Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

Energy research and innovation
Report 2023

Editorial

Energy supply security and the challenges of climate change are among the most important topics in Switzerland and worldwide. Alongside the implementation of efficiency measures and the application of renewable energy technologies, energy research plays an important role. Research helps to study the increasingly complex energy system with its various interactions between a wide range of actors and different energy sectors, and to develop technical and non-technical solutions which can be successfully implemented.

The Swiss Federal Office of Energy (SFOE) has been promoting and coordinating Swiss energy research in a programmatic approach for many years and supports application-oriented research, pilot and demonstration projects as well as larger interdisciplinary research consortia. Three different funding instruments are employed for this purpose, which complement each other. This brochure presents examples of projects that are supported and closely monitored by the SFOE, representing a large number of other research, pilot and demonstration projects. The QR codes provided will take you to detailed information.

Swiss Federal Office of Energy SFOE
Section Energy research and Cleantech

(Cover picture) As part of the HyCo (Hydrogen Metal Hydrides Thermal Compressor with low Operational Costs) project, the technical and commercial feasibility of a commercial application for a hydrogen compressor based on metal hydrides is being investigated. Metal hydrides are porous materials with a high hydrogen absorption capacity. The technology has the potential to significantly reduce the costs of hydrogen compression. The compression of hydrogen using metal hydrides has the advantage that thermal energy is required. Therefore, waste heat can be utilised. GRZ Technologies SA, a spin-off from the Laboratory for Renewable Energy Materials at the Swiss Federal Institute of Technology in Lausanne, has already launched a commercial hydrogen compressor made of metal hydrides. As part of the project, a large hyco-metal hydride compressor was installed next to an existing mechanical compressor on the site of Lonza AG in Visp to enable a comparison with a state-of-the-art compressor (source: GRZ Technologies SA, E. Cavin).

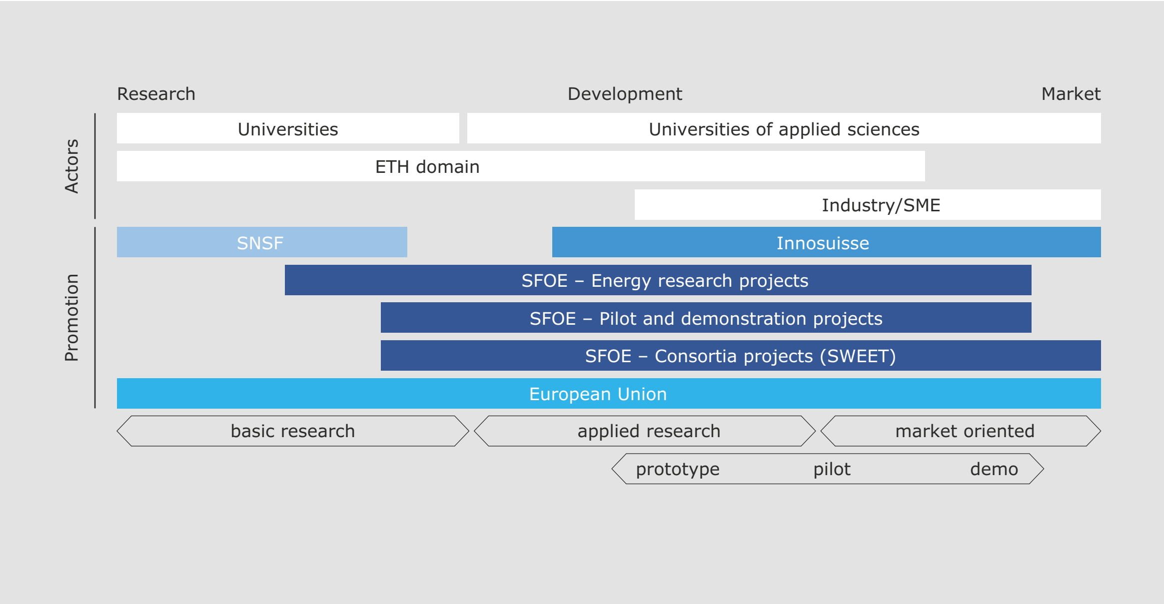
(Left) The use of photovoltaic shading devices is one measure to contribute to reducing the energy footprint and move towards nearly zero energy buildings. This by protecting buildings from direct solar radiation and overheating while producing renewable electricity on-site and increasing the users' thermal comfort. The goal of the SFOE funded project BIPVdSHADING is to demonstrate the technical and economic feasibility for an aesthetic and prefabricated BIPV (building integrated photovoltaics) dynamic shading technology by realising the system in a real building. A BIPV system was installed in the building façade of the new pavilion of Franklin University in Soregno (source: Aziende Industriali di Lugano (AIL) SA).

Content

Promotion of technology and innovation

With three complementary funding instruments for research and innovation in the energy sector, the Swiss Federal Office of Energy (SFOE) covers almost the entire technology spectrum. The SFOE is guided by its own energy research concept 2021–2024, which in turn is based on the federal government's energy research strategy. For the current period 2021–2024, an even stronger focus is put on non-technical research (SSH: social sciences and humanities). Technical sciences and SSH are to work closely together as early as the conception stage of research projects in order to orient research results towards later application at an early stage.

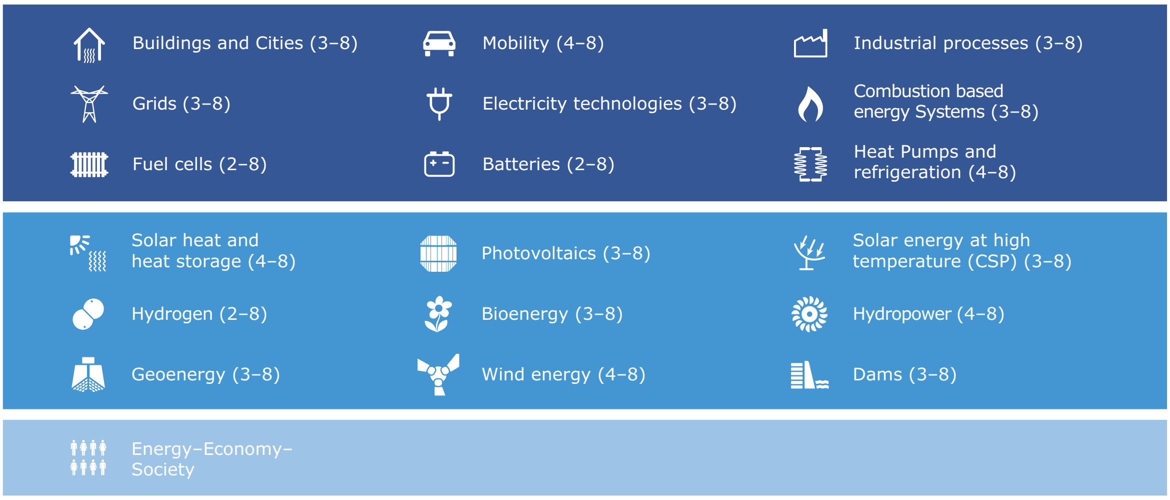
Funds from SFOE for energy research are used in a subsidising manner to close gaps in the funding landscape and thus to coordinate Swiss energy research. Currently, around 50 million Swiss francs per year are available for this and around 300 ongoing projects are closely monitored each year.



The Swiss Federal Office of Energy (SFOE) coordinates research and innovation in the energy sector across a large part of the value chain. (Innosuisse = Swiss Agency for Innovation Promotion; SNSF = Swiss National Science Foundation).

Thematic energy research programmes

With its thematically oriented energy research programmes, the Swiss Federal Office of Energy (SFOE) covers the entire spectrum of energy research in the fields of "Energy Efficiency" and "Renewable Energy". These programmes are closely linked to the SFOE's other funding instruments (Pilot and Demonstration Projects Programme and the SWEET Programme). The individual programmes are oriented along the axes of "Energy efficiency", "Renewable energy", "Humanities and social science topics", "Storage and grids". Central topics such as "digitalisation", "sector coupling" and "energy storage" are addressed across the programmes.



The SFOE's thematic energy research programmes. The numbers in brackets indicate the technology maturity level of projects funded by the corresponding programme.

Inter- and transdisciplinary energy research promotion with SWEET

The SWEET funding programme - "SWiss Energy research for the Energy Transition" - promotes inter- and transdisciplinary research consortia that are researching key questions related to the Energy Strategy 2050 and Switzerland's long-term climate strategy. Thematic calls for proposals are launched for this purpose.

Two new consortia began their work in 2023. The CoSi ("Co-Evolution and Coordinated Simulation of the Swiss Energy System and Swiss Society") consortium aims to establish sustainable collaboration between technical and scientific disciplines, economics and the social sciences and humanities. To do so, the consortium will analyse how the development of the Swiss energy system and Swiss society influence each other.

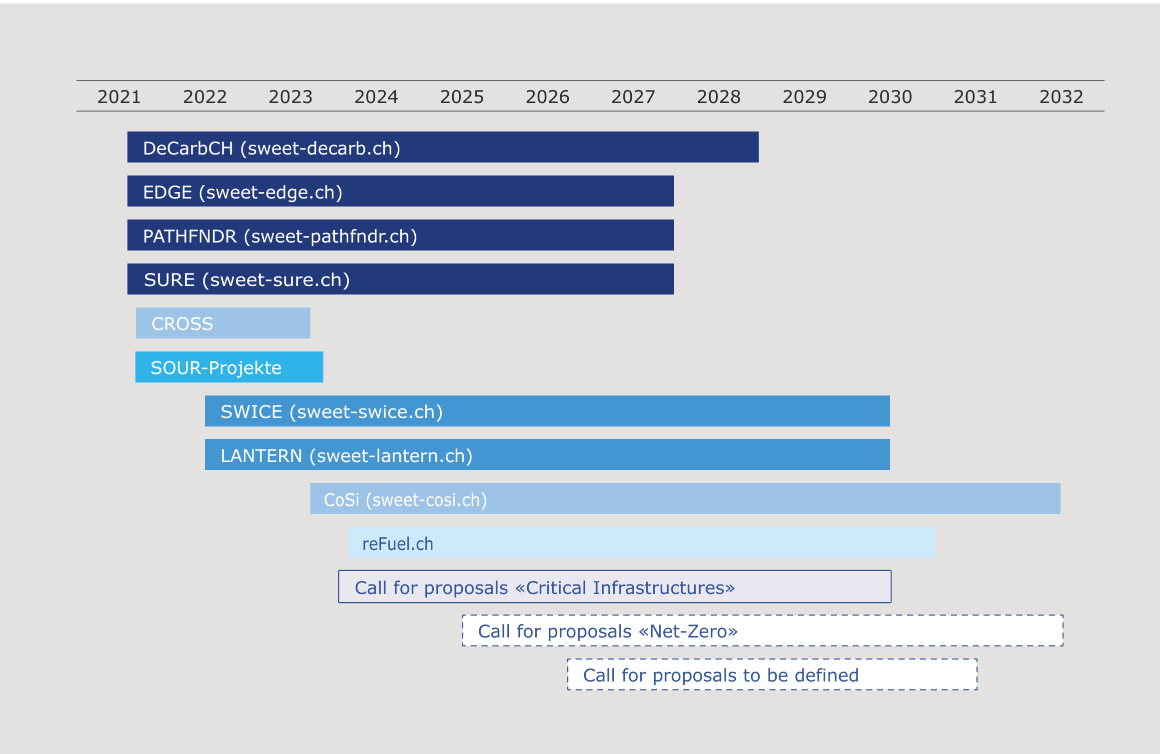
A further aim of CoSi is to incorporate findings and approaches from the social sciences and humanities into modelling and simulations. By harmonising the assumptions and scenarios, the simulation results of the research groups should also become comparable.

The second new consortium focuses on sustainable fuels and platform chemicals. ReFuel.ch ("Renewable Fuels and Chemicals for Switzerland") will investigate how investment security for sustainable fuels and combustibles can be increased by closing technical and non-technical knowledge gaps. In addition, innovative technologies that currently have a low level of technological readiness are to be further developed. The consortium aims to clarify the conditions under which the various technologies are in line with long-term climate policy goals. It also aims to increase the efficiency and load flexibility of production facilities. The researchers will develop concrete pathways for introducing sustainable fuels and platform chemicals into the energy system and other markets.

A call for proposals on the topic of "Critical infrastructures, climate change and resilience of the Swiss energy system" was launched in 2023. The future consortium is required to analyse the impact of critical infrastructures on the energy system, including the effects of climate change. It will also analyse how vulnerable the energy system is to technical, natural and social hazards and how the resilience of the energy system can be increased.

In addition to the long-term SWEET consortia, unconventional projects by individual researchers or small teams are also being funded. Four so-called SOUR projects ("SWEET OUtside-the-box Rethinking") were completed in 2023. These included the ProdUse project, in which a researcher investigated whether and how energy scenarios support decision-making processes in politics, business and society. This reveals a divide: On the one hand, there is science, which is creating ever more detailed scenarios focussing on the technical and economic perspective.

On the other side are potential users who are also interested in social science aspects and want information that is easy to understand. An example of how these two worlds diverge: There are scenarios that forecast in detail how electric motors will replace combustion engines and how this will change electricity consumption and CO_2 emissions. But what will happen if people switch to bicycles for short journeys or if cities are built in such a way that everything they need can be reached by foot in 15 minutes? Changes like these are hardly taken into account in today's scenarios, but they open up interesting solutions. Exactly these types of gaps are now to be closed by incorporating findings from the humanities and social sciences into the development of energy models. These findings from ProdUse are being incorporated into the work of CoSi.



DeCarbCH

EDGE

PATHFNDR

SURE

SWICE

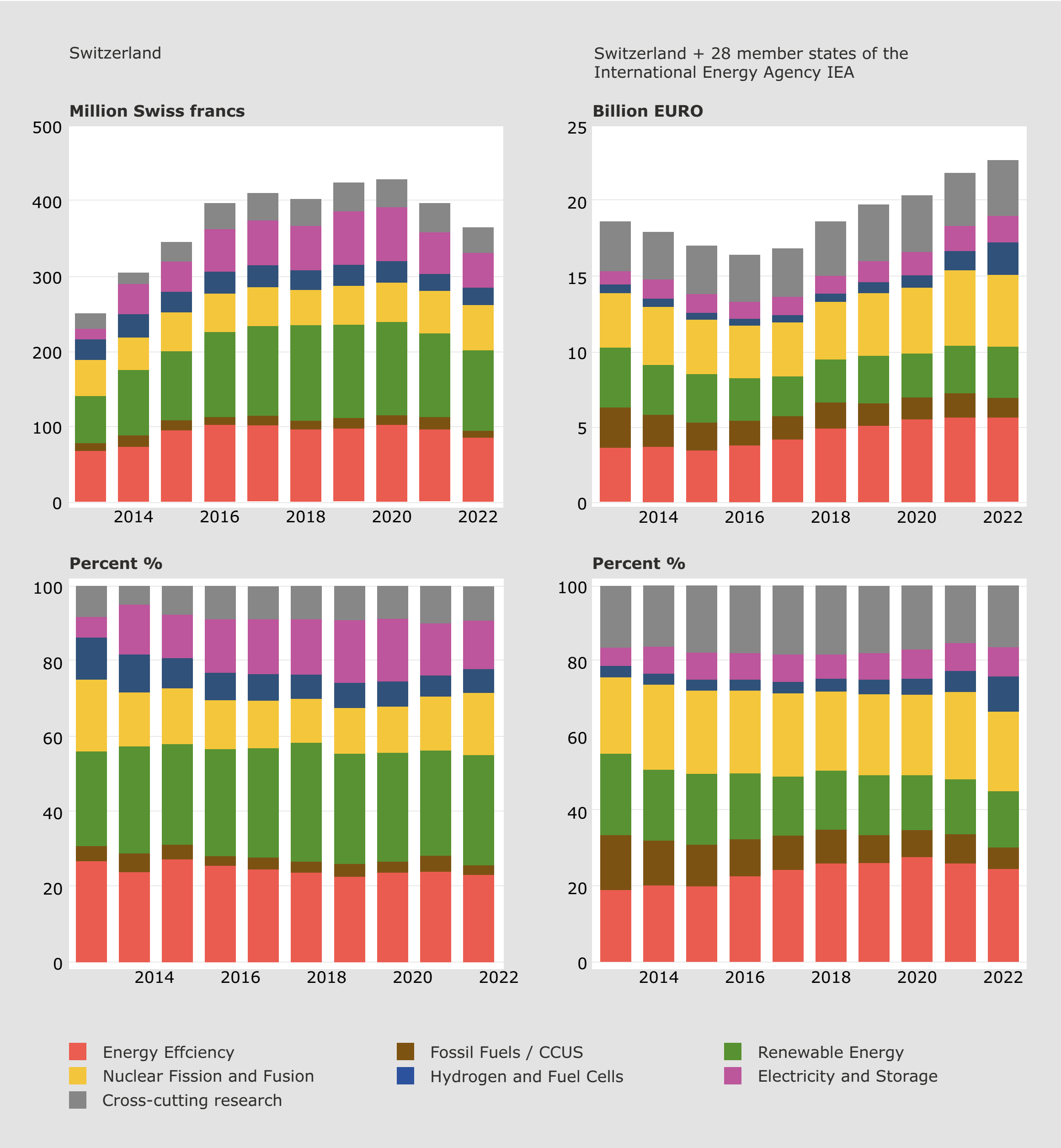
LANTERN

CoSi

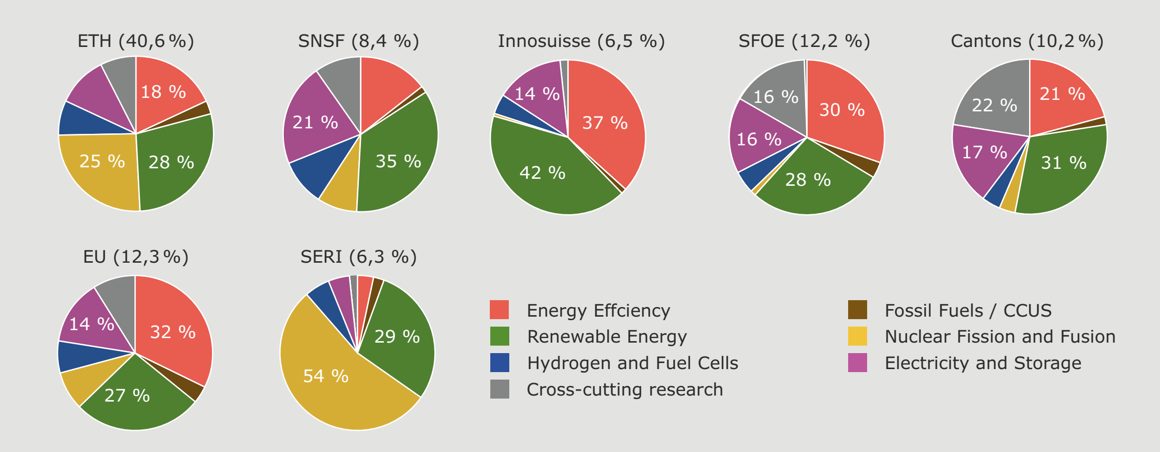
Overview of the consortia of the completed, current and planned calls for proposals of the SWEET funding programme. In 2023, the two new consortia CoSi and reFuel.ch began their work and a call for proposals on the topic of "Critical infrastructures" was launched. The consortia that started research in 2021 and 2022 are still active: DeCarbCH, EDGE, PATHFNDR and SURE are working on various aspects of the future Swiss energy system, including the decarbonisation of the heating and cooling supply, the integration of renewable energies, sector coupling and sustainability and resilience. The two consortia LANTERN and SWICE are developing new ways of living, working and mobility and solutions for a decarbonised, resource-efficient Switzerland as part of so-called Living Labs.

Swiss energy research statistics

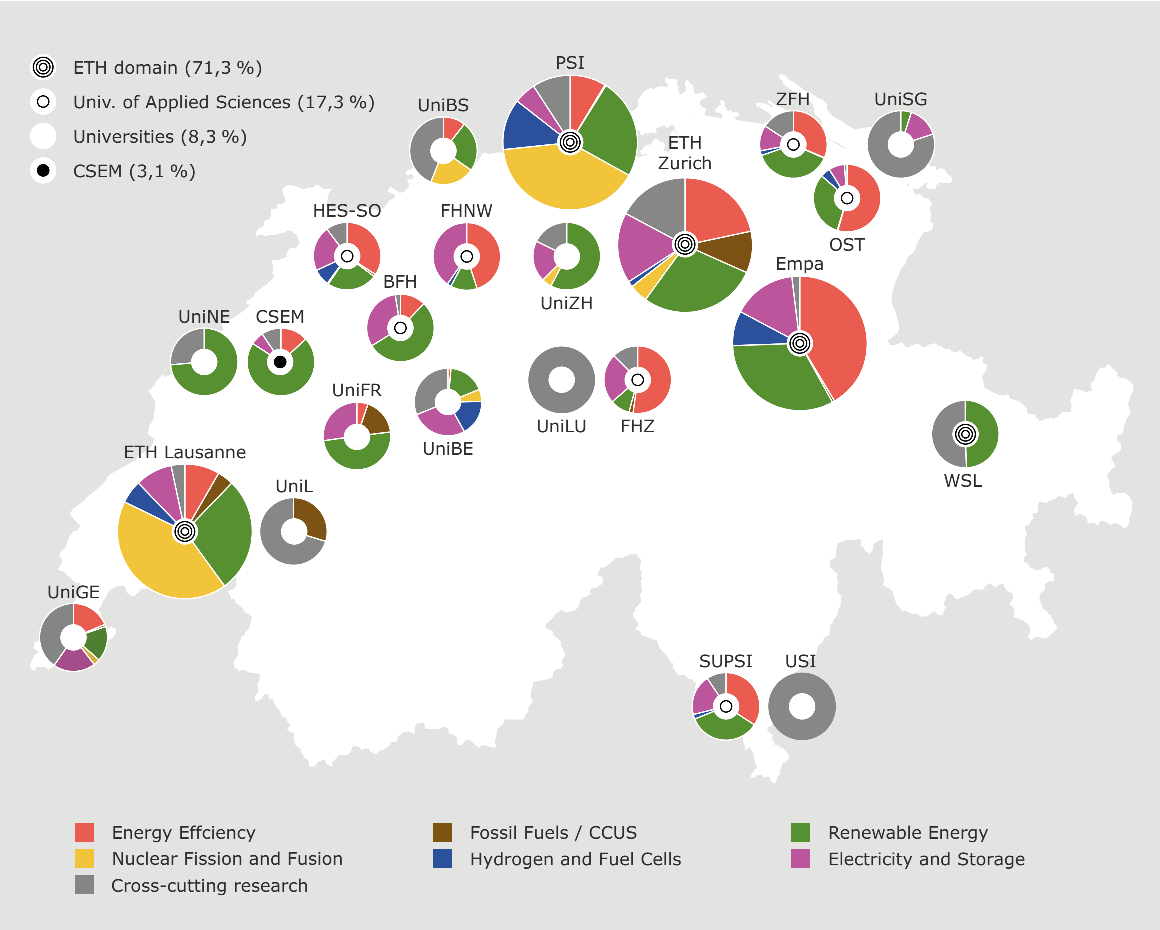
Since 1977, the Swiss Federal Office of Energy (SFOE) has been collecting data on projects that are funded in whole or in part by the public sector (Confederation and cantons), the Swiss National Science Foundation (SNSF), Innosuisse or the European Union (EU). Information on individual projects can be obtained from the publicly accessible information system of the Confederation (www.aramis.admin.ch), the SNSF (data.snf.ch), the EU (cordis.europa.eu) and the respective websites of individual institutes. In 2022, the public sector in Switzerland spent 365 million Swiss francs. At around 40.6 %, the ETH domain contributed the largest share. After the EU with 12.3 %, the SFOE had the third-largest share with 12.2 %. Of the CHF 30.5 million spent by the SFOE, around CHF 12.4 million went to projects in the field of energy efficiency, CHF 10.4 million to renewable energy projects and CHF 7.3 million to projects in the area of social sciences.



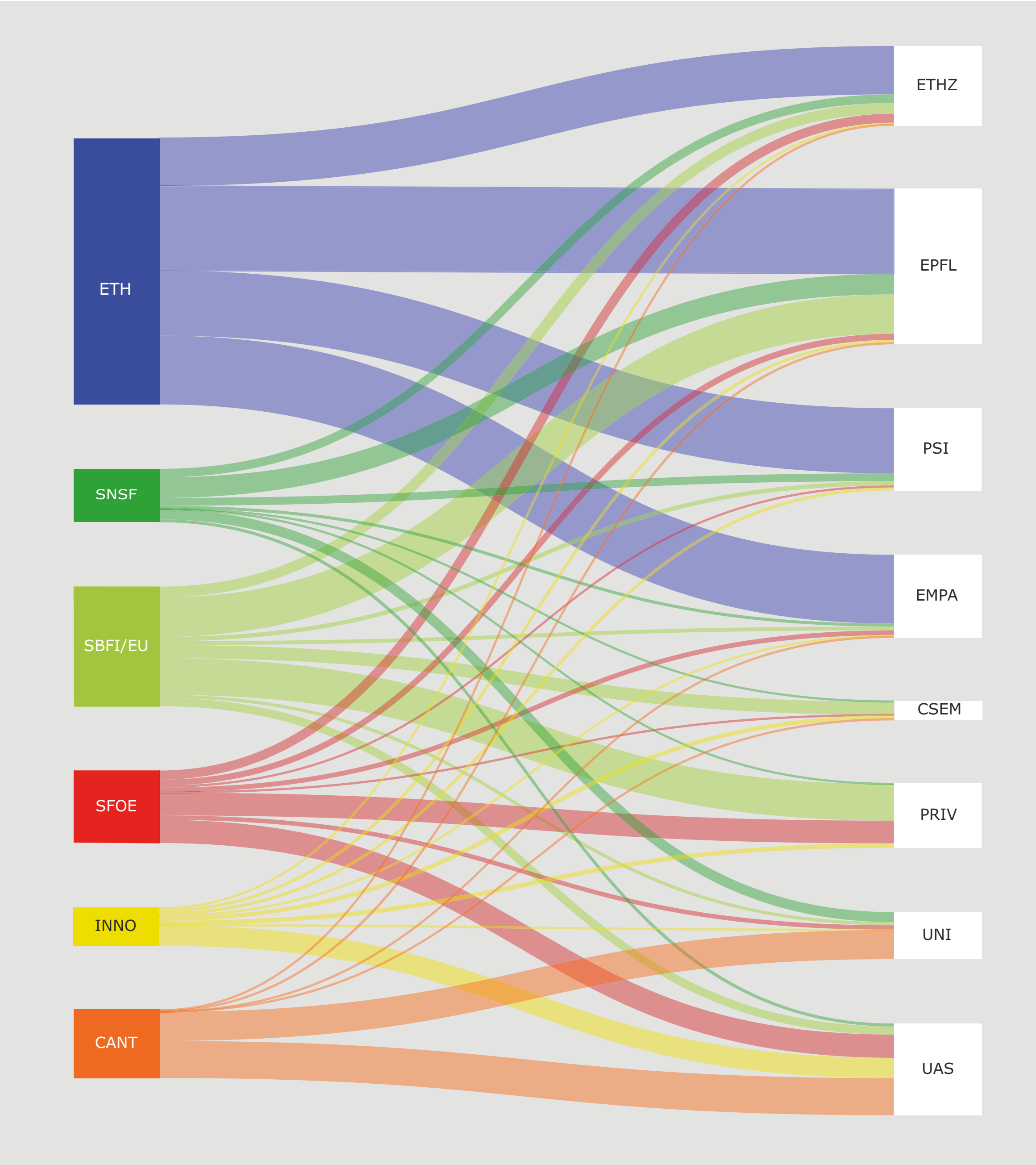
Public funds spent on energy research in Switzerland (left) and in 29 member countries of the International Energy Agency (IEA) (right). Swiss expenditure is in the range of 0.3 to 0.65 per mille of the gross domestic product. The funds are broken down according to the classification of the IEA (source: SFOE energy research statistics).



Public funding for energy research (data 2022) by funding agency and thematic area. Around 40 % of the funding for energy research in Switzerland comes directly from the ETH Domain, and around 10 % from cantonal funding for universities of applied sciences and universities. The rest is competitive funding. ETH: Council of the Swiss Federal Institutes of Technology, SNSF: Swiss National Science Foundation, Innosuisse: Swiss Agency for Innovation Promotion, SFOE: Swiss Federal Office of Energy, EU: European Union, SERI: State Secretariat for Education, Research and Innovation (source: SFOE energy research statistics).



Various energy research topics at Swiss universities (data 2022). The topics are broken down according to the classification of the International Energy Agency (IEA). Most of the public energy research (71 % of the public funds used) takes place in the ETH Domain. BFH: Bern University of Applied Sciences, CSEM: Centre suisse d'éléctronique et de microtechnique, EMPA: Swiss Federal Laboratories for Materials Testing and Research, EPFL: Swiss Federal Institute of Technology Lausanne, ETHZ: Swiss Federal Institute of Technology Zurich, FHNW: University of Applied Sciences Northwestern Switzerland, FHO: University of Applied Sciences Eastern Switzerland, FHZ: University of Applied Sciences of Central Switzerland, HES-SO: University of Applied Sciences of Western Switzerland, PSI: Paul Scherrer Institute, SUPSI: University of Applied Sciences of Italian-speaking Switzerland, UniBE: University of Bern, UniBS: University of Basel, UniFR: University of Fribourg, UniGE: University of Geneva, UniLS: University of Lausanne, UniLU: University of Lucerne, UniNE: University of Neuchâtel, UniSG: University of St. Gallen, UniZH: University of Zurich, USI: University of the Italian-speaking part of Switzerland, ZFH: Zurich University of Applied Sciences (source: SFOE energy research statistics).



Where does the public funding for energy research in Switzerland come from and where does it go? A large part comes directly from the ETH Domain. Funds from private sources, such as own contributions to Innosuisse projects or pilot and demonstration projects of the SFOE, are not included. Cash flows of less than CHF 0.2 million are not shown.

Source of funds: ETH: ETH Board, SNSF: Swiss National Science Foundation, SERI/EU: funds from European projects or from SERI (State Secretariat for Education, Research & Innovation), SFOE: Swiss Federal Office of Energy, INNO: Innosuisse, CANT: cantons.

Use of funds: PSI: Paul Scherrer Institute, EMPA: Swiss Federal Laboratories for Materials Testing and Research, ETHZ: ETH Zurich, EPFL: ETH Lausanne, PRIV: Private Sector, CSEM: Centre Suisse d'Electronique et de Microtechnique, UNI: Universities, UAS: Universities of Applied Sciences, (source: SFOE energy research statistics).

(Right) In the project DemoUpCARMA, CO_2 is injected into the basaltic underground. The CO_2 is then permanently stored through mineralisation (source: DemoUpCARMA/ETH Zurich).

Storing CO_2 in Icelandic basalt

A pilot project shows that carbon dioxide (CO_2) can be captured in Switzerland, transported to Iceland and then stored underground. Although the carbon footprint is positive, the project has also identified various points that still need to be clarified for a large-scale implementation.

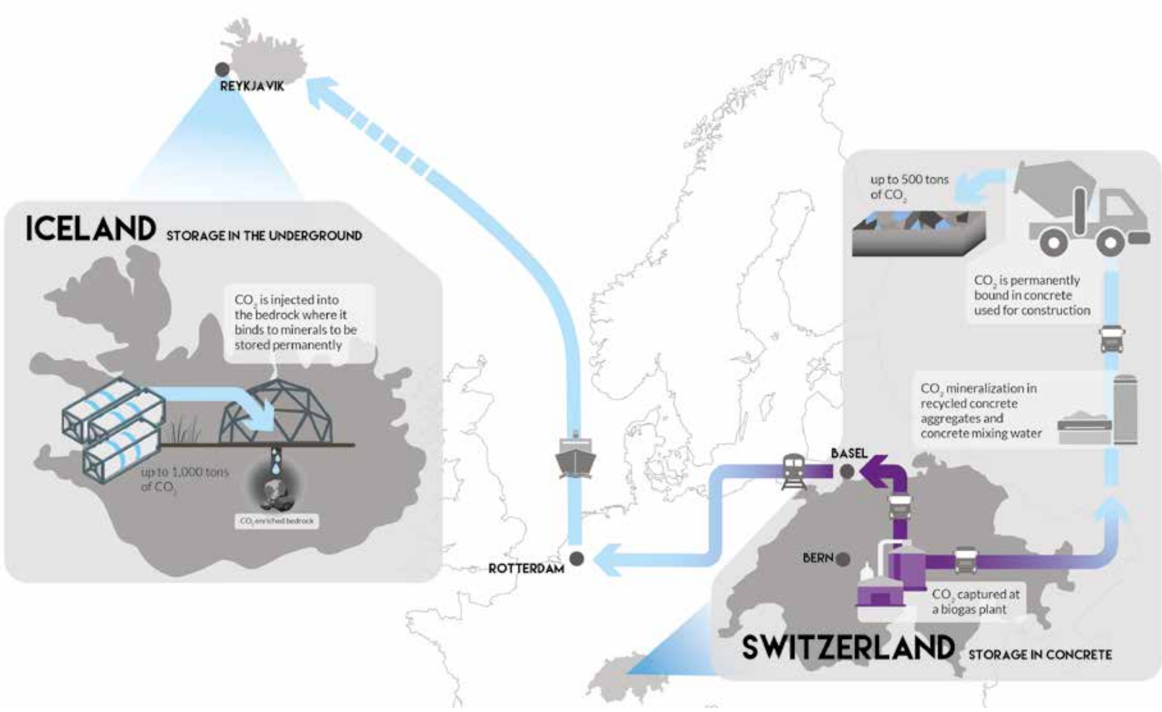
In order for Switzerland to reduce its greenhouse gas balance to almost zero by 2050, emissions must be avoided wherever possible. Solutions are also needed to offset emissions that are difficult to avoid. With the pilot project DemoUpCARMA (Demonstration and Upscaling of Carbon dioxide Management solutions for a net-zero Switzerland), which is supported by the federal government, science and industry, researchers under the lead of the Swiss Federal Institute of Technology Zurich (ETH Zurich) are investigating how two methods for storing CO_2 can be implemented on a large scale. In addition to the storage of CO_2 in concrete in Switzerland, the project is examining the transport and permanent storage of CO_2 in a geological reservoir in Iceland.

New injection process

One sub-project demonstrates the feasibility of this CO_2 supply chain. This involves liquefying CO_2 from biological material on site at the Bern wastewater treatment plant and transporting it to Iceland in containers by truck, rail and ship. At an existing site, the CO_2 is mixed with fresh water and pressed into the basaltic rock underground, a process known as injection. Chemical processes bind it to minerals and store it permanently. In addition, the researchers are testing a process at a new location for the first time in which CO_2 is dissolved in seawater and injected underground. Another sub-project will investigate until the end of 2024 how well the injections and the mineralisation process work with this new method.

Technically feasible

The findings to date show that the entire CO_2 supply chain, from capture to storage, is technically and ecologically feasible. The carbon footprint is positive, even though 200 to 250 kg of CO_2 are produced per tonne of stored CO_2. The majority of this is caused by the transport, which still requires fossil fuels. If these are replaced by renewable energies in the future, these emissions will be reduced. Because biogenic CO_2 was used for the pilot project, it was even



DemoUpCARMA studied two methods of permanent CO_2 storage: in concrete in Switzerland and the transport and permanent storage of CO_2 in a geological reservoir in Iceland (source: DemoUpCARMA/ETH Zurich).

At two locations in Iceland, the CO_2 is mixed with fresh water and, for the first time, with seawater and injected into the basalt (source: DemoUpCARMA/ETH Zurich).

possible to generate negative emissions. The costs per tonne of stored CO_2 currently amount to several hundred francs, although this is due to the pilot nature of the project. One can assume that these costs are likely to fall if storage takes place on an industrial scale. However, the pilot project also shows that there are still unresolved issues. These include the different legal regulations in Switzerland and the EU, gaps in the knowledge of all those involved, but also the development of systematic CO_2 tracking.

By the end of the DemoUpCARMA project in September 2024, the research team will collect further data on the economic viability and ecology of the CO_2 supply chain and carry out a final assessment. The findings will serve as the basis for further steps towards large-scale operation.

The liquefied CO_2 is transported from Switzerland to Iceland in special containers by truck, train and ship (source: DemoUpCARMA/ ETH Zurich).

The pilot project was carried out on the "Energypolis" campus in Sion (dark building in the centre of the picture). The EPFL Valais and the HES-SO Valais are located there (source: HES-SO Valais-Wallis).

Easier installation of pipes for district heating

Low temperature thermal networks - so-called anergy networks - are usually run with water. A project in Valais shows that they also work with carbon dioxide (CO_2). Because CO_2 has a higher energy density than water, there are advantages, especially in urban areas.

Supplying buildings with renewable heating and cooling is one of the major challenges of the energy transition. In Switzerland, district heating and cooling networks can make an important contribution to this. These so-called thermal networks generally connect a centre that generates energy with the buildings that consume the energy. The advantage of this is that not every building needs its own renewable energy source such as groundwater, geothermal energy or waste heat. Instead, these are tapped centrally and the generated energy is then distributed via pipes.

Water needs thick pipes

In thermal networks, water is usually used to transport energy. It is heated to a certain temperature in the centre by heat pumps or heat exchangers and then transported to the individual buildings. There, heat is extracted for heating or hot water. In the process, the water in the thermal network cools down slightly. It is then fed back to the centre, where it is reheated. This creates a cycle that supplies an area, a neighbourhood or an entire district with energy.

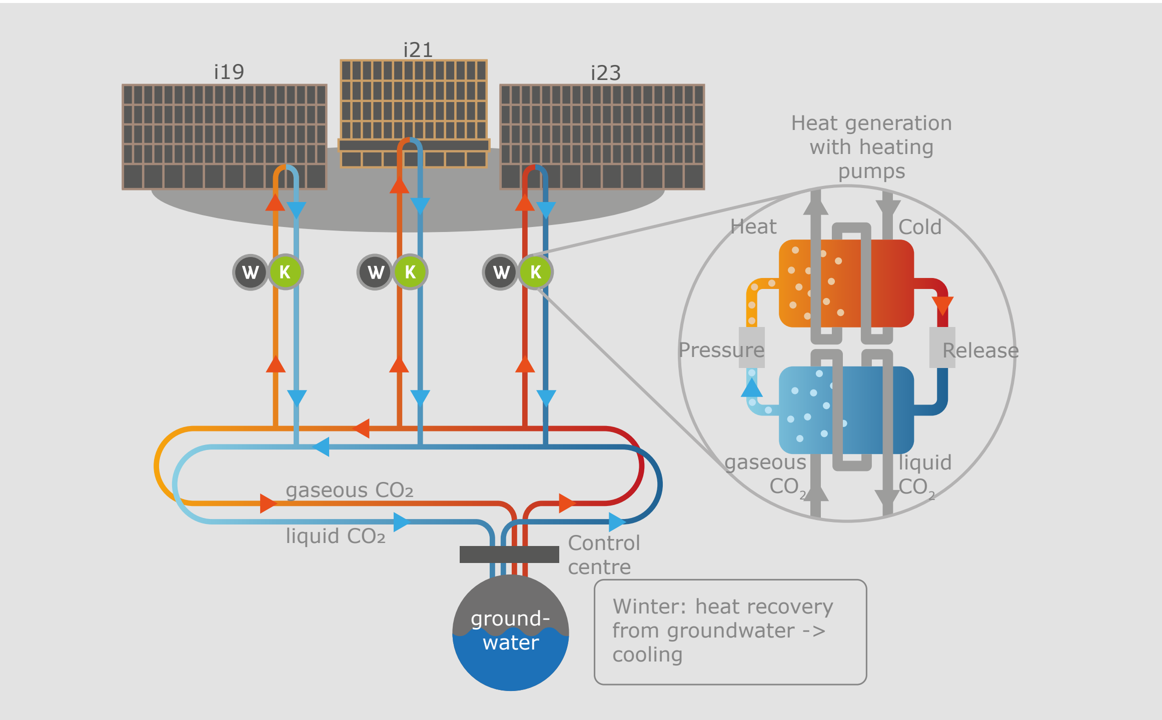
In general, water is very well suited to transporting heat: it is available (almost) everywhere, is inexpensive and poses no risk to the environment in the event of a leak. However, water also has some disadvantages, particularly for the construction of pipes. For example, the pipes for heat distribution need to be quite large to ensure that enough water can flow through them. They also need to be heavily insulated to prevent the heat from escaping. Such pipes can therefore be up to 40 cm in diameter, which is quite large for the limited space underground. In addition, unless glycol water is used, the pipes have to be laid quite deep into the ground to protect them from frost. This means that planning and laying new pipes for a thermal network is quite costly - both in terms of time and money.

CO_2 as an alternative

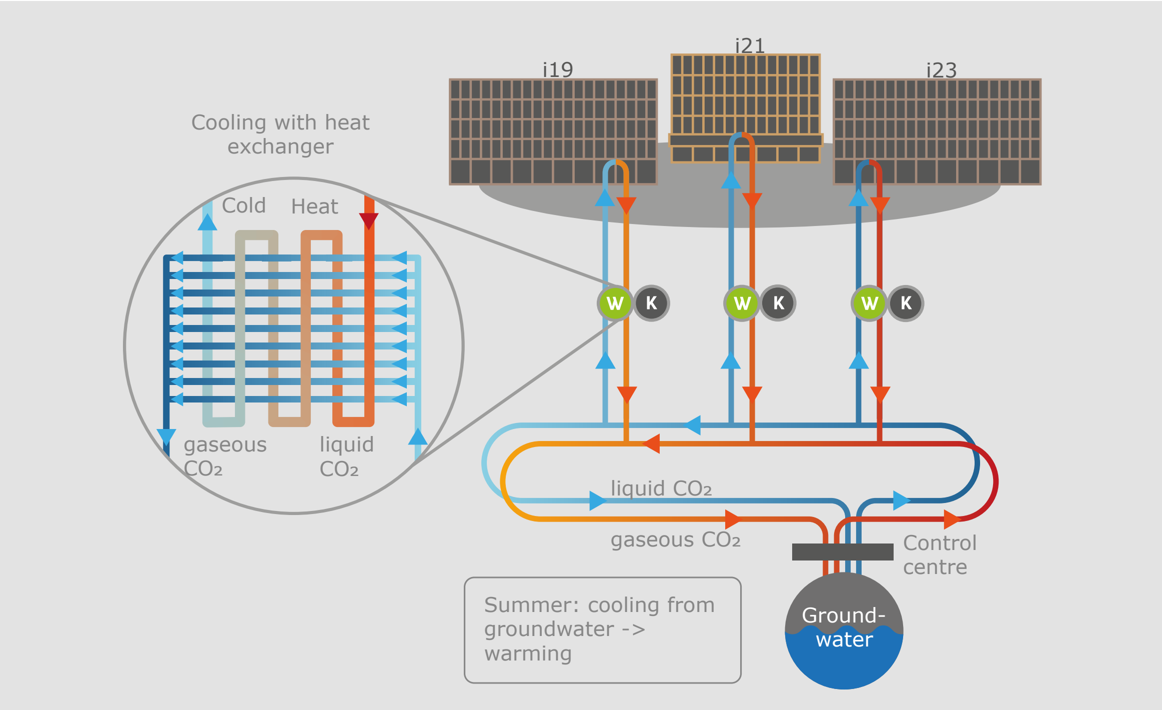
A pilot project supported by the Swiss Federal Office of Energy was carried out in Valais in 2022/2023 to find out whether pipeline construction using a heat transfer medium other than water would be easier. The universities HES-SO Valais-Wallis and EPFL Valais and the industrial partners Zero-C, ExerGo and OIKEN were involved. In the project, three buildings on the joint campus of the two universities in Sion were connected to a thermal network that is operated at a very low temperature level - a so-called anergy network. CO_2 is used as the carrier medium.

The CO_2 energy network consists of two separate circuits that connect the control centre with the substations of the three buildings. Liquid CO_2 circulates in one circuit and gaseous CO_2 in the other. If a building needs to be heated, the circuit with the gaseous CO_2 is tapped (see graphic below). The heat pump in the building's substation cools the CO_2 until it condenses, i.e. becomes liquid. During this transition from gaseous to liquid, a lot of heat is released, which the heat pump uses to heat the building's heating circuit. The liquefied CO_2 is pumped back to the centre in the anergy network. There, a heat exchanger heats the liquid CO_2, which has a temperature of around 7 °C, using an external energy source to turn it back into a gas and start the cycle all over again. In the pilot project in Sion, groundwater at a temperature of 10 to 12 °C serves as the energy source.

If a building needs to be cooled, the liquid CO_2 cycle is activated. The processes are exactly the opposite



Heating: When gaseous CO_2 cools down, it condenses. This change from gaseous to liquid releases heat that can be used to heat buildings (source: HES-SO Valais-Wallis, edited).



Cooling: When the liquid CO_2 is heated, it vaporises and becomes gaseous. This process releases cold, which can be used to cool buildings (source: HES-SO Valais-Wallis, edited).

of those for heating (see graphic above). The building's cooling system transfers heat to the liquid CO_2 in the network, causing it to vaporise. The heat contained in the gaseous CO_2 can in principle be used for heating in other buildings. If there is no need for this, the gaseous CO_2 is returned to the centre at a temperature of around 15 °C, where it is cooled and liquefied by the groundwater via a heat exchanger. The cycle starts over again. The excess heat is released back into the groundwater.

Less space required

The use of CO_2 as a carrier medium instead of water offers various advantages. Vaporising one kg of CO_2 releases or binds significantly more heat than heating or cooling the same amount of water. As a result, less mass has to be transported through the network, which means that the pumps require less energy and energy costs are reduced. Another advantage is that the diameter of the pipes for the CO_2 is only a third of the diameter of the water pipes and therefore less space is required. And because CO_2 doesn't freeze before it reaches -78.5 °C, the pipes can be laid closer to the surface than water-bearing pipes. This can significantly reduce the effort and costs involved in installing the pipes and enables faster planning and implementation, especially in densely populated cities with little available space.

Existing potential

The energy outputs of heat pumps are similar for anergy networks with CO_2 and those with water. The pipework

The inner pipe carrying the CO_2 is surrounded by another pipe for safety reasons. Both pipes can withstand a pressure of 90 bar (source: HES-SO Valais-Wallis).

The white pipes were laid underground from the coil and now transport the CO_2. Thanks to the smaller cross-section compared to water pipes, fewer deep excavation pits had to be dug (source: HES-SO Valais-Wallis).

costs are around half of those for the CO_2-based systems, but the costs for the substation are around 25 % higher. The construction time for CO_2-based anergy networks is likely to be significantly lower than for conventional ones, although this still needs to be proven in practice. According to the research team, experience from commercial operation is the next step in order to gain insights into the regulation and dimensioning of the lines, among other things. However, the project in Valais has made it clear that CO_2 energy grids have the potential to simplify and accelerate the decarbonisation of the heat supply.

In the energy centre of the anergy network, the groundwater cools or heats the CO_2 via a heat exchanger (source: HES-SO Valais-Wallis).

The outlet of the bypass tunnel on the Albula, through which the debris is channelled past the Solis dam (source: VAW ETH Zurich).

A water slide for stone and gravel

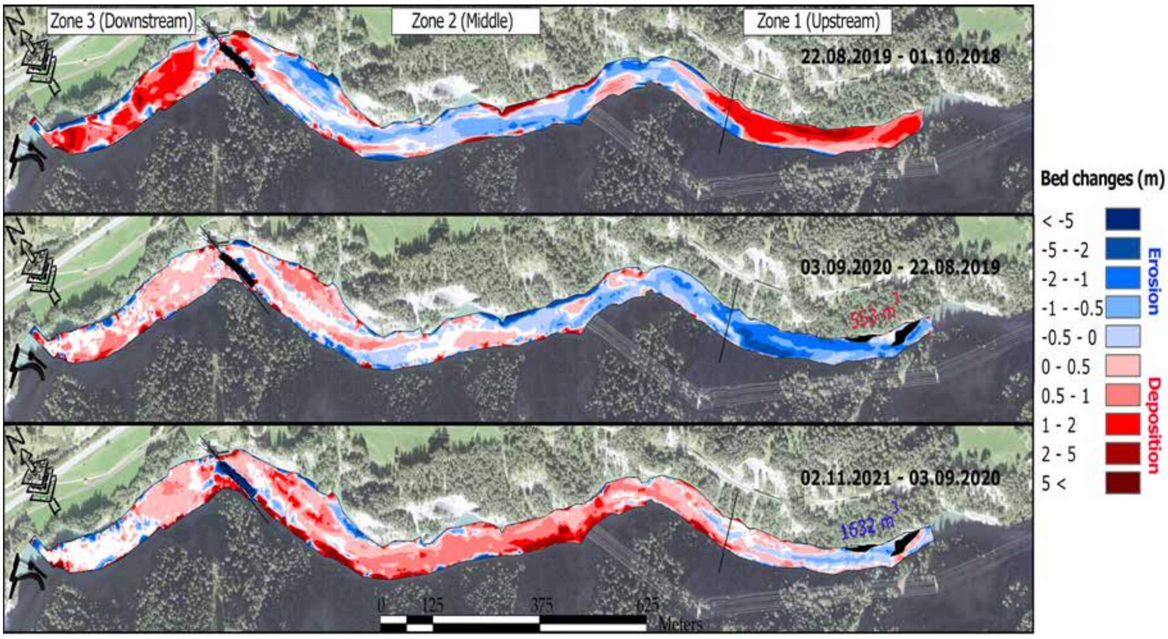
More than half of Switzerland's electricity requirements are covered by hydropower. For the security of supply, it is therefore important to maintain, modernise and expand the capacities in the domestic power plant park. Using the Solis reservoir as an example, the Swiss Federal Institute of Technology Zurich (ETH Zurich) has researched how the storage volume - with a bypass tunnel for the sediment - can be maintained in the long term and even increased again after silting up.

Utilising hydropower sustainably means protecting ecosystems as much as possible. In the Albula Valley in Central Grisons, both interests are combined. In 2012, the Solis reservoir was equipped with an additional tunnel that can divert the bedload from the tributaries past the dam. This bypass fulfils an ecological requirement in the National Water Protection Act: Stones, gravel and fine sand do not remain in the retention barrier, but also provide dynamic habitats in the riverbed below the dam.

The structure has an equally significant economic benefit for hydropower. The Solis reservoir silted up for a long time. Its volume shrank by around 50 % within 25 years. However, since the tunnel was put into operation, most of the bedload has been channelled past the dam. Researchers at ETH Zurich were able to measure this effect: During floods, the sediment tunnel channels a large proportion of the bedload directly into the riverbed below the dam. At other times, only a small amount of material is deposited in the reservoir.

Floods as a lucky chance

The RESEMO research project also investigated how much water flows through the tunnel and is thus lost for electricity production. Between 2018 and 2021, ETH hydraulic engineering researchers collected a lot of data on water runoff and bedload transport using several random samples. Three



A result from the research project: bedload deposition (red) and bedload erosion (blue) in the Solis reservoir for three periods in the period from 2018 to 2021. The black dotted line in the lower area of the reservoir indicates the tunnel inlet (flow direction: from right to left; source: VAW ETH Zurich, edited).

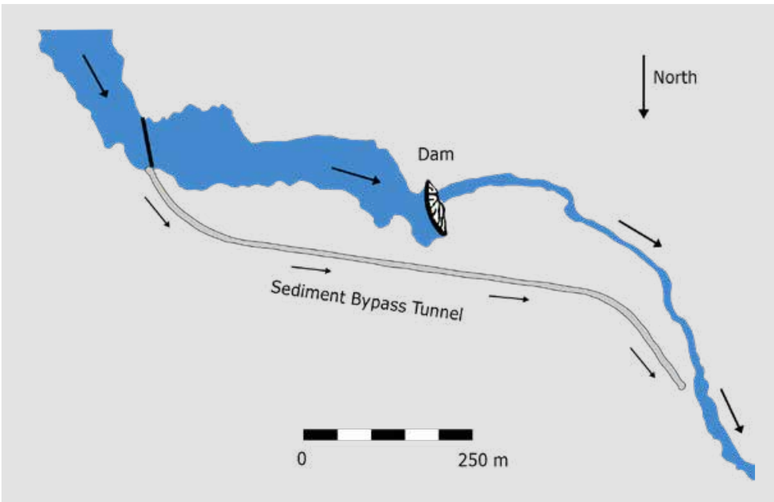
flood events that occurred during the research campaign proved to be a stroke of luck, as this is the only time the sediment tunnel is put into operation and the reservoir is partially lowered at the same time. The data obtained during these events contributed greatly to proving the bypass effect.

One key result is that the tunnel not only diverts the bedload carried by floodwaters, but also washes away rock that sedimented in the lake bed in earlier periods. According to the data collected, the extent of the flushing effect depends largely on the level of the reservoir: the lower the water level, the better the additional tunnel flushes. This finding plays into the hands of the power plant operator: during floods, the operator has to decide how to discharge excess water anyway. Now he knows: A short-term lowering of the water level clears out the lake bed.

Maintaining capacity

Finally, the ETH researchers were able to show that a bypass tunnel does not disrupt the operation of a reservoir in any other way. Although the necessary lowering of the lake level reduces electricity production in the short term, the measure preserves storage capacity in the long term. To prevent the usable volume from dwindling, the lake would otherwise have to be extensively dredged every few years

The research project in the Albula Valley is groundbreaking for the future of domestic hydropower. On one hand, comparable bypass tunnels are in operation at ten locations; on the other hand, climate change and glacier retreat are increasing the bedload in Alpine waters. Power plant operators are now better equipped to deal with this. A bypass tunnel like the one on the Albula provides valuable services as a "slide" and " vacuum cleaner" for stones, gravel and other debris. As a result, almost nothing is left behind to favour the silting up of reservoirs.



Situation of the Solis reservoir in the Albula valley with the schematically drawn diversion tunnel (source: VAW ETH Zurich, edited).

Wood as a building material is significantly less energy-intensive to produce than concrete and has a significantly lower impact on the climate: Unterfeld development in Steinen (SZ) (source: Holz100 Schweiz AG).

Construction and renovation with almost zero greenhouse gas emissions

If Switzerland is to achieve its climate targets by 2050, buildings must not only be operated in an energy-efficient and climate-friendly manner, they must also be constructed in such a way. With the right materials and concepts, greenhouse gas emissions from the constructi-on of buildings can be reduced by up to 40 %.

The approximately 2.3 million buil-dings in Switzerland are responsible for around 45 % of energy consump-tion and a third of domestic green-house gas emissions. Thanks to tight, insulated building envelopes, efficient building technology and the use of renewable energies, energy consumption and the resul-ting greenhouse gas emissions for the operation of buildings have fal-len steadily in recent decades.

As a result, the construction process has become more important: if one considers the entire life cycle of a building, today more than half of the energy consumption and green-house gas emissions can be attribu-ted to its construction, depending on the quality standard and cons-truction method. These so-called "grey" emissions are generated during the production, transport and disposal of building materials as well as during construction. If we are to achieve the ambitious net-zero target, construction and renovation must become significantly more climate-friendly.

Creating a data basis

The ZeroStrat study by the consultancy firm intep and the Swiss Federal Institute of Technology Zurich aims to make a contribution to this. In the first phase of the project, the researchers looked for building materials and components that have the least possible impact on the climate. In addition to the proportion of grey emissions, they also assessed how readily available the required bio-based raw materials are, how they affect the construction time and how suitable they are for reuse or recycling. The project team also analysed a selection of innovative building materials such as CO_2-storing concrete, insulating panels made from grass and hemp or prefabricated components made from clay, wood and straw. Where the necessary data for the ecological assessment of such alternative building materials was lacking, the researchers worked with the manufacturers to gather it.

Great potential

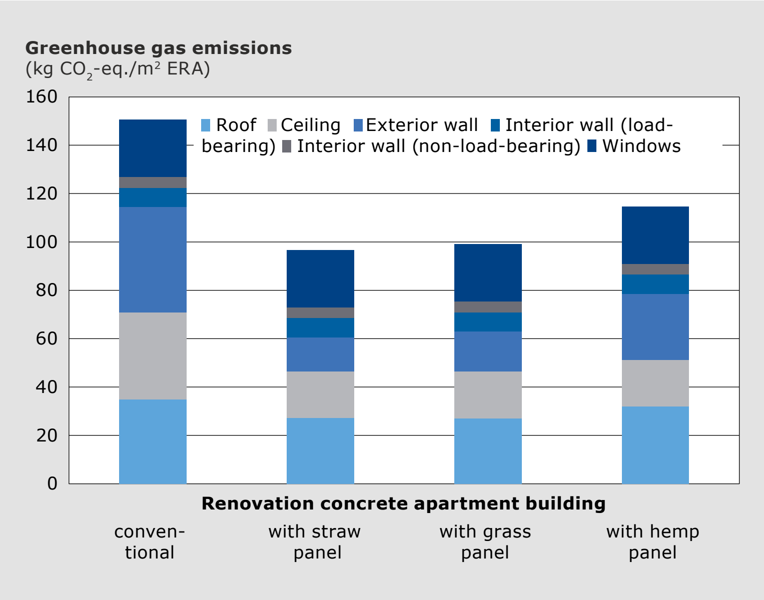
In the second phase of the project, the researchers analysed the extent to which greenhouse gas emissions are reduced by using ecological building materials. Only the shell of the building was analysed, without the interior construction and building services. Using the example of an apartment block, they calculated the emissions for various insulation materials:

- a new concrete building,
- a new wooden frame building and
- the refurbishment of an existing concrete house.

This showed that the potential of alternative insulation materials is large: they can reduce the greenhouse gas emissions of a new concrete shell building by up to 40 %. In the case of a wooden shell, up to 45 % is possible (see graphic on p. 22).

Reusing instead of demolishing

However, if greenhouse gas emissions in construction are to be reduced to almost zero, the use of sustainable building and insulation materials in new buildings alone is not enough. The most effective strategy is to preserve the existing building structure for as long as possible by repurposing, extending or renovating the buildings. This is also confirmed by the model calculations for thermal renovation: if an existing concrete shell building is



When thermally renovating a concrete building, greenhouse gas emissions are reduced by up to a third by using sustainable insulation materials such as straw, grass or hemp (graphic: ZeroStrat final report, edited).

re-insulated with conventional glass wool and continues to be used, this causes 65% fewer grey emissions than if a new concrete building of the same size is built. If, for example, straw insulation boards are used to insulate the existing building, grey emissions are reduced by as much as 78 % (see graphic on p. 23).

However, if a new building has to be constructed anyway, the design of the building is a major lever: a single large building with an optimum number of residential units performs better in terms of grey emissions than many small buildings with the same number of residential units. In principle, the ratio between the building envelope and the energy reference area should be as small as

Lightweight construction, such as the wooden frame construction with straw insulation shown here, generally has a lower impact on the climate and environment than solid construction with ceramic or mineral building materials such as bricks or concrete (source: Shutterstock).

possible. The energy reference area is the sum of all surfaces that are heated or air-conditioned. A lightweight construction, in which only the load-bearing elements are made of wood, steel or concrete, has a better greenhouse gas balance than a solid construction, in which the walls and ceilings are made entirely of one material. Minimising the number of basement floors and the proportion of windows on the façade also have a major impact.

Obstacles to the use of alternative building materials

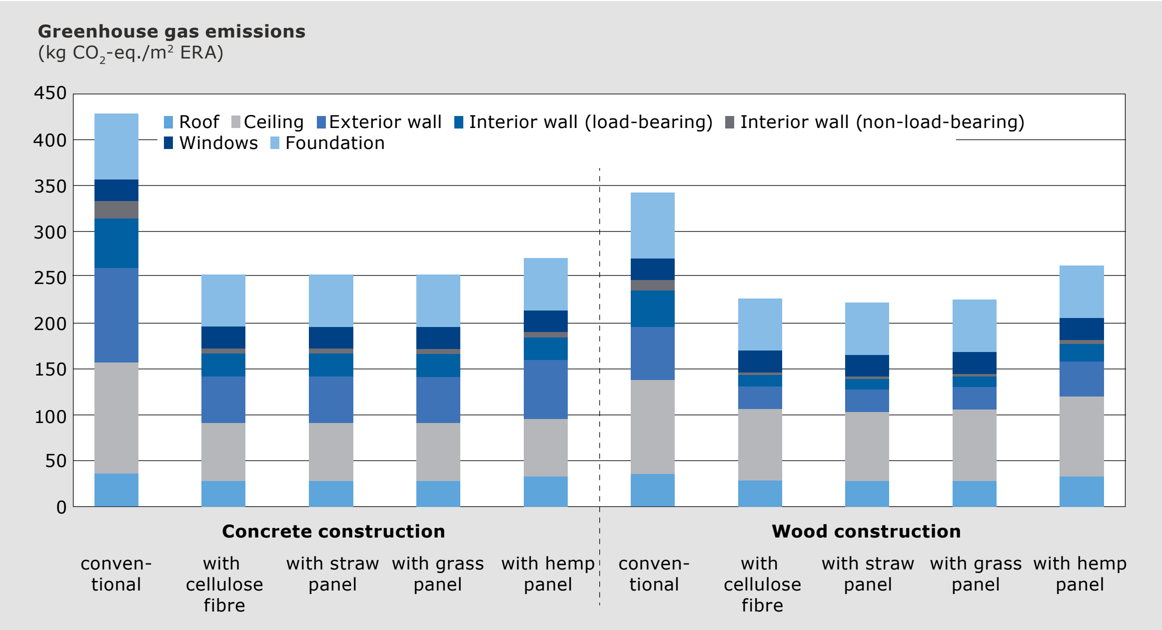
Although materials for climate- and resource-friendly construction are available on the market, they are only being used hesitantly. To find out why this is the case, the project team surveyed building owners, architects and employees of large construction companies in the third phase of the project regarding the obstacles to the use of sustainable building products. A key result of the surveys is that the relevant information on new, climate-friendly building materials and components is still difficult to find and interpret in some cases. To change this, we need, among other things:

- more independent, recognised test results,
- reliable data on the emissions saved,
- information on the advantages over tried and tested materials or conformity with building labels.
- Direct contact with manufacturers can also increase confidence in a new product or one that is not yet well established on the market.

Another finding is that it is not enough to publicise the possibilities of low-greenhouse gas materials and construction methods based on individual built examples. To ensure that buildings are built in a more climate-friendly way in the future, experts must also be provided with testimonials that show how the principles of climate-friendly construction can be integrated into the planning and construction process. It must also be explained which decision-making principles are crucial for the selection of materials and how all relevant stakeholders can be involved. After all, communication and interdisciplinary dialogue in construction projects are key to the successful use of innovative building products. Everyone involved must develop a common vision in the early project phases.

Many interviewees are also of the opinion that climate targets can hardly be achieved on a voluntary basis alone. They would therefore like to see economic incentives or stricter requirements for sustainable construction.

Overall, the study shows that materials and solutions for climate-friendly and energy-efficient construction and renovation are already available and have great potential.



Climate-friendly building materials can significantly reduce greenhouse gas emissions during the construction of buildings. This applies to both concrete buildings (five pillars on the left) and wooden buildings (five pillars on the right). The diagram shows this using various insulation materials as examples (graphic: ZeroStrat final report, edited).

Charging electric vehicles without overloa-ding the grid

Charging electric vehicles requires a lot of electricity in a short amount of time. In order for the power grid to provide this power, it needs to be expanded. A pilot project has therefore investigated how battery storage and more flexible charging can reduce the load on the grid.

In order to reduce greenhouse gas emissions in the transport sector, it must be electrified. This requires, among other things, a well-developed network of public charging stations. However, this also poses challenges for the electricity grid, particularly due to fast charging stations: They use a large amount of power from the grid in a short amount of time. In many places, the local and regional distribution grids are not designed for such peak loads.

Integrated battery storage

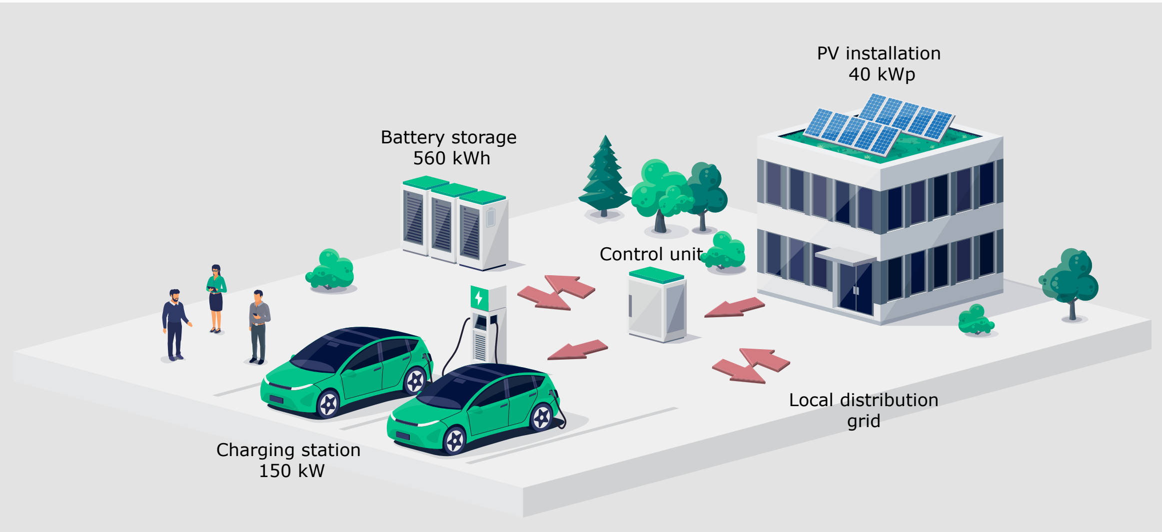
How can the load on the grid from fast-charging stations be reduced without the need for expensive and complex expansion? A project supported by the Swiss Federal Office of Energy at the Swiss Federal Institute of Technology in Lausanne (EPFL) investigated this very question. The project team set up a publicly accessible fast charging station with a total output of 172 kW on the EPFL campus. This can charge two standard electric vehicles (EV) within around 15 minutes to provide enough energy for a distance of more than 100 kilometres.

The system also includes a large battery storage unit with a capacity of 560 kWh and a photovoltaic system with a maximum output of 40 kW (see graphic below). Algorithms developed by the project team ensure optimum coordination between the photovoltaic system, battery and charging station. They also reliably predict photovoltaic production and the electricity requirements of the charging stations. This allows the EVs to be charged without overloading the grid.

Fewer deviations

The results of the project prove that such controllable charging stations with battery storage offer measurable advantages. Grid operators must specify their plans for energy procurement from the higher-level grid, and any deviation from this plan incurs costs for balancing the grid. The unpredictable loads caused by fast-charging stations often lead to such deviations. The study shows that they can be reduced by up to a factor of 10 by controlling the stations in conjunction with the use of batteries.

However, this is not possible without investing in the infrastructure, as battery storage systems are required and are still quite expensive at present. Nevertheless, the project team is convinced that such systems can



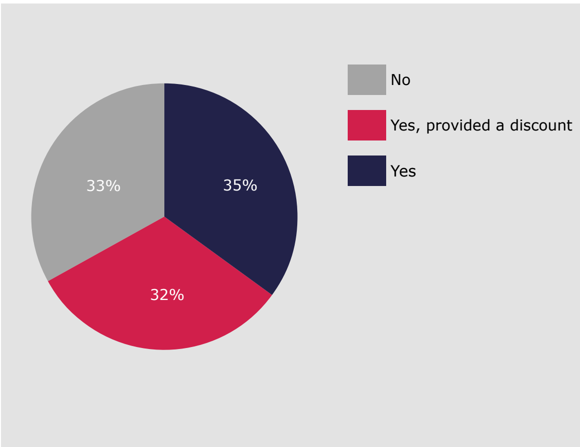
An intelligent control system coordinates the various components of the charging station to minimise the amount of electricity required from the local distribution grid for charging (graphic: B. Vogel / Shutterstock).

Within 15 minutes, the fast-charging station on the EPFL campus can supply two electric cars with enough electricity to drive 100 kilometres (source: MESH4U).

be economically viable if the storage systems are appropriately dimensioned. What's more, cost-effectiveness can be increased if the battery storage systems provide additional grid-supporting services. This means that the flexibility of the battery to draw or feed-in electricity can be used tosupport the grid when it is not being used for charging. It can for instance minimise peak loads for the distribution grid operator or provide services to stabilise the national grid. Different actors such as Swissgrid or the local grid operators may remunerate these services as appropriate.

Flexible users needed

The researchers also took a close look at user behaviour. They asked the users of the fast-charging station whether and under what conditions they would allow a certain amount of flexibility in terms of the time they charge their EVs. According to the survey, around two thirds are prepared to extend the charging process by a few minutes (see graphic below) so that the charging station can be operated in a more grid-friendly manner. However, half of them expect a discount on the electricity price in return. The research team therefore proposes a model in which pricing encourages flexible charging.



(Left) Around 100 users of the fast charging station were asked whether they would extend the charging process by a few minutes and thus ensure that the charging station could be operated in a more grid-friendly manner. A third refused, just over a third agreed and just under a third agreed if a discount was granted (graphic: MESH4U, edited).

(Right) The battery storage unit is located in this container. With its capacity of 560 kWh, it can store enough electricity from the photovoltaic system and/or from the grid to support the charging of electric cars and thus relieve the power grid (source: MESH4U)

With an energy management system, the electricity from a photovoltaic installation can be used optimally to charge an electric vehicle (source: Remdiaprod).

Helping energy management achieve a breakthrough

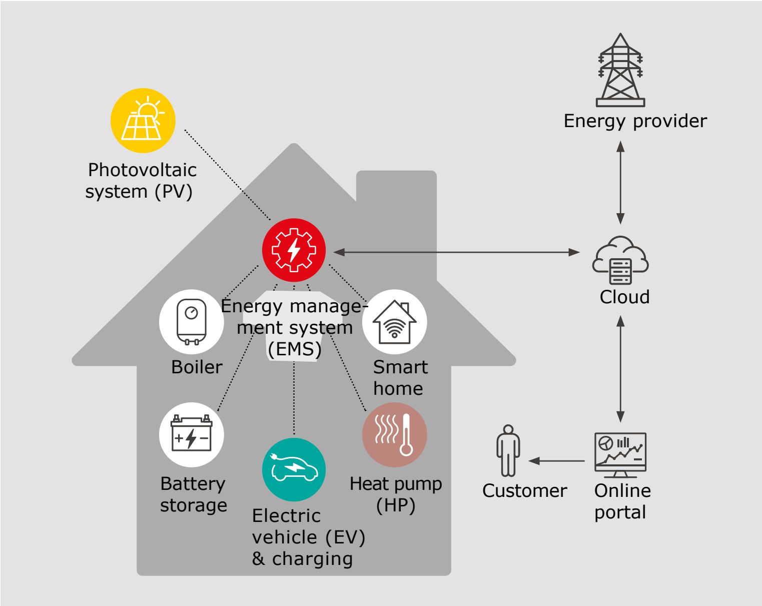
To ensure that our electricity supply continues to function reliably in the future, electricity must be used sensibly and efficiently. Energy management systems (EMS) can help with this, but are still used too sparingly today. A study provides an inventory and recommendations.

EMS are a new technology that ensures that energy is used efficiently and sensibly. In practice, this means, for example: They control the hot water system to ensure that the heat pump charges the storage tank when the photovoltaics on the roof are supplying a lot of electricity. The same applies to charging electric cars or operating large appliances such as washing machines or tumble dryers. On the one hand, this benefits the residents, for instance because the electricity from their own roof is cheaper than that from the grid. But it also benefits the public power supply by smoothing out peak loads and stabilising the grid. This is important because the proportion of weather- and season-dependent solar and wind power is growing and the heat supply to our homes is becoming increasingly electrified.

Survey shows distribution and potential

In the interests of a secure and efficient energy supply, EMS should therefore be used as widely as possible. How this could be achieved is one of the topics of the Inno-Net-Energy research project. It was funded by the Swiss Federal Office of Energy and realised by the Swiss Federal Institute of Technology Lausanne (EPFL) in collaboration with Energie Zukunft Schweiz and Protoscar. This study analysed how widespread EMS are already in residential buildings, as well as why and by whom they were purchased - or not. To this end, 4850 households that purchased either a photovoltaic system and/or an electric vehicle between 2019 and 2022 were surveyed.

Of those surveyed, 16 % had an EMS. In most cases, it was purchased together with the photovoltaic system and the electric car or heat pump. It is typical of EMS owners that they want to promote renewable energies, optimise their energy



An energy management system ensures that energy is used efficiently and sensibly in a building. This benefits the owner through lower energy costs. This benefits the public power supply because it reduces power peaks in the grid and thus improves stability (graphic: EPFL, edited).

requirements and energy costs and become more energy independent.

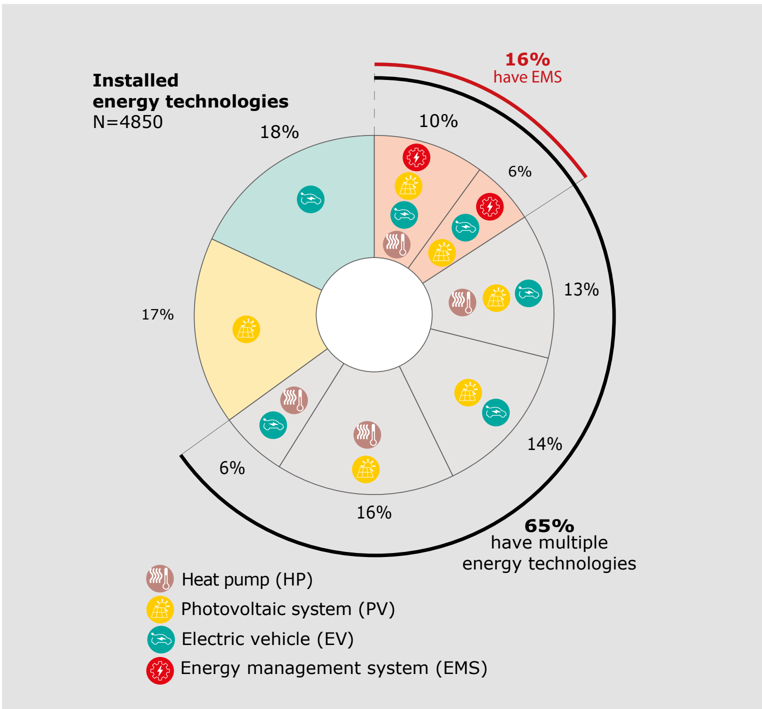
How can this be encouraged?
As 65 % of those surveyed operate a combination of electric car, photovoltaic system or heat pump, it would make sense for them to optimise their energy consumption and thus use an EMS. What was decisive for the fact that only 16 % had purchased one?

The respondents cited their own expertise, access to information about such systems as well as trust and geographical proximity to providers as favourable factors. The main obstacles were concerns about profitability and the lack of harmonised technology standards or labels that could have been used as a guide. The confusing situation with providers who integrate EMS into building technology was also seen as an obstacle.

Based on the results of the study, the authors recommend the following in particular to promote the use of EMS:

- Providers of EMS should communicate their costs and benefits transparently and in a way that laypersons can understand.
- It would also be helpful if providers had their systems certified according to independent labels, making it easier for interested parties to make a choice.
- The federal government should promote the harmonisation of technical standards.
- The trade associations can contribute by helping providers to fulfil their role as technology brokers and system integrators.

But local energy suppliers, municipalities and sector-independent organisations can also help - for example by organising information events at which the advantages and feasibility of EMS are communicated.



Anyone who has an energy management system usually also has a photovoltaic installation, an electric vehicle and a heat pump (graphic: EPFL, edited).

International cooperation

Switzerland attaches a great deal of importance to international cooperation in the field of energy research. At the institutional level, the Swiss Federal Office of Energy (SFOE) coordinates its research programmes with international activities in order to utilise synergies and avoid redundancies. Cooperation and exchanges of experience within the framework of the International Energy Agency (IEA) are of particular importance to Switzerland. Here, for example, the SFOE participates in various IEA "Technology Collaboration Programmes" (cf. www.iea.org/tcp), see list on following page.

At the European level, wherever possible Switzerland participates in EU research programmes. Here, at the institutional level the SFOE coordinates its energy research in alignment with the European Strategic Energy Technology (SET) Plan, the European Partnerships (formerly known as ERA-NET), the European technology platforms, joint technology initiatives, etc. Beyond that, intensive multilateral cooperation with selected countries also exists in certain fields (smart grids, geothermal energy, hydrogen etc.).

Aquifer storage systems use naturally occurring, water-bearing rock layers - known as aquifers - at depths of several hundred metres as seasonal heat reservoirs. Scientists at the University of Geneva are investigating the potential of aquifer storage for Geneva's district heating network in the SFOE-funded P2ATES project. The idea is to use heat pumps and waste heat from waste incineration to store very cheap heat seasonally in summer. In Bern, the municipal energy supplier Energie Wasser Bern is testing a geothermal storage facility at the Forsthaus energy centre, which stores the summer heat surplus from the waste incineration plant in water-bearing sandstone layers at a depth of 240 to 500 m for the winter. The borehole is shown on the left. According to plans, the storage facility has a capacity of 12 to 15 GWh (source: Energie Wasser Bern).

Participation in technology cooperation programmes of the IEA

Energy Conservation through Energy Storage (iea-eces.org)

Energy Efficient End-Use Equipment (iea-4e.org)

User-Centred Energy Systems (userstcp.org)

High-Temperature Super Conductivity (ieahts.org)

Clean and Efficient Combustion (ieacombustion.com)

Hybrid & Electric Vehicles Technologies (ieahev.org)

Geothermal Energy (iea-gia.org)

Hydropower (ieahydro.org)

Solar Heating and Cooling (iea-shc.org)

Wind Energy Systems (iea-wind.org)

Energy Technology Systems Analysis Program (iea-etsap.org)

Energy in Buildings and Communities (iea-ebc.org)

Heat Pumping Technologies (heatpumpingtechnologies.org)

International Smart Grid Action Network (iea-isgan.org)

Advanced Fuel Cells (ieafuelcell.com)

Advanced Motor Fuels (iea-amf.org)

Bioenergy (ieabioenergy.com)

Hydrogen (ieahydrogen.org)

Photovoltaic Power Systems (iea-pvps.org)

Concentrated Solar Power (solarpaces.org)

Greenhouse Gas R&D (ieaghg.org)

Participation in European Partnerships

Accelerating CCS Technologies (act-ccs.eu)

Concentrated Solar Power (csp-eranet.eu)

Materials (m-era.net)

Solar (solar-era.net)

Bioenergy (eranetbioenergy.net)

Geothermica (geothermica.eu)

Smart Energy Systems (eranet-smartenergysystems.eu)

Further international cooperation

Fuel Cells and Hydrogen Joint Undertaking

International Partnership for Geothermal Technology

Driving Urban Transitions (dutpartnership.eu)

DACH-Cooperation Smart grids

Clean Energy Transition Partnerhsip (cetpartnership.eu)

Climate change will significantly increase the need for cooling and the importance of urban heat islands. Building façades can make a significant contribution to alleviating this problem. On the one hand by integrating PV surfaces to generate electricity for cooling, and on the other hand by integrating greenery with a cooling effect in the outdoor space. As part of the SFOE-funded GreenPV project, four façade systems were measured on the HSLU campus (from left to right): ground-bound greenery, wall-bound greenery, opaque PV system, transparent PV system. The researchers recommend a combination of the two types of use: it may make sense to green the lower part of the building, which is close to people and more heavily shaded, and to use the upper part to generate solar power. Calculations have shown that photovoltaic façades facing south, but also east and west, have the best life cycle assessment in terms of greenhouse gas emissions (source: GreenPV final report).

Imprint:

Swiss Federal Office of Energy SFOE
CH-3003 Bern
alice.feehan@bfe.admin.ch

Swiss Federal Office of Energy SFOE
CH-3003 Bern

www.energy-research.ch