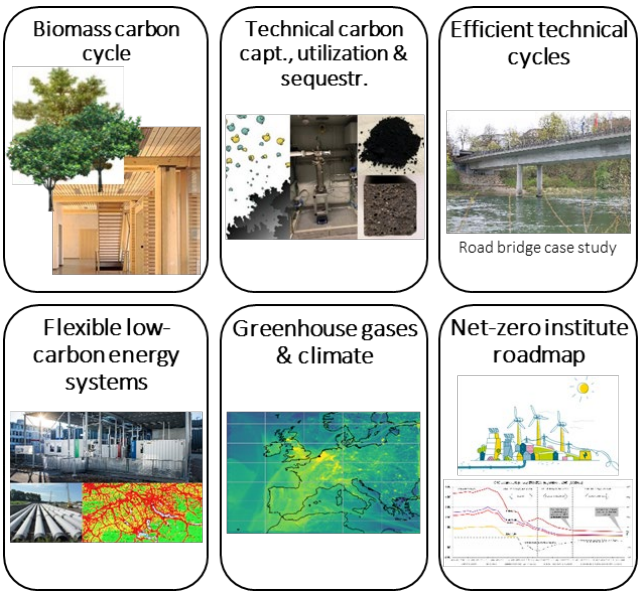
Swiss Center of Excellence on Net-Zero Emissions (SCENE)



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.

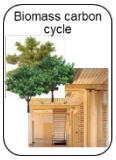
In order to support the achievement of the goal of net-zero emissions by 2050, described in the Federal Government's climate and energy strategy, SCENE performs holistic research in six Net-Zero Action Areas (Figure 1), covering the avoidance, removal, monitoring and analysis of greenhouse gas emissions.

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

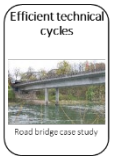


We demonstrate optimization pathways of forest and landscape management, the utilization of woody biomass, and substitution effects to mitigate climate change.

AA 2: Technical carbon capture, utilization, and sequestration

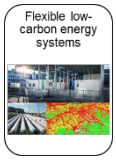
We establish a sustainable energy supply chain with negative CO_2 emissions, enabling global transport, large-scale seasonal storage, and carbon sequestration in Switzerland using existing infrastructure.

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



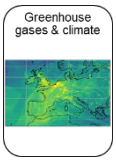
We support the decarbonization of the construction sector (30% of Swiss emissions) by providing decision-making tools and strategies, including design for disassembly and materials/component reuse, enabling carbon-neutral, circular infrastructure by 2050.

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.

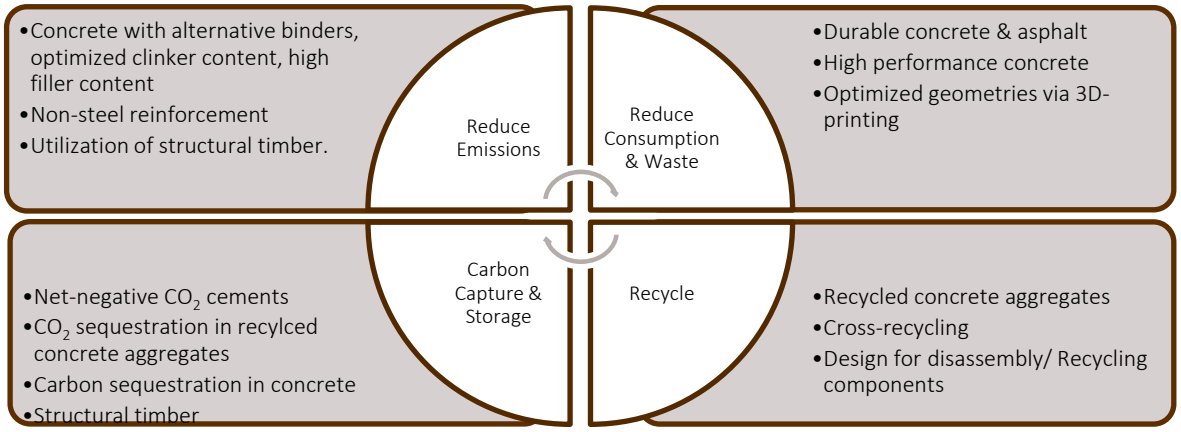
AA 6: Net-zero institute roadmap

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 3: Efficient Technical Cycles

Motivation and Main Outcomes:

The construction sector in Switzerland contributes about 30% to the CO_2 emissions. Efforts to achieve circular, net-zero goals in this sector, where CO_2-heavy and high-volume materials such as concrete, steel and asphalt are of common use, are in the early stages and require an integrated, multidisciplinary approach. SCENE's net-zero bridge case study investigates ways to reduce CO_2-emitting materials, optimize material use, and promote sustainability through advanced manufacturing, digital fabrication, and recycling. These goals include using net-zero / net-negative concrete mixtures or sustainable timber-based materials, optimizing component geometries, implementing design for disassembly, and reusing materials from old structures for new projects.



The proposed net-zero bridge designs will need to comply with all valid guidelines regarding structural and operational limit states, safety, durability, and robustness. These requirements are defined in guidelines and standards published by the Federal Road Authority (ASTRA), the Swiss Society of Engineers and Architects (SIA), and the civil engineering offices (Tiefbauämter) of the cantons. Key actors, stakeholders, decision makers leverage points, and potential transition pathways in the construction sector will be identified.

Our study aims to yield insights applicable to the broader construction sector in Switzerland, offering recommendations for a sustainable circular economy to achieve the net-zero goals by 2050.

Who we are:

Our team is comprised of researchers with various backgrounds and expertise, including material scientists, structural engineers, forestry specialists, life cycle assessment experts, and social scientists. The following institutes are contributing with their expertise:

Participating Laboratories

Empa Structural Engineering Research Lab

Empa Concrete & Asphalt Lab

Empa Technology & Society Lab

WSL Resource Analysis Lab

WSL Forest Resources & Management Lab

Eawag Policy Analysis & Environmental Governance Lab

PSI Laboratory for Waste Management

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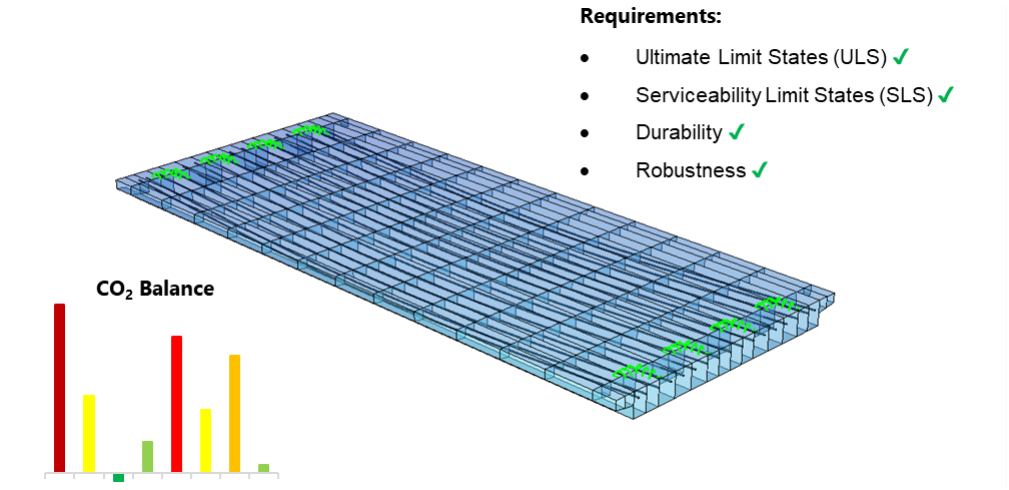
Activities:

We are focusing on road bridges in Switzerland, which are built less frequently than buildings, but are subject to much higher loads and stricter material requirements. Such an investigation allows us to study many more materials compared to a building construction. We aim to demonstrate that solutions developed for such demanding structures can be easily adapted to more common building construction, where requirements on the load-bearing structure are less stringent.

We plan to design a hypothetical road bridge (Figure 4), suitable for common conditions within the Swiss infrastructure network, i.e. a two-lane bridge deck, 1-2 spans, with a total bridge length ranging between 10-80 m. In order to focus on the structural aspects, we assume that the hypothetical bridge complies with the forest, nature and cultural heritage protection, and water protection codes. The bridge will be situated along a main street route axis, with a moderate-to-high traffic volume, low-to-medium seismicity, and in a non-flooding region. The increased air temperature due to climate change will also be considered.



Structural bridge components are mainly divided into two categories: the superstructure (bridge deck, expansion joints etc.) and the substructure (piers, abutments, foundations, retaining walls). Technical bridge components, such as the wearing surface, sealing membrane, drainage, guard rails etc., may not carry a static function, but are essential for a safe and efficient operation of the structure. While the CO_2 balance of a bridge encompasses both structural and non-structural components, the main focus of the work in SCENE AA 3 is on developing solutions for a net-zero emissions load-bearing structure.