CASE STUDY

sympheny

City of Chur Development

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Introduction

IBC Energie Wasser Chur wanted to implement technologies and renewable energy sources into the energy system supplied to the city of Chur. The primary objective was to conduct a direct cost-emissions analysis of energy systems, and secondarily, to facilitate the early-stage, large-scale quantification of both the investment needed and the specific types of investments required to transition towards a net-zero energy system.

Key facts

- Site: City of Chur
- Size: 3’168’360 m2 energy reference area
- System highlight: District heating

What was achieved

- Optimized three scenarios
- Identified a CO_2-free energy supply
- Maintained a similar life cycle cost

The Challenge

Complex analysis

In a first step, a catalogue of potential conversion and storage technologies was modelled for the energy hub of the city of Chur.

Each technology was defined by its energy carrier, inputs and outputs, conversion efficiency, investment costs, and maintenance costs. The technology costs within the catalogue referred to empirical values and calculations by Sympheny. Production surpluses were set to be able to be exported.

Various framework conditions were set to limit the use of specific technologies, for example only a certain amount of wood would be available per year in order not to overuse regional resources. These limitations were given by ELIMES.

Features of the Sympheny analysis

IBC wanted to determine which technologies and renewable energy sources would be best suited to supply the city of Chur in the future. The main information to extract from the optimization was two-fold: firstly, to directly compare the cost of the energy systems with the generated emissions, and secondly, to quantify, in an early step and at a large scale, the amount as well as the type of investment required to move toward a net-zero energy system.

The complexity of such an analysis, combined with the ambition of having an optimal and reliable solution, fully taking advantages of the synergies between energy carriers, led the client and the energy planners to Sympheny.

Who are IBC?

The IBC has a history spanning over 125 years. In 1896, the city of Chur consolidated the electricity plant, gasworks, and water supply into a single entity. Today, IBC stands as the unique multi-utility company in Graubünden, serving as the trusted partner for energy and water needs in the region.

They provide 24/7 secure access to electricity, gas works, heating/cooling, and drinking water to their customers. As the leading utility provider in the region, IBC continuously innovate and implement diverse energy solutions whilst remaining market-oriented.

Scenario name	Energy demand	Price of electricity (CHF/kWh)	Capacity based price (CHF/kW)
2018 Energy price	2018	Incl.	0
2035 Capacity price	2035 (efficiency)	Incl.	Incl.
2050 Capacity rice	2050 (efficiency)	Incl.	Incl.

The 3 scenarios executed

The system diagram within the Sympheny Web-App

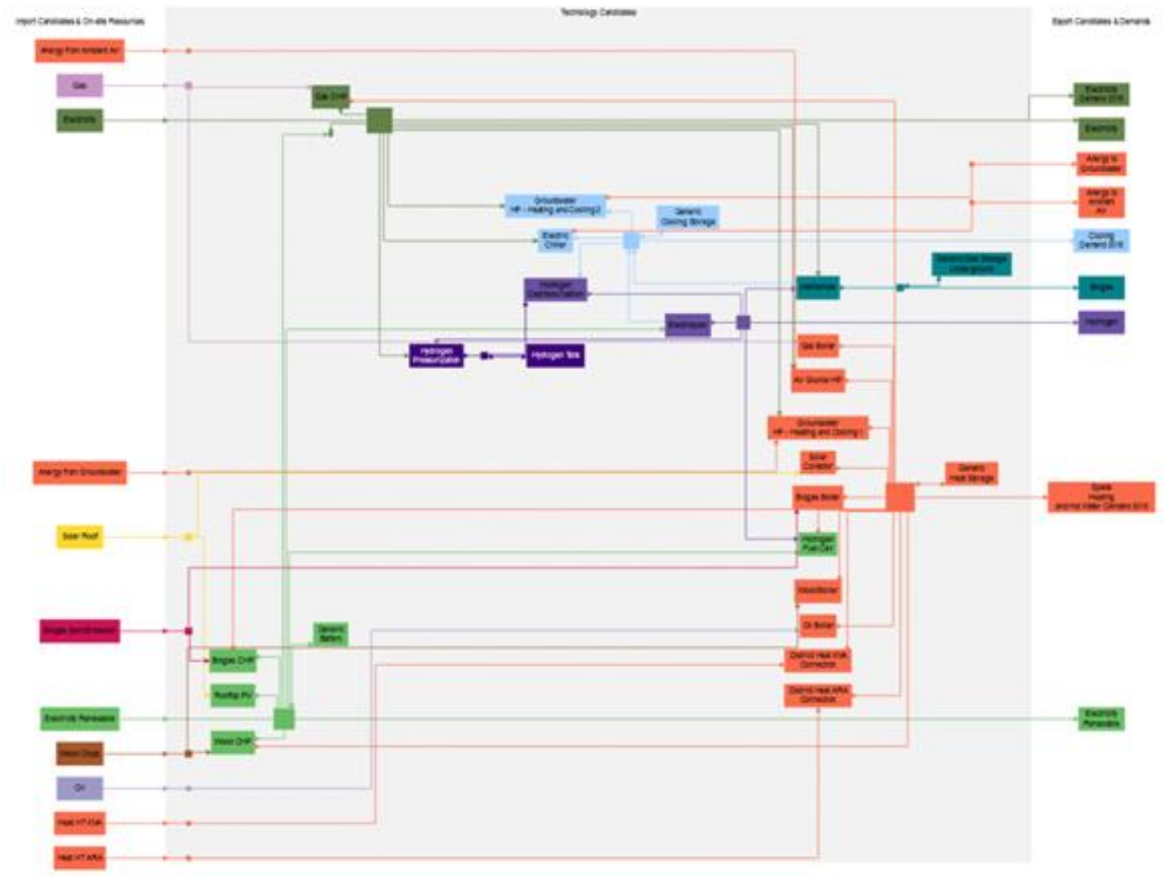


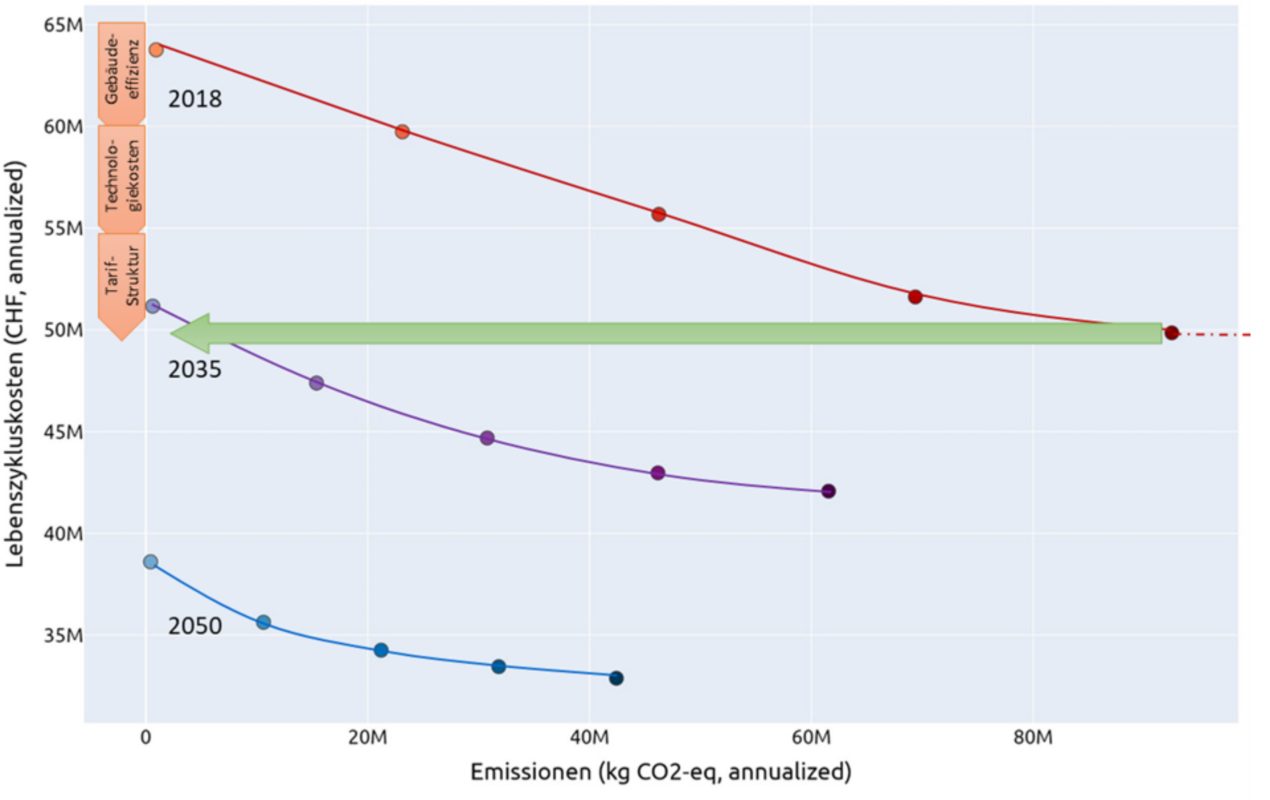
Figure 1 shows the Energy Hub model for Chur with all technologies, imports and exports. For each of the three scenarios (2018, 2035 and 2050), the energy planners of Elimes quantified the energy requirements of the city, considering an increase in the building efficiency for the years 2035 and 2050. The 2018 scenario modelled the current price structure of the market, where electricity is paid per kWh. For the energy demand of 2035 and 2050, the scenarios included a pricing based on capacity.

The solar potential of Chur assumed an available roof area of 700,000 m2 (50% of the total roof area) and the irradiation values in the horizontal plane from the station square in Chur in 2016 were used.

The Result

After being modelled as described in the section above, the three scenarios (2018, 2035 and 2050) were optimized: the Sympheny algorithm selected and dimensioned technologies that would meet the predefined energy demand at optimal costs and CO_2 emissions (on the so-called pareto front). For each of the scenarios, five solutions on the pareto front (i.e. solutions with optimal energy systems) were evaluated.

Figure 2 shows the total annual costs and CO_2 emissions for each solution. From left to right, the annual costs decrease but the CO_2 emissions increase. Systems with zero emissions are possible but are expensive. The top (red) curve is the 2018 energy price scenario. The middle(purple) curve is the 2035 power price scenario, and the bottom (blue) curve is the 2050 power price scenario.



Pareto fronts of the three scenarios for the Energy Hub Chur. Each point represents a specific solution for an optimal energy system. From left to right, annual costs decrease and CO2 emissions increase. The top (red) curve is the 2018 energy price scenario. The middle (purple) curve is the 2035 power price scenario and the bottom (blue) curve is the 2050 power price scenario.

From the results, it becomes apparent that a transformation of today's energy supply to a CO2-free energy supply in 2035 is possible with similar life cycle costs as in 2018. The main three drivers that make such a solution possible are: (1) increasing energy efficiency through building renovation and equipment replacement; (2) reducing technology costs through economies of scale; and (3) adjusting the tariff structure by weighting power purchases more heavily than energy purchases.

It should be noted that the energy system must be restructured to strictly use technologies based on renewable energy, which in some cases, requires massive investments. However, it was shown that with such investments, the new, completely renewable energy system can be operated with similar life cycle costs as the current system. The simulations and optimizations also showed that IBC should secure future renewable gas (bio or synthetic) and renewable electricity through long-term supply contracts to achieve attractive energy prices for the converted energy system.