H2020 Work Programme

D4.2 – SIMPLIFIED VERSIONS OF SO WHAT TOOL FOR QUICK DECISION MAKING

Lead Contractor: IES R&D (IESRD)

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[1] PU = Public
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13/11/2022	2	Nick Purshouse	Updated with financial analysis section

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Executive summary

This document represents part of the work completed as part of Task 4.1 – 'SO WHAT simple tool to enable quick decision-making'. As such, this report details the final SO WHAT simple tool created to identify the opportunities and potential for WH/C recovery within the industrial environment from both an economic and technical perspective.

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TABLE OF CONTENTS

Horizon 2020
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TABLE OF FIGURES

Horizon 2020
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1 Introduction

1.1 Objective of the Task

This document represents part of the work completed as part of Task 4.1 – 'SO WHAT simple tool to enable quick decision-making'. The Grant Agreement states:

"This task will develop a simplified version of the prototype SO WHAT software, starting from REEMAIN project experience to identify the opportunities and potential for WH/C recovery within the industrial environment and the potential for use of local RES and any surplus or excess energy from local RES. This will enable the decision maker to decide quickly if they wish to investigate and invest further in the creation of a detailed simulation model, which will carry out a detailed technical and economic feasibility study with respect to implementing a full solution for the industrial park. An easy to use and intuitive dashboard will also be provided to allow the end user explore different what-if scenarios defined in T2.4 relating to technical environmental, social, legal and financial objectives and constraints that are unique to their own situation. According to WP1-2-3 outcomes RINA-C will set up a KPI panel both for the simple and detailed SO WHAT tool that will be also useful for WP5 validation."

This report details the final SO WHAT simple tool created to identify the opportunities and potential for WH/C recovery within the industrial environment from both an economic and technical perspective.

The 'KPI panel' mentioned in the task description was completed as part of D4.1 'SO WHAT tool KPI Panel'.

1.2 Limitations

This report details the final SO WHAT simple tool created to identify the opportunities and potential for WH/C recovery within the industrial environment from both an economic and technical perspective. However, due to resource and technical constraints, it should be noted that from the description above, it has not been possible to complete the aspects Community modelling and the integration of Renewable Energy Systems modelling in such a simple tool (more explanation on this is shown in Section 2).

1.3 Relationship with other activities in the project

The relationship in terms of inputs and outputs of this task to the rest of the WPs and tasks in the project are as follows:

Inputs into this task are:

- **Task 2.1** – Definition of ends-users' requirements through a participatory approach – this defined what functions and features the users would require from the software.
- **Task 2.4** – Definition and selection of scenarios – defined the methodology to guide the user on which technologies would be most suitable to use for their needs.
- **Task 3.5** - Input for algorithms to be included in SO WHAT tool for business and deployment plan – This was used for the risk and financial analysis parts of the tool

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Outputs from this task will be used for::

- Task 7.2 - Public and market acceptance of SO WHAT TOOL: TRL9 roadmap – In order to gain market acceptance it is imperative that the tool has been used in the pilot sites so the results can be used as case studies.

1.4 Structure of the document

The rest of the report is divided into the following sections:

Section 2 details the design and development of the Tool following on form the user requirements, workflow and use cases documented in WP2.

Section 3 explains the Methodology followed to create a Tool that is simple enough to be used by non-experts yet robust enough to stand up to academic scrutiny.

Section 4 is the demonstration of the Tool in its entire, whilst Section 5 is the Conclusion of the report.

2 Design and Development

2.1 Summary of Requirements from WP2

Deliverable 2.4 gave an overview of the requirements of the simplified version of the SO WHAT tool based on what was stated in the grant agreement and stakeholder/user feedback as contained in deliverables 2.1 Definition of ends-users' requirements through a participatory approach.

The broad requirements of the tool from these deliverables can be summarised as follows:

- Tool should be a starter/guide to allow the user to understand the rough potential for waste heat before conducting detailed analysis (using the SO WHAT Commercial Tool)
- Online and free
- User to collect & enter as little data as possible
- End to end workflow should take no longer than 30 minutes
- Appeal to a variety of users (technical, financial, interested in individual site or larger area)
    - Industry - Operation/Energy Manager of Industrial Facilities
    - Municipality / Regional Energy Agencies /Public Authorities
    - ESCOs / DH Operators
- Online workflow to guide user through each step
- 3D Building / Community View
- Industrial waste heat / cooling assessment based on industry profile
- Results visualisation of waste heat/cooling potential for technical and economic KPIs
- Ability to select technologies to simulate potential waste heat recovery to be used in same factory
- Visualise local community energy consumption
- View uses for waste heat/cooling in community & how to balance local waste heat supply with demand
- Business model guide

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It should be noted that at this stage in WP2, the need for the SO WHAT simplified tool to simulate RES and other sources of energy supply was no longer part of the simplified tool due to the technical complexity involved and would instead be contained in detail in the detailed tool.

2.2 Updates to IT Architecture and Workflow

Work with IESRD User Experience team highlighted some key issues and updates to this functionality, and the following conclusions about the tools functions were drawn:

Firstly, if the tool is to be free and open, the barrier of having to log in with a password should be removed as it does not add value and detracts from the tool. As well as this, the user workflow should be very simple and intuitive so that a separate user manual/guide is not required, but can instead be contained within the Tool as a pop up icon if the user requires some help.

In terms of the 3D view, there did not seem to be value to the user in this functionality since the backend calculations for waste heat potential do not depend on the specific location of the facility. The 3D view was therefore removed from the requirements.

It was also felt that the Tool should be standalone and not connected to IES' software in order for it to be easy and quick to use as well as having longevity with little or no maintenance and support requirements.

From the updated specification requirements, the IT architecture and workflow as shown in deliverable 2.4 were revisited and updated. Rather than have a number of different backend software interacting with an online front end software, it was decided that this was no longer necessary and that the use of Microsoft Power BI as the front end software would be ideal. Microsoft Power BI is interactive data visualisation software product developed by Microsoft with a primary focus on business intelligence. This could be used to allow users to enter the required data, look up against back end data and formulae and give the users the necessary results in a visual way. It also meant it could be embedded within the SO WHAT project website with no ongoing maintenance and support.

As well as this, it was felt that it would be possible to use Python scripts to utilise the existing work from SO WHAT on technology simulations to be run in the simplified tool as well as looking up against IES databases for building type energy consumption.

Development began on the creation of the SO WHAT simplified tool, however when the developers tried to use the Python scripts for each of the waste heat/cooling technologies that had been developed with the University of Birmingham as part of Task 4.2, it became clear that these were far too complex for the needs of the simplified tool and would not be compatible. Therefore, a different approach was taken whereby previous academic studies on waste heat/cooling technologies were obtained and key efficiency and input/output parameters.

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3 Methodology

The sources used to show the potential for waste heat/cooling by industry are outlined in this section and are either taken from previous EU funded projects, from research conducted as part of the SO WHAT project, or from existing academic studies.

For the referenced source information for all of the below, please see Appendix A.

In the Tool itself, for each source or calculation, where the User sees an 'I' icon, this can be clicked to bring up the required source or information.

3.1 Waste Heat/Cooling available per industry sector

The data used to obtain Waste Heat/Cooling available per industry sector used same method that was also used and validated in the following EU funded projects:

- STRATEGO
- HEAT Roadmap Europe 4
- PLANHEAT
- WASTE HEAT

3.2 Waste heat/cooling temperature ranges by industry sector

The data used to calculate the waste heat/cooling temperature ranges by industry sector came from an academic study in 2018 conducted by Papapetrou et al, titled 'Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country'

3.3 Waste Heat/Cooling Recovery and Re-Use Technologies temperature input /output and efficiency

For data regarding Waste Heat/Cooling Recovery and Re-Use Technologies temperature input /output and efficiency ranges, the main source was SO WHAT D1.6 Report On H/C Recovery / Storage Technologies And Renewable Technologies. However it was found that this contained some gaps in the data and it was therefore supplemented by a variety of academic sources. Where a ranges of temperature or efficiencies was found depending on the context and application of a technology, the mid-point of the range was chosen to represent the result in the tool.

3.4 Financial and Risk Analysis

The economic part of the Tool used the recommendations for risk analysis from D3.6 Guidelines for algorithms development for economic evaluation, which summarised the outputs of other WP3 tasks into requirements for SO WHAT tool. The financial KPis were also taken from this deliverable and corroborated with the calculations and KPIs contained in D4.1 SO WHAT tool KPI Panel.

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4 Demonstration of SO WHAT Simplified Tool for Industry

The Tool went live on SO WHAT website at the end of August 2022, following validation from the SO WHAT pilot sites. The tool can be found at: https://sowhatproject.eu/sowhat-tool/ which takes you to the Home page as shown below:

Figure 1 SO WHAT Simplified Tool Homepage

The User clicks on either Industry or Community depending what their interest is.

4.1 Industry

The User selects their country, industry and main fossil fuel used. This allows for a calculation on the percentage of Waste Heat not possible to be recovered. The User also enters their overall Energy Consumption based on the site's annual bill that is relevant to the potential waste heat. This page can be seen below:

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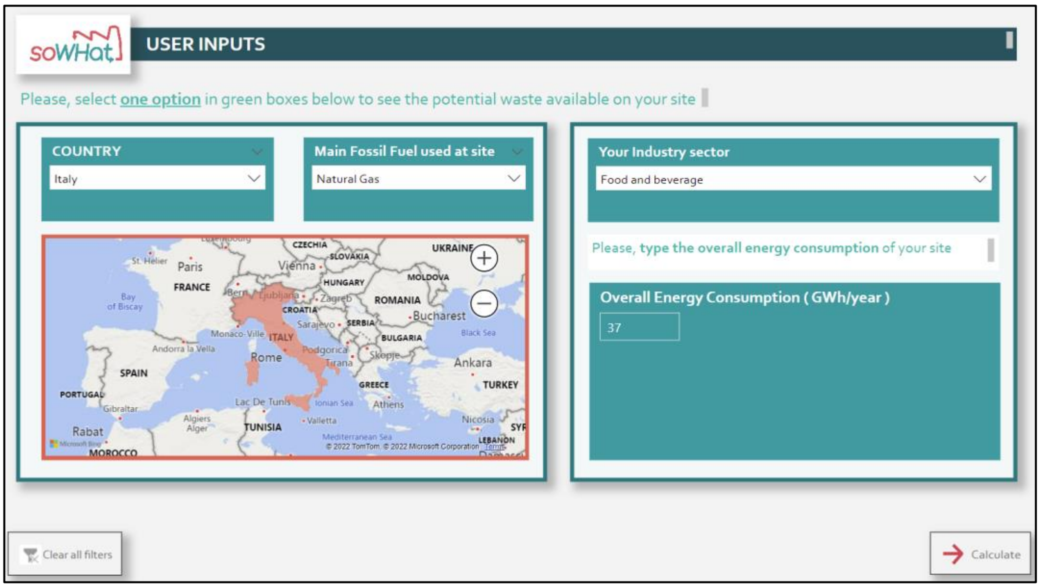

Figure 2 User inputs page

4.2 Waste heat resource assessment

Based on user's selection, the tool calculates the GWh/year of Waste Heat available. Graphs show how the WH changes with the temperature range at the site. They show the final figures as well as the percentage waste heat per temperature range. This page can be seen below:

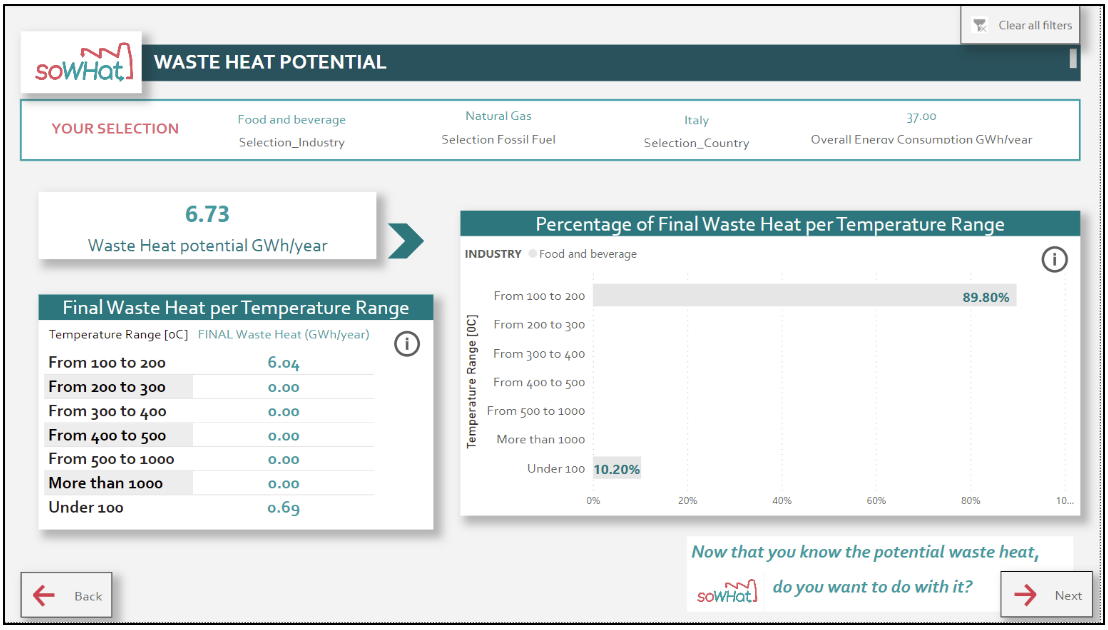

Figure 3 Waste heat resource assessment page

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4.3 Waste heat resource recovery technologies

Depending on the temperature range the user is interested in, a list of the most suitable technologies is shown as well as a guide to the Market maturity of each technology. This page can be seen below:

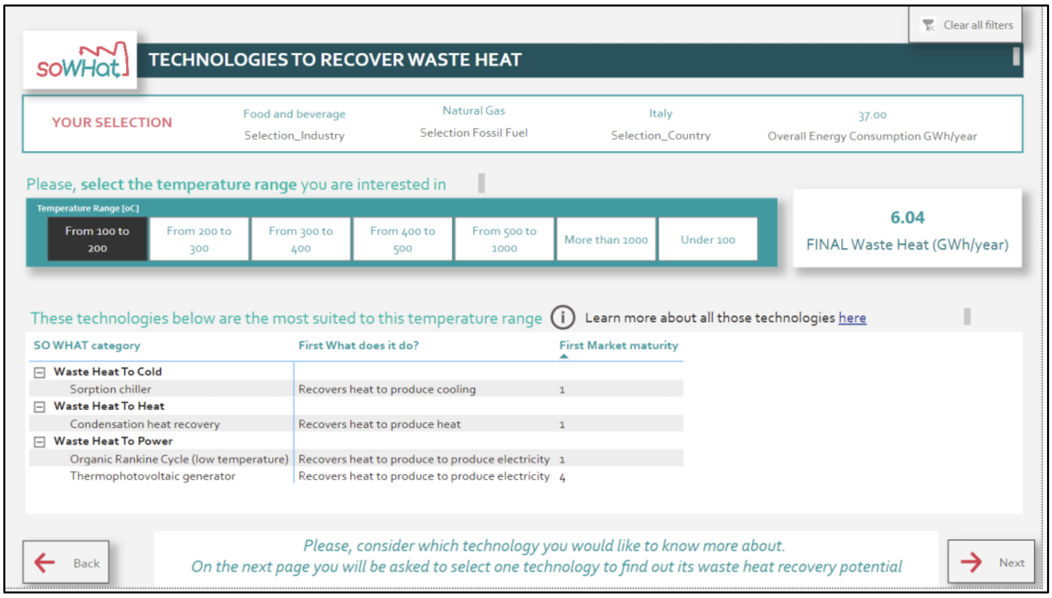

Figure 4 Waste heat resource recovery technologies page

4.4 Waste heat resource exploitation

Finally, the user needs to select that technology he/she is concern about. Thus, the tool applies an efficiency ratio and displays the Final Waste Heat that can be potentially produced. The maximum outlet temperature of that technology selected is also shown in the last page. This page can be seen below:

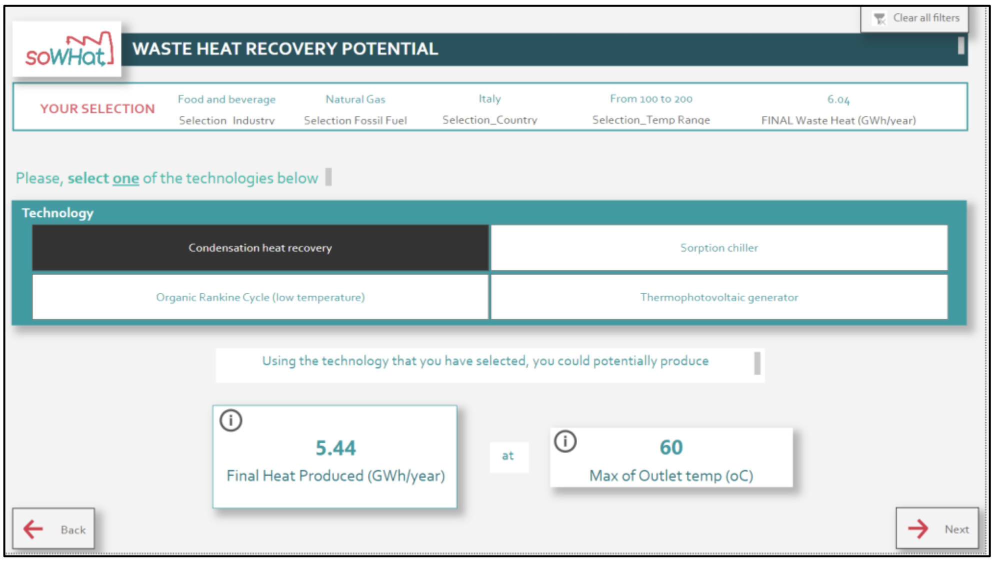

Figure 5 Waste Heat resource exploitation

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4.5 Risk Analysis

The risk analysis part of the Tool asks the user to assess how likely specific risks are to occur if the technology they have chosen is implemented. This page is shown below:

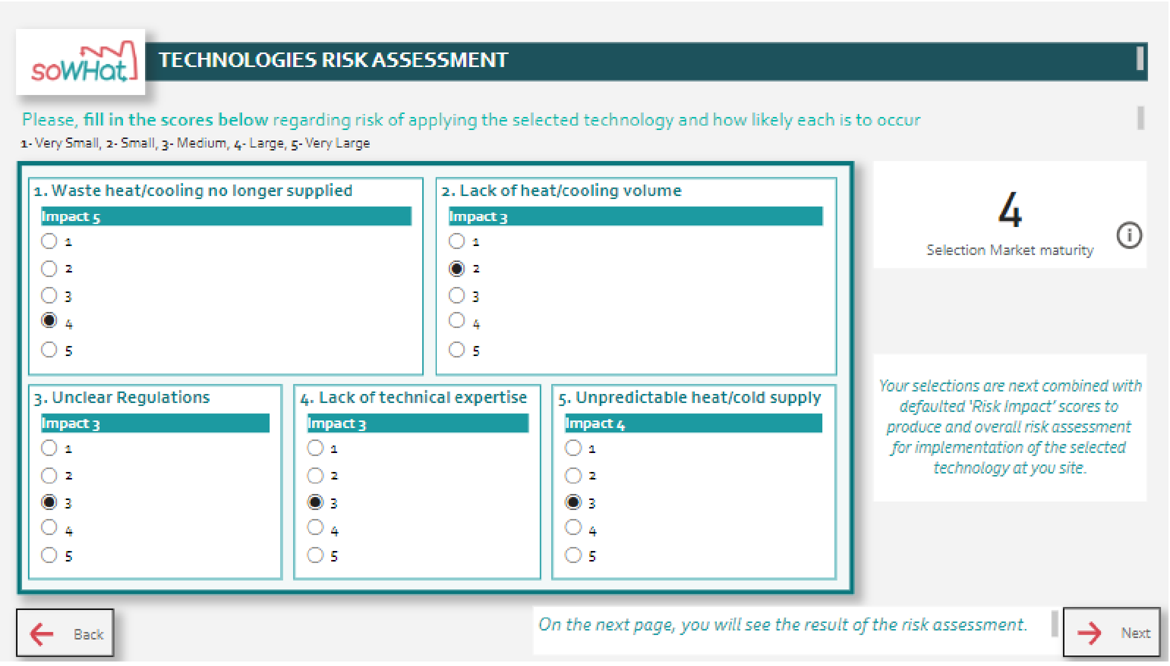

Figure 6 Risk Assessment page

This is then coupled with a Risk impact score (the score is already defaulted based on WP3 research). The risk scores and assessments are shown as both individual scores and also as a spider diagram which gives a fuller picture. This page can be seen below:

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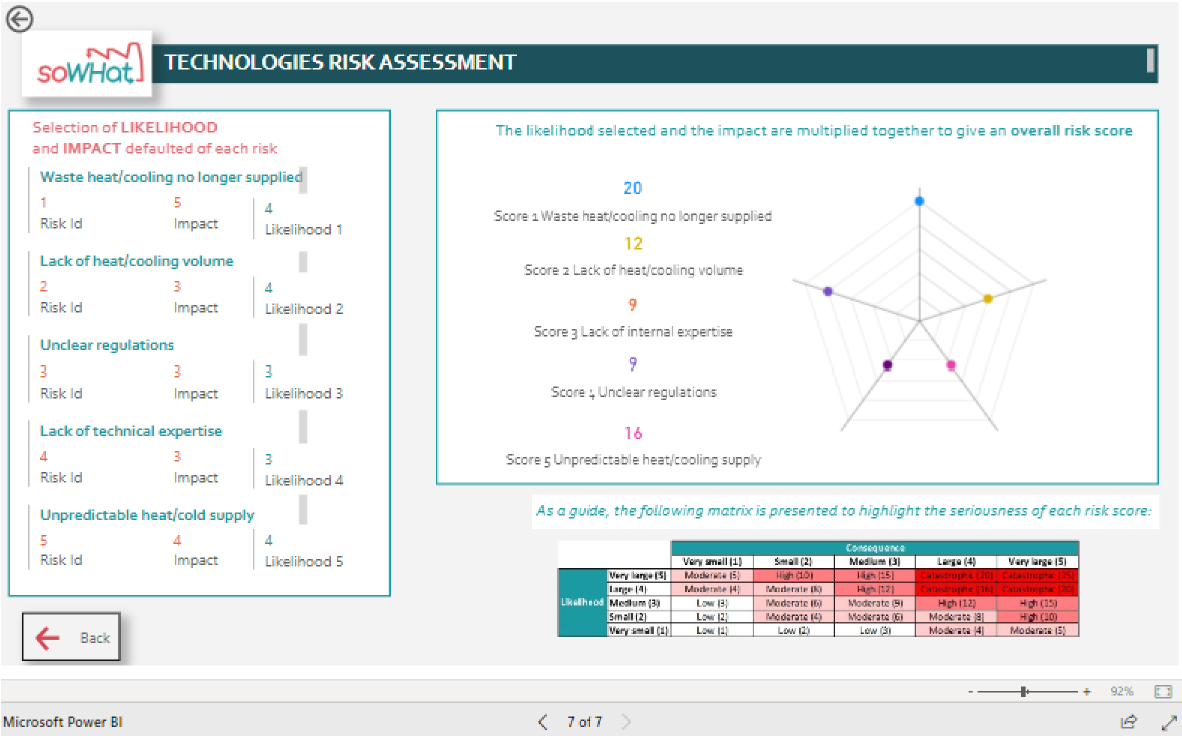

Figure 7 Risk Assessment result page

4.6 Financial Analysis

The financial analysis part of the tool is split into two parts, both of which are contained within the same page: User inputs and Results. The calculations involved in obtaining the results are a simplified version of what is available in the Advanced tool.

The User inputs are as follows

1. Input baseline annual O&M costs (k€): Fixed and variable (including energy supply) annual operation & maintenance costs, k€, of the current baseline installation.
2. Input scenario annual O&M costs (k€): Fixed and variable (including energy supply) annual operation & maintenance costs, k€, for the investment scenario installation of interest.
3. Input scenario investment cost (k€): Investment cost, k€, for the investment scenario installation of interest.
4. Select investment lifetime (no. years): Select number of years considered for the investment scenario of interest.
5. Select discount interest rate (%): Discount interest rate, %, considered for the investment scenario of interest.

Once user inputs have been set-up, the initial investment cost and the non-discounted delta annual cash flow (i.e. scenario against baseline, including O&M costs) for the investment scenario installation of interest are calculated in the background.

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Once the initial investment cost and non-discounted delta annual cash flow (i.e. scenario against baseline, including O&M costs) for the investment scenario installation of interest have been updated in the background, the user can visualise the economic KPIs for the investment scenario of interest, including the investment internal rate of return (IRR, %), the discounted payback period (DPBP, no. years), and the net present value (NPV, €), as well as a waterfall figure detailing on the discounted annual cash flows over the investment lifetime.

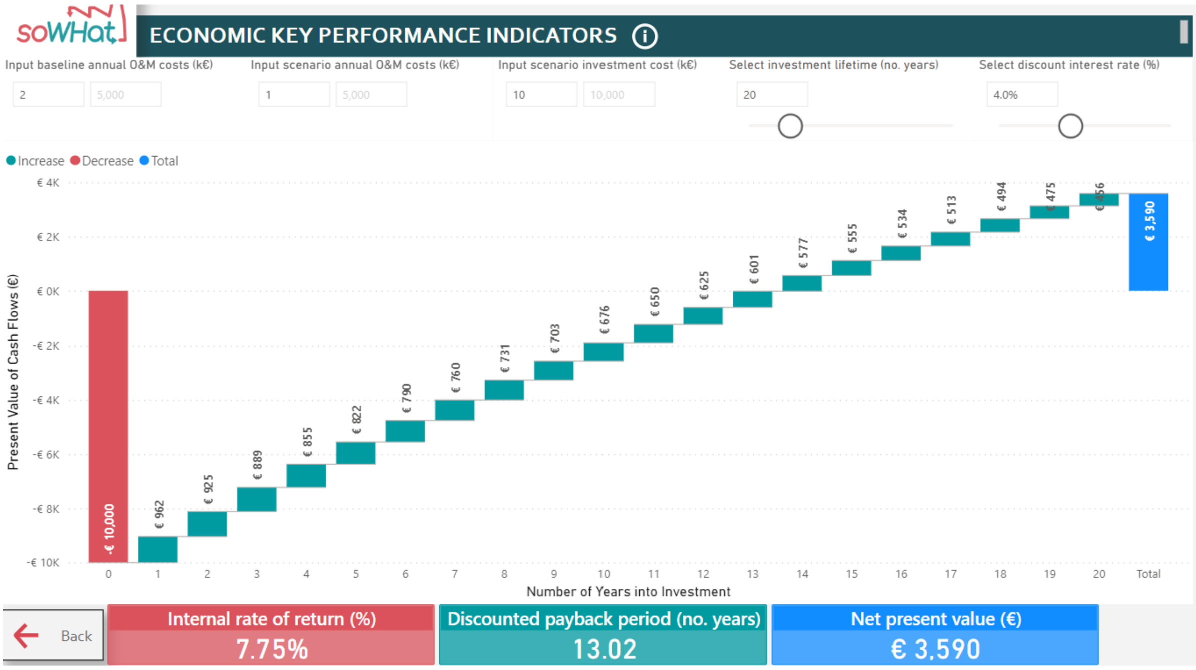

Figure 8 Financial Analysis User inouts and Results page

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5 Conclusion

The final SO WHAT simple tool created to identify the opportunities and potential for WH/C recovery within the industrial environment from both an economic and technical perspective, has been demonstrated in this report.

Starting from the user requirements, workflows and use cases documented in WP3, the Tool has been designed for non-experts that require a guide as to the potential of waste heat/cooling in their facility. The Tool has as little input from the user as possible but can still be considered as robust as it is based on peer to peer reviewed academic studies or the extensive research done in the SO WHAT project.

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6 Appendix A: Sources

Sources for industry Waste Heat profiles:

- Connolly, D., Lund, H., Mathiesen, B.V., Werner, S., Möller, B., Persson, U., Boermans, T., Trier, D., Østergaard, P.A., Nielsen, S., 2014. Heat Roadmap Europe: Combining district heating with heat savings to decarbonise the EU energy system. Energy Policy 65, 475-489.
- Connolly, D., Vad Mathiesen, B., Alberg Östergaard, P., Möller, B., Nielsen, S., Lund, H., Persson, U., Werner, S., Grözinger, J., Boermans, T., Bosquet, M., Trier, D., 2013. Heat Roadmap Europe 2050 - Second pre-study for EU27. Euroheat & Power, Brussels. Available at: (http://www.euroheat.org/Heat-Roadmap-Europe-165.aspx).
- Connolly, D., Vad Mathiesen, B., Alberg Östergaard, P., Möller, B., Nielsen, S., Lund, H., Persson, U., Werner, S., Nilsson, D., Trier, D., 2012. Heat Roadmap Europe 2050 - First prestudy for EU27. Euroheat & Power, Brussels. Available at: (http://www.euroheat.org/HeatRoadmap-Europe-165.aspx).
- Persson, U., 2015. District heating in future Europe: Modelling expansion potentials and mapping heat synergy regions, Dissertation Thesis. Series Nr: 3769. Energy and Environment. Chalmers University of Technology, Göteborg.
- Persson, U., Möller, B., Werner, S., 2014. Heat Roadmap Europe: Identifying strategic heat synergy regions. Energy Policy 74, 663-681.

Source for the waste heat/cooling temperature ranges by industry sector:

- Papapetrou et al: Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country, Applied Thermal Engineering, Volume 138, 2018, Pages 207-216 https://www.sciencedirect.com/science/article/pii/S1359431117347919

Sources for technologies and input temperature ranges:

- The main source was SO WHAT D1.6 Report On H/C Recovery / Storage Technologies And Renewable Technologies: https://sowhatproject.eu/wp-content/uploads/2018/05/SO-WHAT_D1.6_Report-on-HC-recoverystorage-technologies-and-renewable-technologies_FINAL_updateMARCH2021.pdf

Where there were gaps in the data, this was supplemented by:

- Thermal Energy Storage (water, phase change material, thermochemical): https://iea-etsap.org/E-TechDS/PDF/E17IR%20ThEnergy%20Stor_AH_Jan2013_final_GSOK.pdf

Sources for technologies and output temperature ranges:

- The main source was SO WHAT D1.6 Report On H/C Recovery / Storage Technologies And Renewable Technologies: https://sowhatproject.eu/wp-content/uploads/2018/05/SO-

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WHAT_D1.6_Report-on-HC-recoverystorage-technologies-and-renewable-technologies_FINAL_updateMARCH2021.pdf

Where there were gaps in the data, this was supplemented by:

- Thermal Energy Storage (water, phase change material, thermochemical): https://iea-etsap.org/E-TechDS/PDF/E17IR%20ThEnergy%20Stor_AH_Jan2013_final_GSOK.pdf

Sources for technologies efficiencies:

- The main source was SO WHAT D1.6 Report On H/C Recovery / Storage Technologies And Renewable Technologies: https://sowhatproject.eu/wp-content/uploads/2018/05/SO-WHAT_D1.6_Report-on-HC-recoverystorage-technologies-and-renewable-technologies_FINAL_updateMARCH2021.pdf
- Where D1.6 showed a range of efficiencies for a technology, then the average between the figures was used.

Where there were gaps in the data, this was supplemented by:

- Condensation heat recovery: https://www.process-heating.com/articles/90731-condensing-heat-recovery-for-industrial-process-applications, https://www.thermalenergy.com/heat-recovery-faq.html
- Waste heat boilers: http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/index-boiler-operations/
- Heat pipe heat exchanger: https://www.intechopen.com/chapters/76428
- Thermal Energy Storage (water, phase change material, thermochemical): https://iea-etsap.org/E-TechDS/PDF/E17IR%20ThEnergy%20Stor_AH_Jan2013_final_GSOK.pdf
- Steam Rankine Cycle: https://www.sciencedirect.com/science/article/pii/S1364032113000592

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