WP5-Task T5.4

RESTORE Use-Cases Modelling
Summary

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036766.

PROJECT INFORMATION SHEET	
Project Acronym	RESTORE
Project Full Title	Renewable Energy based seasonal Storage Technology in Order to Raise Environmental sustainability of DHC
Grant Agreement	101036766
Call Identifier	H2020-LC-GD-2020-1
Topic	Innovative land-based and offshore renewable energy technologies and their integration into the energy system
Project Duration	48 months (October 2021 – September 2025)
Project Website	www.restore-dhc.eu
Disclaimer	The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the funding authorities. The funding authorities are not responsible for any use that may be made of the information contained herein.

DELIVERABLE INFORMATION SHEET	
Number	**(D5.4.0):** The current report contains general information about "RESTORE Use-Cases Modelling", related to WP5 Task T5.4, dealing with implementation, optimization, management & validation of the six RESTORE Use-Cases, using the Simulation Web Platform. This document is publicly available in the RESTORE's Zenodo Community account https://zenodo.org/communities/101036766/records.
Full Title	WP5-Task T5.4 - RESTORE Use-Cases Modelling Summary
Related WP	WP5 (RESTORE EU-wide Replication in Virtual Representation on Real Use-Cases)
Related Task	Task 5.4 (Implementation, optimization, management & validation of RESTORE Use-Cases using the Simulation Web Platform), and related Sub-tasks ST5.4.1; ST5.4.2; ST5.4.3; ST5.4.4; ST5.4.5; and ST5.4.6.
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Summary

This document summarizes the development of WP5 task T5.4 on "Implementation, optimization, management & validation of RESTORE Use-Cases using the Simulation Web Platform", led by SIMTECH with close cooperation with the Use-Cases Providers.

This report supports Results of task T5.4 reported in month M46 of RESTORE project, via the Deliverables:

- D5.4: Implementation and validation of RESTORE Use-Case I: Residential / Industrial DH with Biomass and Solar Collectors.
- D5.5: Implementation and validation of RESTORE Use-Case II: Integration of different heat sources in DH of Cement Industry.
- D5.6: Implementation and validation of RESTORE Use-Case III: Integration of different heat sources in DH of Paper Mills Industry.
- D5.7: Implementation and validation of RESTORE Use-Case IV: Integration of different heat sources in DH of Steel-working industry.
- D5.8: Implementation and validation of RESTORE Use-Case V: District heating with Geothermal Technology.
- D5.9: Implementation and validation of RESTORE Use-Case VI: Small-scale DHC network of Politecnico di Milano campus.

The main purpose of this report (in version 1.0) is to describe the preliminary specifications for the six Use-Cases modelling, within the RESTORE virtual tool powered by the IPSE GO simulation web-platform.

The information provided in this document builds upon collaboration between SIMTECH and all RESTORE development partners, in the sense that it considers inputs not only from other tasks of WP5, but also from work packages WP1, WP2, WP3 and WP4.

As an open science publication from RESTORE project, this report is available in the project's Zenodo Community account (https://zenodo.org/communities/101036766/records).

Table of Contents

1. Introduction

This document summarizes the development status of WP5 task T5.4 on “Implementation, optimization, management & validation of RESTORE Use-Cases using the Simulation Web Platform”, led by SIMTECH with close cooperation with the Use-Cases Providers. Results of task T5.4 are to be reported in month M46 via the Deliverables D5.4, D5.5, D5.6, D5.7, D5.8 and D5.9, respectively related to the Use-Cases:

- Use-Case I: Residential / Industrial DH with Biomass and Solar Collectors.
- Use-Case II: Integration of different heat sources in DH of Cement Industry.
- Use-Case III: Integration of different heat sources in DH of Paper Mills Industry.
- Use-Case IV: Integration of different heat sources in DH of Steel-working industry.
- Use-Case V: District heating with Geothermal Technology.
- Use-Case VI: Small-scale DHC network of Politecnico di Milano campus.

The purpose of this report (in version 1.0) is to describe the preliminary specifications for the six Use-Cases modelling, within the WP5-T5.4, using the RESTORE virtual tool powered by the IPSE GO simulation web-platform. The information provided in this document builds upon collaboration between SIMTECH and all RESTORE development partners, in the sense that it considers inputs not only from other tasks of WP5, but also from work packages WP1, WP2, WP3 and WP4.

2. Task T5.4

WP5 task T5.4's main objective is to implement each of the defined RESTORE Use-Cases using the Simulation Web Platform, for their further optimization, management, as well as validation within the RESTORE Virtual Tool, using the overall process model of the project technology implemented using the IPSEpro simulation environment. Task T5.4 is composed of 6 sub-tasks (ST5.4.1-ST5.4.6) covering the specific virtual representations of the 6 Use-Cases I, II, III, IV, V and VI.

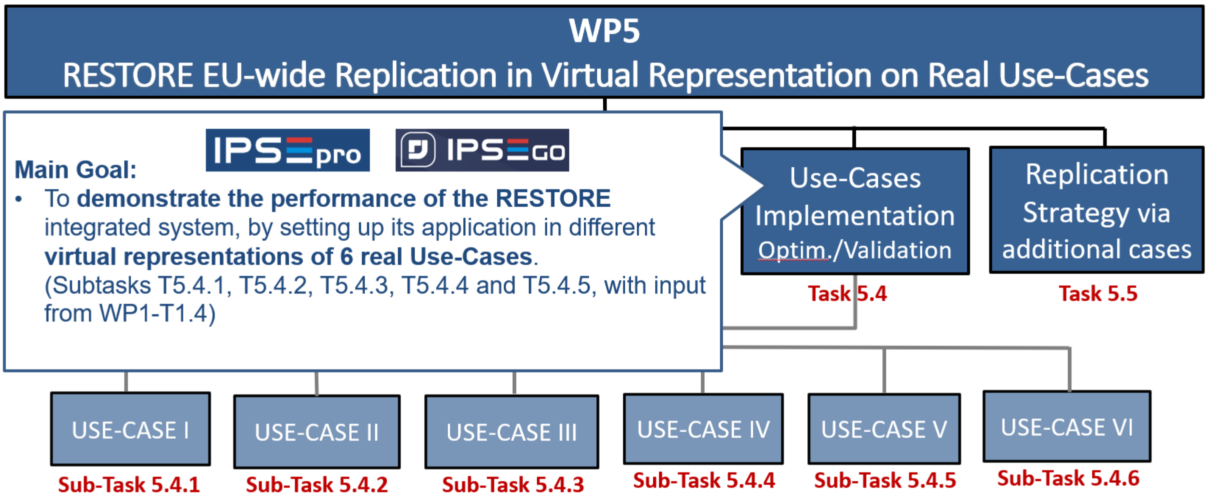


Figure 1: WP5 Task T5.4 Structure.

As stated in [1], in task T5.4 the simulated RESTORE Use-Cases, defined by the providers; AAL, CEN, AND, TUR and POL, are configured and made available as interactive models in the IPSE GO Web-based Simulation Platform, which once customized for the project's needs, caters for the virtual implementation, simulation and optimization of all Use-Cases. The experience from partner UBB will be used to implement also a quantification of the environmental impact. It will be made available to a wider audience of end-users and stakeholders related to the virtual Use-Case provided. Using the platform, end-users will be able to adapt Use-Cases according to their requirements via their web browsers, as well as to create and contribute with new Use-Cases, multiplying the impact of the project's concept validation. Thus, within the work delivered in task T5.4, SIMTECH will ensure that the Use-Cases are available as interactive models in the RESTORE Virtual Tool, powered by IPSE GO web-based simulation platform. T5.4 will also deliver an estimate (with the support of the cooperation with UBB) a quantification of the environmental impact of the virtual Use-Cases.

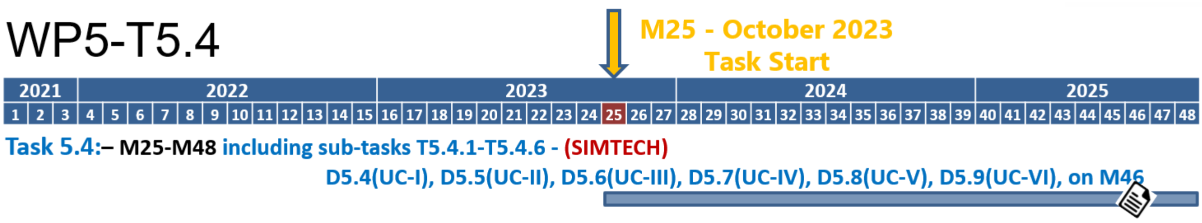


Figure 2; Task T5.4 Timeline.

Task T5.4 started in month M25 (October 2023) and is supposed to deliver its final results in M46. Pro-action for Task T5.4: Since the 1st RESTORE GA Meeting in Nov.2022 in Spain on month M14, SIMTECH has already requested the involved project partners to provide a general configuration information of the installations of the Use-Cases (in their current status), to contribute for structuring the work on task T5.4. The planned work phases followed within task T5.4 are listed below.

WP5 – Task T5.4 Work Phases:

- **Phase 1 - M25** – Organization of the work within T5.4. Production of task summary for the acquisition of relevant data for implementing the Use-Cases (SIMTECH)
- **Phase 2 - M26-M28** – Interactions with the Use-Case Providers and their representatives in RESTORE, to define the modelling of the Use-Cases with real data from their installations, using the specifications of Deliverable D1.4 [3], via group and individual collaboration meetings. (SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 3 - M29-M31** – Creation of customized models for the implementation of the Use-Cases, using the IPSEpro-MDK Model development Kit. Preliminary modelling of the Use-Cases implemented together with the Use-Cases Providers within the RESTORE Virtual Tool, powered by IPSE GO. (SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 4 - M32-M39** – Further development of the Use-Cases, implemented and shared with all Use-Cases Providers and project partners via the RESTORE Virtual Tool, powered by IPSE GO. (SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 5 - M30-M46** – Continuous interactions with selected stakeholders, via organized events together with partners from WP6 and WP7, to perform the steps of the "Replication Strategy via Stakeholders Test-Cases" planned in WP5 task T5.5 (see D5.10 [8]), using the current results of the modelled Use-Cases.
- **Phase 6 - M35-M43** – Interaction with partner UBB to implement the quantification of the estimated environmental impact of the RESTORE Use-Cases. (UBB, SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 7 - M40-M46** – Further development of the Use-Cases, implemented and shared with all Use-Cases Providers and project partners via the RESTORE Virtual Tool, powered by IPSE GO. (SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 8 - M46** – Submission of the Deliverables D5.4, D5.5, D5.6, D5.7, D5.8 and D5.9, with the respective implementation results of RESTORE the Use-Cases I, II, III, IV, V and VI. (SIMTECH, AAL, TUW, CEN, AND, TUR and POL).
- **Phase 9 - M46-M48** – Main focus: (1) Collection of feedback from the Use-Case Providers (potential early adopters of the RESTORE technology) about the virtually implemented Use-Cases using the RESTORE Virtual Tool. (2) Interaction with partners from WP6 and WP7 for tasks related to the dissemination and exploitation of the project using the results of the modelled Use-Cases.

Within the periods stated above, several meetings were organized among partners involved in the Use-Cases. The meetings were mostly done individually per Use-Case. The collaboration meetings foreseen in Phase 6 happened involving all Use-Cases providers in the same group.

The results from task T5.4 are fundamental for the successful implementation of WP5 task T5.5, concerning the "Replication Strategy via Stakeholders Additional Test-Cases" [8].

3. The Simulation Tools in RESTORE

The overall goal of the simulation within RESTORE includes the precise behavioural and numerical representation of the involved components and process models, at a high accuracy level in relation to the real data provided / acquired, so that their evaluation and implementation within real-data virtual use-case scenarios can be validated.

The RESTORE concept will be validated both in lab-scale, and also via virtually represented applications with district heating and cooling networks. At a first stage, the consistency of the specific component models is checked and validated with the partners' experience largely obtained from the experimental activities within the project. Then, those component models are used for building the virtual demonstrations. Those virtual demonstrations represent showcases of real use-cases allowing the simulation of the project concept in scaled-up scenarios. For this to happen, the overall RESTORE system will be virtually implemented and optimized using SIMTECH's simulation tools (IPSEpro and IPSE GO), and incorporated in the six specific Use-Cases defined for the project. Refer to D1.4 [3] for a detailed description of the simulation tools (IPSEpro, IPSEpro-MDK, IPSEpro-PSE, and IPSE GO) used in RESTORE, as well as for the explanation of how the six Use-Cases representations will be made publicly available online.

For the sake of powering the RESTORE Virtual Tool, the cloud-based simulation platform IPSE GO (https://about.ipsego.app/) uses the capabilities of the process simulation system IPSEpro via the web, and was designed to run in all internet browsers, from any device you may wish to work with (computers, mobile devices, etc.). In addition, it is based on an intuitive user interface that can handle the complexity of the industrial level within a user-friendly way. A strong advantage of using IPSE GO is the "effortless collaboration" aspect that it offers to all its users.

3.1. The RESTORE-Virtual Tool

The RESTORE Virtual Tool, powered by IPSE GO, enables the showcase of RESTORE's overall process model solution, the performance evaluation of the Use-Cases interactively; making the results available to a wider audience of end-users, stakeholders related to the defined virtual Use-Cases segments. The RESTORE simulated process models will be made available online, via their internet browsers, without the need for any software installation.

The RESTORE Virtual Tool allows end-users to adjust the Use-Cases according to their requirements, using the platform via web browsers. Additionally, using IPSE GO, the platform users will be able to investigate new testing cases, multiplying the impact of the project's concept validation.

In *Annex I. RESTORE Virtual Tool powered by IPSE GO,* and in *Annex II. RESTORE Virtual Tool – Projects* Page, you find larger graphic detail of both Figure 3 and Figure 4.

Figure 3: RESTORE Virtual Tool powered by IPSE GO.

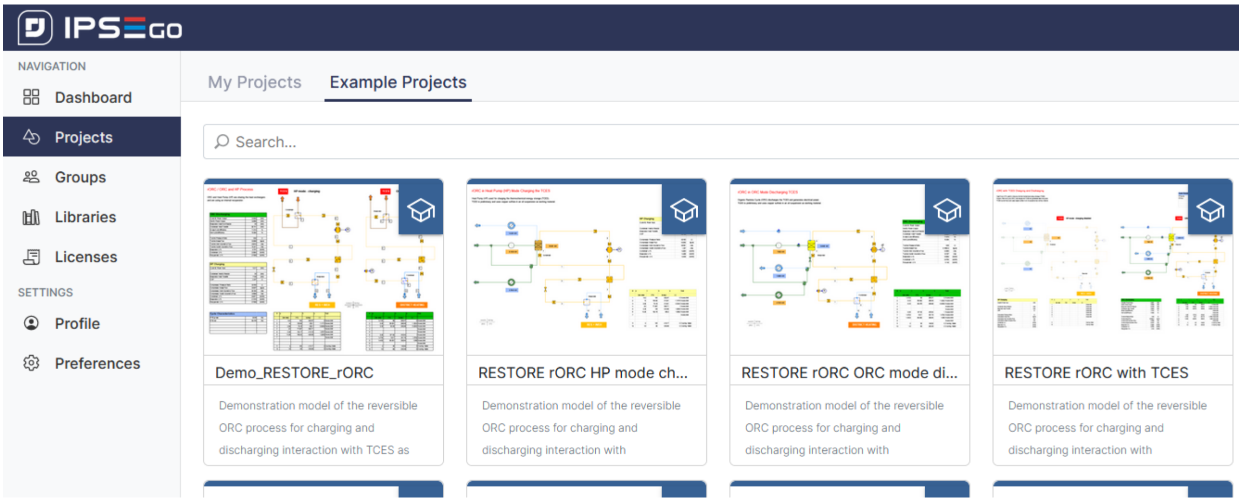


Figure 4: RESTORE Virtual Tool showing some RESTORE process models.

The implementation of the RESTORE process models using the simulation tool IPSE GO follow the specifications and requirements of relevant aspects like feasible computational effort, object-oriented philosophy, compatibility between models, and adaptability to the web-platform, modularity and flexibility, which align with the defintions in WP1-T1.4. Hence, the RESTORE Virtual Tool presents the following characteristics: Usability; System Robustness; as well as Sharing, Portability, Compatibility, and Security related to collaborating Project-Files.

3.1.1. RESTORE Preliminary Simulated Models

The current process models available in the RESTORE Virtual Tool include the Thermo-chemical Storage (TCES) Charging Model, and the TCES Discharging Model. In Annex III and in Annex IV you find illustrations of of both RESTORE TCES charging and discharging process models. See D1.4 [3] for more details.

The process models are designed with component models from the project library RESTORE_Lib. RESTORE component models were implemented and fine-tuned within WP5-T5.1 and WP5-T5.3 with input from WP1, WP2 and WP3. Extensions and updates of both RESTORE_Lib and process models continuously followed throughout the project. Annex 4 shows the RESTORE_Lib **Available Units,** currently with 86 units contained in the library.

3.1.2. Workflow of RESTORE Model Development and Availability of Process Simulations

With the RESTORE Virtual Tool being available online for stakeholders, the use cases can be used as templates to simulate modified cases interactively by anyone interested in the technology. Additionally, stakeholders will be able to create their own testing cases, such that the number of different application examples will grow continuously. For displaying simulation results and dissemination of selected use cases, projects can be embedded in websites. The workflow how RESTORE Models are developed and made available for different stakeholders is shown in Figure 5.

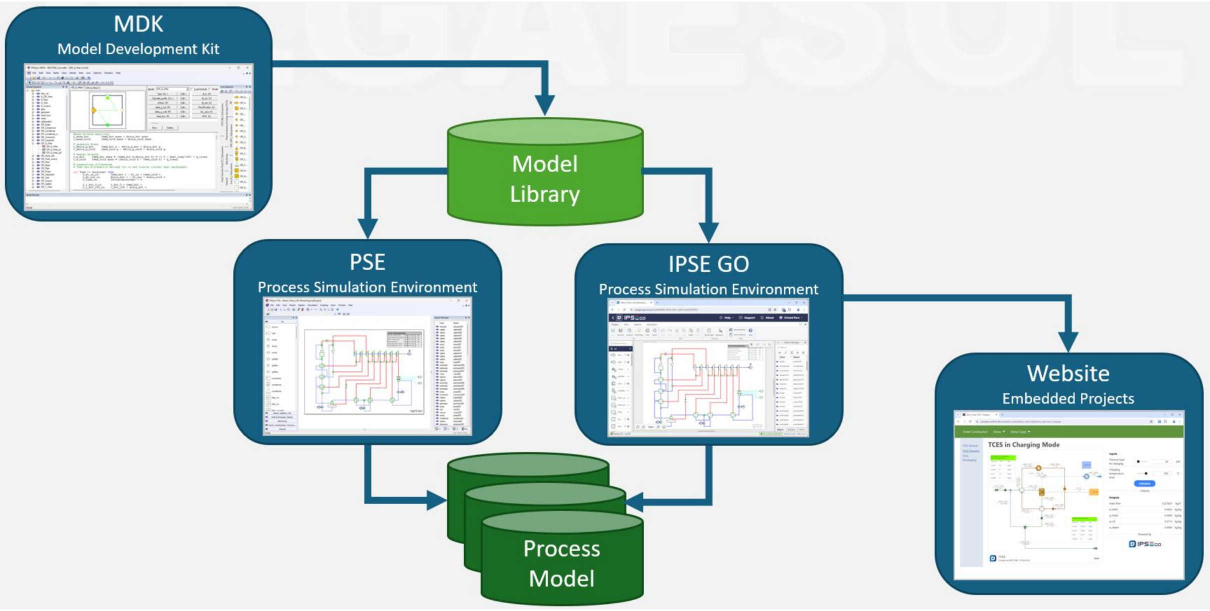


Figure 5: Workflow of model development and process simulation.

3.2. The Use-Cases simulated in RESTORE Virtual Tool

The RESTORE Virtual Tool will host and showcase the RESTORE virtual Use-Cases. The overall RESTORE concept will be virtually implemented and optimized for six DHC Use-Cases with real data from the Use-Case providers.

The six Virtual Use-Cases will analyze potential configurations for integrating the RESTORE technology and RES, potentially available on site, into different plants connected with DHC networks. They integrate with real DHC networks spread over different locations in Europe, including large and small district heating networks, as illustrated in Figure 6.

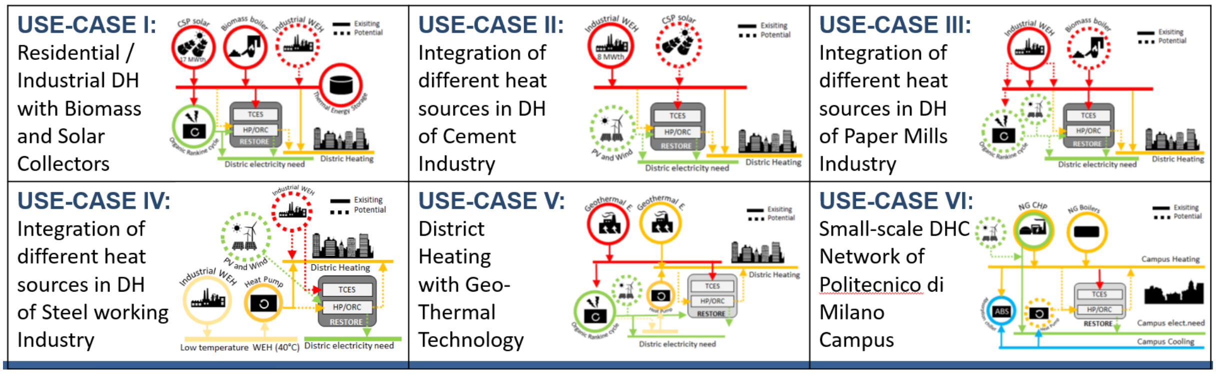


Figure 6: RESTORE Use-Cases.

- ***Use-Case I*** *deals with a residential and industrial DH with biomass and solar collectors in Denmark.*
- ***Use-Case II*** *deals with the integration of different heat sources in DH of a cement factory in Austria.*
- ***Use-Case III*** *integrates RESTORE with different heat sources in DH of a paper mill in Slovakia.*
- ***Use-Case IV*** *deals with the integration of different heat sources in DH of a steel industry in Italy.*
- ***Use-Case V*** *concerns the district heating with geothermal technology in a plant in Germany.*
- ***Use-Case VI*** *deals with the small-scale DHC network of POLIMI University Campus in Italy. See Annexes VI to XI for a more detailed description of the RESTORE Use-cases.*

3.2.1. Specification of the high-level modelling data to implementing the Use-Cases

The specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases was defined in D1.4 [3], considering the boundary conditions imposed by each specific use-case application. In this context, D1.4 provides a general basis to be considered as a guide during the project process modelling and Use-Cases implementation.

In general terms, the use cases' models calculation will require the following inputs to be implemented using IPSE GO: User Input: (a) For the Charging Mode coming from Waste Heat: Maximum of Q_Waste / Maximum of E_Waste; Number of Hours; Number of Months; Temperature of Waste Heat. User Input: (b) For the Discharging Mode going to District Heating (DH): Supply Temperature to DH; Return Temperature from DH, Max. And Min. of Q_DH in operation. Internal Input and main outputs can be observed in Figure 7, about the Use-Cases Models' Basic Information [3].

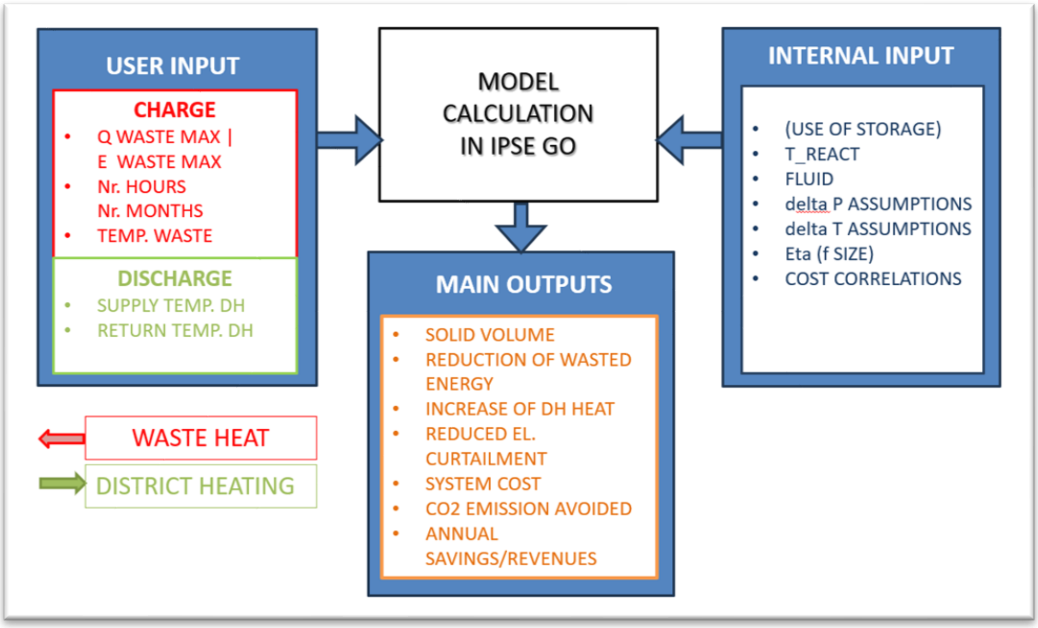


Figure 7: Use-Cases Models' Basic Information (from RESTORE WP1-T1.4-D1.4).

4. RESTORE Use-Case I

USE-CASE I: Residential / Industrial DHC with Biomass and Solar Collectors and industrial WEH - Location: BRONDERSLEV PLANT (CSP INTEGRATED WITH BIOMASS-ORC) – Denmark.

● **Use-Case provider:** Aalborg CSP, based on detailed engineering data and integration experience. ● **Use-Case Area of Application:** District heating for the city of Bronderslev, Biomass and Solar collectors as renewable technologies to provide heat to the District. ● **Expected goals to be achieved:** Maximization of renewable energy integration in the district, and optimum waste heat utilization from local industry for highly efficient seasonal storage of electricity.

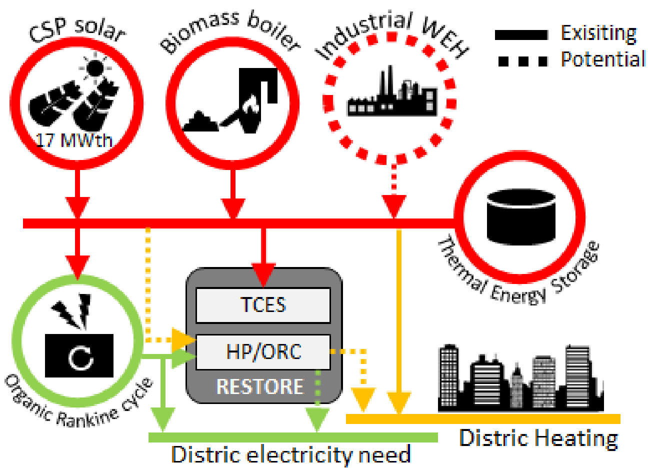


Figure 8: RESTORE proposed solution in Use-Case I.

4.1. Use-Case I Description

Brønderslev Forsyning A/S has implemented a District Heating concept: power and district heating supply are generated in its own combined heat and power unit which is one of the most efficient plants worldwide due to the combination of solar, biomass and HPs. After a comprehensive feasibility study and 0.8MWth test facility campaign Brønderslev Forsyning A/S started the contraction of a CSP plant to supply 16.6 MWth which has been in operation since March 2018. The solar energy plant is based on the parabolic trough technology consisting of 40 rows of 125m U-shaped mirrors with an aperture area of 27,000 m² and glass vacuum tube receiver. Thermal oil is used as heat transfer fluid with a maximum temperature of 330°C. The system was designed and constructed by project partner AAL. Collected energy can be stored in a thermal energy storage unit based on pressurized water tanks that are connected to an existing biomass-fired ORC power plant or directly provide heat to the local district heating system adapting its operation temperature according to the specific needs of the district's energy system. Similarly, the biomass boiler provides heat to the ORC or the district. The ORC (40 CHPRS SPLIT) is manufactured by project partner TURBODEN and has a power output of about 3.8 MWe and was originally fed by thermal oil coming both from the 2 biomass boilers. Overall system represents an advanced DH solution based on non-conventional hybrid solar-biomass ORC plant able to provide sustainable heat and electricity. District heating return and supply water temperature are 50°C and 72ºC.

4.2. Use-Case I - RESTORE proposed solution

The virtual pilot will be based on the energy system described above, integrating a specifically optimized RESTORE energy storage unit. The existing parabolic trough solar collector field can then charge the TCES system during summer months, thereby solar heat is stored for heating in winter. Additionally, residual heat from industry or excess low-temperature heat from solar collectors in the district is used to efficiently store off-peak cheap electricity.

4.3. High-level modelling data for Use-Case I

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case I, specific information from the template (shown in Figure 9) is requested from the Use-Case Provider.

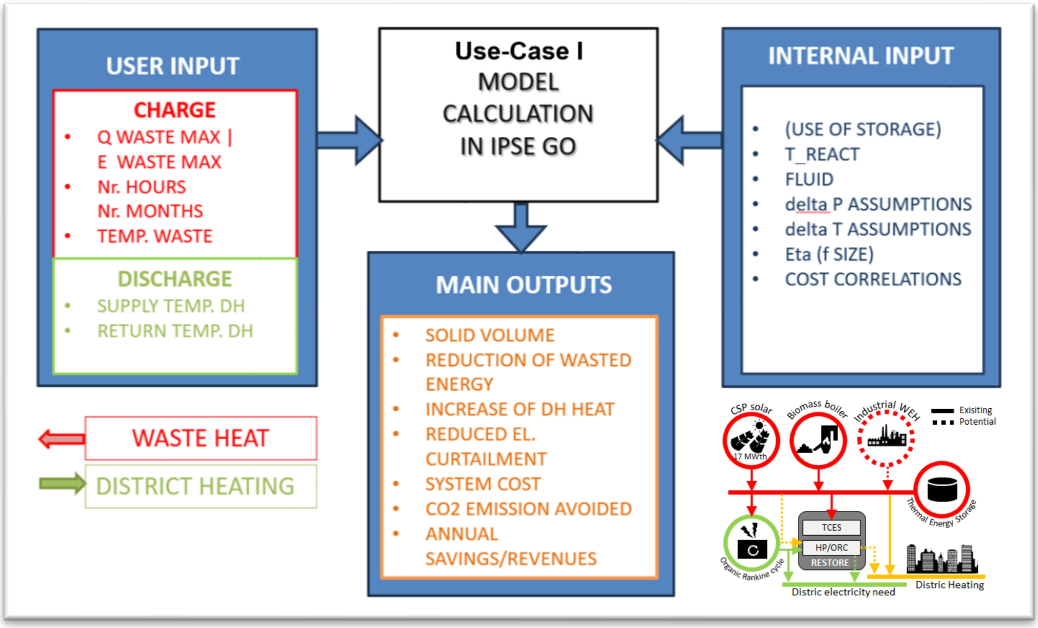


Figure 9: Use-Case I Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.1, in Deliverable D5.4 (Implementation and validation of RESTORE Use-Case I: Residential / Industrial DH with Biomass and Solar Collectors), and made openly available in the RESTORE project's Zenodo Community account.

5. RESTORE Use-Case II

USE-CASE II: Integration of different Cement Industry heat sources in DHC - Location: GMUNDEN CEMENT FACTORY - Gmunden, Austria.

● **Use-Case provider:** CENER & TU-WIEN based on detailed engineering data and integration experience from the owner Rohrdorfer of the Gmunden cement plant. ● **Use-Case Area of Application:** Analysis of potential configurations of integrating the RESTORE technology into the Cement production plant and its relation to the neighbouring heat consumers. ● **Expected goals to be achieved:** Maximization of renewable energy integration and optimum WEH utilization from the factory for highly efficient seasonal storage of electricity using RESTORE.

5.1. Use-Case II Description

The Gmunden site cement plant of Rohrdorfer group has currently the capacity of ~1.900 ton/day of cement clinker, with a district heating connection (capacity of ~8 MWth). The clinker process offers multiple options of heat integration with district heating and cooling, either via the WEH coming from air cooled clinker coolers, or from the off gas from cyclone tower. In the case of a waste heat steam cycle plant such as in the Rohrdorf site, also, or from extraction steam from a steam turbine can be used which itself is fed by steam from the waste heat recovery steam generator. The installation of a waste heat steam generator is under consideration in the frame of a national research project. The state-of-the-art cement factory in Gmunden produces huge amounts of WEH that cannot be used by the cement production process itself. Its recent connection to a local district heating network allowed 8 MW thermal power to be provided covering the heat demand for roughly 1,000 homes. Additional excess heat is available, especially during summer months when no space heating is required.

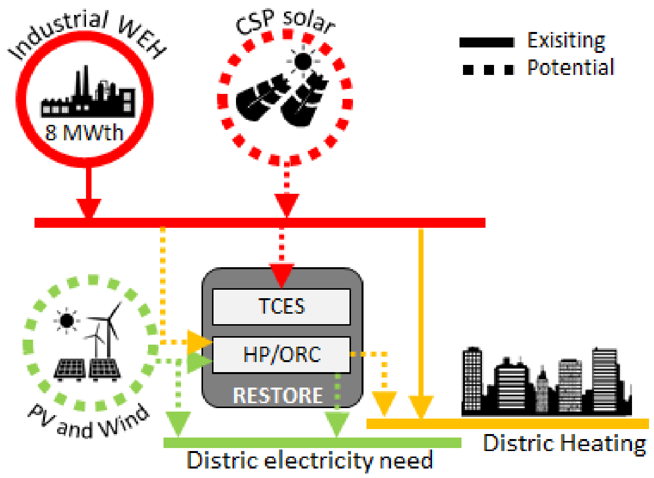


Figure 10: RESTORE proposed solution in Use-Case II.

5.2. Use-Case II - RESTORE proposed solution

Within the RESTORE project, the virtual pilot will simulate the integration of the developed concept within the industrial plant in order to maximize WEH utilization and RES integration for seasonal storage of heat using cheap off-peak electricity. RESTORE concept allows to transfer excess heat from the summer to the winter, when cement plants are typically shutting down for at least 6 weeks thus continuously providing DH with carbon free heat. In this virtual pilot, the integration of additional RES will be studied. The RESTORE project counts with the support of the owner of the plant (member of the RESTORE project External Stakeholders and Advisory Board ESAB), being actively involved in configuring the virtual pilot and in supplying the needed technical data as well as important considerations for the system as final user of the RESTORE system.

5.3. High-level modelling data for Use-Case II

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case II, specific information from the template (shown in Figure 11) is requested from the Use-Case Provider.

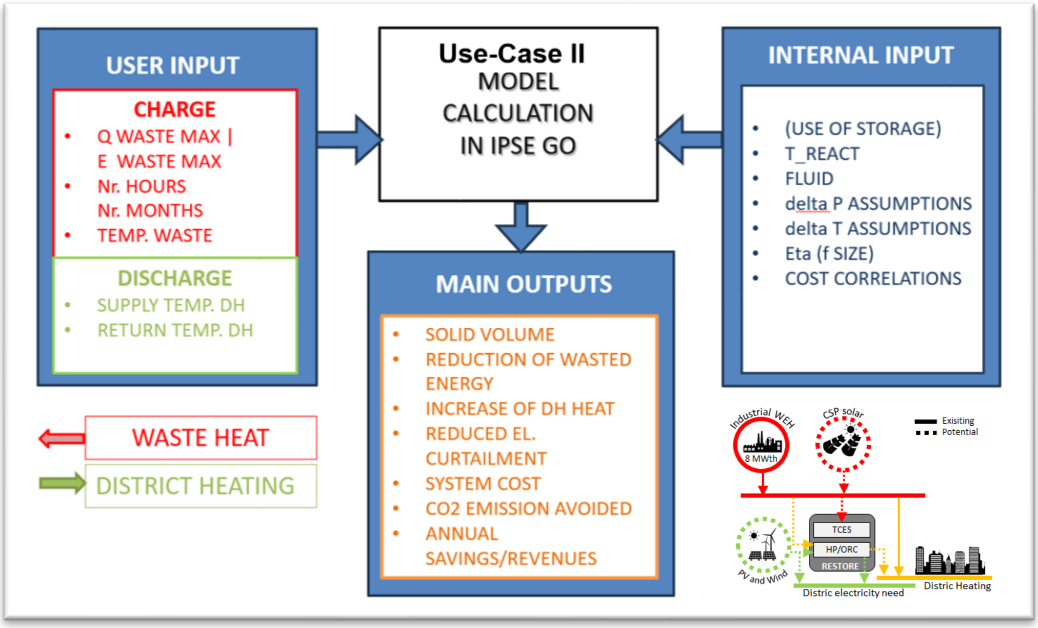


Figure 11: Use-Case II Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.2, in Deliverable D5.5 (Implementation and validation of RESTORE Use-Case II: Integration of different heat sources in DH of Cement Industry), and made openly available in the RESTORE project's Zenodo Community account.

6. RESTORE Use-Case III

USE-CASE III: Integration of different heat sources in DHC of Paper Mills Industry - Location: MONDI SCP PLANT - Ružomberok, Slovakia

● **Use-Case provider:** ANDRITZ (AND), based on detailed engineering data and integration experience from its customer MONDI SCP in Slovakia. ● **Use-Case Area of Application:** Analysis of potential configurations for integrating the RESTORE technology into plants of the Pulp and Paper Industry connected to DH and RES. ● **Expected goals to be achieved:** Maximize the renewable energy integration and optimize WEH utilization from the factory for highly efficient seasonal heat storage.

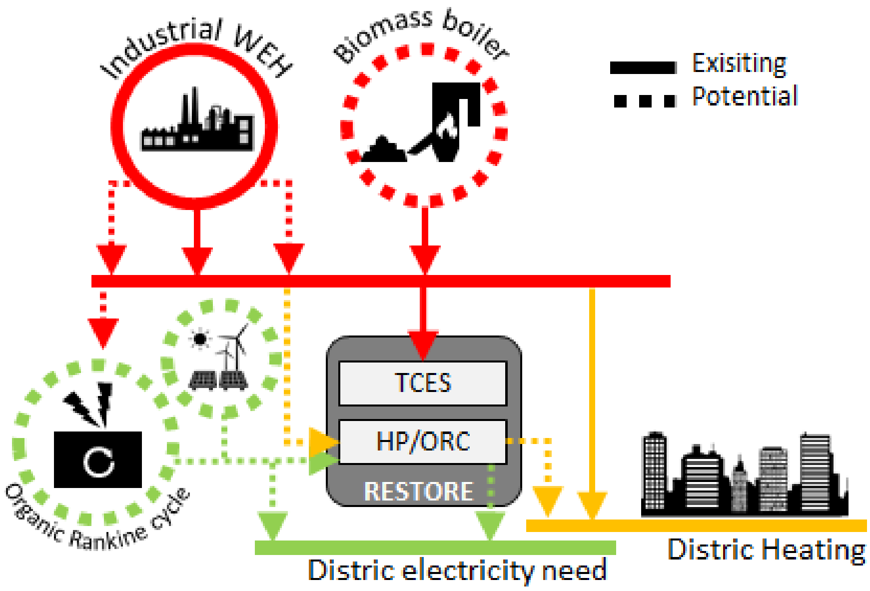


Figure 12: RESTORE proposed solution in Use-Case III.

6.1. Use-Case III Description

Mondi SCP in Ružomberok is one of Mondi's largest plants and is the biggest integrated mill producing paper and pulp in the Slovak Republic, with a production capacity of 560,000 tonnes of uncoated fine paper, 66,000 tonnes of packaging paper and 100,000 tonnes of market pulp. After its latest investment into a new recovery boiler, the mill is 100% energy self-sufficient with over 94% of its energy coming from renewable resources. The wood comes from certified, well-managed forests. The production continuously decreases footprint on the environment. Part of the heat produced by the Mondi mill is used for the district heating system in the form of 5 bar steam. Steam enters a heat exchanger station, where heat exchangers transfer heat into water. Hot water is pumped via a distribution network into the city, local heat exchangers and flowing back to the steam/ water heat exchanger station to gain heat again.

6.2. Use-Case III - RESTORE proposed solution

The utilization of the following energy sources will be explored and integrated in RESTORE concept and use to store heat on seasonal base: (i) utilisation of waste steam in case of reduced heat demand in district heating (e.g.: summer time), (ii) flue gas recovery from boilers at LT which is not used so far, (iii) hot water streams available at site which may be used for water preheating or HP energy input. Moreover, synergies with thermal and electrical based energy sources will be investigated considering also adding new RES sources in order to limit additional fossil fuel consumption. The expected outcome is a huge reduction of the GHG through a high increment in the RES share and the waste heat capacity factor.

6.3. High-level modelling data for Use-Case III

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case III, specific information from the template (shown in Figure 13) is requested from the Use-Case Provider.

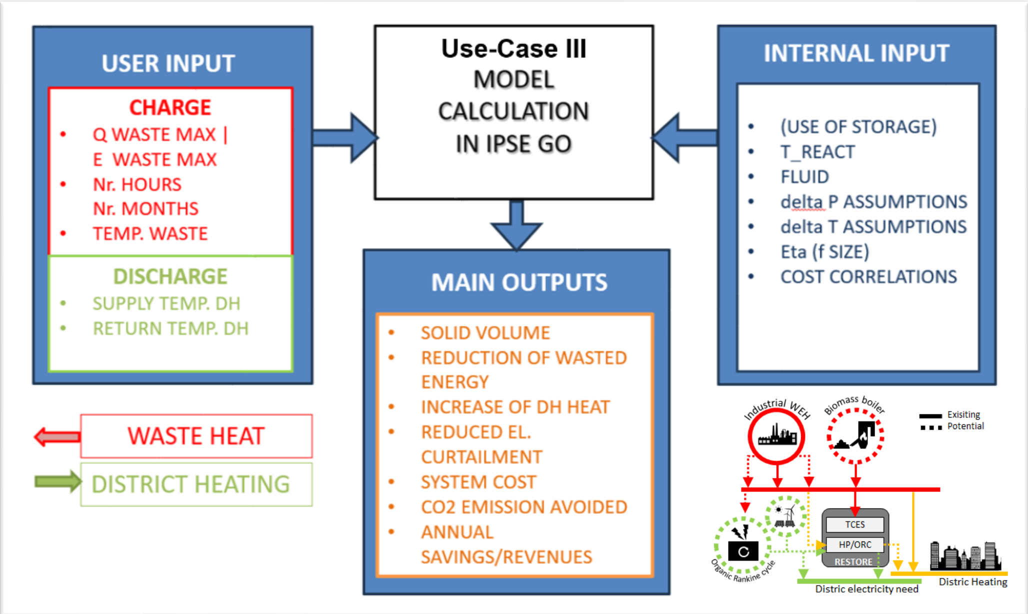


Figure 13: Use-Case III Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.3, in Deliverable D5.6 (Implementation and validation of RESTORE Use-Case III: Integration of different heat sources in DH of Paper Mills Industry), and made openly available in the RESTORE project's Zenodo Community account.

7. RESTORE Use-Case IV

USE-CASE IV: Integration of different heat sources in DHC of Steel-working industry - Location: BRESCIA – Italy.

● **Use-Case provider:** TURBODEN based on detailed engineering data and integration experience from the potential final user and Use-Case provider Alfa Acciai, from Brescia. ● **Use-Case Area of Application:** The use case will apply the RESTORE concept to a DHC network linked to one of the largest Electric Arc Furnace steel mills in Italy. ● **Expected goals to be achieved:** Achieve higher efficiency of Alfa Acciai production process, improve HP utilization during summer season and increase share on local DH.

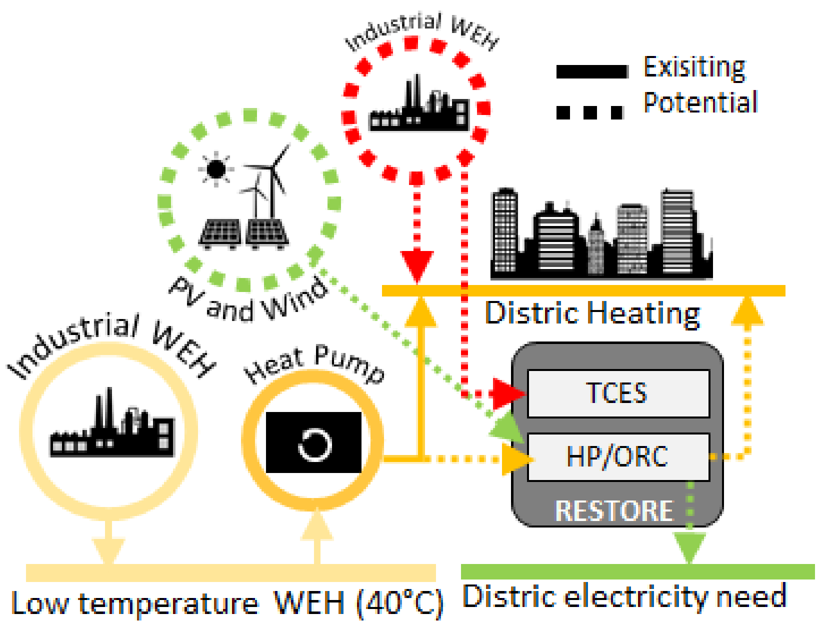


Figure 14: RESTORE proposed solution in Use-Case IV.

7.1. Use-Case IV Description

Alfa Acciai is one of the largest Electric Arc Furnace Steel Mill in Italy. It started producing steel in Brescia in the mid-1950s. The Alfa Acciai Group has been increasingly oriented towards customer service, by focusing on the production of steel for the reinforcement of concrete, while respecting the environment and the worker health and safety in the workplace. Alfa Acciai site in Brescia is composed by 2 Electric Arc Furnace units and 3 rolling mills. Current strategy for waste heat recovery system based on a large HP able to recover WEH from the cooling system of the “pipe to pipe” circuit of the furnaces. The temperature of available heat is in the range of 30°-40°C and can be upgraded up to 90°C through the HP and used for district heating instead of being wasted. The recovered upgraded thermal energy will be used and integrated in the local district heating of municipality of Brescia and distributed to the final users in order to satisfy the heat demand in a smart and green way.

7.2. Use-Case IV - RESTORE proposed solution

RESTORE technology can dramatically increase the utilization of existing equipment and WEH utilization during summer months when heat is not required by DH and so the HPs are not working. With RESTORE heat released by EAF is upgraded to High Temperature all year long: during winter heat is directly used by DH while during summer heat is exploited by RESTORE HP and allows storing energy for the winter season. Integrated solution with renewable energies and synergies with other industry subsystems will be investigated. The expected impact is a strong increase of HP capacity factor and a final energy provided to the DH network nearly double of the current state of the art.

7.3. High-level modelling data for Use-Case IV

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case IV, specific information from the template (shown in Figure 15) is requested from the Use-Case Provider.

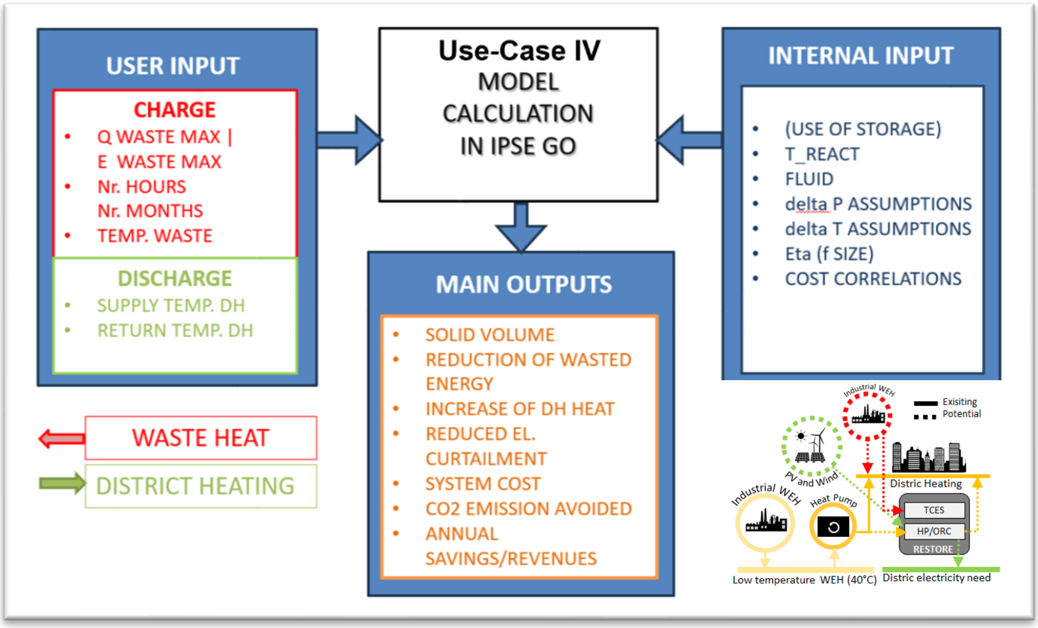


Figure 15: Use-Case IV Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.4, in Deliverable D5.7 (Implementation and validation of RESTORE Use-Case IV: Integration of different heat sources in DH of Steel working industry), and made openly available in the RESTORE project's Zenodo Community account.

8. RESTORE Use-Case V

USE-CASE V: District heating with Geothermal Technology - Location: Geothermie Holzkirchen Plant, Holzkirchen- Germany.

● **Use-Case provider:** TURBODEN based on detailed engineering data and integration experience from its Use-Case provider Geothermie Holzkirchen GmbH from Holzkirchen in Germany. ● **Use-Case Area of Application:** The use case will apply the RESTORE concept to a DHC network (local utility of Holzkirchen) with Geothermal Technology. ● **Expected goals to be achieved:** Maximization of the geothermal heat exploitation and optimum WEH utilization for highly efficient seasonal storage of heat.

8.1. Use-Case V Description

Geothermie Holzkirchen GmbH is a wholly owned subsidiary of the local utility of Holzkirchen, a town located in the south of Munich, Germany. The existing conditions for developing geothermal energy are particularly favourable in the southern German Molasse basin, as there is particularly hot water at the appropriate depth (500 meters). Heat can be used as direct supply to district heating and, from a temperature of around 120 degrees Celsius, electricity production is possible. It is estimated that in the long term up to 80 percent of Holzkirchen's district heating network demand can be covered with geothermal energy equivalent to around 10,000 tons of climate-damaging carbon dioxide avoided every year. An ORC from TUR is already installed on site to exploit geothermal hot water during the summer from a temperature of 140°C, producing a power output of 2.8 MWel and contributing to the amortization of the project due to the feed-in tariff. Moreover, in order to increase the geothermal heat exploitation TUR will study a large HP in order to achieve higher flexibility in terms of heat and power production as well as increased geothermal utilisation.

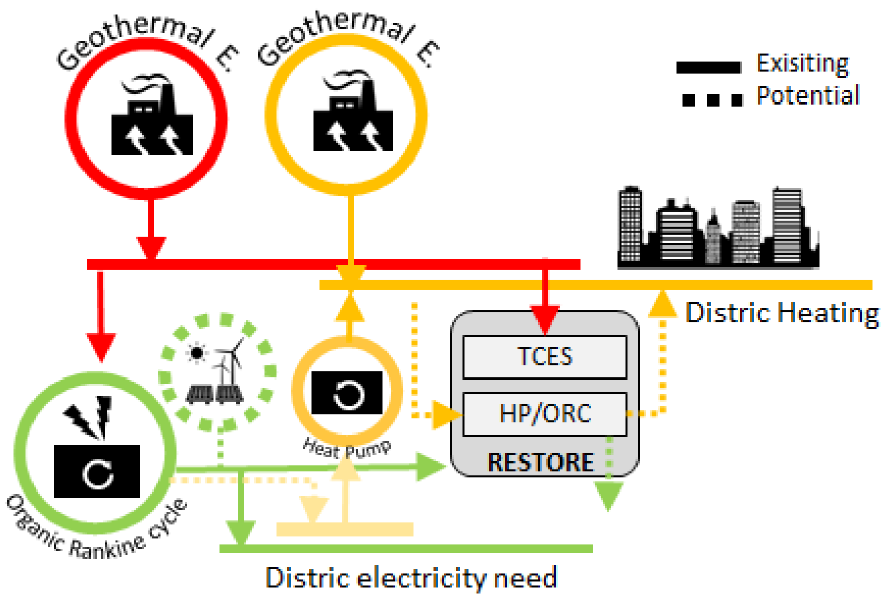


Figure 16: RESTORE proposed solution in Use-Case V.

8.2. Use-Case V - RESTORE proposed solution

RESTORE technology can be integrated with geothermal energy exploiting it during summer to store heat for the cold season. From this point of view RESTORE is a competitive solution against ORC and this Use-Case provides a unique possibility to evaluate and compare the economic feasibility of both solutions. The integration of additional RES technologies due to RESTORE technology will be investigated. Expected impact are a dramatic increase of energy to the DH and a marked reduction of GHG emission. Availability of HP during summer and other RES will be investigated.

8.3. High-level modelling data for Use-Case V

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case V, specific information from the template (shown in Figure 17) is requested from the Use-Case Provider.

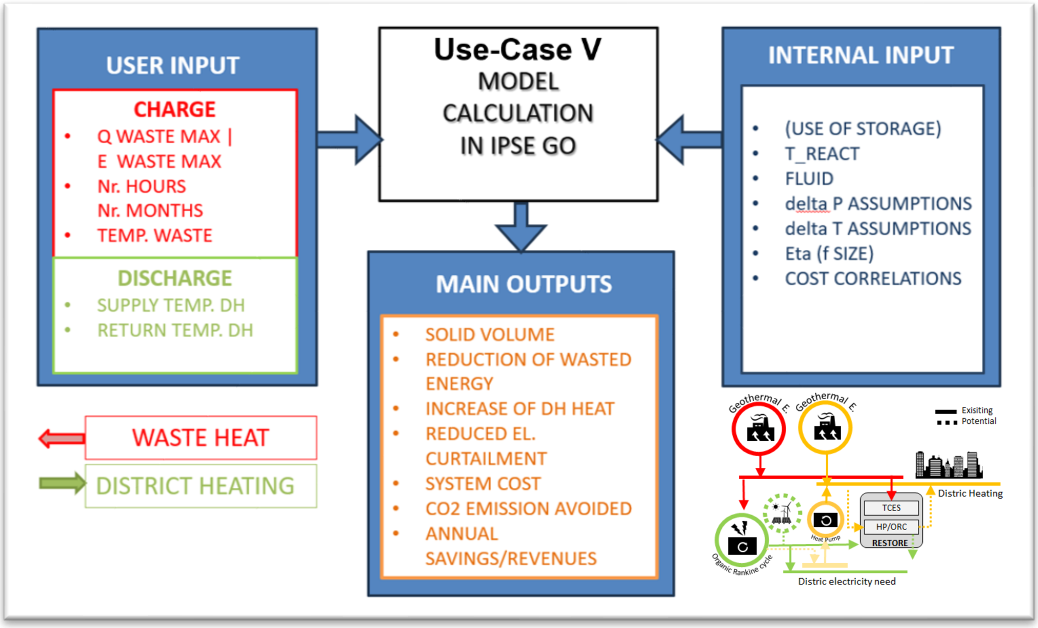


Figure 17: Use-Case V Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.5, in Deliverable D5.8 (Implementation and validation of RESTORE Use-Case V: District heating with Geothermal Technology), and made openly available in the RESTORE project's Zenodo Community account.

9. RESTORE Use-Case VI

USE-CASE VI: Small scale DHC network of Politecnico di Milano campus - Location: POLIMI CAMPUS, Milan - Italy.

● **Use-Case provider:** POLIMI, based on detailed engineering data and integration experience from its small DHC network. ● **Use-Case Area of Application:** This use case aims to exploit RESTORE in small-scale DHC networks. ● **Expected goals to be achieved:** Apply the RESTORE concept to a small DHC network available at Politecnico di Milano campus and representative of small size decentralized solutions.

9.1. Use-Case VI Description

Politecnico di Milano adopts a small DH network to provide electricity and heat to a relevant fraction of campus offices, classrooms and laboratories serving approximately 120.000 mq. Moreover, cooling is also provided to some buildings during the summer season. Maximum thermal power request is around 15 MWth and thermal plant of the DHC encompasses three natural gas boilers of 6 MWth each and one natural gas internal combustion engine in CHP configuration able to provide 2 MWel plus 1.8 MWth. Cooling power 1.25 MW is generated by one absorption chiller (LiBr) exploiting CHP unit waste heat. The CHP unit is operated in thermal load following and most of electrical energy (80%) is for internal consumption while the remaining (20%) is sold to the grid. Annual hours of operations of the CHP unit thanks to the integration with the cooling network is around 5000 h. In addition to the DHC network, the Energy Department of Politecnico di Milano located in Bovisa Campus can also provide accurate information on the availability of solar PV energy thanks to the availability of PV panels of different technologies for a total 75 kWel and a storage system constituted by 70kWh Lithium-ion Samsung battery. All the quantities related to DHC network, the thermal plant operation and the PV fields are continuously monitored and detailed dataset are available for the last years of operation.

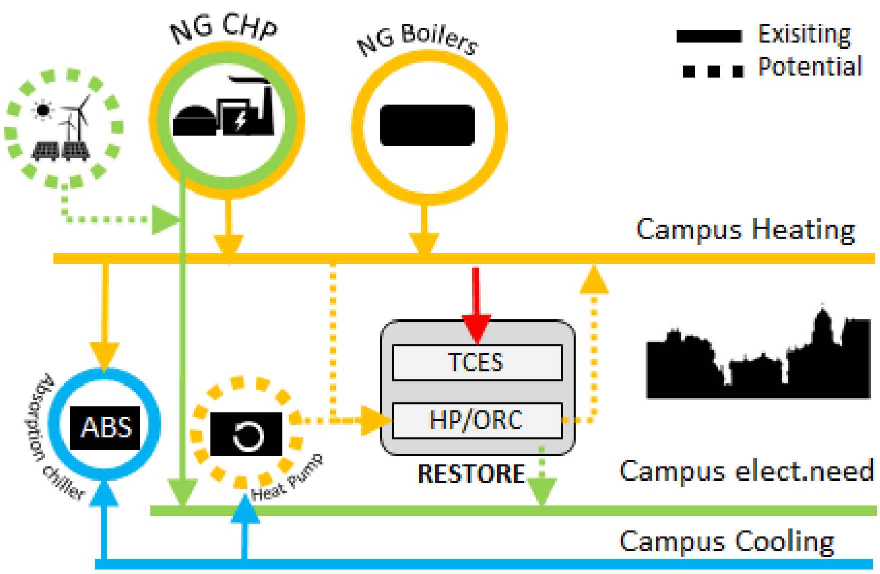


Figure 18: RESTORE proposed solution in Use-Case VI.

9.2. Use-Case VI - RESTORE proposed solution

The POLIMI Campus Use-Case aims to understand the role of RESTORE technology in small decentralized DHC networks and to understand the constraints in terms of space in urban contexts. First, an evaluation of fuel shifting from natural gas to biogas will be investigated, then the RESTORE concept is implemented understanding the synergies with district cooling operation and RES integration. Final results would assess the environmental and economic sustainability of seasonal thermal storage.

9.3. High-level modelling data for Use-Case VI

Based on the information identified in Figure 7, concerning the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases (defined in D1.4 [3]), WP5-Task T5.4 needs to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project. Hence, for the current Use-Case VI, specific information from the template (shown in Figure 19) is requested from the Use-Case Provider.

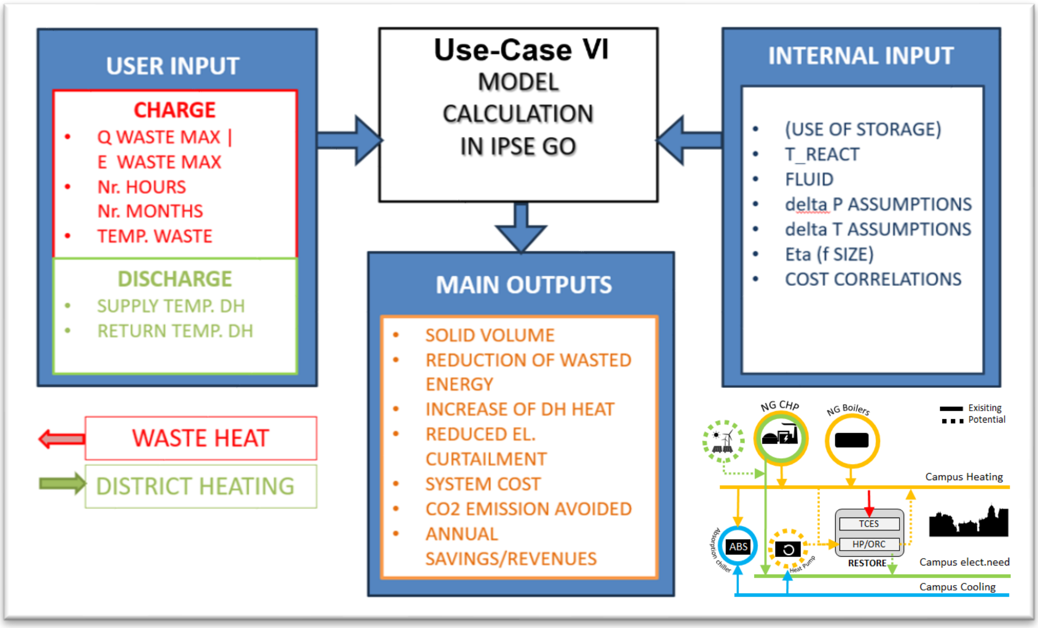


Figure 19: Use-Case VI Models' Basic Information Requirement.

Further details about the modelling and the results of virtually implementing this use-case will be published, as a result of sub-task T5.4.6, in Deliverable D5.9 (Implementation and validation of RESTORE Use-Case VI: Small-scale DHC network of Politecnico di Milano campus), and made openly available in the RESTORE project's Zenodo Community account.

10. Remarks & Further Work

This report was designed to guide the WP5-T5.4 involved partners in the development of their use-cases implementation tasks, up to RESTORE project month M46, serving also as input for the production of the deliverables D5.4, D5.5, D5.6, D5.7, D5.8, and D5.9.

The work of task T5.4 directly contributes to the practice of the Replication Strategy steps in task T5.5, which aims that selected stakeholders create their own testing cases within and beyond the project lifetime.

The RESTORE Virtual Tool (under https://ipsego.app/) will be available for both project partners and end-users (during the project lifetime and beyond) to assist all project phases (design, development, testing, replication cases, and exploitation), demonstrating the project's Use-Cases and interacting with the RESTORE stakeholder ecosystem for exploitation purposes. It will host the simulated use cases and will remain online after the project ends, to stimulate a new technological direction and the emergence of a European innovation ecosystem around the RESTORE paradigm.

As part of the outcomes of WP5 Task T5.5 [8], SIMTECH will also provide online, on a dedicated website for the use-cases results, compact description of the six RESTORE Use-Cases developed in the project, including their embedded models from the IPSE GO platform. This information will be accessible via the link: https://usecases.restore-dhc.eu/use-cases/.

11. References

[1] European Commission, Horizon 2020 Project RESTORE "Renewable Energy based seasonal Storage Technology in Order to Raise Environmental sustainability of DHC", https://cordis.europa.eu/project/id/101036766,Grant Agreement GA Nr.101036766, August 207th, 2021.

[2] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. Deliverable D1.1 - Report on Requirements and Specifications of the Overall Concept (V1), ed.: Francisco Cabello (CENER), March 31st, 2023.

[3] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. Deliverable D1.4 - Specifications of RESTORE Use-Cases and Models, ed.: F. Dargam (SIMTECH), E. Perz (SIMTECH), September 30th, 2023.

[4] SIMTECH GmbH, "The Process Simulation Environment IPSEpro", https://www.simtechnology.com/cms/ipsepro/process-simulation-and-heat-balance-software, © 2023 SimTech GmbH.

[5] SIMTECH GmbH, "IPSE GO: The Future of Simulation", https://about.ipsego.app/, © 2023 SimTech GmbH.

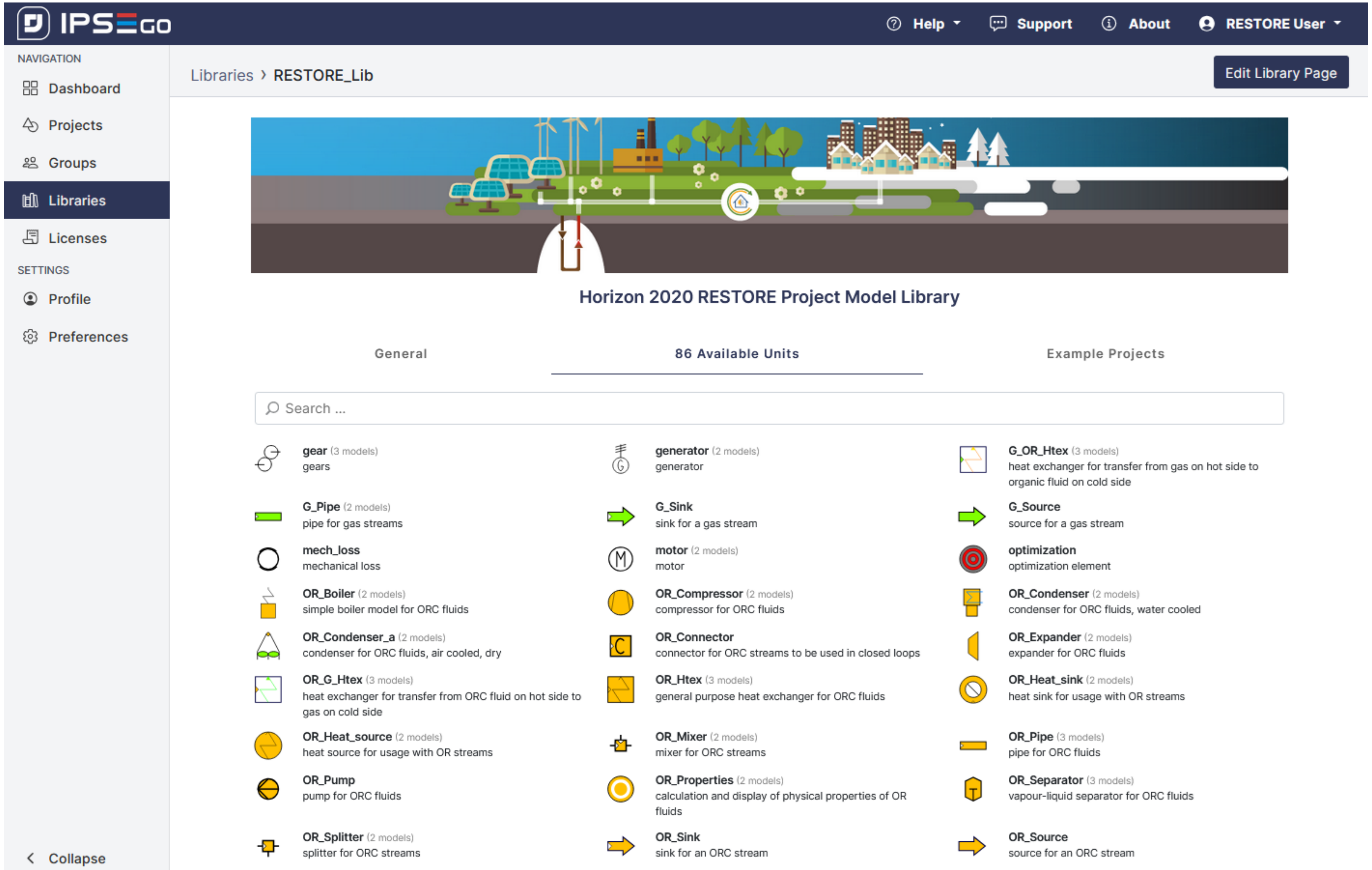
[6] SIMTECH GmbH, "IPSEpro & IPSE GO - Powerful Process and Heat Balance Simulation Solutions", https://www.linkedin.com/pulse/ipsepro-ipse-go-powerful-process-heat-balance-simulation/, © 2023 SimTech GmbH.

[7] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. RESTORE 1st Interim Report, ed.: Francisco Cabello (CENER) & All Partners, M18, March 30th, 2023.

[8] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. Deliverable D5.10 - RESTORE Replication Strategy (V1), ed.: F. Dargam (SIMTECH), E. Perz (SIMTECH), November 30th, 2023.

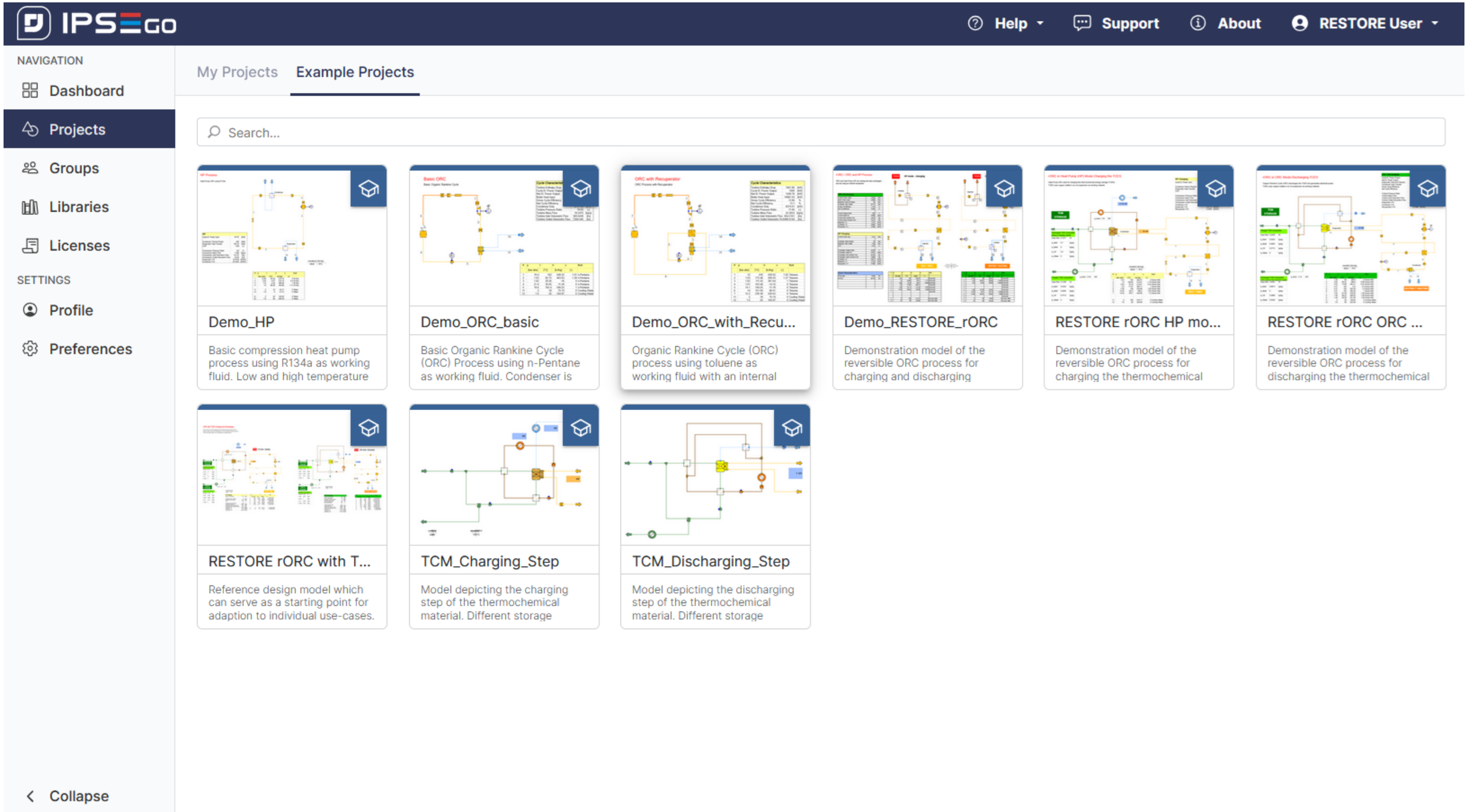
Annex I. RESTORE Virtual Tool powered by IPSE GO

Landing Page of the RESTORE Virtual Tool powered by IPSE GO, showing the navigation Tabs for: Project Overview; RESTORE_Lib Available Units; and RESTORE Example Projects.



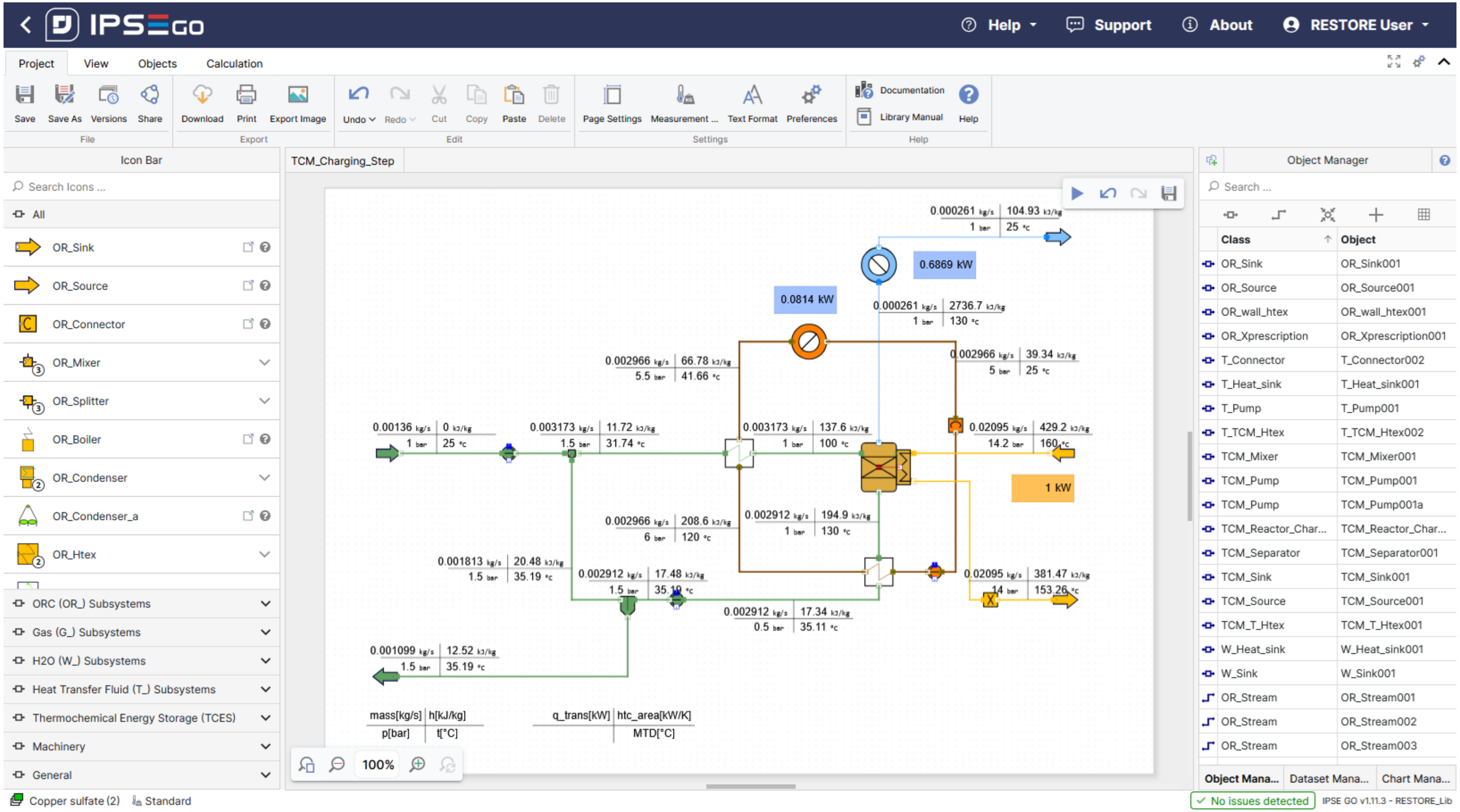
Annex II. RESTORE Virtual Tool – Projects Page

RESTORE Virtual Tool powered by IPSE GO, showing the available RESTORE process models.



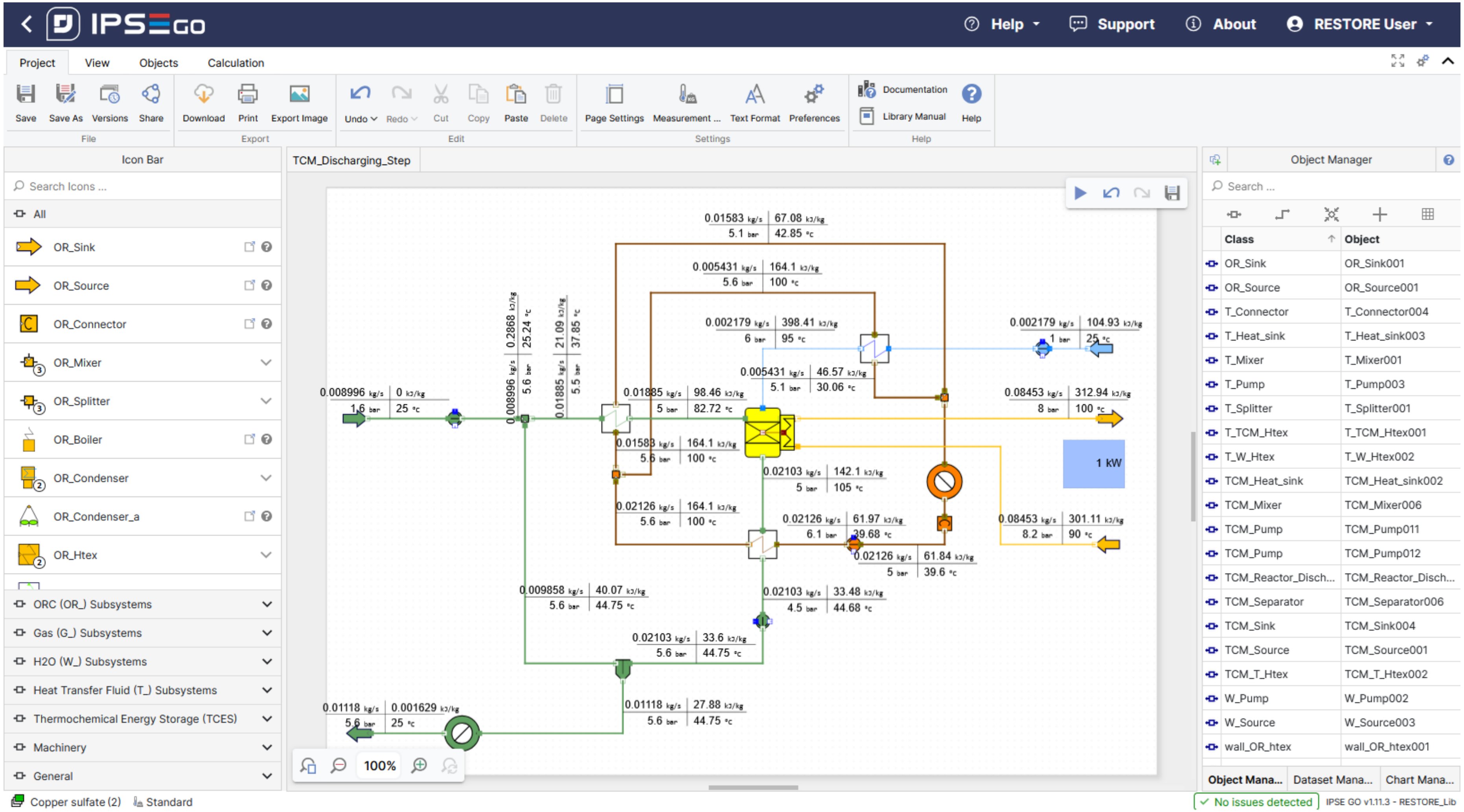
Annex III. RESTORE TCES Charging Model

RESTORE TCES Charging Model within IPSE GO.



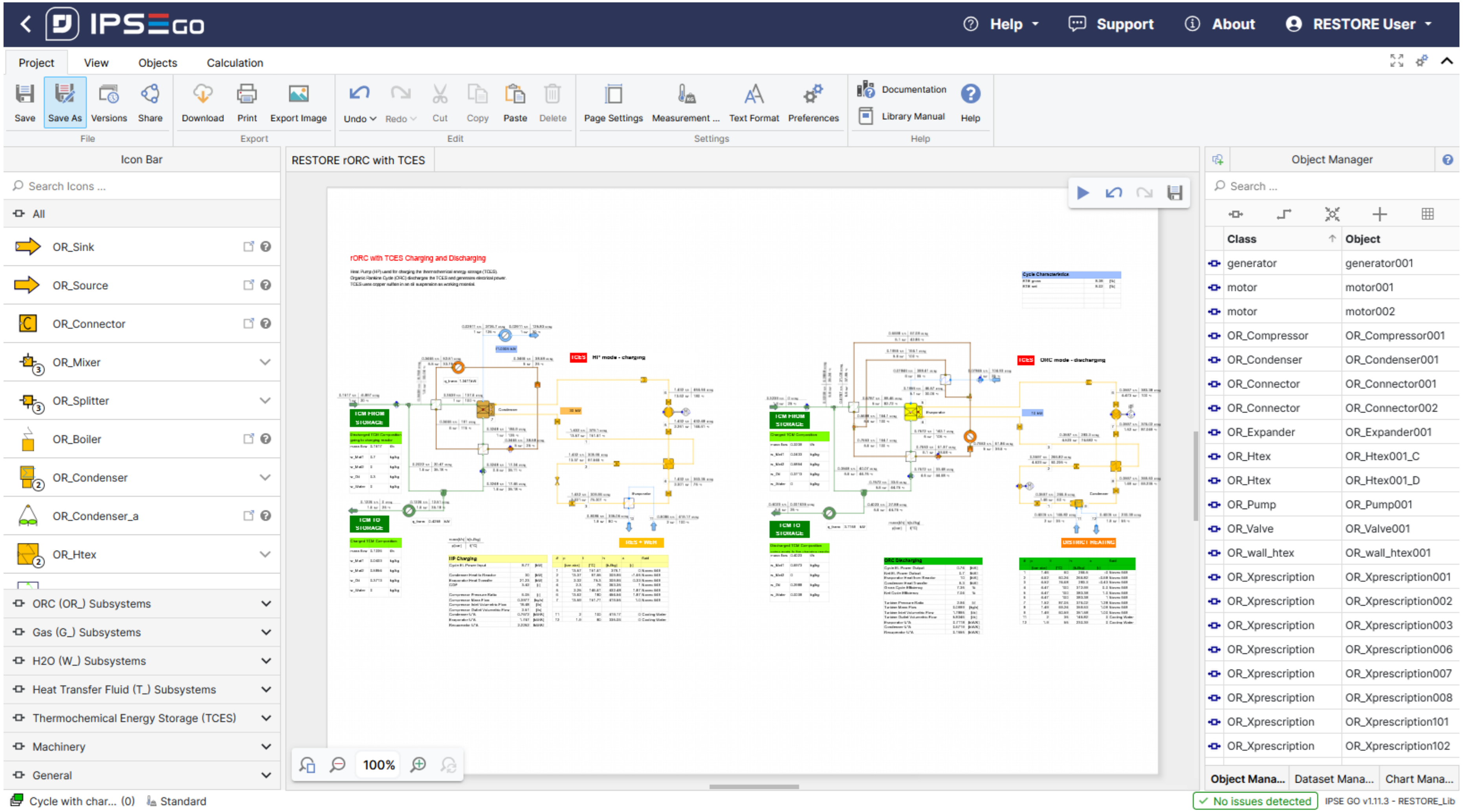
Annex IV. RESTORE TCES Discharging Model

RESTORE TCES Discharging Model within IPSE GO.



Annex V. RESTORE Reference Design Model

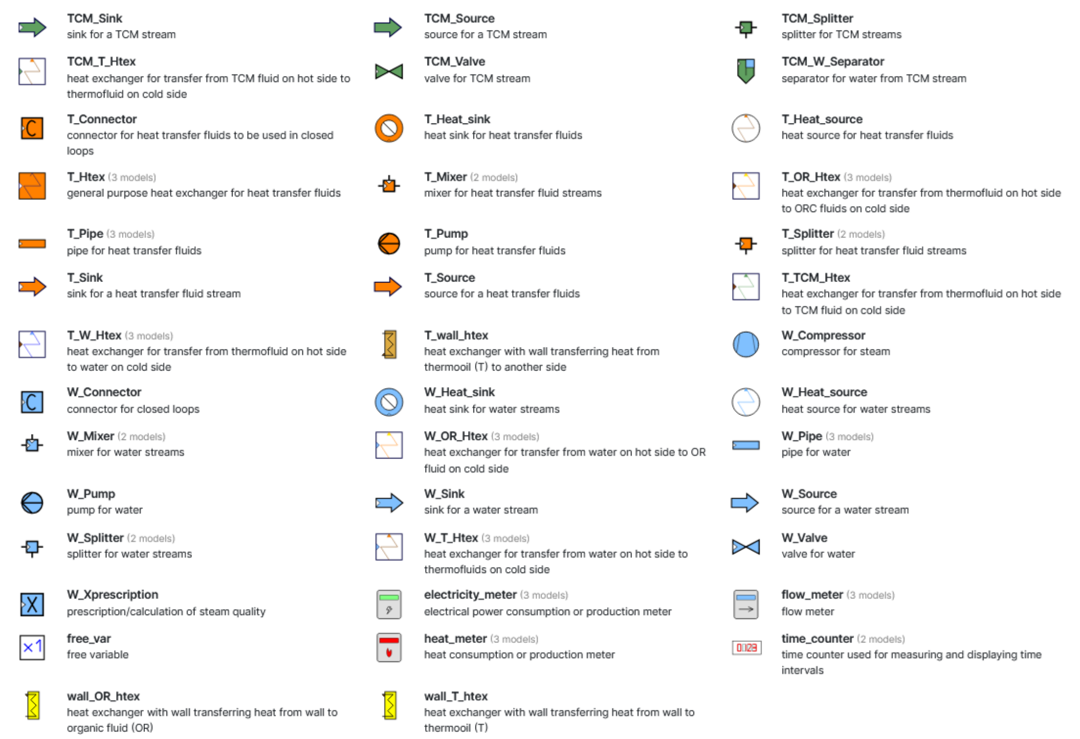
RESTORE Reference Design Model which can be used as a starting point for setting up a use-case.



Annex VI. RESTORE_Lib Components

RESTORE_Lib Component Models (as of July 2025). The model library was produced using IPSEpro-MDK and is used in both IPSEpro and IPSE GO.

- **gear** (3 models) gears
- **generator** (2 models) generator
- **G_OR_Htex** (3 models) heat exchanger for transfer from gas on hot side to organic fluid on cold side
- **G_Pipe** (2 models) pipe for gas streams
- **G_Sink** sink for a gas stream
- **G_Source** source for a gas stream
- **mech_loss** mechanical loss
- **motor** (2 models) motor
- **optimization** optimization element
- **OR_Boiler** (2 models) simple boiler model for ORC fluids
- **OR_Compressor** (2 models) compressor for ORC fluids
- **OR_Condenser** (2 models) condenser for ORC fluids, water cooled
- **OR_Condenser_a** (2 models) condenser for ORC fluids, air cooled, dry
- **OR_Connector** connector for ORC streams to be used in closed loops
- **OR_Expander** (2 models) expander for ORC fluids
- **OR_G_Htex** (3 models) heat exchanger for transfer from ORC fluid on hot side to gas on cold side
- **OR_Htex** (3 models) general purpose heat exchanger for ORC fluids
- **OR_Heat_sink** (2 models) heat sink for usage with OR streams
- **OR_Heat_source** (2 models) heat source for usage with OR streams
- **OR_Mixer** (2 models) mixer for ORC streams
- **OR_Pipe** (3 models) pipe for ORC fluids
- **OR_Pump** pump for ORC fluids
- **OR_Properties** (2 models) calculation and display of physical properties of OR fluids
- **OR_Separator** (3 models) vapour-liquid separator for ORC fluids
- **OR_Splitter** (2 models) splitter for ORC streams
- **OR_Sink** sink for an ORC stream
- **OR_Source** source for an ORC stream
- **OR_Turbine** (4 models) turbine for ORC fluids
- **OR_T_Htex** (3 models) heat exchanger for transfer from ORC fluid on hot side to thermofluid on cold side
- **OR_Valve** valve for ORC fluid
- **OR_W_Htex** (3 models) heat exchanger for transfer from ORC fluid on hot side to water on cold side
- **OR_Xprescription** (3 models) prescription/calculation of vapor quality of an ORC fluid
- **OR_wall_htex** heat exchanger with wall transferring heat from organic fluid (OR) to another side
- **RESTORE_EA** component model supplying economic analysis information
- **TCM_CD_Transformer** transformer to combine charging and discharging operations of TCM
- **TCM_Connector** (2 models) connector for TCM to be used in closed loops
- **TCM_Heat_sink** heat sink for TCM
- **TCM_Heat_source** heat source for TCM
- **TCM_Htex** heat exchanger for transfer from TCM fluid on hot side to TCM fluid on cold side
- **TCM_Mixer** mixer for TCM streams
- **TCM_Pipe** (2 models) pipe for thermochemical material (TCM)
- **TCM_Pump** pump for TCM fluids
- **TCM_Reactor_Charging** Reactor for charging step of TCM. High temperature side transferring heat to the reactor is optional. Different heat delivering working fluids (OR_ or T_) can be connected.
- **TCM_Reactor_Discharging** Reactor for discharging step of TCM. Low temperature side receiving heat from the reactor is optional. Different heat receiving working fluids (OR_or T_) can be connected.
- **TCM_Separator** separator for TCM stream



- **TCM_Sink** sink for a TCM stream
- **TCM_Source** source for a TCM stream
- **TCM_Splitter** splitter for TCM streams
- **TCM_T_Htex** heat exchanger for transfer from TCM fluid on hot side to thermofluid on cold side
- **TCM_Valve** valve for TCM stream
- **TCM_W_Separator** separator for water from TCM stream
- **T_Connector** connector for heat transfer fluids to be used in closed loops
- **T_Heat_sink** heat sink for heat transfer fluids
- **T_Heat_source** heat source for heat transfer fluids
- **T_Htex** (3 models) general purpose heat exchanger for heat transfer fluids
- **T_Mixer** (2 models) mixer for heat transfer fluid streams
- **T_OR_Htex** (3 models) heat exchanger for transfer from thermofluid on hot side to ORC fluids on cold side
- **T_Pipe** (3 models) pipe for heat transfer fluids
- **T_Pump** pump for heat transfer fluids
- **T_Splitter** (2 models) splitter for heat transfer fluid streams
- **T_Sink** sink for a heat transfer fluid stream
- **T_Source** source for a heat transfer fluids
- **T_TCM_Htex** heat exchanger for transfer from thermofluid on hot side to TCM fluid on cold side
- **T_W_Htex** (3 models) heat exchanger for transfer from thermofluid on hot side to water on cold side
- **T_wall_htex** heat exchanger with wall transferring heat from thermooil (T) to another side
- **W_Compressor** compressor for steam
- **W_Connector** connector for closed loops
- **W_Heat_sink** heat sink for water streams
- **W_Heat_source** heat source for water streams
- **W_Mixer** (2 models) mixer for water streams
- **W_OR_Htex** (3 models) heat exchanger for transfer from water on hot side to OR fluid on cold side
- **W_Pipe** (3 models) pipe for water
- **W_Pump** pump for water
- **W_Sink** sink for a water stream
- **W_Source** source for a water stream
- **W_Splitter** (2 models) splitter for water streams
- **W_T_Htex** (3 models) heat exchanger for transfer from water on hot side to thermofluids on cold side
- **W_Valve** valve for water
- **W_Xprescription** prescription/calculation of steam quality
- **electricity_meter** (3 models) electrical power consumption or production meter
- **flow_meter** (3 models) flow meter
- **free_var** free variable
- **heat_meter** (3 models) heat consumption or production meter
- **time_counter** (2 models) time counter used for measuring and displaying time intervals
- **wall_OR_htex** heat exchanger with wall transferring heat from wall to organic fluid (OR)
- **wall_T_htex** heat exchanger with wall transferring heat from wall to thermooil (T)