Energy
National Research Programmes 70 and 71

Project

Hydropower and geo-energy

How water and geothermal energy should shape our electricity future

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How can Switzerland generate more electricity from hydropower without harming mountain streams? How can geothermal energy plants be constructed without triggering earthquakes? Various research teams got to the bottom of these questions as well as others.

Hydropower is a cornerstone of Swiss electricity production – and should remain so. *Source:* Shutterstock

At a glance

- As part of a joint project, researchers looked at the question of how deep geothermal energy and hydropower can achieve their objectives within the framework of Energy Strategy 2050.
- Hydropower is already a cornerstone of Swiss electricity production and should be optimised further. The objective is to increase production by 10 %.
- At present, no electricity is generated in Switzerland using deep geothermal energy. One of the reasons for this is that earthquakes can be triggered during the construction of plants.
- For the expansion of these energy sources, both technology and economic viability play a role as well as environmental protection and the involvement of the population.

Two renewable energies should play a decisive role in Energy Strategy 2050: hydropower and deep geothermal energy, where hot water from underground serves as a source of energy. As part of a joint project, researchers therefore addressed both electricity generation methods in detail. The requirements of the two energy sources could hardly be more different.

At present, hydropower is responsible for 60 % of the Swiss electricity mix. Possibilities for expansion are limited, meaning that research work is focussing on the optimisation and further development of existing power plants. The objective would be to increase production by 10 %.

The situation is very different in the case of deep geothermal energy: although it should soon take on an important role, no electricity is currently generated in Switzerland using this method. Researchers therefore looked at the question of whether geothermal energy is even in a position to in future account for a substantial share of national electricity production – as well as how it can be utilised in a safe manner.

From acceptance to economic viability

In seven sub-projects, it was researched how the objectives for hydropower and geothermal energy can be achieved. Among others, this research work looked at the aspects of economic viability, climate change, safety, environmental impacts and the acceptance of the population.

The federal government believes that geothermal energy offers great potential in Switzerland. Up to 2050, 4.4 terawatt hours of electricity is to be generated in this way – this equates to around 7 % of Switzerland's current electricity consumption. However, several attempts at exploiting this potential have failed in the recent past. In each case, the conditions encountered underground were less favourable than had been expected.

Upper Muschelkalk as a CO_2 store?

Up until recently, the Upper Muschelkalk, a rock layer situated deep beneath Switzerland's Mittelland region, appeared promising. However, researchers from the Universities of Bern and Lausanne as well as ETH Zurich discovered that it is not suitable for the generation of geothermal electricity at an industrial scale. This is because due to the high load exerted by the overlying rock layers, the pores of the Upper Muschelkalk have been compressed over millions of years. The level of permeability is too small for the operation of a geothermal plant.

On the other hand, the Upper Muschelkalk could be suitable for the storing of carbon dioxide (CO_2). The researchers concluded that around 52 million tonnes of CO_2 could be stored in an area stretching from Olten to Schaffhausen. This corresponds to the emissions of a gas-fired power plant with a capacity of 400 megawatts over 75 years.

Man-made earthquakes as a risk

A major obstacle on the way to utilising geothermal power are the earthquakes that can be triggered during the development of this energy source. In order to make underground zones permeable enough for a power plant, water is pressed into these areas at high pressure. This leads to the expansion and joining together of natural cracks. After this process led to palpable earthquakes at the surface, pilot projects in Basel and St. Gallen were discontinued.

In order to prevent this from happening in future, geologists from ETH Zurich and geophysicists form the University of Lucerne conducted a range of rock experiments under laboratory conditions. Using the data they collected, more precise simulations can be conducted in future, allowing for the earthquake risk to be reduced.

Models for risk reduction

Renewable energies also have other risks, however. ETH researchers looked at these risks. They created models with the aim of establishing how earthquakes, the bursting of reservoir dams and landslides can be better predicted and evaluated.

Using a survey, the researchers also determined how risks can best be communicated to the public. The result revealed that the population prefers the provision of numerical data and a comparison of the risks posed by different variants.

The researchers can now also quantify the uncertainties associated with their forecasts. However, when these figures are communicated, the trust of the population in the scientists and their information falls.

According to the survey, the Swiss population has a favourable stance towards deep geothermal energy – despite the earthquake risk. The survey also shows, however, that their preference is for geothermal energy plants to be installed in rural locations that are situated as far away as possible from densely populated settlement areas.

Healthier mountain rivers despite hydropower

As is the case with geothermal energy, hydropower also has an environmental impact. In order to limit the damage, the legislation in place for electricity generation states that a body of water may never be fully dried up. However, for many rivers, this legal requirement does not suffice to protect biodiversity on a sustainable basis, as ascertained by researchers from both Federal Institutes of Technology as well as the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and the University of Lausanne.

It is known that in the case of natural rivers a continuous variation in discharge volumes has a positive impact on them as habitats. If hydropower plants were to imitate these natural dynamics, their negative environmental impact could be reduced. The researchers concluded that this could be brought about through the clever use of storage basins without electricity production being hit.

The operation of water extraction points in high Alpine waters also has an impact on nature. These need to be freed from sediment on a regular basis. A surge of sand and gravel then spills into the streams and decimates the small organisms living there, such as insects.

In the current Waters Protection Act, however, neither the sedimentation issue nor the significance of variable flow rates are taken into account. According to the researchers, the legislation needs to be adjusted in these areas in order to also ensure the protection of nature in the event of greater hydropower use. The computer models developed in the projects can help in the further investigations required to this end.

Better weather forecasts for greater efficiency

Climate change is a further challenge faced by the hydropower sector. This is because the changed weather conditions affect the processes within the power plants. Researchers from the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) have therefore developed a calculation model that can forecast dry periods using real-time data up to three weeks in advance.

Such forecasts help hydropower plant operators to better estimate flow rates and make better use of the water. According to the researchers, they can therefore generate up to 4 % more income each year.

Sediments clog up turbines

Tiny particles also cause problems for the power stations: in the large Alpine plants, fine sediments from the rivers act like sandpaper against the turbines and clog them up. Due to the maintenance work required as a result, an estimated CHF 6 million is lost every year.

So-called desanding systems should actually remove a large part of the suspended load from the water – but they only do so inadequately. Using computer models, researchers from ETH Zurich have now worked out with which type of tanks the desanding process works best: suspended matter is best able to settle in long tanks in which the water flows for a long time.

Reservoirs at the site of former glaciers

The hydropower sector will primarily have to grow by increasing its level of efficiency. However, new reservoirs could also help to cover energy requirements – and especially in areas that are being released by shrinking glaciers. Researchers from ETH Zurich examined 62 glaciers beneath which new reservoirs could be built.

With seven additional reservoirs at the most suitable sites, the additional 1.1 terawatt hours per year that Switzerland wants to produce by 2035 could be generated. However, with the exception of one area at the Trift Glacier in the canton of Berne, all of the locations are situated in protected areas. Here, the construction of new reservoirs would not only be expensive, but would likely also face massive resistance in light of concerns relating to the protection of the environment and landscapes.

Produkte aus diesem Projekt

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Connected projects

Connected projects

Deep underground heat reservoirs

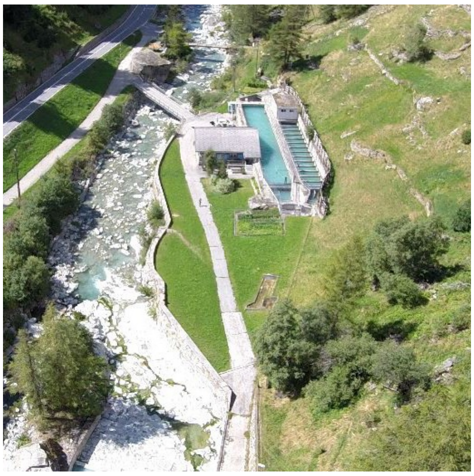
Use hot water, store CO_2 – the potential deep beneath our feet

Hydrometeorological predictions

Long-term weather forecasts for hydropower plants

Periglacial zones and hydropower

Reservoirs where glaciers once were?



Sediments in high-head hydropower plants

Tiny Particles Threaten Hydroelectric Turbines

Deep-heat mining

Geothermal energy utilisation – researched on a virtual basis

Aquatic ecosystem

Healthier mountain rivers despite more hydropower

Risk governance for geothermal and hydro energy

Earthquakes, dam failures and landslides - risk assessment for power generation

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