EFFICIENCY OF INDUSTRIAL PROCESSES

Swiss Competence Center for Energy Research
Efficiency of Industrial Processes

Vision, Mission and Innovation Roadmap 2017-2020

Supported by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Innosuisse – Swiss Innovation Agency

1 Vision

The **vision of the SCCER EIP** is to develop the science and technology that allows Swiss industry to transition to a sustainable use of energy in its processes, to reduce greenhouse gases and to ensure that the target of 14 TWh energy consumption reduction until 2050 is achieved while at the same time keeping the impacts on the economics of the corresponding processes to a minimal.

2 Mission

The **mission of the SCCER EIP** is two-fold:

- **Develop novel technologies and materials** that result in energy savings:
  - in industrial heating and cooling processes as well as in electricity (WP2)
  - of some key industrial processes (separations) (WP3)
  - to reduce the energy cost for cleaning water (WP4)
- **Support implementation** (WP1) of energy efficiency by:
  - assessing the techno-economic feasibility at technology level
  - providing new assessment methods at company level
  - assessing the energy transition at national level

3 Innovation Roadmap

3.1 Innovation Update and Challenges

Innovation is not only related to products but also to methods and competences.

WP1 – Implementation of Industrial Energy Efficiency

The energy efficiency potential in industry remains high and many established energy efficiency measures that are economically viable are not implemented (diffusion gap). The reasons can be diverse, such as conservative attitude (“never change a running system”), focusing on single components while neglecting system view, wrong orientation on purchasing price (instead of total costs), or lack of knowledge on saving potential. WP1 contributes to lower the techno-economic barriers to the implementation of energy efficiency measures by:

- raising the awareness through providing cross-companies decision support tools to estimate one’s own specific saving potential
- evaluating possible new and established energy efficiency measures and technologies by means of their cost-effectiveness, thereby also establishing the potential size of the “energy efficiency market”
- raising attractiveness of energy efficiency measures by providing standardized methodologies, tools and documented best practices to include multiple benefits upstream (i.e. before energy efficiency measures implementation) in investment decisions-making processes for energy efficient measures. To date, multiple benefits are not properly and systematically recognized and valued [IEA2014].
- revealing solutions for an entire industry site instead of focusing on single components and processes.
- providing clarity on how the goals of the Energy Strategy 2050 can be achieved considering efficient electricity usage and reduction of the CO2 emissions in the different industrial sectors.

WP2 – Energy Efficiency (direct)

The major challenge in refrigeration, industrial heat, and steam generation is the current low cost of all fossil fuels, which makes it very difficult to implement new energy efficient solutions. As a response, WP2 channels its research focus on the most promising technologies such as highly efficient refrigeration systems, high temperature heat pumps using waste heat, solar thermal heat generation and water vapour recompression for steam generation. All these technologies are on the brink of widespread implementation and only need some improvements on the component and system level. In addition, industry needs standardization. Good examples and implementation guidelines are part of the first and second phases of the SCCER. This allows alleviating current demands of low investment cost, ease of implementation and flexibility of use.

WP3 – Process Efficiency (indirect)

The major challenge resides in the very nature of the measures that this work package addresses, namely the enhancement of energy efficiency obtained by rethinking, improving and optimizing the processes. Although such research activities are carried out in co-operation with industry and address issues of great importance, the new solutions which are developed would require major changes in how specific chemical, pharmaceutical, food products are manufactured. Resistances to implement such major changes are obvious. It is important that the SCCER EIP brings to the forefront the impact that such changes may achieve in terms not only of product quality, but also of energy efficiency.

WP4 – Decentralized Wastewater Management

Urban hygiene and environmental protection has significantly benefitted from building a network of sewers, transporting wastewater to a centralized wastewater treatment system, and optimizing end-of-pipe treatment. But this centralized approach is expensive to implement and operate and it is not resource efficient [Larsen2016]. Research has demonstrated significant opportunities for alternative approaches for wastewater management. Alternative approaches are typically most effective close to the source (i.e., in the building). The goal of WP4 is to demonstrate that robust treatment of wastewater or greywater is feasible at the household level and that such treatment in the building provides improved opportunities for making use of treated water for cooling or heating purposes. The work in the SCCER EIP, in collaboration with the SCCER FEEB&D, will allow to implement and test relevant technologies together with industry at an industrial level using the NEST building as a research platform. Based on developing, testing, and demonstrating technologies at scale is an important step towards convincing the relatively conservative wastewater industry to include a more resource and energy efficient water treatment in the portfolio.

3.2 Innovation Potential

WP1 – Implementation of Industrial Energy Efficiency

While the Energy Strategy 2050 sets the energy goals to be achieved by the Swiss industry, no implementation plan towards these objectives is available. WP1 in phase II of the SCCER will develop comprehensive information, methodologies and best practices on the technology, company, and national level that facilitate most effectively the implementation of current and future energy efficiency measures.

For this purpose, new datasets for the cost effectiveness of energy efficiency technologies and processes will be created and linked to existing scenario modelling methods at the national level (Energy Scope).

Moreover, although industrial symbiosis and advanced district thermal energy networks such as CO_2 networks and energy networks have been studied independently, new methods for the design and assessment of systems comprising both elements will be developed and will open a new dimension in the energy reduction potential of the Swiss industry as an ecosystem, as well as at a higher level, considering the potential for district heating demand coverage with waste heat.

Finally, to date, energy efficiency programs in Switzerland only consider the benefits on energy cost reduction realized by the implementation of a measure. To date in the international and national research the methodologies to assess comprehensive multiple benefits and costs related to energy efficiency measures impacts rely on case studies and are only applied after implementation of energy efficiency measures. Standardized methodologies and structured guidelines are needed to appropriately and systematically recognize multiple benefits prior to the potential implementation of energy efficiency measures: "*this is an area that merits significantly scaled-up research by the energy efficiency community […] and where there is an urgency to accelerate progress*" [IEA2014]. A new tool and best practices will be developed to identify, quantify and monetize relevant multiple benefits that support companies' strategies by considering the peculiarities of Swiss industries.

WP2 – Energy Efficiency (direct)

Within high temperature heat pumps the novelty lies in the achievable operating temperatures. While current systems are limited to approximately 100°C, new components such as small-scale turbo compressors allow higher temperature ranges of up to 140°C, also as a result of the absence of oil. In addition, current high temperature heat pumps mostly operate on refrigerants with a high GWP, whereas the current WP2 investigates environmentally sound approaches. The main innovation in solar thermal systems lies in establishing guidelines for easy implementation in industrial processes and to determine the appropriate system level for integration. The calculation tools to determine the gains using high temperature collectors will be the first ones designed specifically for industrial processes. The innovations in steam technology using vapour recompression are potentially very large, since currently only fossil fuelled and electrically driven steam generators in power ranges up to several MW are used due to their low installations costs. The product envisioned here is a mid-power-range steam generator reducing energy consumption by 30-50% compared to conventional technology.

By 2020 prototypes of a high temperature heat pumps will be built and a detailed analysis / design of a steam generator based on vapour recompression will be developed. The high temperature heat pump is expected to be introduced to the market a few years after 2020 while the steam generator is expected to reach the same technology readiness level a few years later.

WP3 – Process Efficiency (indirect)

Research has always driven innovation in the chemical, pharmaceutical and food industry. The potential of the technologies on which WP3 focuses is extremely high, particularly because it enhances process efficiency through energy efficiency and vice versa. Micro-technology for continuous processes is the new frontier in the pharma sector. The researchers involved in this area may certainly reach a break through. CO_2 capture for further utilization or storage is a technology which must be deployed if the climate change issue is to be taken seriously, as the Paris Agreement demand us to do. Due to its rather limited use, innovation potential is still very significant, and potential for improving efficiency is huge. Transferring the results and methods of microtechnology science and engineering to new materials, surfaces, structures that can enhance mass and heat transfer is the right thing to do today, especially considering how this domain of science has grown in the recent past and the opportunities it presents in terms of transport phenomena within all processes of industries mentioned above.

WP4 – Decentralized Wastewater Management

Whereas researchers and practitioners alike have been working on energy-saving measures at the wastewater treatment plant for several decades, the substantial potential of heat energy in wastewater at the household level has been mostly neglected. There are great advantages of recovering this energy at the household or neighbourhood level where temperatures are high and the energy is required onsite as compared to recovering the energy at the sewer level. However, small-scale energy recovery has typically not been considered competitive from an economic point of view, due to high maintenance requirements. Emerging maintenance-free and energy-efficient greywater treatment as well as new energy-recovery technologies, which users can easily clean themselves, are promising innovations with a high chance of commercial success. Due to increasing warm summers, the use of wastewater for cooling purposes has an immense potential in a national as well as in an international context.

3.3 Top Innovation Chart

WP	Phased-out by the end of 2016	Newly started in 2017
1	Observatory of industrial energy utilization	Decision support tool; recommendations and impact assessment
2	Concept for high-temperature heat pumps	Steam generators and networks
3	Concept for high-temperature heat pumps	Intensification of key industrial processes; surfaces for heat exchange
4	Integrated into new WP1	Completely new WP