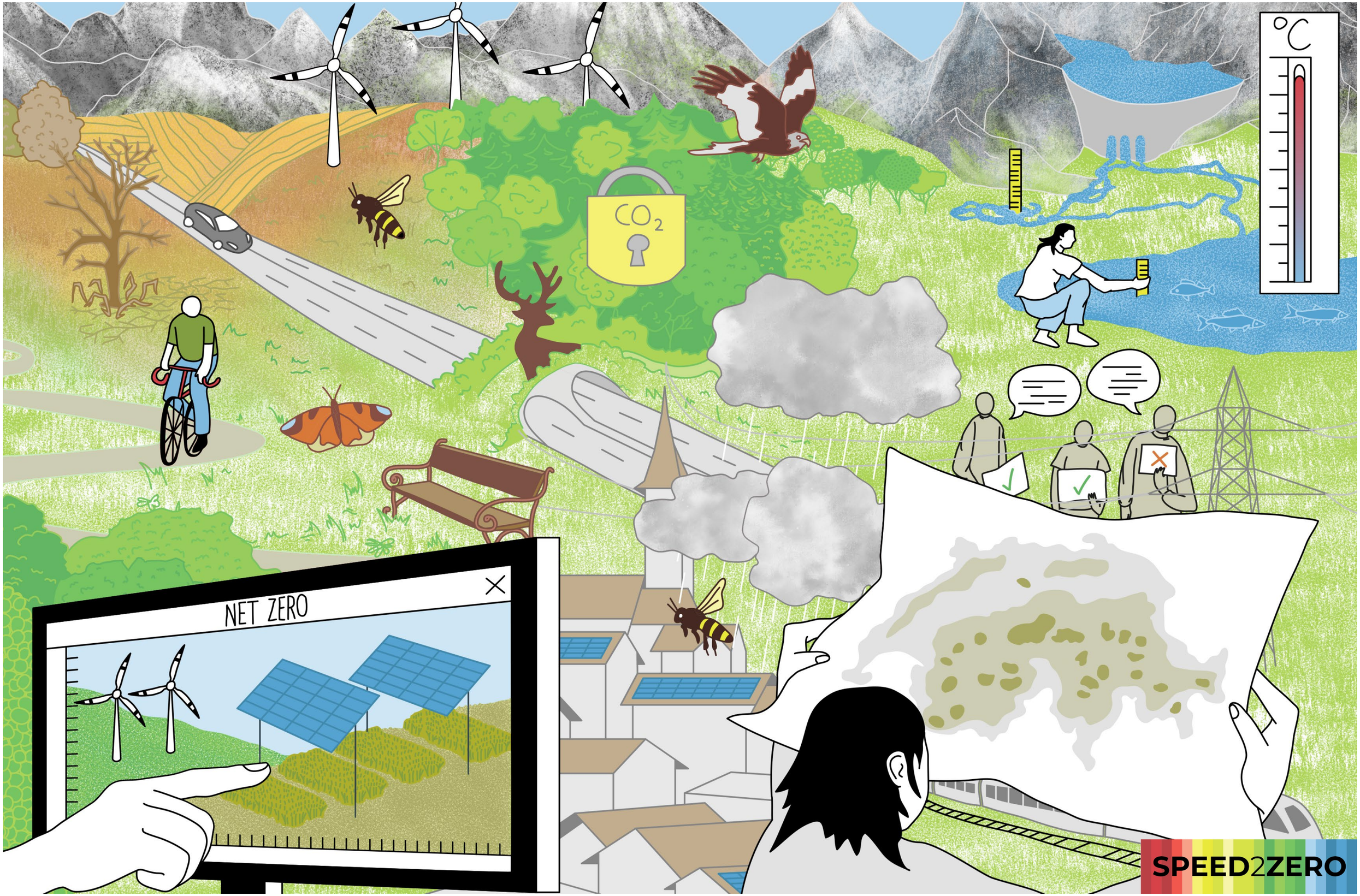
SPEED2ZERO Summary

The intersection of climate, energy and biodiversity



Introduction

The current challenges of climate change, biodiversity loss and energy security are closely interlinked. Interdisciplinary knowledge is essential for developing robust and feasible solutions to these systemic challenges.

SPEED2ZERO's work therefore focused on the intersections of climate, biodiversity and energy: How does climate change affect biodiversity and the energy system? How can biodiversity conservation and the expansion of renewable energies be harmonised? And how can effective and socially accepted policies support the transition to net-zero emissions?

This summary concludes the three-year interdisciplinary research within SPEED2ZERO. Drawing on many of the scientific findings generated within the programme, this report synthesises key insights and formulates evidence-based recommendations to support informed decision-making towards a net-zero greenhouse gas (GHG) and biodiversity-positive Switzerland.

Our main findings are structured around five guiding questions that help to navigate the different research strands. The topics addressed are among the most complex and pressing of our time; hence, the insights should not be seen as final answers, but as a selection of building blocks within a broader set of measures needed to drive transformative change[1].

1 As this publication is not a scientific paper but a selective summary of findings relevant to societal stakeholders beyond academia, we present selected insights and refer to the specific SPEED2ZERO research that informed them. The list is not exhaustive. Detailed citations and preliminary research findings are documented in the corresponding scientific publications (studies).

Switzerland: status and goals

Climate Change is happening and its impacts are getting stronger. Switzerland has already warmed by 2.9 degrees Celsius and is disproportionately affected by global warming (global average: 1.4 degrees Celsius) (1). Whether climate change continues or whether it can be limited depends on our future global greenhouse gas (GHG) emissions. Switzerland's climate strategy has two milestones: a 50% reduction in GHG emissions by 2030 and net-zero emissions by 2050. The 2030 target is a crucial contribution to stabilising global warming close to 1.5°C (2). Switzerland has the technological and financial resources to achieve its targets. However, like many other countries, it is currently not on track to do so (3).

Switzerland is in the midst of the decarbonisation of its **energy system**. Domestic electricity generation in Switzerland has been almost completely decarbonised for many decades, but the rest of the energy system, especially heating and transport, still relies heavily on fossil fuels (4). The switch from fossil fuels to low-carbon electricity and the growing population will significantly increase electricity demand in Switzerland by 2050 (5, 6). The Swiss Energy Strategy 2050 plans to meet this increase in demand with renewable energy sources such as photovoltaics, hydropower, wind power and other energy sources that can be switched on according to demand (7).

Biodiversity is under severe pressure in Switzerland. Global biodiversity declined by 73% between 1970 and 2020 (8). Drivers include deforestation and land-use change, direct exploitation of natural resources, pollution, climate change and the spread of invasive species (9). In addition, nearly half of all habitats are endangered in Switzerland, especially open and aquatic ecosystems on the Swiss Plateau. One third of all species are threatened with extinction, critically endangered or vulnerable, many of them dependent on specific habitats. Losses are mainly caused by intensive land use, nitrogen and pesticide inputs, land conversion (e.g. drainage of wetlands), soil sealing, fragmentation, and increasingly climate change. Urgent action is needed to preserve biodiversity and the ecosystem services it provides, while resilient ecosystems also help to mitigate climate change and its impacts. Currently, only 13.4% of Switzerland's area is protected (10, 11). Switzerland has set a national target of protecting 17% of its territory in terms of biodiversity (12), which is well below the international UN target of 30% (13).

Switzerland is addressing these (global) challenges. We have strategies, progress has been achieved, and yet so far, we are not on track to reach the goals. SPEED2ZERO is intended to help close this interconnected implementation gap.

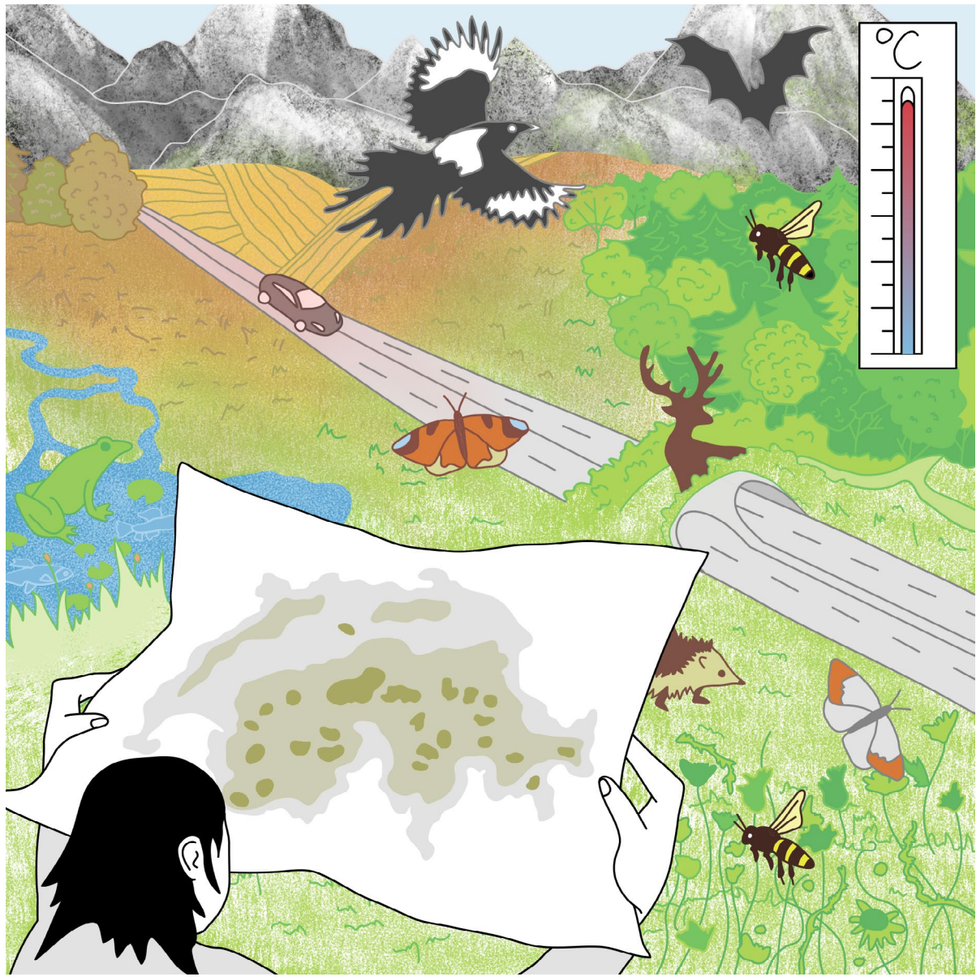
SPEED2ZERO

About SPEED2ZERO
SPEED2ZERO is a Joint Initiative of Switzerland's leading institutions in environmental research and applications. The consortium has members from ETH Zürich, WSL, EPFL, Eawag, PSI and Empa, and is supported by the ETH Board. It was created to provide scientific insights, scenarios and tools to support Switzerland in moving towards net-zero emissions, providing a resilient energy infrastructure while allowing for the country's biodiversity to regain some of its richness. It does so through continuous dialogue with stakeholders, connecting research with policymakers and practice to provide evidence-based findings that help with handling some of the underlying trade-offs.

References:

1 MeteoSwiss, & ETH Zürich, Klima CH2025 – Klimazukunft Schweiz. Bundesamt für Meteorologie und Klimatologie MeteoSchweiz, Zürich, 24 S. (2025). https://doi.org/10.18751/climate/scenarios/ch2025/brochure/1.0/de
2 Federal Office of the Environment FOEN, Long-term climate strategy to 2050 (2021).
3 Climate Action Tracker. https://climateactiontracker.org/countries/switzerland/ (last accessed 3 September 2026)
4 Swiss Federal Office of Energy, Overall energy statistics (2024).
5 Swiss Federal Office of Energy, Energy Strategy 2050 - Monitoring Report 2025 (2025).
6 Marcucci, A. et al., CROSS Scenarios and Drivers Definition. Scenario version: CROSS-v2022-09. (2022).
7 Swiss Federal Office of Energy, Energy Perspectives 2050+ (2020).
8 WWF & ZSL. The Living Planet Index database. Living Planet Index (2024). https://www.livingplanetindex.org/ (last accessed 3 September 2026)
9 Keck, F. et al., The global human impact on biodiversity. Nature 641: 395–400 (2025).
10 Federal Office for the Environment, Zustand der Biodiversität in der Schweiz UZ-2306-D (2023).
11 Forum Biodiversität. Biodiversität in der Schweiz verstehen und gestalten. SCNAT/Swiss Academies Reports: 21 (2026). http://biodiversitaet2026.ch/
12 Fedlex, Bundesgesetz über den Natur- und Heimatschutz (NHG) (2022); https://www.newsd.admin.ch/newsd/message/attachments/70478.pdf.
13 Convention on Biological Diversity (CBD). Kunming-Montreal Global Biodiversity Framework. Decision 15/4, adopted at the fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP15), Montreal, 18 December 2022.

❶ Which areas in Switzerland should be prioritised for biodiversity conservation in a warming climate?



Biodiversity loss undermines human health and the sustainable use of natural resources. The existing pressure on biodiversity is increased by climate and land-use change. This threatens essential ecosystem functions, such as climate change mitigation. Biodiverse ecosystems remove 31% of global man-made CO_2 emissions every year. If we protect biodiversity, we also protect our climate, and vice versa.

Switzerland is strongly affected by climate change and its biodiversity is under severe pressure: almost 50% of habitat types and one third of all species are considered endangered. It is therefore essential to understand which areas in Switzerland are especially important for strengthening the resilience of ecosystems and enabling migration as a natural part of species' life cycles and as a reaction to climate change. SPEED2ZERO focused on assessing biodiversity risks, resilience to climate change and combined pressures and developed a system of informed prioritisation for biodiversity conservation.

Identifying aspects that will help biodiversity to become more resilient to growing pressure from climate change

Insights and selected findings:

Biodiversity is not evenly distributed across the landscape, and therefore, a sound pathway avoiding the greatest negative impacts on biodiversity does not simply mean protecting the most biodiverse locations. It requires careful optimisation procedures based on a few principles:

- **Sufficient area:** Biodiversity requires networks of intact and sufficiently large patches of similar habitat. Some of these areas should be solely protected for the purpose of biodiversity, while others can still be used for other purposes, but with some constraints.
- **Connectivity:** The better we connect habitats and preserve biodiversity at all levels (from genes to species to population to habitats), the more resilient ecosystems will be to heat, drought and diseases (1).
- **Complementarity:** Areas should be protected to include all species, and thereby complement each other, including rivers, riparian zones, wetlands, alpine areas and extensively used areas in urban and agricultural zones (1, 2, 3).
- **Anticipating change:** Biodiversity conservation should account for projected changes in species distributions and habitat suitability under climate change (4).

Recommended action:

- Protect and connect intact habitats to strengthen ecosystem resilience, safeguard biodiversity and maintain essential ecosystem services, including natural climate change mitigation.
- Strengthen the public's and policymakers' awareness of biodiversity's ecological and societal value and its links with climate change to enable coordinated action on both crises.
- Considering future biodiversity patterns alongside current ones can help to build more resilient conservation networks.

Studies:

1 Adde, A. et al., Projecting untruncated climate change effects on species' climate suitability: insights from an alpine country. Global Change Biology 30: e17557 (2024).

2 Brunner, C. et al., Gekoppelte Herausforderungen für die Schweiz: Schnittstellen im Klimaschutz, Biodiversitätsschutz, Energiesicherheit und Landschaftsschutz, ETH Zürich, white paper (2024); doi: 10.3929/ethz-b-000673411.

3 Cadelli, E. et al., Warum Biodiversität wichtig ist und welche Rolle sie bei der Klimaregulierung spielt, ETH Zürich, white paper (2024); doi: 10.3929/ethz-b-000692462.

4 Adde, A. et al., Spatial biodiversity indicators and a composite index for conservation prioritization in Switzerland (2025). bioRxiv: 2025.06.10.657334.

Prioritisation and mapping as a basis for effective biodiversity conservation in a warming climate

Insights and selected findings:

Biodiversity is multidimensional. Understanding and protecting it requires several mutually reinforcing indicators that help to guide conservation choices.

Within SPEED2ZERO, we mapped 7,500 species to assess how landscapes support terrestrial and aquatic biodiversity today and in the future (5). We then built extinction risk, connectivity and complementarity indicators and combined them into a single composite index that represents landscape support for biodiversity across Switzerland (SDMapCH; 6).

Using such spatial indicators in energy infrastructure planning can help to mitigate impacts on biodiversity and support decisions that protect ecosystems under increasing pressure.

Recommended action:

- Integrate biodiversity data and multidimensional ecological indices systematically into spatial and infrastructure planning to ensure that conservation priorities are aligned with energy and land-use developments.

Tools:

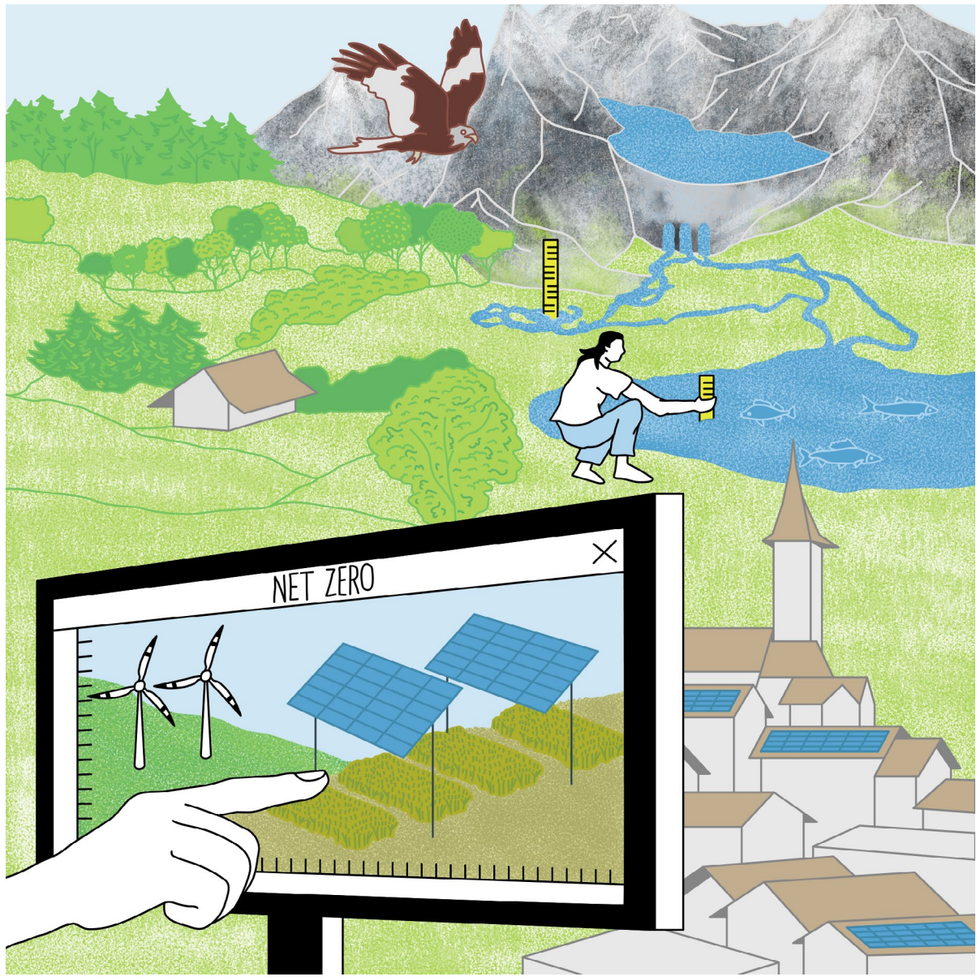
The SDMapCH database was integrated into the Swiss SolarWind Explorer web tool to support biodiversity-sensitive renewable energy planning.

Studies:

5 Adde, A. et al., SDMapCH: a comprehensive database of >7,500 modelled species habitat suitability maps for Switzerland, Sci Data 12, 1752 (2025); doi: 10.1038/s41597-025-06037-x.

6 Adde, A. et al., Spatial biodiversity indicators and a composite index for conservation prioritization in Switzerland (2025). doi: 10.1101/2025.06.10.657334.

❷ How can renewable energy be expanded while protecting landscape and preserving biodiversity?



The transition to net-zero emissions requires the expansion of low-carbon electricity generation, which undoubtedly affects landscape and biodiversity. On the other hand, if climate change remains unaddressed, it will become a major driver of biodiversity loss and landscape changes.

Switzerland's densely populated terrain, scarce land for biodiversity and direct democracy mean that siting new energy infrastructure requires careful weighing of competing criteria to enable a timely and broadly supported transition.

SPEED2ZERO focused on combining the different demands of land use from power generation as well as landscape and biodiversity protection to offer a holistic view and enable information-based decisions and compromises.

Low-conflict planning of new solar and wind energy infrastructure

Insights and selected findings:

While the Swiss climate and energy policy mandate the expansion of solar and wind energy in Switzerland, a nationwide mapping of suitable areas and constraints is lacking.

The web tool Swiss SolarWind Explorer provides harmonised maps of key criteria, such as energy potential, grid connection, accessibility, importance for biodiversity, landscape quality, conflicting land uses and legal restrictions. The mapping, as well as in-depth analysis using the energy system modeling platform Nexus-e, have shown that even with comprehensive protection of biodiversity and landscape (30% most valuable areas), there are still sufficient suitable locations to reach the envisaged renewable energy capacities in Switzerland. Consequently, expansion of renewable energies while conserving biodiversity and landscapes is feasible, when planned systematically and with an interdisciplinary perspective (1).

Concerning the role of public acceptance in the expansion of renewable energy, there were further research findings that could help to generate support for new projects:

- The expansion of photovoltaic capacity on existing infrastructure still offers significant potential, with low investment risk, minimal to no adverse effect on biodiversity and high public acceptance (2).
- In general, large free-field renewable energy projects risk less local opposition when sited away from natural, unique or recreation-oriented pristine landscapes (3).
- Agrivoltaics (Agri-PV) is a dual land-use technology that combines solar power generation with agricultural production and holds the potential to reduce local opposition to land-based solar energy. Agri-PV projects gain broad bipartisan support when they are well integrated into agricultural landscapes, do not interfere with crop yields, and involve local ownership with transparent benefit-sharing (4).

Recommended action:

- Use integrated spatial planning and tools like the Swiss SolarWind Explorer to identify optimal areas for solar and wind energy, balancing energy potential with environmental and social considerations.
- Explore well-integrated, participatory projects as a socially accepted pathway for expanding solar and wind energy.

Tools:

https://swiss-solarwind-explorer.ethz.ch | The first applications by spatial planning authorities in cantons have demonstrated this tool's utility for performing a comprehensive screening and assessment of available areas. The tool and the interdisciplinary dialogue with stakeholders will be further developed and maintained by PLUS – Planning of Landscape and Urban Systems at ETH Zürich.

Studies:

1 Reusser, M. et al., Swiss SolarWind Explorer (2.0) (2025). Zenodo; doi: 10.5281/zenodo.17962422.
2 Brunner, C. et al., Gekoppelte Herausforderungen für die Schweiz: Schnittstellen im Klimaschutz, Biodiversitätsschutz, Energiesicherheit und Landschaftsschutz (ETH Zurich, white paper, 2024); doi: 10.3929/ethz-b-000673411.
3 Früh, J. et al., RE-Acceptance map (in review).
4 Fesenfeld, L. et al., Agrivoltaics can reduce political polarization and local opposition to solar energy on land (2026). Zenodo; doi: 10.5281/zenodo.18166238.

Biodiversity-friendly adaptation of hydropower production

Insights and selected findings:

Hydropower is a low-carbon energy source. However, of all the renewable energy sources, it has the greatest adverse effect on biodiversity because its operation often leaves only a small amount of water in rivers, known as the environmental flow (e-flow). The impact of e-flow requirements on decrease in hydropower production has been repeatedly overestimated. At the same time, e-flows represent a minimum for survival for river ecosystems – a standard that is still unmet in many river sections (4).

The lack of publicly available data has hindered evidence-based decision-making on balancing energy production, water quality and biodiversity conservation. The newly developed e-flow database ("Restwasser-Datenbank") helps to close this gap by providing open-access data – an important contribution at a time when climate change is reshaping water availability and numerous water usage concession renewals are approaching. Recent modelling indicates that hydropower production and environmental protection through environmental flow requirements are more compatible than previously assumed (5).

Recommended action:

- Design water use rights that enable more sustainable water resource management under changing conditions and put a higher focus on biodiversity protection and application of the Swiss Waters Protection Act (WPA), while maintaining financial planning security for hydropower operators.

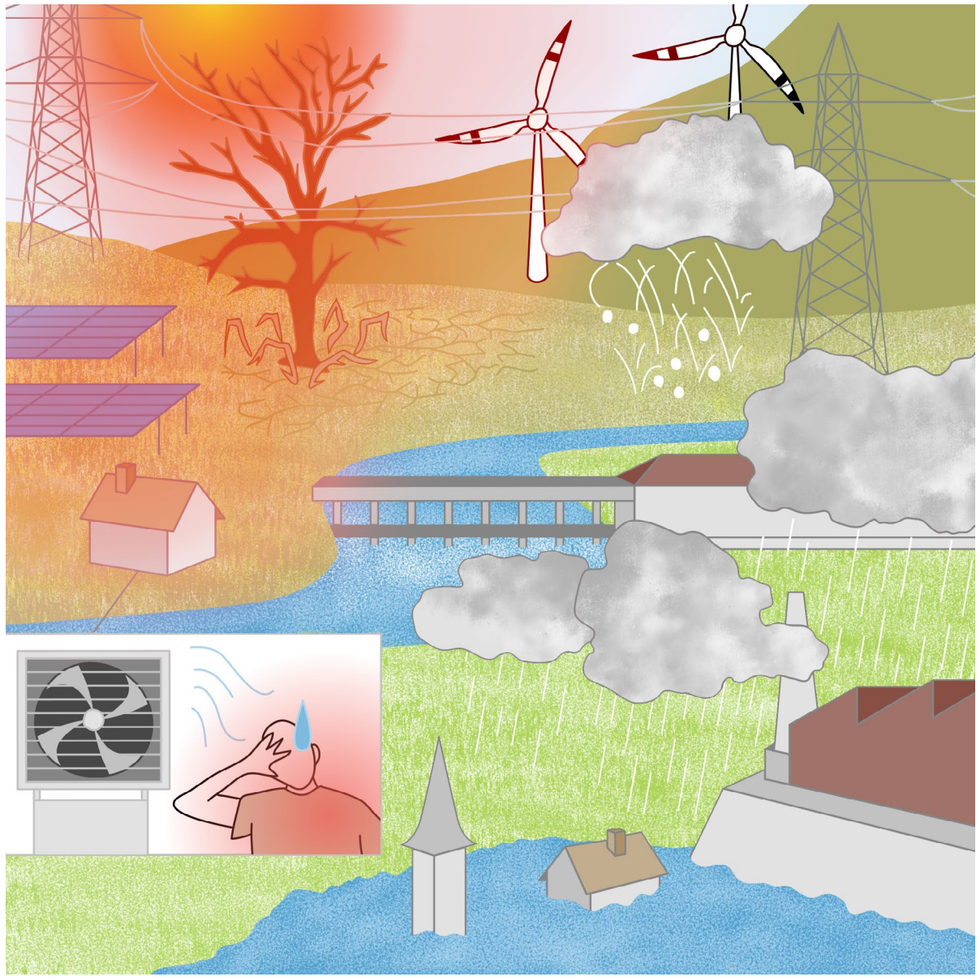
Tools:

E-flow database ("Restwasser-Datenbank") https://www.envidat.ch/#/metadata/restwasser-datenbank
The tool will be further developed and maintained by WSL.

Studies:

5 Wechsler, T. et al., Restwasser. Die Suche nach der angemessenen Menge - Festlegung, Wirkung und Anforderungen, Aqua Gas (2025).
6 Wechsler, T. et al., Restwasser-Datenbank: eine schweizweite Datengrundlage zu festgelegten Dotierwassermengen bei Ausleitkraftwerken (≥ 3 MW).WSL. 25 S (2025). https://www.dora.lib4ri.ch/wsl/islandora/object/wsl%3A42014/datastream/PDF/Wechsler-2025-Restwasser-Datenbank-%28published_version%29.pdf.

❸ What risks do climate change and extreme weather pose to the energy system and the economy?



The occurrence of extreme weather events and climate variability is increasing, and their impacts on energy systems and the economy are already evident. Rising temperatures and shifting precipitation patterns affect water availability, directly influencing energy production, while disruptions to supply chains and economic activities are expected to intensify as climate change progresses.

In Switzerland, hydropower – currently our most important domestic energy source – is highly dependent on climatic conditions. Anticipating and adapting the energy system to these evolving conditions is therefore crucial for ensuring long-term resilience.

Within this context, SPEED2ZERO focused on modelling future climate impacts and identifying the associated risks to both the energy system and the economy.

How to maintain energy system reliability under increasing climate impacts?

Insights and selected findings:

The expansion of renewable and sustainable energy sources such as photovoltaics and wind increases the energy system's sensitivity to weather and climate, while the electrification of heating and transportation further intensifies demand fluctuations (1, 2).

Climate change and variability alter electricity generation – for example, through changes in water availability. In general, higher inflows are expected in winter and lower inflows in summer, potentially leading to an increase in overall hydropower production in the near future. In the long term, however, production is expected to decline, as winter generation will stagnate and summer generation will continue to decrease. In addition, changes in precipitation patterns and earlier snowmelt will shift peak water availability to earlier in the year. Trends in measurements already show this shift (1, 3).

Climate change also affects energy demand. It is expected to reduce overall heating demand by 10–50% while cooling demand will increase, proving that energy systems are highly responsive to climatic conditions, particularly on the demand side. These effects can undermine system reliability. The vulnerability or resilience of an energy system to climate change largely depends on its design (3, 4).

To maintain a resilient, affordable and secure electricity system, climate risks must be systematically incorporated into planning strategies, infrastructure projects and technology deployment. Relevant risks include extreme snowfall at high altitudes, landslides due to permafrost thawing or extreme precipitation, and heat stress on transmission lines and transformers (4).

Recommended action:

- Systematically incorporate climate risks and variability into energy system design and develop robust long-term strategies that enhance system flexibility and resilience.

Studies:

1 Haddad Y. Y. et al., Aerosols-aware regional projections of climate-impacted renewable energy generation and energy demand in Europe (in preparation).

2 Bloin-Wibe, L. et al., Climate change impacts on net load under technological uncertainty in European power systems, Environ. Res. Lett. 21 084004 (2026); doi: 10.1088/1748-9326/ae5727.

3 Haddad Y. Y. et al., Recent climate impacts on run-of-river hydropower and electricity systems planning in Switzerland, Environ. Res. Lett. 20 084020 (2025); doi: 10.3929/ethz-b-000744273.

4 De Marco F. et al., Climate-resilient energy systems planning via system-informed identification of stressful events, Adv. Appl. Energy, vol. 19, p. 100235 (2025); doi: 10.1016/j.adapen.2025.100235.

Improving reliable, local-scale climate predictions in the face of weather extremes

Insights and selected findings:

How often will heatwaves or heavy rainfall with potential for flooding hit Zurich in 2050? Answering such questions requires localised climate predictions that global climate models can only provide at a high computational cost. Combining data-driven approaches with physics-based simulations offers an efficient alternative (5, 6, 7, 8).

Recommended action:

- Invest in hybrid climate modelling approaches that combine physics-based simulations with data-driven methods for future Swiss scenarios.
- Include local-scale risk assessment as a basis for adaptation measures.

Studies:

5 Zilker, F. & Karger, D. N., CHELSAch-highres-climatologies at high resolution. EnviDat (2025); doi: 10.16904/envidat.689.

6 Effenberger, N. & Knutti, R., Uncertainty in wind and solar projections depends on global and regional climate models, arXiv: 2603.20052v1 [physics.ao-ph] (preprint); doi: 10.48550/arXiv.2603.20052.

7 Schillinger, M. et al., En-Scale: Temporally-consistent multivariate generative downscaling via proper scoring rules (in press).

8 Effenberger, N. et al., Bridging CORDEX and CMIP6: Machine learning downscaling for wind and solar energy droughts in Central Europe (in review).

How can Swiss society build resilience to climate risks?

Insights and selected findings:

Even with efforts to reduce emissions, some changes are unavoidable, so adaptation reduces vulnerability and builds resilience to protect people, infrastructure and ecosystems. Early adaptation cuts costs by preventing greater damage in future and helps to ensure sustainable development in a changing climate (9). However, adaptation can never replace the reduction of emissions, which also results in lower costs overall.

Climate impacts abroad pose a significant economic threat to Switzerland, primarily through disrupted supply chains. Industries like manufacturing, pharmaceuticals and finance face the highest absolute losses, with Germany, France and China being critical risk sources due to their economic ties and climate vulnerabilities (e.g. river flooding, tropical cyclones).

The security of supply for certain sectors such as food, pharmaceuticals and critical raw materials (CRMs) is jeopardised by international climate hazards. Switzerland's heavy reliance on imports and concentrated global production (e.g. in Asia for pharmaceuticals and CRMs) makes it susceptible to climate-driven shortages and price volatility.

Indirect climate impacts from abroad are likely to deepen social inequalities within Switzerland. Rising costs for essentials and potential job insecurity from supply disruptions may disproportionately affect lower-income households, which in addition are often more exposed to domestic climate risks (10).

Recommended action:

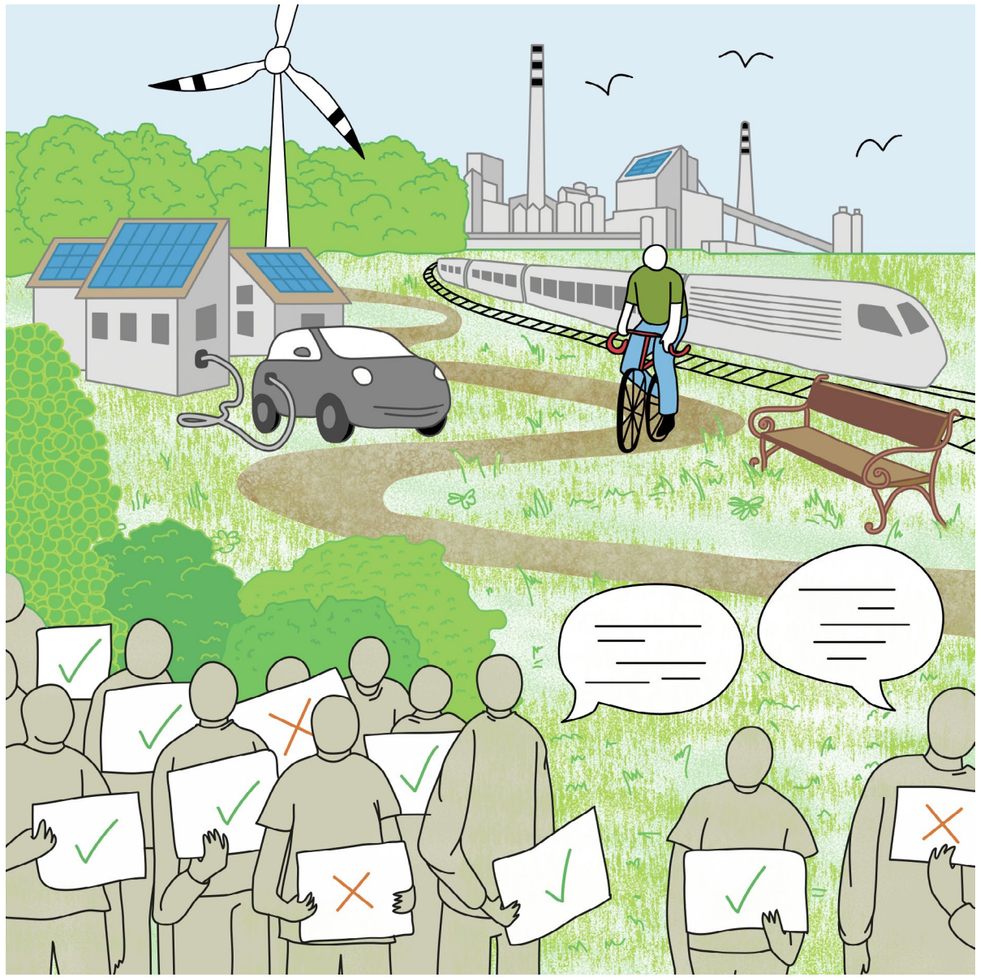
- Develop and implement national and corporate strategies that diversify supply chains, strengthen climate risk assessment and embed climate considerations into security and social policies.

Studies:

9 MeteoSwiss & ETH Zurich. Climate CH2025 - Scientific Report. Federal Office of Meteorology and Climatology MeteoSwiss, Zurich (2025); doi: 10.18751/climate/scenarios/ch2025/sr/1.0/.

10 Juhel, S., NCCS Global impacts of climate change on Switzerland Data Collection (2025); doi: 10.3929/ethz-c-000785985.

❹ Which factors improve public acceptance of net-zero policies?



In democratic societies, public acceptance is one of the central challenges to defining and implementing effective regulations for climate change mitigation. Policies that are poorly designed or perceived as unfair are unlikely to gain majority support, regardless of their long-term benefits.

Understanding which factors shape public attitudes – and which societal co-benefits of reaching net zero could help to build broader support – is therefore essential for designing policies that are both effective and socially legitimate.

Given the breadth of this topic, SPEED2ZERO focused its research on selected policy areas to identify relevant drivers of acceptance and economic opportunities as a key co-benefit that is appreciated across different political and societal positions.

The role of fairness in net-zero policy support

Insights and selected findings:

Social fairness is not a uniform concept. Different people have fundamentally different ideas about what constitutes a fair distribution of costs and benefits. Understanding this heterogeneity is crucial to designing climate policies that can actually win public support.

A representative survey of Swiss residents revealed the following preferences (1):

- Nine out of ten people show distribution-sensitive justice orientation. Therefore, policies that focus solely on market mechanisms without addressing inequalities are consistently rejected.
- Low stringency does not lead to higher policy support. When given the choice between different levels of strictness, the majority of the Swiss public accepts some stringency in regulatory climate policy – but only if the policy packages are perceived as fair.
- Exemptions for low-income households are an effective tool. They can substantially increase public support for controversial policies, such as bans on fossil fuels or carbon taxes, without undermining the stringency of the measures.

Recommended action:

- Focus on regulatory and redistributive climate policies that combine strict standards with mechanisms to protect particularly vulnerable groups in order to ensure broad public support.

Studies:

1 Joon, K. et al., Climate justice orientation is linked to preferences for decarbonisation policy design, Communications Earth & Environment (2026); doi: 10.1038/s43247-026-03255-y.

Public preferences for specific net-zero measures in Switzerland

Insights and selected findings:

- **Dynamic electricity tariffs:** For dynamic electricity tariffs to be implemented on a wide-scale, electricity utilities need a clearer legal framework with more regulatory flexibility and households need low-risk and high-reward options (2, 3).
- **Aviation policy:** Swiss people prefer to pay more than fly less. A general or frequent flyer fee is perceived as an acceptable way to cover the additional costs of using sustainable aviation fuels to reduce aviation emissions (4).
- **BEV mileage taxes:** BEV mileage taxes are most accepted when they are linked to vehicle weight and power. However, as BEV adoption increases, growing resistance among BEV owners could reduce overall acceptance. People perceived GPS-based mileage tracking as provoking significant privacy concerns (5).
- **Carbon storage:** Swiss people prefer storing domestic CO_2 within the country over sending it abroad, provided that the polluting industry bears the associated costs (6).

Studies:

2 Luther, A. et al., Determine realistic hedged dynamic electricity tariffs for utilities (in preparation); preregistration doi: 10.17605/OSF.IO/T2KNB.

3 Luther, A., et al., Determine realistic hedged dynamic electricity tariffs for households (in preparation); preregistration doi: 10.17605/OSF.IO/J2G3R.

4 Joon, K. et al., People would rather pay more than fly less: implications for aviation decarbonisation (in review); doi: 10.21203/rs.3.rs-10239437/v1.

5 Levis, A. et al., Compensating losses in fossil fuel tax revenues: First evidence of public support for a BEV mileage tax, Transport Policy (2025); doi: 10.1016/j.tranpol.2025.05.007.

6 Joon, K. et al., Where to store CO_2? Perspectives from Switzerland and China on CCS location preferences (in preparation); preregistration doi: 10.17605/OSF.IO/AR85C.

Economic opportunities as an argument supporting the transition

Insights and selected findings:

Next to having a positive impact on human and planetary health and limiting the costs associated with climate change, the net-zero transition also offers tangible opportunities for the local economy, provided that it has the skilled workforce needed.

Active participation in clean energy supply chains creates job opportunities. Developing regional manufacturing capacity for solar photovoltaics, batteries and heat pumps can generate jobs and strengthen self-sufficiency in Switzerland and Europe.

International cooperation keeps technologies affordable and deployable at scale. Open trade and global collaboration lower costs, speed up deployment and support workforce growth, while overly restrictive measures risk slowing the transition (7).

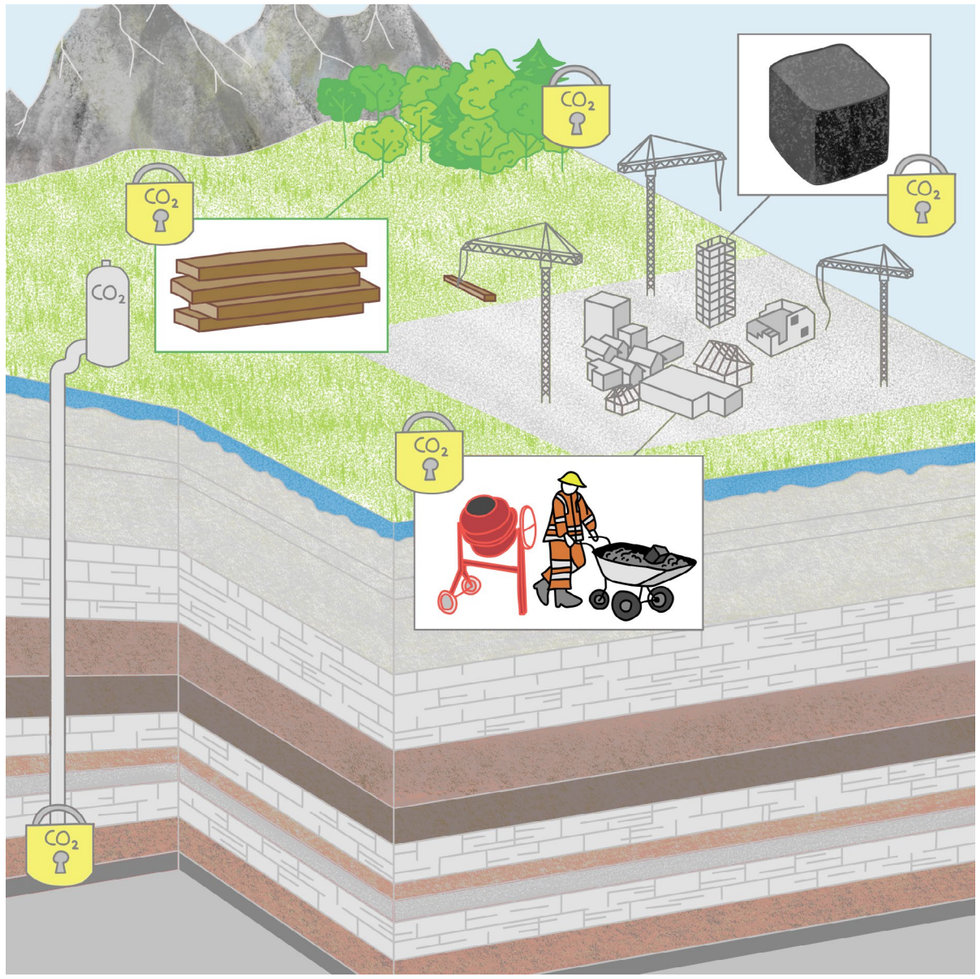
Recommended action:

- Invest in regional clean energy manufacturing and actively engage in international supply chains to create jobs, strengthen self-sufficiency and promote affordable technologies.
- Provide, together with companies, the skills and technology training needed to build up a sufficient local workforce.
- Increase awareness among the public and decision-makers of the tangible economic co-benefits of the net-zero transition.

Studies:

7 Cui, C. et al., Policy-driven transformation of global solar PV supply chains and resulting impacts, Nature Communications (2025); doi: 10.1038/s41467-025-61979-5.

❺ What role do different carbon storage innovations play in achieving net-zero emissions in construction?



Turning the construction sector from one of the largest Swiss GHG emitters and energy consumers into a carbon-neutral sector, or even a net carbon sink, requires solutions that replace GHG-intensive building materials with materials that ideally durably store more atmospheric CO_2 in new buildings and renovations than their production emits. SPEED2ZERO focused on testing materials innovations based on biomass and concrete and demonstrating them in a pilot building.

While it is important to substitute cement and steel in construction, along with using them more efficiently, both building materials will have a place in a net-zero society. Carbon capture and storage is one of the major options for substantially reducing the remaining emissions of cement production. For this, the captured CO_2 needs to be stored durably. Therefore, SPEED2ZERO also included a project on geological CO_2 storage in Switzerland.

Carbon storage potential at the urban scale?

Insights and selected findings:

Buildings can help to mitigate climate change. Retrofitting or constructing buildings with carbon-negative materials offers potential to capture and store carbon rather than release it. While producing conventional materials like concrete emits carbon, alternatives like biochar or cellulose insulation can store it over different time periods.

An integrated approach that combines urban development and building construction is essential for effective climate change mitigation (1). Analytical toolsets such as the City Energy Analyst support this process by enabling data-driven planning and optimisation at the city scale.

Recommended action:

- Promote climate-smart construction by reuse, considerate retrofitting, and constructing with carbon-negative materials, and align urban development with sustainable building practices.

Specific material solutions which have been developed, some of which are also being implemented at NEST (Next Evolution in Sustainable Building Technologies):

- **Concrete:** Concrete is the world's most used building material and can naturally remove CO_2 from the air through a process called carbonation, which can be sped up using new technologies. The moisture level of concrete is the main factor determining how carbonation affects the lifespan of reinforced structures such as buildings and bridges. Carefully controlling moisture levels can extend the lifespan of concrete while also enhancing its ability to capture CO_2 from the air (2).
- **Biochar insulation boards:** Biochar insulation boards store carbon and are made from renewable resources, offering a climate-friendly alternative to conventional insulation materials. Produced from agricultural or landscape waste, biochar boards repurpose biomass that would otherwise be discarded. Beyond functioning as carbon sinks, they make buildings more efficient by insulating them (3).
- **Wood-hybrid structures:** By extracting calcium from recycled concrete and binding it with CO_2, carbon-rich minerals can be created. These minerals can be valorised by embedding them into wood to improve durability and flame retardancy. Buildings constructed with wood-mineral composites act as carbon storage materials, storing CO_2 both through the natural photosynthesis of wood and through additional CO_2 mineralisation following the decarbonisation of cement production. This circular material innovation can be used in building elements such as coatings, wood boards and bricks (4).

Studies:

1 Meshkinkiya, M. et al., Assessing biogenic carbon storage at urban scale through urban building energy modelling. Sustainable Cities and Society (2025); doi: 10.1016/j.scs.2025.106355.
2 Zhang, Z. et al., RILEM Techn Lett (in review).
3 Kyeremeh, S. K. et al. (in preparation).
4 Ding, Y. et al., Valorization of demolition waste and biomass byproduct into sustainable building materials via carbon mineralization and 3D printing, Chemistry–Methods (2025); doi: 10.1002/cmtd.202500007.

Assessing the feasibility of geological CO_2 storage in the Swiss subsurface

Geological storage of CO_2 returns the carbon to the subsurface, where it originally came from. Injecting CO_2 deep into suitable rock formations is a safe process when executed carefully and monitored.

CO_2 storage has been safely applied in Europe since the 1990s, with several commercial projects now in operation or under development both onshore and offshore.

Studies show that suitable geological formations for CO_2 storage exist in Switzerland, but practical experience is still lacking. The CITru pilot project aims to provide a blueprint for future initiatives by demonstrating what is needed to inject CO_2 into the subsurface for permanent storage: from technical and operational steps to costs, communication and permits (5, 6).

Recommended action:

- Support pilot projects and research on geological CO_2 storage to build practical experience and assess the potential of the Swiss subsurface.

Studies:

5 Diamond, L. W. et al., Geochemical – hydrogeological study of a proposed CO_2 injection pilot at Trüllikon, Switzerland. Contributions to the feasibility study for project CITru. – Rep. swiss geol. Surv. 19 (2025).
6 Schultz, R. et al., Pre-screening of induced seismicity risks for CO_2 injection at Trüllikon, Switzerland, International Journal of Greenhouse Gas Control, Volume 138, 104239,ISSN 1750-5836 (2024); doi: 10.1016/j.jggc.2024.104239.

Outlook

The Joint Initiative SPEED2ZERO officially concludes at the end of 2026.

Beyond the findings and tools presented in this publication, some of which will continue to be developed and applied in other contexts, the network established through SPEED2ZERO will also endure. Over several years of collaboration, researchers from the fields of climate, energy and biodiversity science have developed not only shared projects but also a deeper mutual understanding across disciplines.

At the same time, the programme has fostered lasting connections with decision-makers from politics, public administration and the private sector. The dialogue between science, policy and broader society will continue through a range of projects and initiatives, including:

- NCCR CLIM+
- SWEET ACHIEVE
- SWEET RECIPE

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