Energy for the future

Highlights from three years of research at the Swiss Competence Centers for Energy Research (SCCERs)
As part of the Swiss Coordinated Energy Research action plan, the Commission for Technology and Innovation (CTI) and the Swiss National Science Foundation (SNSF) manage eight competence centres among higher education institutions. I am delighted that these Swiss Competence Centers for Energy Research (SCCERs) achieved almost all the planned goals and milestones in the 2013–2016 funding period, and in some cases even exceeded them. For example, the majority of SCCERs contributed more funds than originally planned. And capacity building was so successful that the SCCERs created about 230 full time equivalent positions more than originally envisaged.

The SCCERs have successfully built a network throughout Switzerland. While energy research used to be about working in parallel, it is now about working together. Instead of staying stuck in a competitive mindset, researchers from the federal institutes of technology, cantonal universities, universities of applied sciences and research institutions now speak to each other as partners. This productive exchange results in synergies and saves resources, which ultimately improves the way in which research contributes to transforming the Swiss energy system.

This publication offers interested readers a concise overview of the SCCERs’ first funding period. In the second period, 2017–2020, we intend to build on these successes, further promote networking between the SCCERs through joint activities, and enhance knowledge and technology transfer – for the benefit of Switzerland.

Walter Steinlin, CTI President
Far-sighted research

Switzerland faces a gradual and far-reaching transformation of its energy system. The Federal Council wants to see energy research promote the development and use of innovative technologies, making a major contribution to the new energy strategy through efficiency and substitution. Under the Swiss Coordinated Energy Research action plan, the CTI and the SNSF have been mandated to develop and manage interdisciplinary research networks between higher education institutions.

Eight Swiss Competence Centers for Energy Research (SCCERs) in seven action areas are working to identify solutions to the technical, social and political challenges arising as a result of the energy transition. They offer researchers and businesses the full spectrum of the current energy innovation chain, from basic research and applied R&D to legal, regulatory and behavioural aspects. The SCCERs also provide research infrastructure and networking opportunities with key experts and young researchers in the various fields, and they ensure knowledge and technology is transferred to industry.

In the first funding period, from 2013 to 2016, CHF 71.5 million was available for this purpose. A seven-member steering committee supervises execution of the mandate by the SCCERs. The committee is supported by an international evaluation panel, made up of 21 experts and the 10 members of its core group, which evaluates the activities of the eight SCCERs on an annual basis. This involves five members of the panel spending a day visiting each SCCER, accompanied by representatives from the CTI and the Swiss Federal Office of Energy. The overall SCCER programme is subject to an external impact analysis once during each funding period. The steering committee sets out clear guidelines for this purpose and takes on board the recommendations made.

The SCCERs have been operational since 2014. Each SCCER is managed by a leading house with its own head. The Board is responsible for strategic management, while the central management tool is the innovation roadmap – a constantly updated action plan that forms the basis of strategy development and monitoring. There are between 6 and 16 universities involved in each SCCER and over 170 implementation partners in total.

A brief track record

The SCCERs had notched up some impressive achievements by the end of 2016:

- Capacity building was immensely successful: instead of the stated 552.2 full time equivalent positions, the SCCERs created 785.7 new and attractive jobs. At the end of 2016, a total of 1,214 researchers were working in the eight SCCERs.
- The SCCERs gave rise to new research communities involving 25 higher education institutions of all types and various research disciplines.
- The SCCERs played a big role in their own success: the majority of the competence centres provided more own funds than stipulated by a considerable amount.
- Barriers between research institutions have been removed and replaced with a Swiss-wide network. This has sparked unprecedented innovation momentum in Switzerland.
- A total of over 500 projects were launched in the SCCERs. They focus on the topics where Swiss research can make a real contribution to innovation.
The eight SCCERs – an overview

**FEEB&D**

**Future Energy Efficient Buildings & Districts**

Highly efficient materials for heat insulation / Usage- and climate-dependent energy management / Sufficiency potentials and energy recovery / Decentralised power, heat and cold systems

pp. 6–9

**EIP**

**Efficiency of Industrial Processes**

Industrial efficiency / Energy-saving processes and procedures / Process heat from renewable energies / Waste heat use / Decentralised power, heat and cold systems

pp. 10–13

**FURIES**

**FUtuRe Swliss Electrical InfraStructure**

Grid stability / Load flow management / Integration of intermittent power from renewables / Smart grids and high performance electronics / System aspects of power storage

pp. 14–17

**HaE**

**Heat & Electricity Storage**

Principles of electricity storage / Batteries / Efficient electrolysis / Heat management / Mechanical, chemical and pneumatic storage technologies

pp. 18–21
SoE
Supply of Electricity

Deep geothermal and carbon capture / Hydropower use / Hydropower infrastructure

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CREST
Competence Center for Research in Energy, Society and Transition

Regulatory issues and framework conditions for markets / Analyses of individual and group behaviour and general trends / Sufficiency / Incentive systems

pp. 28–31

Mobility
Efficient Technologies and Systems for Mobility

Electrically powered transport / Batteries / Fuel cells / Integrating decentralised renewable electricity generation / Lightweight construction / Experimental aspects of new urban models

pp. 32–35

BIOSWEET
BIOmass for SWiss EnErgy fuTure

Sourcing and use of biomass / Biogas to generate electricity and heat / Gaseous and liquid biofuels

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The SCCERs in brief: FEEB&D

FEEB&D

Future Energy Efficient Buildings & Districts

The SCCER’s activities

The legal requirements for building insulation have become much stricter in recent years. In particular when renovating older, heritage-protected buildings, innovative insulation materials with minimum thickness and maximum thermal characteristics are required so that the aesthetic appearance of the buildings can be preserved.

Energy management is the second focus of the SCCER’s activities. Building standards such as Minergie are highly complex, and if they are to contribute to the energy transition, they require a high degree of professional planning and implementation. The SCCER develops the instruments necessary to achieve this.

The third level is networking. Optimising energy use over a whole site achieves more than focusing on a single building. The SCCER therefore works with site operators to set up pilot projects that can then be put into practice. An example of this would be a multi-energy network involving heat, cold, electricity and gas, and a central hub that can convert, store and distribute energy.

And finally, the SCCER looks at how already developed technologies can be best implemented and brought to the market. Socioeconomic questions are involved in this area: what factors drive new technologies, and what prevents them being successful?

In its activities, the SCCER wants do justice to the variety of architectural styles and of the urban context. There is no single solution for everyone: what is suitable for an old building may not work in a new one; different housing developments and towns require individual solutions. For example, if a powerful energy source such as geothermal is available, maximum insulation is not required; on the other hand, optimum use should be made of the energy source.
FEEB&D SCCER model projects

DYNAMIC GLAZING
Smart windows save energy
Innovative window glazing optimises light incidence in rooms that are exposed to strong sunlight. The windows are coated in a micro-thin mirror, leaving them transparent, but reducing the need for artificial light and minimising the energy required for cooling and heating the building. In future there may be no need for window blinds thanks to this system. The European Patent Office recently awarded it patent protection.
Partner: EPFL; Co-funder: SFOE

ENERGY CONCEPT OF TOMORROW
A commune sets energy standards
In order to achieve the objectives of the 2000 Watt society, HSLU has developed an energy concept on behalf of BKW and Wohlen BE for the commune of Uettligen. This concept paves the way for other similar small towns, since Wohlen is representative of 20 per cent of all Swiss communes. Firstly, the current state and potential of local energy resources were analysed, then an alternative energy supply concept developed covering electricity, heat and gas. There is now a defined set of measures to implement this concept by 2050.
Partners: Commune of Wohlen near Bern, HSLU, BKW Energie AG

HOLISTIC URBAN ENERGY SIMULATION
Promoting decentralised energy systems
The Holistic Urban Energy Simulation (HUES) platform is an open-source initiative that brings together IT resources to support the development of decentralised energy systems (DESS). The aim of the simulation platform is to foster and accelerate research into DESS by making existing models, data and codes centrally available and allowing researchers to compare proposed DESS with existing energy supply systems. This gives rise to useful tools for creating DESS that can be used by planning departments and industry.
Partners: Urban Energy Systems Laboratory, Empa; Co-funder: CCEM (ETH Domain’s Competence Centre Energy and Mobility).
The SCCERs in brief: FEEB&D

Facts and figures

80% in buildings
We spend 80 per cent of our time in buildings. New construction solutions only have a chance of becoming established if they meet people’s needs at least as well as current ones do.

1% renovation rate
In Switzerland just one per cent of the housing stock is renovated each year. So it will take 100 years to renovate the entire stock.

33% of CO₂ emissions
A third of all Switzerland’s greenhouse gas emissions are produced by buildings.

66% fossil-fuel heating
Two thirds of all buildings in Switzerland are heated using fossil fuels. Oil and gas prices have been low for a long time, and so fossil-fuel heating systems are even being installed in new buildings.

7.5m tonnes of construction waste
Each year 7.5 million tonnes of construction waste is produced in Switzerland – almost one tonne per person.

How the FEEB&D SCCER contributes to the 2050 Energy Strategy

Under the 2050 Energy Strategy, the carbon footprint of the Swiss housing stock could be reduced by two thirds. To achieve this, we must increase energy efficiency and reduce the carbon content of the energy sources used.

➡️ In order to reduce energy requirements at source, the SCCER looks at building shells, working with industry partners on highly efficient insulation materials and modern glazing concepts.

➡️ The SCCER processes reliable data on the behaviour of buildings and their users, developing tools that predict this behaviour. This data is fed into intelligent building guidance systems that actively regulate building use.

➡️ The SCCER has developed a range of tools for planning and implementing decentralised energy systems (DESs), and been involved in developing a data-based geographic information system to aid spatial planning. Data from three or four model regions is now being validated; the instruments will then be made available to planning offices, which will use them to carry out their own particular tasks.

➡️ New technologies, materials and systems are tested, researched, developed further and validated under actual conditions in a range of demonstrators. Thanks to close cooperation between researchers, those working in the field of energy efficiency and the public sector, efficient and innovative construction and energy technologies can quickly be brought to market.

Participating institutions

• Empa Swiss Federal Laboratories for Materials Science and Technology (leading house)
• EPFL Federal Institute of Technology Lausanne
• ETHZ Federal Institute of Technology Zurich
• FHNW University of Applied Sciences and Arts Northwestern Switzerland
• HSLU Lucerne University of Applied Sciences and Arts
• University of Geneva

You’ll find our innovation roadmap and further information here

➡️ www.sccer-feebd.ch
What is your vision of the future of energy in 2050?
We can and must source our energy almost entirely from renewables by 2050. In Switzerland we have the financial means to achieve the energy transition; we just have to invest them correctly.

What do you find fascinating about energy?
Our civilisation has undergone a massive development in the past 250 years because it was able to exploit energy resources to an almost unlimited degree. This is what I find so fascinating. Unfortunately the majority of these resources are fossil-based. I enjoy getting to grips with this important and complex problem.

Which of your SCCER’s successes are you particularly proud of?
We have always focused on connecting districts and multi-energy networks. Initially we were criticised for this, but now I am happy to say that everyone is talking about interconnectedness.

Dr Peter Richner, Empa, Civil and Mechanical Engineering Department
Peter Richner studied chemistry and at the ETHZ and went on to earn a PhD at the same institution. Following a postdoc in the USA he developed a new research group in ultratrace analysis at Empa, where he later headed the Corrosion and Surfaces Protection section. Since 2002 he has been head of the Civil and Mechanical Engineering Department and since 2012 deputy director of Empa. In addition he is active in various national and international bodies. His research interests are in energy efficient construction and promoting technology transfer; as the initiator of NEST, Empa’s and Eawag’s modular research and innovation platform, he has managed to combine the two. Dr Richner headed the FEEB&D SCCER in Phase I from 2014 to 2016.

“In Switzerland we have the financial means to achieve the energy transition; we just have to invest them correctly.”
The SCCERs in brief: EIP

EIP
Efficiency of Industrial Processes

**Leading house**
Swiss Federal Institute of Technology Zurich (ETHZ)

**Head**
Prof. Philipp Rudolf von Rohr,
ETHZ, Institute of Process Engineering, Transport Processes and Reactions Laboratory

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The SCCER’s activities

Industrial processes are very diverse, ranging from a small screw factory to the complex production processes of a pharmaceuticals manufacturer. These processes can often be made more energy-efficient in a very short space of time. But companies are interested in their product – the screw or the medicine – rather than the process itself. It is therefore important that any interventions in processes do not adversely affect the products involved.

The EIP SCCER started by determining the industries in Switzerland that are important and energy-intensive. It then focused on the chemicals, pharmaceuticals and food industries, as over 50 per cent of the energy consumed by these sectors is in the form of heat, and heat recovery offers significant energy-saving potential.

This SCCER works with interested companies to develop new methods and materials that lead to energy savings. On the one hand, this involves processes such as heating and cooling, carbon capture and thermal management of water systems, and on the other, ways of saving electricity and using less energy-intensive materials. In a second step, the EIP SCCER helps companies implement these innovations by testing technical and economic feasibility. It also provides companies with new analysis methods.

Specifically, this SCCER advises mainly small and medium-sized companies in the field of heating, such as on how they can operate an efficient heat-recovery system using existing but more sophisticated methods, and how they can utilise waste heat from third parties. For example, it would make much more sense to use the waste heat from incinerators or swimming pools for industrial processes rather than for domestic heating, as the latter will anyway be replaced by more efficient systems sooner or later. A group at this SCCER is exploring how to link larger systems in towns and cities.

Developing new, more efficient processes is another focus of the SCCER’s work. Specifically, the EIP SCCER is working to develop continuous production processes which would eliminate unnecessary heating and cooling steps. These include concrete solutions for manufacturing pharmaceutical products and vitamins. Another key topic is increasing the efficiency of carbon capture; this process currently wastes a great deal of energy.

The workstreams within this SCCER work closely together, but each maintains its own relationships with certain businesses and works with firms on individual CTI projects.
EIP SCCER model projects

HEAT INTEGRATION

Energy-efficient reactors for the chemicals industry
Chemical reactions are often carried out in stirred tank reactors, which have a number of drawbacks. The EIP SCCER is researching structured tubular reactors to allow continuous chemical reactions in the manufacture of vitamins; in this type of reactor, heat can be easily integrated and so energy saved. In addition, the separation of newly developed lead-free catalysts on the reactor surface eliminates the energy-intensive step of separating the product from the catalyst, which is necessary in stirred tank reactors.

Partner: DSM Nutritional Products SA; Co-funder: CTI

DISTRICT HEATING

Optimised waste heat utilisation reduces gas consumption
New methods and tools for energy optimisation that were developed by this SCCER are already being used by industry. At Flumroc, the integration of a water reservoir with a volume of 2,600m³ reduces the gas consumption of the local district heating network by around 2,500MWh per year, which pushes down carbon emissions and operating costs considerably. Five hundred new-build homes are now heated with waste heat rather than with natural gas. Installing a heat storage system of this size is an innovative solution to increase waste heat utilisation for district heating.

Partners: Flumroc AG, HSLU; Co-funder: none (financed solely by Flumroc)

PLANT CULTIVATION

Energy-efficient greenhouses
A detailed analysis of current and past consumption figures for a greenhouse with an area of 50,000m² revealed significant energy-saving potential. Adjusting the temperature profile and optimising management of ventilation, shade and sun protection resulted in a saving of 15 to 20 per cent, while optimised heat distribution contributed to an additional 15 per cent energy saving. Multiple use of waste heat from extracted air not only reduces energy demand by up to 50 per cent, it also improves the growth conditions for plants.

Partners: Rutishauser AG, NTB; Co-funder: Office for the Environment and Energy, Canton of St Gallen (AFU)
How the EIP SCCER contributes to the 2050 Energy Strategy

Industry accounts for around 20 per cent of Switzerland’s total energy consumption. Under the 2050 Energy Strategy, this requirement is to be reduced by 20 per cent, or 9TWh, between 2014 and 2035, and by a total of 33 per cent, or 14TWh, by 2050.

- The EIP SCCER researches methods and processes to increase energy efficiency in industry, and aims to get companies interested in them. Researchers from the SCCER actively approach companies with their findings, and companies also contact the SCCER of their own accord.

- Work with companies often starts with an on-site situation analysis, from which the SCCER derives potential measures. Small and medium-sized companies have the greatest saving potential as they do not usually have their own energy advisors and energy is not their priority.

- The SCCER always has to keep an eye on costs. A new process or solution may not cost more than a previous one: Swiss industry is under tremendous economic pressure.

- And finally, the EIP SCCER trains young people and teaches them about new technologies – knowledge which they can then take with them into the world of business. Instructing prospective engineers about new methods in a lecture on heat exchange is an ideal way of disseminating this knowledge widely.

Facts and figures

20% of total consumption
Industry accounts for some 20 per cent of Switzerland’s energy consumption; more than 50 per cent of this is used for process heating.

⅓ of industrial demand
The biggest energy consumers are the chemicals, pharmaceutical and food industries. Together they account for almost a third of industrial energy demand.

20 industry partners
The EIP SCEER has formed a core group of scientists from 5 higher education institutions and works with more than 20 industry partners.

Over 100 course participants
Training courses offered by the SCCER teach specialists from industry about new methods and tools. Well over 100 people have attended the courses to date.

Up to 40% energy savings
Industrial processes that do not run continuously often have significant energy-saving potential. Installing heat storage systems reduces energy demand: if excess heat is stored in heat accumulators and re-used later, energy savings of up to 40 per cent can be achieved.

Participating institutions

- ETHZ Swiss Federal Institute of Technology Zurich (leading house)
- EPFL Swiss Federal Institute of Technology Lausanne
- HSLU Lucerne University of Applied Sciences and Arts
- HSR Hochschule für Technik Rapperswil
- NTB Interstate University of Applied Sciences of Technology Buchs
- University of Geneva

You’ll find our innovation roadmap and further information here

➤ www.sccer-eip.ch
What is your vision of the future of energy in 2050?
I’m sceptical as to whether we’ll be able to get enough resources from renewables by 2050. Many of us will only react when we find ourselves having to switch off the television in the evenings. It’s therefore time we took action at all levels.

What role do you see your SCCER playing in achieving this vision?
The aim is for students to learn a lot at this SCCER, and then to take that knowledge into industry and put it into practice. Our SCCER provides an opportunity to make broad-based changes.

Which of your SCCER’s successes are you particularly proud of?
I’m proud that in a short time we’ve set up a team and agreed on questions that were accepted by the CTI and the community. I’m also proud of some specific projects in which we have already made concrete savings. Now we want to multiply that.
FURIES
FUtuRe SwIIss Electrical InfraStructure

The SCCER's activities

Electricity grids comprise a transmission system and a distribution grid. Power distribution in Switzerland is highly complex, as there are around 650 power distribution companies, both large and small. This means that Switzerland has one of the highest numbers of power distribution companies per head of population in the world. The transmission system, on the other hand, is simply regulated, with Swissgrid as the sole, national power transmission company.

For a long time, grid operators could operate in a fairly stable environment. The construction, expansion and operation of the infrastructure was based on experience gained over many years. Nowadays, power generation is more complex: more and more consumers also generate electricity, for example with their own solar panels. Electricity flows in two directions and fluctuates considerably since renewables such as wind and solar produce electricity irregularly, depending on the weather and time of day. This creates instability and makes it harder to manage the infrastructure.

Grid operators will face even greater challenges in future as the decentralised generation of renewable energy becomes more widespread. Appropriate technologies and business plans are needed to ensure the stability and efficiency of the whole power grid.

The FURIES SCCER develops planning, monitoring and regulating instruments for grid operators. With real-time information about the condition of the grid and the ability to regulate it, grid operators can deliver high-quality power to their end-consumers. By localising sources of error and reducing bottlenecks, operators can prevent power cuts or at least restore the power more quickly when there is an outage. Furthermore, load-balancing mechanisms make it easier for end-consumers to generate their own electricity.

The research done by the SCCER provides Swissgrid with information about socio-economic and ecological factors upon which planning can be based, helping the transmission company to expand the grid in an optimum way. At the same time, with extensive knowledge of the Swiss energy system, Swissgrid is ideally positioned to interact with the European energy market. FURIES also conducts research into grid components; taken together, all these activities help to maximise the efficiency of the power system as a whole.

The technologies into which the SCCER conducts research allow grid operators to pursue objectives within the scope of the new energy system that would be out of reach if they were reliant on their own resources. These objectives include reducing energy costs, managing grid capacity, and increasing flexibility and planning capability.
FURIES SCCER model projects

RENOVHYDRO
Making black starts easier
Following a power cut, power stations have to be able to restart their generators, and usually the power required to do this is provided by hydroelectric power stations. This process is known as a black start. There are several critical phases in restoring the entire grid and retransmitting power along long-distance lines. In the RENOVHydro project, the SCCER is developing software that replicates the behaviour of power stations and so gives the operators information about black starts and managing the grid. Power producers can then retrofit their power stations as required.
Partner: SoE SCCER; Co-funder: CTI

COMMELEC
Managing the grid
A lot of renewable energy in a power grid makes it very volatile. Agreements between producers and consumers, for example to define times at which power should be used, stored or fed into the grid, can create greater stability. Commelec is a grid management system which anonymises the parties involved and allows them to communicate in a common language. By means of algorithms, supply and demand can be optimally regulated in the grid, making it more stable and reliable without the need for huge investment.
Partners: Romande Energie SA, Swissgrid AG; Co-funder: SNSF

NANO TERA
Monitoring the grid
A test power grid on the EPFL site demonstrates the challenges that grid operators have to cope with today: power generation fluctuates widely, as the amount of solar energy being fed into the grid depends on the weather, and this influences the reliability of the electricity supply. SCCER has developed sensors and phase meters for monitoring load in real time. The Services Industriels Lausanne (SIL) power company now monitors and manages the city grid using this EPFL-tested technology. The monitoring system is being tested under real conditions in Rolle VD and Onnens VD.
Partner: EPFL; Co-funder: SNSF
How the FURIES SCCER contributes to the 2050 Energy Strategy

In order to fill the gap left when Switzerland’s nuclear power stations are decommissioned, the 2050 Energy Strategy envisages increasing the share of renewables (not including hydropower) by 4.4TWh per year up to 2020 and by 11.4TWh per year up to 2035. 4.4TWh is about 45 per cent of the energy produced by Leibstadt nuclear power station.

◆ The SCCER provides grid operators and energy companies with planning and regulation instruments which help them to integrate irregularly generated renewable energy into the transmission and distribution grids. The SCCER’s research is thus helping to ensure the seamless and sustainable supply of power to Swiss households, businesses and towns in accordance with the 2050 Energy Strategy.

◆ The costs of the transmission and distribution grid can be reduced thanks to instruments that the SCCER employs to connect and manage production, storage and consumption. This creates financial advantages for the grid operator Swissgrid and the energy suppliers from which end-users also benefit.

◆ The SCCER informs the Federal Electricity Commission (ElCom) of its research findings and the commission then checks their compatibility with current and planned network regulations. ElCom uses this information in the political process, for example in the Confederation’s power grid strategy.

Facts and figures

1/3 of power consumption
Under the 2050 Energy Strategy, new renewables will make up around a third of current power consumption by 2050.

650 grid operators
Switzerland has the most complex power distribution grid in the world: there are around 650 different operators on the market.

110 projects
Leading players in energy in Switzerland from the fields of science, industry and the public sector are working on 110 different projects in the FURIES SCCER.

4 spin-offs
Besides founding four spin-offs, the SCCER’s partners have registered 6 patents and produced 44 prototypes and demonstrators.

300 publications
The SCCER has produced over 300 scientific publications and has held over 200 presentations at conferences.

Participating institutions

- EPFL Federal Institute of Technology Lausanne (leading house)
- BFH Bern University of Applied Sciences
- ETHZ Swiss Federal Institute of Technology Zurich
- FHNW University of Applied Sciences and Arts Northwestern Switzerland
- HES-SO University of Applied Sciences and Arts in Western Switzerland
- HSLU Lucerne University of Applied Sciences and Arts
- HSR Hochschule für Technik Rapperswil
- SUPSI University of Applied Sciences and Arts of Southern Switzerland
- Università della Svizzera italiana
- ZHAW Zurich University of Applied Sciences
- CSEM Centre Suisse d’Électronique et de Microtechnique*
- University of Basel*

* Higher education institution participating in the SCCER; not a funding recipient

You’ll find our innovation roadmap and further information here

⇒ http://sccer-furies.epfl.ch
What is your vision of the future of energy in 2050?
Our energy system will be entirely decentralised and therefore quite complex. We are currently undergoing a revolution in the energy sector similar to that sparked by the internet in information technology. In 2050 the energy sector will be completely different from how it looks today.

What do you find fascinating about energy?
It is one of the biggest challenges facing humans. If we do not find any satisfactory ways of quenching our ever-increasing thirst for energy, our world will collapse, and all of us with it. This is a view that I always put forward, both in research circles and when teaching.

Which of your SCCER’s successes are you particularly proud of?
The fact that we persuaded so many companies to come on board. We have almost trebled the number of industrial partners, and now have 50 companies working with us. Some have become even more involved and are now strategic partners.

““We have almost trebled the number of our industrial partners.””

Prof. Mario Paolone,
EPFL, Distributed Electrical Systems Laboratory
In 1998 Mario Paolone graduated in electrical engineering from the University of Bologna, and obtained a doctorate from the same institution in 2002. From 2005 to 2011 he was a lecturer in energy systems at Bologna. Prof. Paolone has been associate professor at the EPFL since 2011 and heads the Distributed Electrical Systems Laboratory. He is the author or co-author of over 200 scientific publications in renowned journals and at international conferences. His areas of research are real-time monitoring, energy distribution grid operation, integrating stored energy production in power grids and the protection and stability of energy systems.
HaE
Heat and Electricity Storage

The SCCER’s activities

With the broader dissemination of renewable energy sources, the storage of electricity and heat is becoming increasingly important. Short-term capacities for the temporary storage of electricity are required to stabilise the electricity system. Long-term capacities are required for seasonal storage of energy from summer until the winter period. The HaE SCCER develops storage technologies for heat and electricity, and uses energy system modelling to show which storage option works best and is economically viable, and which one is technically limited and less appropriate.

At the moment, there is not a huge demand for storage, since there are other less expensive solutions available. In Germany, for example, wind turbines are to a large extent programmed to stop working when there is too much electricity on the market. This situation may change rapidly if the economic conditions change.

Since it is still unknown which storage technologies the market will eventually require, R&D covers a broad scope and is divided into five areas: battery storage, heat storage, hydrogen, synthetic fuels and storage technology integration. Work focuses both on classic solutions, such as developing battery storage and heat storage further, and on non-established storage solutions, such as converting electricity into fuels such as hydrogen or methanol.

Apart from electricity, heat is one of the most frequently required forms of energy. In modern industrial society, 50 per cent of primary energy sources are used to generate heat (space heating, service water, process heat). Using energy responsibly therefore also applies to heating.

The SCCER works together with industry partners to identify the relevant issues, develop tools and methods for assessing technologies and create demonstrators and prototypes for evaluated new technologies. An example of this is the experimental ESI (Energy System Integration) platform created with the BIOSWEET SCCER at the PSI, on which promising solutions can be tested in their complex interrelationships and in cooperation with industry partners. A new visitor centre has been set up to bring the ESI to the widest possible audience.
HaE SCCER model projects

ADIABATIC COMPRESSED AIR ENERGY STORAGE
Heat storage and conversion into electricity
Pumped storage has been state-of-the-art technology for over 100 years; the most viable locations have already been developed. Since pumped storage has very low storage losses and a favourable cost profile, alternatives with a similar profile are being sought, such as adiabatic compressed air energy storage. The process of storing energy as compressed air generates additional heat, which is stored separately and, if required, converted into electricity by a turbine generator. The HaE SCCER has developed in an unused tunnel what could well be the world’s first adiabatic compressed air energy storage system.
Partners: ETHZ, EPFL, SUPSI, Alacaes SA; Co-funder: SNSF (NRP 70)

SODIUM-ION BATTERIES
Efficient storage of electricity for grid stabilisation
Batteries are the most efficient, but also the most expensive means of storing energy, which is why they are particularly suited as a short-term storage medium. Lithium-ion batteries have very high energy densities and are ideal for use in portable devices such as mobile phones. Sodium-ion batteries are an interesting alternative for stationary electricity storage to stabilise the grid. The SCCER has developed the necessary material properties of the sodium-ion battery and has built a first single-cell battery out of inexpensive materials in the laboratory.
Partners: PSI, ETHZ, Co-funder: CTI

ELECTROCHEMICAL CO₂ CONVERSION
An attractive synthetic energy carrier
Renewable energy, which is in surplus in summer, can be converted into a liquid or gaseous substance and stored. Although the efficiency of the conversion is low compared to batteries or hydropower, such synthetic energy carriers are attractive because handling and energy density are similar to that of fossil fuels used in the transport and chemical industries. The SCCER has managed to demonstrate the feasibility of direct electrochemical conversion, and in a second phase will develop a prototype on a 1-kW scale.
Partners: PSI, ETHZ, University of Bern
How the HaE SCCER contributes to the 2050 Energy Strategy

In line with the 2050 Energy Strategy, the energy supply gap must be closed using renewable energies. This requires storage systems that can, for example, provide energy produced at night for use during the day or produced in summer for use in winter.

➜ The HaE SCCER develops storage technologies that link various independent energy sectors, which provides the necessary flexibility for restructuring Switzerland’s energy system.

➜ The SCCER is developing a broad portfolio of possible storage technologies and is hoping to make a significant contribution to meeting Switzerland’s energy needs in 2050 by tapping into fluctuating renewable sources.

➜ The storage technologies developed at the SCCER lay the foundations for some energy services to enter the market. Interim storage, for example, currently opens up broad possibilities for still underused technologies.

➜ The SCCER creates prototype facilities to test existing or new technologies. On the ESI (Energy System Integration) experimental platform, for example, the HaE and BIOSWEET SCCERs combine existing technologies that have not been successful in isolation, resulting in biomass and storage solutions that are potentially of use to the industry.

➜ Finally, working groups from various projects publish their results, for example in white papers, and make them available to industry and research institutions. These working groups are currently focusing on power-to-gas.
What is your vision of the future of energy in 2050?
In 2050 energy systems will be significantly decarbonised, since we will almost exclusively be using renewable energies. This will stabilise the climate system for the future.

What role do you see your SCCER playing in achieving this vision?
Electricity and heat that can be produced should also be used. We are helping to make full use of renewable energy, especially wind and solar power, by providing storage options.

What do you find fascinating about energy?
Energy and energy research are technical topics that at the same time are very political. I find it fascinating to be able to make a contribution that brings the two aspects together in a meaningful way.

“Electricity and heat that can be produced should also be used.”

Prof. Thomas J. Schmidt,
PSI, Electrochemistry Laboratory
Thomas J. Schmidt graduated in chemistry from Ulm University in 1996, and went on to earn a PhD there in 2000. He worked as a postdoctoral researcher at the Lawrence Berkeley National Laboratory in the United States and at the PSI. Schmidt then worked eight years in the chemical industry, latterly as Director of Research and Development at BASF Fuel Cells, before being appointed both Professor of Electrochemistry at the ETHZ and Head of the Electrochemistry Laboratory at the PSI in February 2011.
23 research institutions* throughout Switzerland participate in the SCCERs. Five of these act as leading houses. The higher education institutions and research institutes in the ETH Domain, cantonal universities and universities of applied sciences cooperate closely in the SCCERs.

* funding recipient

Universities of applied sciences
BFH Bern University of Applied Sciences
FHNW University of Applied Sciences and Arts Northwestern Switzerland
HES-SO University of Applied Sciences and Arts in Western Switzerland
HSLU Lucerne University of Applied Sciences and Arts
HSR Hochschule für Technik Rapperswil
NTB Interstate University of Applied Sciences of Technology Buchs
SUPSI University of Applied Sciences and Arts of Southern Switzerland
ZHAW Zurich University of Applied Sciences

Research institutes (ETH Domain)
Eawag Swiss Federal Institute of Aquatic Science and Technology
Empa Swiss Institute for Materials Science and Technology
PSI Paul Scherrer Institute
WSL Swiss Federal Institute for Forest, Snow and Landscape Research
The SCCER’s activities

The SoE SCCER conducts research into the relatively new field of geothermal energy, and into the more familiar one of hydropower. It looks at whether it is possible to generate five to ten per cent of the electricity we need in Switzerland from deep geothermal sources reliably and at competitive prices. The SCCER examines whether electricity production from fossil sources can be made nearly climate-neutral by using carbon capture and storage. And it looks at how the performance of hydroelectric power stations could be increased by nine per cent, at the costs this would involve, and at how electricity production can be made more flexible. On all these issues it works closely with industry and the federal offices.

The researchers are developing a sound understanding of geothermal processes, when stone is cut to access deep geothermal reservoirs. In one method, water is pumped under high pressure into rock, creating a large system of cracks in the ground to serve as a heat exchanger. The researchers are also investigating more efficient methods to extract heat from rock several kilometres underground. The SCCER, in conjunction with its industry partners, wants to launch a number of innovative technologies on the market by 2025. Furthermore, it wants to find ways of reducing the cost of drilling, which is currently very high, so that exploiting this energy source becomes economically viable.

Hydropower is no longer really economically viable, and there are growing restrictions on production owing to environmental concerns; as a result, the industry is reluctant to invest large amounts. So that the main source of renewable energy in Switzerland can maintain its relevance in the future, the SoE SCCER is working with businesses to improve turbines and develop new technologies for small-scale hydropower. Other major topics include predicting water volumes in the light of climate change, the potential of future glacial lakes and optimum sediment management in reservoirs. The SCCER uses simulation models to predict developments, and takes account of ecological and socio-economic objectives such as minimising the detrimental impact on the environment.

Finally, the SCCER takes a holistic look at energy supply in Switzerland. It compares all the relevant electricity generation technologies with regard to their potential, cost and environmental impact, and analyses power scenarios using economic models. It also looks at the issues of risk, security and public acceptance.
SoE SCCER model projects

IN SITU STIMULATION AND CIRCULATION (ISC)
Cracking compact rock
In two experiments involving one tenth to one hundredth scale models, researchers aim to find out how to fracture compact rock by injecting water in a process of hydraulic stimulation, and so create an efficient, 1,000-metre-long and 5,000-metre-deep heat exchanger required to tap the geothermal energy used to generate electricity. The SCCER also conducts research into minimising the number and strength of earthquakes generated by the stimulation. The final results of the study will not be available until in 2020; however, interim findings will be made available to industry partners before this date.

Partner: National Cooperative for the Disposal of Radioactive Waste; Co-funders: SNSF, SFOE, Shell, Elektrizitätswerke des Kantons Zürich

GEOTHERMAL ENERGY 2020
Equipping a city for geothermal energy
In a bid to promote the use of geothermal energy in Geneva, the Services Industriels de Genève (SIG) and the Canton of Geneva have launched a large-scale project named GEothermie 2020. As the main project partner, the SoE SCCER has updated a geological 3D model of the city and proposed where drilling should take place. The first drilling will be carried out this year, down to 500 metres underground. The project includes developing underground storage capacity for 110GWh of waste heat from the city refuse incinerator, heat which can be stored in summer for use in the winter.

Partner: University of Geneva; Co-funders: SIG, Canton of Geneva

MAPPING ALPINE GLACIERS
Using climate change to harness energy
In order to obtain data on how glaciers will develop in future, measurements are taken from them using a newly developed radar device mounted in a helicopter. By evaluating the data, the thickness of the ice or depth of the valley floor under the glacier can be calculated. The topography of the valleys shows the best place to create reservoirs in future. Simulators use these data to calculate how glaciers will melt over time. This makes it possible to predict the runoff characteristics of the Alps over the course of the year, and this provides a basis for new hydropower plants.

Partners: ETHZ, Laboratory of Hydraulics, Hydrology and Glaciology; Co-funder: Swiss Geophysical Commission
How the SoE SCCER contributes to the 2050 Energy Strategy

Under the 2050 Energy Strategy, nuclear power – 40 per cent of the energy mix – is to be replaced by renewables. Seven per cent of the Swiss energy requirements, amounting to 4.4TWh, is to be met by geothermal energy by 2050, and a further 5 per cent – 3.1TWh – by hydropower; these will provide continuous base load.

➜ The SCCER develops new methods and user-friendly software with which hydropower and geothermal plants can be designed, tested and optimised virtually and specifically for Switzerland.

➜ In the field of geothermal energy, the SCCER tests and simulates the fracturing of rock to create underground heat exchange capacity, establishing the basis from which heat can be transported to the surface. It also calculates the risk of intentionally generated small earthquakes, so that damage can be avoided.

➜ The SCCER models and simulates the impact of climate change on hydropower, and draws up prognoses for power producers, providing a basis on which they can plan power production and investments.

➜ The SCCER’s tests and computer simulations show reservoir operators how to avoid damage from impulse waves, which can be sparked by landslides or glacier calving.

➜ The SCCER works on new technologies to reduce energy costs. These include a new drilling technology, a new type of cement to fill bore holes, corrosion-resistant materials, optimising part-load efficiency in turbines and developing new turbines for small-scale hydropower plants.

Facts and figures

91 doctoral students
At the end of 2016, 91 doctoral students were working in the SCCER, of whom 24 were women.

Between 150 and 180 °C
The average temperature 5 kilometres underground is between 150 and 180 °C. This is unused energy that geothermal technologies hope to tap.

Plus 1.8 °C
The average annual temperature in Switzerland has risen by 1.8 °C since 1864, which is double the average global increase.

90% less area
Swiss glaciers are predicted to retreat by an average of 90 per cent by 2100. That is a dramatic amount, but it opens up new opportunities in hydropower.

Participating institutions

- ETHZ Federal Institute of Technology Zurich (leading house)
- Eawag Swiss Federal Institute of Aquatic Science and Technology
- EPFL Federal Institute of Technology Lausanne
- HES-SO University of Applied Sciences and Arts in Western Switzerland
- HSLU Lucerne University of Applied Sciences and Arts
- HSR Hochschule für Technik Rapperswil
- PSI Paul Scherrer Institute
- Università della Svizzera italiana
- University of Bern
- University of Geneva
- University of Lausanne
- University of Neuchâtel
- WSL Swiss Federal Institute for Forest, Snow and Landscape Research
- University of Basel*

* Higher education institution participating in the SCCER; not a funding recipient

You’ll find our innovation roadmap and further information here

⇒ www.sccer-soe.ch
What role do you see your SCCER playing on the path to the energy future?
If we are to ensure a stable supply of energy in future, we need to use as wide a range of new technologies as possible. We do research into some of the main ones.

What do you find fascinating about energy?
I am a physicist. I don’t like the idea of there being energy we cannot use. I want to change this state of affairs.

Which of your SCCER’s successes are you particularly proud of?
I think it’s great that we can do ‘big science’ with the SCCER. That five to ten professors from all corners of Switzerland work together on a single project – without the SCCERs, that would not happen.

Prof. Domenico Giardini, ETHZ, Institute of Geophysics
Domenico Giardini studied physics at the University of Bologna and went on to obtain his doctorate there in 1987. He has been professor of seismology and geodynamics at the ETHZ since 1997. He has held positions at Harvard University, the Istituto Nazionale di Geofisica in Rome and at the University of Rome Tre, where he was professor of seismology. Giardini was director of the Swiss Seismological Service and headed the Competence Center Environment and Sustainability of the ETH Domain (CCES) up to 2011. He has been president of the International Association of Seismology and Physics of the Earth Interior and heads the Seismological Risk sector of the Italy’s Commission for Large-Scale Risks.

“I don’t like the idea of there being energy we cannot use.”
The SCCERs in brief: CREST

CREST
Competence Center for Research in Energy, Society and Transition

**Action area**
Economy, environment, law, behaviour

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**Leading house**
University of Basel

**Deputy head**
Prof. Bettina Furrer,
Zurich University of Applied Sciences (ZHAW)

**Head**
Prof. Frank Krysiak,
University of Basel, Faculty of Business and Economics,
Chair in environmental economics

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**The SCCER’s activities**

CREST is the only SCCER that does not focus on technologies, but instead on people and their behaviour. Researchers in economics and business administration look at energy markets and corporate behaviour; political scientists address policy structures and processes; legal scholars research the shaping of energy legislation and participation procedures, and psychologists consider people’s personal choices. This SCCER develops interdisciplinary and research-based recommendations for policy and business measures that support the energy transition. A significant portion of the non-technical research conducted in the field of energy in Switzerland is linked to this SCCER.

One of the overarching issues CREST addresses is how renewable energies can be promoted to ensure the sufficient supply of electricity at reasonable cost. The research looks at incentive schemes, social acceptance and company behaviour.

This SCCER investigates measures that encourage the proliferation of efficient technologies and behavioural changes in private households. For example, a major survey has revealed that efforts to get people to change their behaviour to save energy should address households differently depending on the way in which they consume energy. The results are regularly discussed with industry partners and local authorities in focus groups. The work also includes laboratory experiments and field tests on individual energy use.

At meso level, CREST looks at strategies and business models that allow businesses and regions to benefit from the energy transition. For example, companies can modernise their business models or acquire a stake in start-ups in the energy sector. The CREST SCCER runs Energy Start-up Days, where start-ups can present ideas and projects, and network with established players. Workshops are held to help companies develop innovative business models, while an open platform allows regions to develop joint strategies to implement the energy transition locally.

Finally, the CREST SCCER analyses various policy measures in relation to their cost and their contribution to the energy transition. Researchers work on topics in an interdisciplinary manner and submit consolidated recommendations in the form of white papers. This raises awareness of relevant topics among a broad specialist audience and fuels political debate.
CREST SCCER model projects

BIKE4CAR

Ditch the car to test-ride an e-bike

For the last few years, motorists have had the option of handing over their car keys for two weeks in the summer to test an electric bike for free. In a survey in 2016, 54 per cent of those who took part in the campaign in 2015 said they used their car less. Six per cent of them no longer owned their own car. More than half were keen to buy an e-bike or had already done so. Bike4Car shows that good campaigns can make lasting changes to people’s mobility choices.

Partners: myblueplanet, myStromer AG, Saxonette, Coop Bau+Hobby, numerous energy cities, Mobility, Pro Velo and Swiss Cycling; Co-funder: SFOE

SWISSMOD

The cost of self-sufficiency

Dependency on imports is a key issue in Switzerland. In order to investigate the cost of autonomous power supply, a team from the University of Basel used its electricity market model Swissmod to carry out a simulation analysis. This showed that significantly more power plant capacity would be required than is currently available to ensure supply at all times. Additional power plants would be inefficiently utilised, however, as in times of low domestic demand the power they produced could not be exported. Overall, this would leave both Switzerland and its European neighbours significantly worse off.

Partner: University of Basel; Co-funder: none

BEST IN CLASS OR SIMPLY THE BEST?

How energy labels affect perception

The EU is considering introducing standardised energy labelling for cars, but there is some controversy over the choice of labelling system. An off-road vehicle with high fuel consumption could be awarded the top A rating in a relative label system if it uses less fuel than similar vehicles. With an absolute system, an off-road vehicle would always have a poor rating. Experiments showed that rating information has a greater influence on people’s assessment of environmental friendliness than fuel consumption. Relative labels are therefore misleading for consumers.

Partners: University of St Gallen, University of Kentucky; Co-funder: none
The 2050 Energy Strategy aims to reduce final energy consumption in Switzerland by 53 per cent per capita by 2050. This cannot be achieved by technical innovation alone. With its interdisciplinary approach, the CREST SCCER makes a direct contribution in the following ways:

- The SCCER produces and publishes regular white papers on current policy topics. These white papers are a synthesis of various studies and research fields, provide science-based recommendations on policy and strategy issues, and fuel political debate.

- In projects with industry partners, the CREST SCCER highlights the opportunities for businesses and regions when the energy strategy is implemented, and offers support in developing relevant business models.

- By running simulations and drawing up scenarios, the SCCER analyses the potential contribution of regional energy systems to the energy transition and makes its findings available to the regions so that they can find locally adapted solutions.

- The SCCER conducts extensive surveys focusing on socio-economic, psychological and sociological aspects, and so can compile the data authorities and businesses need when selecting initiatives and incentives that optimally support the energy transition.

- The SCCER regularly liaises with policy actors and authorities, in particular the Swiss Federal Office of Energy (SFOE).
What do you find fascinating about energy?
The way the technical, environmental and economic aspects are so closely linked. New technologies trigger changes in markets and mean that policies need to be changed. And policy decisions open up new opportunities at a technological level.

What role do you see your SCCER playing on the path to the energy future?
We’re identifying the direction that needs to be taken in society, politics and business, and the areas that Switzerland must focus on if it wants to ensure a sustainable energy system by 2050.

Which of your SCCER’s successes are you particularly proud of?
We’ve shown that as non-technicians we can make an important contribution to the energy transition. We’ve successfully brought together researchers from nine institutions and seven disciplines and demonstrated that the energy transition cannot be achieved by technological innovation alone.

“The energy transition cannot be achieved by technological innovation alone.”

Prof. Frank Krysiak,
University of Basel, Faculty of Business and Economics
Frank Krysiak graduated in 1998 with a degree in energy and process engineering from the Technical University of Berlin, where he went on to obtain a PhD in economics in 2002. He stayed at TU Berlin as a postdoctoral student until 2006, before moving to the University of Basel to take up a position as assistant lecturer in environmental economics until 2011. Frank Krysiak held an associate professorship from 2011 to 2013, and has held a full professorship since 2013. He has been research dean at the Faculty of Business and Economics since 2013, and member of the Federal Energy Research Commission CORE since 2011. His research interests are the long-term impact of environmental policy and the economics of sustainability.
Mobility

Efficient Technologies and Systems for Mobility

The SCCER’s activities

Traffic volumes in Switzerland are increasing. The population is growing and becoming more and more prosperous, so more people are travelling and more goods are being transported by road, rail and air. Mobility now accounts for at least 40 per cent of CO₂ emissions and over a third of our overall energy consumption, a figure which does not include international air travel. In industry and households, per capita CO₂ emissions are declining much more rapidly than in transport; this is becoming one of the biggest challenges for the climate.

The Mobility SCCER has identified three possible ways to curb this trend, despite population growth:

• Demand: suitable policies and technologies restrict the increase in the number of passenger and tonne kilometers and take account of the needs of industry and businesses.
• Efficiency: engines are made more efficient, cars and other vehicles lighter and less powerful.
• Energy sources: electricity, hydrogen and synthetic fuels replace fossil fuels.

If the energy transition is to be successful, action has to be taken at all levels. The SCCER is therefore developing a range of methods and technologies to minimise CO₂ emissions and energy requirements in the transport sector.

Research in this field is not restricted to technology. It also addresses socio-economic aspects and behavioural issues, and the way these two interact.

Energy research in the field of mobility is thus a highly complex issue, requiring an interdisciplinary and at the same time systematic approach. A multimodal approach is also needed, since the field includes all aspects of both road and rail, passenger and goods transport. The following three levels are considered:

• The smallest unit to be researched and improved are propulsion systems, in particular battery systems for electric vehicles, fuel cells and more efficient combustion engines.
• The vehicle is the next biggest system to which improvements can be made. Lightweight construction and intelligent energy management lead to greater efficiency.
• The mobility sytem as a whole can be improved so that new technologies can have an impact and efficiency gains are not cancelled out by unlimited transport growth.

The SCCER’s aim is to combine these three levels so that energy requirements and CO₂ emissions can be reduced throughout the entire system.
Mobility SCCER model projects

SWISS BATTERY RESEARCH PLATFORM
Testing large batteries
The platform provides research and testing capacity to develop battery systems for use in buses, lorries, light railway vehicles, communal vehicles, agricultural machinery and construction machinery. Swiss industry is well-positioned in these niche markets. The growing demand for alternative propulsion systems means it has a good chance of success, provided it can bring suitable innovations in storage technology to market.
Partners: Empa, ETHZ, BFH, HSLU; Co-funders: Various project partners incl. BKW Energie AG and CSEM

GOECO!
App reveals how we get around
This digital platform allows researchers to analyse people’s mobility patterns and find out what influences changes in our behaviour. The app uses GPS to record users’ movements round the clock. The users receive a daily report of the greenhouse gas emissions caused by their movements, as well as tips on how to improve their carbon footprint by selecting better routes and modes of transport. The competitive spirit is aroused when users set themselves reduction targets and measure themselves against friends and family.
Partners: SUPSI, ETHZ; Co-funder: SNSF

SWISSTROLLEY PLUS
Trolleybus of the future
This high-performance trolleybus can run for long stretches on a battery, without the need for an overhead line or a back-up diesel engine. In addition to a powerful battery to drive the bus, a sophisticated control and regulating system is also required. The SwissTrolley plus can reduce power peaks in the overhead cable, thereby reducing pressure on the power grid. Its regenerative braking system reduces energy consumption by about 15 per cent. The bus runs more quietly and more cleanly on a battery than on a back-up diesel engine. The battery-operated trolleybuses are already being tested in operation in Zurich, and are on order for Bern and Biel.
Partners: Carrosserie HESS AG, Verkehrsbetriebe Zürich (VBZ), BFH, ETHZ; Co-funder: SFOE
Facts and figures

23 research groups
The Mobility SCCER funded 23 research groups in the first funding period to build up capacity to promote more efficient and low-carbon mobility.

3 + 1 degree programmes
In 2016 the SCCER launched three new CAS degree programmes, which are integrated in a masters degree programme. The ETHZ’s Mobility of the Future MAS/CAS was taken in the first year by 12 experts and managers from a range of sectors, including transport operators, transport associations, industrial companies and public authorities.

40% of CO₂ emissions
Transport accounts for 40 per cent of CO₂ emissions in Switzerland. This figure does not include international air travel.

47% more cars
Between 1990 and 2014 the number of cars registered in Switzerland rose by 47 per cent, to 4.38 million vehicles. During the same period, the population only grew by about 23 per cent, and annual mileage increased by 27 per cent. Thanks to technological improvements, vehicle CO₂ emissions only rose by 5 per cent. However, this figure is still too high.

17 times more cars worldwide
The number of cars in the world rose seventeen-fold from 1950 to 2016 – from 70 million to 1.2 billion.

Participating institutions
- ETHZ Federal Institute of Technology Zurich (leading house)
- BFH Bern University of Applied Sciences
- Empa Swiss Federal Laboratories for Materials Science and Technology
- EPFL Federal Institute of Technology Lausanne
- FHNW University of Applied Sciences and Arts Northwestern Switzerland
- HSLU Lucerne University of Applied Sciences and Arts
- NTB Interstate University of Applied Sciences and Arts Buchs
- PSI Paul Scherrer Institute
- SUPSI University of Applied Sciences and Arts of Southern Switzerland
- ZHAW Zurich University of Applied Sciences

You’ll find our innovation roadmap and further information here

www.sccer-mobility.ch
What do you find fascinating about energy?
Energy is key to our prosperity. It is the link between nature and society. We use energy to improve our human existence, but this also creates environmental problems, which we then try to mitigate. I find this constellation fascinating.

Which of your SCCER’s successes are you particularly proud of?
We have built up a community that works as one to achieve a greater goal. And we have created an exceptional course in the Mobility of the Future MAS.

What is your personal motivation in heading the SCCER?
Working with my colleagues, I can help to shape a very important area of our lives, and I can learn a lot at the same time. As a young man I got a lot from society, and now I want to give something back. An SCCER lays the foundation for the work of the next generation.

Prof. Konstantinos Boulouchos, ETHZ, Institute of Energy Technology
Konstantinos Boulouchos earned a doctorate in thermodynamics and combustion engineering from the ETHZ in 1984. He did a postdoc at the University of Princeton in the USA, returning to the ETHZ in 1988 to build up a research group in transient combustion processes. In 1995 Boulouchos was appointed head of the Combustion Research Laboratory at the PSI, and coordinated the joint ETHZ-PSI combustion research programme up to 2005. He has been a professor and head of the Aerothermochemistry and Combustion Systems Laboratory at the ETHZ since 2002.
The SCCER’s activities

The BIOSWEEt SCCER shares the vision of the Swiss government’s energy policy, that in 2050 energy from biomass will make up twice as much of the energy mix as it does today, namely 100 petajoules. If this target is to be reached, the use of biomass must be gradually increased; to achieve this, the SCCER is optimising existing technologies, developing new ones and trying to bring them to market maturity.

Biomass is a very versatile source of energy. It can be used to produce electricity and heat, as well as liquid, solid or gas fuels. Furthermore, it can also be stored, unlike other renewables.

The SCCER conducts systemic research based on idealistic assumptions, asking what the best possible use of biomass might be. How can we generate the maximum amount of energy? How can we achieve the highest possible reductions in CO₂? At the moment it is not clear whether people will one day be prepared to pay a premium for this kind of energy – bioenergy is often more expensive than other types – or which of these energy services will be in demand in future.

For this reason, the SCCER conducts fairly wide-ranging research and concentrates on technologies that could be suitable for the market in 10 or 15 years at the latest. For each technology it works with a partner from industry. The minimum requirement is for researchers to have a clear idea of how to attract an industry partner, even if the technology they are working on is at a very early development stage. They must have already filed a patent application and have a master plan for launching the technology on the market. The SCCER actively publicises its research results and is one of the few SCCERs to have already employed a knowledge and technology transfer officer in the first funding period.

Research is centred on the supply side. It focuses on increasing the efficiency of conversion technologies (generating bioenergy from biomass and biofuels), better integration of the various energy systems and innovative value-added chains. Demonstrators such as the Energy Systems Integration (ESI) trials platform are also employed. On the demand side, the SCCER conducts research into replacing fossil fuels with biomass in order to generate heat and electricity and for transport use. Finally, researchers are involved in developing models of optimum biomass value-added chains as a basis for policy decisions.
BIOSWEET SCCER model projects

INDUSTRIAL WOOD DUST BURNER
Producing asphalt with CO₂-neutral biomass
Asphalt is produced by drying and heating aggregate and then mixing it with bitumen. The aggregate is dried in rotary tumblers heated by the exhaust generated from burning fossil fuels. The aim of this project is to use CO₂-neutral biomass as the fuel in the drying process, such as wood dust or other plant material, which produces few pollutants when burnt. The new burner is being developed using experimental methods and fuel analyses, and numerical calculations of the gas flow and reaction processes.
Partners: FHNW, Ammann AG; Co-funder: CTI

SALT SEPARATOR
Salt separator for gasifying biomass
The PSI has developed an efficient process for producing a methane-rich gas from damp biomass. In a pilot, a salt separator prototype was developed, constructed and integrated into an existing plant at the Karlsruhe Institute of Technology (KIT). A trial conducted under realistic conditions with glycerine and fermentation residue from a biogas plant produced a methane-rich gas with stable results, in large part thanks to the prototype. Based on the positive results from this project, a large-scale industrial model is planned at the PSI.
Partners: KIT, PSI, FHNW, Kasag AG; Co-funder: SFOE

TORPLANT
Refining biomass by drying
Wet and smelly biomass cannot be used to produce energy, but in the torrefaction process it can be turned into a useable and storable product. Laboratory trials and then a pilot installation have shown that the energy density of dried biomass pellets is a third higher than that of conventional wood pellets. This reduces transport and storage costs. Waste heat can also be recovered from the process, so a plant that produces 500kg of pellets per hour can be run profitably under current economic conditions.
Partners: HEIG-VD, GRT Technology Group, Ökozentrum; Co-funder: Canton of Vaud
How the BIOSWEET SCCER contributes to the 2050 Energy Strategy

Under the 2050 Energy Strategy, 100 petajoules of energy will be produced using biomass by the year 2050. This is double the amount currently consumed.

➜ The SCCER has recorded and analysed the potential of all biomass substrates in Switzerland. It gathered data from 600 stakeholders and compared the findings with existing studies, and concluded that the 100-petajoule target is realistic.

➜ The SCCER optimises and researches conversion technologies with the aim of making better use of biomass substrate. It develops regional value-added chains and small-scale plants for sources which are not yet exploited since only small amounts of biomass are available.

➜ The SCCER also develops business models with biomass and optimises the logistic processes and pre-treatment methods involved. Interfaces are important here: which requirements does a plant need to meet in order to process biomass of a certain quality?

➜ The SCCER creates prototype plants to test existing or new technologies. On the ESI (Energy System Integration) experimental platform, for example, BIOSWEET and the HaE SCCER combine existing technologies that have not been successful in isolation, resulting in biomass and storage solutions that are potentially of use to the industry.

Facts and figures

No 2 in Switzerland
Biomass is the second most important source of renewable energy produced in Switzerland.

5 energy types
Biomass is the most versatile of the renewable energy sources, providing five different energy services: heat, electricity, solid fuel, liquid fuel and gas.

55 partners
The nine research partners cooperate with 55 private and public organisations: 8 large corporations, 38 SMEs and 9 public institutions or associations.

45% unexploited potential
Only 55 per cent of domestic biomass substrate is currently used to produce bioenergy; there is, therefore, considerable potential to exploit.

32 petajoules
The greatest unused potential for producing bioenergy lies in farmyard waste and timber. These materials could provide 32 petajoules of primary energy.

Participating institutions

- PSI Paul Scherrer Institute (leading house)
- BFH Bern University of Applied Sciences
- EPFL Federal Institute of Technology Lausanne
- ETHZ Federal Institute of Technology Zurich
- FHNW University of Applied Sciences and Arts Northwestern Switzerland
- HES-SO University of Applied Sciences and Arts in Western Switzerland
- SUPSI University of Applied Sciences and Arts of Southern Switzerland
- WSL Swiss Federal Institute for Forest, Snow and Landscape Research
- ZHAW Zurich University of Applied Sciences

You’ll find our innovation roadmap and further information here

⇒ www.sccer-biosweet.ch
What do you find fascinating about energy?
As a human being living on this planet, I use energy and am myself part of the problem. Through my work as a researcher I can contribute to solving the problem. And what is more, I owe this to my three children.

Which of your SCCER’s successes are you particularly proud of?
We have succeeded in bringing together the bioenergy research environment under one roof; it used to be fragmented but is now more united.

What is your personal motivation in heading the SCCER?
I can increase my visibility as a researcher and have a greater influence; my voice is heard more clearly. This is motivating and makes the job attractive.

Prof. Oliver Kröcher, PSI, Laboratory for Bioenergy and Catalysis
Oliver Kröcher obtained a degree in chemistry from the University of Würzburg in 1993. From 1994 he worked as an assistant at the Laboratory of Organic Chemistry at the ETHZ, obtaining a PhD in 1997. From 1997 to 2001 he worked at Degussa researching catalytic processes and towards the end of his time there headed the research group. In 2001 he moved to the PSI, where he took on responsibility for the Catalysis for Energy Processes group. Oliver Kröcher has also been head of the Laboratory for Bioenergy and Catalysis (LBK) at the PSI since 2011, and a member of the board at Hydromethan AG, a PSI spin-off. He has been a professor at the EPFL since 2013.
For even greater impact

In the first funding period, the SCCERs laid a solid foundation on which they can build – and by focusing their work, they can achieve an even greater impact in the second period. They have CHF 120 million at their disposal between 2017 and 2020 to carry out their mandate.

Focus 1

In the second funding period, the SCCERs will continue to work on projects at all stages of the innovation chain and at various levels of technology readiness, from exploring innovative approaches to transferring solutions to market players. However, there must be greater emphasis on knowledge and technology transfer (KTT) from research to industry.

In order to professionalise these steps, all SCCERs will employ experienced KTT managers with industry contacts who will support them at the interface between research, industry and the market. Projects with a high level of technology readiness will be increasingly passed on to industry partners. This will free up research capacities, so researchers will be available to pursue further new ideas. The success of KTT will be evaluated in the impact analysis.

Focus 2

A second focus area are five projects in which the competence centres collaborate, termed joint activities. The aim of these projects is to increase interdisciplinary collaboration between the centres and so boost overall impact.

In some joint activities, such as the Scenario & Modelling Initiative for developing coherent and robust scenarios, all of the SCCERs pool their strengths. Others involve bilateral or multilateral cooperation between individual SCCERs. This is the case, for example, with the Coherent Energy Demonstrator Assessment (CEDA), in which four SCCERs, each with their own demonstrators, look for synergies between individual demonstrators. Another multilateral joint activity concerns the socio-economic and technical planning of multi-energy systems in individual buildings and whole sites.

Besides the joint activities, cooperation will be structured and stepped up between the technical SCCERs and CREST, the socio-economic SCCER.
The SCCERs will continue to be managed by the CTI in 2017. From 1 January 2018, the CTI’s successor organisation, Innosuisse, will take over all the related tasks and duties.

Focus 3

The SCCERs are to focus on topics that, on the basis of exploration in the first phase, are likely to make a relevant contribution to the 2050 Energy Strategy. When novel, long-term approaches are taken, there is of course less certainty of success.

The SCCERs are to make greater use of compelling demonstration activities, such as pilot and demonstration projects.

The capacities and structures developed up to the end of 2016 need to be maintained. This includes the partnerships that have been established with businesses and local authorities.

Focus 4

The federal government regards the founding and development of the SCCERs as an initial step to provide impetus. The SCCERs should continue to generate expertise and work with industry in the Swiss research landscape to develop solutions for the future of energy beyond 2020.

➡️ Maintaining capacities
➡️ Preparing for autonomy
The SCCERs have already achieved great things

**Researchers at the SCCERs**

By the end of 2016, a total of 1,214 researchers were employed by the SCCERs (2015: 1,073). Around 44 per cent of these were PhD students and research assistants and 12 per cent professors. It had been planned to increase capacity by 552.2 full time equivalent positions (FTEs); in actual fact, 785.7 FTEs were created. The SCCERs exceeded the original target by 42 per cent.

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full professors</td>
<td>143</td>
</tr>
<tr>
<td>Assistant professors, lecturers</td>
<td>44</td>
</tr>
<tr>
<td>Head researchers, senior researchers</td>
<td>239</td>
</tr>
<tr>
<td>Postdoc researchers</td>
<td>191</td>
</tr>
<tr>
<td>Technicians</td>
<td>45</td>
</tr>
<tr>
<td>PhD students, scientific staff</td>
<td>539</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
</tr>
</tbody>
</table>

**Participating implementation partners**

At the end of 2016, 176 implementation partners were involved in the SCCERs; some appear several times in this figure. Altogether, the SCCERs cooperate with over 700 implementation partners.

**Approved CTI projects**

From 2014 to 2016, the CTI approved 58 projects to be carried out under the auspices of the SCCERs. The SCCERs launched 500 projects in total; this number includes projects run in conjunction with the Swiss National Science Foundation (SNSF), the Swiss Federal Office of Energy (SFOE) and other partners.
The seven-member steering committee and 31 experts on the evaluation panel support the SCCERs

**SCCER steering committee**
The CTI and the Swiss National Science Foundation (SNSF) jointly manage the SCCERs. The director of the Swiss Federal Office of Energy (SFOE) plays an advisory role.

**Chair**
Walter Steinlin (CTI), Switzerland

**Members**
Dr Bernhard Eschermann (CTI), since 2017
Prof. Marc Gruber (SNSF), Switzerland, until end of 2016
Prof. Martina Hirayama (CTI), Switzerland, until end of 2016
Dr Matthias Kaiserswerth (CTI), Switzerland
Prof. Marcel Mayor (SNSF), Switzerland
Dr Martin Riediker (SNSF), Switzerland
Prof. Frank Scheffold (SNSF), Switzerland
Prof. Paul Söderlind (SNSF), Switzerland, since 2017
Dr Walter Steinmann (SFOE), Switzerland (advisory), until end of 2016
Benoît Revaz (SFOE), Switzerland (advisory), since 2017

**SCCER evaluation panel core group**
The evaluation panel is made up of 31 specialists who provide factual advice to the steering committee and evaluate the SCCERs once a year. The panel comprises 21 experts and the 10 members of its core group.

**Chair**
Andreas Umbach, Switzerland, until end of 2016
Dr Stefan Nowak, Switzerland, since 2017

**Members**
Prof. Andreas Balthasar, Switzerland
Prof. Hubert Fechner, Austria
Dr Henning Fuhrmann, Switzerland
Prof. Martin Kaltschmitt, Germany
Prof. Anke Kaysser-Pyzalla, Germany
Prof. Hans-Rudolf Schalcher, Switzerland
Dr Stefan Nowak, Switzerland, until end of 2016
Prof. Hans-Rudolf Schalcher, Switzerland
Prof. Philippe Thalmann, Switzerland
Prof. Eberhard Umbach, Germany
One vacancy from 2017

**Financial overview**
Between 2013 and 2016, the SCCERs had a total budget of CHF 247.2 million, of which CHF 71.5 million was CTI funding. This funding was awarded on the condition that the SCCERs provide their own funds, competitive federal funding and third-party funds from industry amounting in each case to at least 50 per cent of the CTI funding. The SCCERs met this condition in all three categories; they even exceeded the target for their own funds by more than double.