RESTORE

Renewable Energy based seasonal Storage Technology in Order to Raise Economic and environmental sustainability of DHC

D5.10 – RESTORE Replication Strategy V1

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Summary

This document provides information about the project's EU-wide replication strategy from task T5.5 on "Replication Strategy via Stakeholders additional Cases", led by SIMTECH and PI. Results of task T5.5 are reported in 2 incremental versions of D5.10 (V1) & D5.11 (V2), to be released in months M26 and M48.

Deliverable D5.10 is the result of the work carried out in T5.5 during the period of M9 to M26 of the project. The main purpose of this report is to describe the preliminary replication strategy specification to allow and motivate RESTORE's stakeholders to create additional cases and trials during the project lifetime, within the RESTORE virtual tool powered by the IPSE GO simulation web-platform. The creation of stakeholders' additional test-cases will be based on the RESTORE 6 virtual use-cases [1] and worked-out in WP5 task T5.4 (Implementation, Optimization, Management & Validation of RESTORE Use-Cases using the Simulation Web Platform).

The information provided in this document builds upon collaboration between SIMTECH and PROSPEX Institute (PI), with contributions from other RESTORE partners, in the sense that it considers inputs from published results from WP1, WP6, and WP7, namely: the general guideline of Deliverable D1.1 of the RESTORE overall concept [2]; the Deliverable D1.4 on the specifications of RESTORE Use-Cases and Models [3]; the technology watch and market evaluation report, Deliverable D6.6 [4]; the Deliverable D6.9 - Report on Exploitation & Stakeholders Group Management (V1) [5]; and Deliverable D7.9 on community building activities [6].

Deliverable D5.10 production was led by SIMTECH in collaboration with PI.

As part of RESTORE project's participation in the "Open Research Data Pilot", Deliverable D5.10, as a public dissemination-level document, will be made available in the RESTORE open-access research data repository within the Zenodo RESTORE Community (https://zenodo.org/communities/101036766/?page=1&size=20), for further reference and dissemination.

Table of Contents

1. Introduction

This document (D5.10) focuses on the specifications of RESTORE preliminary replication strategy to allow and motivate stakeholders to create additional cases and trials during the project lifetime, within the RESTORE virtual tool powered by the IPSE GO simulation web-platform. D5.10 is a result of the work carried out in Task T5.5 “Replication Strategy via Stakeholders additional Cases” of WP5 (RESTORE EU-wide Replication in Virtual Representation on Real Use-Cases). As the results of task T5.5 are planned to be reported in two deliverable report-versions, the current document (V1 - D5.10) covers the development period of M9 to M26, while the next version (V2 - D5.11) to be released in month M48, will report about the final replication strategy established within WP5-T5.5 up to the end of the project (see Figure 1).

D5.10’s main purpose is to describe the preliminary replication strategy specifications, which allows and motivates RESTORE’s stakeholders to create additional cases and trials during the project lifetime, within the RESTORE virtual tool powered by the IPSE GO simulation web-platform. The creation of stakeholders’ additional test-cases will be based on the six defined virtual use-cases for RESTORE [1] and worked-out in WP5 task T5.4 (Implementation, Optimization, Management & Validation of RESTORE Use-Cases using the Simulation Web Platform).

The development of the replication strategy for the use of RESTORE’s Virtual Tool has its main work defined in WP5. However, D5.10 also considers inputs from the following published results: Deliverable D1.1 [2]; Deliverable D1.4 [3]; Deliverable D6.6 [4]; Deliverable D6.9 [5]; and Deliverable D7.9 [6]. Moreover, task T5.5 needs information based on technical development from almost all other WPs, input concerning the exploitable project results and their applications; as well as stakeholders community building and communities of practice relevant to the project. Hence, the definition of the replication strategy embeds relevant inter-dependencies, receiving inputs and delivering results from/to the following tasks: WP1-T1.1 (led by CENER) – about the overall concept requirements and specification; WP1-T1.2 (led by CENER + SIG) – about the interfaces of RESTORE system with DHC and energy sources; WP1-T1.4 (led by SIM + POLIMI) – about the specification of RESTORE numerical models and virtual use-cases for simulation; WP2-T2.5 (led by TUW) - about the TCES dedicated models for the reactor simulation; WP3-T3.5 (led by POL) - about the dedicated models for the thermodynamic cycle and the dynamic behavior of RESTORE system; WP5-T5.1 (led by SIM) - about modelling the individual components of the overall RESTORE system; WP5-T5.2 (led by CENER) - about the techno-economic modelling of the RESTORE integrated systems; WP5-T5.3 (led by SIM) - about the web-platform adaptation for RESTORE dynamic and techno-economic modelling to represent the use-cases; WP5-T5.4 (led by SIM) - about the implementation, optimization, management and validation of RESTORE use-cases using the simulation web-platform; WP6-T6.2 (led by SIG) – about the technology watch and market evaluation within the project’s exploitation of results and business development; WP6-T6.3 (led by CENER) – about the exploitation and stakeholders group management; and WP7-T7.4 (led by PI) about stakeholders engagement & ecosystem community building.

The work carried out in task T5.5 so far (up to M26) has been guided by the following phases:

- M9-M17 – Preliminary strategy specifications for the replication of use-cases in stakeholders additional test-cases. Inputs from involved relevant tasks, concerning stakeholders identification. Collaboration meetings (SIMTECH, PI).
- M17-M18 – Compilation of the work done in task T5.5 for contributing to the 1st RESTORE Periodic Report.
- M16-M24 – Refinements on the preliminary strategy. Activities plan involving stakeholders. Inputs from involved relevant tasks & interaction with tasks-leaders. Further specifications and collaboration meetings (SIMTECH, PI, CENER).
- M25-M26 – 1st Virtual Stakeholders Workshop. Compilation of the requirements and specifications for the preliminary replication strategy for the production of the D5.10(V1).

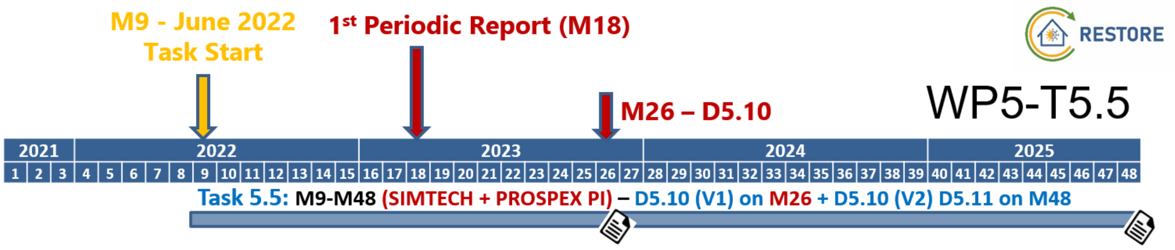

Figure 1: Task T5.5 Work Phases Timeline.

WP5-T5.5 Meetings with collaboration partners:

Within the periods stated above, several meetings were organized, mainly among SIMTECH and PI, and also others concerning the CoPs definition also including CENER, during the 1st RESTORE reporting period. Those meetings, together with the face-to-face meeting during the 1st RESTORE GA Meeting in Nov.2022 in Spain on month M14, largely contributed for structuring the work on task T5.5.

D5.10 is structured in the following way:

- The Introduction chapter (1) includes a brief recap about the use of simulation tools in RESTORE, considering the simulation tools IPSEpro, the IPSE GO web-platform, and focusing on the description of the “RESTORE Virtual Tool” and its simulated process models and use-cases. The 6 use-cases are summarized in the Annexes.
- Chapter (2) describes the relevant aspects of the specification of the Test-Cases Replication Strategy for RESTORE, focusing on two particular phases and the main steps to be taken in each of them. In (2), also challenges to be faced on the replication strategy phases 1 and 2 are identified.
- Chapter (3) describes the planned activities related to the replication strategy for the test-cases, in cooperation with the work done in WP6 and WP7.
- Chapter (4) draws some concluding remarks about the work carried out in T5.5 so far.
- Chapter (5) lists the references upon which the work done was based.

- Finally, eleven annexes (Annex I – Annex XI) show illustrations of the RESTORE Virtual Tool; available process models; components of the library RESTORE_Lib; and the summary of each use-case.

1.1. The use of 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.

1.2. The RESTORE-Virtual Tool

The RESTORE Virtual Tool 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. This leads to valuable impact with the project stakeholders, aggregated via RESTORE's exploitation replication strategy, enabling external stakeholders to build additional test cases.

As a result, RESTORE project will be able to profit from a more interactive ecosystem community building with more stakeholder engagement (WP7-T7.4), via the experimentation of the RESTORE simulated process models online via their internet browsers, without the need for any software installation.

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

Figure 2: RESTORE Virtual Tool powered by IPSE GO.

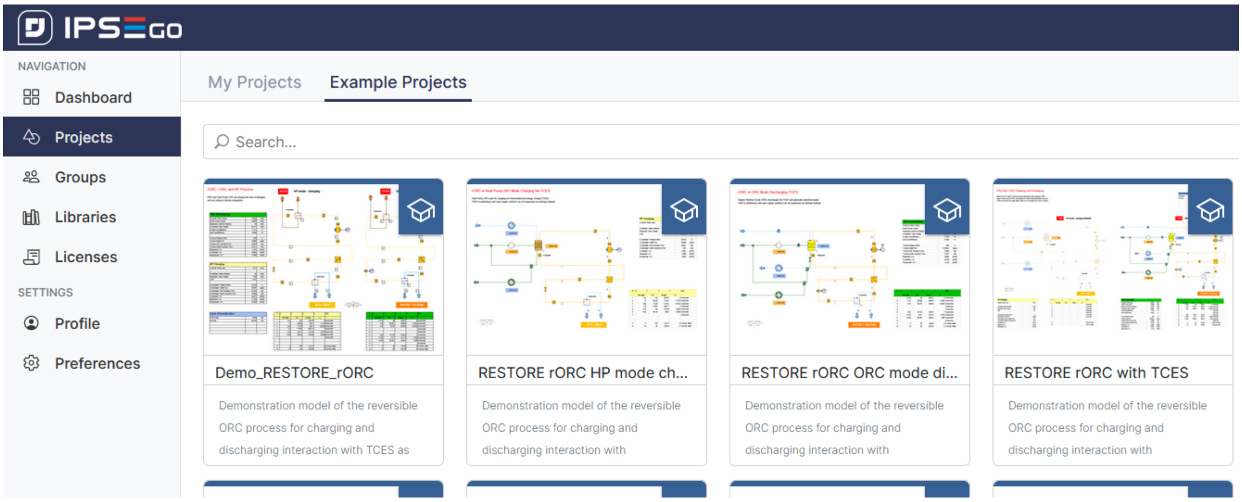

Figure 3: RESTORE Virtual Tool showing some RESTORE process models.

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 2 and Figure 3.

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.

1.2.1. 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 and are still being implemented and fine-tuned within WP5-T5.1 with input from WP1, WP2 and WP3. Extensions and updates of both RESTORE_Lib and process models will continue to follow throughout the project. Annex 4 shows the RESTORE_Lib **Available Units,** currently with 52 component models.

Once RESTORE Virtual Tool is made available online for stakeholders, the use cases will 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.

1.3. 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 4.

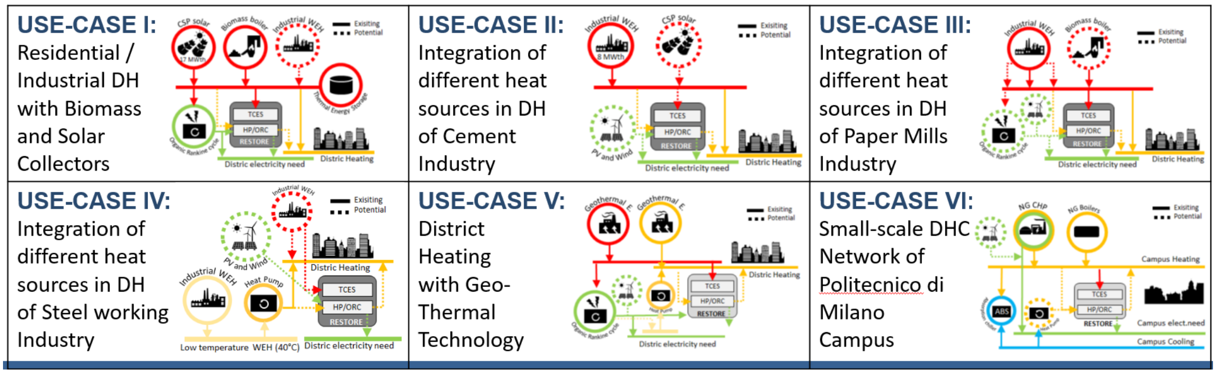

Figure 4: RESTORE Use-Cases.

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.*

In D1.4 [3] you find the specification of the high-level modelling data and requirements for implementing the RESTORE Use-Cases, 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 5, about the Use-Cases Models' Basic Information [3].

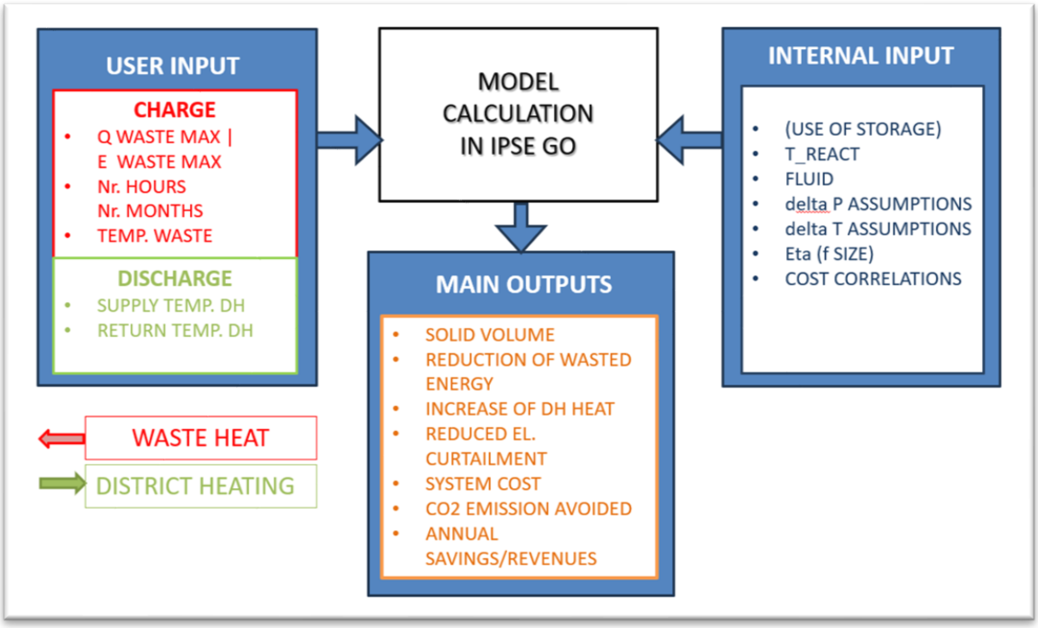

Figure 5: Use-Cases Models' Basic Information (from RESTORE WP1-T1.4-D1.4).

From the information identified in Figure 5, a template will be produced within WP5-Task T5.4 to adapt the required input data and the expected outputs for each of the six Use-Cases in RESTORE project.

2. The Replication Strategy

2.1. RESTORE Replication Specification

The RESTORE replication specification planned in [1] is still being considered within the development of task T5.5. As illustrated in Figure 6, the lab-scale validation and prototyping of the RESTORE system takes place first, following the design of small scale and large scale DHC commercial units, to the implementation of the virtual use-cases and the possibility of testing additional stakeholder's cases.

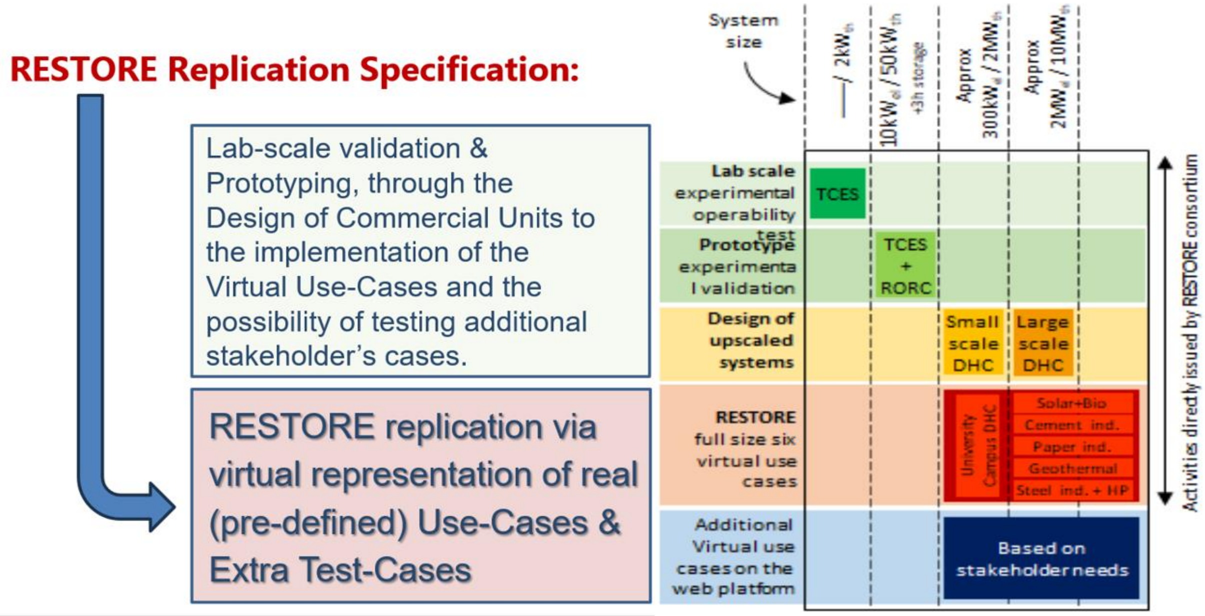

Figure 6: RESTORE Replication Specification.

Although the Test-Cases Replication Strategy for RESTORE stakeholders will be made available and put into practice still during the project lifetime, we can see in Figure 6 that the additional virtual cases based on stakeholders needs for test-cases, are also going to be an expected activity for the exploitation phase of the project, after the project ends. This means that the RESTORE Virtual Tool will be up and available online as a showcase and testing tool beyond the project lifetime.

This way, WP5 task T5.5 concentrates on:

- The use of the web-platform for virtual use-cases as showcase for the additional Cases of other Stakeholders and potential End-users (Members of the ESAB).
- The definition of the replication strategy for the RESTORE testing cases, based on the use-cases selected for the project.
- Interacting with WP6 + WP7 and engaging with the project's dissemination and exploitation activities.
- Aligning and engaging with the "User-Community building around the RESTORE Virtual Tool", via WP7 task T7.4 [M3-M48].

2.2. Replication Strategy Development

2.2.1. Stakeholders Identification

- Identification of the "*User-Community building around the RESTORE Virtual Tool*" (Communities of Practice (CoP) - T7.4 - PI).
- Stakeholders Identification via:
    - RESTORE ESAB Members.
    - Communities of practice (CoP) groups.
    - SIMTECH's Customers (Clients & Contacts).
    - IPSEpro's & IPSE GO Users.
    - Partner's and Use-Case Providers' Networks.
    - Contacts resulting from RESTORE Dissemination & Exploitation Network.
    - Contacts resulting from RESTORE stakeholders' engagement process.

2.2.2. Replication Strategy Dependencies:

The success of the use-cases simulation within the RESTORE Virtual Tool will be the key to propagate the easy-of-use approach of the IPSE GO simulation web-platform for test-cases to other stakeholders with similar applications. Moreover, the use-cases providers, once convinced of the usefulness of the simulated demonstrations for showcasing their virtual pilot installations of the RESTORE developed system integrated in their scenario-facilities, will act as multipliers ambassadors of the RESTORE use-cases. This is expected to accelerate decision-making within the exploitation roadmap of the project, concerning: (1) being early adopters themselves of the RESTORE technology via piloting the project solution in their real installations/plants; and (2) positively influencing other stakeholders within related application areas to try out the web-based RESTORE Virtual Tool for testing the project solution on customized test-cases based on the simulated use-cases. More details on the engagement strategy can be seen in deliverable D.7.9 [6].

Figure 7: RESTORE Replication Strategy Dependency.

Following this reasoning, the test-cases replication strategy adopted by the RESTORE project is strongly dependent on the successful implementation of the simulated use-cases. Notwithstanding, the achievement of a high number of extra test-cases using the RESTORE Virtual Tool and the RESTORE models and simulated use-cases as templates, does not only depend on the successful technical implementation of the project. It will also be dependent on the appropriate alignment of the replication strategy with the project's exploitation strategic plans, within the identified communities of practice of the project.

Task T5.5 Replication Strategy for Test-Cases must be aligned with:

- RESTORE's dissemination and exploitation (DEC) strategic plans, so that T5.5 can profit from engagements with WP6 & WP7 planned activities.
- WP7 Task T7.4, to be able to engage with the identified "User-Community around the RESTORE Virtual Tool".

T5.5 Replication Strategy is strongly dependent on the RESTORE Virtual Use-Cases, so that other identified stakeholders can be encouraged to try out the RESTORE modelled solution with their own cases.

2.3. Phases of the Replication Strategy

The RESTORE replication strategy considers two distinct phases, as shown in Figure 7, namely: Phase 1 that considers the period from M9 up to ~ M30, before the RESTORE virtual use-cases are modelled; as well as the initial stage of stakeholder engagement is currently taking place. and Phase 2 that involves the period after M30, already counting with preliminary results of the implementation of the virtual use-cases demonstrations using the RESTORE Virtual Tool, powered by IPSE GO.

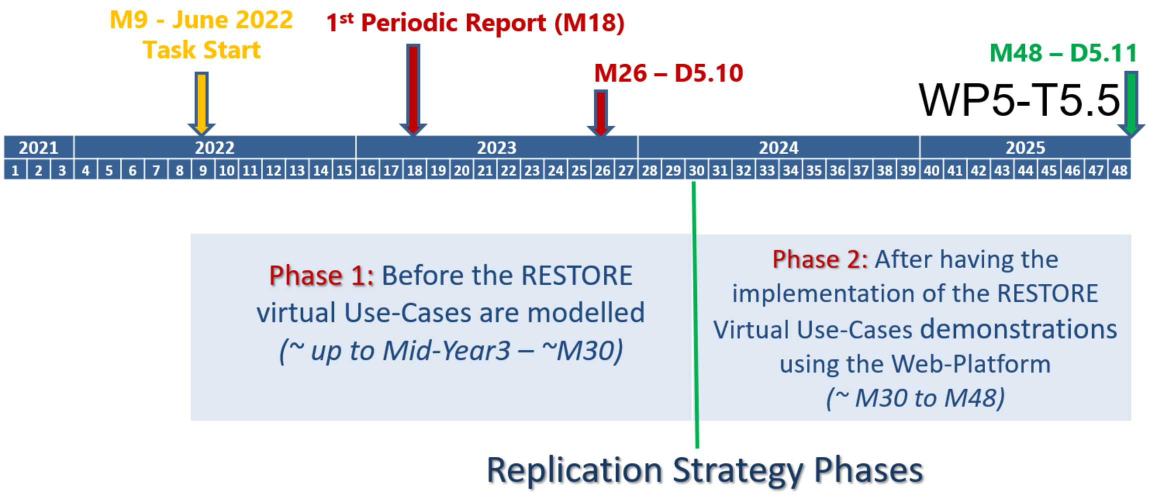

Figure 8: Replication Strategy Phases 1 & 2, during project lifetime.

Replication Strategy - Phase 1: Before the RESTORE Virtual Use-Cases are modelled *(~ up to Mid-Year3 – ~M30):*

- Use Conceptual Information about the project for awareness making among identified stakeholders.
- Survey identified stakeholders about potential use of RESTORE solution on their own installations (do it via application areas).
- Use Information about RESTORE's Use-Cases to promote the interest among stakeholders on creating extra test-cases.
- Use SIMTECH's Training and Promotion Material of the Web-Platform to motivate selected/identified stakeholders.

Replication Strategy - Phase 2: After having the implementation of the RESTORE Virtual Use-Cases demonstrations using the Web-Platform *(from ~ M30 to M48):*

- Use the representation of RESTORE overall Process Model to reinforce the initial interest of selected / identified stakeholders and to gain the interest of new ones.
- Explore the virtual representation of the 6 RESTORE's Use-Cases to promote specific interest among stakeholders on creating extra test-cases on related areas of application.
- Offer guidance and training on the use of the Web-Platform to the selected/identified stakeholders, supporting the creation of extra virtual test-cases for RESTORE.

2.4. Steps defining the Replication Strategy

As illustrated in Figure 9, the Test-Cases Replication Strategy for RESTORE follows 7 main steps, within phases 1 and 2, considering the group of stakeholders have already been identified. Steps 1, 2 and 3 are part of Phase 1, while Phase 2 takes care of Steps 4 to 7.

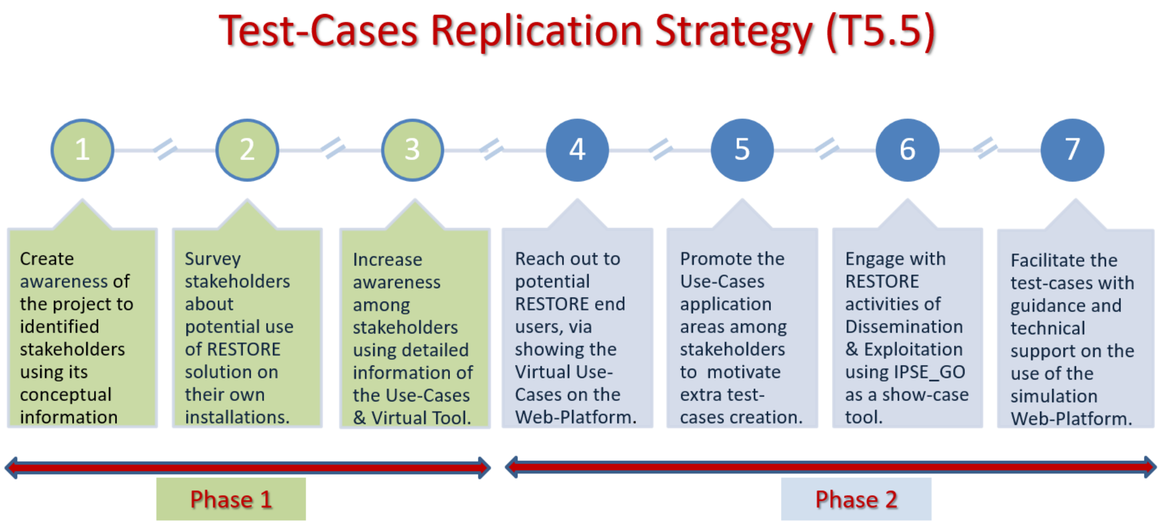

Figure 9: Important Steps of the Test-Cases Replication Strategy.

The strategy steps shown in Figure 9 are not to be executed sequentially. More precisely, it is not the case that once a step concludes, the subsequent one starts. In the project implementation, some steps overlap each other on their execution. For instance, steps 1, 2 and 3 are overlapping on their execution during some months of phase 1, Steps 2 and 3 start in phase 1 and are also present in the first half of phase 2. Steps 4, 5, and 6 shall be executed concurrently from M30 to M48. Step 7 is due to happen during the last year of the project, in phase 2. For a better understanding of the execution schedule of the replication strategy steps, see the timeline chart of Figure 10.

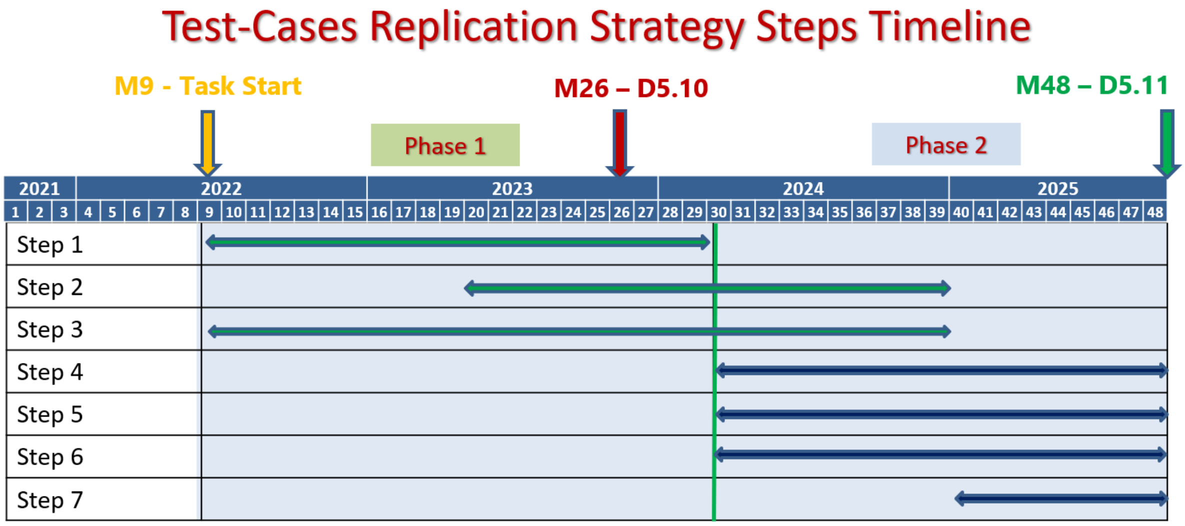

Figure 10: Execution Timeline of the Replication Strategy Steps.

Step 1: The awareness-creation about the project, using its conceptual information and the information about its use-cases, towards identified stakeholders is a crucial step within the replication strategy. In this respect, the RESTORE Consortium altogether has been actively and continuously disseminating preliminary results of the project in various conferences, exhibitions and other events (see [10]).

Step 2: Survey stakeholders about potential use of the RESTORE solution on their own installations. This is a way to get some feedback from selected stakeholders about their initial impressions of their needs and preparedness for testing the project's technology using the simulated use-cases as process-model-templates in the future. Such a step is planned to be performed in phases 1 and 2. (PI has already promoted "Stakeholders Engagement" internal seminars to prepare the Consortium in the direction of this step).

Step 3: Increase awareness among stakeholders using detailed information of the Use-Cases & Virtual Tool. SIMTECH has been continuously promoting, within the stakeholders of the Consortium and also externally, the information about the use-cases and about IPSE GO used as RESTORE Virtual Tool, including its already available process models. Among other events planned, SIMTECH has taken part in a Stakeholders Workshop of the Horizon Europe project NET-Fuels, in November 2023, presenting the RESTORE Virtual Tool for simulating the project's Use-Cases.

Step 4: Reach out to potential RESTORE end users, via showing the Virtual Use-Cases on the Web-Platform. This is an effective approach, for which various activities (webinars, online workshops, face-to-face presentations, etc.) are planned. Even though Step 4 belongs to Phase 2, starting after M30, SIMTECH and PI have already co-organized the online workshop "Introduction to the RESTORE Virtual Tool" for selected stakeholders, users of IPSEpro / IPSE GO, on October 5th, 2023. In this workshop, the participants were given the opportunity to experience more details about IPSE GO and to discuss with SIMTECH and other RESTORE partners their own impressions of the RESTORE Virtual Tool in an interactive manner.

Step 5: Promote the Use-Cases application areas among stakeholders to motivate extra test-cases creation. This is a very important step to be taken in Phase 2 of the Replication Strategy (after M30), as soon as some preliminary process models simulated for the use-cases can be show-cased within the RESTORE Virtual Tool. In the future (between M30-M48], the simulated use-cases will be validated and made available as process-model-templates for other stakeholders' test-cases.

Step 6: Engage with RESTORE activities of Dissemination & Exploitation using IPSE_GO as a show-case tool. This step is vital for the alignment of the replication strategy with the DEC strategic plans, aiming at a successful result for the implementation of T5.5. In Chapter (3), some panned activities are listed in collaboration with WP6 and WP7.

Step 7: Facilitate the test-cases with guidance and technical support on the use of the simulation Web-Platform. To implement this step, SIMTECH will be guiding the stakeholders with training material made available via recorded videos and/ or via direct technical support, whenever possible. This step is planned to be performed during the last year of the project.

Internally for RESTORE Consortium, SIMTECH already performed in 2022 an online training for its simulation tools (with recordings), including the following sessions: (1) "Introduction & Getting Started: overview, building a simple Organic Rankine Cycle"; (2) "Basics of Process Simulation with Interaction via the cloud platform IPSE GO"; (3) "Advanced Simulation: how IPSEpro-PSE works" (including modelling off-design, especially part-load turbomachinery and heat exchangers; advanced mechanisms; and model library development with IPSEpro-MDK). The material of this training can be also used to guide other external stakeholders with their test-cases implementation.

Following the defined strategy, it is expected that stakeholders will be able to create their own testing cases, such that the number of different application examples will grow continuously.

The platform with the collection of virtual use cases will remain online after the project to stimulate a new technological direction and the emergence of an European innovation ecosystem around the RESTORE paradigm.

2.5. Test-Cases Replication Strategy Challenges

Both Phases 1 and 2 of the Replication Strategy face identified challenges, as shown on the Tables to follow. Those challenges need to be tackled during project development. On the sequel, together with the challenges identifications, some mitigation measures were sketched, so that the challenges are monitored through the implementation of task T5.5, to avoid risks on the RESTORE Test-Cases implementation.

Table 1: Replication Strategy - Phase 1 Challenges.

Phase 1	Challenges to be faced
P1.1	Compilation and attraction of selected stakeholders among all identified sources. (Identify if stakeholders have interest on the project and need to make a virtua test-case using RESTORE's solution when it is ready.)
P1.2	Lack of specific examples and representations of the Use-Cases to promote interest among stakeholders to create extra test-cases.
P1.3	Lack of information on the needed modelling skills and technical abilities from the side of the stakeholders. (Identify if stakeholders have experience using simulation tools and/or experience on interacting technically with online platforms.)

Table 2: Replication Strategy - Phase 2 Challenges.

Phase 2	Challenges to be faced
P2.1	Compilation of selected stakeholders matching the specific areas of the 6 RESTORE Use-Cases to facilitate potential extra Test-Cases‘ creation.
P2.2	Identification among the selected stakeholders, the groups of different levels of technical support-needs, so that appropriate guidance and/or training can be offered for the use of the web-based simulation platform IPSE GO, to model theTest-Cases using the RESTORE process model solution.
P2.3	Supply insightful tutorials about the use of IPSE GO for RESTORE and keep technical skills needed at low and simple levels, so that they do not create a barrier for the stakeholders to try out extra Test-Cases.

The work carried out in task T5.5 monitors the challenges identified above, so that mitigation measures can be taken well in advance to prevent the risk of failing a successful replication of test cases for the project in its exploitation phase.

For preventing that the identified challenges, relative to the replication strategy, entail risks to the project implementation, some mitigation measures will be implemented, as presented in Tables 3 and 4, with their estimated levels of the probability for them to happen and the respective impact severity on the replication strategy performance.

Table 3: Phase 1 Challenges – Mitigation Measures (Probability and Severity Levels: Low / Medium / High).

Phase 1 Challenge	Probability	Severity	Planned Mitigation Measures
P1.1	Low	High	Challenge P1.1 has very low probability to become a risk to the replication of test-cases, since steps 1, 2, 3 and 4 have specific targeted efforts, involving from partners members involved in WP1, WP5, WP6 and

			WP7, to attract appropriate groups of stakeholders that will be interested on the project's results. As mitigation measures, the following is planned to avoid the high severity impact of this challenge: - In WP5-T5.5, a continuous monitoring will be performed for the identification of the selected stakeholders' needs to make virtual test-cases using RESTORE's solution. - The use of the RESTORE Virtual Tool, powered by IPSE GO, counts with a user-interface that is friendly and self-explanatory and easy to attract the stakeholders to try out. - Several workshops and webinars are planned to be organized within WP5, WP6 and WP7, to cope with specific trainings involving stakeholders.
P1.2	Low	Medium	Challenge P1.2 is very unlikely to become a risk to RESTORE replication strategy, as there are several specific examples to be explored by the project with the stakeholders and potential end-users, given that the project counts with 6 Use-Cases in different application areas. The mitigation measures to be performed build up on the ones of P1.1, and they are: - Promote interest among the stakeholders to create extra Test-Cases, using the examples of each of the six Use-Cases application areas to serve as basis for their own cases. - To continuous identify new examples for potential test-cases to offer as examples to the selected stakeholders.
P1.3	Low	Medium	Challenge P1.3 has low probability to become a risk, by the same reasons identified for P1.1, added to the fact that during the interactions between RESTORE activities (trainings, seminars, surveys, etc.), it is always a requisite to ask the stakeholders/participants about their level of technical skills in process modelling about their abilities and experience with simulation tools and online platforms. The mitigation measures planned to be performed are:

			- Integrate individual forms to be filled in by the stakeholders previous to the workshops and webinars, with specific questions about their experiences and abilities in relation to process modelling, simulation tools and online platforms. - Provide the proper technical assistance needed for the stakeholders with lack of modelling skills, during the workshops. - Ask for feedback after the organized workshops, so that the next event can be better tailored for the stakeholders / participants needs.

Table 4: Phase 2 Challenges – Mitigation Measures (Probability and Severity Levels: Low / Medium / High).

Phase 2 Challenge	Probability	Severity	Mitigation Measures
P2.1	Low	Medium	Challenge P2.1 has very low probability to become a risk to the replication of test-cases, for the same reasons given in Table 3 for Challenge P1.1, added to the fact that it is even easier to identify stakeholders matching the specific areas of the RESTORE Use-Cases, since there are six of them in different application areas. Apart from the mitigation measures used for Challenge P1.1, the following other ones will also be taken into account by the WP5-T5-5 monitoring procedure: - Group stakeholders in relation to the Use-Cases application areas, in order to deal with specific examples with them, to facilitate potential extra Test-Cases' creation. - Identify in a continuous way new examples for potential test-cases, within the specific matching area of Use-Case application, to offer to the selected stakeholders, encouraging them to try out their own Test-Cases using the RESTORE Virtual Tool. - Encourage the stakeholders to follow-up in an active and interactive way the developments of their matching Use-Cases (allowing for Q&A, etc.).

P2.2	Low	Medium	Challenge P2.2 relates very much to the Challenge P1.3, and as such it is also unlikely to become a risk to the replication strategy. The mitigation measures to be performed build up on the ones of P1.3 and on the activities planned for the strategy steps 4, 5, 6 and 5, including: - Integrate individual forms to be filled in by the stakeholders previous to the workshops and webinars, so that the groups of different levels of technical support needs are identified via the workshops, trainings and webinars promoted by RESTORE, and the respective appropriate guidance is offered for the use of the simulation platform and the modelling work. - Make sure that a feedback form is organized for the workshops, with specific questions about the „high“ and „low“ experiences the stakeholders had, so that the next event can be better tailored for their needs. - Offer several group or individual technical support hands-on seminars about the use of the web-based simulation platform IPSE GO, to facilitate the modelling of the Test-Cases using the RESTORE process model solution.
P2.3	Low	Low	Challenge P2.3 has very low probability to become a risk to the replication of test-cases, since SIMTECH, as developer of the IPSE GO web-based platform, and RESTORE within its work packages WP5, WP6, and WP7, promote and organize several means of support (via recorded tutorials, training courses, workshops, webinars, etc.) to cater for the minimum skills that the stakeholders need to be able to create their own Test-Cases using the RESTORE Virtual Tool and the project’s technology. The planned mitigations measures to avoid that Challenge P2.3 becomes a risk are the following: - Produce specific specific and insightful tutorials about the use of IPSE GO to the selected stakeholders, focusing on the use of the RESTORE process model solution.

			- Provide specialized, but simplified models for usage on the web platform with the Test-Cases. - Make sure that the technical skills needed in the tutorials are at simple levels, using simple models to build up more complex ones if needed. This will avoid the creation of barriers for the stakeholders to try out extra Test-Cases. - Provide guidance and reviewing support of the Test-Cases initiated by the stakeholders, so that eventual errors can be identified at an early stage of their work with the RESTORE Virtual Tool.

If any risk is identified during the execution of WP5 Task 5.5, it will be informed to the project Coordinator to update the Risks list built within the context of WP1 - *Task 1.5 Key Performance Indicators (KPIs) for RESTORE development, validation & Risks Analysis*.

3. Planned Activities related to the Replication Strategy

The activities listed below, reproduced from D6.9 [5] are organized by RESTORE, mainly aligning the interests of WP1, WP5, WP6, and WP7.

Table 5: ESAB related Technical Events & Use-Cases/Test-Cases related Events.

Event	Description	Event Date
Event ESAB-1	**Advice for the upscaled solutions** *(During this meeting, the preliminary results of the project will be presented by the project consortium, with a particular focus on the progress and experience obtained during the design of the prototypes. EAB members will provide their feedback oriented to considerations to bear in mind for the upscaled solutions.)*	estimated for M31 of the project
Event ESAB-2	**Advice for maximizing impact and final overall concept definition** *(This event will take place after the preparation of the 1st RESTORE assessment document reported in D1.6 and in D1.8. The feedback received from the EAB will be useful for improving the definition of the final overall concept re-defined in the second phase of Task 1.1.)*	estimated for M38 of the project
Event 1-UseCase	**Analysis of the preliminary models of the use cases** *(This event is estimated to take place after 9 months of initiating the 6 sub-tasks involved in T5.4 for the implementation, optimization, management and validation of RESTORE Use-Cases. Around this month of the project, the first mature version of the modelling of the use-cases is expected to be ready. The partners will also present to the DPG members and other stakeholders invited some preliminary results of the models. Feedback will be used to improve the models and the accuracy of their results.)*	estimated for M34 of the project
Event 2-UseCase	**Analysis of first results and impact on the use cases** *(This event is expected to be held after developing a very advanced version of the models of the use-cases and deeply testing them. The final feedback from the DPG will be collected in order to fine-tune the last details of the models and the assessment and improve the final results as well as the associated deliverables in WP5 T5.4.)*	estimated for M42 of the project
Test-Cases related Events	**Events related to the Replicability of Test Cases** *(These events - most likely organized online - will count with the co-organization of the involved partners of WP5, WP6, and WP7, with ESAB participation. All members of RESTORE Consortium are expected to support the meetings and to indicate selected stakeholders from the Communities of Practices to participate. These events are expected to be planned within the specific task T7.4, with support from the use of the RESTORE Virtual Tool powered by IPSE GO web-platform.)*	estimated to happen within the interval [M30-M48] of the project

As shown in Table 5, the events related to the Replicability of Test Cases are not specifically instantiated yet. They are expected to be planned within tasks T5.5 and T7.4, with support from the use of the RESTORE Virtual Tool powered by IPSE GO web-platform.

The main objectives of the events related to the Test Cases cover the following aspects:

- Showcase and Validation of the Use-Cases modelled with RESTORE solution (T5.4);
- Stakeholders Engagement and Ecosystem Community Building (Task T7.4);
- Validation of the Replication Strategy for Stakeholders Additional Cases (Task T5.5);
- Support on the Elaboration of the Roadmap for RESTORE Key Exploitable Results (Task T6.2).

Already organized events related to the Replicability of Test Cases:

- In October 2023, the 1st Workshop of this category happened virtually, co-organized by PI and SIMTECH for a selected group of stakeholders, with the following agenda: (1) Presentation of the RESTORE Project; (2) Introduction to RESTORE virtual Tool and IPSE GO Web-Platform, followed by Q&A; (3) Demo / Practical Introduction to the RESTORE Virtual Tool Usage; and (4) Feedback from participants. The feedback from participants was collected by undertaking an interactive approach and will feed back into the next steps and events.

4. Conclusion

Deliverable D5.10 reported about the project's EU-wide replication strategy from task T5.5 on "Replication Strategy via Stakeholders additional Cases", lead by SIMTECH and PI, covering the period of M9 to M26 of the project. This report mainly described the preliminary replication strategy specification to allow and motivate RESTORE's stakeholders to create additional cases and trials based on the RESTORE 6 virtual use-cases, during the project lifetime, using the RESTORE virtual tool powered by the IPSE GO simulation web-platform.

The simulation environments used in the project were briefly described, as well as the showcase outcome and valuable impact with the project stakeholders that the online RESTORE-Virtual Tool will be able to aggregate via its exploitation replication strategy. D5.10 described the relevant aspects of the specification of the Test-Cases Replication Strategy for RESTORE, focusing on two particular phases and the main steps to be taken in each of them, as well as the challenges to be faced on the replication strategy Phases 1 and 2. A list of planned activities was presented, considering technical events related to the ESAB, events related to the use-cases testing, and related to the replication strategy test-cases, mainly in cooperation with the work done in WP5, WP6 and WP7.

Following the defined Replication Strategy, it is expected that stakeholders will be able to create their own testing cases, such that the number of different application examples will grow continuously within and beyond the project lifetime. It is worth noting that the RESTORE Virtual Tool will be available for both project partners and end-users (during the project lifetime) to assist all project phases (design, development, and testing), as well as to demonstrate the project's Use-Cases 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 an European innovation ecosystem around the RESTORE paradigm.

This way, task T5.5 promotes support for interested stakeholders to use the web-platform for modelling their own cases. Outcomes from tasks T5.5 and T7.4 (RESTORE User-Community building) will certainly maximize impact on the dissemination as well as on the exploitation of the project.

The information provided in this document was built upon collaboration between SIMTECH and PROSPEX Institute (PI), with contributions from other RESTORE partners.

5. References

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[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.

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[5] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. Deliverable D6.9 - Report on Exploitation & Stakeholders Group Management (V1), ed.: Francisco Cabello (CENER), September 30th, 2023.

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

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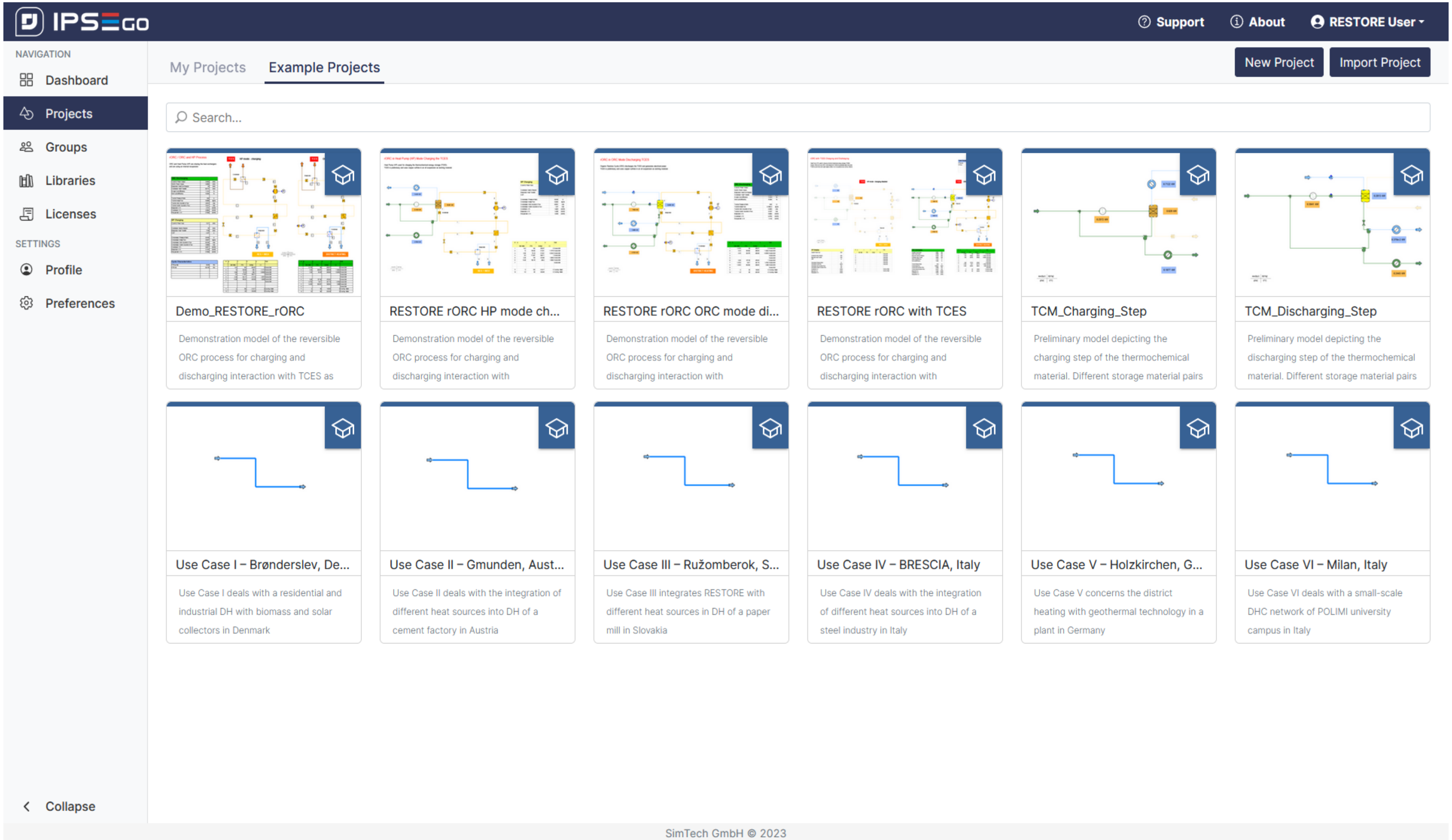
[10] European Commission, RESTORE Horizon 2020 Project GA Nr.101036766. RESTORE 1st Interim Report, ed.: Francisco Cabello (CENER) & All Partners, M18, March 30th, 2023.

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.

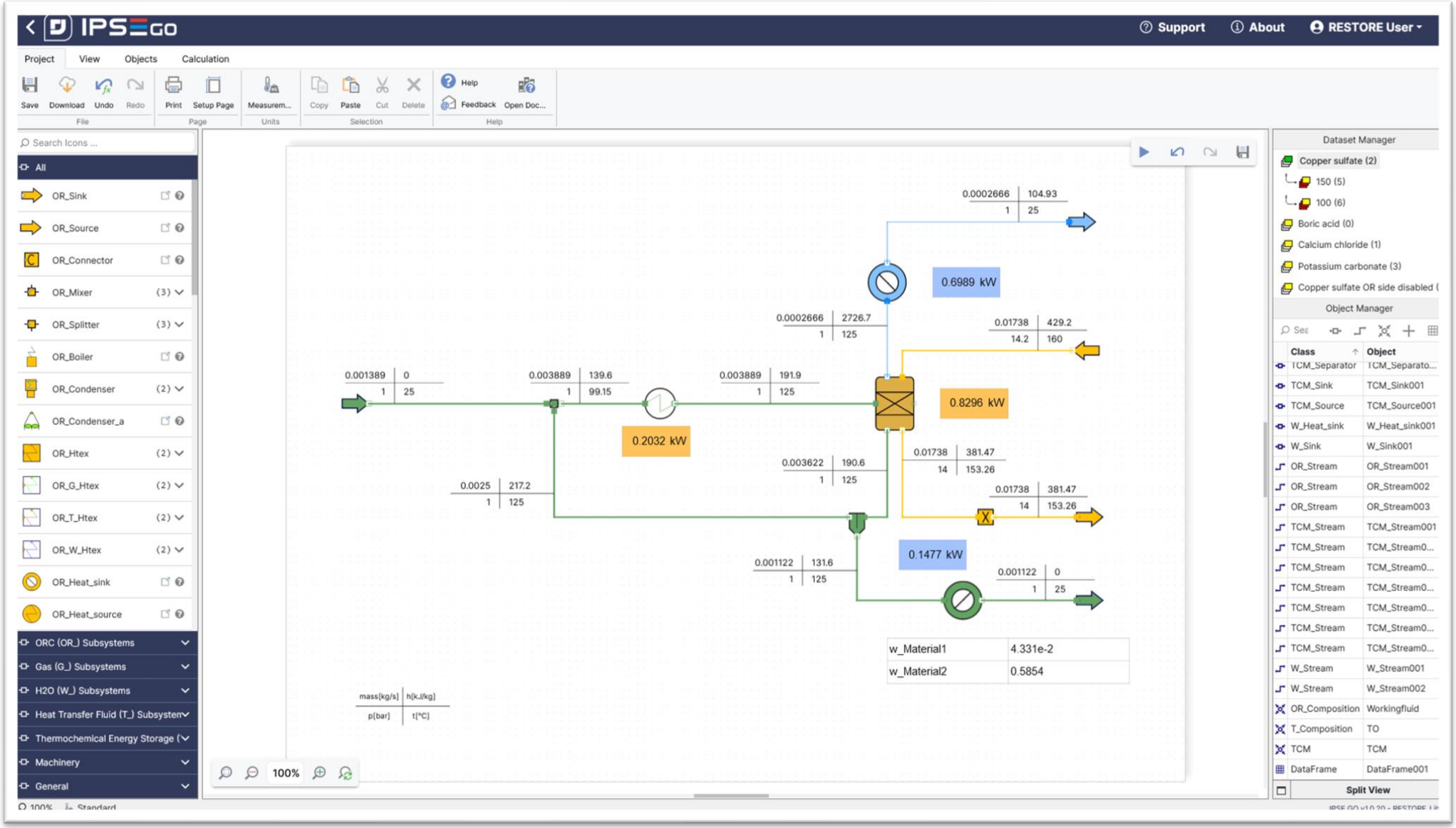
Annex II. RESTORE Virtual Tool – Projects Page

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



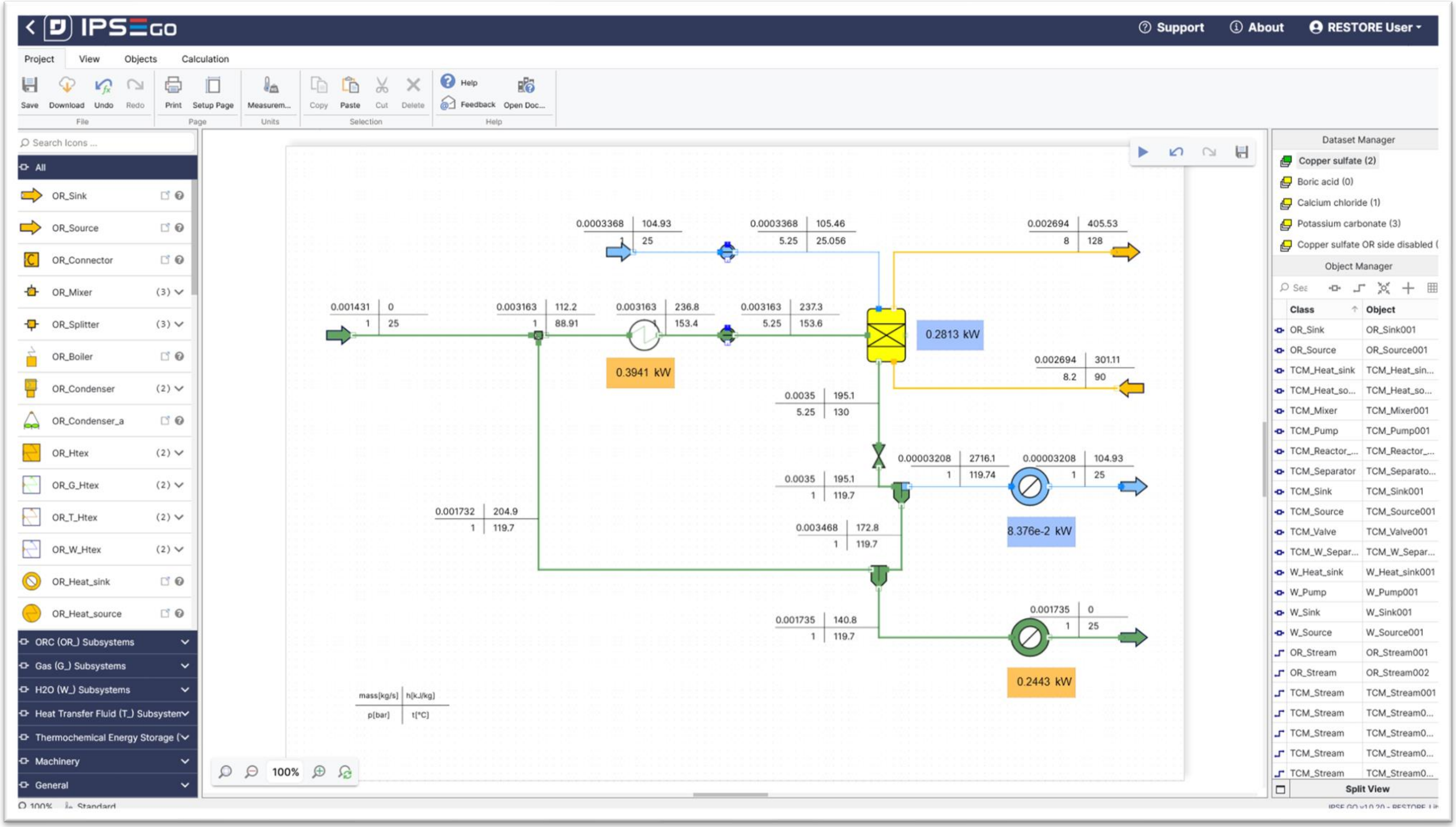
Annex III. RESTORE Preliminary TCES Charging Model

RESTORE Preliminary TCES Charging Model within IPSE GO (as of September 2023).



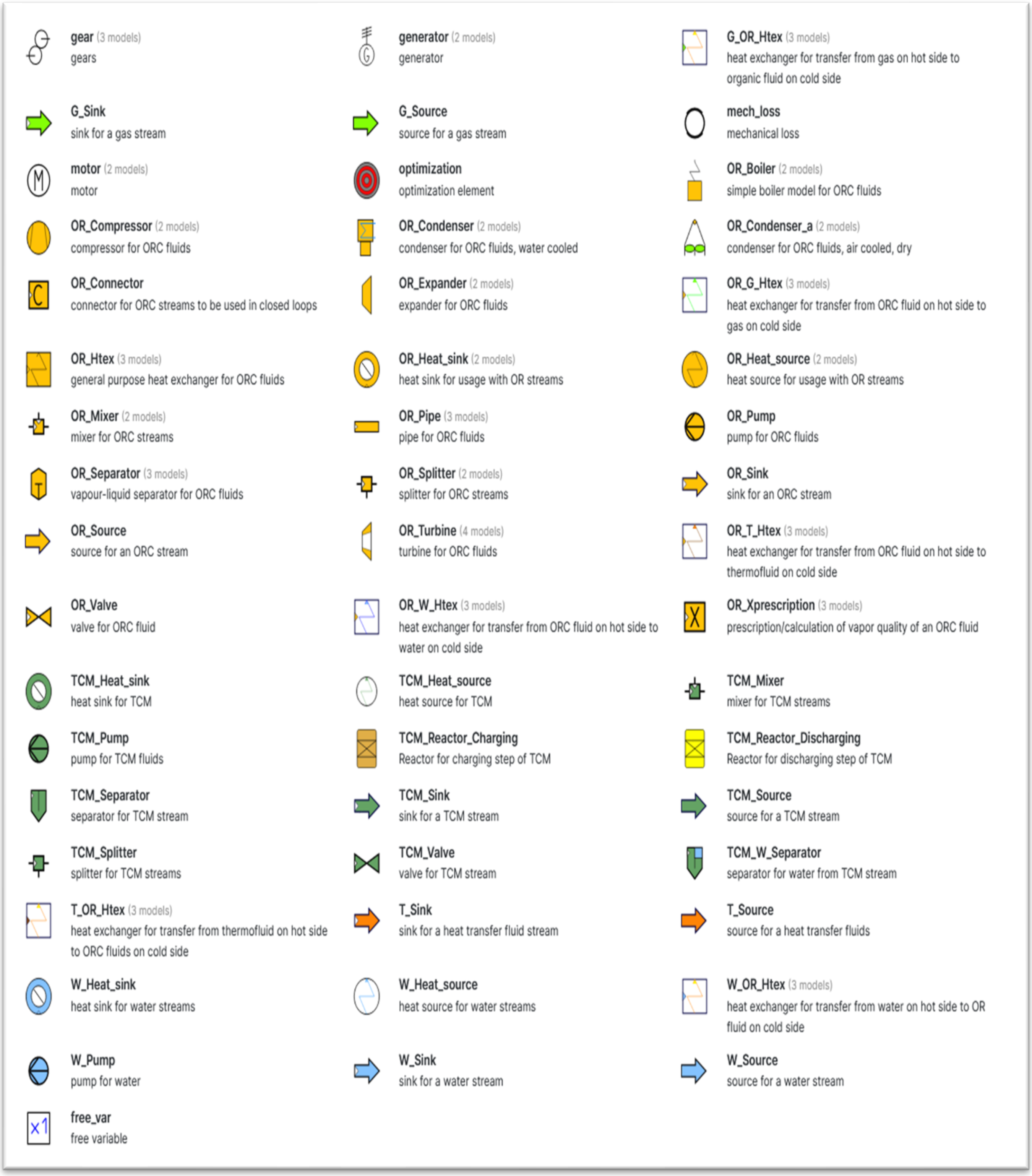
Annex IV. RESTORE Preliminary TCES Discharging Model

RESTORE Preliminary TCES Discharging Model within IPSE GO (as of September 2023).



Annex V. RESTORE_Lib Components

RESTORE_Lib Component Models (as of September 2023) produced by TUWIEN with SIMTECH support. RESTORE_Lib was produced using IPSEpro-MDK and is used in both IPSEpro and IPSE GO.



Annex VI. 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.

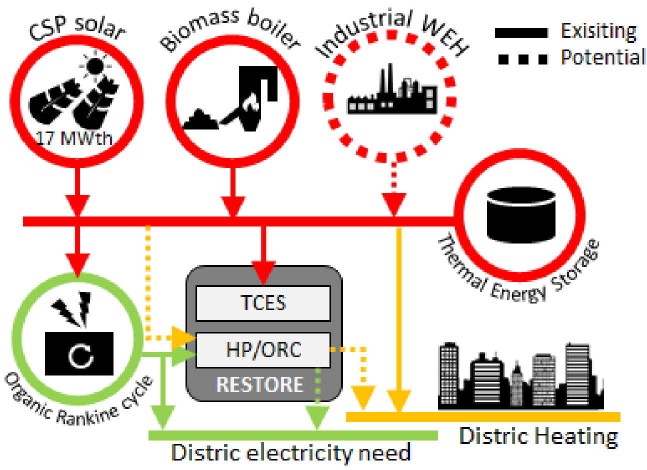


Figure 11: RESTORE proposed solution in Use-Case I.

Use-Case 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.

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, i.e. 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.

Annex VII. 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 ROHR 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.

Use-Case 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.

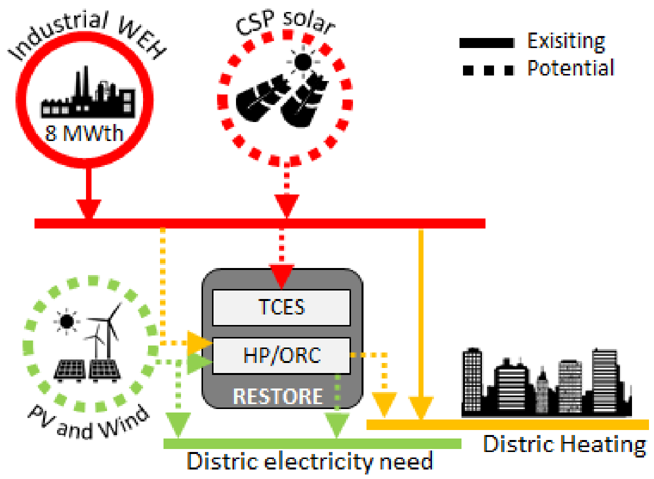


Figure 12: RESTORE proposed solution in Use-Case II.

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 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.

Annex VIII. 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.

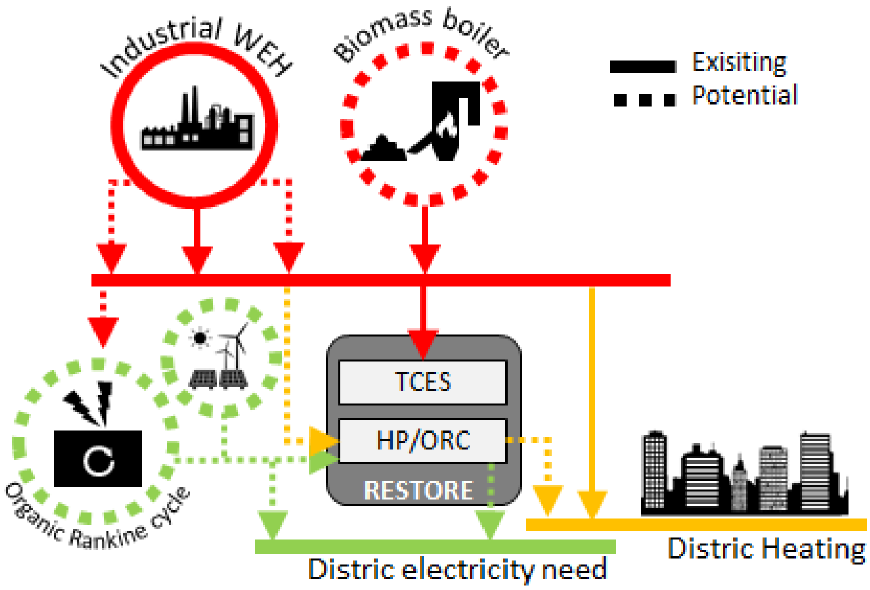


Figure 13: RESTORE proposed solution in Use-Case III.

Use-Case 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.

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.

Annex IX. 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.

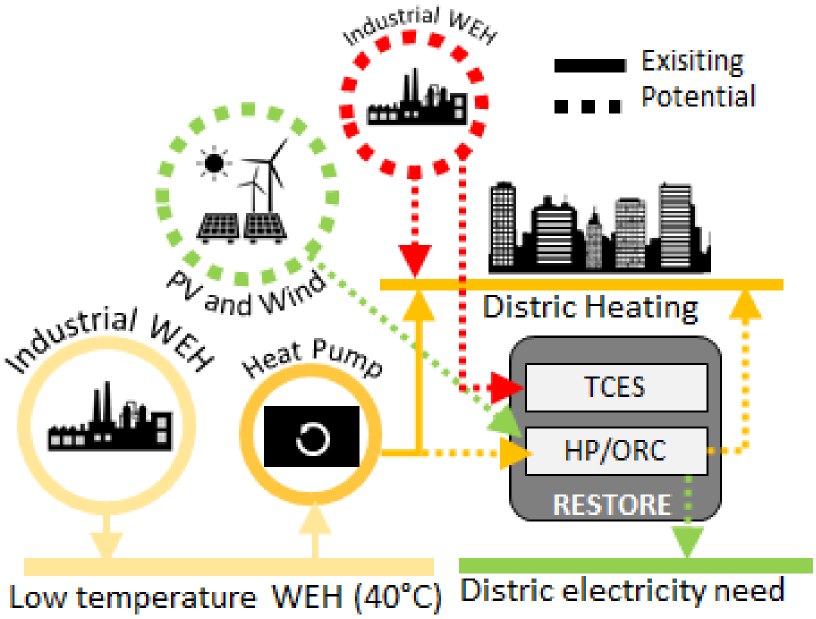


Figure 14: RESTORE proposed solution in Use-Case IV.

Use-Case 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.

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.

Annex X. 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.

Use-Case 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.

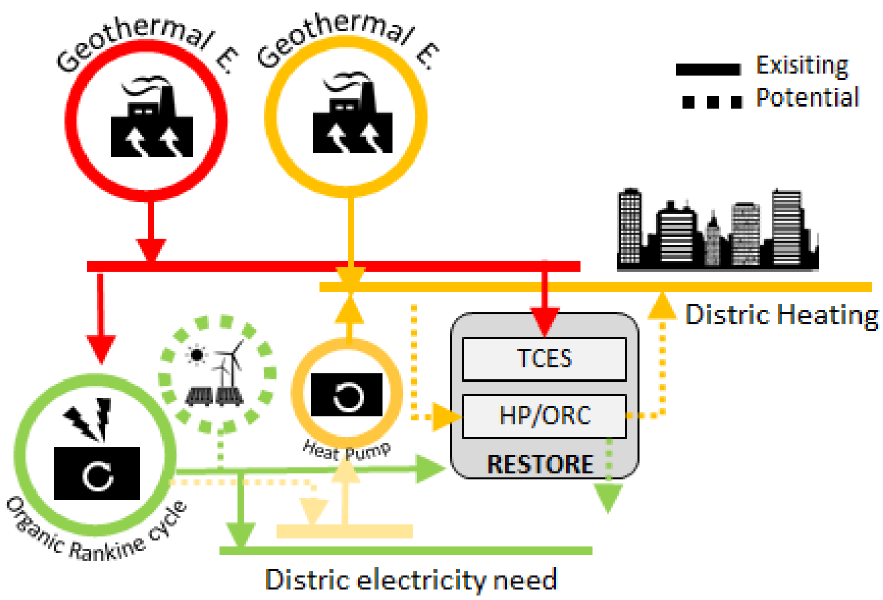


Figure 15: RESTORE proposed solution in Use-Case V.

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.

Annex XI. 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.

Use-Case 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.

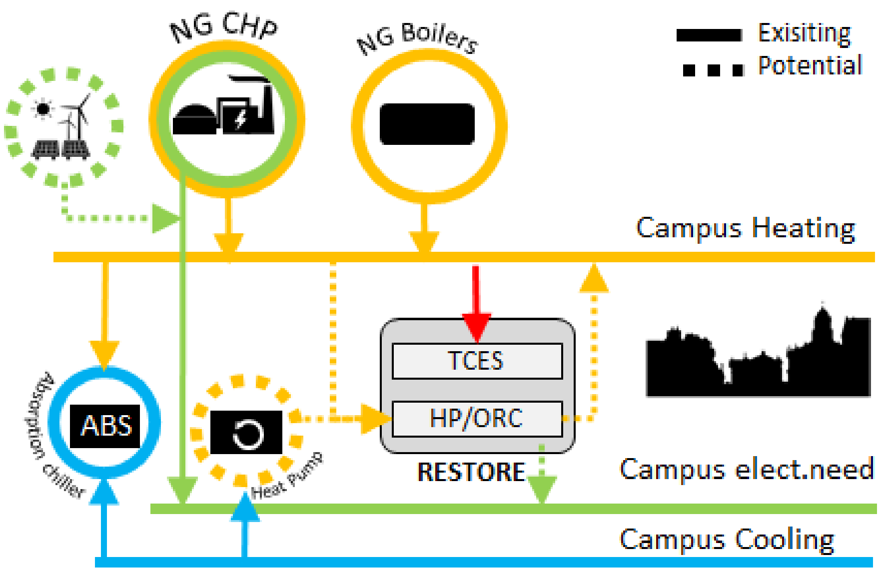


Figure 16: RESTORE proposed solution in Use-Case VI.

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.