

symphony

EMPA Campus Development

Authors:

A. Bollinger, A. Chevrier, Y. Li

Year: 2023



Illustrations: SAM Architekten / Filippo Bolognese Images

Introduction

Empa, the Swiss Federal Laboratories for Materials Science and Technology, has adopted the ambitious goal for its main campus in Dübendorf to become climate neutral by 2030. At the same time, the campus needs to address the high complexity of its energy system, which is expected to increase as the campus grows. Empa turned to Symphony to gain a holistic view of the site's energy system and of the options for its future development.

Key facts

- Site: Research campus
- Size: Up to 26 buildings, divided into 12 hubs
- System highlight: multi-temperature networks

What was achieved

- Clarity of the system's behavior
- Validation of the existing model
- Identifying optimal operational behavior

The Challenges

Managing increasing complexity

Empa's existing energy system presents a high degree of complexity, in terms of spatial decomposition and sector-coupling: the campus has high heating, cooling and electricity demands, various on-site production and storage components, as well as multiple thermal networks. This complexity is expected to increase as the site develops.

Achieving climate neutrality

The Empa team also realized that achieving its 2030 climate neutrality target requires a clear and detailed view of how the different system elements work together in dynamic concert with one another.

With this two-fold challenge, Empa identified the need to gain a holistic view of the current system's state to plan future extension options and reach their climate objectives. They turned to Sympheny to create a holistic digital twin of the site.

These challenges came with two underlying goals from Empa:

- To determine if the current operation is optimal for the site. Or if there are some uncovered potentials contingent to an optimal sector-coupled operation.

And,

- To ensure the model is flexible for the client to be able to transfer and integrate existing expertise into the new digital system without any knowledge transfer loss, and allows to build on it.

Our solution

1. Collecting data and defining boundary conditions

In a first step, the Sympheny and Empa teams discussed the boundary conditions of the study in an online workshop. The purpose was to exchange about on-site knowledge and to jointly review the data gathered. This was the chance to show the stakeholder how their data would be integrated and linked together within the model, thus ensuring no data would be lost in the process and could be built upon.

2. Capturing complexity into a single, holistic model

Based on these discussions and after validation of the data, Sympheny created a model for three defined stages: initial, current and planned states, based on several criteria defined by Empa:





- **Energy demands**, such as electricity, heat at different temperature levels, cooling, and more.
- **Energy storage, energy conversion technologies and energy networks** available.
- **Spatial decomposition** of the campus (modelled as 12 distinct hubs, as shown in Figure 1).
- **Time resolution** of one hour.

The story of EMPA

Empa, the Swiss Federal Laboratories for Materials Science and Technology, conducts cutting-edge materials and technology research. Empa's R&D activities focus on meeting the requirements of industry and the needs of society, and thus link applications-oriented research to the practical implementation of new ideas.

The new buildings of the campus extension will enhance comfort, attractiveness and safety for staff and guests – and offer more space for research and innovation. In-house innovations from Empa's and Eawag's labs will be applied in the process, for instance in the fields of energy generation and storage as well as in wastewater treatment.

Table. 1 – Summary of the three modelled states

	Initial state	Current state	Planned state
	<ul style="list-style-type: none"> HT network Cooling network 	<ul style="list-style-type: none"> HT network Cooling network MT network 	(same as current state)
	22 buildings	+3 new buildings	+3 new buildings
	172 kWp	+274 kWp	+542 kWp
	<ul style="list-style-type: none"> Gas boilers Chillers 	(same as initial state)	New technologies: <ul style="list-style-type: none"> CHP Heat pump Geothermal probes

*Note that the modelling of the initial and current states was relatively constrained in terms of available technologies, whereas the planned states offered more flexibility for the optimization algorithm to select the most suitable technologies.

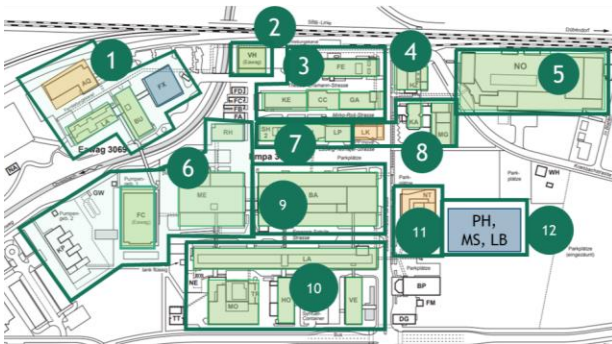


Fig. 1 - Spatial decomposition of all buildings on-site into 12 hubs in the Sympheny Model.

Results and benefits

Clarity of the system’s behavior

Based on monitored data of different energy sources at an hourly resolution, Sympheny was able to give a clear overview of the system’s behavior. Relative to the initial state, the results show that a 10% reduction in CO₂ emissions can be achieved in the current state, and a further 25% can be achieved in the planned state.

Validation of the existing model

The presentation of the models and results for the initial and current state allowed to spot some monitoring inaccuracies and, as a second step, to easily update the model with the updated data.

Identifying optimal operational behavior

The model enabled a detailed understanding of the optimal operational behavior at an hourly level by capturing intermittent renewables and demand patterns. The operation of the campus’ energy systems was optimized according to imports and exports and enabled to identify and coordinate the different technologies and storage units, charging and discharging.

Quantifying the expected impact of new technologies

The model developed enabled to analyze spatial and temporal heat exchanges within the campus' networks. This was particularly interesting for analyzing the campus' medium temperature networks and seasonal patterns in heat usage.

By showcasing the source of the medium temperature heat aggregated at a monthly level, the results allowed specifically to validate the integration of borehole technology into the future concept for the site.

Modeling and optimizing these flows with a holistic, site-spanning approach enabled to identify energy mutualization potentials that would have otherwise been unrecognized and unexploited

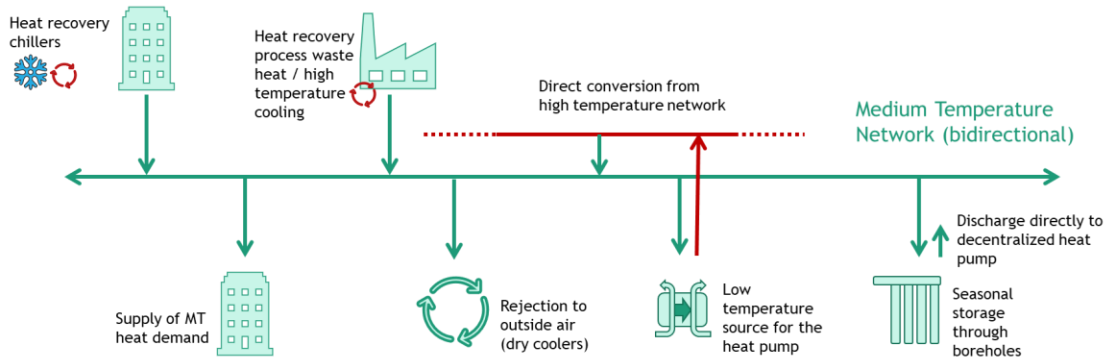


Fig. 2 - Medium temperature networks exchanges with buildings

Ensuring accuracy of economical behavior

The results of the model showed the pre-sizing of the networks, as well as the energy flows per network link. This allows to compare the sizing in the planning against what Empa had originally planned and validate their existing data.

Outlook

At the end of the study, Sympheny delivered the model to the Empa project team directly on their account of the web application. This model holds the potential to become a "living energy plan", enabling the Empa team to explore different future scenarios for the future development of the site's energy system, and evaluate the effects of future changes in boundary condition such as energy prices. By integrating the data into the digital structure early on, Empa will be able to use existing knowledge and data as a baseline for its future energy plans.

Importantly, it also gives the Empa team a holistic view of the evolving energy system - spanning the full scope of energy demands, energy carriers and system components. Going forward, this will enable the Empa team to optimally exploit sector coupling opportunities as well as synergies between the different system elements in line with their 2030 climate neutrality targets.

Visit www.sympheny.com to view more case studies or contact us to discuss your projects!

sympheny