EMB3Rs
Heat and Cold matching platform

D6.8 - Training Materials

AUTHORS : SHRAVAN KUMAR, JAGRUTI THAKUR, FRANCESCO GARDUMI, ALI KÖK, ANDRE LISBOA, JOSE MARIA CUNHA, ANTONIO SERGIO FARIA, BILAL SIDDIQUE KHAN

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SPIRE PROJECT

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

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Summary

This report presents the training materials for the EMB3RS platform. These materials aim at guiding users on how to work with the platform and illustrating different platform functionalities. In particular, this report includes step by step instructions with illustrations to run 3 different simulation types, using a demo case in the EMB3RS platform. The demo case consists of 4 industrial sources of excess heat and also includes a total of 8 sinks, consisting of 5 industrial sinks, the district heating and cooling systems in a nearby town, a greenhouse and a building. The different types of sinks are used to demonstrate different types of characterisations that can be performed in the platform. Three different types of simulations are performed: the full simulation i.e., simulation calling all modules, and 2 internal heat recovery simulations, i.e., Organic Rankine Cycle (ORC) and pinch analysis.

These training materials have been used in 1 internal workshop and 2 external stakeholder workshops where participants were able to successfully run simulations using these materials. The feedback received in the context of such workshops has helped to improve and refine these materials.

They may now be used as a reference for a beginner wishing to start using the EMB3Rs platform.

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Disclaimer

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1 Introduction

The main objective of this workshop is for the user to understand the main concepts and workflow of the EMB3RS Heat and Cold matching platform. The examples provided below are fictional and try to represent how users can work with the platform and what they can find from its results, regarding industries data and/or techno-economic data when assessing internal heat recovery options or possible District Heating Networks (DHN). By performing the workshop, a clear insight is given to the user on how to use and get the best performance of the platform.

Case description

The case to be modelled for this workshop refers to the Volos Industrial Park (lat=39.396082; long=22.807625), located near the town of Agios Georgios (lat=39.369967; long=22.776940) in Greece. In the Industrial Park of Volos, there are several industries with excess heat and industries that could benefit from the use of this excess heat in their processes. There is also a large office and a greenhouse near the industrial park that could serve as heat consumers. The town of Agios Georgios, although it is about 6 km away from the Volos Industrial Park, is also an interesting large consumer of heat due to the consumption of hot water by households and space heating. The details of the sources and sinks are shown in Figure 1.

In the exercise that follows you will run a simulation which determines the least-cost matching between available excess heat sources and the potential sinks, building a new District Heating Network where needed and respecting constraints given by the heat loads (both on the supply and demand side) and other resources. The optimisation covers the year 2023 and has a time resolution of 48 intra-annual timesteps.

You will receive insights on:

- The layout of the least-cost grid network that matches the heat demands, and its costs and losses.
- Installed capacities and operational profiles of all the technologies needed to match sources and sinks (including e.g. heat exchangers, heat pumps for boosting the source temperature to match the network or the sink, solar thermal heating options connected directly to the sinks, etc.)
- Best market framework aligned with the users' economic, environmental, and social interests.
- The financial profitability of the project for all actors potentially involved (who pays for what and who profits from what)

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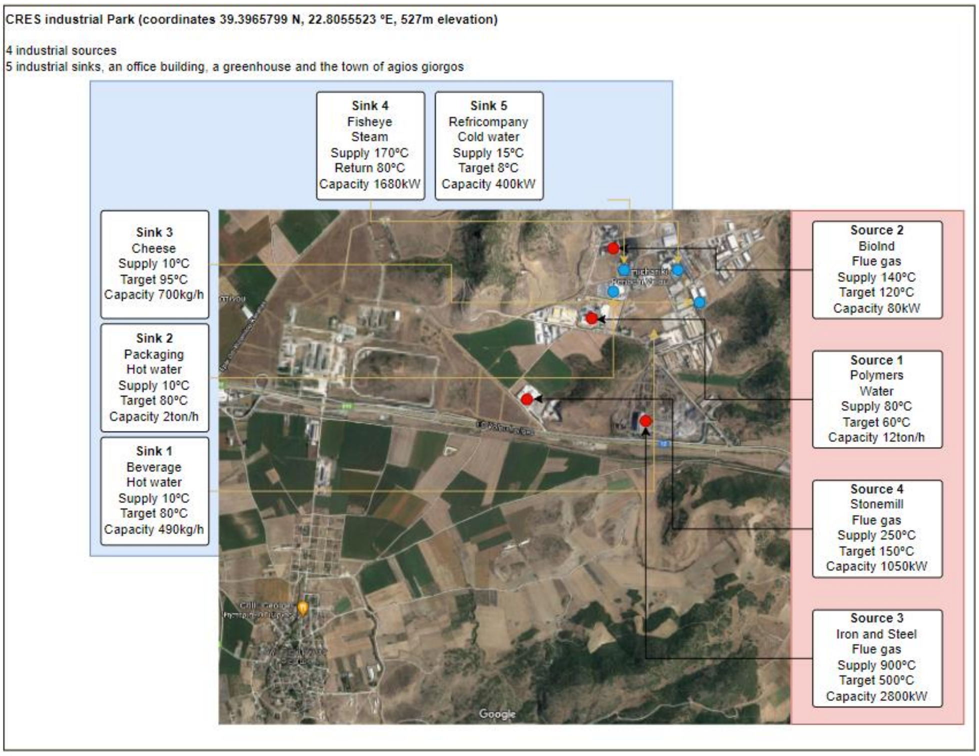

Figure 1: Sources and sinks in the case

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Step 0: Sign up on the EMB3RS platform

Everyone wishing to use the EMB3Rs platform needs to create an account. Please open the EMB3RS platform in your web browser using this link (https://platform.emb3rs.eu). You will see the window shown below.

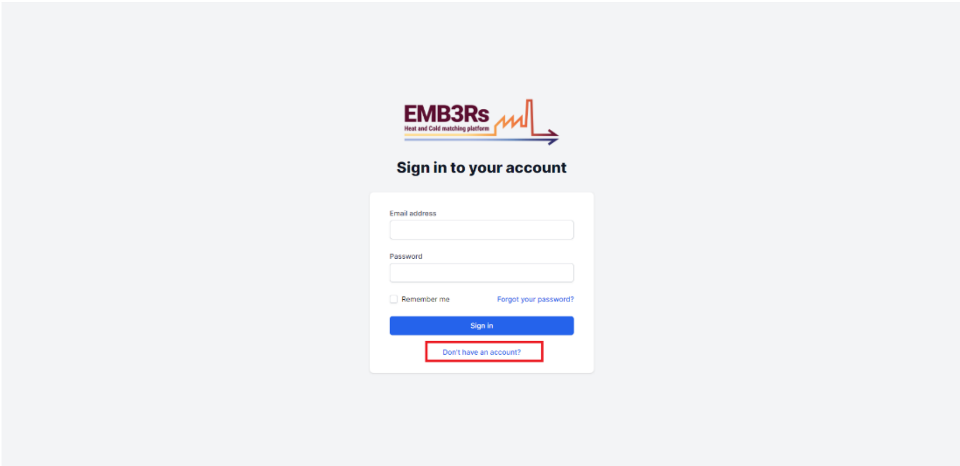

Figure 2: Platform sign in

If you already have an account, please log into the platform. If not, please click on the 'Don't have an account?' button highlighted in the above figure. The window will appear as shown below.

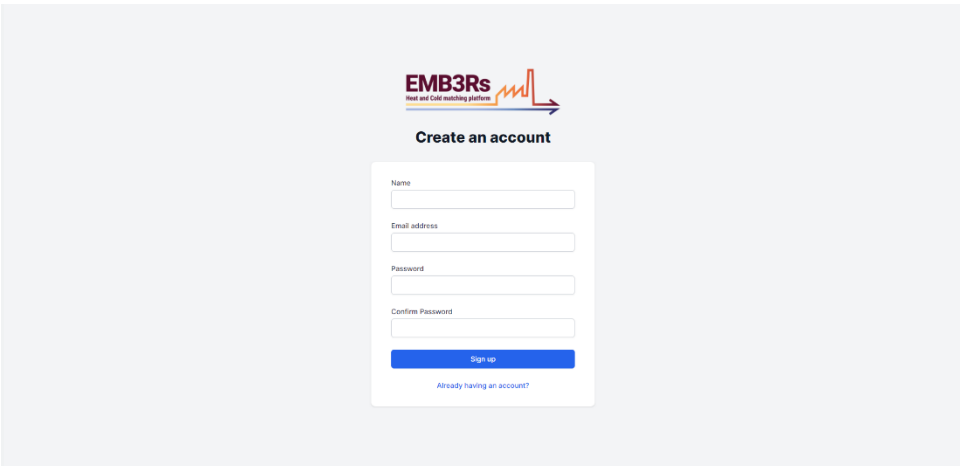

Figure 3: Platform registration

Sign up to the platform with an email address and password. You will receive a confirmation email to your registered address. The account will be created once you open the link in the confirmation email.

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Challenge 1: Create a new DHN Network

Step 1: Log into the platform and create a project

As the first step, you need to log into the platform. The platform can be loaded in a web browser using this link. Please log into the platform using the username and password shown in Figure 4.

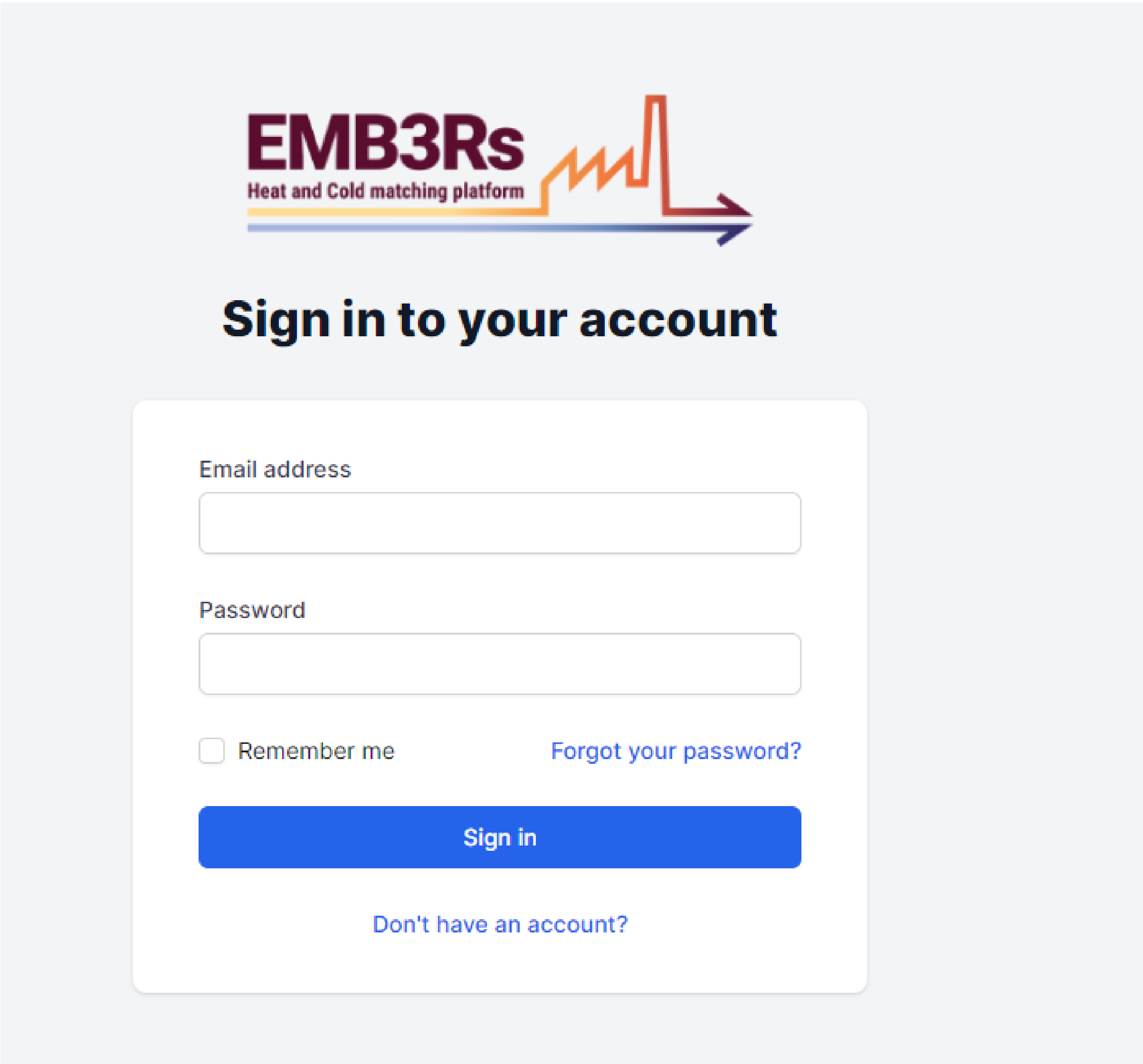

Figure 4: Signing up on the platform

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Once you have logged in, you will be able to see the dashboard as shown in Figure 5. Click on ‘Objects’ in the left side panel on the platform. You need to first create new sources and sinks. They will be the ones to be matched in this exercise.

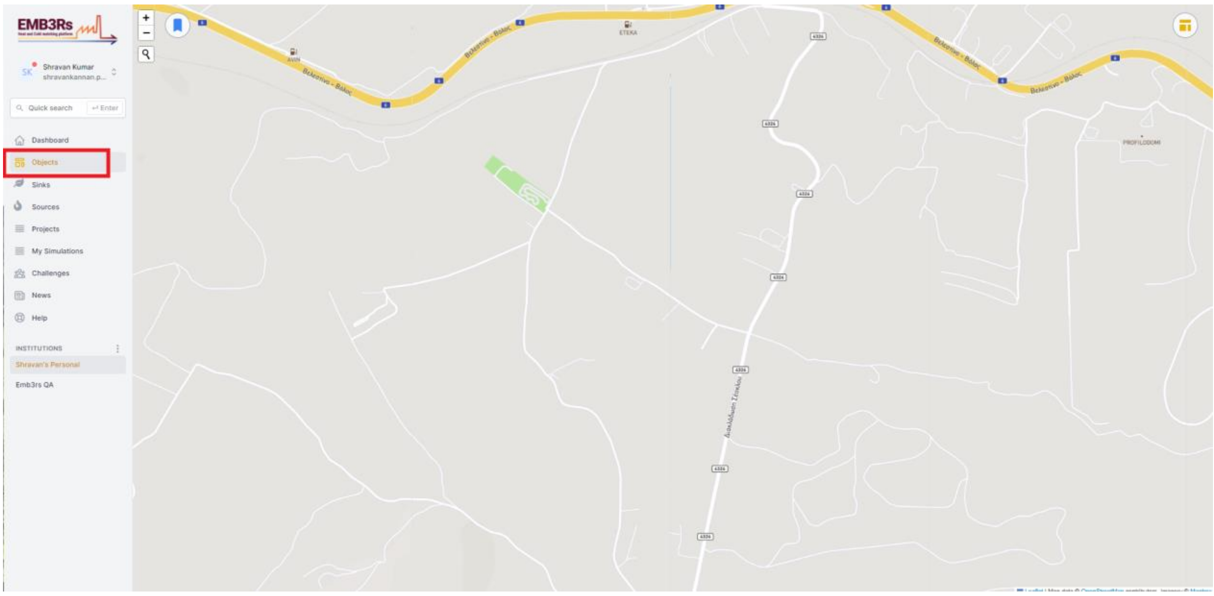

Figure 5: EMB3RS dashboard

Step 2: Creating and characterising Sources and Sinks

The case to be modelled refers to the Volos Industrial Park, located near the town of Agios Georgios in Greece, and the town itself.

In the industrial park, 4 potential excess heat sources were identified:

1. **Polymers**
2. **BioInd**
3. **Iron&Steel**
4. **Stonemill**

As sinks, a total of 6 sinks were identified:

1. **Beverage Unlimited**
2. **BestPackaging**
3. **MilkCheese**
4. **Fisheye**
5. **RefriCompany**
6. **Agios Georgios Town**

The sources and sinks have the characteristics reported in Table 1 and Table 2. We will guide you on inserting these into the platform.

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Table 1: Source details

Property	Unit	Sources			
Name		Polymers	BioInd	Iron&Steel	Stonemill
Template	-	Simple source	Simple source	Simple source	Simple source
Latitude	º	39.393056	39.398611	39.385556	39.397222
Longitude	º	22.803611	22.804444	22.806944	22.804167
Fluid	-	water	flue gas	flue gas	flue gas
Supply Temperature	ºC	80	140	900	250
Target Temperature	ºC	60	120	500	150
Capacity	kW	-	80	2800	1050
Fluid cp	kJ/kg	4.2	-	-	-
Mass Flowrate	kg/h	12000	-	-	-
Daily Periods	hours	[[0,24]]	[[6,21]]	[[0,6],[22,24]]	[[6,24]]
Saturday On	-	YES	NO	YES	YES
Sunday On	-	YES	NO	YES	YES
Shutdown Periods	days	[]	[[182,240]]	[]	[[1,10],[140,160]]

Start by inserting Iron&Steel. Click on the small brown round icon appearing in the top right corner of the window as shown in Figure 6.

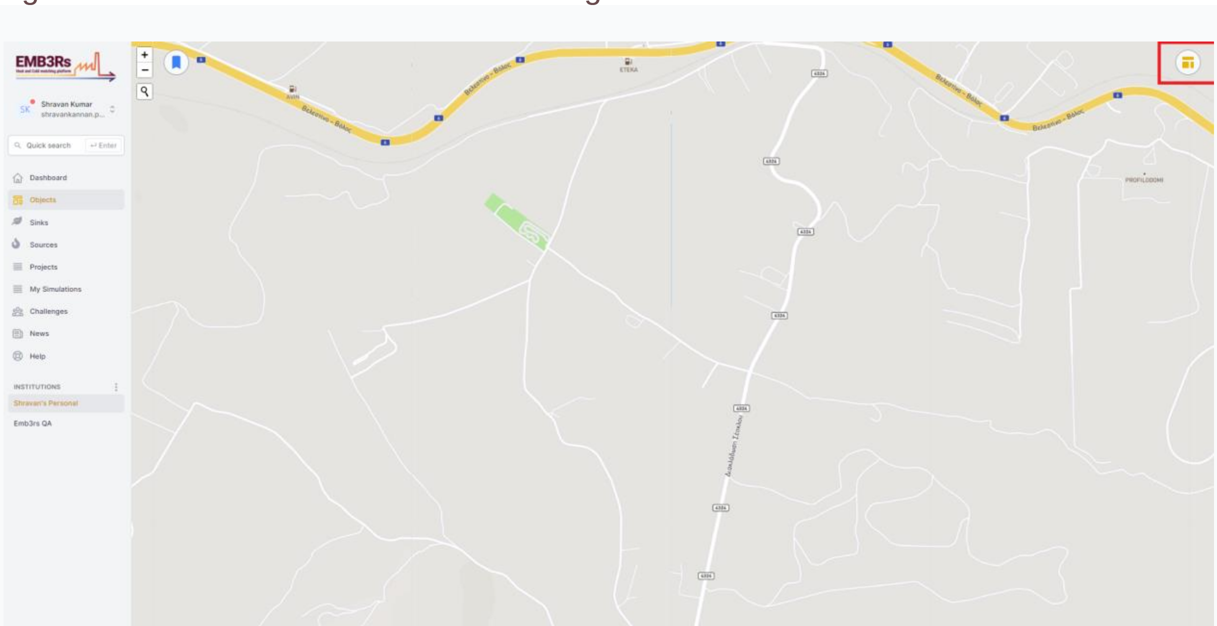

Figure 6: Objects in the EMB3RS Platform

You can choose whether it is a source, sink, or link using the dropdown highlighted in Figure 7.

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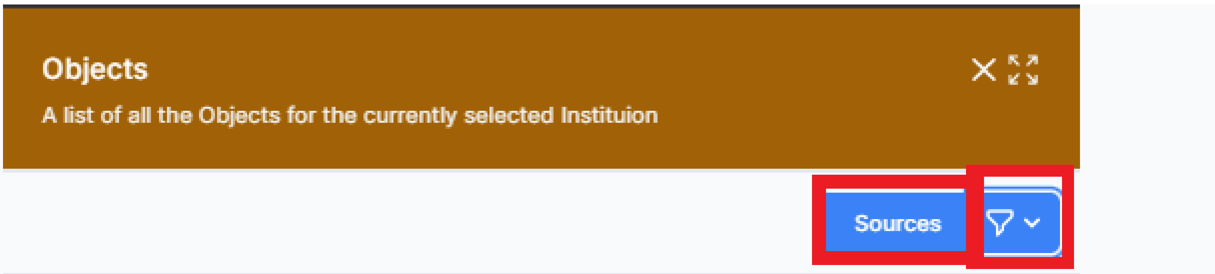

Figure 7: Adding objects in the EMB3RS Platform

Select in this case Source from the drop-down menu. Then click 'Create new source' at the bottom as shown in Figure 8.

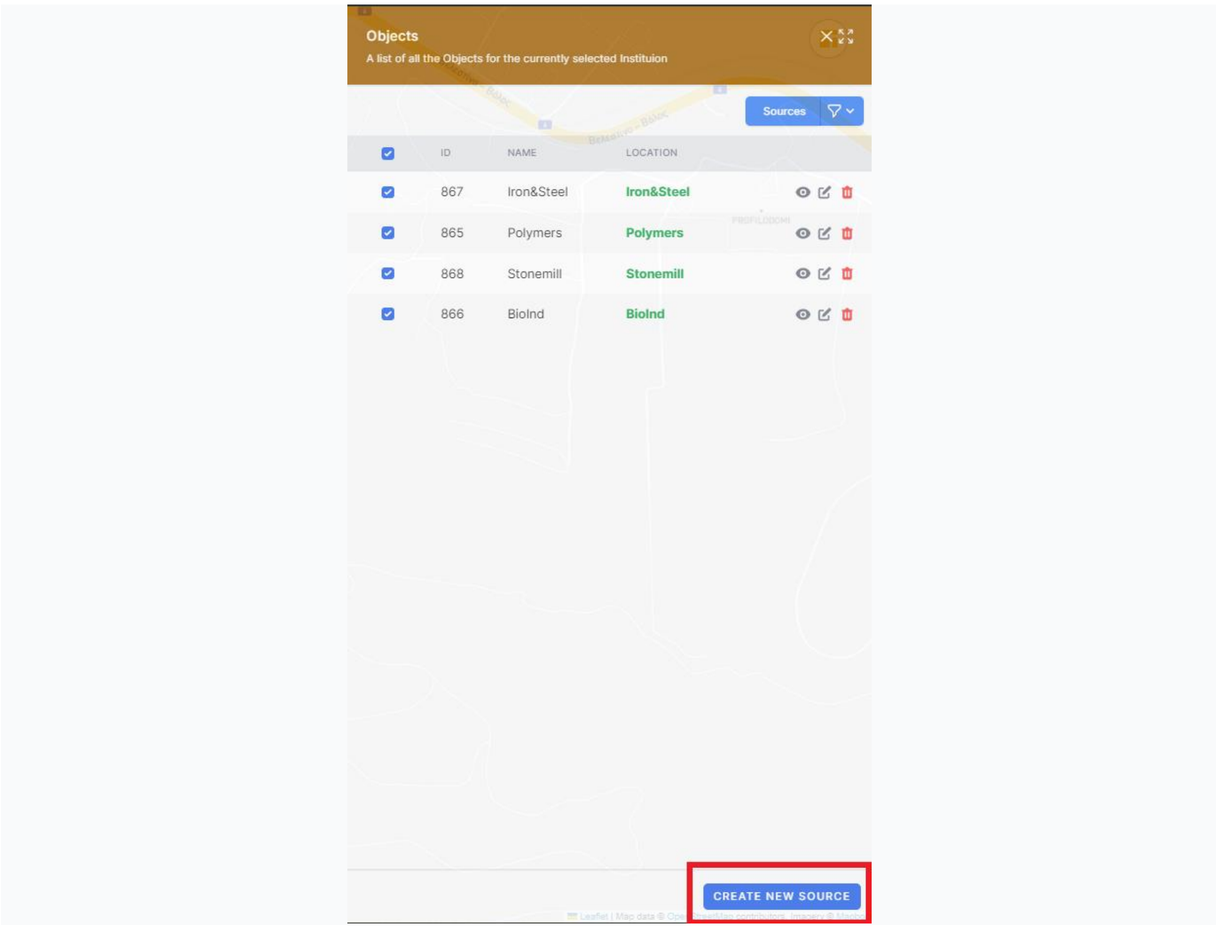

Figure 8: Creating a new source in the EMB3RS Platform

Then, you provide the coordinates of the sink/source. You can select the coordinates by directly right-clicking on the map if you know exactly where a sink/source is, or otherwise, you can click 'Fill in your coordinates' and insert the coordinates manually. Since we provide the coordinates in Table 1, for this exercise you will do the latter. Finally, you input all the details specified in the table. Here, 'Daily Periods' indicates the hours of the day during which stream/building is available/occupied and 'Shutdown Periods' indicates the Periods of days during the year the stream/building is not available/occupied.

Also notice that, for some sources, the Fluid Cp and Mass Flowrate are used to determine the capacity of the source. While in the case of the other sources, we already

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have the predetermined capacity of the excess heat streams. Thus, there are two ways to input the source capacity into the platform.

Any inputs not mentioned in Table 1 can be left as they are for this exercise. You may ask the tutors what they are about if you are interested.

Note: When copy-pasting the values from Table 1 into the platform, you must remember to remove any space before or after the brackets.

After entering all the properties listed in Table 1 you may click Next at the bottom left of the window. You will be taken to a further step in the definition of the process, 'Additional streams'. An additional stream is used to add sources with more than one excess heat stream. For this simple exercise, you may skip these steps and click 'Next' in all of them.

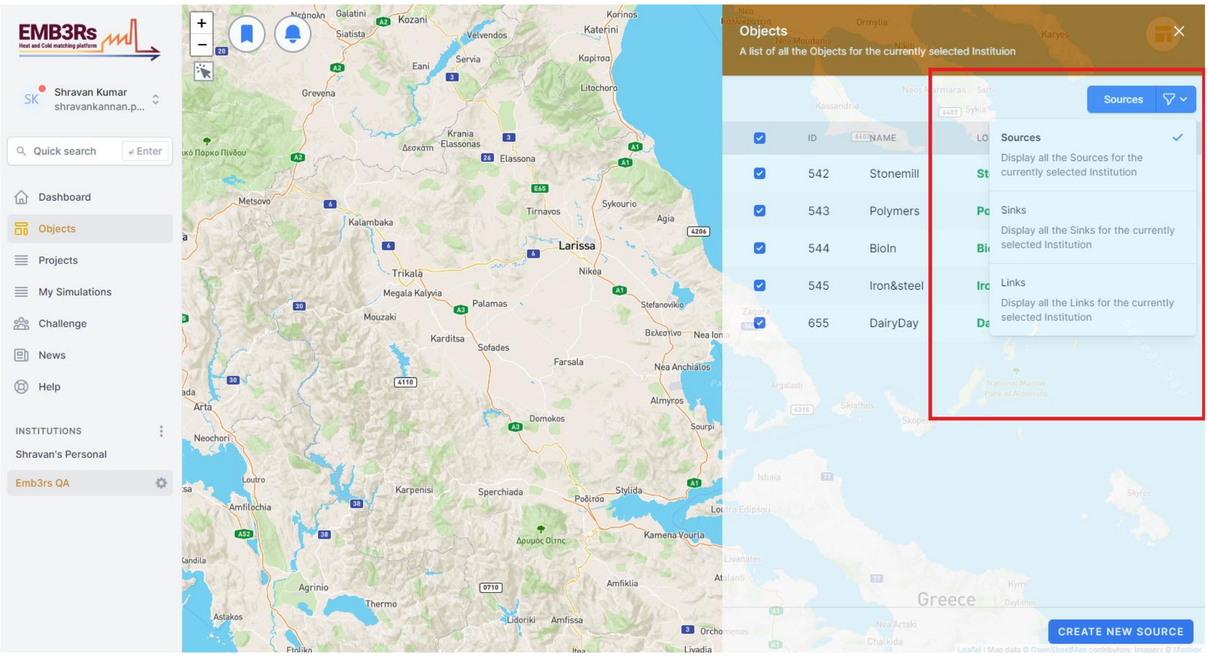

Figure 9: Adding sources and sinks

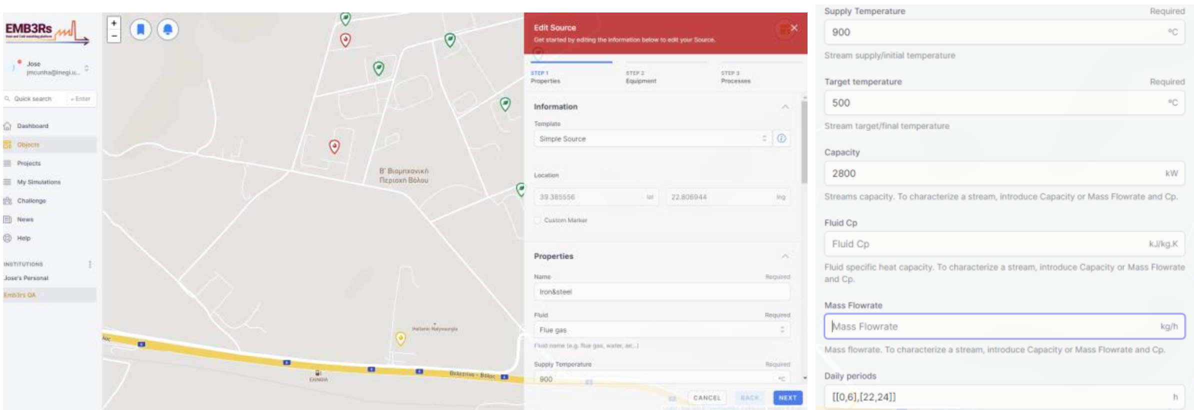

Figure 10: Source details inputs

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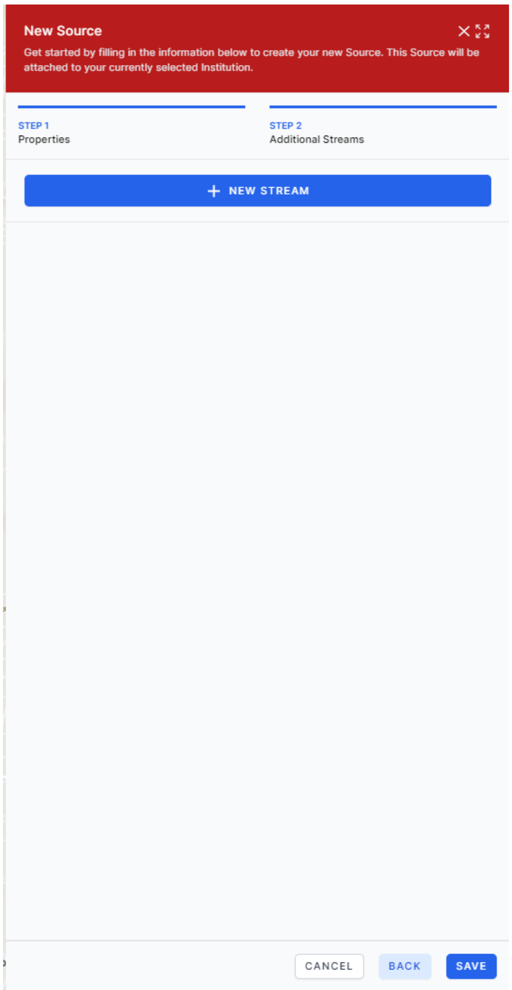

Figure 11: Steps in Source details input

Note: Following the above steps to add the source ‘Iron&Steel’, you are expected to add the other sources and sinks in Table 1. However, in the case of a shortage of time, it is enough to add at least two sources - ‘Iron&Steel’ and ‘Polymers’

Figure 12 demonstrates the workflow of adding the sink “Beverage” to the platform. Like the source, the object fills out the details specified in Table 2.

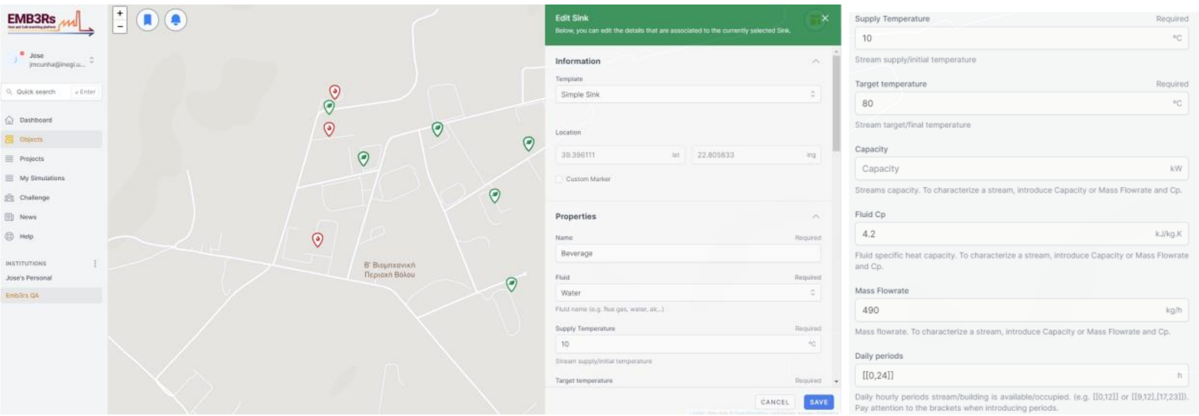

Figure 12: Sink details

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Table 2: Sink details

Property	Unit	Sinks						
Name	-	Beverage	Packaging	MilkCheese	Fisheye		RefriCompany	Town (Hot Water)
Template	-	Simple sink	Simple sink	Simple sink	Simple sink		Simple sink	Simple sink
Latitude	º	39.3960678	39.398090	39.3949277	39.397556038		39.39662745	39.371016214
Longitude	º	22.8058791	22.803829	22.8121608	22.809172868		22.81391501	22.77753353
Fluid	-	water	water	water	water	steam	water	water
Supply Temperature	ºC	10	10	10	15	80	15	15
Target Temperature	ºC	80	50	95	80	180	8	60
Capacity	kW	-	-	-	280	1400	400	700
Fluid cp	kJ/kg K	4.2	4.2	4.2	-	-	-	-
Mass Flowrate	kg/h	490	2000	700	-	-	-	-
Daily Periods	hours	[[6,23]]	[[8,15]]	[[4,23]]	[[0,24]]	[[0,24]]	[[8,18]]	[[6,7],[12,13],[20,22]]
Saturday On	-	NO	NO	YES	YES	YES	NO	YES
Sunday On	-	NO	NO	NO	YES	YES	NO	YES
Shutdown Periods	days	[[244,300]]	[[210,240]]	[]	[]	[]	[]	[]
Ref. System - Fuel Type	-	biomass	natural gas	natural gas	natural gas	natural gas	electricity	natural gas
Ref. System Efficiency	-	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Note: Following the above steps to add the sink 'Beverage', you are expected to add the other sinks in Table 2. However, in the case of a shortage of time, it is enough to add at least one sink - 'Beverage'.

Note: For the sink 'Fisheye', you have two streams, i.e., water and steam. You need to create two separate sinks for this case. You can name one sink as 'FisheyeW' and the other as 'FisheyeS'.

As described before, there are also in the industrial park an office building and a greenhouse which can be interesting sinks. However, since the heating needs of these are climate dependent, the profile of the streams is not as easy to characterize as one of the sinks and sources described before. This applied to an extent to the hot water demand, however, for this case, the hot water demand is assumed to be the same throughout the year with daily variations.

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General data, presented in Table 3 and Table 4, were obtained for both the office building and greenhouse so that the EMB3RS platform could be used to generate an approximate heat consumption profile. You may create the two sinks by still clicking ‘Create sink’. But this time you also need to specify the building type in the menu that opens Figure 13 and Figure 14. For Office Building, it is ‘Building’. For the Tomatoes Greenhouse, it is ‘Greenhouse’.

Table 3: Building sink details

Property	Unit	Sinks
Template	-	Building
Name	-	Office Building
Latitude	º	39.388763066
Longitude	º	22.795579476
Building Type	-	office
Building Orientation	-	South
Number of floors	-	2
Width floor	m	100
Length floor	m	50
Height floor	m	3
North facade wall ratio	-	0.2
South facade wall ratio	-	0.7
East facade wall ratio	-	0.5
West facade wall ratio	-	0.5
Daily Periods	-	[[6,7], [12,13], [20,22]]
Saturday On	-	yes
Sunday On	-	yes
Shutdown Periods	-	[]
Space Heating Type	-	conventional
Ref. System - Fuel Type Heating	-	natural gas
Heating Ref. System - efficiency		0.9
Cooling Ref. System - Fuel Type	-	electricity
Cooling Ref. System - efficiency		3.3

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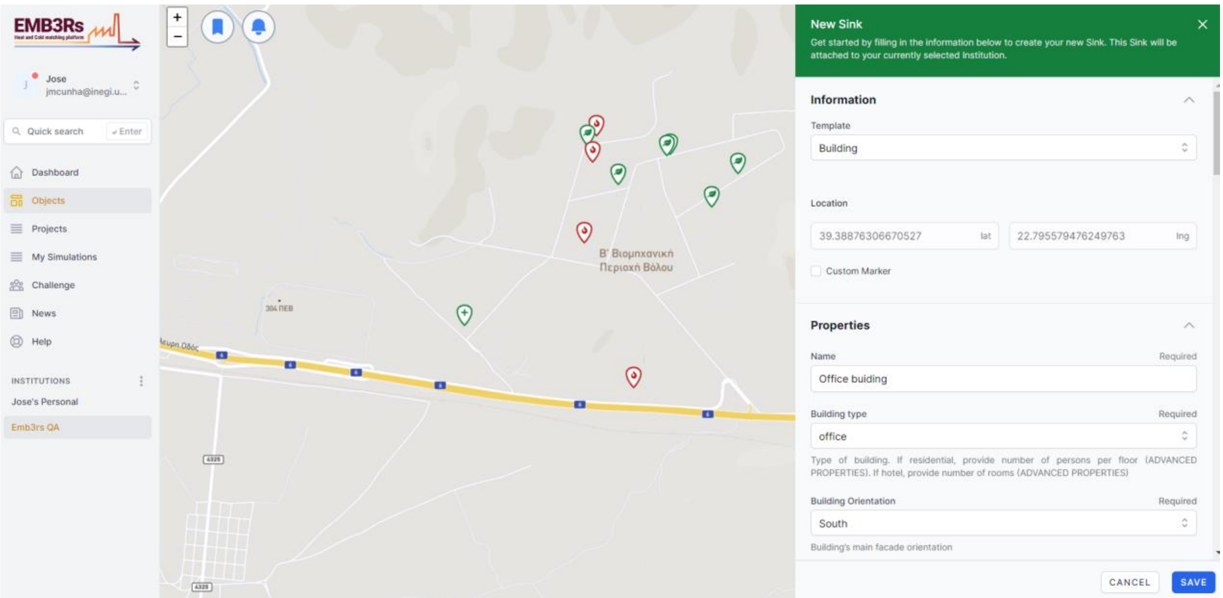

Figure 13: Adding details for building sink in the platform

Table 4: Greenhouse sink details

Property	Unit	Sinks
Template	-	Greenhouse
Name	-	Tomatoes Greenhouse
Latitude	º	39.3882655528
Longitude	º	22.8139901593
Greenhouse Orientation	-	South
Greenhouse Efficiency	-	Tight Cover
Width	m	50
Length	m	100
Height	m	2
Daily periods	-	[[0,24]]
Shutdown periods		[]
Heating Setpoint Temperature	ºC	15
Greenhouse artificial lighting	-	Does not have
Thermal blanket		Does not have
Ref. System - Fuel Type	-	electricity
Ref. System - Equipment Efficiency		0.9

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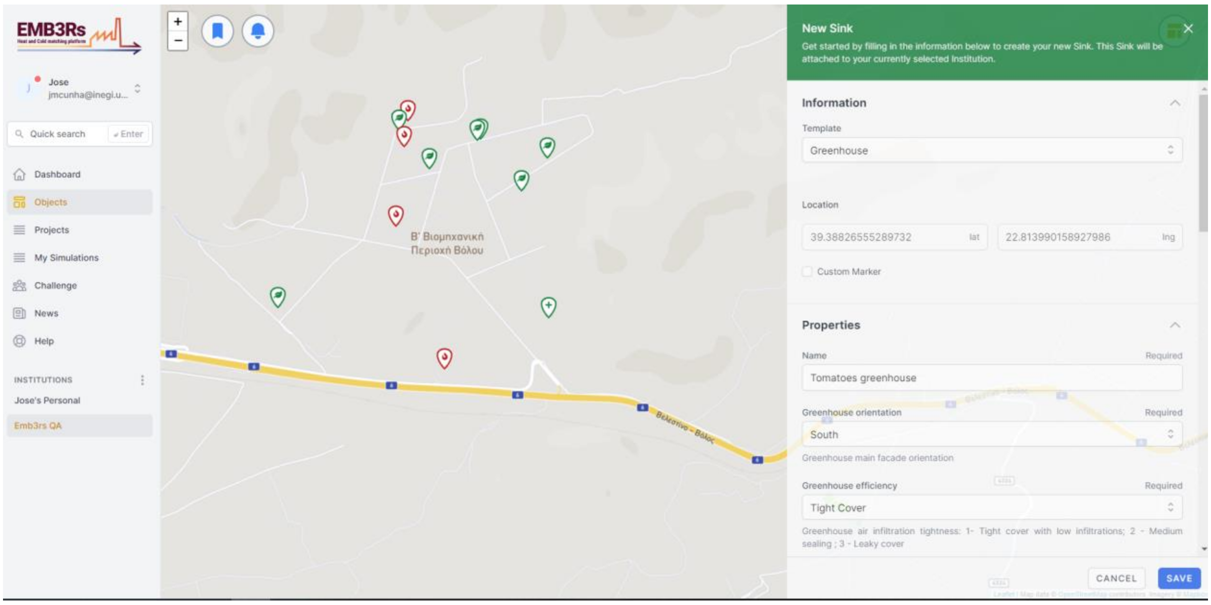

Figure 14: Adding details for the greenhouse sink

Note: It is required to add the sinks for the building and greenhouse.

Step 3: Create a Project and Simulation

Once all sources and sinks have been added, click on ‘Projects’ in the list on the left of the screen as shown in Figure 15.

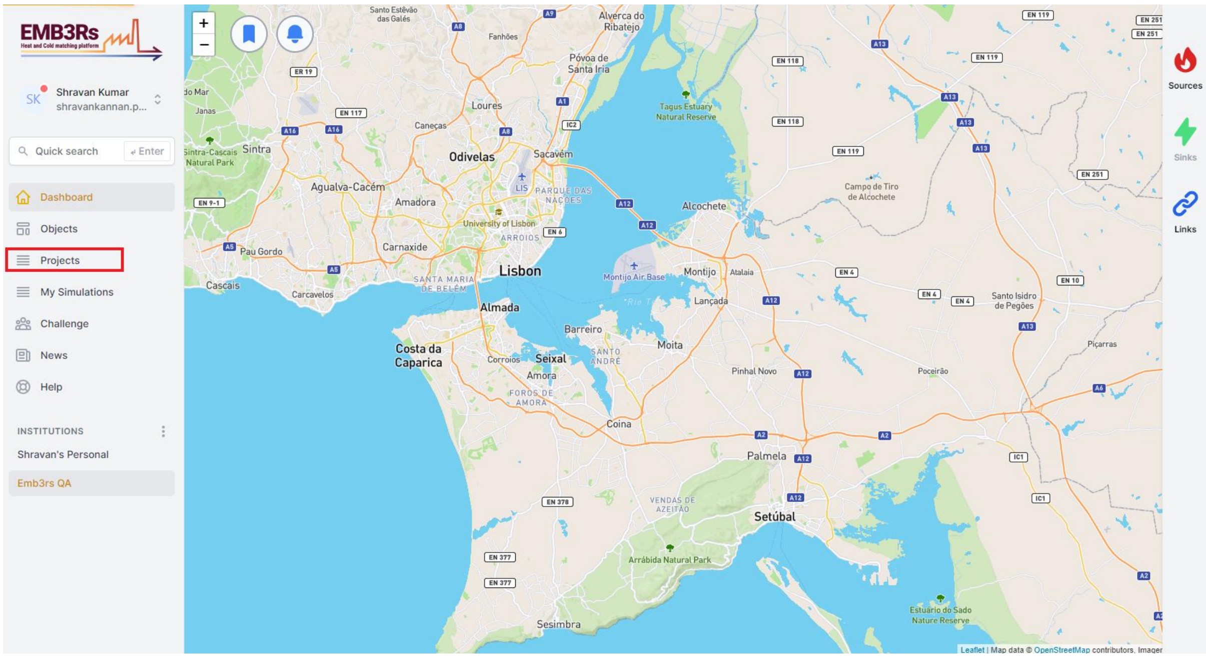

Figure 15: Projects on the EMB3RS platform

Click on the ‘Create a project’ button at the top right-hand corner of the screen as shown in Figure 16.

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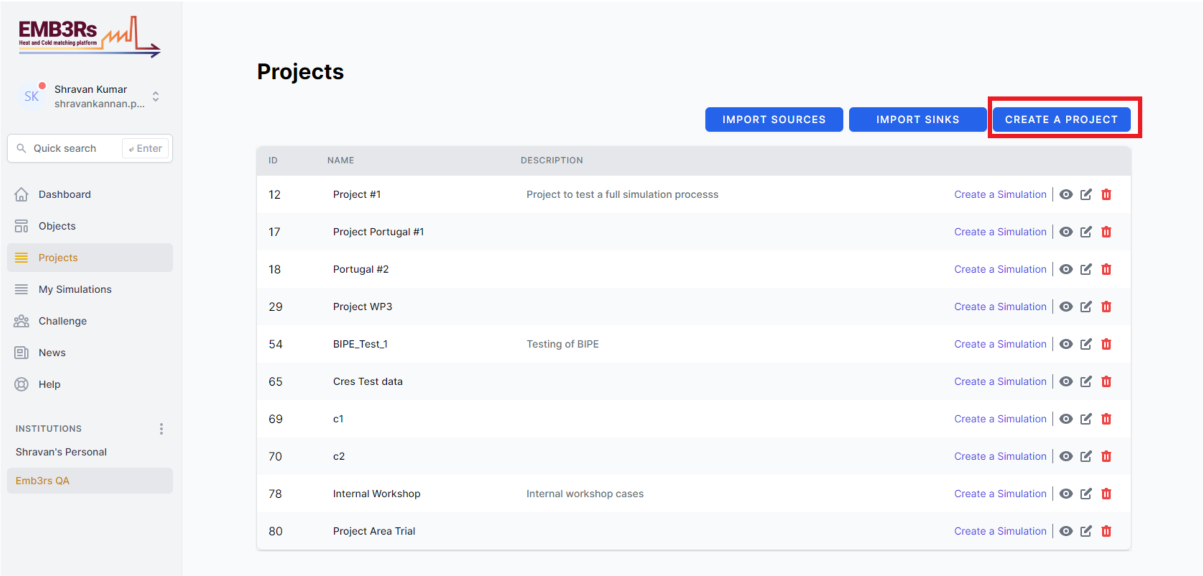

Figure 16: Creating a project on the EMB3RS platform

Enter a name and a description for the project as shown in Figure 17.

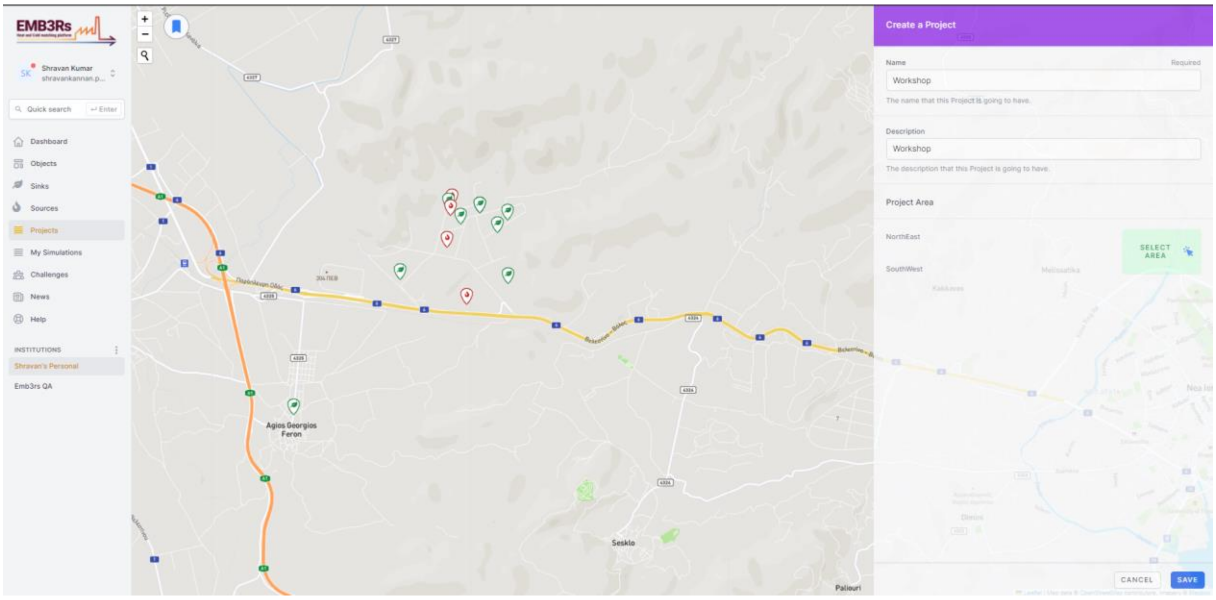

Figure 17: Project details on the EMB3RS platform

In the 'Create Project' window, a button called 'SELECT AREA' is used to set the project area for the case. The project area determines the area that will be considered by the GIS module and thus it needs to cover all sources and sinks. The area can be set by drawing a rectangle on the map. The area must be set in such a way that all sinks and sources added in step 2 are included in the map as shown in Figure 18. The area should be only large enough to cover all sources and sinks to minimize computation time. If a very large area is selected, it leads to inclusion of irrelevant paths in the geospatial optimisation and increase the simulation time. After selecting the area click Save.

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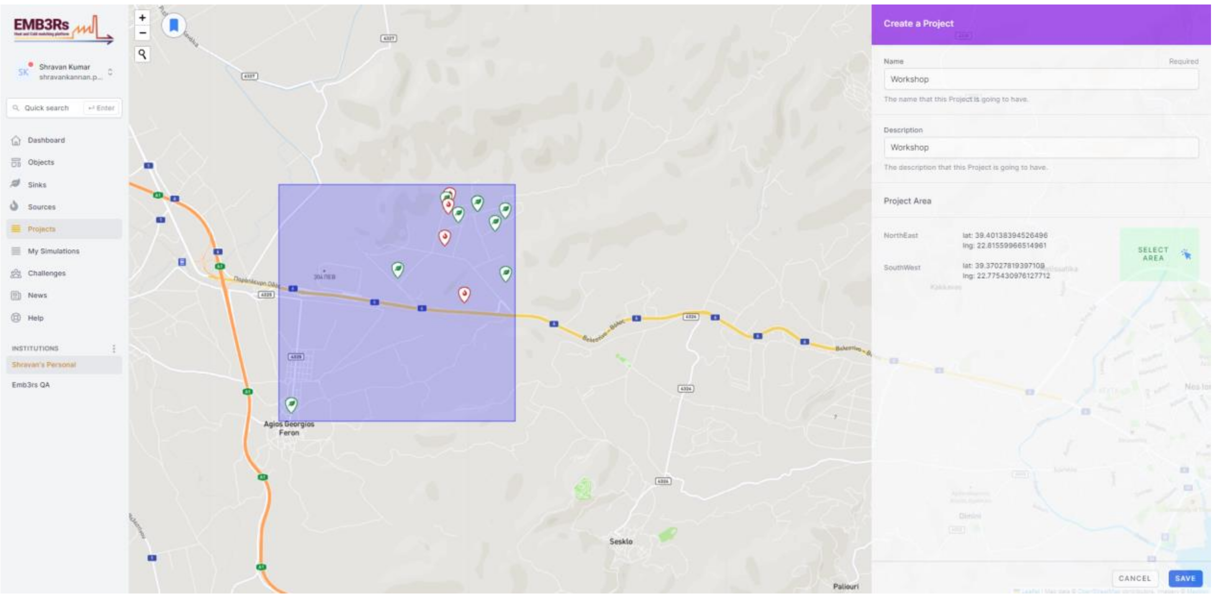

Figure 18: Selecting project details on the EMB3RS platform

Once the project is created, click on the projects tab again and click on 'create a simulation' next to the project you just created.

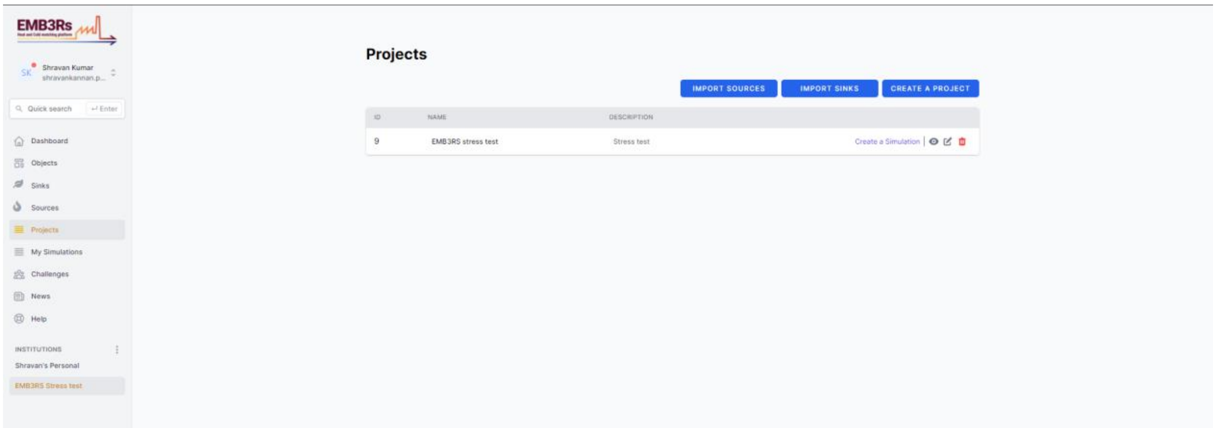

Figure 19: Creating a simulation on the EMB3RS platform

You will then see this screen in Figure 20. Proceed with Steps 4-7 to provide inputs for the modules, as described below.

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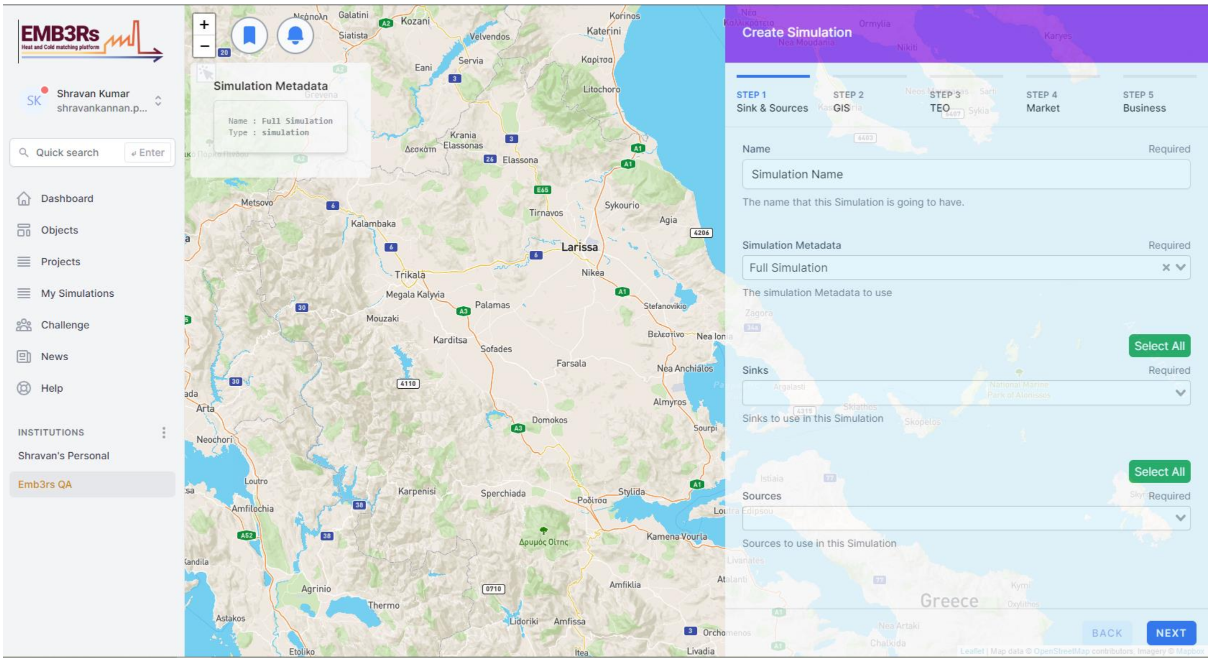

Figure 20: Simulation details on the EMB3RS platform

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Step 4 - Choose Sources/Sinks and design the DHN

It is important to analyse all sinks and sources so that an optimal solution is obtained. The most important factor when designing the DHN is identifying the best matching sources and sinks in terms of capacity and supply/consumption profiles, as well as the distance of the sources/sinks since it will have a large impact on the final cost of the DHN. For this exercise, you need to choose all the sinks and sources that you added in Step 2.

For ‘Simulation type’ choose ‘Full simulation’.

When the sources and sinks are chosen, the data input for each source and sink is used by the Core-functionalities (CF) module to characterise these sources and sinks, i.e., create the supply and demand profiles, determine the maximum capacity and the possible list of technologies for each source and sink.

Step 5: GIS

The purpose of the Geographical Information System (GIS) module is to analyse the spatial dimension of the EMB3Rs platform. The GIS module conducts several calculations represented by the following main features:

- **district heating and cooling (DHC) network calculation based on different heat/cold sources and sinks to be included,**
- **calculation of the thermal losses and investment costs of the resulting DHC network (grid).**

The main outputs of the GIS module are:

- **Structure and map of the DHC network where all the possible sources and sinks are connected,**
- **investment cost of the calculated DHC network,**
- **thermal losses of the calculated DHC grid.**

Inputs and Outputs
The inputs of the GIS module consist of three main categories:

1. **Fundamental inputs,**
2. **Cost parameters,**
3. **Advanced properties.**

Step 5.1: Fundamental Inputs

After the user chooses the sources, sinks, and the design of the DHC network, the next step is filling the GIS module’s fundamental inputs. The fundamental inputs that are expected from the user, their labels, and descriptions of the inputs are given in Table 5. It is also indicated if the input is mandatory or not. Please note that all mandatory inputs except for “Project Area” have a default value stored in a database (called EMB3RS Knowledge Base). In other words, if the users do not have enough information to set a value for those variables or want to use default variables, they have

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the option not to give input. For this exercise, we recommend you use the inputs we report in Table 5, so that your results may be comparable with those of other users creating the same case.

Table 5: Fundamental inputs of the GIS Module.

Label	Mandatory	Description	Unit	Value
Network Resolution	TRUE	Defines if network resolution is high or low, i.e., how detailed the streets are loaded. If a large network is used, network resolution should be set to low to decrease computational time. Set to high by default.	-	high
Resolution Timeout limit	TRUE	Defines the timeout limit, when the GIS reach this limit it will return the best solution so far. if it's defined as 0 then there won't have a time limit and the simulation may take longer time	minutes	0
Solver	TRUE	This indicates the solver the user wants to use. The EMB3RS platform offers several open-source and commercial solvers to the user- COPT, SCIP, GUROBI and HiGHS. For this workshop, we will use GUROBI to have the best performance.	-	COPT
Average Flow Temperature	TRUE	Yearly average flow temperature. Set to 100 by default.	°C	100
Average Return Temperature	TRUE	Yearly average return temperature. Set to 70 by default.	°C	70
Average Ambient Temperature	TRUE	Yearly average ambient temperature. Set to 25 by default.	°C	25
Average Ground Temperature	TRUE	Yearly average temperature of the ground in the project area	°C	8

Figure 21 shows the GIS module's fundamental inputs on the platform. Please note that the average ambient temperature input is not necessary as there is no surface pipe in this case study.

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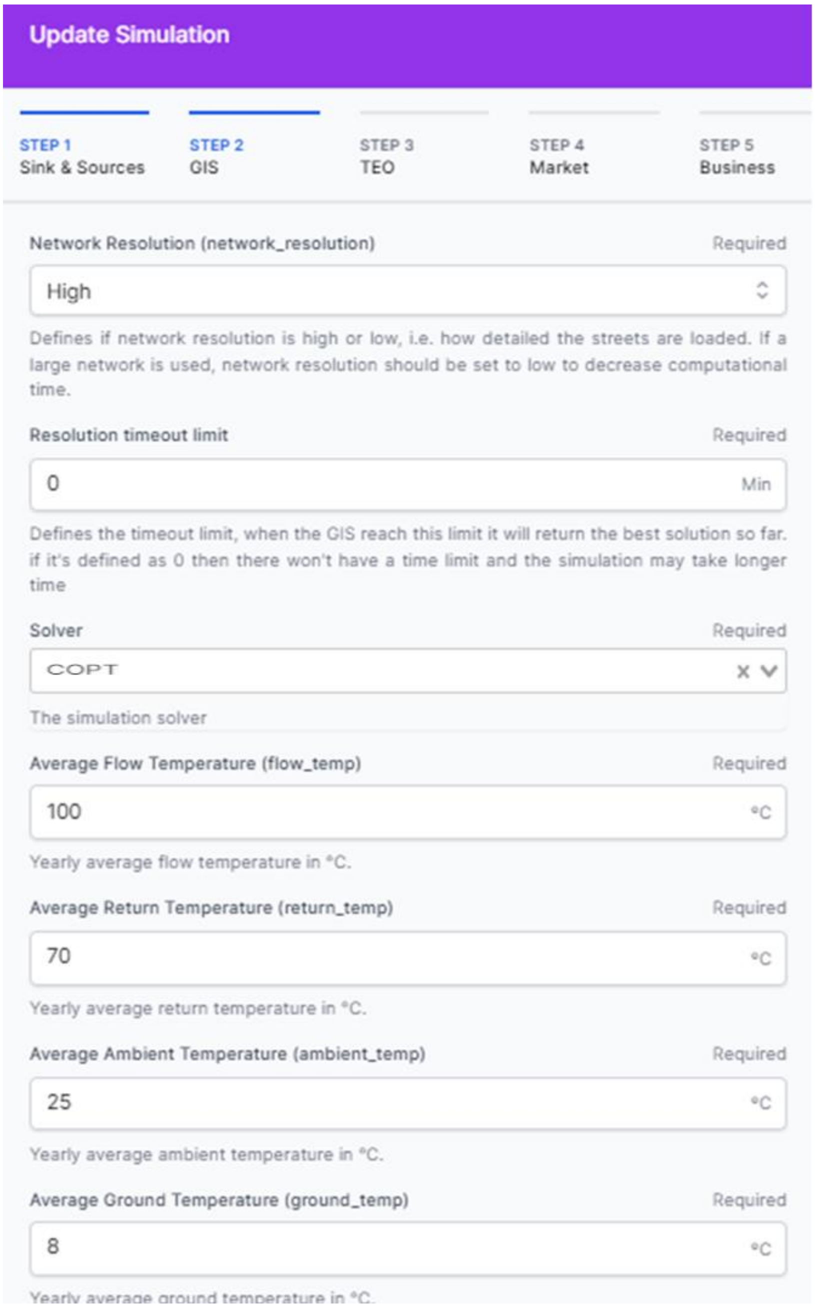

Figure 21: Fundamental inputs of the GIS Module.

Step 5.2: Cost Parameters

You need to scroll down to reach this section.

The cost parameters expected from the user are given in Table 6. The unit digging and piping costs are calculated in the following way:

$$\text{Unit Digging/Piping Costs}\left[\frac{EUR}{m}\right] = \text{fixed cost} + [(\text{diameter})(\text{variable cost})]^{\text{exponent}}$$

Therefore, all the inputs named as a fixed cost in Table 6 correspond to the fixed cost in the formula above. Similarly, inputs named as a variable cost corresponds to the variable cost in the formula above. Finally, the inputs named as the exponent corresponds to the exponent in the formula above. The GIS module calculates the diameter of the pipes; therefore, it is not a user input.

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Table 6: Cost parameters of the GIS Module.

Label	Mandatory	Description	Unit	Value
Fixed Digging Cost for Street	TRUE	Fixed digging cost for streets. Set to 350 by default.	EUR/m	350
Variable Digging Cost for Street	TRUE	Variable digging cost for streets. Set to 700 by default.	EUR/m²	700
Exponent Street	TRUE	The exponent of the digging cost for the street. Set to 1.1 by default.	-	1.1
Fixed Piping Cost	TRUE	The fixed component of the piping cost. Set to 50 by default.	EUR/m	50
Variable Piping Cost	TRUE	The fixed component of the piping cost. Set to 700 by default.	EUR/m²	700
Exponent Piping	TRUE	The exponent of the piping cost. Set to 1.3 by default.	-	1.3

Figure 22 shows the section for the GIS module’s cost parameters on the platform.

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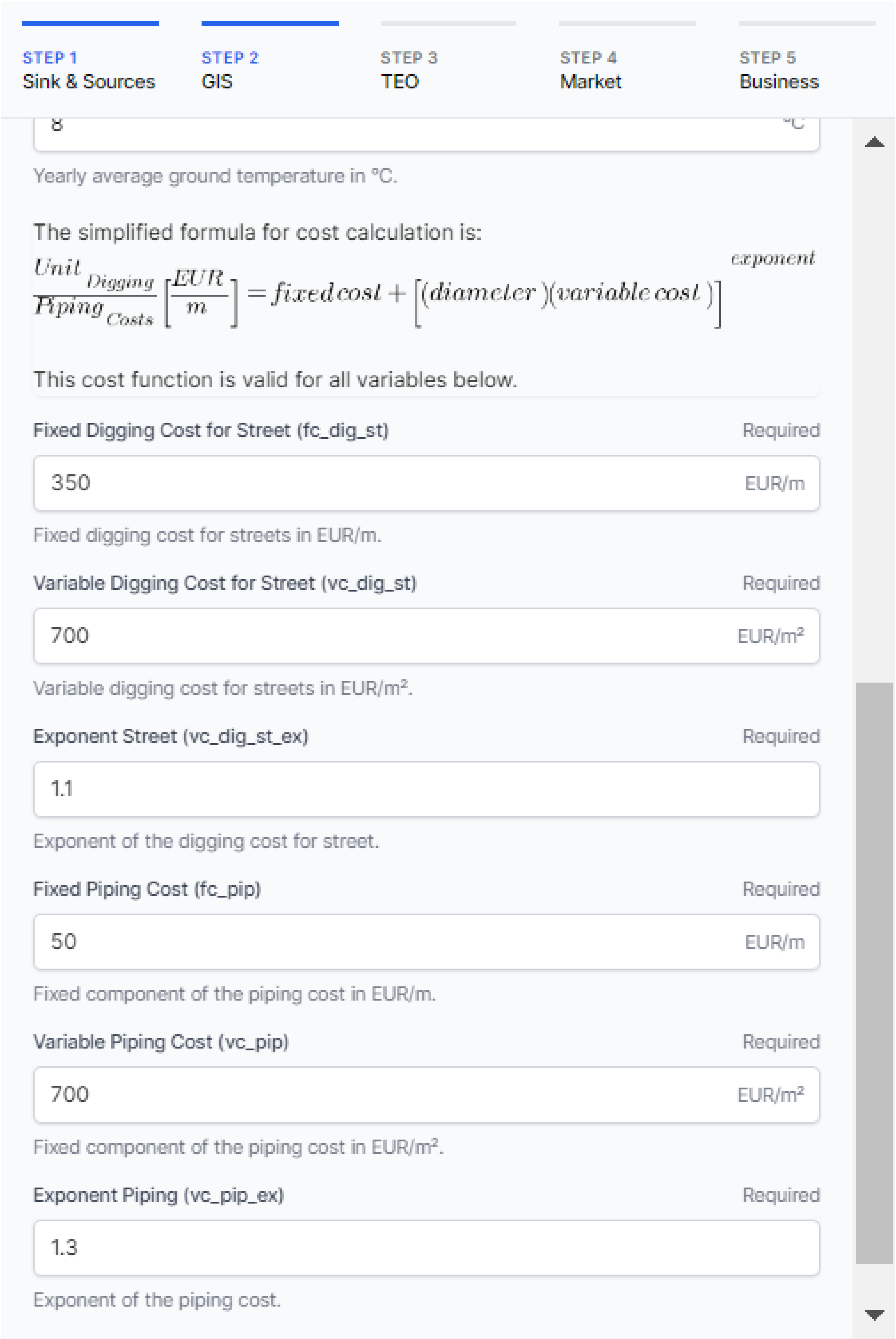

Figure 22: Cost parameters of the GIS Module.

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Step 5.3: Advanced Properties

The advanced parameters expected from the user are given in Table 7. The user needs to scroll down and click on “Advanced Properties” to reach this section.

Table 7: Advanced input parameters of the GIS module.

Label	Mandatory	Description	Unit	Value
Heat Capacity	TRUE	Heat capacity at a specific temperature (average of flow and return temperatures). Set to 4.18 by default.	J/kgK	4.18
Water Density	TRUE	Water density at a specific temperature (average of flow and return temperatures). Set to 1000 by default.	kg/m3	1000

Figure 23 shows the section for the GIS module’s advanced input parameters on the platform. The user needs to scroll down and click on “Advanced Properties” to reach this section. Please enter the inputs as shown in Figure 19.

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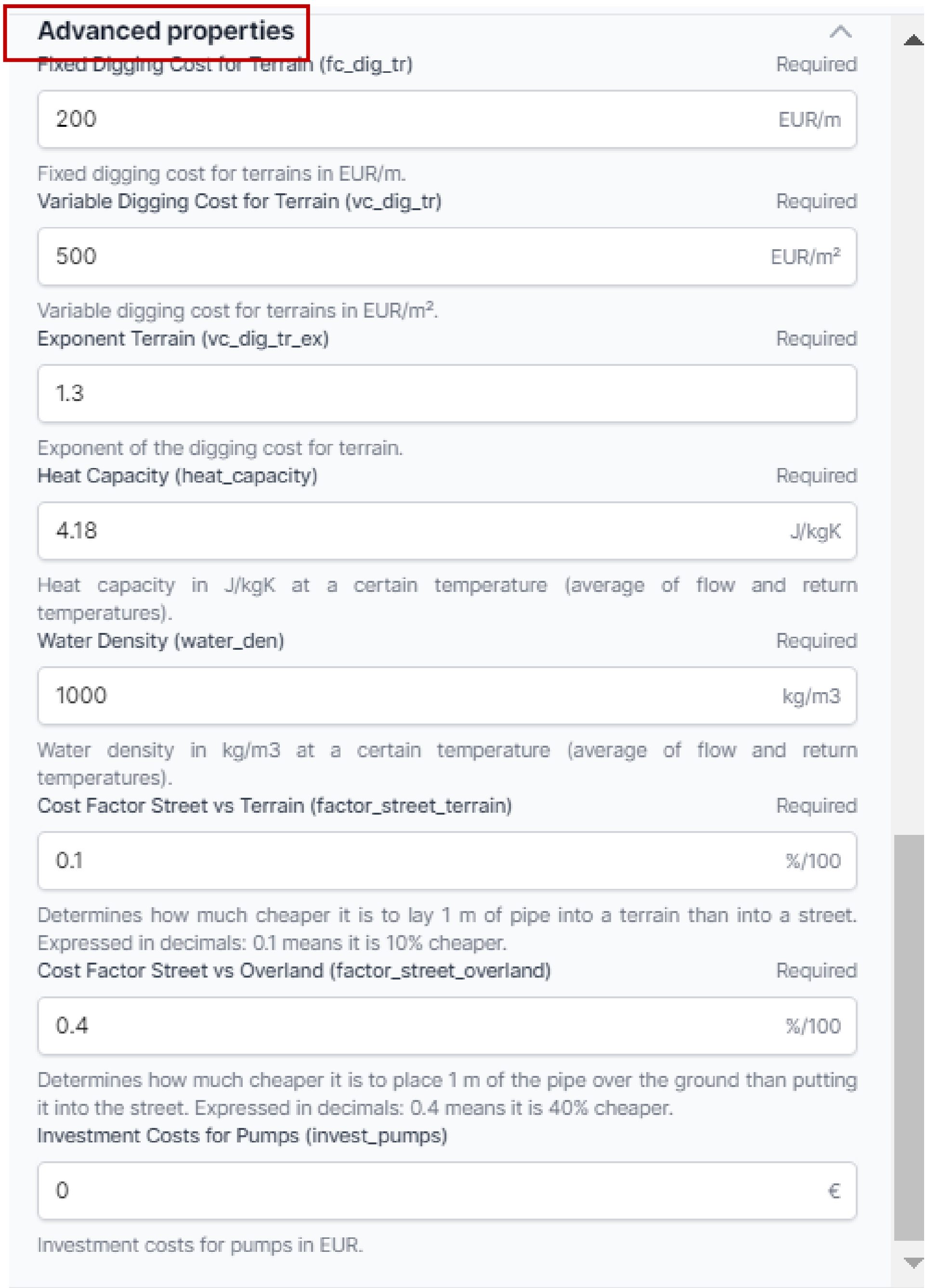

Figure 23: Advanced input parameters of the GIS module.

Step 6: TEO (Techno-economic optimisation module)

The Techno-Economic Optimisation (TEO) module identifies the least-cost combinations of technologies (such as heat exchangers, heat pumps, boilers, ORC etc.) for using and conveying excess heat from defined sources to defined sinks. This calculation step is important as the most cost-competitive technologies to match the sinks and sources may differ from case to case, depending on the capital and operational costs of the technologies, their availability, commodity prices (e.g., electricity from the distribution grid or gas), physical or regulatory constraints, etc. The

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user (representing the excess heat producer - i.e., source – or a demand point – i.e., sink) wants to evaluate the options of utilising excess heat generated to meet the heating demand for one or more known/assumed sinks. The objective of the optimisation is to find the least-cost mix of technologies and match between sources and sinks that satisfies the demands under constraints dictated by regulation, availability of heat, load profiles, techno-economic characteristics of technologies, investment plans, etc.

Inputs

The input from the user to the Techno-economic optimisation (TEO) module defines the global sets in the model and parameters associated with thermal storage, emissions, and budget constraints.

Step 6.1: SETS

The initial inputs to the TEO module consist of the global sets in the model. The 'sets' define the physical structure of a model, usually independent from the specific scenarios which will be run. They define the time domain and time resolution, the spatial coverage, the technologies, and energy vectors to be considered, etc. Some of these inputs are mandatory since they are essential for building the optimisation. These are shown in Table 8. The description for each set is also provided in Table 8. The value to be entered for each SET is shown in the column value. An intra-annual time resolution of 48-time slices is used in this case (but it can be lower or higher, up to hourly time steps!). This has been done to obtain quick results for the workshop. A time period of one year has been used (but longer periods can be analysed, with results given per year).

Table 8: TEO Global SETS

Label	Description	Value
Region	It sets the regions to be modelled, e.g., different countries, cities, counties etc. For this analysis, it is enough to have one region name. For each of them, the supply-demand balances for all the energy vectors are ensured. On some occasions, it might be computationally more convenient to model different countries within the same region and differentiate them simply by creating ad hoc fuels and technologies for each of them.	'Greece'
Emission	It includes any kind of emission potentially deriving from the operation of the defined technologies. Typical examples would include atmospheric emissions of greenhouse gasses, such as CO2. The user must fill in 'co2' as a mandatory entry. Other entries are also allowed	'CO2'
Emissions Penalty (CO_2)	This input indicates the carbon tax in the region. The tax is expressed in €/KgCO_2. This field will be automatically filled in based on the location of the sources and the sink. But the user is allowed to change the value in case the user wants to simulate with a different taxation	15
Time resolution	It represents the time steps of each modelled year, therefore the time resolution of the model.	Weekly

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Time period (Year)	It represents the period of the model; it contains all the years to be considered in the analysis.	2023
Solver	This indicates the solver the user wants to use. The EMB3RS platform offers several open-source and commercial solvers to the user- COPT, SCIP, GUROBI and HiGHS. For this workshop, we will use GUROBI to have the best performance.	COPT
Mode of operation	It defines the number of modes of operation that the technologies can have. If a technology can have various input or output fuels and it can choose the mix (i.e., any linear combination) of these input or output fuels, each mix can be accounted for as a separate mode of operation. The user must input at least 1 mode of operation. There must be two modes of operation if storage is used in the model	1,2

Insert the value for each set in the TEO inputs section of the 'Create simulation' window on the platform as shown in Figure 24 and Figure 25.

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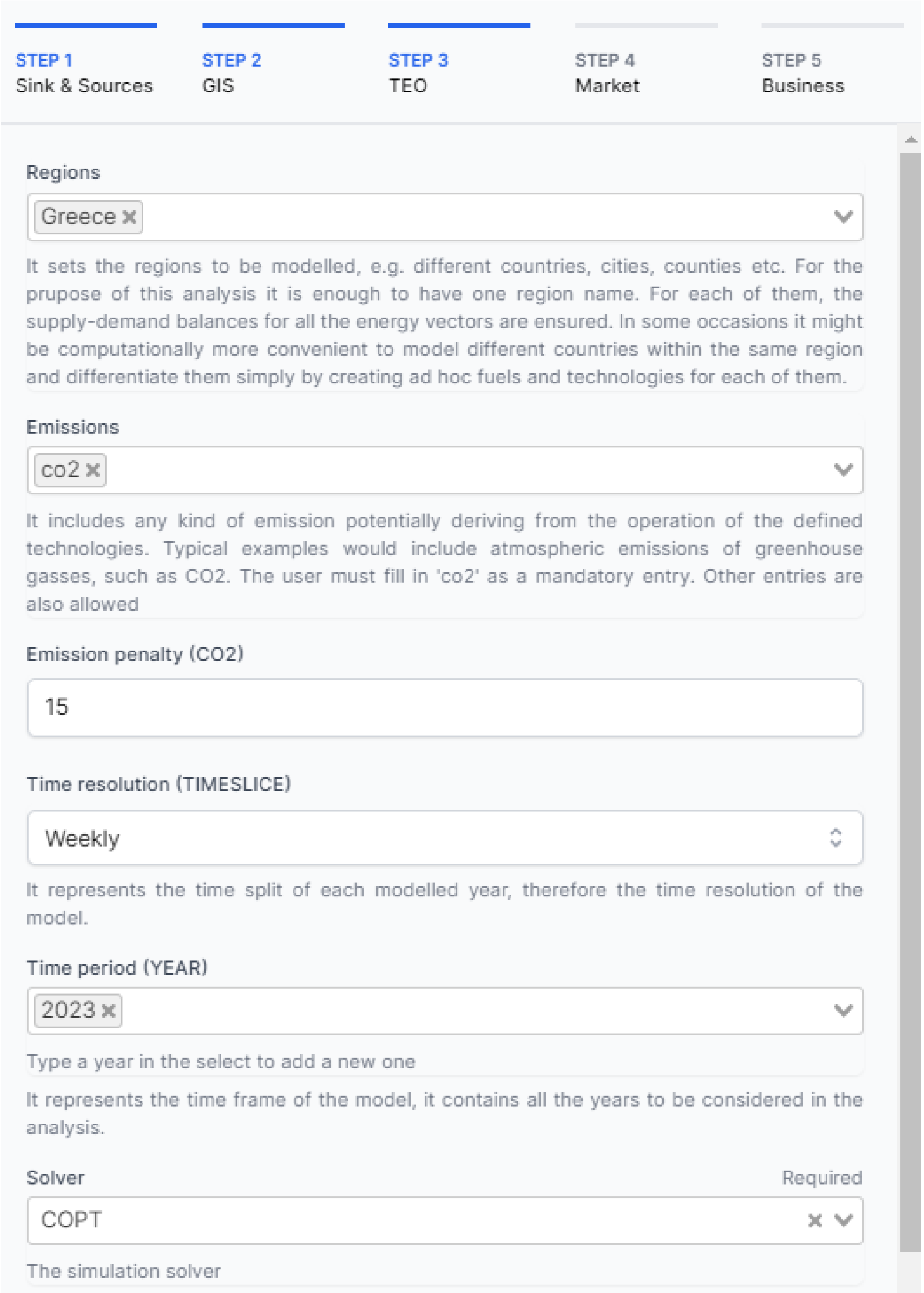

Figure 24: Inputs to the TEO -1

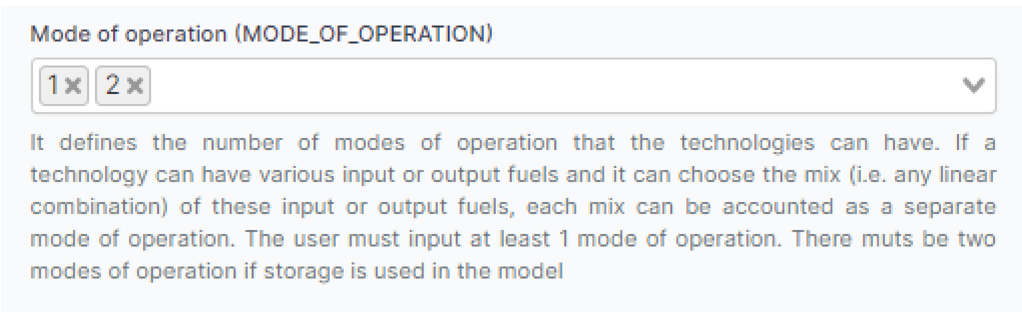

Figure 25:Inputs to the TEO -2

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Step 6.2: Storage inputs

For this workshop, we will not consider the existing default storage. Delete the existing storage by clicking the delete button as shown in Figure 26.

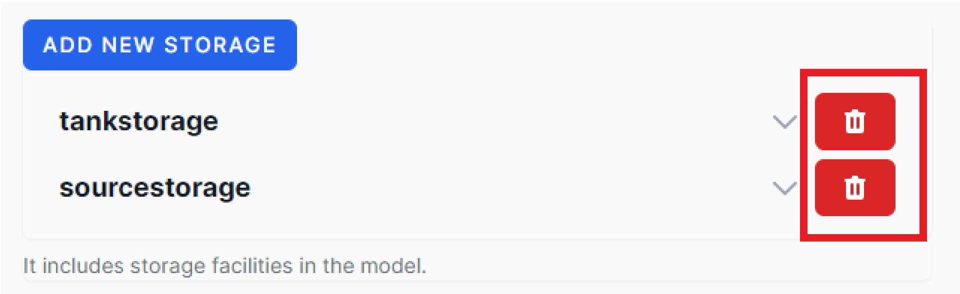

Figure 26: Storage inputs to the TEO

Additional storage can be added by using the 'Add new storage' shown in Figure 27. Add new storage as shown in Figure 27.

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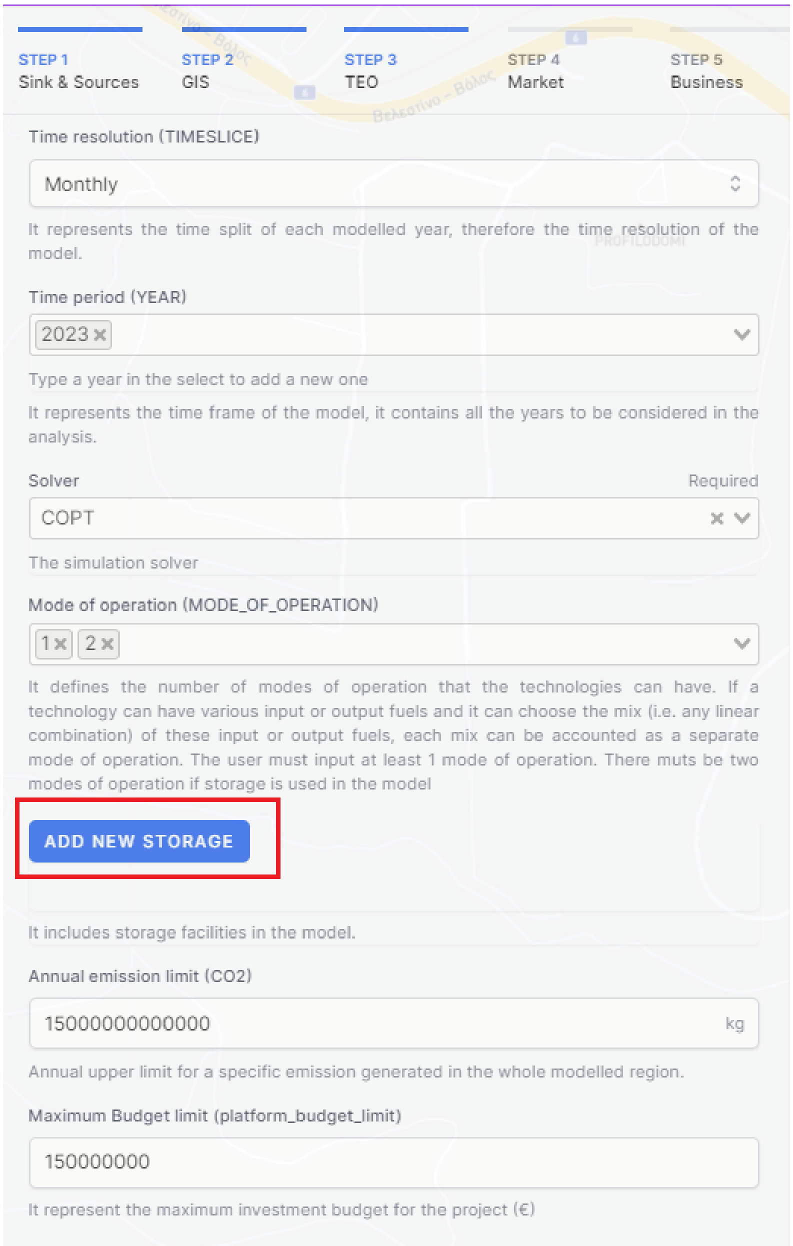

Figure 27: Adding new storage to the TEO

Enter the storage name in the box called ‘Storage Name’. The storage will be named ‘CentralStorage’ since it will be connected to the district heating network.

The techno-economic parameters for thermal storage are defined by the user. In the previous step, we defined two thermal storages in the model. The techno-economic parameters for storage, their description and the value to be entered are presented in Table 9. The techno-economic parameters for the storage are necessary for the model to determine whether it is cost-effective to install any thermal storage in the system. The technical parameters such as supply and return temperatures, the heat transfer coefficient and the ambient temperatures are used for calculating the losses for the thermal storage. The maximum capacity and charge and discharge rates are used to place constraints on the operation of storage in the model.

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The inputs for the storage can be given by clicking on the down arrow in each storage as shown in Figure 28. The default inputs for the storage are prefilled and the user can change these values. Enter the values for each storage as shown in Table 9, Figure 28, and Figure 29.

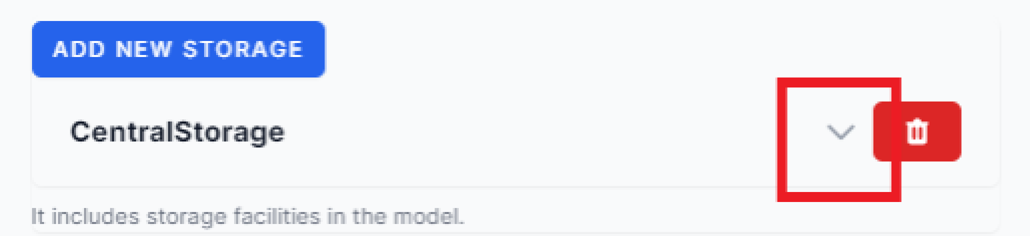

Figure 28: Storage inputs for TEO

Table 9: TEO Storage inputs

Label	Description	Value (Unit)
Storage capital cost	Investment costs of storage additions, defined per unit of storage capacity.	750 €/kWh
Storage discount rate	Storage-specific value for the discount rate, expressed in decimals	0.04
Storage operational life	The useful lifetime of the storage facility.	50
Storage maximum charge rate	Maximum charging rate for the storage	2000 kWh
Storage maximum discharge rate	Maximum discharging rate for the storage	2000 kWh
Storage length to diameter ratio	A binary parameter which indicates the length-to-diameter ratio of the thermal energy storage tank. Value is 0 if the L2D is 2 and is 1 if the L2D is 4.	1
Storage heating tag	Binary parameter indicating whether the thermal energy storage is connected to the district heating network. 1 if it is connected and 0 if it is not.	Yes
Storage cooling tag	Binary parameter indicating whether the thermal energy storage is connected to the district cooling network. 1 if it is connected and 0 if it is not.	No
Storage hot water return temperature	The return water temperature in the heating grid where the thermal energy storage is connected.	50 °C
Storage hot water supply temperature	The temperature of water inflow into thermal energy storage.	80 °C
Average ambient temperature of the region	The average ambient temperature of the locations where the thermal energy storage is located.	15 °C

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Residual storage capacity	Exogenously defined storage capacities at the start of the modelling period	0 kWh
Maximum storage capacity	Maximum allowed capacity of storage in a year	15000 kWh
Starting level of storage	Level of storage at the beginning of the first modelled year	0 kWh
Heat transfer coefficient of the thermal storage	Heat transfer coefficient of the thermal energy storage tank.	0.21 kW/KgK

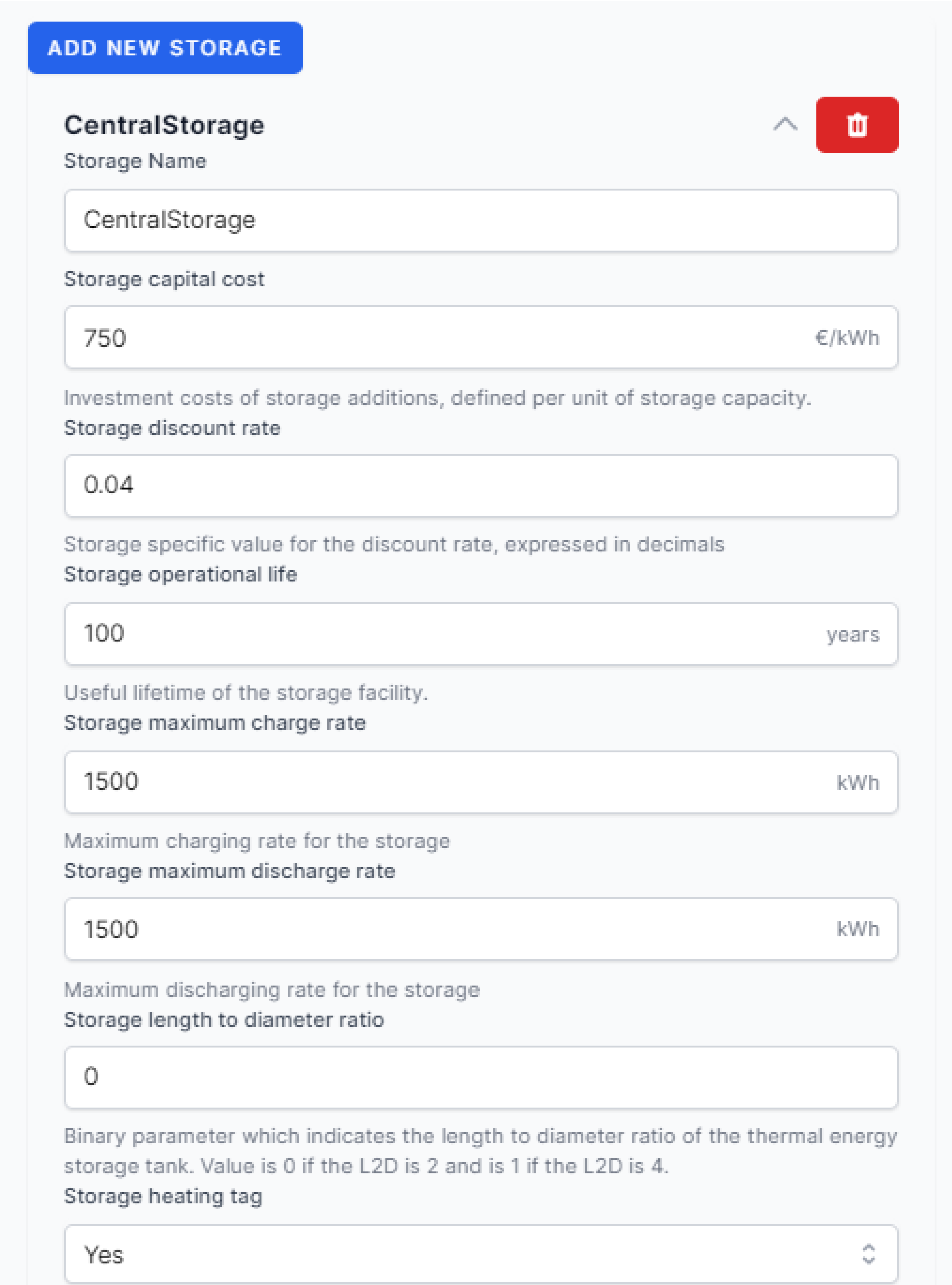

Figure 29: Storage inputs for TEO

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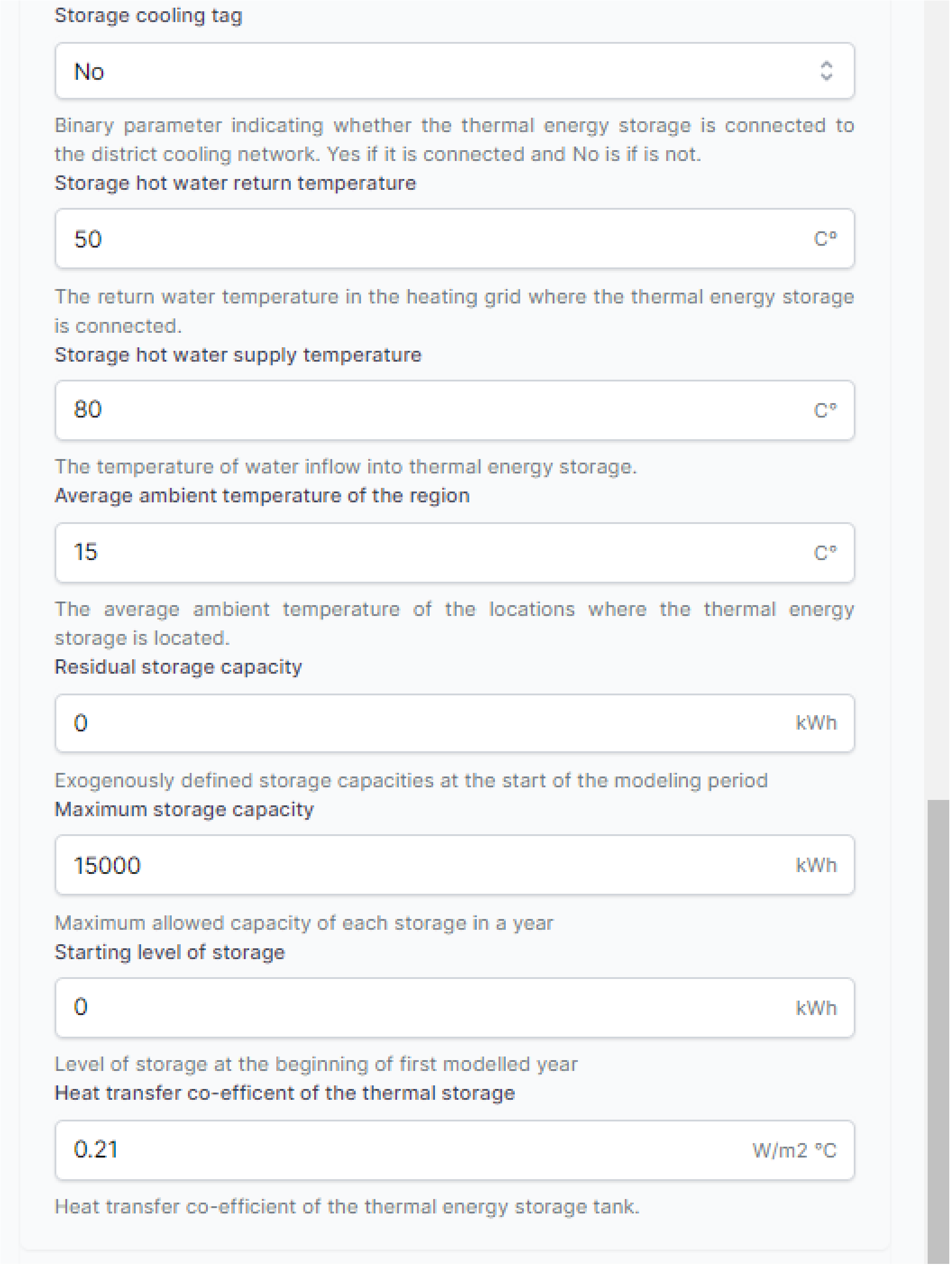

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Figure 30: Storage inputs for TEO

Step 6.3: Emission and budget constraints inputs

The TEO module also accounts for the emission from each technology in the system. In the SETS, we had earlier defined ‘CO2’ in the ‘EMISSION’ set (more emissions could be defined, but we do not consider them in this case, for simplicity). The emission factor (kgCO2/kWh) for each technology is provided to the TEO from the knowledge base. Using this, the emission from each technology is calculated in the TEO. As a constraint, it is possible to limit the emission from the excess heat recovery system. For the workshop, the emission limit is defined as shown in Table 10.

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Table 10: TEO Emission Limit

Label	Description	Value (Unit)
Annual emission limit	The annual upper limit for a specific emission generated in the entire modelled region.	150000000000 Kg CO2

The TEO module also accounts for the maximum budget for the project. This can be done using the 'Maximum Budget Limit' constraint. The input is shown in Table 11.

Table 11: TEO Budget Limit

Label	Description	Value (Unit)
Maximum Budget limit	It represents the maximum investment budget for the project (€)	1500000000 €

The inputs can be entered as shown in Figure 31.

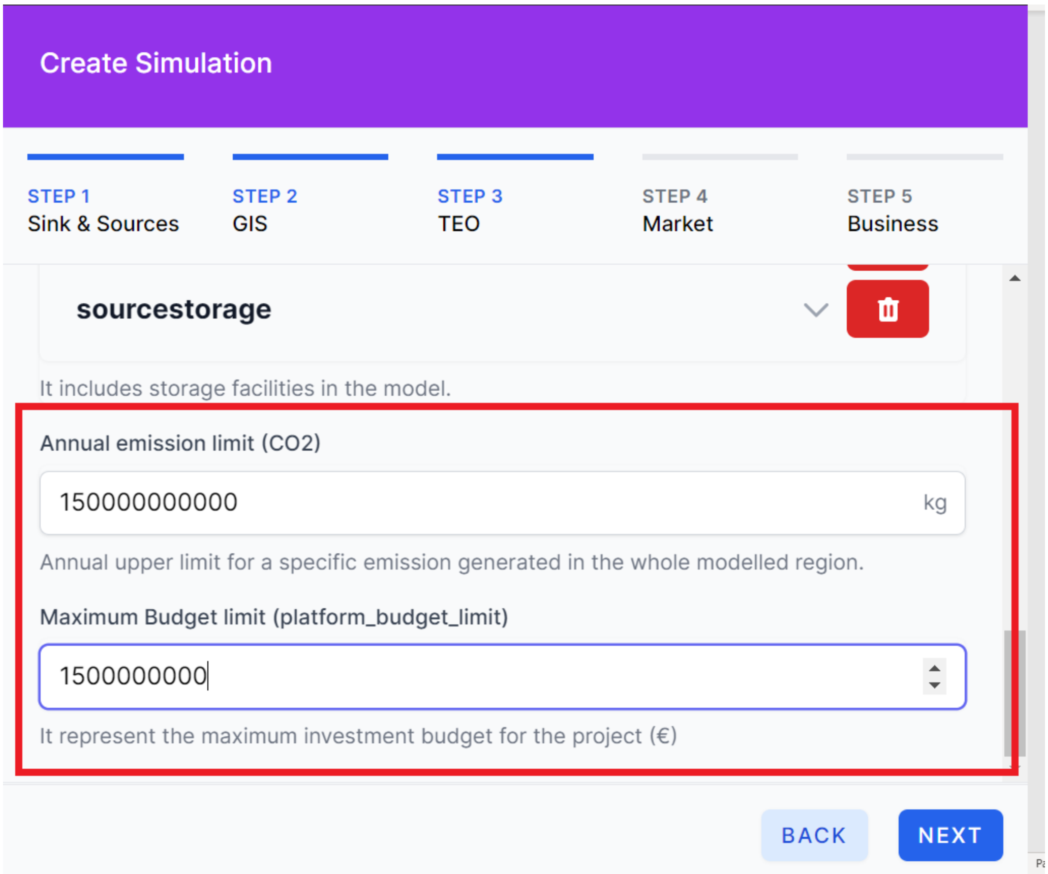

Figure 31: Emissions and budget constraints for the TEO module

Step 7: Market Module

Here, the market module considers the long-term market. The Market Module - Long Term allows users to simulate current and future trends for the HC markets, allowing them to choose the best market framework aligned with the users' economic, environmental, and social interests. Therefore, the Market Module - Long Term models and implements the centralised and decentralised market designs. In this way, users

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can create, test, and validate different market structures for energy matching in DHC systems. The outputs of the market analysis enable users to estimate potential costs and revenues for different market participants from trading excess heat.

Inputs from other modules

The MM exchanges data with all previously defined modules (CF, GIS and TEO). CF is responsible for providing the sink IDs and hourly demand profiles, and TEO provides source IDs, available capacity, costs, and CO_2 emissions. GIS is providing network-related data such as agents' location, distances, and losses.

Inputs from the user

In addition, there are some requirements from the user side regarding the market design, simulation period and granularity, product differentiation preferences and monetary bids from sinks. These inputs are summarised in Table 12. The user must insert the values for each input according to Table 12 and Figure 32-Figure 34.

Table 12: MM User inputs

Label	Description	Options/Examples	Input
Market Design	Market design to simulate.	centralised or decentralised	Centralised
Horizon Basis	Simulation horizon period.	weeks, months, or years	Years
Data Profile	Defines the level of data aggregation and simulation time slot between iterations.	hourly or daily	Hourly
Solver	This indicates the solver the user wants to use. The EMB3RS platform offers several open-source and commercial solvers to the user- COPT, SCIP, GUROBI and HiGHS. For this workshop, we will use GUROBI to have the best performance.	'COPT'	'COPT'
Recurrence period	Several instances to simulate according to Horizon Basis. In this case, Years is selected on Horizon Basis and 1 is selected here, so a 1-year simulation will be run.	10	1
Start Date Time	The date simulation will start.	01-01-2023	01-01-2023
FBP Time	This feature finds the best price a source must submit in the market to achieve higher revenue. The user must select a simulation period.	2	2
FBP Agent	This feature finds the best price a source must submit in the market to achieve higher revenue. The user must select a source.	BioInd, Iron&Steel, Stonemill, Polymers	BioInd
Maximum willingness to pay (utils)	Monetary bid by sinks. The platform allows one constant value or will generate fields so the user can introduce one value per sink.	0.7	0.7

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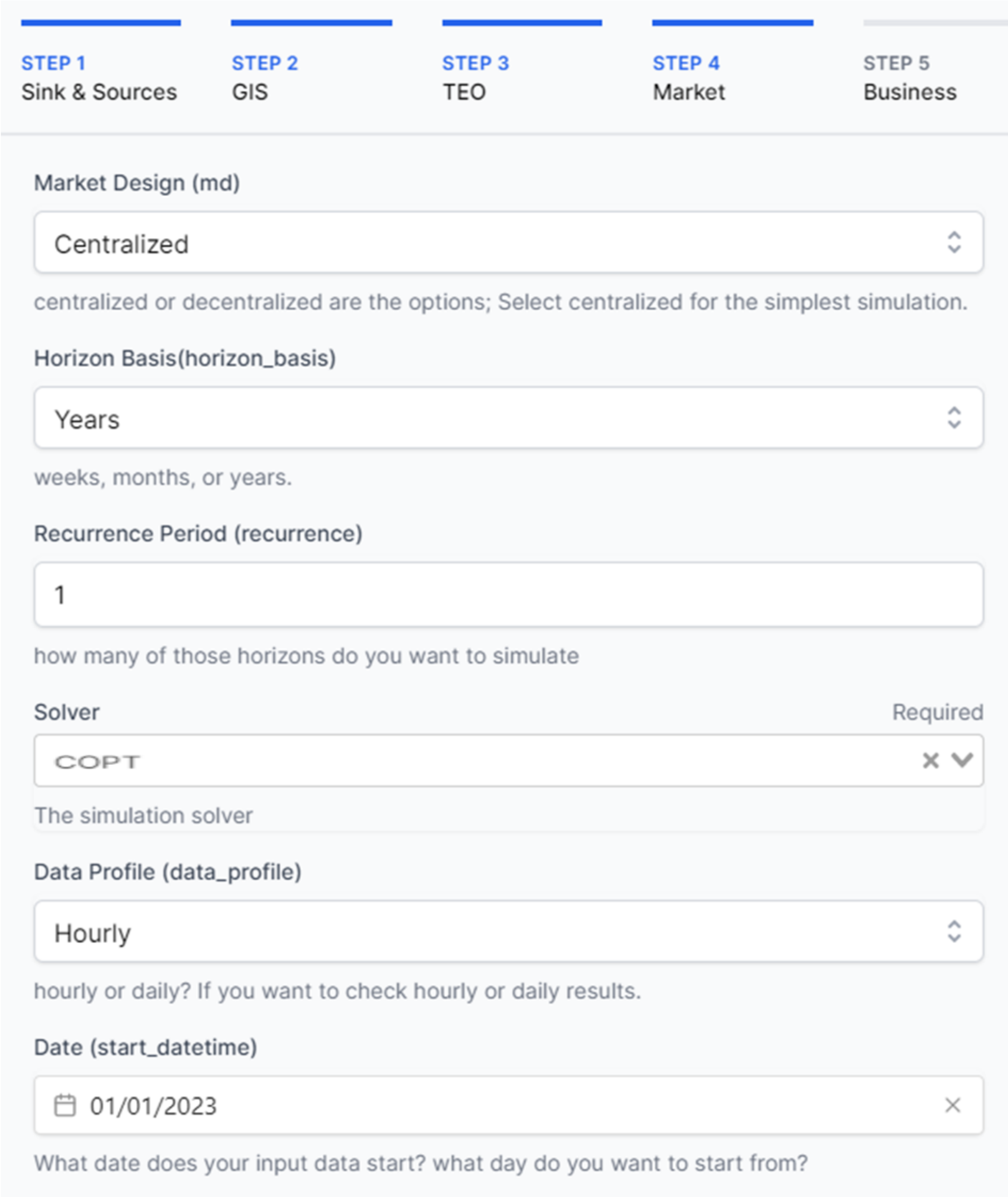

Figure 32: Inputs to the market module - 1

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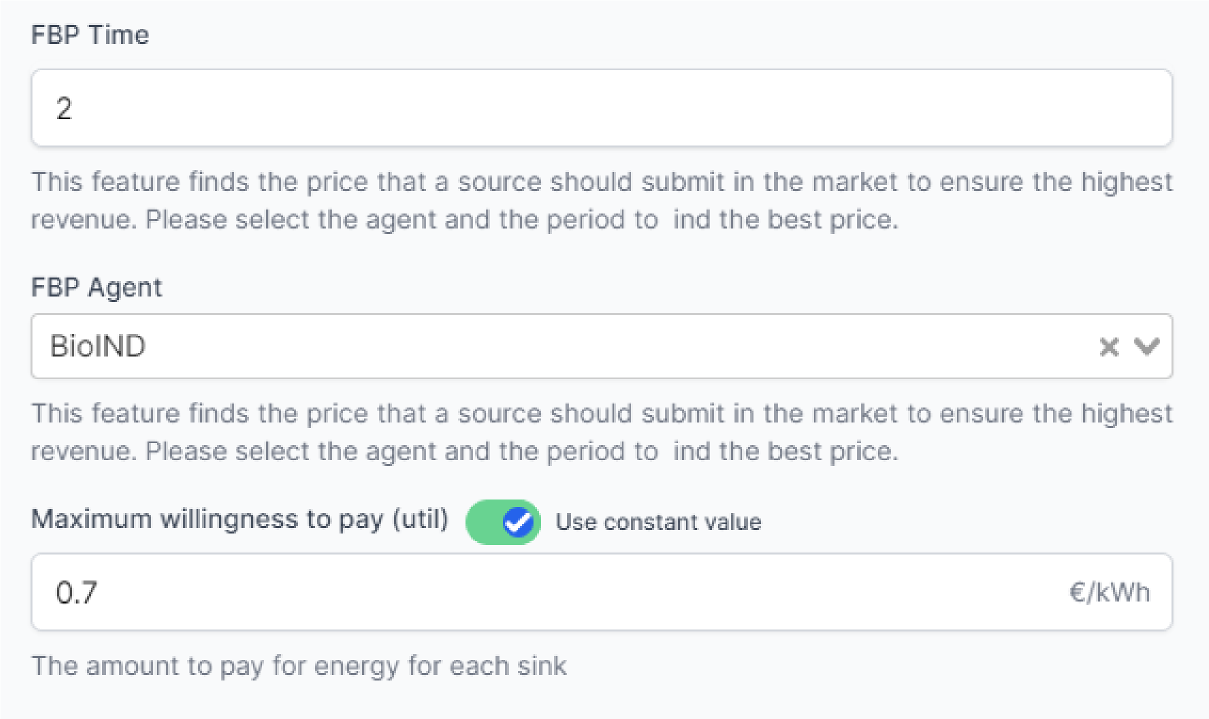

Figure 33: Inputs to the market module - 2

Users can also define a different utility value for each sink by unlocking this option, as depicted in Figure 34. **This functionality must be used for this exercise.**

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Figure 34: Inputs to the market module – 3

If the willingness to pay for any sink is not specified in Figure 34 enter the default value of 0.7.

Step 8: Business Module

The business module evaluates the financial profitability of a given excess heat extraction and utilisation project by calculating the following metrics: Net Present Value (NPV), Internal Rate of Return (IRR), and Payback period. The business module considers different ownership structures, which represent different business models.

The business module interacts directly with the techno-economic optimisation module (TEO), market module (MM), and the user. TEO provides input regarding the capital investment into different technologies suitable for a given excess heat/cold project. MM provides operational costs for running these technologies and revenues generated by selling/buying excess heat/cold under different market frameworks. Finally, the user provides inputs regarding discount rates, project duration, and ownership structures.

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Inputs

Table 13 presents the different inputs required from the user. Figure 35 represents the input from the BM in the EMB3RS platform.

Table 13: BM User inputs

Input Label	Description	Input Value
Socio-economic and private business discount rates.	Discount rate for both scenarios: socio-economic and private business. User must provide both discount rates	[4, 4]
Lifetime in years of the project	The lifetime of the project is in years.	10
CO2 intensity of existing heat supply (optional)	The CO2 intensity of the existing heat supply is to be replaced by the excess heat project at hand.	5

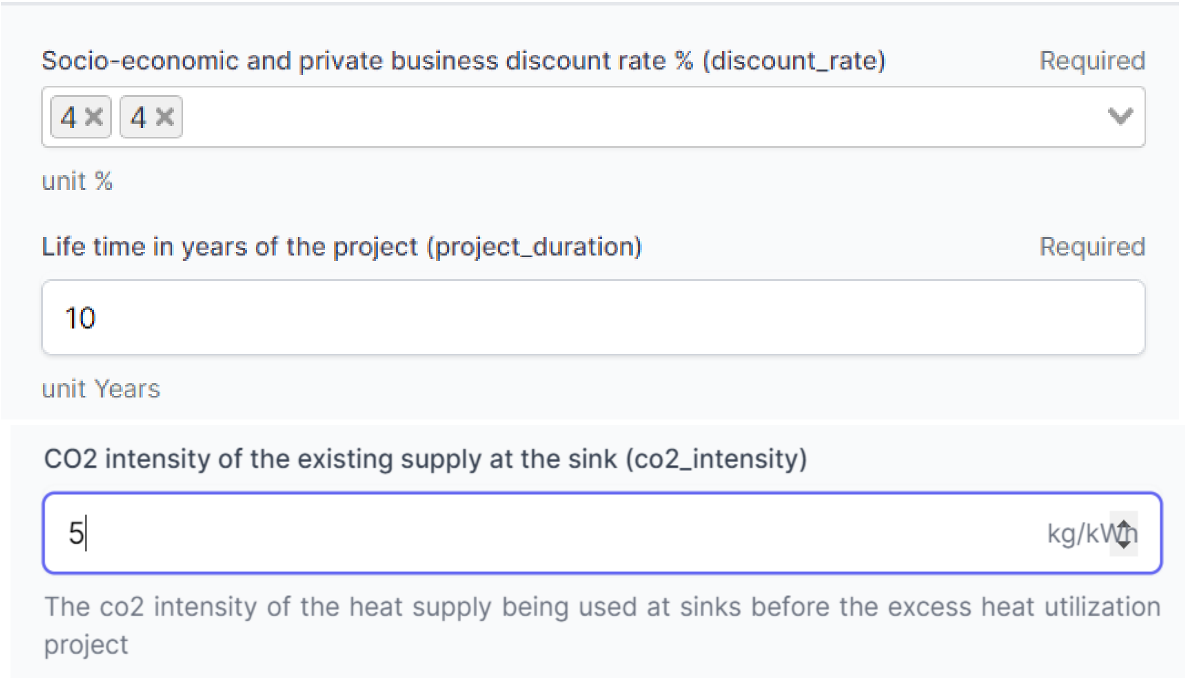

Figure 35: BM inputs

Distribution grid ownership:

Like technology ownership, the user must determine the ownership of the distribution network, and all the technologies that are connected to the grid. It may form the major share of investment into the overall excess heat/cold utilisation project. Users can distribute the cost of the distribution grid among different actors in terms of a percentage share of the total cost of the distribution grid.

For example, if there are two sources and one sink then there are 3 actors in total. Grid ownership represents how the cost of the network will be divided among these actors. If two sources share the cost of the grid then input to grid ownership will be such that 50% of the cost goes to source 1 and 50% goes to source 2, while 0% to sink. This input is shown in Figure 36.

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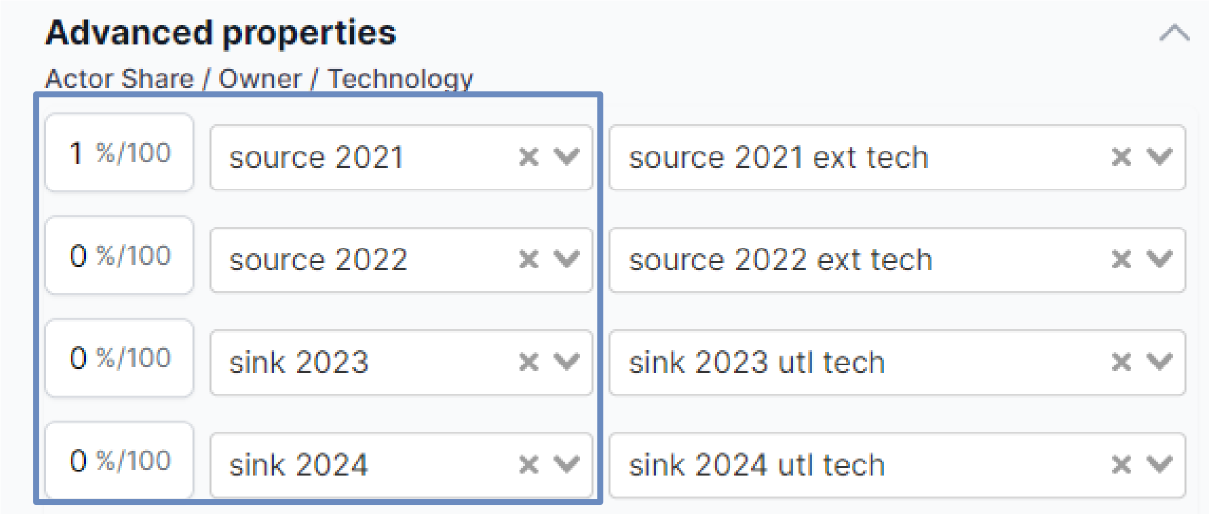

Figure 36: BM grid ownership inputs

Technology ownership:

The business module allows users to select different ownership structures for technologies that TEO calculates to invest. These technologies could include heat exchangers, thermal storage, backup boilers, and so on. The ownership structure determines which actor owns what technology. Once a technology is owned, let's say, by actor A, the capital investment cost and subsequent operation and maintenance costs and revenues of that technology are assigned to actor A when calculating its NPV and IRR.

The user can select the ownership structure for each actor involved in the project. An actor is a commercial entity, and each source and sink form a separate actor. An actor must own each technology so that no technology is left unowned. Figure 37 depicts the selection of the technology ownership structure.

All the technologies at the source side are grouped under "source extraction technologies" while all the technologies at the sink side are grouped under "sink utilisation technologies". Ownership structure assigns these groups of extraction and utilisation technologies to different actors involved.

For example, if there are 2 sources and 1 sink in a given project, then the following 2 ownership structures can be defined:

Ownership structure 1:

[['source 1', 'source 1 ext tech'],
['source 2', 'source 2 ext tech'],
['sink 1', 'sink 1 until tech']]

Under this ownership structure, all the actors own (or invest in) technologies that are installed at their respective premises.

Ownership structure 2:
[['source 1', 'source 1 ext tech'],
['source 1', 'source 2 ext tech']

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['source 1', 'sink 1 until tech']]

Under this ownership structure, only one actor (source 1) invests in all the technologies. Similarly, more ownership structures can be defined, and all these different ownership structures form different business models. The input is shown in Figure 37.

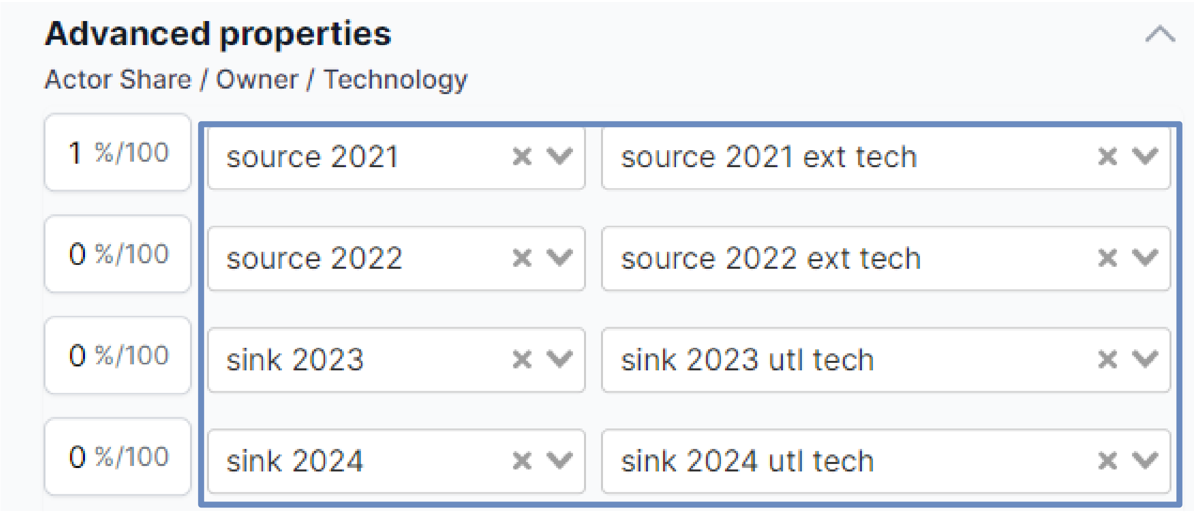

Figure 37: BM Ownership structure user input

Step 9: Running the simulation

Once you have given the inputs for all the modules, the next step would be to simulate the case on the EMB3Rs platform by running a full simulation (calling all the modules). Click on the ‘Create simulation’ button in the bottom left of the window as shown in Figure 38.

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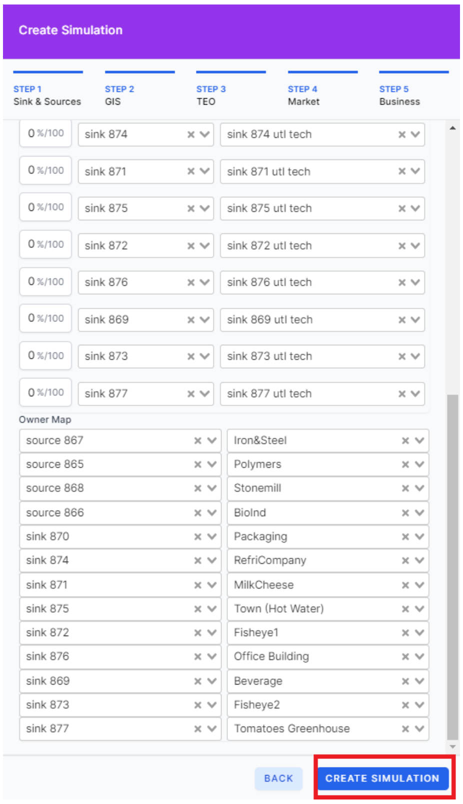

Figure 38: Creating a simulation

Click on 'Confirm' in the box asking if you are sure that you want to create the simulation. You will be redirected to a new window as shown in Figure 39.

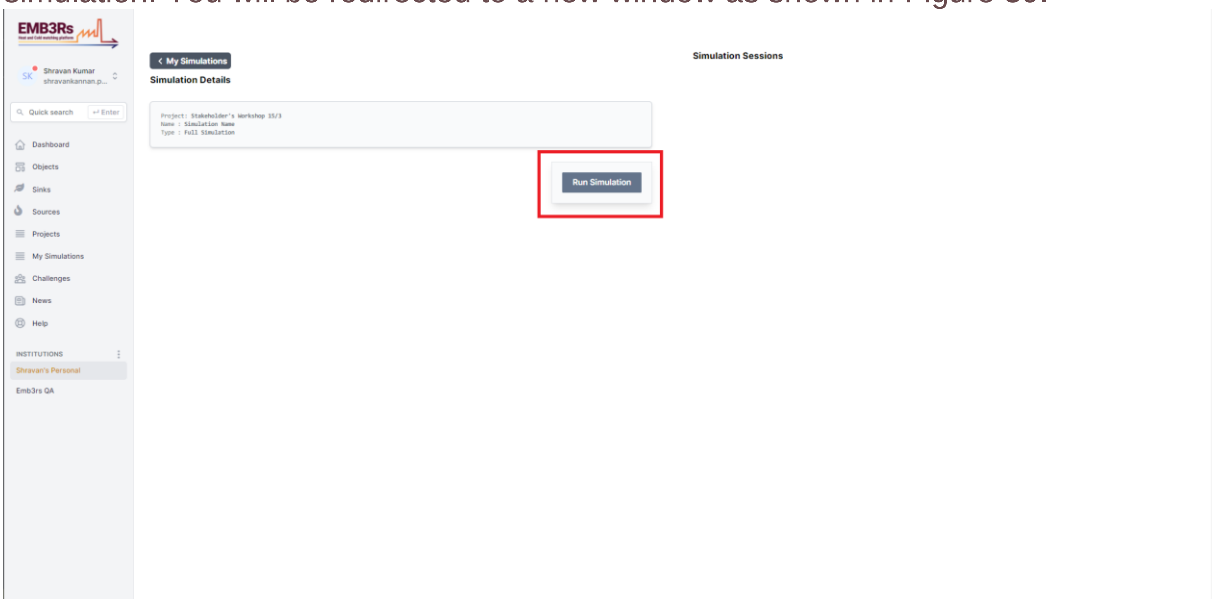

Figure 39: Simulation window

Here click on the box 'Run Simulation'. Your simulation will start running and you can access it by clicking the rectangle on the right as shown in Figure 40.

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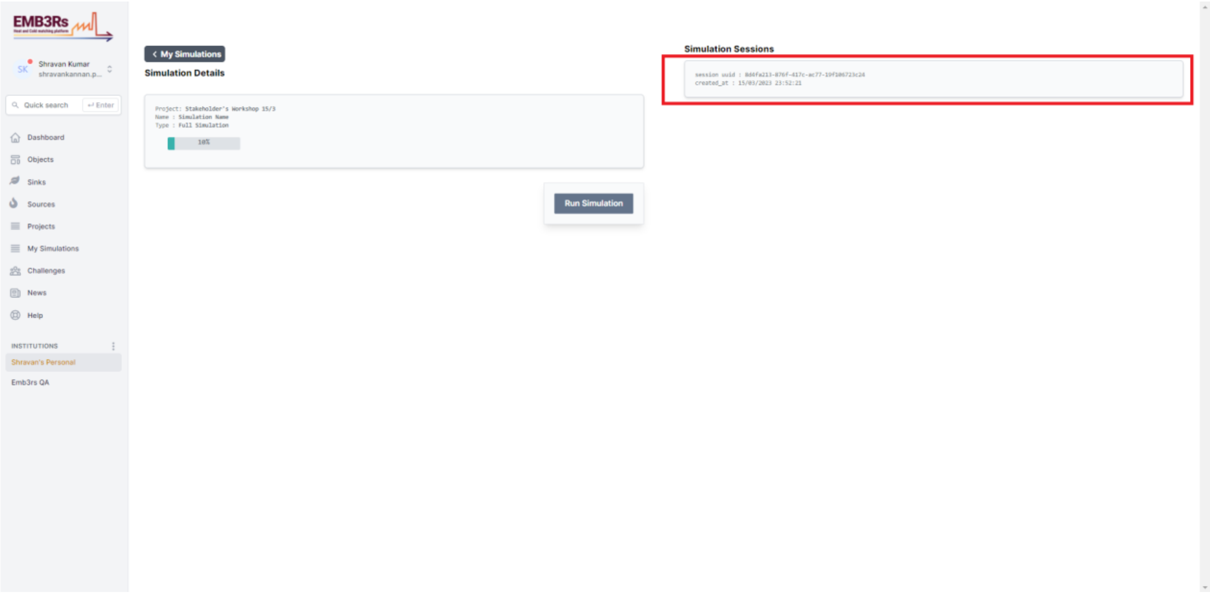

Figure 40: Accessing simulation

You will now be redirected to a new window as shown in Figure 41. Here you can view the progress of the simulation.

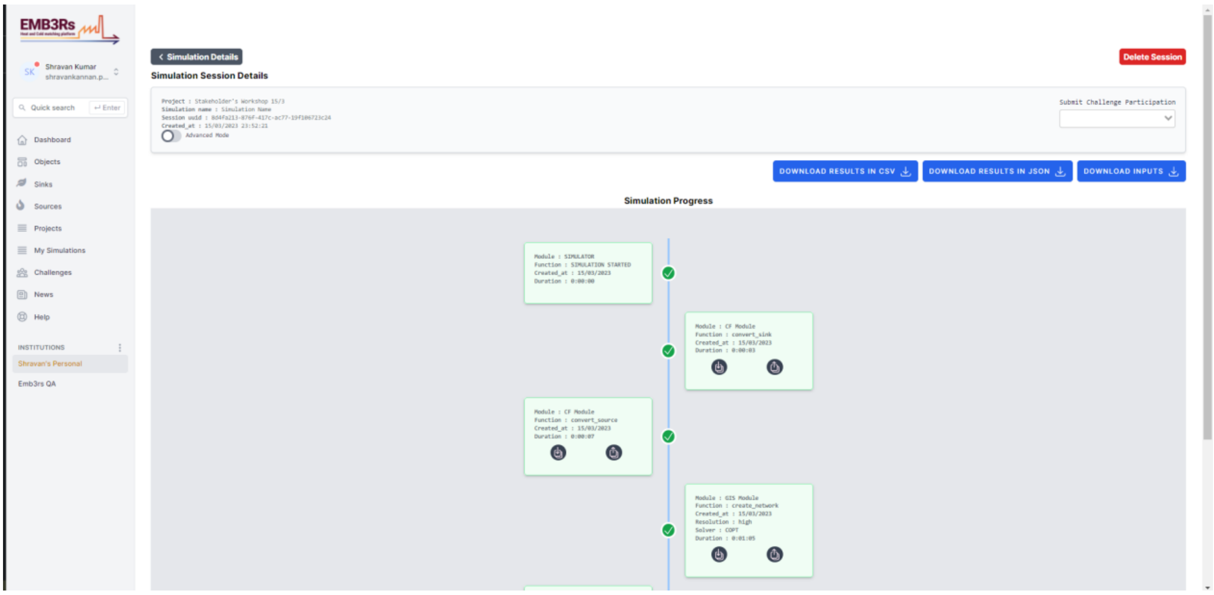

Figure 41: Detailed simulation window

Step 10: Intermediate inputs for TEO

The simulation starts with the Core functionalities and the GIS modules. Then, the TEO module is run. The TEO module has an intermediate input step which will be used to enforce some additional constraints on the model. The constraints for the intermediate steps are listed below.

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Table 14:TEO Intermediate inputs

Parameter	Description
Availability factor	The maximum time a technology can run in the whole year, as a fraction of the year ranges from 0 to 1. It gives the possibility to account for planned outages.
Technology discount rate	Technology-specific value for the discount rate, expressed in decimals (e.g. 0.04).
Capacity to Activity ratio	Conversion factor relating the energy that would be produced when one unit of capacity is fully used in one year.
Residual capacity	Remained capacity available from before the modelling period.
Maximum annual capacity addition	Maximum capacity of a technology that can be added in a year expressed in power units.
Minimum capacity	Total minimum existing (residual plus cumulatively installed) capacity allowed for technology in a year.
Minimum annual capacity addition	The minimum capacity of a technology that must be added in a year is expressed in power units.
Minimum annual heat generation	Total minimum heat generation allowed for technology in one year.
Maximum annual heat generation	Total maximum heat generation allowed for technology in one year.
Minimum model period heat generation	Total minimum heat generation allowed for technology in the entire modelled period.
Maximum model period heat generation	Total maximum heat generation allowed for technology in the entire modelled period.

In the intermediate steps, the user can configure the above inputs for each technology that is chosen by the CF module. The CF module chooses all technologies that are allowed and are temperature-feasible on the source and sink side. The user can configure certain constraints on these technologies using the inputs in Table 14.

For this workshop, we will demonstrate the intermediate steps using the technology ‘gridspecifichp’. In this case, we are assuming that the local district heating utility has planned to set up a Heat pump (HP) to supply heating. So, we will analyse how the excess heat from the sources can support this. However, the techno-economic optimisation in the platform is designed such that the excess heat is prioritised over other backup heat generation technologies. Therefore, we must force the optimisation to consider the addition of an HP. We can do that by using the intermediate inputs to the TEO. The window for the intermediate inputs to the TEO is shown in Figure 42.

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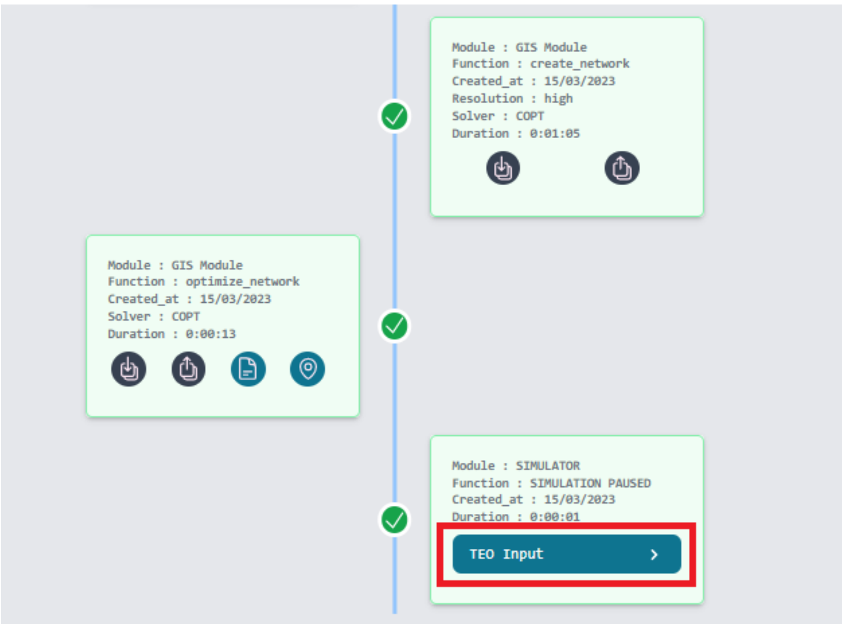

Figure 42: TEO intermediate inputs

Here, you can enter the values for each technology by clicking on the down arrow next to the technology name. The dropdown will contain all the inputs for the technology. Click on the dropdown next to 'gridspecifichp' as shown in Figure 43.

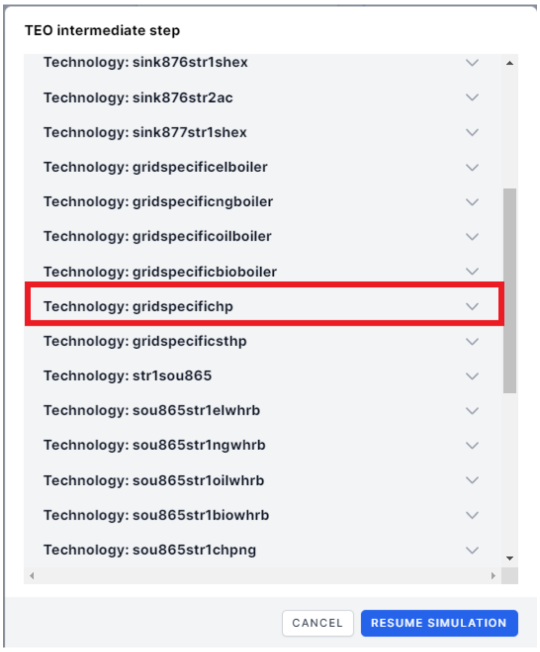

Figure 43: TEO intermediate inputs for gridspecifichp

Table 15 indicates the values to be filled for 'gridspecifichp' in the intermediate inputs to TEO. When it says 'Default value' in the table, do not change the value in the input. Leave the default values filled in.

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Table 15: Inputs for TEO intermediate steps

Parameter	Value
Availability factor	0.80
Technology discount rate	0.04
Capacity to Activity ratio	8760
Residual capacity	0
Maximum annual capacity addition	Default value
Minimum capacity	350
Minimum annual capacity addition	Default value
Minimum annual heat generation	Default value
Maximum annual heat generation	Default value
Minimum model period heat generation	Default value
Maximum model period heat generation	Default value

By using the minimum capacity, we are forcing the techno-economic optimisation to install 350 kW of HP. The model will not install more than 350 kW since there are already excess heat technologies that are preferred over the backup technologies. We can verify this in the next step when we visualise the results. The inputs are shown in Table 15.

Step 10: Result visualisation

The simulation in the platform is complete when all the modules have run and provided the report. The completion of the simulation in the Business module is the last process in the simulation. A box saying 'SIMULATION FINISHED' at the end of the page as shown in Figure 44 indicates a successful simulation of the case. Once the case is simulated, the results can be visualised by clicking on the button 'Final Report' as shown in Figure 44.

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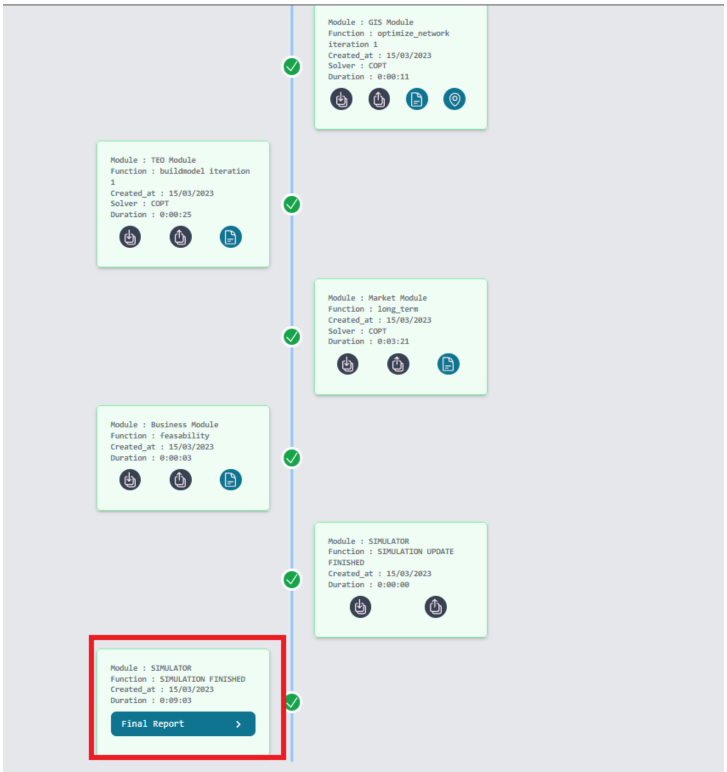

Figure 44: Final report

A new window will open as shown in Figure 45. The new window contains the report of each module. These reports are briefly presented below. The reports contain the results as well as an explanation for the different result variables. You can scroll down this page to access all the module reports. Each module report can be opened in separate tabs by clicking on the report names in the summary box shown in Figure 45. Note that CF does not produce a report for full simulations.

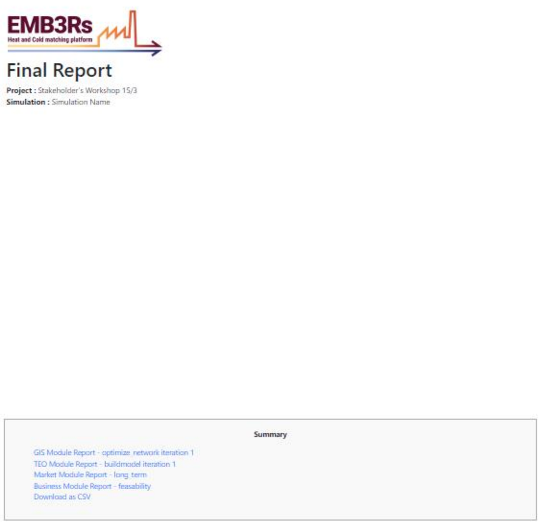

Figure 45: Final Report

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Reports

This section briefly presents the reports from each module. The main results from the module's reports are shown in the figures below. The detailed results can be seen in the report produced by the module on the platform. The results in the report the for the case should be like the ones shown here.

GIS Module

The GIS module's contribution to the main simulation report is the total network length, total network cost and the total network losses. The individual values for each pipeline are provided in the detailed report. While calculating the total values, the pipes that are used for multiple sources and sinks are counted once to prevent redundancy.

EMB3Rs
Heat and Cold matching platform

GIS Module Report

1. Aggregated Results

The aggregated results for the network are available in this section. The table below shows the total values for the whole network. Please note that a pipe can be used to connect multiple sources and sinks. The pipes used for multiple sources and sinks are counted once to prevent redundancy. Please see the next section for the detailed results.

Table Info

- Total Thermal Loss [W]: sum of the thermal losses of the pipelines used in the grid.
- Installed Capacity [MW]: sum of the installed capacities of the pipelines used in the grid.
- Total Network Length [m]: sum of the lengths of the pipelines used in the grid.
- Total Costs [EUR]: sum of the digging costs (excluding surface pipes), piping costs, and pump cost (if defined by the user) for all pipes in the solution.

Total Thermal Loss [W]	Total Installed Capacity [MW]	Total Network Length [m]	Total Costs [EUR]
754235	4	26841	16357727

Figure 46: GIS Reports

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TEO Module

The TEO module produces a separate simulation report with the main results from the module. The main functionalities of the TEO module are to determine the least cost matching of the sources and the sinks and the corresponding technologies to be installed at the different sources and sinks. The module determines various parameters shown below with illustrations.

EMB3Rs
Heat and Cold matching platform

Techno-economic optimization : Report

Welcome to the module simulation report of the Techno-economic optimization (TEO) module in the EMB3RS platform. The TEO module determines the cost optimal matching of sinks and the sources. The optimal capacity of the technologies and storages, and their optimal operation is determined while considering several constraints.

The Techno-economic optimisation module considers several technologies for each source and sink based on the temperature level of the source. For high temperature sources, heat recovery technologies such as heat exchangers are considered. Whereas, for low temperature sources, temperature boosting technologies such as heat pumps, boilers, Combined heat and power, solar thermal etc. are considered to supplement the heat provided by the source. Similarly for the sinks which function at the grid temperature, a heat exchanger is used to transfer heat. While for heat sinks with a higher demand temperature than the grid temperature, the temperature boosting technologies specified before are used.

Back up technologies called as grid specific technologies are used in cases when the heat supply from the sources is not enough to meet the heat demands in the sink.

The techno-economic optimisation considers an intra annual timestep based optimisation, i.e. the energy balance between the sources and the sinks is considered for each timestep within the year.

The techno-economic optimization of your case has been succesfully completed. The results of the analysis are presented in this report. The report contains several sections. Each of them will present tables, plots and some text describing the main results of your case. For a detailed analysis of the results, you can download the results of the TEO module from the platform. This report contains the following sections

1. Capacity of Sources and Sinks

2. Storage Capacities

3. Annual Heat generation

4. Intra Annual Heat and Cold Generation

5. Overall Heat and Cold Generation and Consumption

6. Emissions

7. Costs

8. Storage operation

Figure 47: TEO report

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Final Source and Sink Capacities in kW

TECHNOLOGY	Installed capacity (kW)
Beverage Stream1 Single Heat Exchanger	21.54
BioInd Stream1 Multiple Heat Exchanger	38.07
Fisheye1 Stream1 Single Heat Exchanger	280.74
Fisheye2 Stream1 Heat Pump	1403.68
Grid Specific	1000.00
Grid Specific Heat Pump	250.00
Iron&Steel Stream1 Multiple Heat Exchanger	1260.00
MilkCheese Stream1 Single Heat Exchanger	59.71
Office Building Stream1 Single Heat Exchanger	39.67
Office Building Stream2 Absorption Chiller	0.45
Packaging Stream1 Single Heat Exchanger	33.49
Polymers Stream1 Biomass Heat Recovery Boiler	412.84
Polymers Stream1 Heat Pump	358.62
Polymers Stream1 Natural Gas Heat Recovery Boiler	587.30
RefriCompany Stream1 Absorption Chiller	143.55
Stonemill Stream1 Multiple Heat Exchanger	708.75
Tomatoes Greenhouse Stream1 Single Heat Exchanger	50.99
Town (Hot Water) Stream1 Single Heat Exchanger	350.92

Figure 48: TEO reports 1

The installed capacity of technologies for all sources and sinks

The installed capacity of technologies for all sources and sinks are visualised in the graph below.

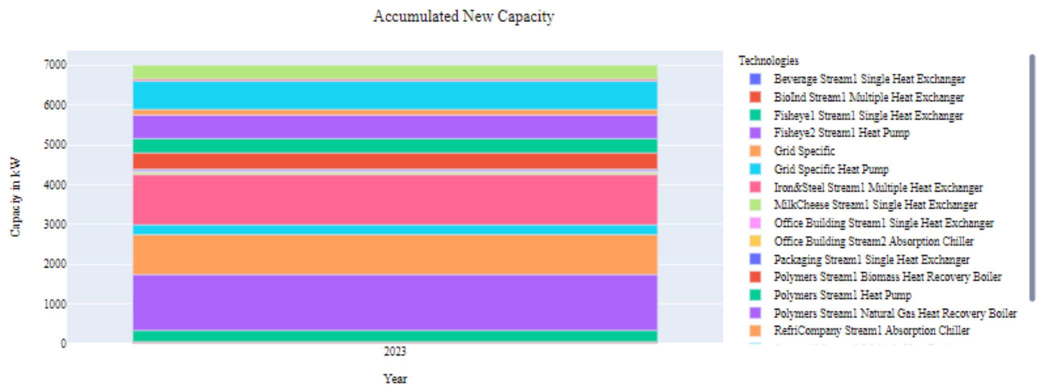

Figure 49: TEO reports 2

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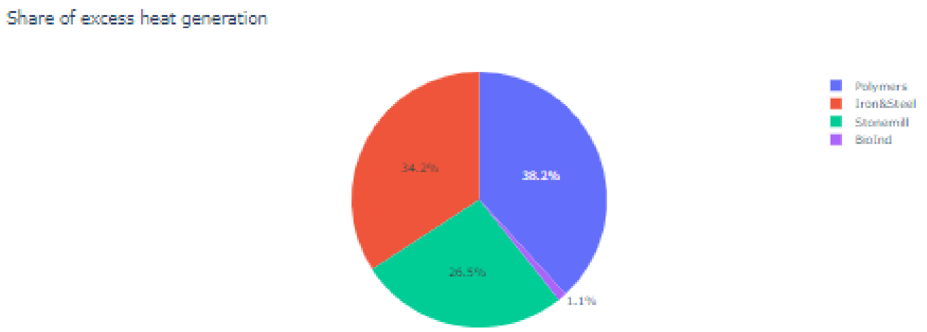
Annual Source Heat Generation in kWh

Technology	2023
Polymers Stream1 Biomass Heat Recovery Boiler	2288349.57
Polymers Stream1 Heat Pump	1169471.5
Polymers Stream1 Natural Gas Heat Recovery Boiler	4769130.97
BioInd Stream1 Multiple Heat Exchanger	237049.68
Iron&Steel Stream1 Multiple Heat Exchanger	7359240.0
Stonemill Stream1 Multiple Heat Exchanger	5717360.38

Figure 50: TEO reports 3



The share of excess heat and cold consumption by each sink is visualised in the pie below.

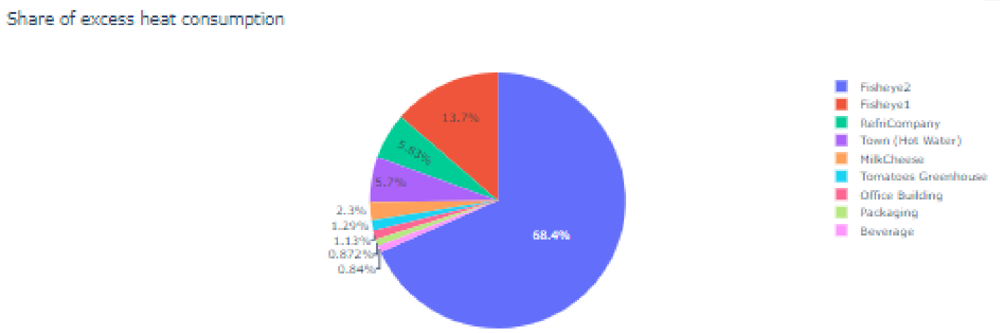


Figure 51: TEO reports 4

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Capital Costs in Euros

Technology	Capital costs (Euros)
Beverage Stream1 Single Heat Exchanger	494.94
BioInd Stream1 Multiple Heat Exchanger	4109.83
Fisheye1 Stream1 Single Heat Exchanger	2532.51
Fisheye2 Stream1 Heat Pump	450804.38
Grid Specific	28485.00
Grid Specific Heat Pump	55106.25
Iron&Steel Stream1 Multiple Heat Exchanger	51145.92
MilkCheese Stream1 Single Heat Exchanger	1107.21
Office Building Stream1 Single Heat Exchanger	437.05
Office Building Stream2 Absorption Chiller	185.02
Packaging Stream1 Single Heat Exchanger	478.73
Polymers Stream1 Biomass Heat Recovery Boiler	1135890.89
Polymers Stream1 Heat Pump	238686.45
Polymers Stream1 Natural Gas Heat Recovery Boiler	1615906.03
RefriCompany Stream1 Absorption Chiller	16605.03
Stonemill Stream1 Multiple Heat Exchanger	37349.00
Stream1 Stream1	42.10
Tomatoes Greenhouse Stream1 Single Heat Exchanger	348.45
Town (Hot Water) Stream1 Single Heat Exchanger	1992.52

Figure 52: TEO reports 5

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Operational Costs in Euros

Technology	Operating costs (Euros)
Beverage Stream1 Single Heat Exchanger	136.30
BioInd Stream1 Multiple Heat Exchanger	582.74
Fisheye1 Stream1 Single Heat Exchanger	599.72
Fisheye2 Stream1 Heat Pump	671537.76
Grid Specific	3322.21
Grid Specific Heat Pump	4487.73
Iron&Steel Stream1 Multiple Heat Exchanger	7696.94
MilkCheese Stream1 Single Heat Exchanger	268.45
Office Building Stream1 Single Heat Exchanger	91.88
Office Building Stream2 Absorption Chiller	91.50
Packaging Stream1 Single Heat Exchanger	112.83
Polymers Stream1 Biomass Heat Recovery Boiler	109226.65
Polymers Stream1 Heat Pump	91276.69
Polymers Stream1 Natural Gas Heat Recovery Boiler	120976.01
RefriCompany Stream1 Absorption Chiller	126524.58
Stonemill Stream1 Multiple Heat Exchanger	5573.77
Tomatoes Greenhouse Stream1 Single Heat Exchanger	72.95
Town (Hot Water) Stream1 Single Heat Exchanger	385.46

Figure 53: TEO reports 6

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Market Module

The market module report is both presented as a direct result from the module on the platform, as well as also included in the Final Simulation Report. Each of the titles can be expanded to show the actual numerical values related to each output quantity calculated by the market module.The outputs of the market analysis enable users (e.g., industries, supermarkets and data centres) to estimate potential costs and revenues for different market participants from trading excess heat and cold.

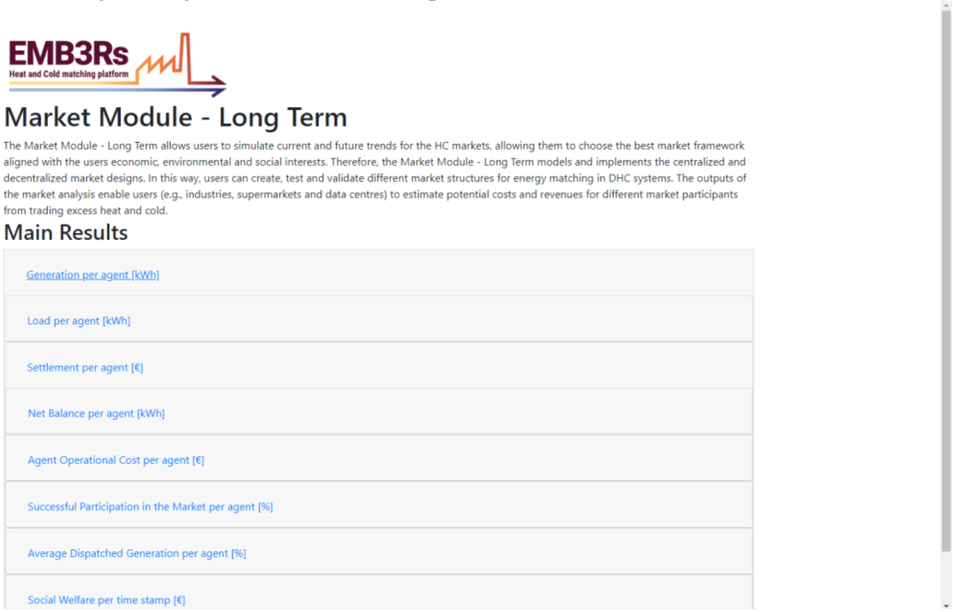

Figure 54: MM report

Business Module

The business module reports module consist of Payback period, NPV and IRR for both socio-economic and private business scenarios. For the socio-economic scenario, only single Payback period, NPV and IRR for the whole project is calculated. The sensitivities of NPV and IRR over different values of socio-economic discount rates are also shown. For private business scenario, Payback, NPV and IRR are shown for each actor involved for a given ownership structure specified by the user. Sensitivity analysis is also performed over the different private business discount rates values.

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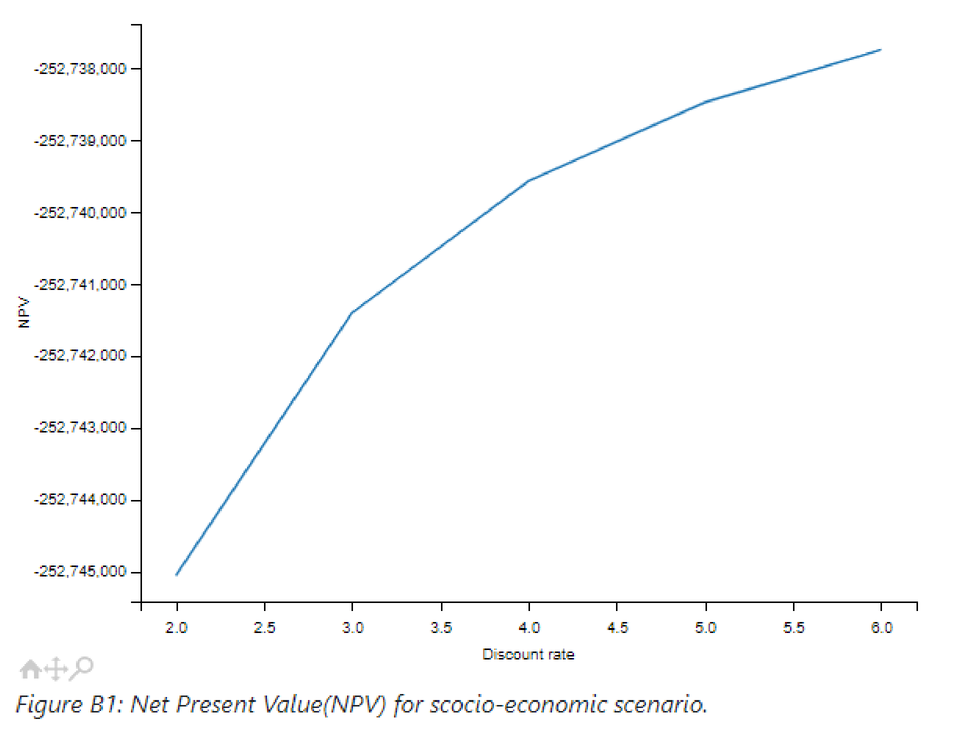

Figure 55:BM report 1

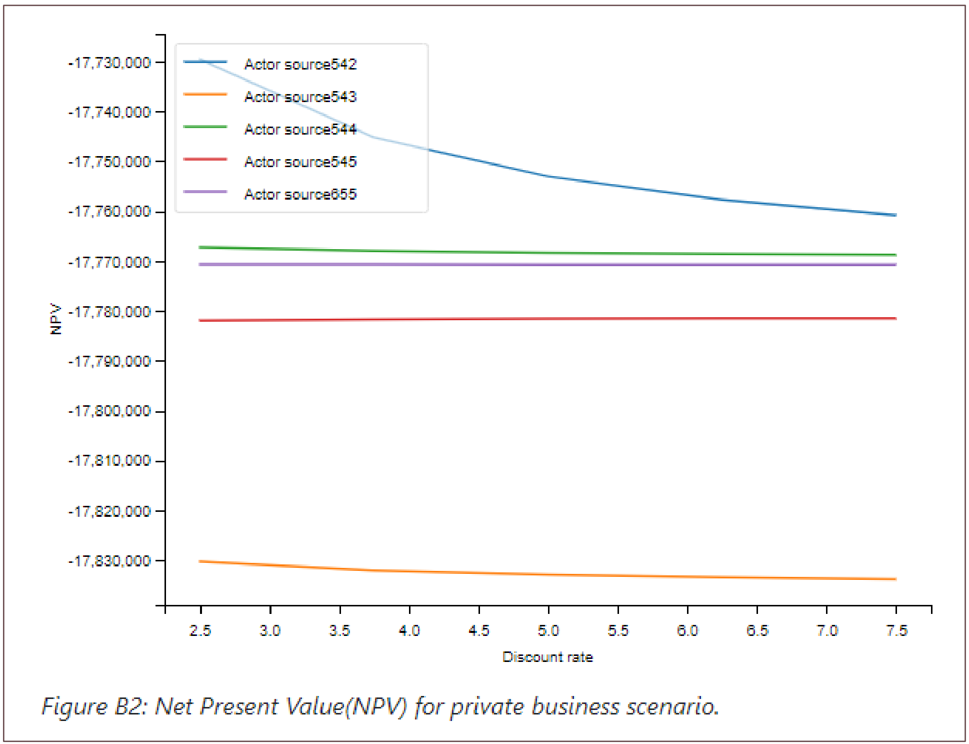

Figure 56: BM report 2

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Levelised Cost of Heat for Sinks

The Levelised Cost of Heat (LCOH) calculated for each sink are shown in the table below:

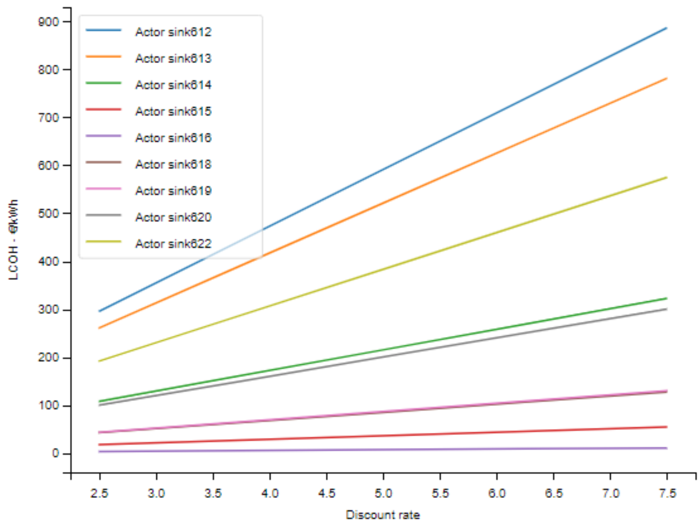

Figure B3: Levelised Cost of Heat (LCOH) for sinks.

Figure 57: BM reports

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Challenge 2: Internal Heat Recovery

Before analysing DHNs, for some industries, it can be more beneficial to look first at their industrial layout and check if they can recover the discarded heat within their processes, or, for example, use that heat to produce electricity.

Challenge 2.1 - Steel&Steel ORC Analysis

Case description

Iron&Steel is very interested in understanding if there is potential in recovering the excess heat to produce electricity since they have a large electrical consumption.

1st Step - Identify Source and ORC parameters

Iron&steel has an excess heat stream cooling its exhaust flue gas from 900 to 500ºC, with a total thermal capacity of 2800kW.

2nd Step - ORC simulation

For this challenge, you need to create a new simulation. Come back to the Projects tab using the menu on the left side of the screen. Click on ‘Create Simulation’ next to the project you created for this workshop. To perform an ORC analysis, you simply have to select “ORC report” on the simulation menu and select the source you intend to perform the analysis and then select the ORC cycle evaporation temperature and condenser temperature as shown in Figure 58.

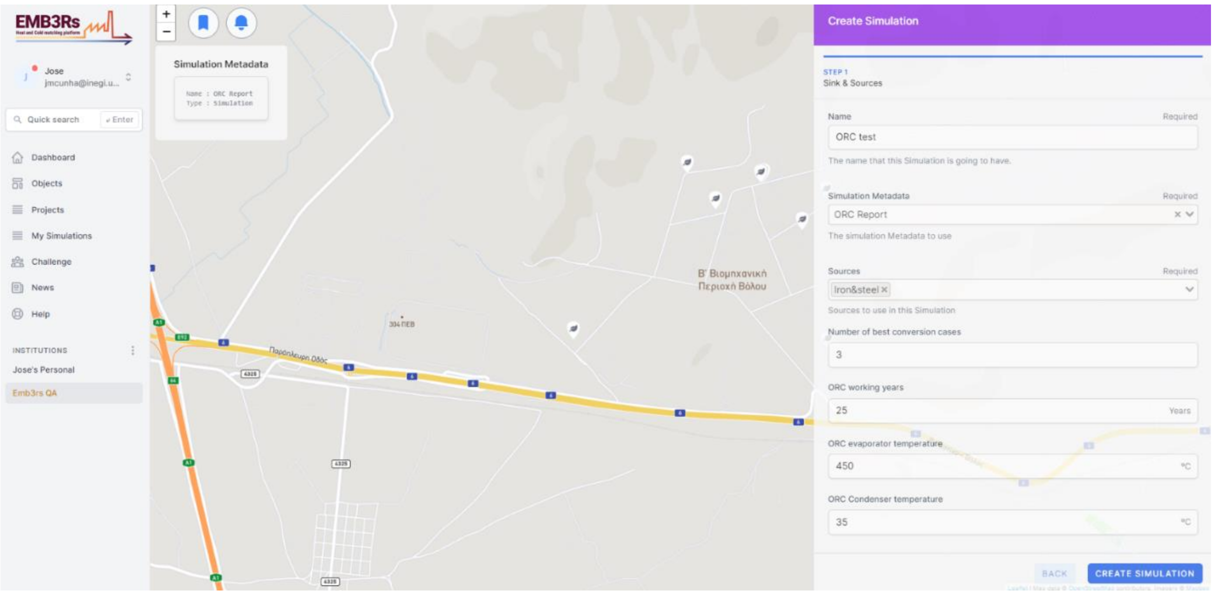

Figure 58: ORC simulation inputs

The platform will then calculate the expected electricity savings and ORC system capacity, assuming an air-cooled condenser with a cooling tower. Since it is cooled by air, the ORC condenser temperature will be around 35ºC. Once you have entered the

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inputs, click on create simulation and follow steps 8 and 10 of challenge 1 to follow the simulation progress and visualise the results.

Once the simulation is finished, you can view the report of the pinch analysis by clicking on the show report symbol in the box with the ‘convert_orc’ function in the simulation progress window as shown in Figure 59.

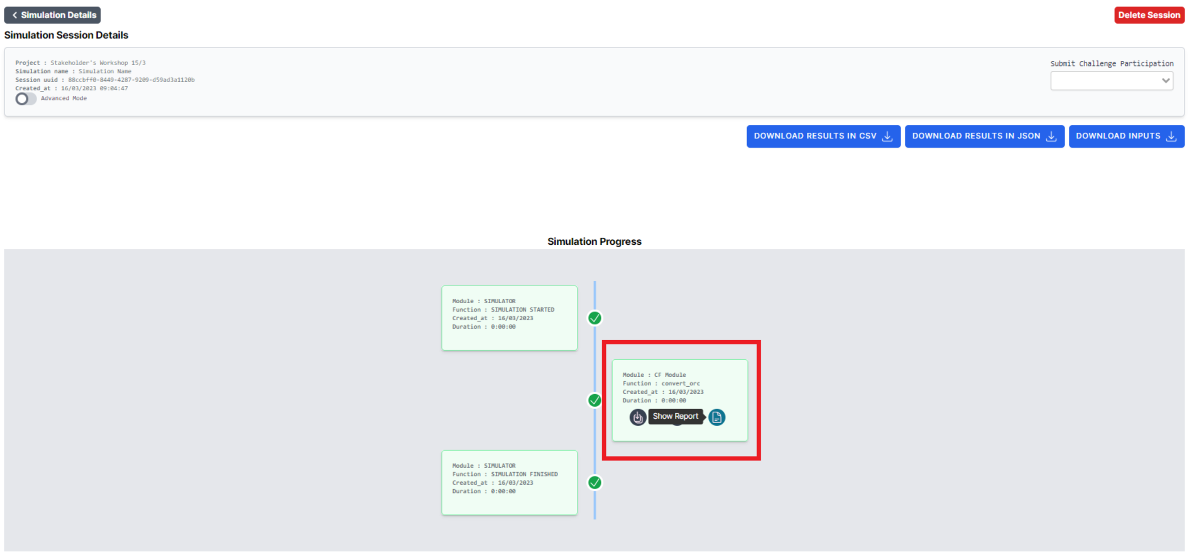

Figure 59: ORC simulation

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EMB3Rs

2023-03-31

REPORT: ORC Analysis

Index

More Info: Introduction

Overview Designed Solutions

Here you can find an overview on the best designed solutions for CAPEX over yearly generated electricity

More Info: Overview Designed Solutions

Table 2. Best Design Solutions

Solution ID	Streams ID	CO_2 Savings [$kgCO_2$/year]	Monetary Savings [€/year]	Yearly Electrical Generation [MWh]	CAPEX [€]	OM Fix [€/year]
1	[1]	1131808	166222	1867	1912034	191203

Technical Data

In this subsection you can find detailed technical data about the ORCs designed

More Info: Technical Data

Table 3. ORC Design Technical Details

Solution ID	ORC Power [kW]	ORC eff [%]	$T_{evaporator}$ [°C]	$T_{condenser}$ [°C]
1	638	25.3	450.0	35.0

Economic Data

In this subsection you can find detailed economic data about the ORCs designed:

More Info: Economic Data

Table 4. ORC Design Economic Details

Solution ID	Turnkey [€]	OM Fix [€/year]	OM Variable [€/year]
1	1912034	191203	698

Figure 60: ORC report 1

To assess the impact of the cycle evaporation temperature on the overall monetary savings, you can simulate the same stream, but instead, input the evaporation

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temperature of 110ºC. You can see that the expected savings and ORC power drop considerably as shown in Figure 60 and Figure 61.

Table 2. Best Design Solutions

Solution ID	Streams ID	CO_2 Savings [$kgCO_2$/year]	Monetary Savings [€/year]	Yearly Electrical Generation [MWh]	CAPEX [€]	OM Fix [€/year]
1	[1]	396881	74534	637	990295	99029

Technical Data

In this subsection you can find detailed technical data about the ORCs designed

More Info: Technical Data

Table 3. ORC Design Technical Details

Solution ID	ORC Power [kW]	ORC eff [%]	$T_{evaporator}$ [ºC]	$T_{condenser}$ [ºC]
1	217	8.6	110	35

Economic Data

In this subsection you can find detailed economic data about the ORCs designed:

More Info: Economic Data

Table 4. ORC Design Economic Details

Solution ID	Turnkey [€]	OM Fix [€/year]	OM Variable [€/year]
1	990295	99029	915

Figure 61: ORC report 2

Challenge 2.2 – Input streams and perform a pinch analysis

Case Description

Some industries know exactly their streams' data. Thus, to ease their work, the pinch analysis can also be done by providing directly the stream data, and the fuel and efficiency of the equipment associated with its heating/cooling - if existent.

1st Step - Introducing the stream's data

As an example, the maintenance engineer of Tough Ceramics (another industry near Volos Industrial Park), would like to check the possibility of analyzing the heat recovery within 4 specific streams which are presented in Table 16. You need to add the simple source as in Step 2 and give the location as 39.398712, 22.806532.

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Table 16: Stream data

Parameter	Unit	Streams			
Name	-	furnace flue gas	dry air	oil process 1	oil process 2
Fluid	-	flue gas	air	thermal oil	thermal oil
Supply Temperature	ºC	180	150	30	80
Target Temperature	ºC	140	60	180	160
Capacity	kW	560	180	120	160
Fluid Cp	KJ/KgK	-	-	-	-
Mass Flowrate	Kg/h	-	-	-	-
Daily Periods	h	[[0,24]]	[[0,24]]	[[0,24]]	[[0,24]]
Saturday On	-	Yes	Yes	Yes	Yes
Sunday On	-	Yes	Yes	Yes	Yes
Shutdown Periods	days	[]	[]	[]	[]

You start by adding the initial stream (furnace flue gas) on the source main input as shown in Figure 62. Like in step 2, leave all the parameters that are not mentioned in Table 16 as default or empty.

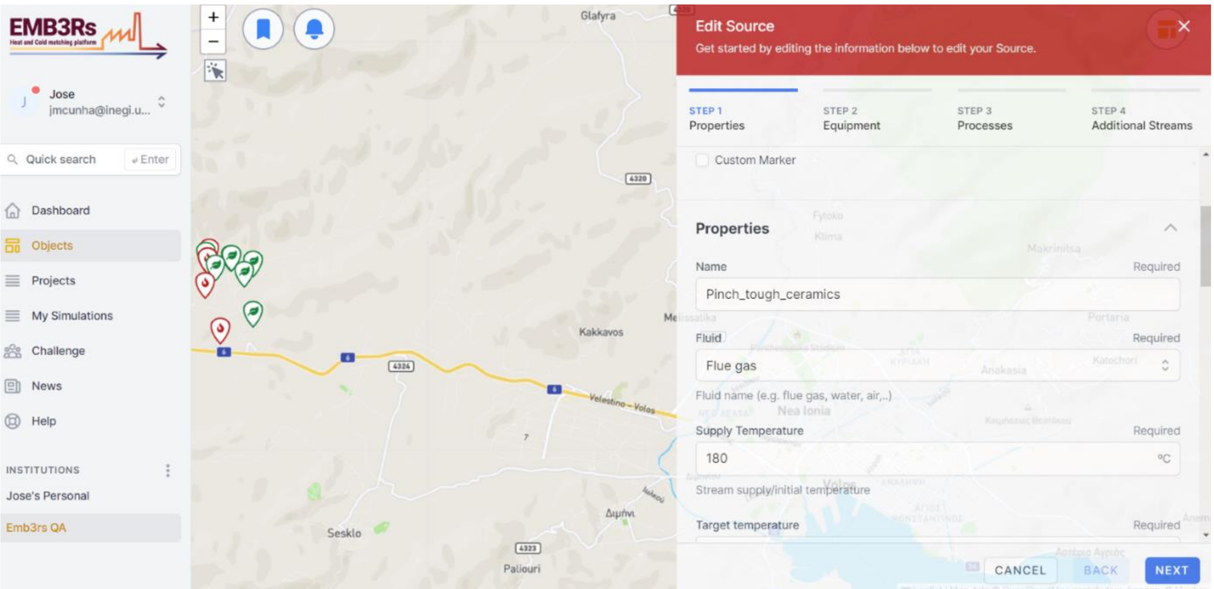

Figure 62: Inserting stream data on the platform

Once you finish the first stream, click on the 'Next' button in the bottom left of the screen. Then you add the remaining streams on the tab "additional streams" according to Table 16. Click on '+ NEW STREAM' to add a new stream. After characterising each stream, click the arrow next to the stream title to minimise it and add the next stream.

After adding all the streams, click on the save button in the bottom left of the screen to save the source.

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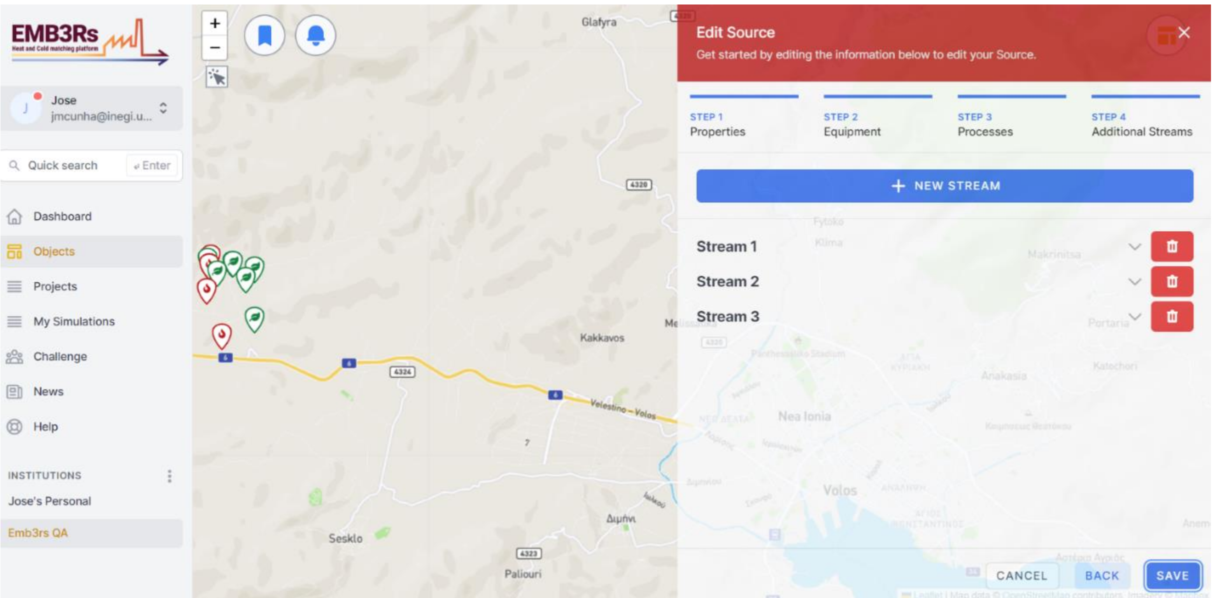

2nd Step - Perform Pinch Analysis

The main objective is to assess the internal heat recovery between the source's streams by designing possible heat exchanger networks. The analysis will always analyse all possibilities between stream combinations, and in the end provide the best 3 solutions in terms of the amount of heat recovered, CO_2 emission reduction, and Heat Recovery Specific Cost. You need to create a new simulation for this. Come back to the Projects tab using the menu on the left side of the screen. Click on 'Create Simulation' next to the project you created for this workshop. Once you have created a simulation choose the Pinch Analysis in the simulation type as shown in Figure 63. Choose the source that you added in the 1st Step of Challenge 2.2. Click on create the simulation and follow steps 8 and 10 from challenge 2 to follow the simulation process and visualise the results.

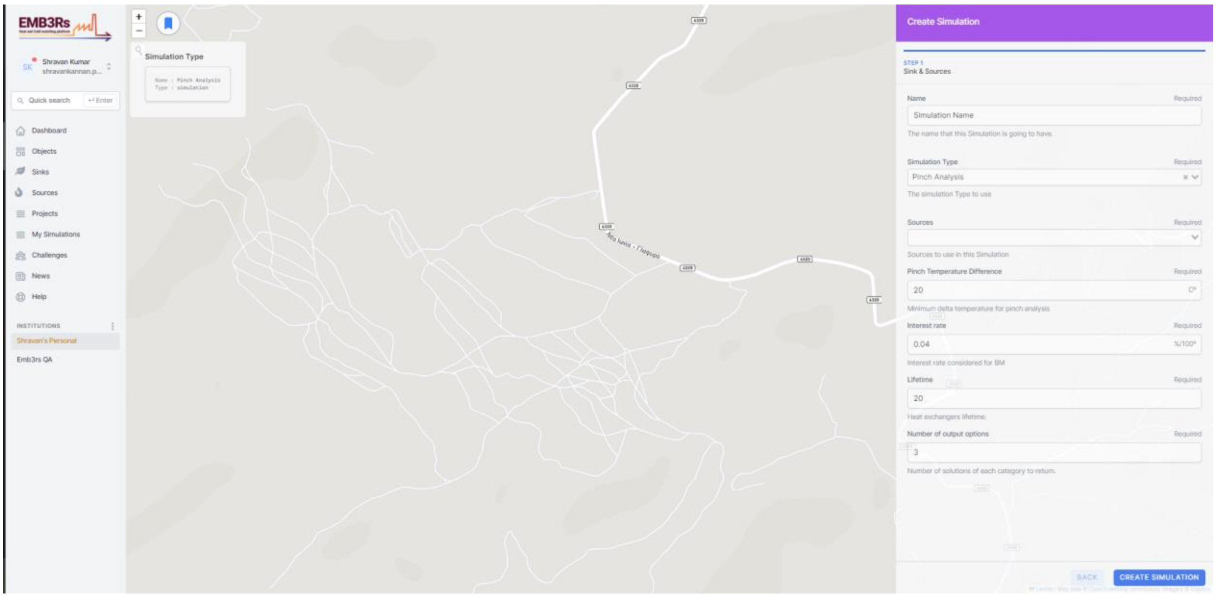

Figure 63: Pinch Analysis

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If there are restrictions in terms of recovering heat within streams, those streams should not be analysed in the same analysis.

Once the simulation is finished, you can view the report of the pinch analysis by clicking on the show report symbol in the box with the ‘convert_pinch’ function in the simulation progress window as shown in Figure 64.

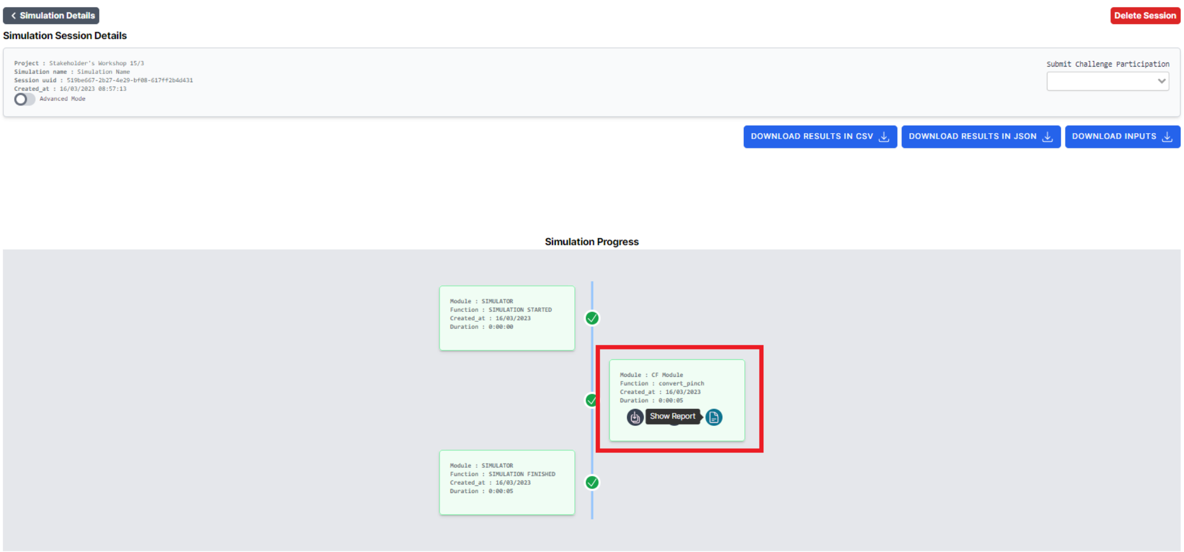

Figure 64: Pinch Analysis simulation

The report from the pinch analysis is shown in Figure 65.

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31/03/2023

REPORT: Pinch Analysis

Index

More Info: Introduction

1. User Streams

Here you can find data regarding all the streams your considered for the pinch analysis and respective details.

Table 1. Stream Table

Stream ID	Name	Fluid	Supply Temperature [ºC]	Target Temperature [ºC]	Capacity [kW]	mc_p [kJ/K]	Stream Type
1	stream1	flue gas	180.0	140.0	560	14.0	Hot
2	stream2	air	150.0	60.0	180	2.0	Hot
3	stream3	thermal oil	30.0	180.0	120	0.8	Cold
4	stream4	thermal oil	80.0	160.0	160	2.0	Cold

NOTE: All streams combinations were analyzed.

Figure 65: Pinch Analysis Report

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