CASE STUDY

sympheny

Achieving energy autarky for a Swiss campus

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Credit: neuhof.org

Introduction

The educational institution, Neuhof in Birr, Switzerland, endeavored to serve as a lighthouse for others with respect to its energy use. It set for itself the ambitious objective of becoming fully energy self-sufficient – that is, to generate all its needed energy from renewable resources on site or in the immediate surroundings. Sympheny were tasked with helping Neuhof achieve their goals using our innovative algorithms.

Key facts

- Site: An educational institution consisted of offices, residential buildings, 9 education facilities, and farm land
- Size: 18'000 m2 built area and 172'000 m2 land
- System highlight: Agri-PV, Power-to-X

What was achieved

- Energy autarky/ Energy self-sufficiency
- Integrated energy concept that supplies energy uses for buildings, facilities, and vehicles

Challenges faced

The Neuhof campus is currently relying on the electricity and gas supplied from the grid to satisfy the on-site energy use. The campus is seeking to achieve an ambitious goal of transforming into a 100% renewable and self-sufficient energy system but unsure with the technical feasibility.

To achieve complete self-sufficiency, the full vectors of energy uses should be supplied with on-site renewable energy resources. An optimal energy system should take advantage of sector-coupling solutions to meet the goal at the lowest costs. The current energy uses are space heating, electricity, and fuels for vehicles, including tractors for agricultural use. Additionally, a new training facility will be added to the campus in the coming years accompanied with renovation of some existing buildings.

A fully self-sufficient energy system also requires space for decentralized production and storage facilities on-site. The proposed energy system should respect the spatial constraints and thus feasible to implement.

Figure 1 – Campus site with various energy uses. (source: neuhof.org)

What is Neuhof?

Neuhof is an educational institution in Birr, Switzerland, with the goal to support young people in their social and professional development.

The site includes various facilities for horticulture, gardening, gastronomy, agriculture, painting, metalwork, and carpentry, as well as residential areas and training rooms.

With its 9 facilities and various living and working spaces, the Neuhof campus can be seen as a small village.

Its challenges and opportunities with respect to energy can, therefore, be seen as representative of those faced by many rural villages and areas in Switzerland.

Why Sympheny

Neuhof tasked Sympheny to help devise a self-sufficient energy concept for its campus. Sympheny's algorithms automatically generate and simulate thousands of possible energy supply solutions for a site, enabling the identification and assessment of a wide scope of energy supply technologies and energy system configurations, and subsequent identification of optimized energy supply solutions in line with client objectives.

Sympheny were the perfect partner for this project as Neuhof had very specific requirements and limitations that needed to be considered when building the optimal energy supply solutions for the site. The holistic software integrates all of their data, such as on-site energy demands and renewable energy resource potentials. The fully sector-coupled modelling environment allows energy planners to evaluate an integrated energy system that supplies multiple energy vectors to achieve full autarky at minimum life-cycle costs.

How Sympheny responded

In approaching this task, the Sympheny team first worked with Neuhof to quantify the on-site energy demands and the available on-site renewable energy sources. Using a combination of measurements and energy simulations, the Sympheny team calculated hourly resolution space heating, hot water and electricity demand profiles for each building on the site, as well as energy demand profiles for the vehicles and tractors. Possible future building renovations were considered as well as planned new constructions. Drawing amongst others from previous assessments of geothermal potential, wind speeds, and water flows, the on-site available renewable energy sources were assessed and quantified. This included solar energy, geothermal energy, wind energy, hydro energy, agricultural waste, manure, and organic waste from the local area.

Following the quantification of on-site energy demands and renewable energy sources, various candidates for energy conversion and storage were identified and specified with respect to their key technical and economic parameters. These candidates included:

- Technologies for capturing renewable energy sources, such as solar PV collectors for rooftops and agricultural surfaces (Agri-PV), geothermal probes and a biodigester.
- Technologies for short-term and seasonal storage of electrical, thermal and chemical energy, such as batteries, an ice storage, a pit hot water storage, a hydrogen storage, a methane storage and others.
- Technologies for converting between energy forms to enable efficient energy storage and subsequent exploitation of stored energy to meet energy demands – for instance an electrolyzer, a fuel cell, a methanizer, and a gas CHP.

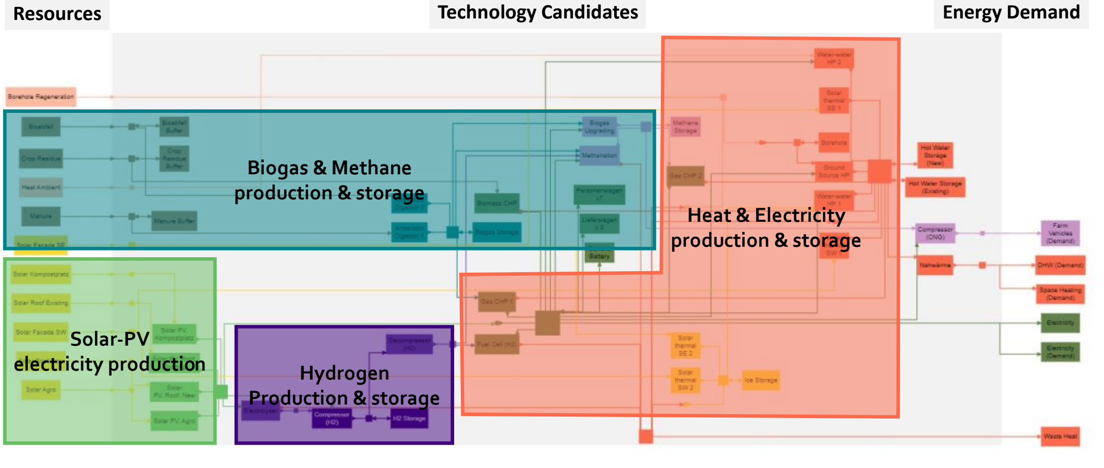

Figure 2 - Energy system diagram for the Neuhof site. (source: Sympheny web-app)

Using the energy demands, renewable energy resources and specified technology candidates as inputs, Sympheny's algorithms were used to generate and simulate many different possible energy supply concepts for the site. The objective was to find a minimal cost, technically feasible solution for achieving energy self-sufficiency. To that end, a wide scope of possible technologies and system configurations was considered. Multiple iterations of the analysis were carried out, with each iteration being used for further refining the problem definition and the data basis of the analysis.

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Results and findings

After reviewing different optimal energy supply system variants, Neuhof and Sympheny identified one energy concept featuring a particularly attractive balance of relatively low system complexity and comparatively low life-cycle costs. The system is based around a large agri-PV system combined with a large methane tank for seasonal energy storage, a gas CHP, an air-source heat pump, and several smaller storage systems for shorter-term energy storage. The large agri-PV system installed in this concept results in a significant amount of excess renewable energy production during the warmer months, which is in this case assumed to be converted to hydrogen, temporarily stored in on-site containers, and subsequently sold to third parties.

In the context of this energy concept, heat, electricity, and methane for farm vehicles are supplied primarily by a combination of solar energy from the agri-PV system and organic waste from the on-site agricultural operations and from the surrounding areas – converted via a biodigester and subsequent upgrading process to methane. Seasonal storage of methane ensures that sufficient energy is available in the winter months, without requiring withdrawals from the electricity or gas grid.

The developed energy concept utilizes the advantages and strengths of the rural/agricultural character of the site to achieve energy autarky, namely by utilizing the ample agricultural surfaces and the available organic waste to provide the needed energy for the site throughout the year.

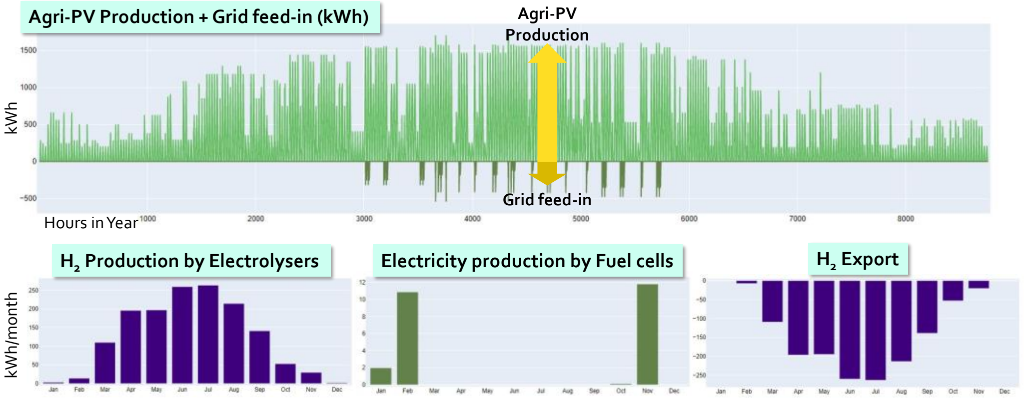

Figure 3 – Energy production and export over a year from technologies chosen in the optimal systems.

The future

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In this sense, the concept is also one that is potentially replicable in other agricultural sites and regions. Realizing this concept at Neuhof would allow to demonstrate how agricultural areas can utilize their unique strengths to be energy self-sufficient, and even energy positive, thus playing an active and constructive role in driving the energy transition.

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