Energy
National Research Programmes 70 and 71

Project

Multi-energy hub systems

Where Generating Power at the Neighbourhood Level Makes Sense

Energy
National Research Programmes 70 and 71

Where Generating Power at the Neighbourhood Level Makes Sense

Decentralised renewable energy systems could drive the energy transition forward. In future, rural areas in particular could cover most of their energy needs on their own.

Photovoltaic systems could help decentralize energy generation *Source:* iStock

At a glance

- Multi-energy systems use energy from various sources and make it available locally.
- Such systems allow neighbourhoods and municipalities to cover their energy needs at least in part themselves.
- In order to create multi-energy systems, however, it is necessary to know what the energy demand is and how much potential there is for renewable energies.

As a result of the nuclear power phase-out decision and because fossil fuels release too much CO_2, the Federal Government's Energy Strategy 2050 aims to reduce energy consumption and to promote the expansion of renewable energies. The Swiss Federal Office of Energy has set targets both for the reduction of CO_2 emissions and for the development of renewable energies. Both objectives are challenges for the electricity grid that call for a restructuring of the energy system. In this context, decentralised, multi-energy-hub systems (MES) may be an important asset, as they harness energy from various sources and distribute it locally. Each of these systems has several "energy hubs", allowing neighbourhoods and municipalities to cover at least part of their electricity needs on their own.

But what is required for reasonable planning of such multi-energy systems? How can the decentralisation of the energy supply structure be accomplished? Where is solar power better suited than hydropower? Which is the most cost-effective storage technology?

The joint project "Sustainable decentralised power supply" answers these questions. Kristina Orehounig and her colleagues at the ETH Zurich have prepared two case studies and developed a detailed method to adapt decentralised multi-energy systems to the respective local conditions and to optimise them. The Altstetten neighbourhood in Zurich and the rural village of Zernez in the canton of Graubünden were studied more closely.

To plan a multi-energy system, it is essential to know how much energy is required in the given area. The Orehounig team therefore determined the evolution of the energy demand in these two regions between now and 2050. To do so, they calculated the current energy requirements for electricity, heating and hot water. To forecast the future, they took into account the annual building renovation rate as well as the increase in temperature to be expected as a result of climate change. To implement a sustainable multi-energy system, one must also know how much energy the renewable sources in the area provide. In a second step, the researchers therefore calculated the potential increase in renewable energy production both in rural and urban areas. This would make it possible to decentralise energy production, and communities could cover at least part of their energy needs on their own, without resorting to fossil fuels. The potential of photovoltaic systems on roofs and ground source heat pumps on properties was investigated for both Altstetten and Zernez. Since the potential for large hydroelectric power plants in Switzerland has largely been exhausted, the researchers contemplated the use of a small hydroelectric power plant with a capacity of 2.3 megawatts in Zernez. Wind power was also considered. As the average wind speeds in both regions are low, a wind turbine for low wind speeds was simulated.

Stable operation thanks to storage options

Stability is an important feature of decentralised multi-energy systems. This means that fluctuations between demand and production must be balanced. In summer, for example, hydroelectric power plants often produce more electricity than necessary, whereas during the winter months they produce less than needed. Short- and long-term energy storage can be a solution to this problem. The scientists examined various storage and conversion technologies in terms of their efficiency, cost and CO_2 emissions. They evaluated natural gas cogeneration plants, heat pumps, batteries and power-to-gas technologies and also analysed the impact of the injection of surplus electricity into the national grid on the development of renewable energy.

Based on this data regarding future energy requirements, on the potential of sustainable energy production and on the costs and benefits of various energy technologies, the researchers determined how the goals of the Energy Strategy 2050 can be achieved in Altstetten and Zernez. Various climate and energy scenarios were considered.

The objectives can be achieved in Zernez but not in Altstetten

The scientists conclude that Zernez can achieve the objectives in all scenarios thanks to its great potential for energy production from renewable sources. Both photovoltaic systems and small hydroelectric power plants proved to be of interest in the calculations for this region. Cogeneration plants and heat pumps are particularly suitable for heat production Wind energy, on the other hand, is not of interest due to the lack of wind. Both long- and short-term storage options proved to be appropriate. The study also underlines the role of feed-in tariffs: the injection of excess energy from renewable sources into the power grid is remunerated, thus reducing the attractiveness of energy storage at the local level.

Unlike Zernez, Altstetten fails to meet the energy targets in all scenarios. In this urban neighbourhood, increasing energy production from renewable sources is practically impossible. Energy must therefore be imported from outside the city, which is why only short-term storage is of interest in such a location. In cities, a particular problem arises due the abundance of old buildings and apartment complexes that require more energy for heating while being less suitable for photovoltaic installations. According to the investigators, this issue makes it all the more important to push ahead with the renovation of old buildings in urban areas.

The results of this project show that multi-energy systems could be used to accelerate the development of renewable energies and to convert the national energy and electricity grid. However, the extent of their contribution will depend strongly on the technical development of these systems and their market price. Currently, these systems are still relatively expensive, but technological developments are likely to contribute to a fall in price.

Produkte aus diesem Projekt

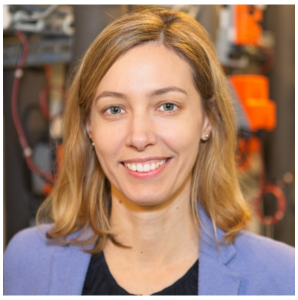
- A comparison of storage systems in neighbourhood decentralized energy system applications from 2015 to 2050
  Date of publication: 01.01.18
- Multi-Energy-Hubs in Quartieren
  Date of publication: 01.01.18
- Power-to-gas for Decentralized Energy Systems: Development of an Energy Hub Model for Hydrogen Storage
  Date of publication: 01.01.18
- Impact of Renewable Energy Potential on the Feasibility of Power to Hydrogen in Different Municipal Contexts
  Date of publication: 01.01.18
- Optimal Design of Multi-Energy Systems at Different Degrees of Decentralization
  Date of publication: 01.01.18
- Power-to-gas for Decentralized Energy Systems:Development of an Energy Hub Model for Hydrogen Storage
  Date of publication: 01.01.18
- Impact of Renewable Energy Potential on the Feasibility of Power to Hydrogen in Different Municipal Contexts
  Date of publication: 01.01.18
- Optimal Design of Multi-Energy Systems at Different Degrees of Decentralization
  Date of publication: 01.01.18
- Integration of Sustainable Multi-Energy Hub Systems (IMES-BP): Power-to-Gas for District Energy Systems from the Buildings Perspective
  Date of publication: 01.01.18
- IMES – Integration of sustainable multi-energy-hub systems at neighbourhood scale
  Date of publication: 01.01.18
- CESAR: A bottom-up building stock modelling tool for Switzerland to address sustainable energy transformation strategies
  Date of publication: 01.01.18
- A GIS based methodology to support multi-criteria decision making for the retrofitting process of residential buildings
  Date of publication: 01.01.18
- Energy system and building retrofitting solutions: From building to district scale
  Date of publication: 01.01.18
- Konzepte für die nächste Generation von technischen Regulierungen im Bereich Gebäude und Energie
  Date of publication: 12.02.20

Contact & Team

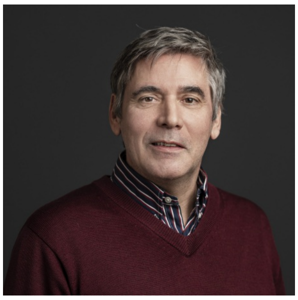
Dr. Kristina Orehounig

Head of Urban Energy Systems Laboratory
Empa - Swiss Federal Laboratories for Materials Science and Technology
Überlandstrasse 129, 8600 Dübendorf, Switzerland

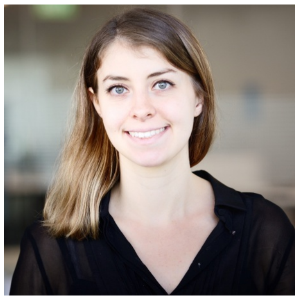
+41 58 765 43 57
kristina.orehounig@empa.ch



Kristina Orehounig
Project direction



Jan Carmeliet



Portia Murray

All information provided on these pages corresponds to the status of knowledge as of 11.06.2019.