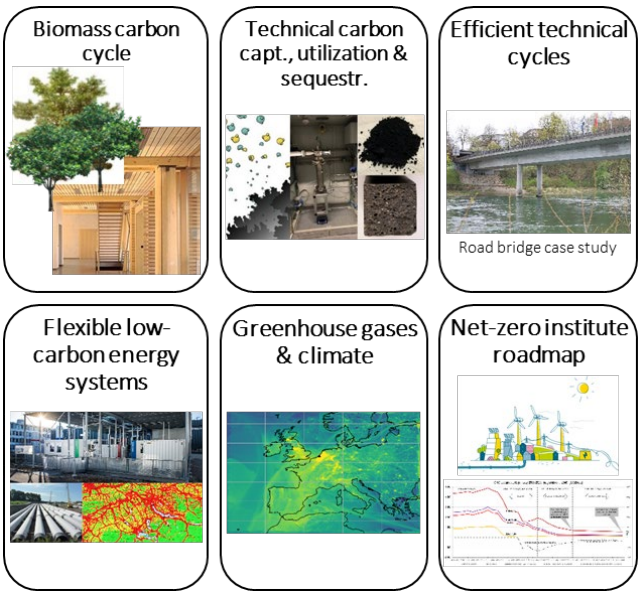
swiss center of excellence on net zero emissions
SCENE

Swiss Center of Excellence on Net-Zero Emissions (SCENE)

The ETH Board is co-financing six Joint Initiatives (JI) in the strategic area "Energy, Climate and Environmental Sustainability" for a duration of three years. These Joint Initiatives are large, strategic projects in which at least two institutes of the ETH Domain must be involved.



The SCENE Joint Initiative has established a Center of Excellence that covers a wide range of research areas related to net-zero emissions and provides a platform for cross-institutional collaboration in the ETH Domain. More than 100 researchers in 30 laboratories from all four Research Institutes of the ETH Domain (PSI, Empa, WSL, Eawag) and the two Technical Universities ETHZ and EPFL are involved. The project is led by PSI and runs from 1.1.2023 - 31.12.2025 with a total budget of approx. 17 million CHF.

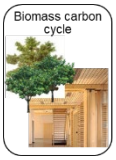
In order to support the achievement of the goal of net-zero emissions by 2050, described in the Federal Government's climate and energy strategy, SCENE performs holistic research in six Net-Zero Action Areas (Figure 1), covering the avoidance, removal, monitoring and analysis of greenhouse gas emissions.

In addition, an Expert Hub strengthens the network within the ETH Domain and pools a broad range of interdisciplinary expertise. It proactively publishes reports and white papers and responds to requests from stakeholders in order to achieve a strong, direct public impact.

In the long term, SCENE plans to create a platform that supports scientifically sound decisions, both at the national level and for stakeholders, so that the technologies, instruments and methods developed at the Center of Excellence can be put into practice in a timely manner.

Action Areas in SCENE

AA 1: Biomass carbon cycle

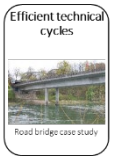


We demonstrate optimization pathways of forest and landscape management, the utilization of woody biomass, and substitution effects to mitigate climate change.

AA 2: Technical carbon capture, utilization, and sequestration

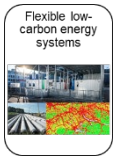
We establish a sustainable energy supply chain with negative CO_2 emissions, enabling global transport, large-scale seasonal storage, and carbon sequestration in Switzerland using existing infrastructure.

AA 3: Efficient technical cycles – Circular carbon-neutral infrastructure



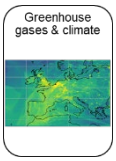
We support the decarbonization of the construction sector (30% of Swiss emissions) by providing decision-making tools and strategies, including design for disassembly and materials/component reuse, enabling carbon-neutral, circular infrastructure by 2050.

AA 4: Flexible low-carbon energy systems



We unlock the flexibility potentials of the Swiss energy system to ensure supply security and social acceptance in a renewable-based future, supporting decision makers with energy investments.

AA 5: Greenhouse gases and climate



We create a publicly-accessible interactive platform with information about integrated greenhouse gas mitigation scenarios towards net-zero, overarching sustainability implications, and related air quality evolution.

AA 6: Net-zero institute roadmap

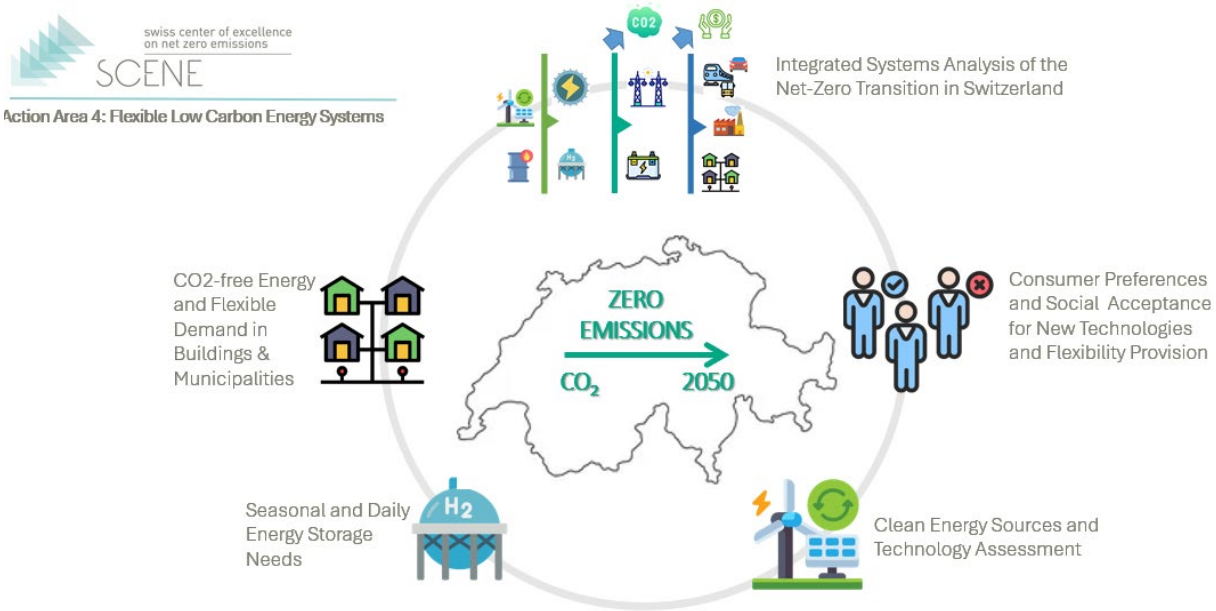
We define science-based, net-zero roadmaps for the four Research Institutes using gap analyses, energy scenarios with possible cost developments, and considerations about the necessary measures and their impacts to reach net-zero.

Action Area 4: Flexible low-carbon energy systems

Motivation and Main Outcomes:

The transition of the Swiss energy system to net-zero entails reliance on weather-dependent and distributed forms of energy supply, increased electrification of heat and transport and adaptation to wider changes in energy supply and usage patterns. Energy system flexibility is the ability to adjust supply and demand to continuously match them without adding more capacity on the supply side; in other words, achieving the energy balance within the energy system at all timescales. Historically, the most flexibility has come from the supply side of the energy system, but the shift to net-zero requires moving energy from where it is produced to where it is needed. This means that flexibility can also be provided by varying demand to help match supply, with consumers increasing or reducing demand or changing the time they consume energy. Demand-side flexibility can be provided by any residential, industrial, and commercial transport sectors, but each has different abilities to respond.

Flexibility allows us to do more with less, but to achieve the net-zero transition, it needs to be provided by all actors in the energy system and in a coordinated way. This requires technical solutions in energy supply (e.g., batteries, hydrogen, and thermal storage) and changes in consumer energy behaviours on the demand side (e.g., load shifts and energy savings).



We combine the competencies of several established research teams in the ETH Domain to analyse the potential and role of the coordinated deployment of flexibility options in meeting the 2050 net-zero emissions target at the lowest cost possible. We employ a robust integrated energy system analysis of the net-zero transition in Switzerland at the national, municipality and building scales, backed by a solid technology assessment of technical flexibility options beyond the electricity system per se, such as large-scale seasonal hydrogen storage. Beyond techno-economic modelling, socio-economic research is performed to investigate consumers' preferences for new energy supply systems, clean technologies for heating and mobility, and the feasibility of demand-side flexibility options such as electricity and heat load shifts. Technology roadmaps and geo-spatially detailed maps of the deployed flexibility mechanisms will inform decision-makers, stakeholders, and citizens about necessary future investments and technology prospects for a carbon-free Swiss energy system.

Who we are:

Our team comprises researchers with various backgrounds and expertise, including scholars in energy systems analysis and modelling at the national and subnational scales, experts in building energy systems and technologies, social scientists, and hydrogen supply, storage, and use technology professionals.

The following institutes are contributing with their expertise:

Participating Laboratories

PSI Laboratory for Energy Systems Analysis

PSI Electrochemistry Laboratory

ETH Energy Systems Analysis

EMPA Urban Energy Systems Lab

Eawag Environmental Economics Group

WSL Environmental and Resource Economics Group

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Activities:

Action Area 4 has five main tasks.

The first task (led by PSI-LEC) is to assess and define the **major economic specifications of hydrogen supply, storage, and use technologies**, given the need for large-scale flexibility provision beyond the electricity system. These include fuel cells, electrolysers, and hydrogen storage in tanks or (underground) pipe storage. Archetypes of hydrogen supply, use, and storage technologies are detailed to understand their technical characteristics.

The second task (jointly led by Eawag-EE and WSL-ERE) aims to **elicit consumers' preferences and social acceptance** of decarbonised energy supply systems and their flexibility options. A unique and innovative survey design will be conducted with two discrete choice experiments. The first discrete choice experiment aims at homeowners and estimates their willingness to pay for energy efficiency measures (e.g., building renovation) and clean heating technologies. The second discrete choice experiment targets tenants and estimates their willingness to accept the provision of flexibility to the energy system via load shifts and other demand response measures.

The findings from these tasks enter the **integrated energy systems analysis of the role of flexibility at building, municipality, and national scales**. Hence, a third task (led by Empa-UESL) involves high-resolution quantification of flexibility at the archetype building scale. In this task, the different flexibility options applicable to buildings are analysed and assessed in relation to increased electrification of heating and mobility, and an upscaling approach is demonstrated for a case study municipality. The well-established building energy demand model, CESAR-P, is further developed and employed for this task.

The **role of the infrastructure and consumer preferences in transforming distributed energy systems** is also analysed in the fourth task (led by ETH-ESA) of Action Area 4. Spatially detailed modelling of the transition of distributed energy systems using an archetype approach for municipalities in Switzerland is employed to analyse cost-optimal supply and flexibility configurations by considering consumers' preferences, regional characteristics in terms of consumption patterns, resource availability and access to energy infrastructure. A new tool in Switzerland has been developed for this task, which optimises archetypes of municipal energy systems based on location-specific characteristics and resource potentials.

The final task (led by PSI-LEA) is to integrate inputs from the previous tasks to **determine the role of deploying the coordinated flexibility options on the Swiss national scale**. We assess the multiple flexibility

options for the Swiss energy system in the context of the national energy and climate strategy. The well-established Swiss TIMES energy system model (STEM) is further developed towards advanced spatial and temporal representation of flexibility options using hourly resolution and geo-spatial disaggregation. These developments support enhanced scenario analyses to assess the complementarity and synergistic effects of the flexibility options in the supply and demand side of the energy system.

The analyses performed in the five tasks of this Action Area will support decision-makers with energy investments required to realise a net-zero Swiss energy system by providing:

- Technology deployment roadmaps to ensure energy supply and demand security.
- Insights on consumers' preferences, social acceptance of new technologies, and flexibility provisions from the demand side.