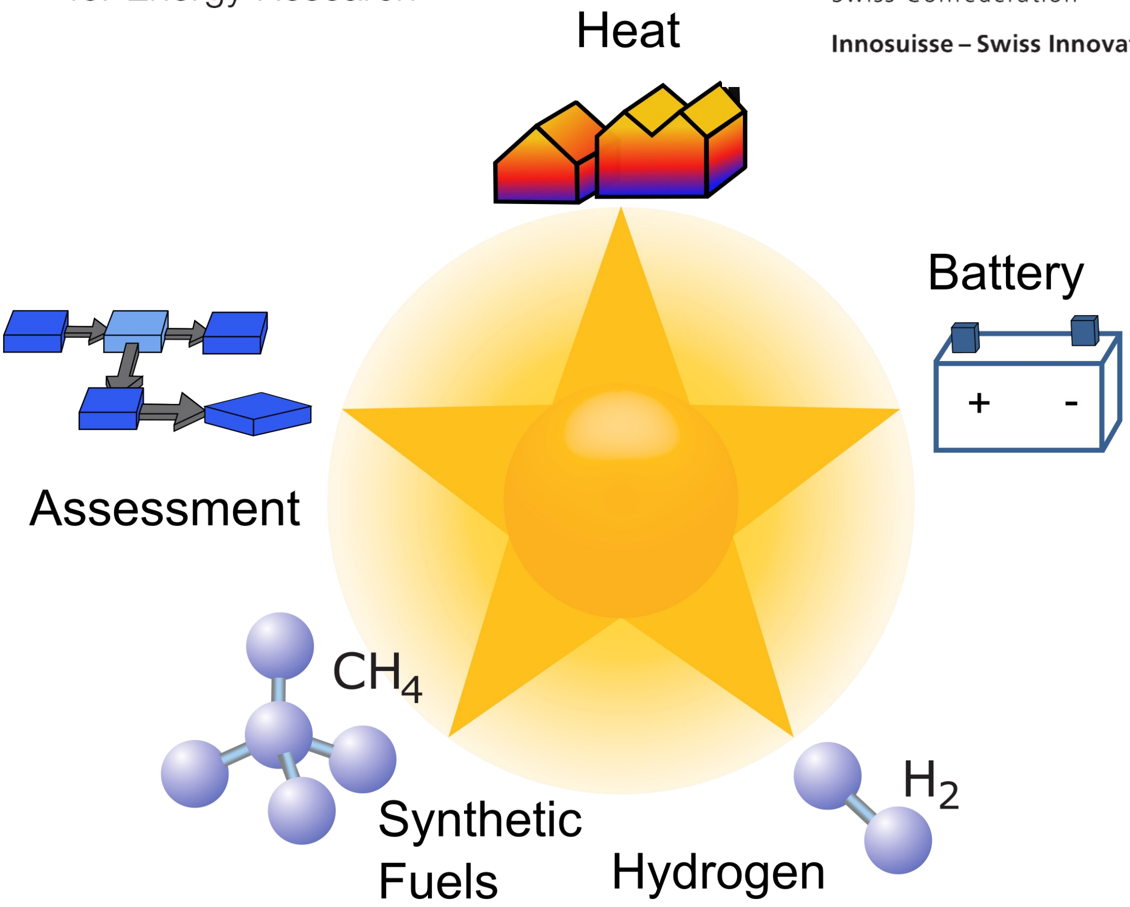
HaE-Storage
Swiss Competence Center
for Energy Research

Supported by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Innosuisse – Swiss Innovation Agency



Swiss Competence Center for Energy Research

Heat and Electricity Storage

SCCER HaE Storage, c/o Paul Scherrer Institut, 5232 Villigen, Switzerland, www.sccer-hae.ch

The Mission

The Swiss Competence Center for Energy Research (SCCER) "Heat and Electricity Storage" (HaE) is one of eight centers, which have been established in the research fields of mobility (SCCER Mobility), efficiency (SCCER FEEB+D, SCCER EIP), power supply (SCCER SoE), grids (SCCER FURIES), biomass (SCCER Biosweet), energy storage (SCCER HaE), as well as economy and environment (SCCER CREST) in light of the Swiss Government's Energy Strategy 2050.
The declared aim of this energy strategy is the transition from nuclear power to a power supply system based on renewable sources to meet the CO_2 emission targets. An important factor is to expand and strengthen the knowledge in the energy field through the increase of personnel resources, e.g., scientists, engineers, technicians alongside with technology development. The centers are organized as virtual consortia of industrial and academic institutions (cantonal universities, federal universities, federal research centers and universities of applied science) distributed all across Switzerland with the intention to maximize the outcome by combining the strongest competencies in each area of expertise.
To maintain a long-lasting effect on the Swiss power supply system, the competence centers were established in 2014 and will receive financial support until 2020.

Energy storage is a key element in this venture since energy, sourced from renewable sources like wind, sun or tidal energy is only available on a stochastic basis, therefore the aim is to store the surplus energy during times of low demand and release during times of high demand.
With an increasing contribution of the aforementioned renewable energy sources to the electricity mix, the significance of energy storage increases. This is clearly demonstrated by countries that have installed a lot of wind power, e.g., Germany and Denmark. Large intermittent discrepancies between electricity production and demand are being observed with the consequence of strongly fluctuating electricity prizes.
These differences challenge the stability of the power supply system. In order to stabilize the grid, an increase in short term electricity storage capacity (hrs) with high response time is needed within the next years. In the long run, seasonal storage becomes important to ensure constant electricity supply without conventional fossil based power generation.

Heat, aside from electricity is one of the most required type of energy today. About 50% of the primary energy carriers are transformed to heat by modern industrialized societies required for space heating, hot water and process heat. Thus, it becomes obvious that a sensible use of energy must not neglect the questions related to heat.

In summary it can be stated that energy storage will become increasingly important in the future.

The research and development within the Competence Center for Heat and Electricity Storage concentrates on five different fields with the involvement of 24 research groups from ten public institutions as well as from the private sector (see last page).
The research includes traditional approaches like the future development of battery systems, but also on novel approaches like heat storage or power-to-gas concepts.

We would like to invite you to learn more about the different area of research on the following pages. For further information, or if you are interested in a collaboration, you may contact us any time, or check our web page (www.sccer-hae.ch) for news and events. Our contact information is given on the last page of this flyer.

Prof. Dr. Thomas J. Schmidt
Head SCCER Heat and Electricity Storage

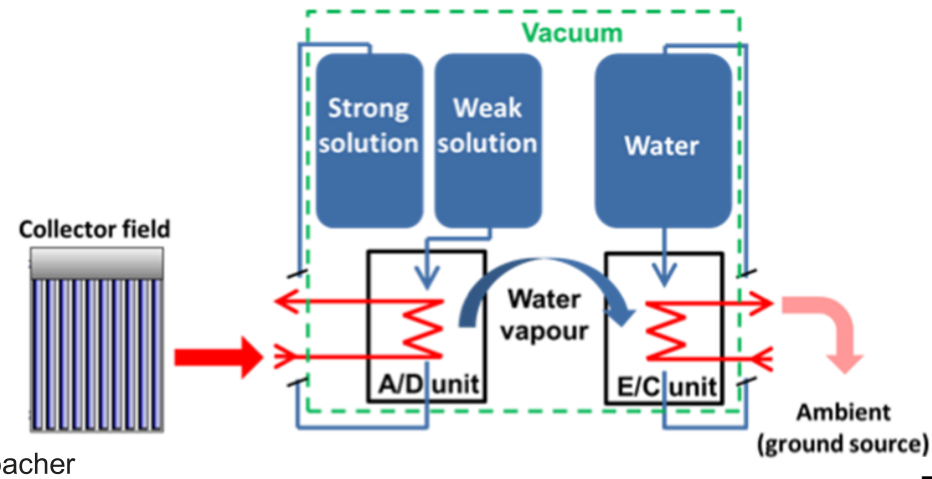
Thermal Energy Storage

As already introduced, a good portion of primary energy is used as heat. Therefore, heat storage is important in the attempt to transform the energy sector.
Industrial applications at a temperature level below 100°C and above 400°C are targeted, as well as residential applications at a temperature level up to 250°C.

Advanced Adiabatic Compressed Air Storage (AA-CAES) Plants based on AA-CAES use electricity during periods of excess power generation to compress air. The heat contained in the compressed air is stored in a Thermal Energy Storage, and the high pressure cooled air is stored confined in a hermetically sealed reservoir. To generate electricity during periods of high demand, the air is released from the reservoir, heated from the storage, and is expanded through a turbine-generator setup.
The efficiency of a well designed AA-CAES plant is projected to reach about 75 % (close to the efficiency of pumped hydro storage).
The heat-storage concept for AA-CAES with temperature and pressure ranges of about 500-600°C and 10-60 bars that is considered is a combination of encapsulated phase-change materials (PCM) with a packed bed of rocks.

High-temperature process heat: The storage of thermal energy at temperatures above 400°C is of interest to process-industry applications such as glass recycling, cement production, and metallurgical processing. Accordingly, research is focused on latent and sensible heat storage for these temperature ranges to provide solutions for economic and compact storage of fluctuating sources of high-temperature heat and/or electricity.

Building Applications: Space heating, hot water generation and industrial processes.
The heating and cooling demands of buildings necessitate storage of thermal energy for winter and summer. Sensible, latent, and sorption storage technologies can be used to bridge the time shift between the availability of energy (like solar radiation) and user demand. The temperature range for heating, ventilation, and air conditioning in buildings will be covered by these storage technologies in the range of about -10°C to 250°C.
One example for residential space and water heating, the dilution energy of concentrated lye is investigated (illustrated in the figure below), here the heat exchanger for enrichment of the lye is in focus of the development. The final application is a seasonal heat storage concept for single family houses in combination with thermal solar panels.



Key Contact:
Dr. Andreas Haselbacher
haselbac@ethz.ch
Institute of Energy Technology
ETHZ
http://www.prec.ethz.ch/staff/management-administration.html

Battery materials

The state of the art electricity storage for many applications is lithium-ion batteries (in cell phones, laptops, E-bikes, ...). Despite of the wide and numerous applications, in terms of power density, cost, and energy density, the full potential of metal-ion based batteries has not been not reached. In order to bring the technology forward, three fundamental research directions will be pursued with strong synergies between them, accompanied by two applied projects.

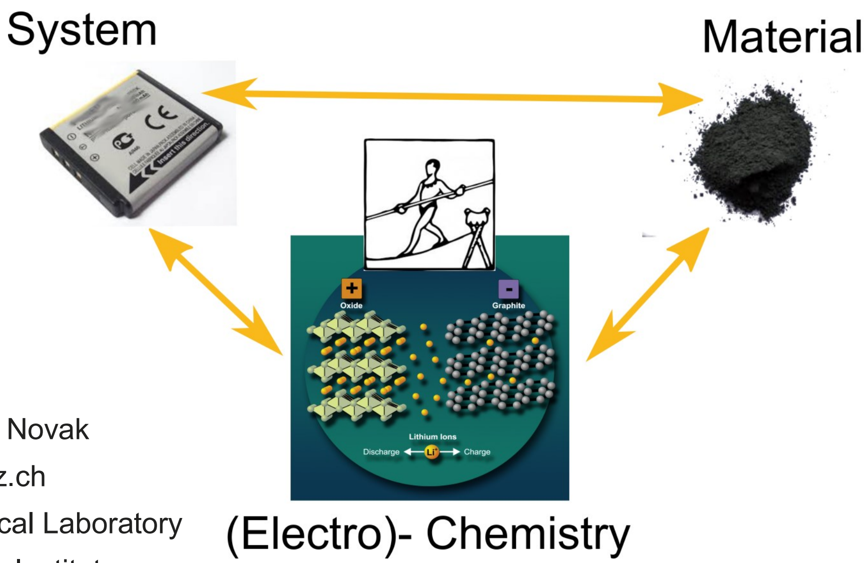
Improvement of Li-ion technology towards higher power density by development of *novel cathode and anode materials for lithium-ion batteries* via nano-structuring, to increase the energy density of current lithium-ion cells by 50 %-100 %. An other way to increase the power density is to increase the cell potential. This requires new materials with long term stability at increased potentials. Computational prediction based on the density function theory (DFT) will guide the experimental efforts.

Cost Reduction by going beyond lithium-ion technologies: Highly exploratory research will target *novel electrode materials which operate via storage of other than lithium ions, such as sodium (Na^+).* This substitution of lithium ions for sodium ions, which have a higher availability and thus allow cost reduction, is one of the mid-term goals. It is targeted to achieve performance data equal to the current state of the art of lithium-ion technology.

Development of manufacturing technology is a task that aims at planning, refining and realization of a pilot production line for lithium- (and sodium) ion batteries in small series. This is required to qualify new material in full cells based on reproducibly assembled cells.

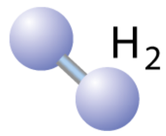
Performance, Lifetime, Safety and Reliability of Battery Systems is addressed by qualification and verification of procedures to estimate reliability and lifetime. Further, the compliance with safety regulations of electricity storage systems with batteries will be established.

The Competencies of the Team are theoretical prediction of physical / chemical behaviour of electrode materials, material synthesis and electrochemical characterization on lap– and application-scale, as well as analysis and optimization of production processes.



Key Contact
Prof. Dr. Petr Novak
novakp@ethz.ch
Electrochemical Laboratory
Paul Scherrer Institut
http://www.psi.ch/lec/electrochemical-energy-storage

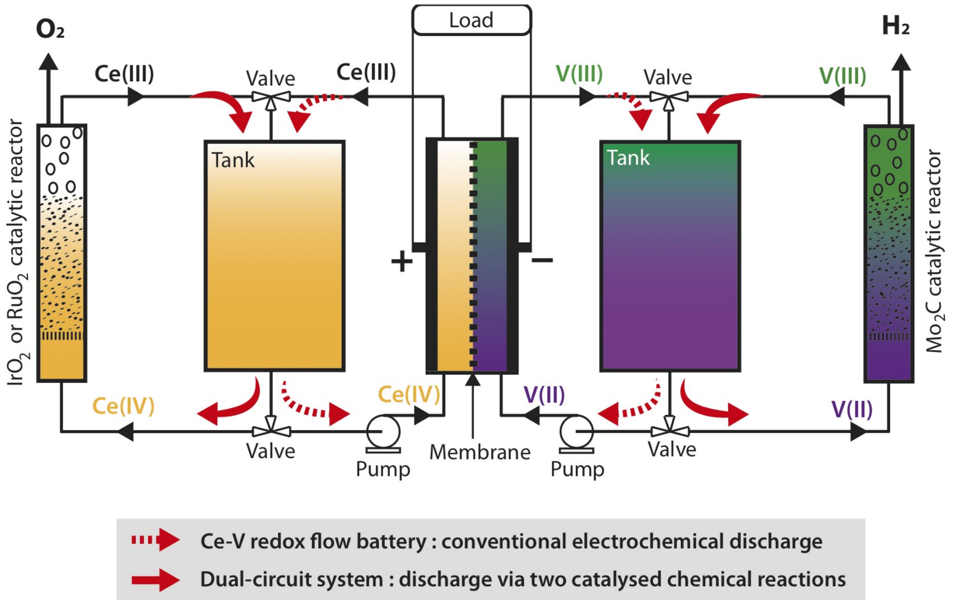
Hydrogen



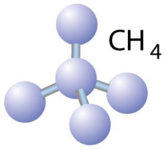
With the growing amount of renewable energy, the demand for H_2 production and storage increases. New and competitive conversion and storage systems on the scale of pilot and demonstrator units are developed to enable the transition from fossil to renewable energy.

H_2 production by electrolysis is an especially important issue since this is the first step in the conversion of electricity to synthetic fuels and realizes a closed material cycle for energy. Inexpensive and safe storage of hydrogen is also crucial in order to enable a hydrogen economy. The emerging technologies in the field including redox flow batteries, radically lower cost catalysts, and high energy density liquid storage routes are in focus.
Redox flow battery for hydrogen production is already established successfully on the laboratory scale (see schematic below), and was implemented as a large scale demonstrator at the water treatment facility in Martigny. The hydrogen produced will be co-mingled with biogas generated at the water treatment facility and later will be used directly in the hydrogenation of CO_2. The charged electrolyte produced in the battery may also be used at a later stage for the direct reduction of CO_2 or the co-generation of hydrogen and CO_2 reduction products.
Beside of electrolysis, photo catalysis, based on novel– metal free catalysts is explored on the level of fundamental research. To generate hydrogen directly from sunlight without the detour to electricity.

The state of the art **hydrogen storage** is either as super cooled liquid or compressed gas (70 MPa). Both ways require significant amount of energy. An alternative is the production of molecules which are easy to synthesise from and easy to decompose to hydrogen. The chemicals can be stored for unlimited time in liquid or solid state. Such molecules are alumina or boric compounds, but also organic compounds like formaldehyde, methanol or formic acid are investigated for energy storage application.



Key Contact:
Prof. Dr. Andreas Züttel
andreas.zuettel@epfl.ch
Laboratory of Materials for Renewable Energy
EPFL
http://sb.epfl.ch/chemistry



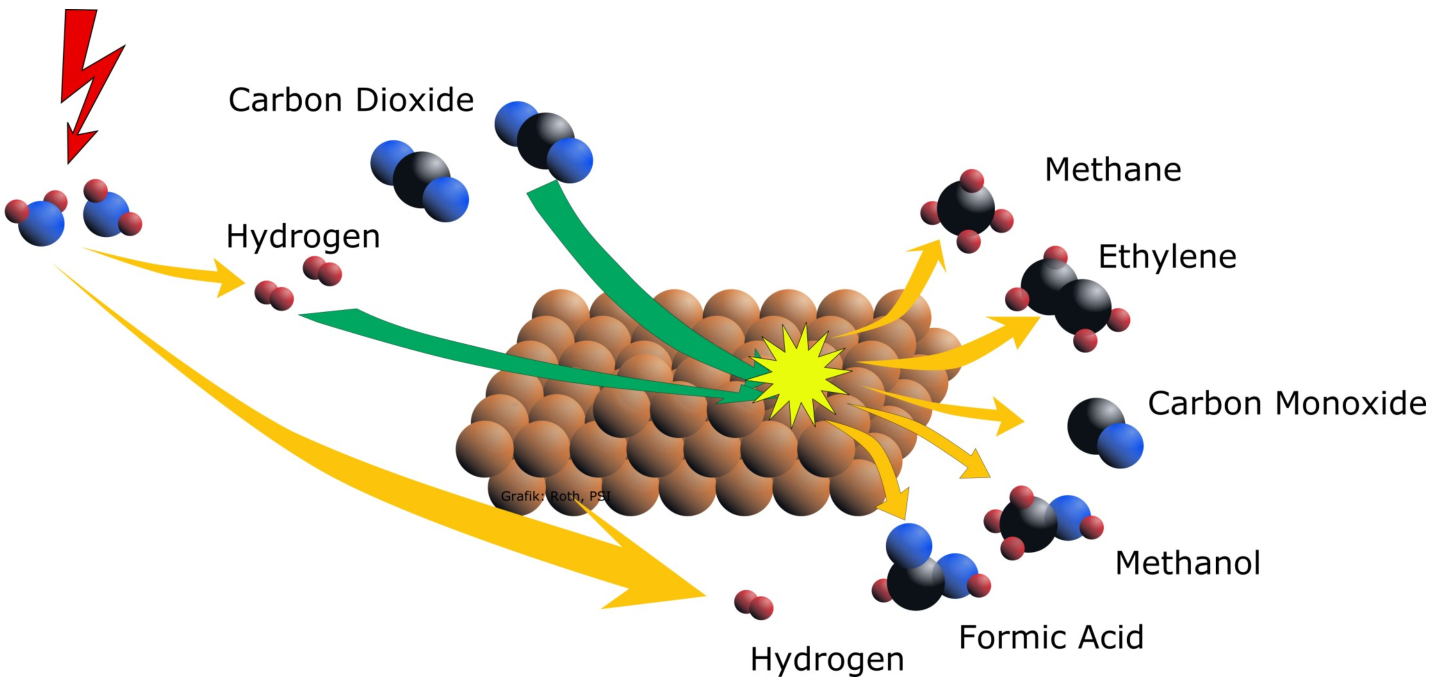
Synthetic Fuels

With the aim to reduce the CO_2 footprint, as proposed and enforced by policy makers in order to reduce the anthropogenic effects on the climate, CO_2 hydrogenation towards fuel production is a way to recycle this greenhouse gas and store abundant renewable energy. E.g. Iceland and even regions in Germany have methanation plants in operation for this purpose.

Switzerland has a vast surplus of hydroelectricity on one hand. On the other hand, companies in Switzerland will pay CHF 25 for every ton of carbon dioxide they produce. This is a strong motivation to find ways of fixing carbon dioxide and produce the anticipated products, e.g. formic acid, methanol and hydrocarbons.

The catalytic and electrocatalytic reduction of CO_2 to form either syngas or hydrocarbons are highly challenging processes with respect to catalyst activity and selectivity.

This project will mainly focus on the development of advanced catalysts within the timeframe of this SCCER. In addition, the demonstration the feasibility of the processes on the laboratory scale reactor level (for catalytic CO_2 reduction) and on the full cell level (the electro catalytic CO_2 reduction, also called co-electrolysis) with an efficiency of >30% and with a selectivity of >60% for syngas/hydrocarbons is planned.



Key Contact:
Prof. Dr. Christophe Copéret
ccoperet@inorg.chem.ethz.ch
Laboratory of Organometallic and Medicinal Chemistry
Department of Chemistry and Applied Biosciences, ETHZ
http://www.coperetgroup.ethz.ch/

Assessment

All the different pieces of the SCCER Heat and electricity Storage must not stand-alone but need to be integrated in a wider context to become powerful. For this reason, questions of technology interaction is part of the research, covering a wide range of aspects from socio-economical questions up to system integration and modelling. Specifically the following fields are addressed:

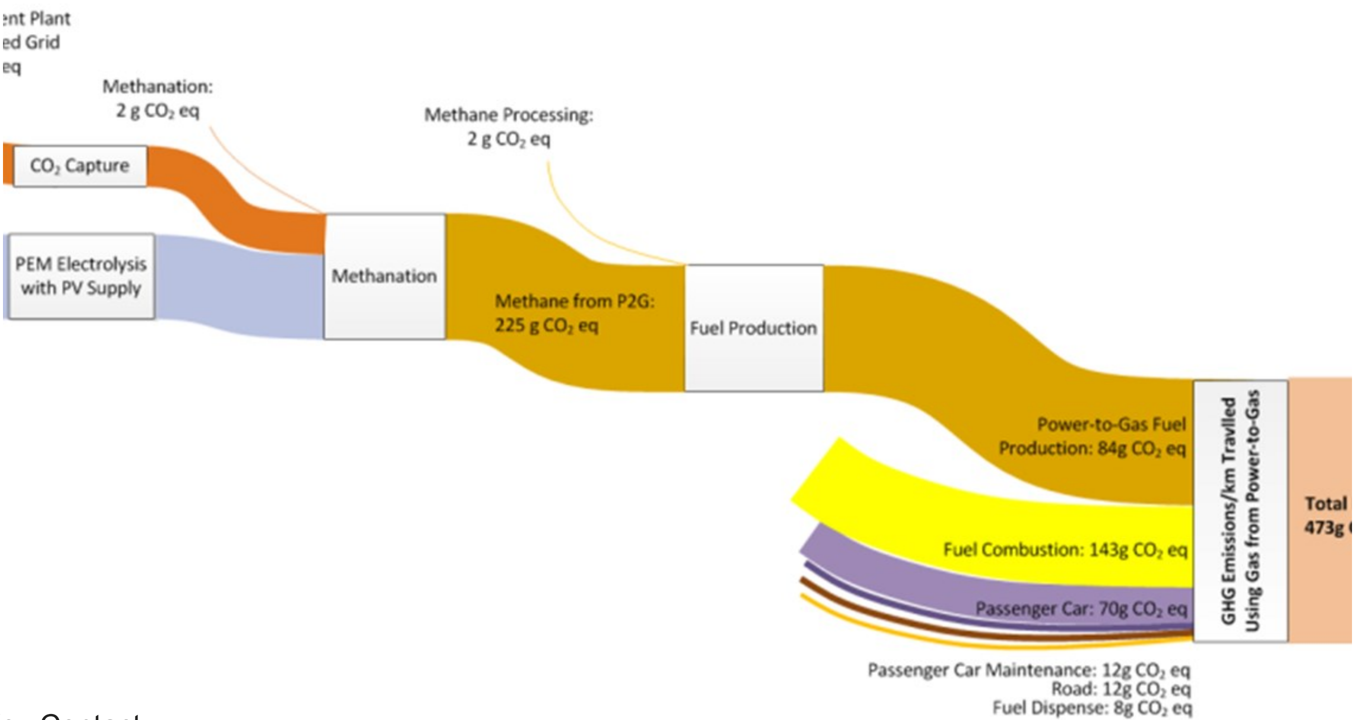
The assessment of **future development scenario** in terms of energy storage systems as part of the energy network (power/heat generation, distribution and consumption) and feeding this know-how into fundamental and applied research.

A comprehensive **sustainability assessment** with a focus on cost and environmental indicators. Here the collaboration with the SCCER CREST is beneficial.

'Competencies on how to improve the flexibility between power, heat, fuel and transportation in the future are essential for Switzerland. Therefore, we run proactively ideation workshops with members throughout the SCCER to generate a new storage concepts by bringing together different storage technologies.

In parallel with the environmental aspects, **economic questions** related to energy storage in future energy systems are addressed in order to guide the process of policy making.

Further, the interaction with the SCCERs in Efficiency, Mobility and Grids to exchange competencies between those SCCERs and to avoid duplication and benefit from synergetic effects.



Key Contact:
Prof. Dr. Jörg Worlitschek
joerg.worlitschek@hslu.ch
Thermische Energiesysteme & Verfahrenstechnik
Hochschule Luzern - Technik & Architektur
https://www.hslu.ch/technik-architektur

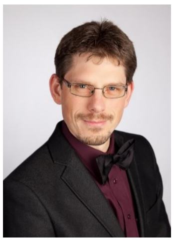
Contact:

Prof. Dr. Thomas J. Schmidt
Head SCCER HaE

Professor for Electrochemistry,
ETH Zürich, Physical Chemistry

Head of Research Division
Energy and Environment

Paul Scherrer Institut



Dr. Jörg Roth
Coordinator

Ursula Ludgate
Administrative Assistance

SCCER Heat and Electricity Storage

info@sccer-hae.ch

c/o Paul Scherrer Institut OVGA 101

5232 Villigen PSI, Switzerland

+41 (0)56 310-2092

www.sccer-hae.ch

Our Partners: