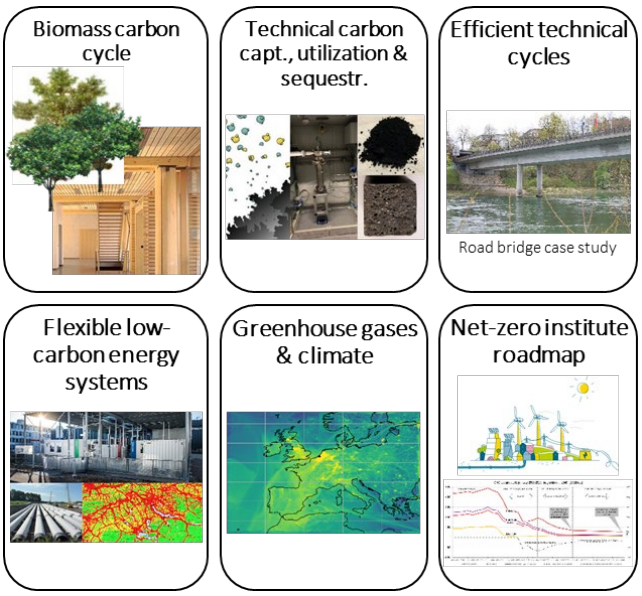
swiss center of excellence on net zero emissions
SCENE

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.

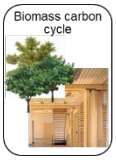
In order to support the achievement of the goal of net-zero emissions by 2050, described in the Federal Government's climate and energy strategy, SCENE performs holistic research in six Net-Zero Action Areas (Figure 1), covering the avoidance, removal, monitoring and analysis of greenhouse gas emissions.

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

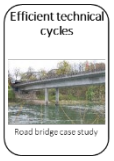


We demonstrate optimization pathways of forest and landscape management, the utilization of woody biomass, and substitution effects to mitigate climate change.

AA 2: Technical carbon capture, utilization, and sequestration

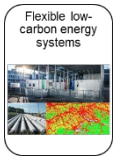
We establish a sustainable energy supply chain with negative CO_2 emissions, enabling global transport, large-scale seasonal storage, and carbon sequestration in Switzerland using existing infrastructure.

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



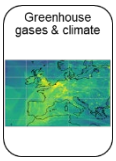
We support the decarbonization of the construction sector (30% of Swiss emissions) by providing decision-making tools and strategies, including design for disassembly and materials/component reuse, enabling carbon-neutral, circular infrastructure by 2050.

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.

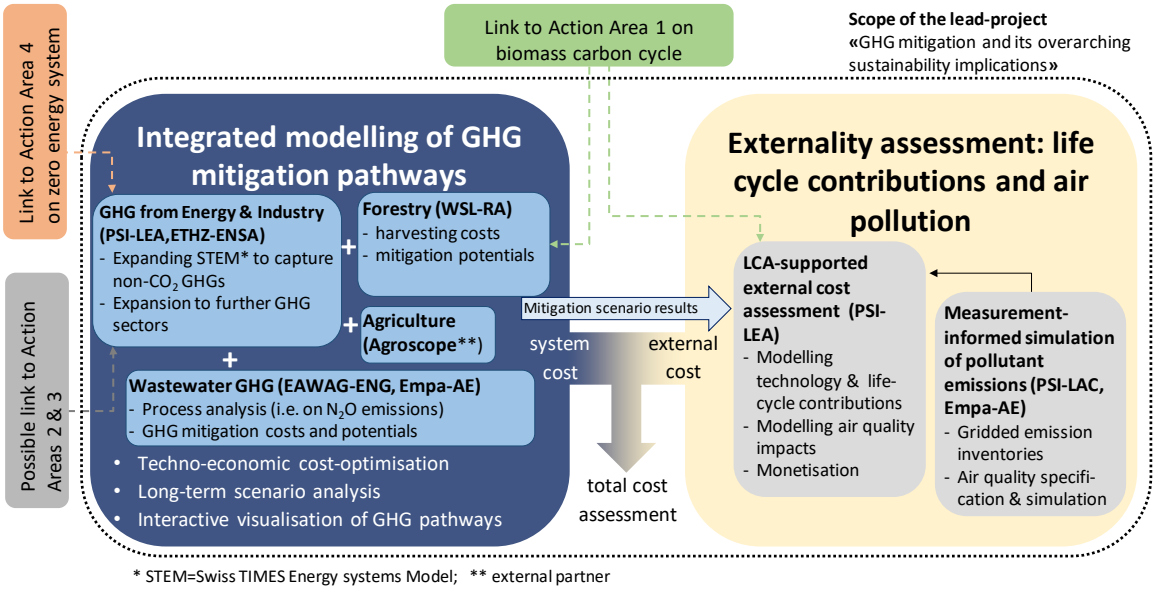
AA 6: Net-zero institute roadmap

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 5: Greenhouse gases and climate

Motivation and Main Outcomes:

Switzerland's ambition to reach net-zero requires decarbonisation and defossilisation measures to reduce greenhouse gas (GHG) emissions as much as possible in all sectors. However, difficult-to-avoid emissions in the industrial sector and agriculture need to be captured at the source and stored in suitable locations or offset using negative emissions technologies. This requires considering the interdependencies, costs, and potential for mitigation measures of the energy and industry sectors in relation to other sectors, including forestry, wastewater, and agriculture. Beyond GHG emissions, many human activities also imply other pollutant emissions that are damaging to human health and the environment. "Think globally, act locally" is a phrase often used to connect the consequences of local activities to regional or global scales or vice versa. Actions to reduce GHG emissions should also aim to reduce local air pollution to outweigh the costs of climate change mitigation and reap co-benefits associated with the climate policy. These co-benefits could have a substantial economic value for quality of life, health, the environment, and energy security.



Action Area 5 addresses the need for an integrated assessment of GHG mitigation pathways across all sectors of the economy and all relevant GHG emissions while also considering broader environmental and human impacts. It has two major pillars in which the competencies of the four Research Institutes and other collaborators are combined. The first pillar, the integrated modelling of GHG mitigation pathways, deals with a techno-economic representation of the GHG-emitting entities in Switzerland and

their systemic interdependencies and potential mitigation options. The scenario analyses inform the second pillar to assess externalities concerning air pollutants and their dispersion at high spatial resolution, and consequently the monetization using an external cost approach. The combination of the external cost assessments with the energy system cost assessment in the first pillar can estimate the total costs associated with reaching net zero in Switzerland by accounting for potential co-benefits from the air pollution reduction. Finally, to increase the impact of the research findings on society and increase citizens' awareness of GHG emissions and air pollution reduction, a hub for scientific staff, students, and external participants will be established. This hub will enable co-working, visualization and communication of the results from SCENE and other projects. It will serve as a direct channel to wider society and is aimed to be used for teaching, seminars, and group work.

Who we are:

Our team comprises experts from forest resources and management research, process engineering and wastewater management, agriculture, external costs assessment, air pollution modelling, and integrated energy systems modelling. The following institutes are contributing with their expertise:

Participating Laboratories

PSI Laboratory for Energy Systems Analysis

ETH Energy Systems Analysis

WSL Forest Resources and Management

Eawag Process Engineering and Urban Water Management

Empa Laboratory for Air Pollution/Environmental Technology

PSI Laboratory of Atmospheric Chemistry

Agroscope - Climate and Agriculture Group and Economic Modelling and Policy Analysis Group

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Activities:

This Action Area entails six main tasks. The first task (led by PSI-LEA) is **an integrated modelling of GHG mitigation pathways**. A techno-economic modelling framework using a linear optimization approach is being further developed by expanding the Swiss TIMES Energy system Model (STEM) to capture all relevant GHG emissions as well as the interdependencies of mitigation measures of the energy and industry sectors with other sectors, including forestry, wastewater and agriculture. The model development will lead to a novel and detailed comprehensive analytical tool, which will be applied for a scenario analysis encompassing several decarbonization and energy policies. It will also inform the externality assessment, allowing for an in-depth evaluation of the impact of air pollution.

The second task (led by WSL-RA) focuses on **reducing GHG emissions from forests and woody biomass**. GHG mitigation related to forests and the use of woody biomass from Action Area 1 inform the integrated modelling of GHG mitigation pathways in Action Area 5 with harvesting costs and potentials for mitigating forestry-related GHG emissions and forestry-related CO2 sinks. To the extent possible, scenarios developed in Action Area 1 will be aligned with the scenario analysis of Action Area 5.

We also **explore strategies and potentials for reducing GHG emissions from wastewater treatment**. This task is jointly led by Eawag-ENG and EMPA-AE. Recent results indicate that the potent greenhouse gas (GHG) and ozone depleting substance nitrous oxide (N_2O) dominates GHG emissions of wastewater treatment (WWT) and accounts for around 20% of N_2O emissions in Switzerland. Eawag and Empa combine the complementary expertise in WWT plant operation / process design & control at Eawag and N_2O isotope analysis / microbial process attribution at Empa in order to better understand N_2O formation in biological WWT. This task will provide an estimation of future long-term GHG emissions trajectories related to wastewaters, assess mitigation strategies, and deliver cost-potential curves for emissions reductions to be implemented in the integrated modelling framework of Action Area 5.

The fourth task (led by Agroscope) looks at **reducing GHG emissions related to the agricultural sector**. The agricultural sector contributes about 13% to the total emissions of the Swiss greenhouse gas inventory. We perform an in-depth assessment of the extent and the complexity of mitigation potentials and

costs in agriculture and explore further mitigation options in an overall policy framework that could also consider interactions between different economic sectors such as the agriculture, forestry and energy sectors. As carbon sequestration can be an option to achieve negative emissions to offset methane and nitrous oxide emissions from agriculture, this option will also be explored.

The fifth task involves **externality assessment, including life cycle contributions** (led by PSI-LEA) **and impacts of air pollution** (led by PSI-LAC and Empa-AE). The Swiss energy system demands human activities that produce local pollutants, in addition to CO_2, which are harmful to human health and the environment. An economic perspective of the energy transition should also include the externalities arising from these impacts, as well as the energy system costs. However, considering the full picture is very challenging, especially when the location of their impacts can be worldwide and, thus, to assess the consequences of local activities on a regional or global scale or vice versa. To address this, we include a technology- and life-cycle-oriented environmental impact assessment method to quantify the total costs (energy system costs plus external costs) associated with achieving net zero GHG in Switzerland, combined with a local perspective on direct emissions and associated air quality impacts.

Finally, a **model lab** (led by ETH-ESA and PSI-LEA) is being established at PSI to serve as a hub for scientific staff, students and external participants to enable co-working, visualization and communication of the results of SCENE and other projects. Thus, it represents a direct channel to wider society and aims to be used for teaching, seminars and group work. The Model Lab will pursue a student-centered approach to engage students as leaders and decision-makers in their own learning. Interactive dashboards combined with smart ICT infrastructure and furniture will create a modern, comfortable and engaging environment for working and learning activities.