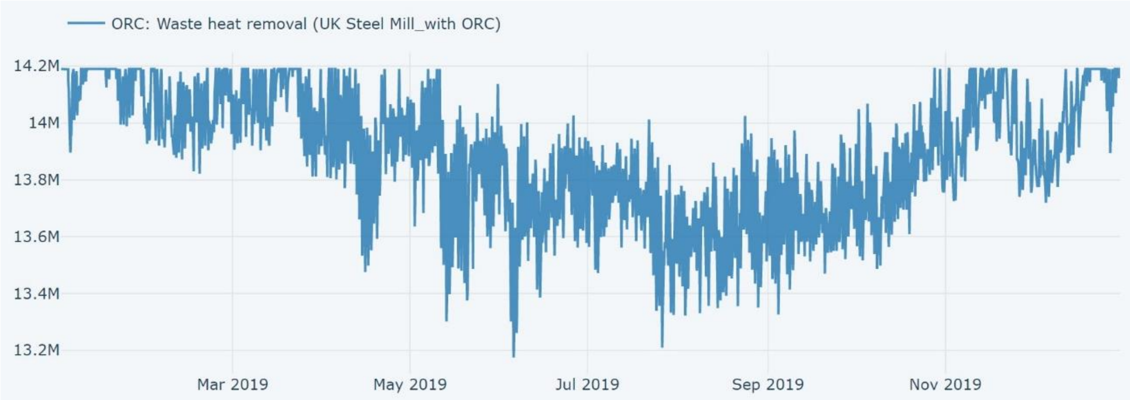

Figure 5.9: SO WHA tool (iVN) output graph of hourly waste heat removal by ORC module

6.1.4 Evaluation of energy savings and avoided GHG emissions

By installing an ORC turbine for electricity production, it is possible to reduce electricity consumption by about 20.5 GWh/year, which corresponds to 40% of the estimated EE consumption. This opportunity also makes it possible to reduce GHG emissions by 4,357 tCO_{2eq}. The gas consumption remains unchanged since the analysed intervention allows only to recover the waste heat to produce electricity.

If there are other users within the plant that require thermal energy, this study could be deepened with the aim of identifying a technological solution that not only allows the production of electricity but also allows the recovery of additional heat from the transformation cycle, as in a CHP plant.

In the following figures, it is possible to notice how the turbine electric production allows to reducing the s from the grid.

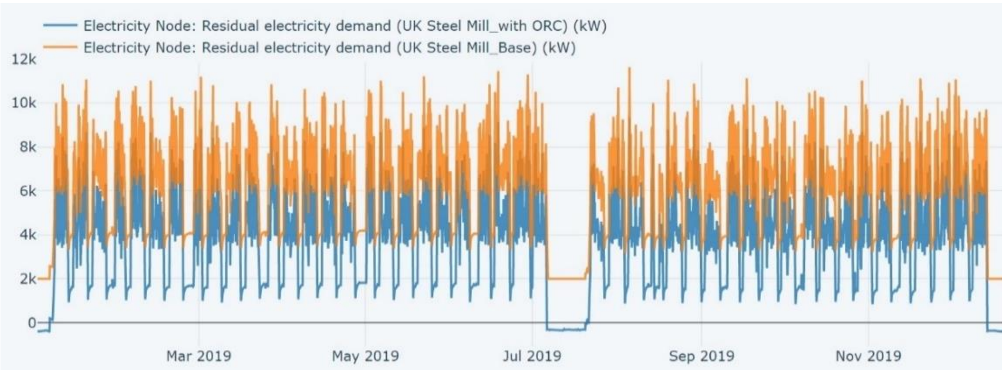

Figure 5.10: SO WHAT tool (iVN) comparison chart of hourly electricity demand (base scenario vs new scenario)

6.1.5 Cost-benefit analysis

The financial parameters evaluation has been carried out through the SO WHAT online tool. The data defined before the analysis are as follows:

- Electricity price: estimated in this case at 0.114 €/kWh (for the United Kingdom), based on statements by the UK Government;
- Baseline O&M costs: in this case related to the cost of electricity supply from the grid of about 2,343 k€/year (calculated through iVN);
- New scenario O&M costs: in this case related to the cost of maintenance of the ORC turbine.
- Useful life of the investment: for a turbine equal to about 20 years.

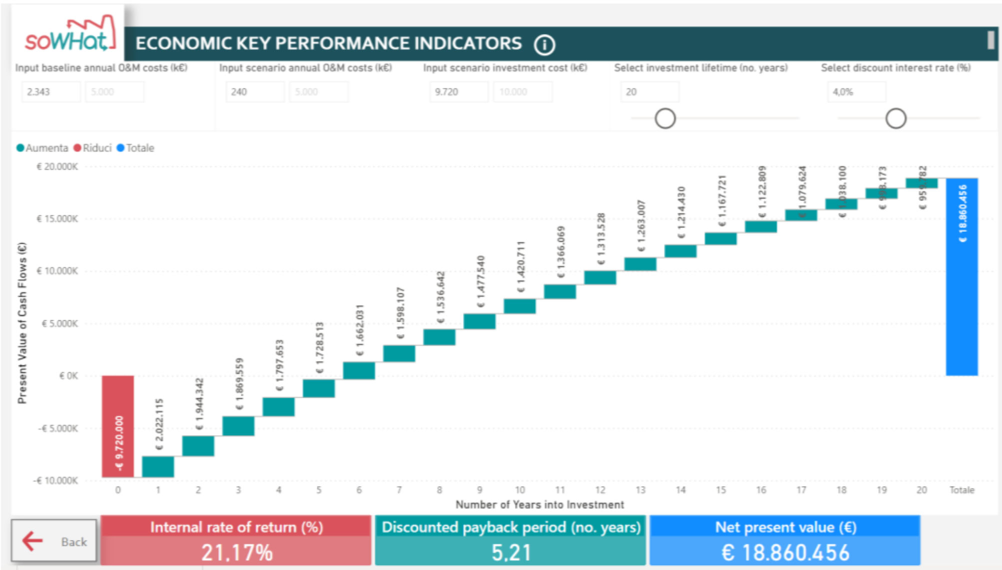

Figure 5.11: SO WHAT tool (online) economic feasibility analysis.

Figure 5.11 shows the following financial parameters, obtained from an investment of 9,720 k€:

- Internal rate of return: 21.17%;
- Discounted payback period: 5.21 years;
- Net present value: 18,860,456 €.

The investment involves a considerable expense, but the payback period parameter is very good for this type of activity. As for the other cases shown above, the cost of electricity is a fundamental factor to define this opportunity from the financial point of view and evaluate its aspects in the event of an increase or decrease in the price of energy.

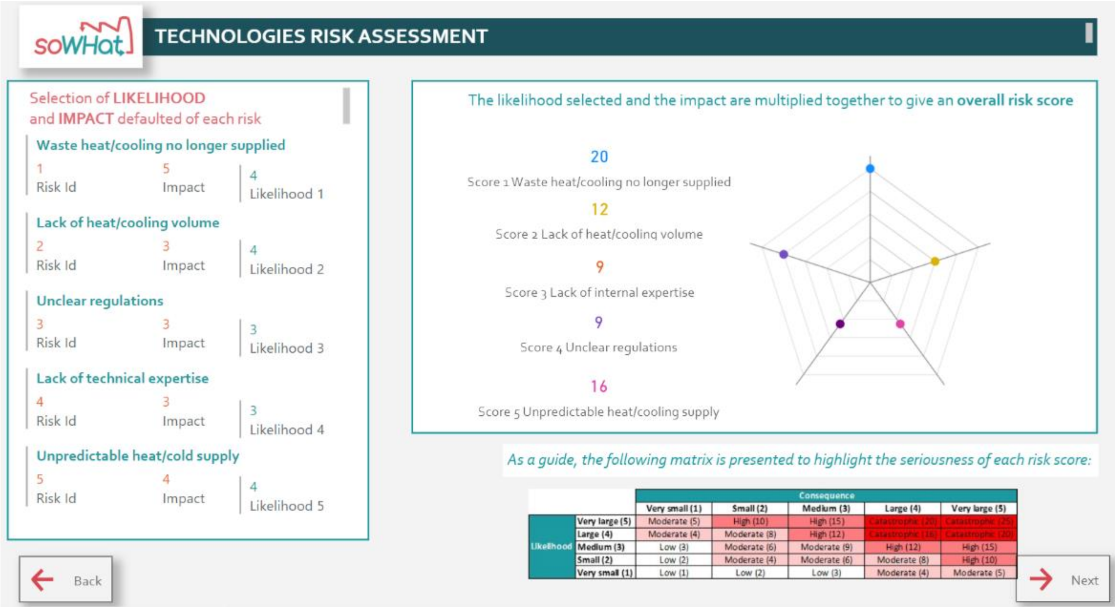

Figure 5.12: SO WHAT tool (online) Risk assessment results.

In the end, a technologies' risk assessment has been carried out, from which it is clear, as shown in Figure 5.12 that, in the event of a lack of waste heat supply and change in the amount required by the ORC turbine, it would no longer be possible to produce electricity and therefore these factors have a significant impact on the success of the investment.

This replication study showed how through the SO WHAT tool it is possible to evaluate a new solution by connecting different factors, from technical aspects to economic aspects.

7 Conclusions

In conclusion, through the analysis of three different replication studies, it has been possible to use the various functionalities of the SO WHAT tool in a different way. This tool would allow to promote the evaluation of new solutions to reuse waste heat or cold, or if not available, to provide for a reduction in GHG emissions through the production of energy from renewable sources.

Indeed, in order to define a replication strategy, the data available and the technical knowledge of the topics are important. Once a correct baseline scenario model has been settled, inserting real input and if necessary, estimated data, it is possible to evaluate different new scenarios.

These new scenarios may involve new users, outside the industrial plant, to be added to the network already created (as in the case of LIPOR) or individual users within a single industrial plant (as in the case of the steel mill). Or even, is not possible to carry out any heat/cold recovery, is it possible to evaluate the annual production of a photovoltaic system in that geographical area and calculate the potential reduction of energy supply from the grid (as in the case of Santo Stefano Belbo).

Through the risk assessment and the economic indexes analysis, it is possible to evaluate the correct strategy of action. For example, in the case of LIPOR complementary scenario it occurs that in the assessment of the investment, the financial parameters are not positive by selling heat only to the Business Hub and the beer factory. To ensure an economic return it is necessary to sell more thermal energy and then involve other companies in the new potential district heating network. For the other case studies, the economic analysis tool could support the choice of new investments, also evaluating market changes that could positively or negatively affect financial parameters.

Therefore, the SO WHAT tool is very useful to evaluate potential scenarios both from a technical and economic point of view, adapting to the level of detail of the inputs available. However, it should be noted that the level of technical knowledge of the user is also important, who must know, at least in general, the fundamentals of thermodynamics and programming.

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