SWISS ENERGY RESEARCH CONFERENCE 2016

FACT SHEETS

Schweizerische Eidgenossenschaft
Confédération suisse
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Swiss Federal Office of Energy SFOE

Coordination & promotion

THE ROLE OF THE SFOE IN THE PROMOTION OF RESEARCH

+ FIND OUT MORE HERE:

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Energy Research Section

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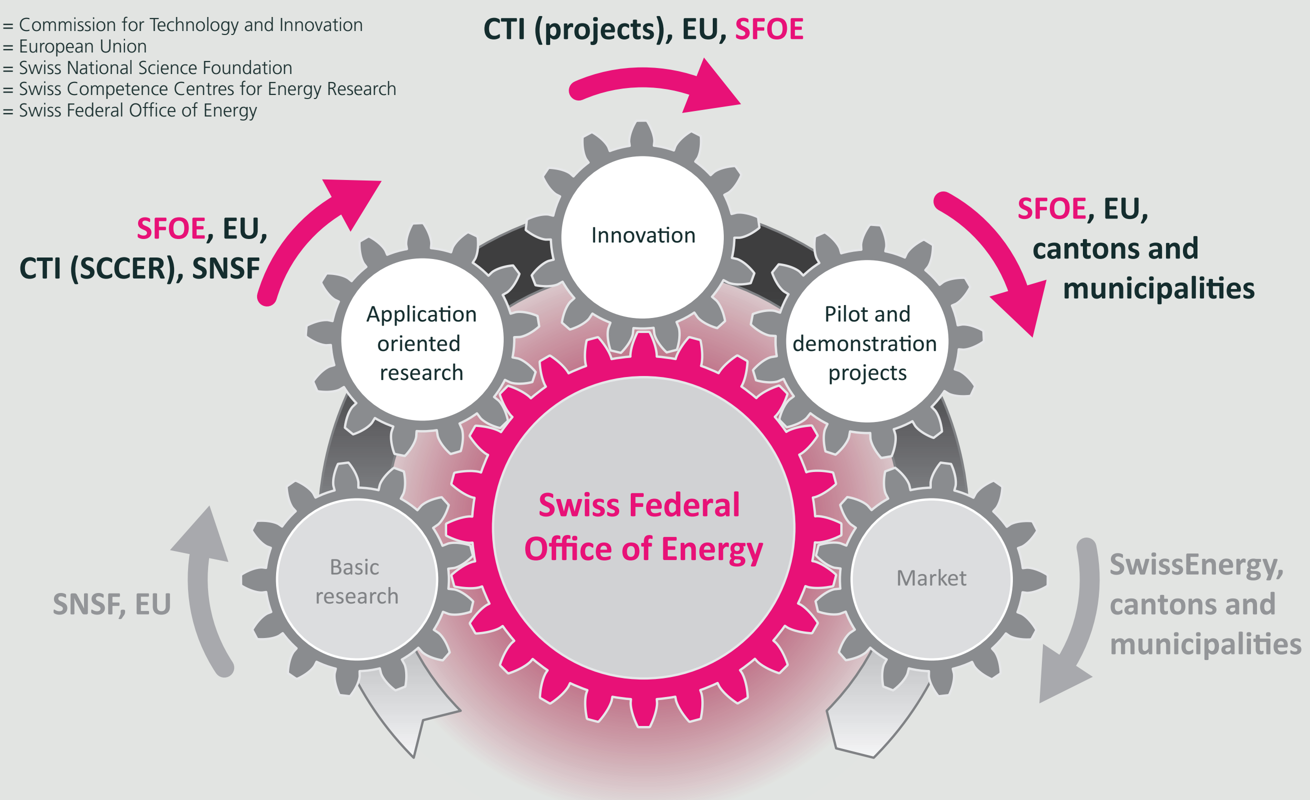
INTRODUCTION

The ability to develop new concepts and introduce them onto the market is a significant factor for the competitiveness of a country's economy. Here the key lies in research, for this is where new findings and ideas come into being that can subsequently be developed into innovative and competitive products. The Swiss Federal Office of Energy (SFOE) plays a central role in the coordination of research and innovation in the energy sector in Switzerland. It is active in all research segments along the entire value chain and thus secures the continual growth of know-how and its implementation in specific applications.

NATIONAL COORDINATION

CTI = Commission for Technology and Innovation
EU = European Union
SNSF = Swiss National Science Foundation
SCCER = Swiss Competence Centres for Energy Research
SFOE = Swiss Federal Office of Energy



SFOE RESEARCH PROGRAMMES

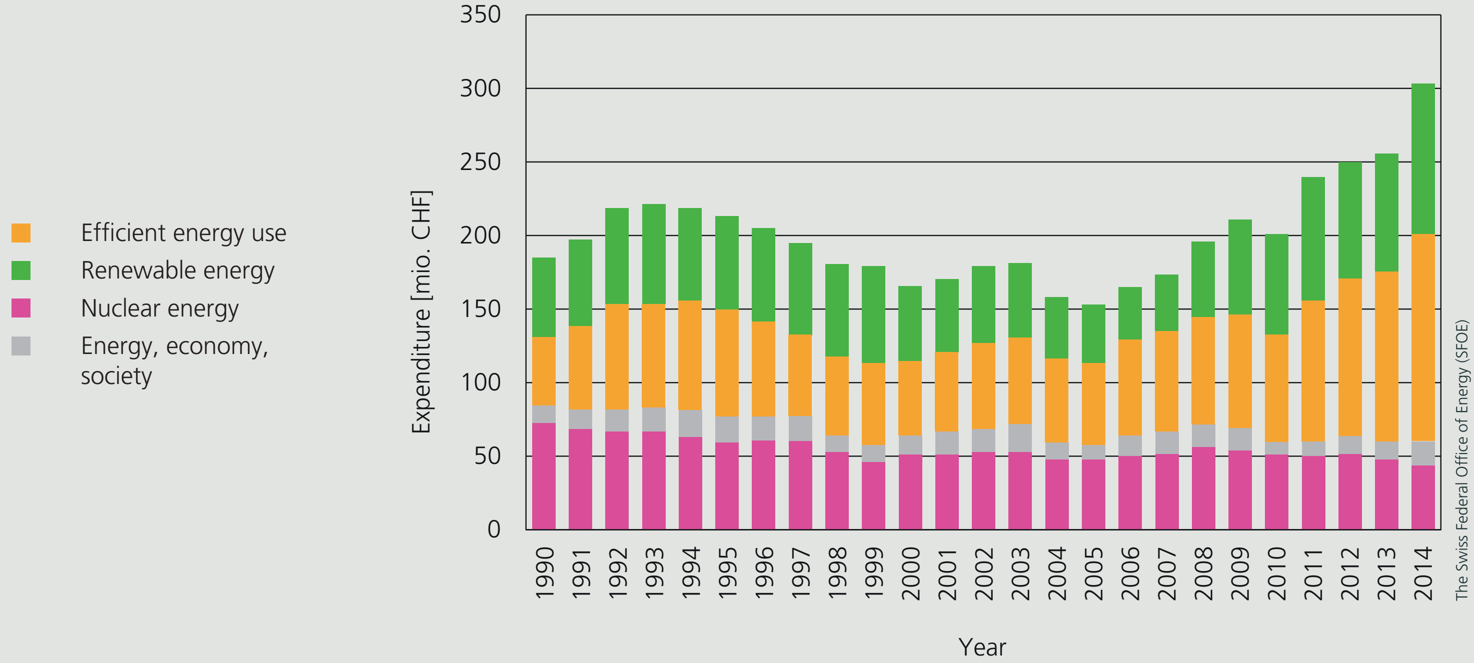
EFFICIENT ENERGY USE

- Buildings and cities
- Mobility
- Electricity technologies
- Fuel cells
- Networks
- Industrial processes
- Combustion-based energy systems

RENEWABLE ENERGY

- Hydrogen
- Photovoltaics
- Solar high-temperature energy
- Solar heat and heat storage
- Heat pumps
- Bioenergy
- Hydropower
- Geothermal energy
- Wind energy

DEVELOPMENT OF FUNDING UP TO 2014



SOCIETY AND ECONOMY

- Energy – economy – society
- Nuclear waste disposal
- Dams and reservoirs

In close cooperation with the leading competitive public promotion agencies, the Swiss Federal Office of Energy (SFOE) supports and coordinates research and innovation in the energy sector along a major portion of the value chain. Here the SFOE has adopted a programmatic and subsidiary approach that is in line with the "Federal Energy Research Masterplan". In addition to its networking activities on the domestic front, the SFOE also focuses on the active transfer of knowledge and exchanges of findings at the international level.

PILOT-, DEMONSTRATION AND FLAGSHIP PROJECTS

The Swiss Federal Office of Energy (SFOE) promotes application-oriented energy research encompasses scientific research as well as pilot, demonstration and flagship projects, which promote economical and efficient energy consumption or the use of renewable energies.

NATIONAL RESEARCH PROGRAMMES (NRPS)

The Swiss National Science Foundation (SNSF) promotes basic research in all scientific disciplines on behalf of the federal government. Its numerous National Research Programmes implement research projects that are intended to look for solutions to major present-day problems. There are currently two energy-related programmes: NRP 70 ("Energy Turnaround") and NRP 71 ("Managing Energy Consumption"). The SNSF also sponsors professorships. For this purpose, a budget of 24 million Swiss francs was granted for the period from 2013 to 2016 within the framework of the Swiss Action Plan for Coordinated Energy Research.

COMMISSION FOR TECHNOLOGY AND INNOVATION (CTI)

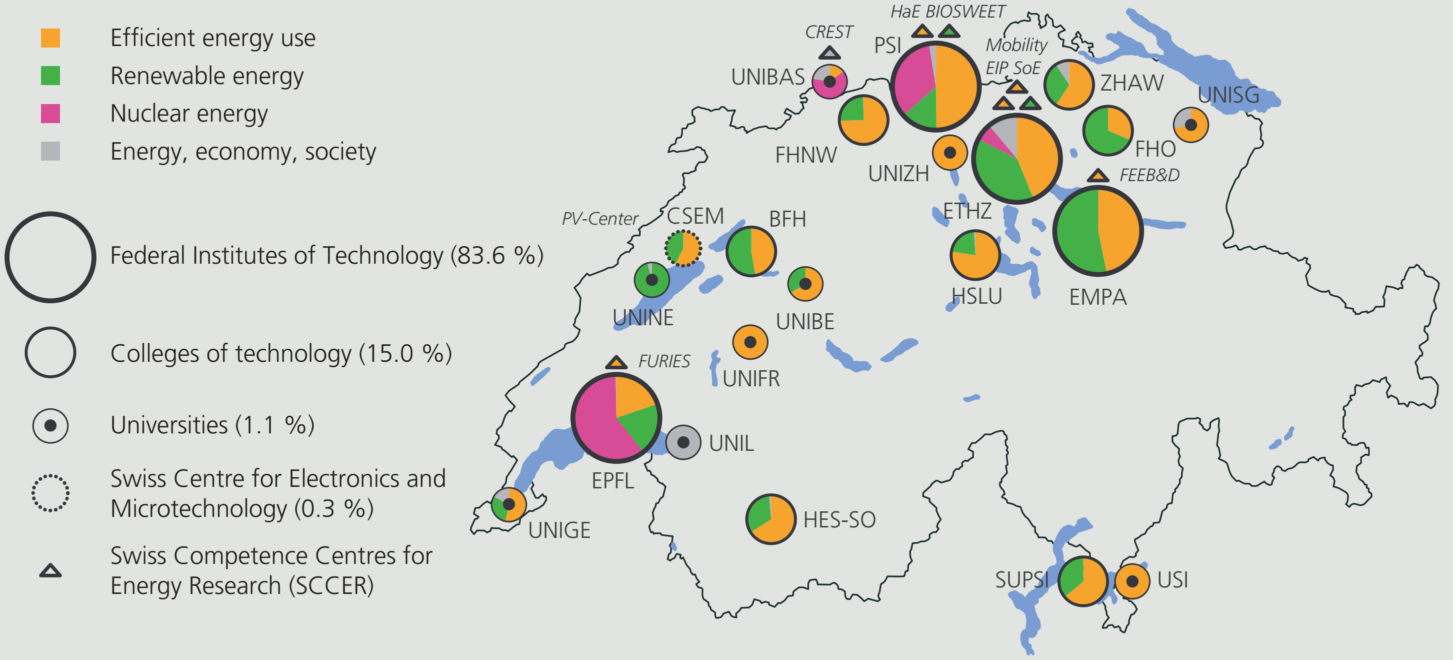
The CTI is the federal government's agency for the promotion of innovation. It is responsible for supporting science-based innovations in Switzerland by providing financial resources, professional consulting and networks. Its focus in the period from 2013 to 2016 is on energy research. The CTI is financing and overseeing the development of the Swiss Competence Centres for Energy Research (SCCERs) with a budget of 72 million Swiss francs, and with an additional budget of 46 million it is also promoting energy-related research and development projects.

SWISS COMPETENCE CENTRES FOR ENERGY RESEARCH (SCCER)

The eight SCCERs are carrying out research aimed at finding solutions that will contribute towards the restructuring of Switzerland's energy system. Their activities encompass both application- and solution-based research, and they also set out to secure the transfer of research findings to the market.

SWITZERLAND'S RESEARCH LANDSCAPE

EXPENDITURE BY SWISS RESEARCH INSTITUTION IN 2013 (APPROX. CHF 256,9 MIO.)



INTERNATIONAL COOPERATION IN RESEARCH

Switzerland attaches a great deal of importance to international cooperation in the area of energy research. Via the SFOE it is involved in various IEA "Technology Collaboration Programmes" (formerly referred to as "Implementing Agreements"), and within Europe it is actively involved in the research programmes of the European Union. Here, at the institutional level the SFOE coordinates energy research with the European Strategy Plan for Energy Technology (SET-Plan) and the European Research Area Networks (ERA-NET).

International cooperation facilitates the utilisation of synergies, helps eliminate redundancies and enables fields of research to be placed in a broader context. Cooperation is of particular importance within the framework of the International Energy Agency (IEA) and the research programmes of the European Union (e.g. Horizon 2020). Switzerland is currently involved in more than fifty percent of the 39 research programmes of the IEA, for which purpose it invests around 1.25 million Swiss francs a year. In addition, the SFOE currently holds five chairs in IEA research programmes, namely: Energy in Buildings and Municipalities; Hydrogen; Photovoltaic Systems; Heat Pumps; Hybrid and Electric Vehicle Technologies.

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30 Years R+D

ELECTRICITY FROM PHOTOVOLTAICS: EXPECTATIONS EXCEEDED

PHOTOVOLTAICS: SUCCESS STORY AND MILESTONES FOR SWITZERLAND

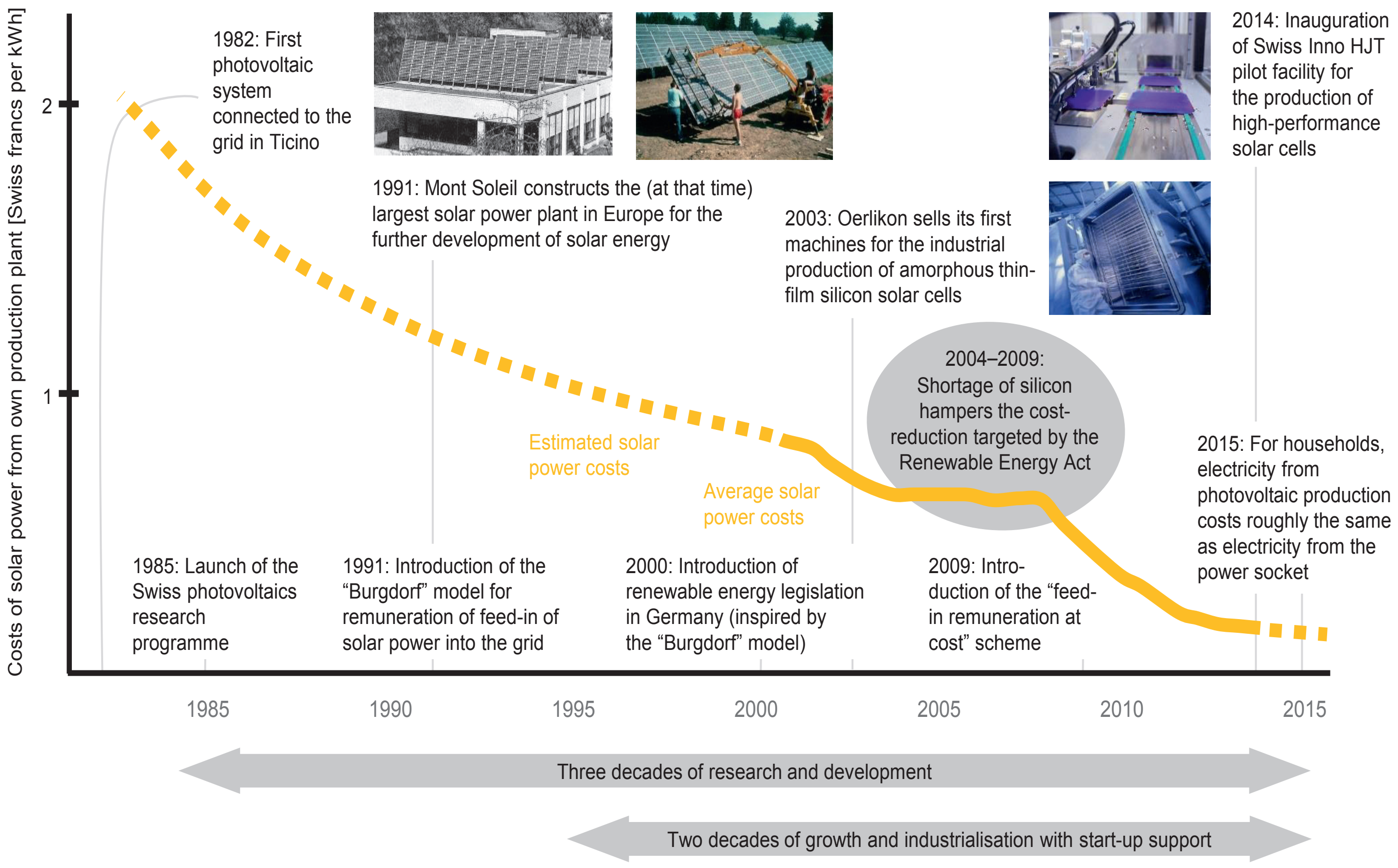

Figure: SFOE; SUPSI-1982; Gesellschaft Mont-Soleil; Oerlikon Solar; Daniel Hager/CSEM-Meyer Burger

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PV INNOVATIONS FOR THE MARKET

Solar power has conquered Switzerland. In the past five years, the production of electricity from photovoltaic systems has increased by a factor of ten. Today, 48,000 decentralised production facilities yield enough electricity to supply 210,000 households. Solar power now meets around 2 percent of Switzerland's electricity demand.

Three decades of research and development have paved the way for this form of electricity production throughout Switzerland. In this timeframe, the costs of solar power have fallen to a tenth of the original price. On average, one kilowatt hour now costs 19 cents (basis: new facility; status, October 2015).

SWISS COMPANIES STRONGLY POSITIONED

Despite fierce international competition, Swiss companies are well positioned along the photovoltaics value chain. They provide materials and components, construct inverters, and supply installation systems, production facilities and sector-specific software tools. Thanks to efficient research and development, and close ties with leading research institutions, they are able to remain competitive on the export markets. Switzerland's photovoltaics sector generates a turnover of around a billion Swiss francs and employs approximately 6000 personnel (full-time equivalent jobs). Unlike fossil-based energy and imported electricity, Switzerland's photovoltaic systems are to a large extent *Swiss made.* More than half the value-added remains in the country and creates jobs.

EFFICIENT RESEARCH AND DEVELOPMENT NETWORK

Swiss research institutions – the ETH domain, colleges of technology, universities, the Photovoltaics Centre at the CSEM (Swiss Centre for Electronics and Microtechnology – have been at the forefront of photovoltaics research for many years. The Swiss National Science Foundation (SNSF), the Commission for Technology and Innovation (CTI) and the Swiss Federal Office of Energy (SFOE) have been supporting the development of this technology since the 1980s through research, pilot and demonstration projects. But the numerous innovative projects initiated by private solar energy pioneers are also a decisive driving force. Here, for example, photovoltaics modules were recently integrated into the façade of two high-rise buildings undergoing renovation in Sihlweidstrasse in Zurich (cf. photo).

Foto: Gataric

WP2: Bulk Multi-Energy Grids

SCCER-FURIES

GRIDS & COMPONENTS

KEY DATA

PROJECT DURATION
01.2017–12.2020

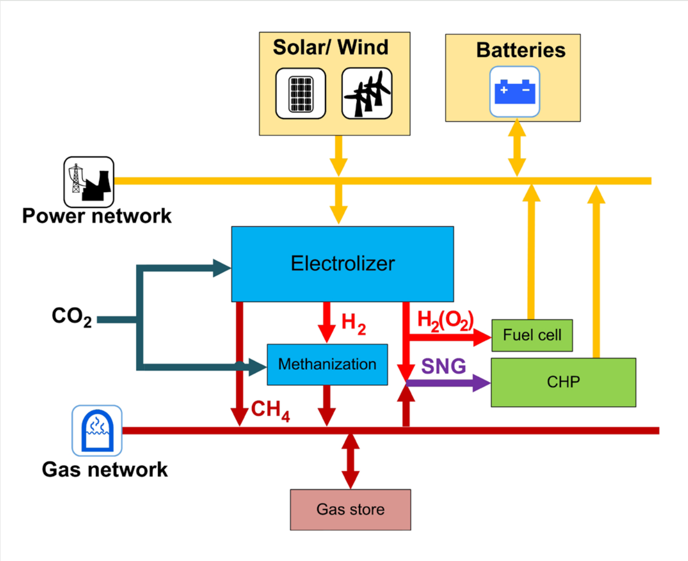
SPONSORS

BFE	BKW
CTI	ABB
SNSF	SwissGas
SwissGrid	Alpiq
Axpo	NEPLAN

ACADEMIC AND COOPERATION PARTNERS

ETHZ-PSL	ETHZ-RRE
ETHZ-FEN	UniBasel-FoNEW
ETHZ-LEC	USI-ICS
ETHZ-IKG	ZHAW

POWER2GAS / GRID INTEGRATION



Picture: CCEM Renerg2 project

MAIN GOAL

To provide simulation tools for the analysis and development of low-inertia energy grids with high share of renewable energy sources, the quantitative evaluation of local and international market potential, to propose new energy management methods, to assess planning options for alternative and more flexible power storage and generation and to identify the risk to operate power grids considering the upcomming challenges.

RELATION TO OTHER PROJECTS

Partners work closely with SCCER-CREST and SCCER-HAE to ensure consistency of the assessed market structures and to involve a direct link to the cross-SCCER activities on scenarios and forecasts. Furthermore international collaboration is envisioned on the identification of the needs for measurements and communication input in the operations of power systems.

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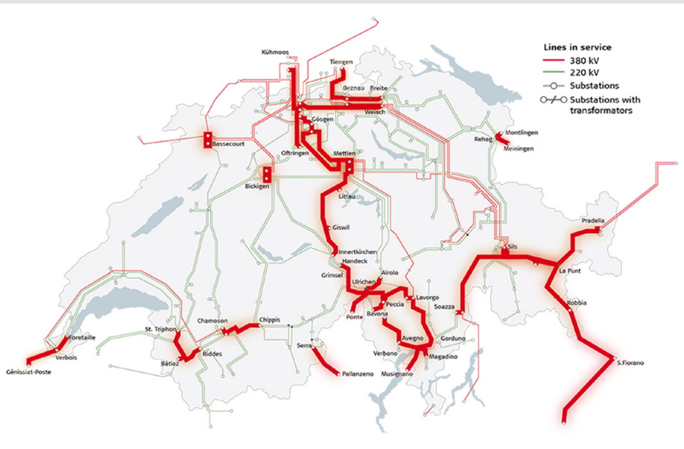
OTHER OBJECTIVES

The planned decommissioning of the Swiss nuclear power plants and the considerably increased penetration of the renewable energy sources into Switzerland and the neighboring countries necessitate the investigation of new alternatives for flexibly distributed power generation and storage technologies Under this prospect, a proper evaluation of the economic benefits of different market structure mechanisms is required in order to provide a quantitative assessment of the Swiss and European electrical grids. Furthermore, identifying and assessing the risks of operating the power grids stemming from (a) the dependency on the grid security based on real-time measurement provided by the communication infrastructure and (b) different portfolios of primary energy resources for the future Swiss energy systems are required.

RELATION TO ENERGY STRATEGY 2050

A set of recommendations and future actions for the purpose of maintaining stability of the Swiss power system facing the future energy challenges will be provided. A theoretic benchmark for the operation of the future European power system from the Swiss will be delivered. A computer simulator that can be used to study how transmission and distribution levels should be coordinated will be developed. The technical and economic performance of the distributed energy storage solutions will be investigated. Feasibility analysis of the scenarios set forth by the Energy Strategy 2050 with respect to the risks of operations and grid dependency on the real-time measurement will also be addressed.

CONGESTIONS / BOTTLENECKS



Picture: Swissgrid

PREVIOUS RESULTS

1) Evaluation of the current and future Swiss energy system with an increasing share of renewable energy sources (RES).

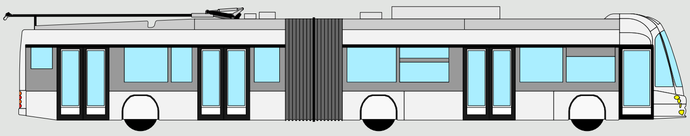
2) Identification of required grid extensions including new lines and energy storages.

3) Evaluation of future technical and economic Swiss energy system aspects.

4) Vulnerability and security assessment and corrective actions to mitigate failure propagation.

A New Vehicle Concept

SWISS-TROLLEY+



+ FIND OUT MORE ABOUT THE PROJECT:

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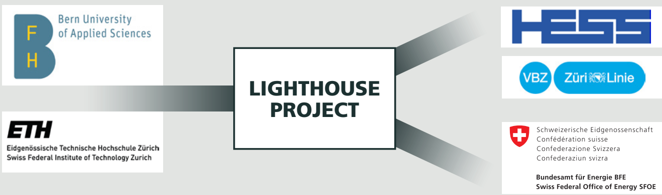
KEY DATA

PROJECT DURATION
05.2015–04.2019

CONTRACTING PARTY
HESS Carrosserie AG

PARTNERSHIP



FULLY ELECTRIC SWISSTROLLEY+

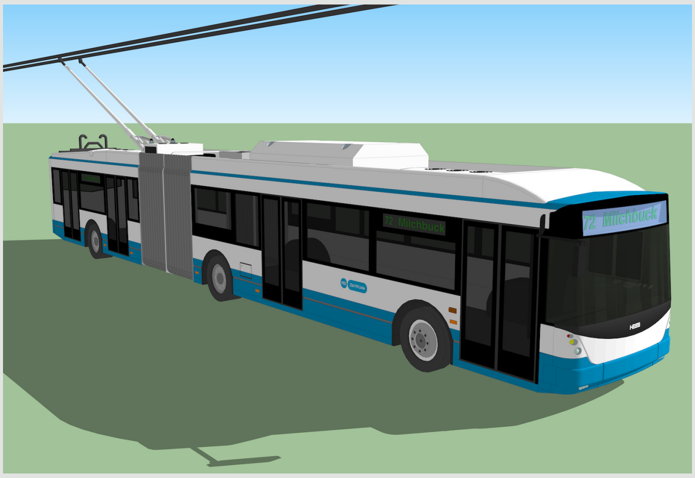


Image: SwissTrolley+

OBJECTIVES

State-of-the-art trolley buses need a diesel-powered auxiliary power unit (APU) to ensure maneuverability during a shortage of electricity. The engine, despite being rarely used, leads to increased vehicle weight and thus increases the energy consumption of the bus. When actually being used, the undersized APU runs mainly in cold-start mode, leading to extreme noise and pollutant emissions.

The goal of SwissTrolley+ is to avoid those drawbacks by replacing the APU with a high-performance traction battery. The aim of the ETH Zürich is to develop a control system for the energy balance of a trolley bus. The tasks at BFH-TI involve the life testing of the battery and the development of a battery life model, which will be included in the energy management system.

CHALLENGES

The SwissTrolley+ has two sources of power: the electricity grid and the traction battery. During operation, the energy demand is mainly defined by the driver. The two power sources, however, provide a new degree of freedom:

In each moment of time, the energy management system of the vehicle needs to decide whether to draw electric power from the grid or from the battery. To solve the decision of how to “split” the power demand between power sources, expertise in control systems theory is necessary. The energy management system will be developed to operate the battery in a conscious manner in order to maximize battery lifetime. Therefore, the development of highly accurate battery life models is crucial for battery usage optimization, and in itself, a highly challenging task.

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PROJECT GOALS

THE GOALS OF THE PROJECT ARE THE FOLLOWING:

- Reduction of noise and pollutant emissions
- Increased energy efficiency by a novel power and energy management
- Drives without overhead wires are possible
- Support of overhead DC-grid by battery is possible
- Maintenance cost savings by not utilizing the overhead wire network
- Guaranteed battery life of > 10 years by conscious battery utilization

LINK TO THE ENERGY STRATEGY 2050

15% REDUCED ENERGY DEMAND

- Regenerative braking always possible
- Predictive optimal energy management strategy

OPTIMIZED HEATING AND AIR CONDITIONING SYSTEMS

- HVAC equals ca. 50% of total vehicle energy demand

BATTERY LIFE MODELS

- Incentive for novel business models by engineers and decision makers

REDUCED PEAK LOADS ON ELECTRIC GRID

- Less grid stabilization energy is required
- Peak load is a main driver of electricity pricing

CONCEPT OF THE SWISSTROLLEY+

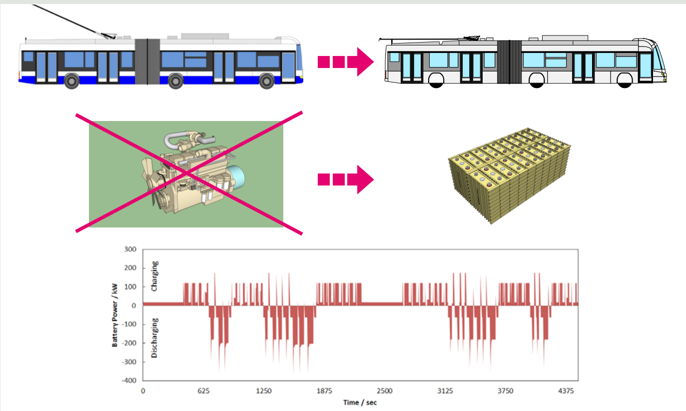

Figure: Energy concept

FIRST RESULTS

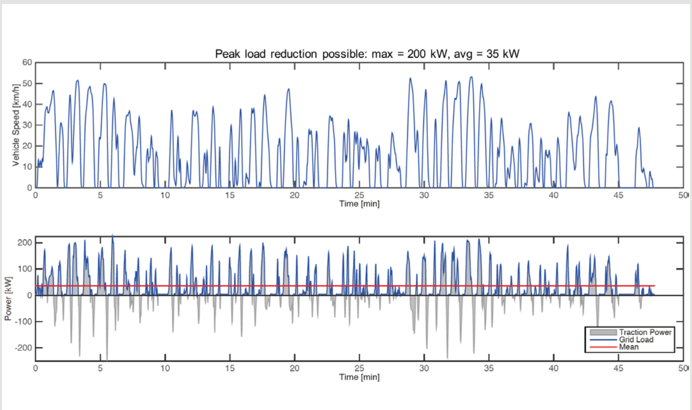

Figure: Peak load reduction potential

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Energy-efficient cooling

PROCESS OPTIMISATION OF A CO_2 COOLING SYSTEM WITH THE AID OF EJECTORS

KEY DATA

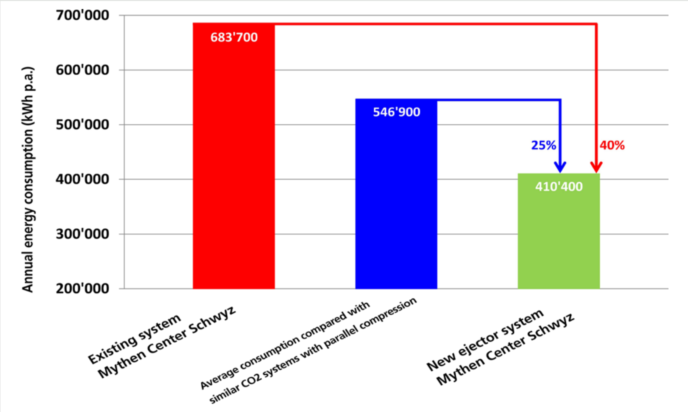
DURATION OF PROJECT
05.2014–12.2015

CLIENT
Migros Genossenschaft, Lucerne

CLIENT'S REPRESENTATIVE
Frigo-Consulting AG, Gümligen Bern

PARTNERS
Swiss Federal Office of Energy
Alpiq Intec West

OVERVIEW OF ENERGY CONSUMPTION



Comparison of energy consumption

MAIN OBJECTIVE

In a field trial, the main objective was to identify the potentials of ejectors in a transcritical CO_2 cooling system. Today, cooling accounts for around 40% of the energy consumption in a supermarket. With the aid of the latest technology and ejectors, energy savings of up to 25% were achieved in the Migros branch in the Mythen shopping centre in Schwyz, in comparison with similar-sized cooling systems. This quantum leap was made possible through the carefully calculated integration of five ejectors, which make direct use within the system of the previously lost expansion energy. Furthermore, as a refrigerant, CO_2 reduces direct CO_2 emissions by a factor of more than a thousand in comparison with similar synthetic refrigerants.

RELATIONSHIP WITH OTHER

The foundation for this technology was laid in autumn 2013 in a project carried out in the Migros branch in Bulle in cooperation with the Swiss Federal Office of Energy. Thanks to the installation of the world's first transcritical CO_2 cooling system equipped with several ejectors, it was possible to achieve energy savings of 15% in comparison with conventional transcritical CO_2 cooling systems based on the current status of technology. The findings obtained from this project were used as the basis for the further development of the concept and control mechanism, and these were subsequently incorporated into the new system that was installed in the Migros branch in the Mythen shopping centre.

+ FIND OUT MORE HERE:

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OTHER OBJECTIVES, PROCEDURE

In addition, the aims are to implement this technology in other projects, gain the confidence of the market and further reduce investment costs. By increasing the demand for systems of this type, the goal is to encourage other manufacturers to include ejectors in their product range. Ultimately, the aim is make commercial CO_2 cooling systems with ejectors cheaper than all other available types. This can be achieved on the one hand thanks to the resulting reduction in energy consumption, and on the other through the subsequent development of smaller systems with the same level of performance.

RELEVANCE FOR ENERGY STRATEGY 2050

An average supermarket of around the same size as the Migros branch in Mythen shopping centre consumes approximately 546’900 kWh per annum (rough estimate). The system installed in the branch in Mythen shopping centre provides the same refrigerating capacity but only consumes 410’400 kWh per annum, and thus saves around 137’000 kWh a year. With approximately 3750 supermarkets throughout Switzerland and an average annual consumption of 250’000 kWh per store (rough estimate), the reduction in energy consumption by around 20% through the use of ejector technology would result in annual savings in electricity consumption of around 190 GWh. This is equivalent to approximately 7% of the output of Mühleberg nuclear power plant, or a solar panel with a surface area of 1,5 square kilometres.

EJECTOR

Close-up view of an ejector

RESULTS TO DATE

Because the summer was unusually warm in 2015, it was already possible to test the system under extremely demanding conditions. It has been operating for more than a year now without any technical difficulties, and has resulted in energy savings of 25%.

Ejector technology has a stabilising effect on the system, and this reflected in the cited efficiency increase, as well as in the extended service life of the components thanks to the reduction in the number of required switching cycles.

Which default to use?

GREEN BY DEFAULT?

WELFARE EFFECTS OF GREEN DEFAULT ELECTRICITY CONTRACTS

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Claus Ghesla | claus.ghesla@econ.gess.ethz.ch
For working paper version check QR-code.

BASIC PROJECT DATA

PROJECT DURATION
09.2014–05.2017

AWARDING AUTHORITY
Swiss Federal Office of Energy

Research Program Energy-Economy-Society (EWG)
Part "Consumer Behavior and Experiments"

MATCHING PREFERENCES

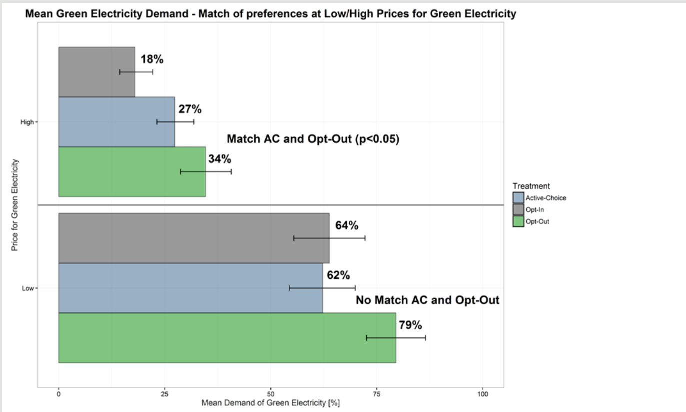

Figure: Matching Preferences

Active Choice (AC): No default present.

MAIN TARGETS

Several utility companies offer **green electricity contracts as a default option.** At a first glance, these defaults seem to be successful since more households hold green contracts than in the case of conventional electricity defaults. However, there is scant evidence on the **welfare effects of green defaults.** This project aims at assessing three potential types of inefficiencies: Defaults may result **(1)** in a mismatch between preferred and contracted electricity mixes, **(2)** in undesired distributional effects, and **(3)** even in environmental inefficiencies. This poster is concerned with the first type of these potential inefficiencies.

RESULTS

Subjects show substantial positive preferences for green electricity. Figure *"The Default Effect"* shows that more subjects choose a 100% green electricity contract when it is presented as the default (Opt-Out default). These findings map well with what is observed in electricity markets.

Figure *"Matching Preferences"* shows the mean shares of green electricity for the different contract choices across treatments. The top half indicates these shares for high prices for green electricity, the lower half for low prices for green electricity. Two main results emerge: **(1)** Currently used green electricity defaults at low prices for green electricity **do not match** individuals' preferences. Subjects demand significantly more green electricity in Opt-Out than in Active Choice.
(2) A green electricity default at high prices for green electricity **matches** individuals' preferences. This default stimulates subjects to choose according to their preferences.

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PROCEDURES

The use of defaults is argued to be legitimate if decision makers judge themselves to be better off. Hence, individuals benefit from a default rule if it matches their preferences and frees them from making an active choice. We use an **economic laboratory experiment** to study individuals' preferences in the absence (active choice) and presence of default options (Opt-Out and Opt-In default). This procedure allows for extensive analysis of preference matches for varying prices for green electricity.

FUTURE CHALLENGES

Economic laboratory experiments are suitable for studying behavioral mechanisms. Future (field) research may investigate the functioning of higher priced green electricity defaults with a representative sample of the population. It has been reported that income, cognitive abilities, or lower education might play a role in decision-making when a default is present. Future experiments will investigate the relevance of these factors.

THE DEFAULT EFFECT

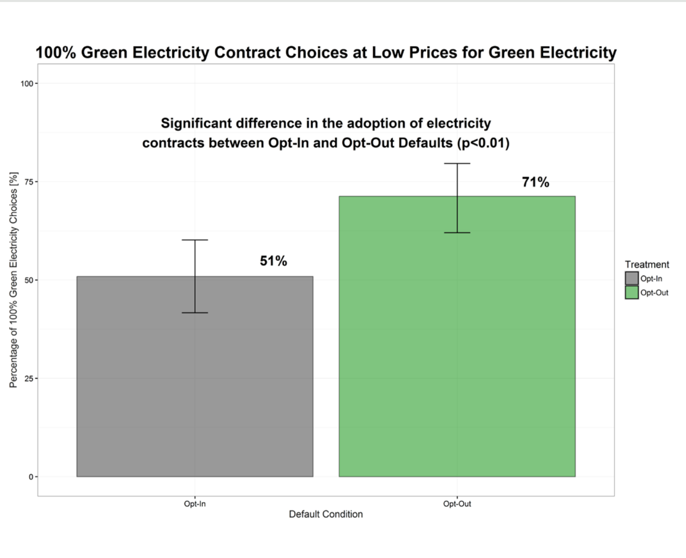

Figure: The Default Effect

Opt-In: 100% conventional contract as default.

Opt-Out: 100% green contract as default.

ENERGY STRATEGY 2050

This research tries to assess hidden costs of green defaults and to derive policy recommendations with regard to a choice architecture that balances potential costs and benefits of green default electricity contracts. In relation to the Energy Strategy 2050 this has two main implications: **(1)** Analyzing experimental data on the effectiveness of electricity defaults will provide new evidence on **how to design default options** that match people's preferences. **(2)** This research may also give guidance on how to **enhance voluntary demand** for **higher priced new renewables** using tools of behavioral economics.

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embedded 3D micro-structures

INNOVATIVE FENESTRATION SYSTEM

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KEY FIGURES

PROJECT DURATION
09.2013–12.2016

FUNDING AGENCY
Swiss Federal Office of Energy SFOE

PARTNERSHIP
SFOE
EPFL
BASF Schweiz
Solar Control SA

RAY PATH SIMULATION

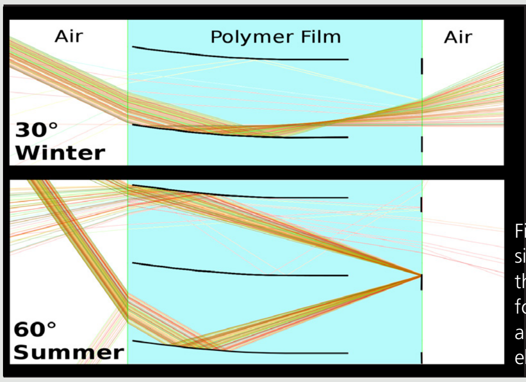

Figure: Ray path as simulated through the proposed CFS for typical summer and winter elevations of the sun

Source: EPFL LESO-PB

MAIN OBJECTIVE

In this project, we propose to study manufacturing methods for a novel and patented embedded microstructure. The research and development activities planned in the framework of the present project aim to prepare the development and production at reasonable cost of the device which was designed and studied within the SFOE project "Integrated Multi-functional Glazing for Dynamic Daylighting".

This novel glazing will combine several functions:

- daylighting
- glare protection/visual comfort/clear view
- overheating protection in summer
- solar gains and thermal insulation in winter

CHALLENGES

The proposed glazing based on embedded micromirrors represents a completely novel and original approach.

Making the new optical microstructures requires several fabrication steps which are inspired from existing methods in microtechnology, but which have to be adapted to particular requirements: size, aspect ratio and shape of the structures, cost-efficient replication, transparent encapsulation, and compatibility with large scale industrial implementation.

Such microstructured glazing will have fascinating novel optical properties, which have to be mastered by architects and engineers for the creation of energy-efficient daylight buildings.

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FURTHER GOALS, APPROACH

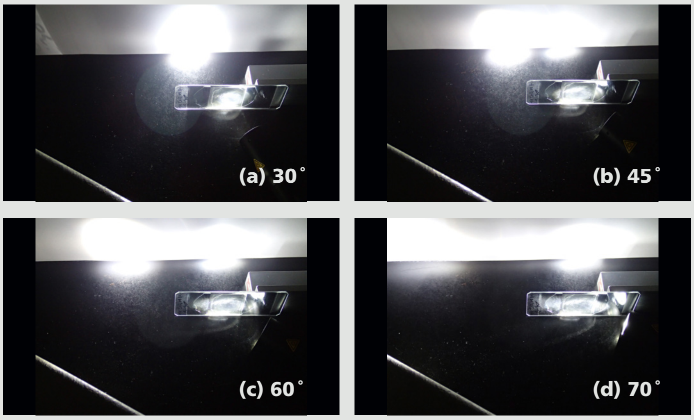
- Studying different possibilities of constructing a microstructured mold with a smooth surface
- Engraving method which might allow to control the curvature and the tilt angle of the surfaces precisely
- Depositing a reflecting layer on the microstructures and optimising its reflectivity
- Choosing a polymer adapted to large scale production (roll to roll or extrusion), long-term sun exposure and thermal constraints
- The choice of the polymer adapted to large scale production will be discussed with the industrial partner
- Studying encapsulating technology for reflecting surfaces
- Studying geometric parameters of the glazing in view of developing a solution that can be adapted to any latitude

ENERGY STRATEGY 2050

Electric lighting, heating and air conditioning of buildings account for more than 40% of the national energy usage. Lighting accounts for 10% of electrical consumption and heating for 46% of fossil energy consumption. Cooling loads have been increasing over the previous years.

The advanced glazing system combines several functions and can contribute to significantly reduce the energy consumption in buildings with favorably oriented glass façades. In winter, solar gains are used to reduce energetic requirements for heating; in summer, the proposed device blocks direct radiation and thus limits air conditioning load as well as overheating risks. Judicious use of daylighting furthermore reduces energy needs for artificial lighting and improves the wellbeing of occupants. A system with microstructures also ensures a certain transparency.

LIGHT REDIRECTION



Source: EPFL-LESO-PB

Figure: Light redirection by curved aluminum mirrors embedded in resin when illuminated with a flashlight. The flashlight is placed in the bottom right quarter and the light beam angle is gradually changed. Despite the clear view through the same sample at normal incidence the light beam is strongly redirected for higher incoming angles.

ACHIEVEMENTS

The parameters for the encapsulation of structures were optimized. This permitted the encapsulation of structures without bubbles or other defects having an impact the transmittance. These samples were encapsulated without the intermediate coating step; this plain encapsulation process yields fully transparent samples.

In 2015, the alignment device was achieved. Angular selectively coated structures were encapsulated. The resulting samples of embedded micro-mirrors provide a very good view through at normal incidence and redirect a large part of the incoming light for elevated angles of incidence. The samples were studied by electron microscopy and the aspect ratio was compared to that of the mold used for replication to assess shrinkage. The mold from FemtoPrint was not purchased because some limitations make it impossible to create sharp tips.

ENERGY SYSTEM INTEGRATION (ESI) PLATFORM

KEY DATA

DURATION OF PROJECT
2014–2016 (first phase)

CLIENT
Federal government (Federal Institutes of Technology)

PARTNERS
SCCER HaE Storage, SCCER biosweet
Competence Center for Energy and Mobility (CCEM)
Swiss Federal Office of Energy SFOE
Commission for Technology and Innovation CTI
SwissElectricResearch
Swissgrid, Federation of the Swiss Gas Industry (VSG)
Energie 360°
Siemens, SwissHydrogen

VIEW OF THE ESI PLATFORM

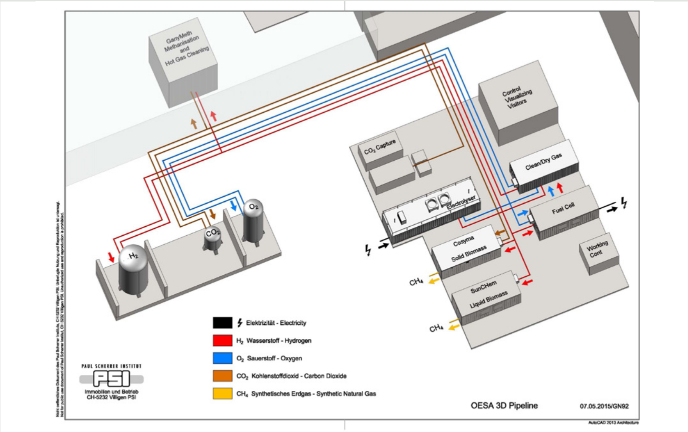


Illustration: Marcel Hofer, PSI

MAIN OBJECTIVE

The aim of this project is to render Switzerland's energy future more sustainable and more environment-friendly through increased electricity production from renewable energy. But the planned increase in solar and wind power production is a major challenge for the distribution networks, because the grid can only take in as much electricity as is currently being consumed, otherwise it becomes overloaded and unstable. With the Energy System Integration (ESI) platform, the Paul Scherrer Institute (PSI) is examining "power-to-gas" technology as a potential solution to this problem. The project is studying the complex interactions between all previously individually researched components for the first time, with the aim of developing a system with an output of 100 kilowatts.

RELATIONSHIP WITH OTHER

ESI is the implementation platform for the following two projects of the Swiss Competence Centres for Energy Research:
"Heat and Electricity Storage" (HaE Storage) and
"Biomass for the Swiss Energy Future" (Biosweet)
ESI is an integral part of the network of demonstration platforms of the Federal Institutes of Technology (Empa: move, NEST, ehub; Federal Institute of Technology, Zurich: ReMap)

The ESI platform is also intended to enable other industrial companies interested in power-to-gas technologies to test their concepts and innovations. In this respect it forms an integral part of the unique service for companies that are based in the "Park InnovAARE" complex.

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Swiss Federal Office of Energy SFOE

+ FIND OUT MORE HERE:

PAUL SCHERRER INSTITUT (PSI)
Energy and Environment Division

Peter Jansohn
peter.jansohn@psi.ch

OTHER OBJECTIVES, PROCEDURE

With the components on the ESI platform, the aim is to identify the technically feasible potentials of power-to-gas, together with the costs and options of scaling to a system in the megawatt range. Other operating modes that can be realised on the platform with the current configuration include:

- Production of synthetic gas (SNG) from biomass-based synthesis gas or biogas
- SNG from moist biomass (sewage sludge, liquid manure, algae)
- Methane synthesis from CO_2 (from industrial sources/the air)
- Power-to-gas (for hydrogen production)
- Power-to-power/mobility (via PEM fuel cell systems)
- Frequency support for electricity networks
- (dynamic coupling of electrolysis/fuel cells)

RELEVANCE FOR ENERGY STRATEGY 2050

Energy Strategy 2050 calls for a pronounced increase in the use of new renewable energy (e.g. solar and wind energy). Integrating this energy, the production of which is decentralised and subject to fluctuations, represents a major challenge for the electricity networks. One potential solution would be to use the surplus electricity that would overload the networks for the production of high-energy gases such as hydrogen and methane, i.e. to store electricity in the form of chemical energy. The produced gases could then be converted back into electricity, heat or engine fuel (for gas-powered engines) as required. This power-to-gas concept is the centre of focus of the new ESI platform at the Paul Scherrer Institute.

INTEGRATION OF ENERGY SYSTEMS

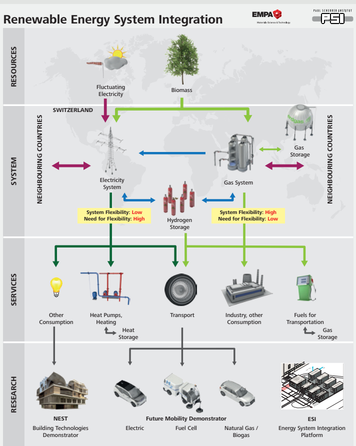

Illustration: PSI, EMPA

RESULTS TO DATE

In the current phase of the project (2014 to 2016), the focus is on realising the platform infrastructure and starting up the first generation of subsystems (PEM electrolysis, PEM fuel cells, fluidised bed methanisation, hydro-thermal methane synthesis).

The platform's supply infrastructure (storage tanks, supplies of gases, electricity and cooling water, control, regulation and safety systems) is currently being finalised. Upon completion of the start-up phase, it will be possible to test the operation of the individual subsystems from June 2016 onwards.

Alternative drives for the transport

NEXTICE

+ FIND OUT MORE HERE:

FEDERAL INSTITUTE OF TECHNOLOGY, ZURICH
Institute for Dynamic Systems and Control
Institute for Energy Technology

EMPA
Vehicle Drive Systems

onder@idsc.mavt.ethz.ch

KEY DATA

DURATION OF PROJECT
12.2013–11.2016

CLIENT
Swiss Federal Office of Energy

PARTNERS
Swiss Federal Office of Energy
Federal Institute of Technology, Zurich, IDSC
Federal Institute of Technology, Zurich, LAV
Empa, Vehicle Drive Systems

FLEXIBLE RAPID COMPRESSION MACHINE

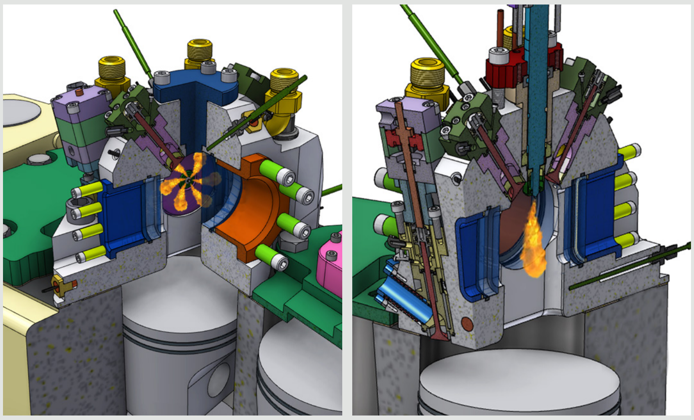

Illustration: LAV

MAIN OBJECTIVE

Today, almost all vehicles and mobile machines are operated with petrol and diesel engines, but alternative fuels can be expected to be used to an increasing extent in the future. However, little is known about the efficiency gains that can be achieved by utilising the properties of a specific fuel. The main aim of the NextICE project is to analyse and improve the use of alternative fuels in conventional energy converters on the basis of three technological innovations.

CHALLENGES

In a diesel engine combustion process with a stochiometric air-to-fuel ratio, attention has to be paid to soot formation, which needs to be inhibited through the use of a fuel containing oxygen. By contrast, the high temperatures that are required for methane oxidation are a challenge for thermo-management. They are in conflict with the low exhaust gas temperatures that are required for efficient engines. With respect to the development of a new type of valve control, the focus is on the requirements of flexibility, costs and energy efficiency.

OTHER OBJECTIVES, PROCEDURE

The project comprises three study packages. In the first package, basic studies are to be carried out concerning the ignition behaviour and soot formation of alternative fuels in a newly developed flexible rapid compression machine. In the second package, the thermo-management for the after-treatment of exhaust gases from a diesel-ignited gas/biogas engine is to be studied, along with the possibility of reducing internal methane emissions. In the third package, a fully variable valve control for the **combustion engine** is to be realised that will ultimately be able to improve the partial load behaviour of car engines.

RELEVANCE FOR ENERGY STRATEGY 2050

The future availability of alternative fuels from production with temporary surplus electricity from renewable sources calls for the further development of energy converters. These fuels, along with those from second and third processes from biomass, could make a decisive contribution towards more CO_2-neutral individual mobility in the future. The energy converters have to be optimised for operation with alternative fuels in terms of highest possible efficiency and lowest possible emission of pollutants.

ALTERNATIVE FUELS

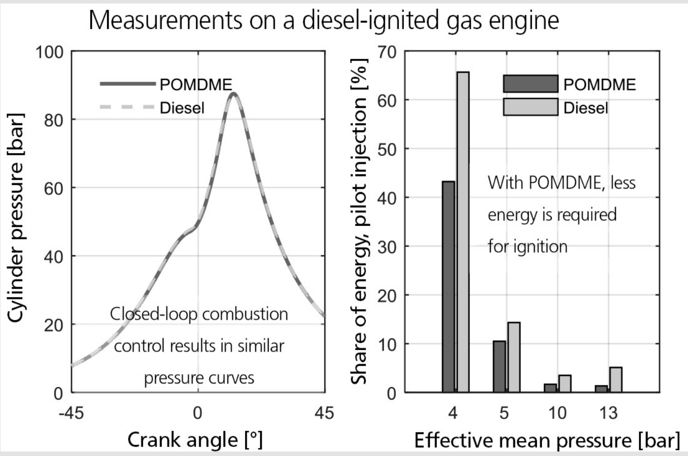

Illustration: IDSC/LAV

RESULTS TO DATE

Results are available regarding the ignition behaviour of various alternative fuels (e.g. **poly(oxymethylene) dimethyl ethers, POMDME**) in practice as main and pilot fuel. It was demonstrated that the applied combustion control also functions with alternative fuels. In addition, sensitivity analyses of the most important engine parameters were carried out for the purpose of reducing internal methane emissions. And a functional model of a fully variable valve control at the inlet valves of a series production combustion engine was also realised.

Process innovation

SWISS STARCH FOR CARDBOARD

KEY DATA, "ALYESKA" PROJECT

DURATION OF PROJECT
2011 to 2015

PARTNERS
Brummer Extrusion Consulting, Wittenbach (Switzerland)
Fraunhofer Institut, Potsdam-Golm (Germany)
Papiertechnische Stiftung, Heidenau (Germany)

RISK GUARANTEE/SUPPORT
Swiss Climate Foundation
Canton of Thurgau (Use of Waste Heat subproject)
Swiss Federal Office of Energy SFOE

COMPARISON OF ENERGY CONSUMPTION

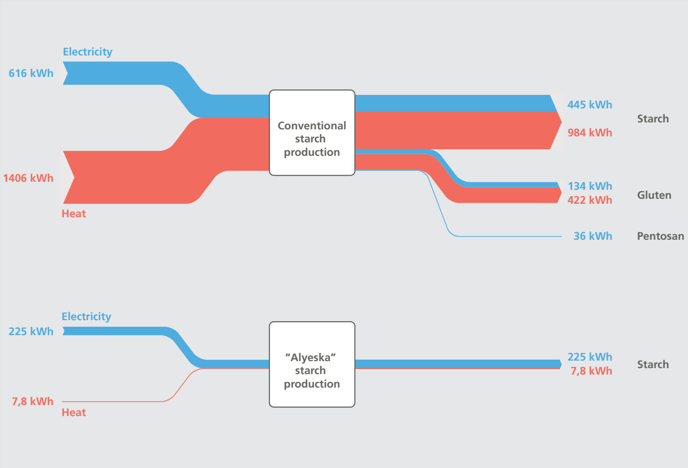

Diagram: Rytec/SFOE

MAIN OBJECTIVE

Swiss paper mills process several thousand tonnes of starch-based adhesive (starch slurry) a year for the production of cardboard. In the past, starch slurry, which is used for stiffening paper to be turned into cardboard, was made from imported wheat, potato or corn starch. In the "Alyeska" project, Meyerhans Mühlen AG (Weinfelden, canton of Thurgau) developed an innovative and energy-efficient method of producing starch slurry. Thanks to this new starch product, for its production of cardboard the Swiss papermaking industry is now able to make use of a substance manufactured in Switzerland.

FEWER PROCESS STEPS

Raw starch is normally obtained from wheat flour in an energy-intensive wet process, and this is then transformed into starch slurry in paper mills for use in the production of cardboard. The innovative process developed by Meyerhans Mühlen AG uses an extruder for the production of starch. The advantage of this method versus the conventional wet process is that the product can be directly configured to meet the requirements of the end user in a single step, thus greatly reducing energy consumption. The new process is also beneficial for paper mills in that it cuts out two process steps and thus greatly reduces their own energy requirement.

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meyerhans mühlen
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PROCEDURE

In addition to proteins, fats, minerals, etc., wheat flour consists largely of starch. Flour is not only suitable for producing foodstuffs, but can also be processed with the aid of an extruder into a starch product for use in the papermaking industry. Together with its Swiss and German project partners, Meyerhans Mühlen AG developed an innovative process for the production of starch. Six million Swiss francs were spent on the development of the process and the construction of the production facility in Weinfelden, which was officially put into operation on 12 November 2015.

RELEVANCE FOR ENERGY STRATEGY 2050

This project is a prime example of the enhancement of energy efficiency in an industry context. In comparison with the conventional wet process, the new method of starch production requires 84 percent less energy: 49 percent less electricity and as much as 99 percent less heat (cf. flow diagram above). This results in energy savings of around 14'000 MWh a year versus the conventional method, which is equivalent to the heating and electricity requirements of 1800 four-person households (new buildings). In addition, the paper mill also saves a great deal of energy and requires less fuel for transport.

EXTRUDER

Photo: Meyerhans Mühlen AG

SYNERGIES THROUGH PARTNERSHIP

The implementation of the new process was made possible thanks to the cooperation between Meyerhans Mühlen AG and Model AG paper mill. Both companies are located in the industrial zone in Weinfelden. Meyerhans delivers its starch product to the paper mill via a pipeline. By working so closely together, the two companies paved the way for process innovation with multiple synergies. The SFOE supported the project within the scope of its pilot and demonstration programme in view of the high degree of innovation involved in the development process, as well as the associated major energy-efficiency potential.

Electricity Market

ELECTRICITY MARKET DESIGN:

POLICY COORDINATION AND ZONAL CONFIGURATIONS

+ MORE INFORMATION:

UNIVERSITY OF BASEL, Division of Environmental and Energy Economics, https://wwz.unibas.ch/umwelt/

Dr. Nicolas Weidmann-Ordóñez, Prof. Dr. Frank C. Krysiak, Prof. Dr. Hannes Weigt

CONTACT: nicolas.weidmann-ordonez@unibas.ch

KEY INFORMATION

PROJECT DURATION
10.2014–12.2016

PROJECT PRINCIPAL
Swiss Federal Office of Energy
Research program Energy-Economy-Society (EWG)

PARTNERSHIPS
SCCER CREST
(Swiss Competence Center for Energy Research)

INTERMEDIATE RESULTS

- There is no need to coordinate policy interventions between the supply and the demand side.
- Hesitancy of consumers to switch suppliers allows for strategic pricing leading to price differences in the market. Suppliers with larger home markets set higher prices.
- Self-sufficiency with regard to electricity production is unlikely without strong policy interventions.
- Promotion of new renewables requires accompanying measures for non-intermittent technologies (e.g. capacity payments, capacity markets) to achieve a socially cost-minimal outcome.
- Subsidies of intermittent renewables need coordination to be cost-minimal.

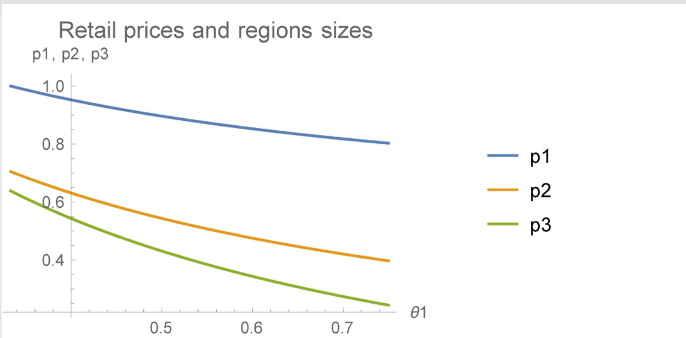
MAIN OBJECTIVE

The Swiss electricity market is subject to ongoing large-scale changes caused by market interventions and altered regulations. Examples are the KEV, a possible market liberalization, adjustments to grid tariffs, or possible capacity payments.

These interventions are likely to interact, which could lead to unanticipated outcomes. Furthermore, different levels of market liberalization could alter the effects of other interventions.

This project analyzes whether and how the interventions need to be coordinated and whether a zonal configuration (regionally differentiated policies) could be beneficial and simplify the required policy coordination.

RETAIL PRICES AND REGION SIZES



Normalized retail prices for three regions as function of the relative size 0 of the largest region 1. Suppliers with larger regions set higher prices than those with smaller ones. Reducing the size of the smallest region leads to lower prices in the whole market.

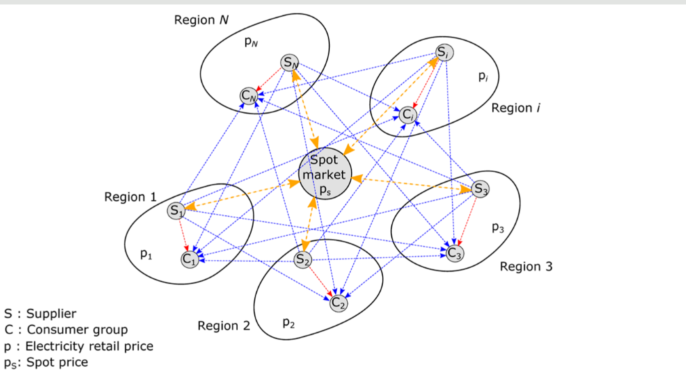
ELECTRICITY MARKET MODEL

We have developed a multi-regional electricity market model with consumers and suppliers of electricity representing

- a partial market liberalization with consumers that have the right to switch suppliers but might hesitate to switch, as observed in several liberalized markets abroad,
- policy measures including feed-in tariffs, grid tariffs, capacity payments,
- intermittent (renewable) and controllable generation technologies, and
- a spot market that links Switzerland with surrounding markets.

Both the retail and the spot market are modeled as being imperfectly competitive.

STRUCTURE OF MODEL



Electricity market with N regions with one supplier and one consumer group in each region. After the market liberalization, consumers can either buy electricity from their local supplier (red arrows) or switch to another region (blue arrows). Suppliers can trade electricity on the spot market (orange arrows).

REFERENCES TO OTHER PROJECTS

This project is part of the SCCER CREST (Swiss Competence Center for Energy Research: Competence Center for Research in Energy, Society and Transition) which is financially supported by the Swiss Commission for Technology and Innovation (CTI). Our project is part of SCCER CREST's research line on the design of electricity markets.

Furthermore, our project is also linked to the parallel EWG project *Oligopolistic capacity expansion with subsequent market-bidding under transmission constraints* analyzing the strategic investment decisions of power producers.

ENERGY STRATEGY 2050

The research within this project aims at investigating possible designs of a future Swiss electricity market in line with important goals of the Energy Strategy 2050.

In particular, we analyze if and how different market interventions in combination interact and thus need to be coordinated. Especially, we consider interventions aimed at an increasing diffusion of (intermittent) renewable generation technologies (e.g. feed-in tariffs) or at guaranteeing an affordable and secure supply of electricity (e.g. market liberalization, capacity payments, and grid tariffs).

Solar thermal energy & heat pumps

ICE STORAGE FOR HEATING SYSTEMS IN BUILDINGS

+ FIND OUT MORE HERE:

HOCHSCHULE FÜR TECHNIK RAPPERSWIL HSR
Institut für Solartechnik SPF
research@spf.ch

KEY DATA

DURATION OF PROJECTS
2012–2015 (High-Ice) and 2015–2017 (Ice-Ex)

CLIENT
Swiss Federal Office of Energy SFOE

PARTNERS
Swiss Federal Office of Energy SFOE
Small and medium sized companies
(ice storage tanks and heat exchangers)

ICE STORAGE TANK AS HEAT PUMP SOURCE

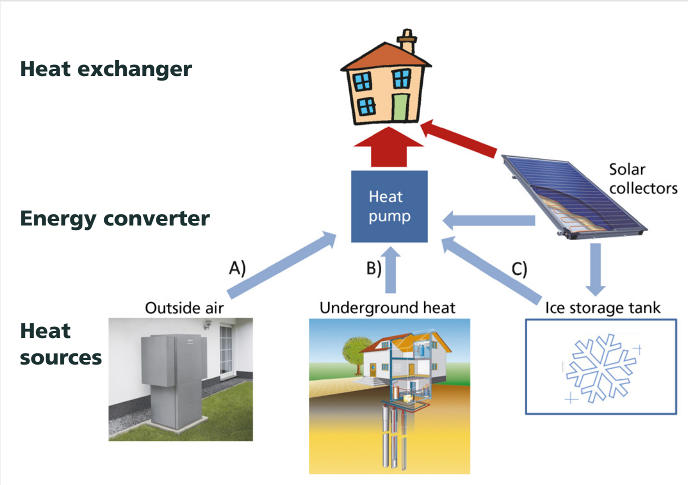


Diagram: SPF

MAIN OBJECTIVE

Ice storage tanks can also be used in existing buildings as an alternative heat source for heating systems using heat pumps. They are loaded using solar heat or low-temperature sources. The focus of the two SFOE projects, "High Ice" and "Ice Ex", is on the integration of ice storage tanks into heating systems using heat pumps, and the development of new concepts and solutions for ice-storage heat exchangers.

The projects aim to demonstrate how ice storage tanks, solar collectors, heat recovery and heat pumps can also be combined to form "solar/ice" heating systems in existing buildings with low utilisation of resources.

CHALLENGES

ICE STORAGE TANKS ARE SOMETIMES THE SOLE SOURCE FOR HEAT PUMPS:

- Dimensioning of ice storage tank is decisive; heating has to be designed carefully (influence on climate/location).

CONVENTIONAL TYPES OF ICE STORAGE TANKS USING REFRIGERATION OUTPUT FROM AIR-CONDITIONING AND INDUSTRIAL PROCESSES GIVE RISE TO VERY HIGH INVESTMENT COSTS:

- Necessity to develop low-cost storage tanks for heating systems in buildings (other than those of competitors).

SPACE REQUIREMENT OF STORAGE TANKS IS CRITICAL, ESP. IN EXISTING BUILDINGS:

- May be insufficient space for tank in building, depending on heat source (solar, waste heat, etc.) and heat load.

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OTHER OBJECTIVES, PROCEDURE

Other objectives include studying the influence of component size (ice storage tank, solar collector surface) on annual electricity consumption, environmental impacts and costs of the system's heat production throughout its useful life. A mechanically de-iceable heat exchanger was developed in the laboratory.

The studies are being carried out for single-family houses on the basis of validated simulations in TRNSYS. Three buildings in three different climate zones (Zurich, Locarno, Davos) are being observed. Non-renewable primary energy, CO_2 and environmental impact points are being used as indicators in the buildings' ecological balance.

RELEVANCE FOR ENERGY STRATEGY 2050

In buildings, by combining solar and waste heat with a heat pump and ice storage tank the use of heat from renewable sources can be increased.

In addition, solar/ice storage heating systems consume significantly less electricity than air/water heat pumps.

And unlike closely adjacent geothermal probes, no heat is lost with ice storage tanks. This means that ice storage tanks can make a considerable contribution towards the achievement of the Energy Strategy 2050 objectives, especially in urban areas.

HEAT EXCHANGERS IN AN ICE STORAGE TANK

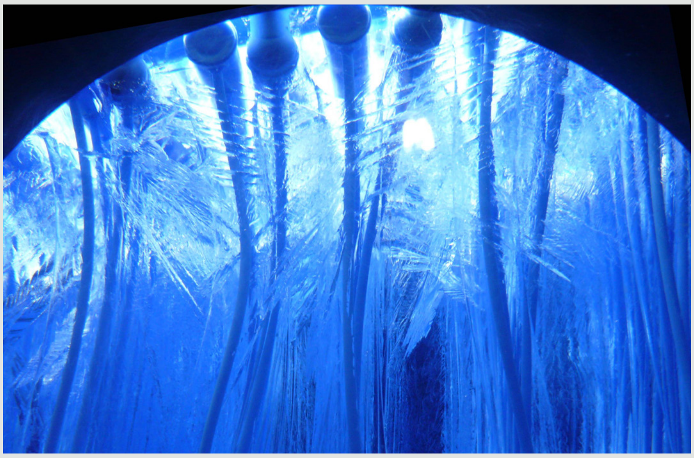

Photo: SPF

RESULTS TO DATE

Simulated solar/ice storage heating can also supply existing buildings with heat (EKZH-WW 75 kWh/a). With the use of normal heat pumps (minimum source, –5 °C), large ice storage surface areas (> 10 m^3) and annual system operating hours of approx. 4,5 to 7 are achievable.

The optimal size of solar/ice storage heating systems with selective collector absorbers is achieved when they are almost monovalent. The ecological impacts are then minimal and the annual operating hours are high.

Solar/ice storage systems are flexible. Dimensioning of storage tank and collector surface (and possibly use of heat recovery) depend on local conditions.

Understanding Deep Geothermal Systems

DEMONSTRATING TECHNOLOGIES FOR DEEP GEOTHERMAL ENERGY IN A DEEP UNDERGROUND

LAB EXPERIMENT, GRIMSEL ROCK LABORATORY

KEY DATA

PROJECT DURATION
01.2015–12.2017

SPONSORS
Shell, EKZ, ETH Foundation, SCCER-SoE, SNF

PARTNERS
Nagra, SCCER-SoE, ETH Zurich

LOCATION
Grimsel Test Site, Switzerland

ENERGY STRATEGY 2050

- The Swiss ES2050 target for DGE is 7% of the Swiss electricity supply: 4,4 TWh/yr, over 500 MWe capacity installed
- Deep geothermal resources are unlimited: cooling 1 cubic km of 180 °C hot granite by 20 °C could deliver heat sufficient to generate over 10 MWe for 20 years
- In Switzerland the geothermal conditions are favorable, with crystalline rocks with 170–190 °C at 4–6 km depth: a water flow of over 200 l/s at 180 °C is required to generate 20 MWe
- Starting in 2025, Switzerland will need to install 20 MWe per year to meet the 7% quota by 2050

MAIN GOAL

- In Switzerland, hydrothermal water has great potential for heating, less so for electricity, as hydrothermal water is scarse and not easily found. We need to create deep reservoirs in hot rock (EGS) and circulate water from the surface to extract the deep geothermal heat.

- The deep underground laboratory (DUGLab) aims at studying the hydro-mechanical coupled processes associated with high-pressure fluid circulation and at demonstrating technologies for Deep Geothermal Energy

CHALLENGES

- Physical processes associated with the creation and maintenance of deep geothermal reservoirs are not yet well understood.
- The main challenge is to create a sustainable heat exchanger at depth, a system capable to operate for 20–40 years with minimal loss in flow, temperature and efficiency, with a sustained flow of > 200 l/s of water at 180 °C.
- New approaches are required to enhance rock permeability, with optimal distribution of micro-cracks and porosity to maximize heat exchange, swept area and water circulation.

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+ WWW.SCCER-SOE.CH

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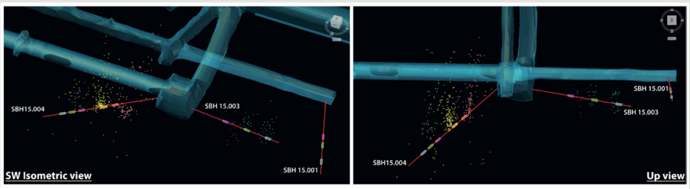
GENERAL APPROACH

Experiments are carried out at a scale of a few tens of meters and at depths of over 500m below the surface, under a fully controlled environment, to

- stimulate a rock volume by injecting high-pressure water and controlling the reaction of the rock and the embedded faults
- validate protocols and procedures before deployment in deep geothermal production systems
- provide a testing ground integrating experimental, modeling and monitoring technologies
- develop and demonstrate innovative methodologies
- increase public confidence in geo-energy technologies

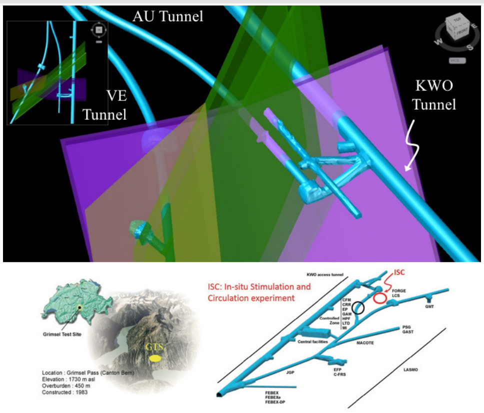
CONTROLLING INDUCED SEISMICITY

Controlling induced seismicity is crucial to enable safe, long-term extraction of deep geothermal energy.



Induced seismicity is a key aspect of stimulation experiments. Initial stress measurements generated numerous, but very small seismic events (seismic magnitudes < –2,0).

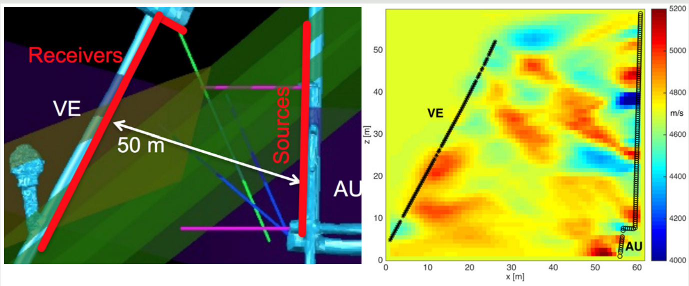
DUGLAB TEST SITE



The test site is located in the Grimsel rock laboratory of NAGRA.

The zoomed section shows the test location (access tunnels in blue, fault zones in magenta/green).

FIRST RESULTS



2D slice through the granitic host rock at the ISC Test Site using seismic tomography. Blue colors (low velocities) indicate the presence of fracture zones.

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Swiss Federal Office of Energy SFOE

Comparison of electric buses

ELECTRIFICATION OF NON-RAIL-BORNE URBAN PUBLIC TRANSPORT

KEY DATA

DURATION OF PROJECT
November 2013 to June 2016

CLIENT
Swiss Federal Office of Energy

PARTNER
Swiss Federal Office of Energy

BATTERY BUSES: FUTURE OF PUBLIC TRANSPORT?

Photo: Michael Schwertner

MAIN OBJECTIVE

The motor vehicle industry has developed a variety of alternative drive concepts in recent years, including diesel-hybrid, fuel-cell and battery-operated buses, the utilisation parameters of which differ from those of diesel and trolley buses. But the introduction of alternative technologies calls for major investments, and this is why operators of public transport services need reliable decision-making bases. The aim of this project is to develop a method for making a comprehensive comparison of drive systems in order to support the decision-making process.

CHALLENGES

One of the main challenges concerns modelling the drive trains with sufficient precision (as precisely as necessary instead of as precisely as possible). And calculating the energy requirement for auxiliary systems, as well as for heating, ventilation and cooling of the passenger are, is also a difficult task.

Another challenge consists in specifying the thresholds for the incorporation of grey energy and procuring the necessary data. For example, how – and to what extent – can the energy requirement for constructing the necessary road infrastructure be allocated to the bus services?

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OTHER OBJECTIVES, PROCEDURE

Calculation of energy requirement (well-to-wheel) based on driving dynamics is the core element of the new method. Its input variables are the key data of a given public transport route (inclination, speeds, no. of stops) and the vehicle parameters (e.g. drive power, no. of occupants). The emissions can be calculated on the basis of the energy requirement, and the latter is a significant input variable for estimating the operating costs. The project also aims to incorporate "grey energy" into the comparison.

The comparison encompasses not only eight drive systems for buses, but also for trams, because the services provided by these two forms of transport are increasingly overlapping.

RELEVANCE FOR ENERGY STRATEGY 2050

Public transport is already making a significant contribution towards a more sustainable transport system. But there is still potential for improvement in the road-related segment, because here, services are still primarily operated using diesel buses. By switching to partial or full electrical operation, it will be possible to reduce the energy requirement, pollutant emissions and noise emissions, as well as the degree of dependence on fossil fuels.

RESULT OF SIMULATION (EXAMPLE)

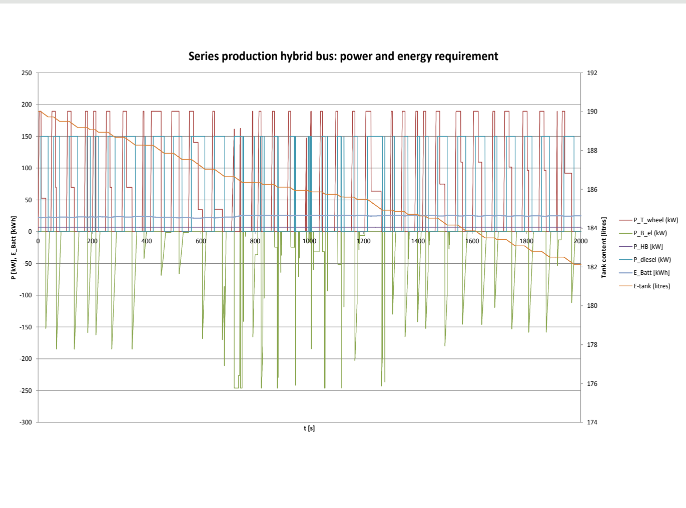

Photo: Michael Schwertner

RESULTS TO DATE

To date, it has only been possible to calculate the energy requirement to a sufficient extent to permit interim findings (example, cf. diagram on the left, which shows an extract from the power and energy requirement calculation for an 18-metre long series production diesel-hybrid bus on an 11,5-kilometre stretch with 29 stops.

A comparison of the calculated results on the basis of this route shows that a trolley bus indicates the lowest primary energy requirement (63%) versus this diesel bus, followed by a battery bus (57%) and series production hybrid bus (18%). It is also interesting to note that a tram with twice the length (36 metres) also indicates a significantly lower energy requirement (48%) than the reference diesel bus.

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wastEturn

A PROJECT IMPLEMENTED IN THE FRAMEWORK OF SNF'S NATIONAL RESEARCH PROGRAM 70 "ENERGY TURNAROUND"

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PROJECT DATA

PROJECT DURATION
10.2014–02.2018

FUNDING AGENCY
Swiss National Science Foundation (SNF), NRP 70

PARTNERSHIPS
Association of MSWI operators (VBSA) • CIMO SA • Federal Office for the Environment • Holcim (Switzerland) and Geocycle (LafargeHolcim) • Zweckverband Kehrichtverwertung Zürcher Oberland • Lonza AG • Neosys AG • Office for Waste, Water, Energy and Air (AWEL) • Stahl Gerlafingen • Swiss Recycling • Infrapark Baselland AG • Dottikon Exclusive Synthesis AG

ENERGY FLOW ANALYSIS OF SWISS WASTE MANAGEMENT

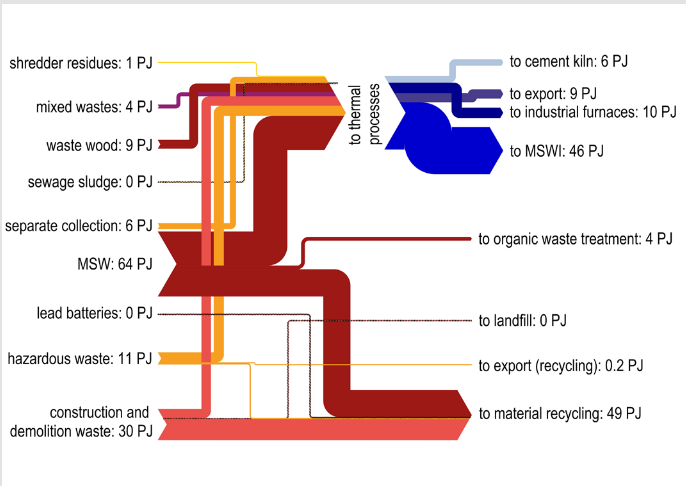

Figure: Adapted from Dettli et al. 2014

MAIN GOAL

Municipal solid waste (MSW) and industrial waste (IW) management in Switzerland show a large improvement potential in terms of direct (Fig. 1) and indirect (a.k.a. grey) energy savings, the latter achieved through material recycling. The *wastEturn* project aims at **optimising the contribution of the Swiss waste management system to the Energy Turnaround, under consideration of environmental and economic performance, and to develop socially robust transition strategies for its implementation.**

CHALLENGES

Modeling optimized MSW and IW management systems requires looking into possible futures of what drives these systems, e.g. future waste amounts and energy policies, in order to appraise future uncertainty. All four subprojects are working closely to develop consistent scenarios of these drivers by integrating existing Swiss energy scenarios and knowledge of waste management experts. This joint effort exemplifies the challenge of integrating various forms of knowledge (e.g., data, case expertise) at different stages of the project in an interdisciplinary setting.

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FURTHER GOALS, APPROACH

Four subprojects (SPs) were set up to cover the most important waste streams (IW and MSW) as well as all three pillars of sustainability and to address the interdisciplinary nature of the overall project. All subprojects are closely interlinked by information exchange, methodology transfer and common case studies encompassing various key waste flows (Fig. 2). Close collaboration with several external partners and stakeholders, both bilaterally within subprojects and through the project's two advisory boards (MSW and IW), ensures a strong link to practical issues and knowledge transfer.

ENERGY STRATEGY 2050

wastEturn contributes to the Energy Strategy 2050 by:

- identifying and assessing potential measures to increase eco-efficiency of the most energy-relevant waste streams;
- evaluating the financial viability of environmentally optimal waste management systems;
- analysing barriers and drivers of the transition to such systems and assess strategies for practical application;
- supporting industries with implementation of waste-to-energy systems through models dealing with planning and scheduling problems under uncertainty;
- fostering capacity building among industry, policy-makers and academia.

PROJECT ARCHITECTURE

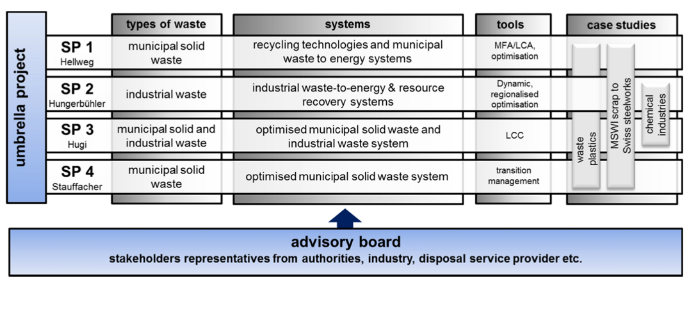


Figure: wastEturn

SP 1: Prof. Dr. Stefanie Hellweg, Ecological Systems Design, ETH Zurich
SP 2: Prof. Dr. Konrad Hungerbühler, Safety and Environmental Technology Group, ETH Zurich
SP 3: Prof. Dr. Christoph Hugi, Institute for Ecopreneurship, FHNW
SP 4: Prof. Dr. Michael Stauffacher, USYS Transdisciplinarity Laboratory, ETH Zurich

RESULTS SO FAR

Results yielded so far are:

- Recovery rates communicated today are formulated inconsistently and hide improvement potential in recycling chain and therewith potential energy savings.
- The electricity demand in steel recycling depends substantially on the resource quality.
- The majority of actors in Swiss MSW management tend to favor material utilization over energetic and thermal utilization (albeit some with conditional support, the conditions being e.g., technical feasibility and re-use value of recycled products in secondary markets).

Dettli, R., R. Fasko, U. Frei, and F. Habermacher. 2014. Transformation der Abfallverwertung in der Schweiz für eine hohe und zeitlich optimierte Energieausnutzung. Zurich, Switzerland.

Spillover effects

HOW FOREIGN ENERGY POLICIES INFLUENCE "GREEN" INNOVATIONS IN SWITZERLAND

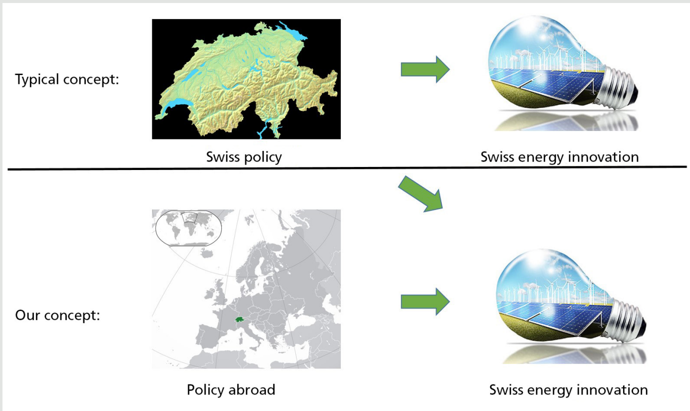
KEY DATA

DURATION OF PROJECT
08.2015–08.2016

CLIENT
Swiss Federal Office of Energy
"Energy – Economy – Society" research programme

PARTNERS
Swiss National Science Foundation, NRP 71
Centre for European Economic Research
Austrian Institute of Economic Research

RESEARCH CONCEPT



MAIN OBJECTIVES

a) To find out how "green energy" innovations by Swiss companies are influenced by **foreign energy policies**.

b) To identify the most effective policy instruments.

c) To determine whether policy effects are influenced by the **export intensity** of companies.

d) To examine whether policy effects differ according to **export region**.

e) To ascertain whether policies abroad are more important for companies in **small countries** like Switzerland than for companies in **larger countries** like Germany.

f) To determine whether the effects vary for **different areas** of "green energy" innovation (production, ICT, etc.)

RELATIONSHIP WITH OTHER PROJECTS

The study is based on data that were collected in autumn 2015 in a **specific survey** concerning the production and distribution of energy technologies by companies in **Switzerland, Germany and Austria**. Most of the survey was developed for an **NRP 71 project**. Specific questions were asked regarding the relevance of policy at home and abroad.

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KOF Swiss Economic Institute; Section Innovation Economics
Tobias Stucki, stucki@kof.ethz.ch

PROCEDURE

The survey results contain detailed information regarding innovation-relevant company characteristics and the relevance of foreign political measures. In addition to enabling useful descriptive evaluations, the survey data also make it possible to estimate the correlation between foreign and Swiss political measures and the innovation capacity of Swiss companies in the form of a well-founded comparison.

RELEVANCE FOR ENERGY STRATEGY 2050

In view of the close ties between Switzerland's and foreign economies, it is to be anticipated that the innovation activities of Swiss companies are also influenced to a very great extent by foreign policies. In order to be able to develop efficient policy instruments it is therefore essential to improve our knowledge of how policy instruments in Switzerland interact with policies in other countries.

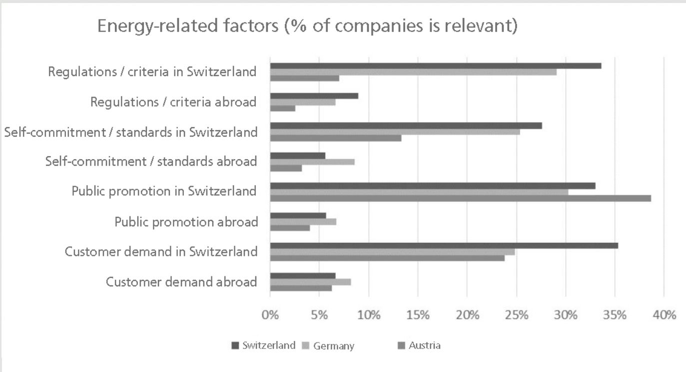
ECONOMETRIC MODEL

The regression model for companies, i is defined as:

$$I_i = f\{PD_i, PF_i, PD_i*PF_i, X_i\}$$

I: Innovation capacity of company i
PD: Political environment of company in Switzerland
PF: Political environment of company abroad
X: Control vector (company size, industry, competition, demand, technological potential, knowledge base)

DESCRIPTIVE FINDINGS



Local energy storage

LOCAL HEAT AND ELECTRICITY STORAGE

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KEY DATA

DURATION OF PROJECT
November 2013 to June 2016

CLIENT
Swiss Federal Office of Energy SFOE

PARTNERS
Ökozentrum
Empa
HSLU
ZHAW
Quantis, Zurich

SIMULATION CONCEPT

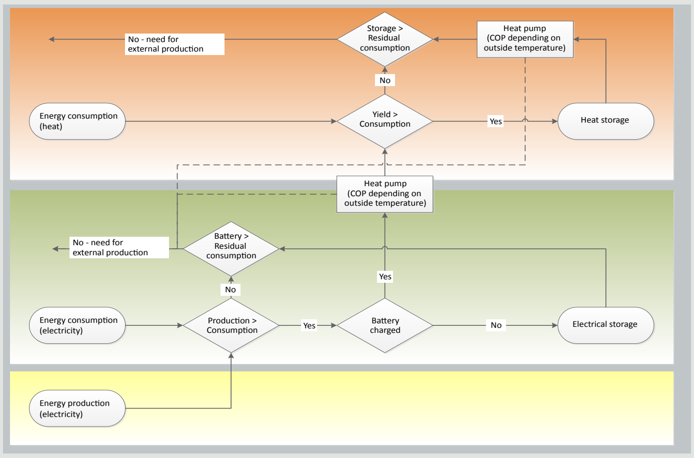

Illustration: Claudia Bless, HSLU – T & A, ZIG Horw

MAIN OBJECTIVE

The aim of this project is to obtain an overview of heat and electricity storage systems and their local use in residential districts. It is assessing the integration of the evaluated storage systems in the context of decentralised energy production and distribution in the Kreuzmatt district of Rheinfelden (canton of Aargau).

The characterisation of the storage systems encompasses the following factors: applicability of the system in the district concerned, integration into energy production and distribution, suitability for short-term or seasonal storage, energy efficiency, environmental indicators, key economic data.

RELATIONSHIP WITH OTHER PROJECTS

- CCEM:
  IDEAS 4 CITIES: Integration of decentralised energy adaptive systems for cities
- CTI SCCER:
  Future Energy Efficient Buildings & Districts
  WP 3 Urban energy systems
- NRP 70 Energy Turnaround:
  Integration of sustainable multi-energy-hub systems at neighbourhood scale
- EU RP 7:
  Combined development of compact thermal energy storage technologies (COMPTES)

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PROCEDURE

The collected and simulated consumption data from 18 buildings in the district form the basis for the evaluation of the involved storage technologies. The development of the future energy requirements was then projected for various scenarios on the basis of the current consumption data:

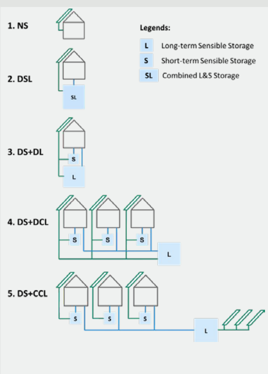
Efficiency 2035/Efficiency 2050: energy demand and production in 2035 / 2050 in accordance with the SFOE energy perspectives.

Maximum 2035/Maximum 2050: energy demand and production in 2035 / 2050 in accordance with the SFOE energy perspectives. In addition, the maximum possible photovoltaic production and exclusive use of heat pumps to cover heat demand by 2050 are assumed.

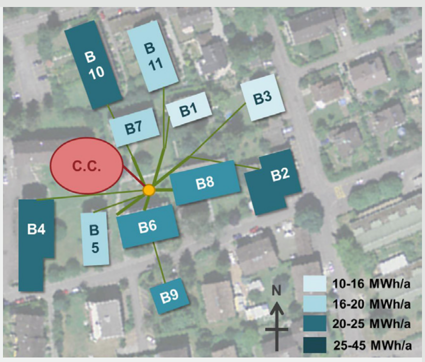
RESULTS TO DATE

A comparison of the variants with and without storage shows that the reduction of consumption through the use of storage is only marginal for the *Efficiency 2035* scenario, and is negligible for the *Efficiency 2050* scenario, because in these scenarios very few photovoltaic systems are installed. It is only with the maximum possible expansion of photovoltaics in the *2 Maximum* scenarios that the weighted energy requirement from the gas and electricity networks is reduced through storage by 25 to 60 percent. Where only marginal changes in energy requirement are observed, the environmental impacts of low-capacity storage systems are also similar to the reference levels without storage. In the *Maximum 2035/Maximum 2050* scenarios, with very high storage capacity, relevant reductions can be observed for some indicators (e.g. greenhouse gas emissions), while with other indicators relating to storage infrastructure the ecological improvements resulting from reduced energy demand are offset again.

EXAMINED CONFIGURATIONS



Examined configurations with short and long term heat storage



Configuration with central storage and district heating network

RELEVANCE FOR ENERGY STRATEGY 2050

The calculations of energy requirements in the district concerned for 2035 and 2050 are based on the consumption scenarios in the energy perspectives of the SFOE, which in turn are based on Energy Strategy 2050.

Transition to the future electricity demand

SCCER SOE
HYDROPOWER

KEY DATA

PROJECT DURATION
01.2017–12.2020

SPONSORS AND INDUSTRIAL PARTNERS

BFE
CTI
SNSF
Andritz Hydro
GE Renewable Energy
Voith Hydro
Alpiq
Axpo
KWO
Groupe E
FMV
Jacquier-Luisier SA
Valelectric Farner SA
Telsa SA
Stahleinbau GmbH
Mhylab

ACADEMIC AND COOPERATION PARTNERS

EPFL-LCH
HES-SO Valais
EPFL-LMH
ETHZ-C2SM
ETHZ-HRWM
ETHZ
EAWAG
WSL
USI
HSLU

INTERDISCIPLINARY PILOT SCHEME

Demonstrator of a "Complex large hydropower scheme"
Flexible operation targeting premium remuneration hours

- changing environment
- production concentration in less hours
- reservoir sedimentation management
- compliance with Waters Protection Act
- management of compensation basin to prevent hydropeaking

Picture: swiss-image.ch/Max Schmid

MAIN GOAL

"By research and innovation, granting hydropower as the main share of the Swiss electricity mix by 2050, taking over the global warming ecological and economical challenges."

RELATION TO OTHER PROJECTS

A close collaboration with NRP70 has been established for aspects concerning energy market and environmental impact of hydropower.

Cross SCCER activities are also developed with SCCER CREST and SCCER FURIES for the definition of realistic exploitation scenarios.

Activities of the SCCER SoE are also contributing to the European FP7 collaborative project HYPERBOLE.

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OBJECTIVES

- Understand effects of climate change and natural hazards on reservoir and sedimentation
  - Controlled fine sediment release from a reservoir
  - Model and simulate the silt erosion in turbines components
- Manage severe peak hydropower operating conditions
  - Assess safety of infrastructures
  - Mitigate effects on river flow regime: hydropeaking
  - Expand operating range of turbines and pump-turbines
- Define schemes for sustainable exploitation of small hydropower
  - Develop innovative technologies dedicates to existing infrastructures (fresh water, waste water, tailrace channels,...)
  - Optimization of power production with minimum negative impacts on stream ecology for small hydropower plant

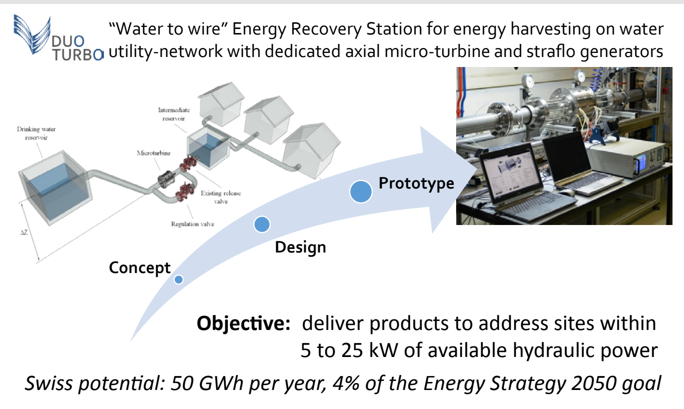
ENERGY STRATEGY 2050

SCCER SoE answers key questions to face challenges for the future of Swiss energy.

According to Energy Strategy 2050, the mean annual hydropower production has to be increased by 1.53 TWh per year and 3.16 TWh per year under present and optimized framework conditions, respectively. In view of environmental and socio-economical constraints, this foreseen increase is extremely challenging. SCCER SoE provides innovative and sustainable solutions for new hydropower plants and for the extension and optimization of existing schemes.

Increasing the flexibility of the hydropower plants is also a key enabler for a wider penetration of intermittent new renewable energy sources such as solar and wind power.

INNOVATIVE TECHNOLOGY: EXAMPLE



Picture: DuoTurbo CTI project no. 17197.1 PFEN-IW

PREVIOUS RESULTS

- Morphoclimatic controls: New sediment transport measurement, new airborne radar system for glacier mapping, development of a new stochastic weather generator for climate scenarios downscaling
- Simulation of hydropower systems: Assessment of climate change impacts on hydrology and hydropower operation under business-as-usual production targets
- Experimental and numerical investigations of Francis turbines at full load, part load and deep part load operating conditions
- Development of Energy Recovery Stations dedicated to energy harvesting on water utility networks (see beside).

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R&D for e-mobility

BFH-CSEM ENERGY STORAGE CENTRE (ESReC)

INTRODUCTION

The ESReC

The BFH-CSEM Energy Storage Centre (ESReC) isa competence centre that brings together various research groups that are active at the Bern University of Applied Sciences and the Swiss CSEM PV Centre.

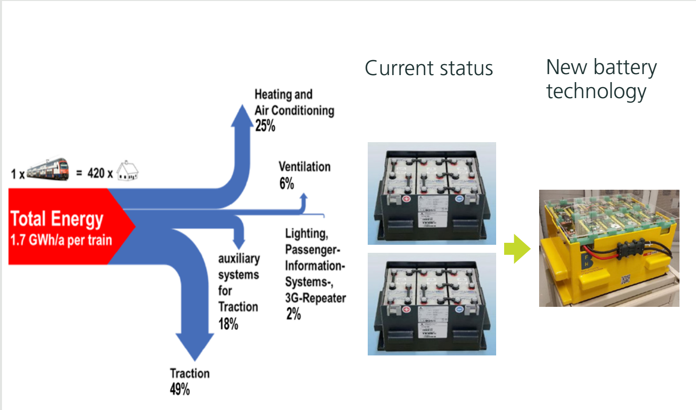
It researches and **develops solutions for the storage of electricity** and for the **e-mobility sector,** which facilitate the integration of renewable energy from decentralised electricity production into the Swiss supply network, as well as **the substitution of fossil fuels and the electrification of the transport sector.**

MAIN OBJECTIVE

The main objective of the ESReC is to draw attention to the know-how and develop the technologies that can contribute towards the sustainability of Switzerland's energy system.

Energy storage is a central component and prerequisite for a CO_2-neutral, sustainable and reliable energy supply system. The principal objective of all the R&D activities of the ESReC is to further the efficient integration of sustainable energy sources such as photovoltaics and wind into the electricity network with the aid of suitable energy storage solutions for stationary applications such as photovoltaic storage systems, as well as for the mobility sector.

RAIL TRANSPORT (BATTERIES, SWISS FEDERAL RAILWAYS)



"New battery technology for Swiss Federal Railways" project

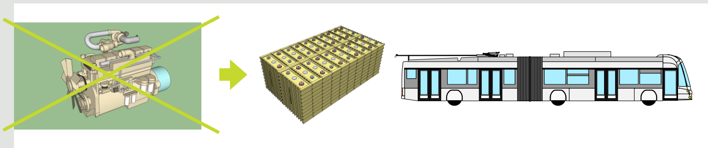
Objectives:

To lower the traction energy requirement by reducing weight

ESReC tasks:

- Selection of battery technology and the associated electrical switching equipment
- Development of an innovative battery management system
- Testing the new system in Swiss Federal Railways trains

ROAD TRANSPORT (SWISSTROLLEY+, HESS)



"SwissTrolley+" project

Objectives:

- CO_2 reduction through use of battery instead of diesel engine
- To increase energy efficiency through regenerative braking
- DC network support and avoidance of network expansion

ESReC tasks:

- Optimise battery management to improve economic viability
- Development of models for estimating length of service life

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Prof. Dr. Andrea Vezzini, Head of BFH-CSEM
Energy Storage Centre (ESReC)
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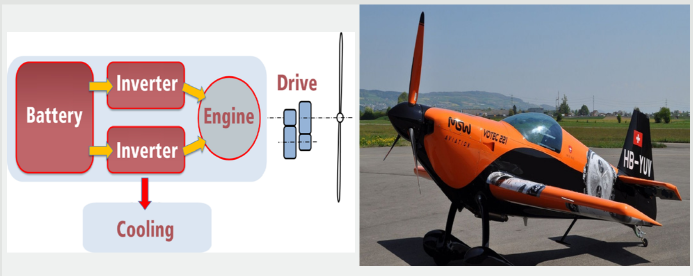
MAIN AREAS OF FOCUS

- Characterisation and modelling of electrochemical energy storage systems
- Development and detailed study of complete battery and energy systems, including battery management solutions
- Manufacturing technologies for battery cells and systems
- Decentralised and mobile fuel cell systems for potential long-term storage in the form of hydrogen
- Electricity storage in the grid for the purpose of integrating renewable energy sources
- Energy storage systems for the mobility sector, and substitution of fossil fuels for road, rail, air and water transport

AVIATION (E-PLANES, EVOLARIS)



"Evolaris – electric aerobatics" project

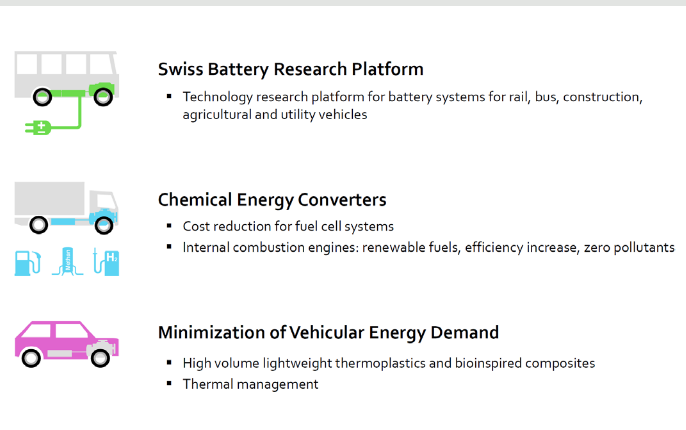
Objectives:

- CO_2 reduction through use of battery instead of diesel engine
- To increase energy efficiency through regenerative downward flight

ESReC tasks:

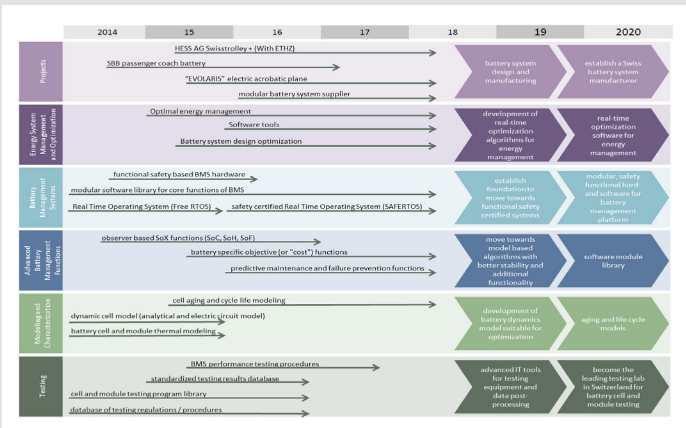
- Selection of battery technology and development of battery system
- Modelling and development of cooling system
- Modelling and development of an innovative electric engine

SWISS-WIDE NETWORK



SCCER Mobility: capacity areas 1, 2 and 3

OUR ROADMAP



Roadmap of the ESReC

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Swiss Federal Office of Energy SFOE

Temperature-stable production

DELTAZERO

+ FIND OUT MORE HERE:

PRODUCTION TECHNOLOGY

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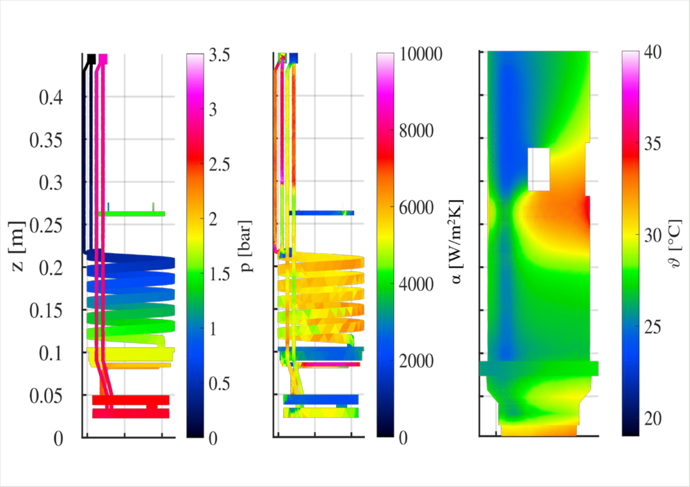
KEY DATA

DURATION OF PROJECT
September 2015 to August 2017

CLIENT
Commission for Technology and Innovation CTI

PARTNERS
inspire AG and Institute of Machine Tools and Manufacturing, Federal Institute of Technology, Zurich, University of Lucerne, Competence Centre for Thermal Energy Systems and Process Engineering, Step-Tec AG

MAKING TEMPERATURE VISIBLE



Simulated pressure loss (p), heat transfer (α) and temperature distribution (ϑ) of a machining spindle

MAIN OBJECTIVE

Machining centres now produce highly complex metal parts from raw parts with micro-metre precision. The core elements of these machines are electrically driven spindles, which drive tools and have to adapt their power and speed as required within fractions of a second. Because of their process proximity, spindles have a direct influence on manufacturing quality. Here, the variable distributions of temperature play a major role. The aim of this project is to minimise these temperature gradients through cooling with the aid of a phase change dispersion and to simulate the optimisation of the cooling duct geometry.

RELATIONSHIP WITH OTHER PROJECTS

All the involved partners are working simultaneously on different projects in order to improve the thermal control of production processes. Targeted cooling, optimised process control and the use of latent heat can simultaneously improve the result and cut costs. The high complexity of thermal analyses represents a challenge here.

Focuses of other projects include the systematic analysis and optimal harmonisation of heat and cooling sources and storage during production, simplified models for mechatronic systems, and interaction of machines with the building installation.

OTHER OBJECTIVES AND PROCEDURE

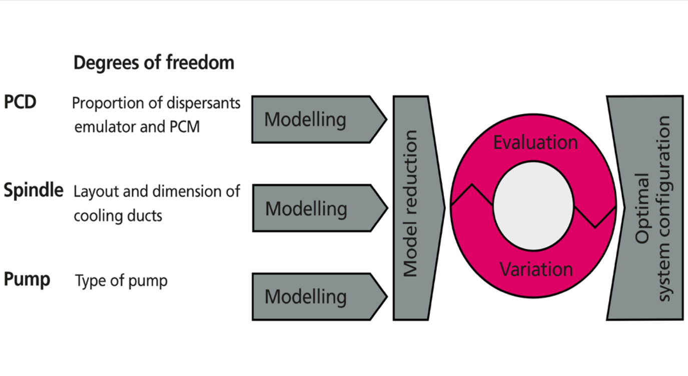
The utilised phase change dispersions contain substances that fuse at the ideal processing temperature of 24 °C and in this way can discharge large quantities of waste heat. The thermodynamic properties of these substances require suitable technical measures that are being developed in the project.

For the development of new spindles as core components of future machine generations with superior productivity and precision, it has to be possible to predict the properties already at the development stage. This can be done with the aid of thermal simulations, which until now were extremely time-consuming. But with new methods they can be calculated within seconds.

OPTIMISATION VIA MODELS

Optimising the system as a whole calls for observation of the interaction of individual components. For this purpose, suitable model reduction methods are being developed and utilised.

These reductions can be adapted at little effort for later developments, and speed up the optimisation process.



System optimisation via model reduction

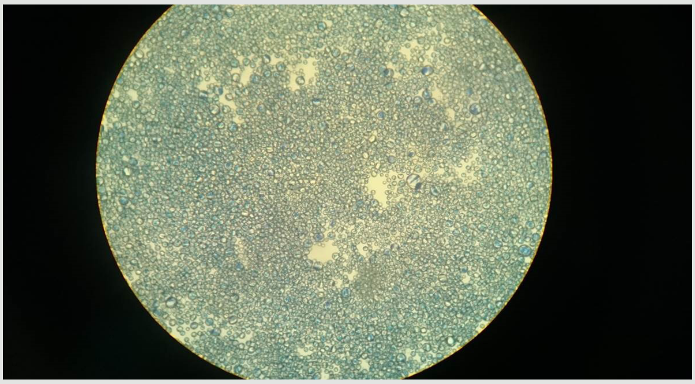
RELEVANCE FOR ENERGY STRATEGY 2050

During production, optimisation efforts are made constantly. But due to high pressure on costs, only those measures are permitted that are also economically viable. Thus both energy and costs have to be saved. This can be achieved through suitable design and intelligent control during operation. In a manner of speaking, energy is replaced by intelligence, and intelligent machines make better products. This is the biggest incentive for the industry to implement such measures.

Effective measures require individual analysis and the development of solutions, but not every company possesses the necessary resources and expertise. And this is where the various federal programmes come in.

RESULTS TO DATE

With the results of the preliminary project with the same name, the implementation partner was able to register the solution as a patent and thus protect the innovation on the market. The thermal simulations and model reductions are already being successfully applied.
Suitable phase change dispersions have already been produced in the laboratory, as depicted microscopically below:



Energy literacy counts!

ENERGY EFFICIENCY AND ENERGY LITERACY IN SWISS HOUSEHOLDS

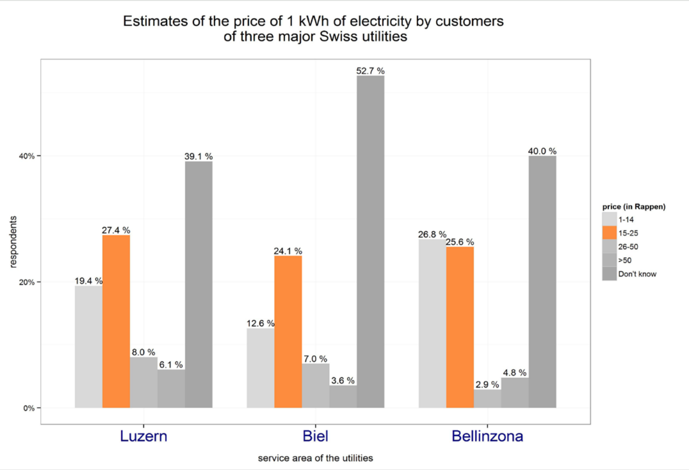
KEY DATA

PROJECT NAME
Underlying energy efficiency and technological change in the Swiss household sector

CONTRACTOR
Swiss Federal Office of Energy (SFOE)
Research program Energy-Economy-Society (EWG)

PARTNERSHIPS
Swiss utilities

KNOWLEDGE OF ELECTRICITY COST



MEASURING ENERGY EFFICIENCY

The primary objective is to estimate, using econometric methods, an energy demand frontier function for a sample of about 6'000 Swiss households. Panel data (2010–2014) is being collected by means of a large household survey in cooperation with nine Swiss utilities.

First, a comprehensive overview of energy consumption in Swiss households with information on dwellings, household composition, energy services, appliances, sociodemographics and also energy-related attitudes and behaviors will be presented. Second, the level of energy efficiency in Swiss households will be estimated.

RELATION TO DSM PROGRAMS

The analysis of energy efficiency is related to the project "An Evaluation of the Impact of Energy Efficiency Policies on Residential Electricity Demand in Switzerland" completed by CEPE in 2015 where the demand side management (DSM) programs of Swiss electric utilities were evaluated. It was found that the intensity of such programs is low compared to a country like the US, although the amount spent on DSM varies significantly within Swiss utilities. Utilities tend to focus more on communication (i.e. information and campaigns) as opposed to financial incentives and energy audits.

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Swiss Federal Office of Energy SFOE

GET MORE INFORMATION HERE:

ETH ZURICH
CENTRE FOR ENERGY POLICY AND ECONOMICS (CEPE)

Prof. Massimo Filippini mfilippini@ethz.ch
Dr. Julia Blasch jblasch@ethz.ch

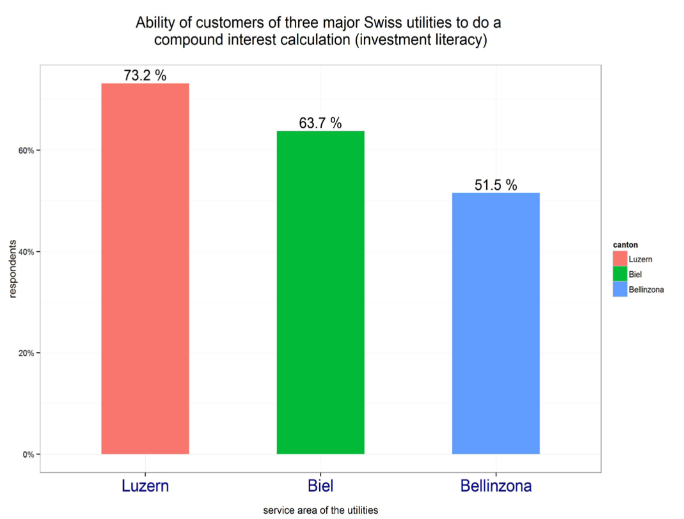
ENERGY LITERACY AND EFFICIENCY

The impact of policy measures and behavioral factors will also be studied with emphasis on the influence of a household's level of energy and investment literacy (e.g., knowledge of electricity costs and making an investment calculation) on the level of energy efficiency. It is hypothesized that households with more knowledge about electricity prices and having higher cognitive abilities to do an investment calculation are more likely to purchase efficient appliances. To test this, an online experiment on the adoption of efficient electric appliances was integrated into the survey.

ENERGY STRATEGY 2050

Results from the project will enable an evaluation of the energy efficiency objectives defined in the Energy Strategy 2050. The econometric analysis will estimate the potential for residential energy efficiency in Switzerland. Since we also account for the influence of policies and behavioral factors, the estimates of the potential for further energy savings in Swiss households can be considered more realistic than bottom-up estimates from an economic-engineering approach. Insights into the role of technological change for future changes in energy consumption will also be gained.

INVESTMENT LITERACY



PRELIMINARY RESULTS

In relation to impact of energy literacy, we find that individuals with a higher cognitive ability to do complex calculations (see image to the left) are more likely to choose a more (cost-) efficient appliance. We also find that displaying the yearly energy consumption in monetary terms (CHF) rather than physical units (kWh) enhances the probability that an individual makes an informed choice. In conclusion, more effort should be taken to empower consumers so they can correctly evaluate lifetime costs of appliances, e.g., by providing decision-support tools at the points of sale.

Energy saving potential in real use condition

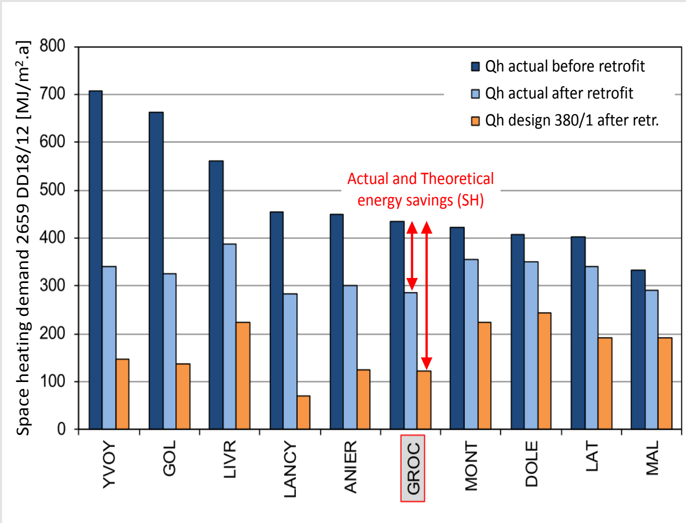
PERFORMANCE GAP IN BUILDING RETROFIT

KEY FIGURES

PROJECT DURATION
11.2013–12.2016
Extension foreseen within 2nd phase of SCCER FEEB&D

FUNDING AGENCIES
Commission for Technology and Innovation (CTI)
SCCER FEEB&D
Swiss Federal Office of Energy (SFOE)

CASE STUDIES



J. Khoury, (2014)

CHALLENGES

Given the slow transformation of the building stock, focus needs to be set on retrofit of existing buildings. Major related challenges are:

- Assessment of the effective energy saving potential of the building stock, taking into account actual performance of retrofitted buildings in real use condition.
- Characterization of the gap between actual (real) and planned energy saving performance (energy performance gap).
- Identification of possible counter-measures for reduction of this gap.

ENERGY STRATEGY 2050

The Energy Strategy 2050 (ES2050) strongly relies on massive reduction of the demand for the building sector (46% of final energy):

Objective: drastic reduction of the heat demand of buildings: 45% by 2035, 64% by 2050.

Underlying assumptions/issues:
1) high retrofit rate (quantity)
2) high retrofit performance (quality)

Understanding and reducing the performance gap is an essential step towards achievement of the ambitious goals of ES2050.

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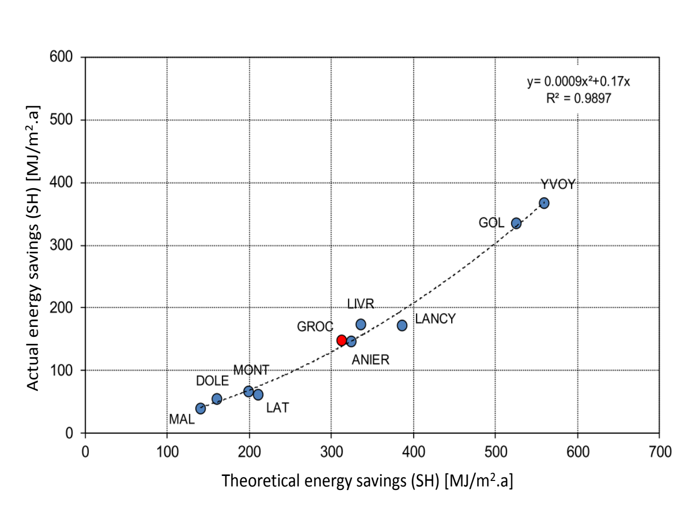
MAIN OBJECTIVES

- Analysis of the performance gap in building retrofit (inaccurate design, imperfect execution, operation and maintenance, user behavioral aspects).
- Identification and characterization of the determining factors in terms of design, execution, operation and user behaviour and estimation of their impact on the energy performance.
- Estimation of the actual energy saving potential of the building stock, under current practice.
- Provide guidance on countermeasures and policy recommendations to reduce the energy performance gap.

APPROACH

- Case studies analysis of several retrofitted post-war multifamily buildings (~ 25 cases studies, 3000 flats, 300'000 m² heated floor area).
- Analysis of the measured energy performance (SH demand) before and after retrofit and comparison with the design values (simulation in normed and actual use conditions).
- Cross-cutting with data concerning the entire building stock (upscaling of results at regional/national scale).
- Constitution of an expert panel on performance gap issues (underlying reasons, corrective actions, etc.).

PERFORMANCE: ACTUAL VS DESIGN



J. Khoury, (2014)

ACHIEVEMENTS

Major achievements so far:

- Statistical correlation between planned and actual energy saving values.
- Estimation of the actual energy saving potential of the building stock, under current practice.
- Upscaling to Geneva's postwar building stock: under current practice, **only 40% of the theoretical potential of building retrofit can be achieved.**

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