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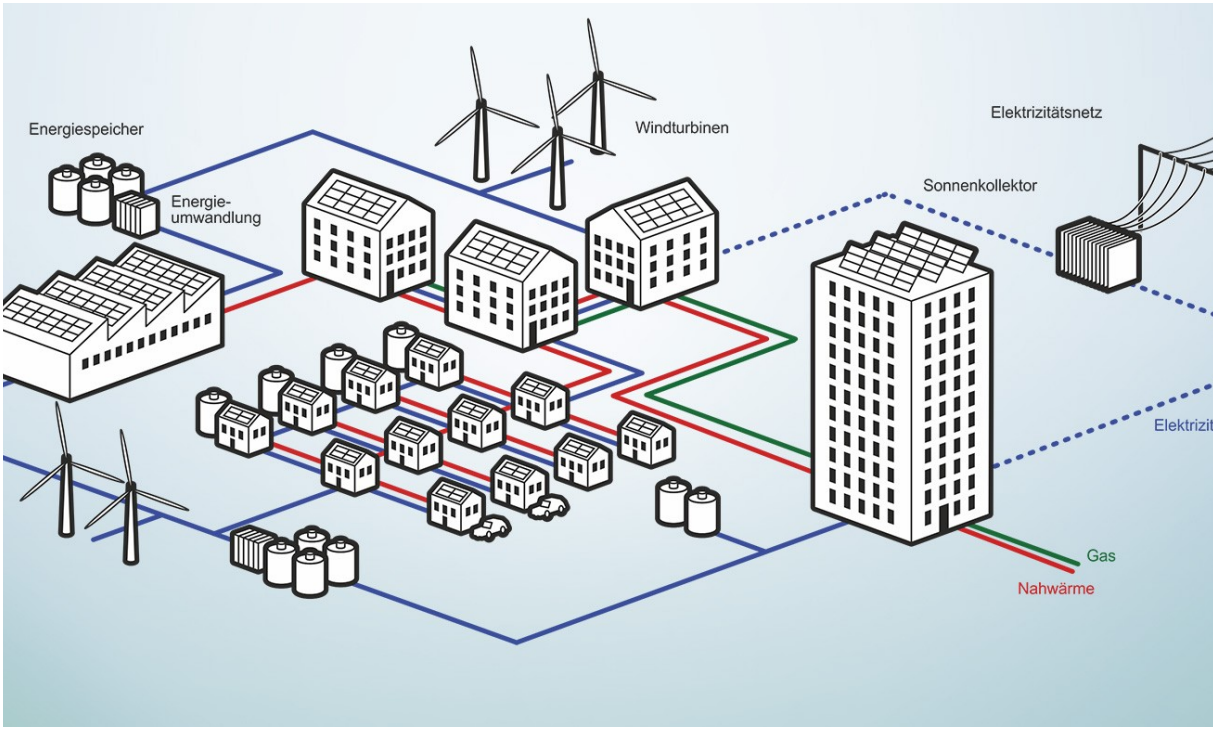
Project

Sustainable decentralised power generation

How many small power plants interact

How many small power plants interact

A decentralised energy supply must be networked. This could in future take place in the form of so-called multi-energy hubs that link together various energy systems: different small power plants and heat stores, for example. As part of a joint project, researchers from ETH Zurich have now developed a method for the planning and evaluation of such energy hubs.



Energy supply of the future: in multi-energy systems, power plants, storage technologies and consumers are linked together. *Source:* Sandro Bösch/ETH Zürich

At a glance

- Until now, it has been difficult to plan and analyse networked systems that generate energy from different sources – electricity, heat or gas, for example. This is because there was no precise method for calculating their output, total costs and impact on CO_2 emissions over the long term.
- Process engineers at ETH Zurich have now developed a method that can do this. With the help of computer models, systems for various districts can thus be planned and simulated under operating conditions.
- The researchers tested their process in two case studies: the first in the rural village of Zernez in the canton of Graubünden and the second in the urban Zurich district of Altstetten.

In future, Switzerland's energy supply will become increasingly decentralised: in addition to several large power plants, more and more small, decentralised power plants will produce energy. These will include, for example, wind and solar parks as well as photovoltaic and solar thermal systems belonging to individual residential buildings. There are also systems that balance out the fluctuations in energy production from renewable sources by storing or converting excess energy – batteries, heat storage devices, heat pumps and so-called power-to-gas systems, for example. The latter convert electricity into gases such as hydrogen or methane that can later be used at any time for heating or powering vehicles.

However, to keep the electricity grid stable in a decentralised supply set-up such as this and at the same time get the maximum from the individual plants, it becomes necessary to link the systems with one another. "We need to directly link energy generation with consumption", explains Marco Mazzotti, a professor for process engineering at ETH Zurich. This is made possible by so-called multi-energy hubs. They control the different energy systems and link them together.

Incorporate all influencing factors

Until now, it has been difficult to plan such multi-energy hubs. This is because there was no precise method that could be used to model the output of the involved systems over the long term and also incorporate future developments. Together with his colleagues at ETH Zurich, Mazzotti has closed this gap: as part of a joint project, the research team has developed a method which allows for it to be determined what an optimal multi-energy system looks like and how it can be integrated in existing infrastructure.

In performing this work, the researchers had to incorporate a large number of factors. For example, the current and future energy requirements of buildings, the potential offered by renewable resources and the current and future efficiency of energy production methods. Other aspects included short- and long-term storage technology developments as well as, last but not least, political framework conditions and acceptance within society. All of these factors were analysed in individual sub-projects and modelled in a computer program. With the help of these computer models, it is now possible to plan multi-energy hubs for a variety of districts, i.e. to determine with which types of systems a multi-energy hub will function optimally under the prevailing conditions and what amount of energy it will provide.

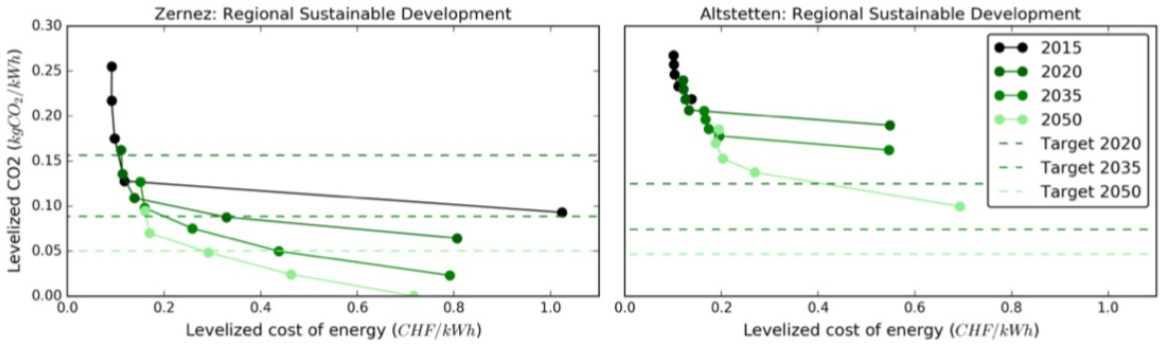
The ETH researchers tested their method as part of two case studies: one in the village of Zernez in the canton of Graubünden and one in the Zurich district of Altstetten, meaning that both but a rural and urban settlement were investigated. In both cases, the objective was to optimally utilise existing renewable energy sources with multi-energy hubs. This means that both CO_2 emissions and annual costs should be as low as possible.

What energy hubs contribute to Energy Strategy 2050

In a first step, the scientists analysed which systems for the generation, storage and conversion of energy were best suited to the respective districts. To this end, they held discussions with local stakeholders from the electricity sector, such as Elektrizitätswerke des Kantons Zürich and Energia Engiadina. They also determined the electricity yield from potential wind and solar power plants as well as the specifications for corresponding heat pumps and energy storage devices – including more short-term storage solutions such as batteries and hot water tanks as well as hydrogen storage devices which should balance out longer-team, seasonal fluctuations.

The researchers then used the computer model to simulate the operation of the selected systems. This allowed them to identify how the technologies best interact with one another: when and for how long should a heat pump run, to what extent are batteries and heat storage devices utilised and from what point is the operation of a hydrogen storage device worthwhile?

The ETH researchers compared the multi-energy hubs for Zernez and Altstetten planned in this way with the objectives of Energy Strategy 2050. To this end, they created future scenarios for the years 2020, 2035 and 2050. These showed that the numbers add up for Zernez. With the planned multi-energy hub, CO_2 emissions would come under the limits stipulated by Energy Strategy 2050. This situation is more difficult for Altstetten, however. Here, the reduction in CO_2 emissions owing to the multi-energy hub is smaller as in the urban district there are fewer opportunities to install systems for the utilisation of renewable energies.



The calculations show how the designed multi-energy hubs would impact CO2 emissions and energy costs in future: Zernez could meet the objectives set in Energy Strategy 2050. However, while Altstetten would emit less CO_2 than at present, its emissions would still be too high.
Mazzotti et al./ETH Zürich

Open-minded Swiss population

As part of a sub-project, the ETH process engineers finally investigated how well the switch to multi-energy hubs would be accepted by the population. To this end, they surveyed in excess of 1,000 people in Switzerland and just more than 500 people in both Germany and Austria. The people of Switzerland proved to be the most open-minded in this regard. The less harmful impact on the environment and climate, in particular, was rated as positive by the respondents. They also welcomed the fact that a decentralised energy supply likewise provides them with the opportunity to contribute to the energy turnaround themselves.

However, the Swiss participants in the survey are sceptical when it comes to the financing of such energy hubs. Marco Mazzotti says that a precise method for planning the systems and simulating their impact is therefore all the more important. “Our method can in principle be applied to any settlement”. At present, discussions are already under way about applying the process to the energy grid of the Hönggerberg ETH campus.

Produkte aus diesem Projekt

- Kick-Off-Poster: Electricity supply: Sustainable decentralized power generation
  Date of publication: 11.10.19
- Integration of sustainable Multi-Energy-hub Systems at neighbourhood scale (IMES)
  Date of publication: 11.10.19
- Workshop on Distributed Generation and Smart Grids
  Date of publication: 11.10.19
- Vortrag: “Die Energiewende in der Nachbarschaft”
  Date of publication: 11.10.19
- Vortrag: “distributed multi-energy-hubs”
  Date of publication: 11.10.19

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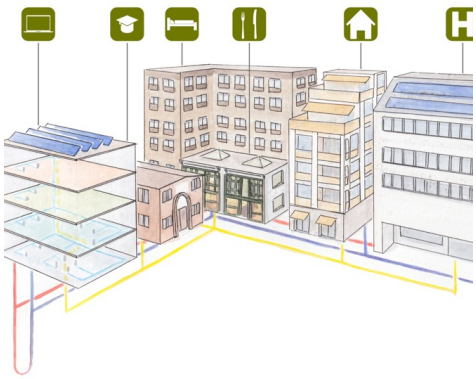
Connected projects

Multi-energy hub systems

Where Generating Power at the Neighbourhood Level Makes Sense

Technical evaluation of multi-energy hub systems

Plan renewable energies in combinations

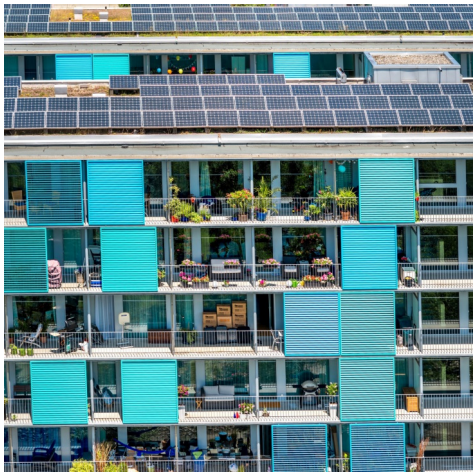


Economics of multi-energy hub systems

Renewable energies – what is most worthwhile?

Control of multi-energy hub systems

How Do Coupled Energy Systems Do What Is Expected of Them?



Multi-energy hub systems and society

Sharing solar electricity with neighbours

All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.