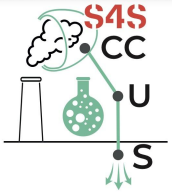
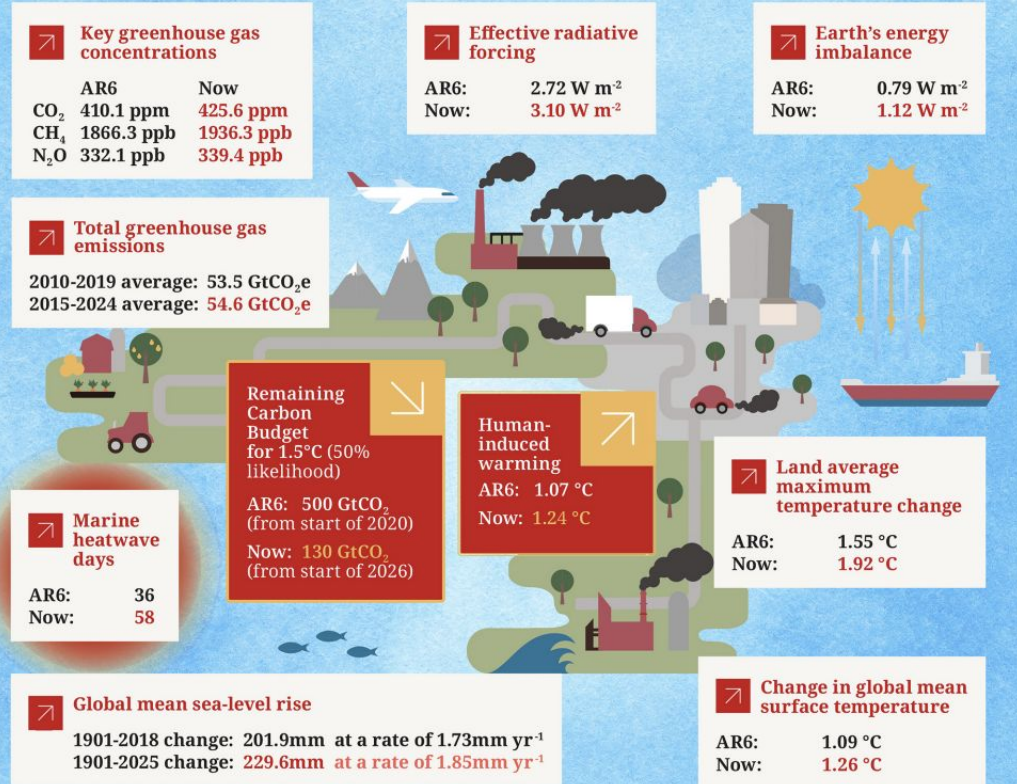


CCUS policy and Swiss net zero

Sascha NICK

Key indicators of global climate change 2025: What's changed since AR6?

Human induced warming is increasing at a rate of about 0.27°C per decade, the result of greenhouse gas emissions being at an all-time high over the last decade, as well as reductions in the strength of aerosol cooling.



Earth System Science Data



Articles / Volume 18, issue 6 / ESSD, 18, 3889–3933, 2026

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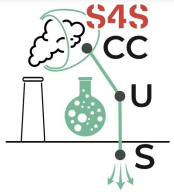
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Indicators of Global Climate Change 2025: annual update of key indicators of the state of the climate system and human influence

Piers M. Forster , Tristram Walsh, Chris Smith, William F. Lamb, Robin Lamboll, Christophe Cassou, Mathias Hauser, Zeke Hausfather, June-Yi Lee, Matthew D. Palmer, Karina von Schuckmann, Aïmée B. A. Slangen, Sophie Szopa, Blair Trewin, Jeongeun Yun, Nathan P. Gillett, Stuart Jenkins, H. Damon Matthews, Krishnan Raghavan, Aurélien Ribes, Joeri Rogelj, Debbie Rosen, Xuebin Zhang, Myles Allen, Robbie M. Andrew, Chris Atkinson, Richard A. Betts, Antonio Bombelli, Samantha N. Burgess, Lijing Cheng, Helen E. Claxton, Pierre Friedlingstein, Thomas L. Frölicher, Catia M. Domingues, Thomas Gasser, Catherine H. Gregory, Rachel M. Hoesly, Daniel Huppmann, Masayoshi Ishii, Christopher Kadow, Alexia Karwat, John Kennedy, Rachel E. Killick, Mahesh V. M. Kovilakam, Paul B. Krummel, Xin Lan, Jean-François Lamarque, Aurélien Liné, Belén Martín-Míguez, Didier P. Monselesan, Colin Morice, Jens Mühle, Pino Mussak, Glen P. Peters, Anna Pirani, Julia Pongratz, Matthew Rigby, Robert Rohde, Abhishek Savita, Sonia I. Seneviratne, Steven J. Smith, Ghassan Taha, Caterina Tassone, Peter Thorne, Christopher Wells, Luke M. Western, Guido R. van der Werf, Susan E. Wijffels, Marco Zecchetto, Junting Zhong, Xiao-Ye Zhang, Valérie Masson-Delmotte, and Panmao Zhai

CCUS between 1.5°C overshoot and Swiss net zero



The remaining space for limiting warming to 1.5°C is closing. In a world with temporary overshoot, durable carbon removal becomes necessary over the long term.

For Switzerland, the near-term issue is different. Net zero by 2050 requires deep emission cuts first, followed by a credible strategy for limited residual emissions.

CCUS is one possible part of that strategy. It can also create new dependencies: on energy, infrastructure, geological storage, burden allocation, and future political commitment.

Key question: which Swiss CCUS policy is relevant under uncertainty? It must be broad enough to prepare for different futures, strict enough to prevent delay, and adaptive enough to change course when evidence changes.

CCUS is especially difficult to govern

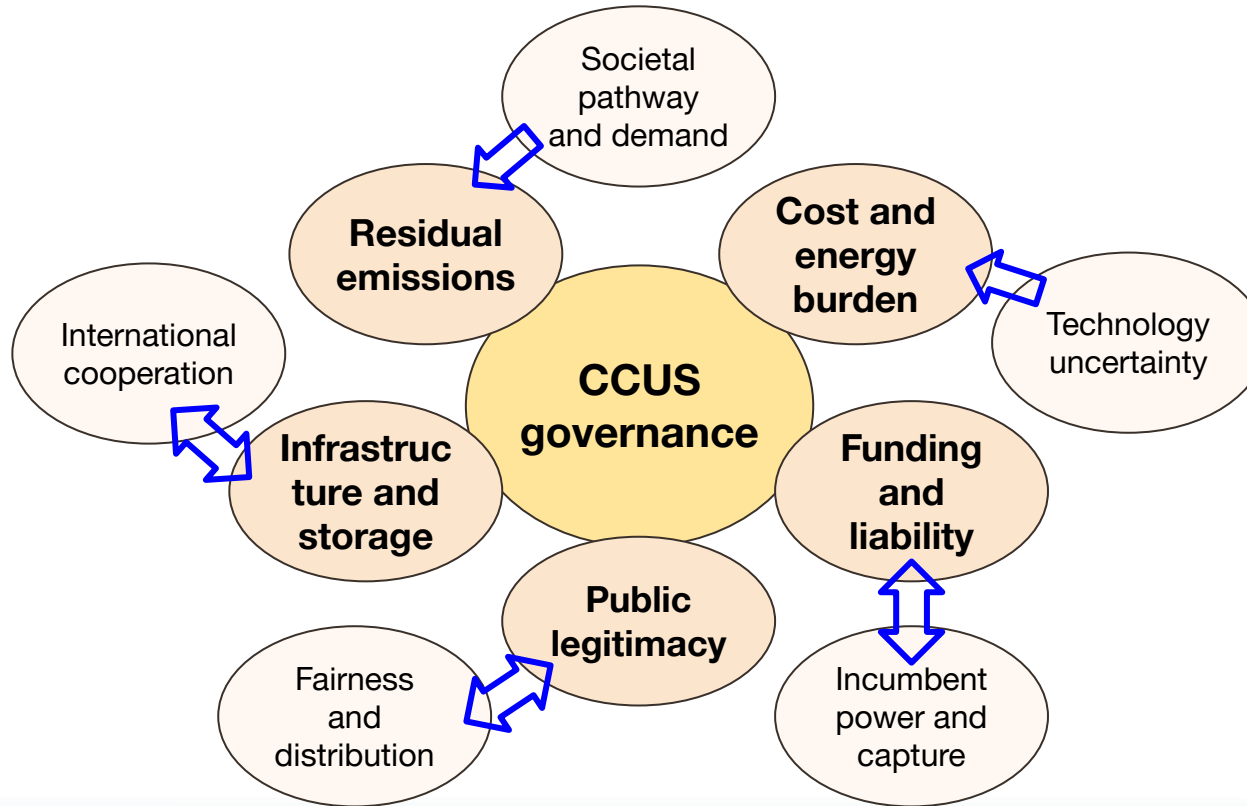
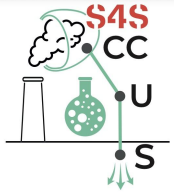
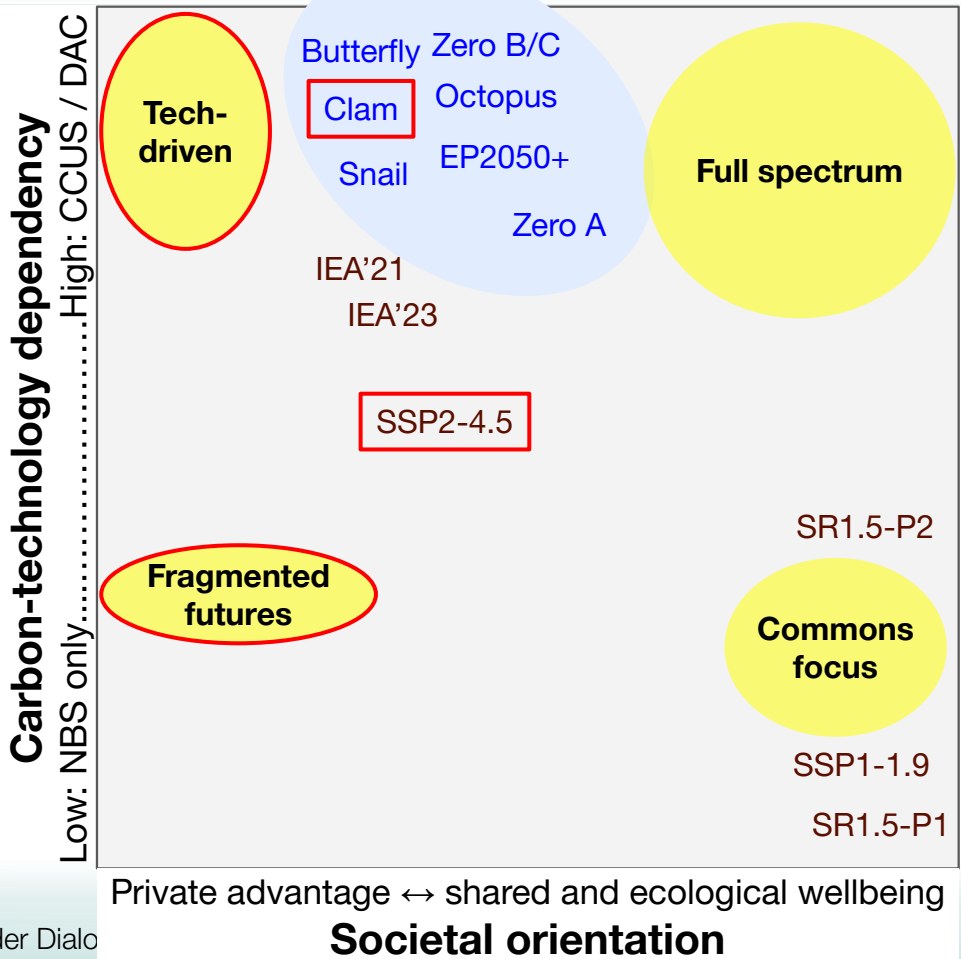
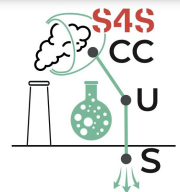


Figure 1. CCUS as a difficult governance problem.

CCUS governance is directly affected by adjacent drivers (dark color). These are shaped by the broader forces in society (light color). The key policy challenge is systemic, as the main drivers interact, compounding uncertainty.

Nick, 2026, forthcoming

Uncertainty requires exploring divergent scenarios



Legend

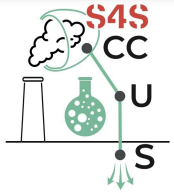
Yellow = stress-test scenarios
Blue = Swiss EP2050+ / DeCIRRA
Brown = IPCC / IEA roadmaps
Red outline = net zero 2050 missed

Note: Positions are indicative of scenario orientation, not modelled coordinates. DeCIRRA extends CROSS/CoSi 2022 scenarios to CCUS.

Figure 2. Plural scenario space for adaptive CCUS governance.

The figure maps proposed stress-test scenarios and selected Swiss and global reference pathways according to their carbon-technology dependency and societal orientation.

Financing CCUS for deployment, risk, and responsibility



PAYG funds early deployment; a net-zero fund reserves money for removals; a damage-linked fund covers residual responsibility for future burdens.

PAYG → early start Current users / emitters pay for current capture, transport, storage, monitoring, and contracts. Does not secure long-term obligations.

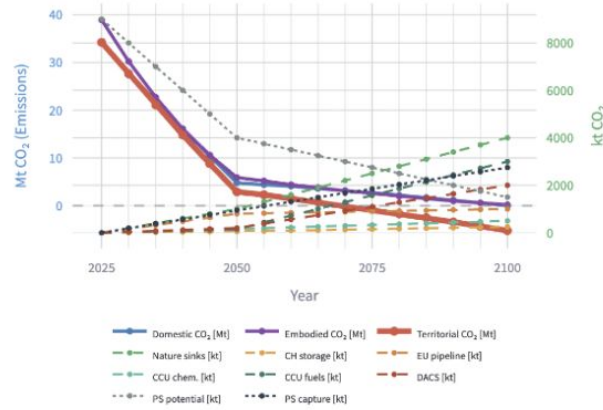
Net-zero fund → guarantee removals Mandatory contributions build a protected reserve for durable removals, and storage liabilities. Vulnerable to underpricing and political weakening.

Damage-linked responsibility fund → global justice Payments scale with overshoot, residual emissions, delayed action, or failed assumptions. Attribution and political acceptance are difficult.

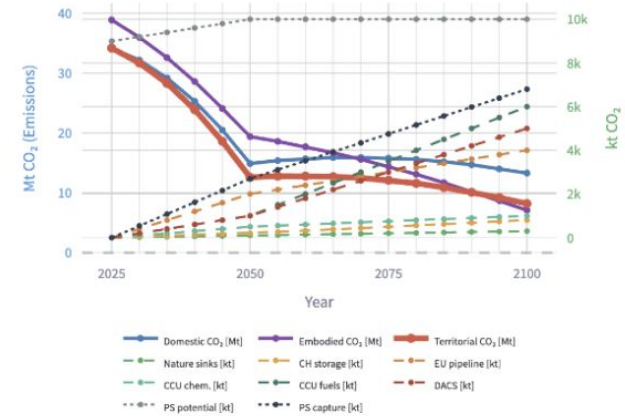
Three complementary layers: start early → guarantee removals → ensure global justice

Input parameter	2025	2050	2100	on/off	sascha.nick@epfl.ch	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2100	Cr	
1. Full spectrum																						
Reset																						
Energy						Energy																
Population [M]	9	11	13			Total final energy [PJ]	1350	1322	1294	1266	1238	1210	1219	1228	1237	1246	1255	1264	1273	1282	1291	1300
Final energy/cap [GJ]	150	110	100			Total domestic final energy [PJ]	810	805	801	796	791	787	805	824	843	862	881	900	918	937	956	975
% domestic final energy	60%	65%	75%			+CCUS energy in CH [PJ]	0.0	3.0	5.8	8.4	10.8	13.0	23.4	33.6	43.4	52.8	61.9	70.7	79.1	87.2	95.0	102.4
% fossil domestic energy	65%	10%	0%			Domestic+CCUS final energy [PJ]	810	808	806	804	802	799	829	858	886	913	943	970	998	1025	1051	1077
% fossil embodied in imports	80%	20%	1%			% fossil domestic energy	65%	54%	43%	32%	21%	10%	9%	8%	7%	6%	5%	4%	3%	2%	1%	0%
Intensity domestic fossil [kg CO ₂ /GJ]	65	60	56		ht	% fossil embodied in imports	80%	68%	56%	44%	32%	20%	18%	16%	14%	12%	11%	9%	7%	5%	3%	1%
Intensity imported fossil [kg CO ₂ /GJ]	90	70	60			Intensity domestic fossil [kg CO ₂ /GJ]	65	64	63	62	61	60	60	59	58	58	58	58	57	56	56	56
Intensity imported fossil [kg CO ₂ /GJ]						Intensity imported fossil [kg CO ₂ /GJ]	90	86	82	78	74	70	69	68	67	66	65	64	63	62	61	60
Point-source CCS [GJ/t CO ₂]	3.8	3.0	2.5			CC Point-source CCS [GJ/t CO ₂]	3.8	3.6	3.5	3.3	3.2	3.0	3.0	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.5
DAC [GJ/t CO ₂]	7.2	6.0	4.5			(1) DAC [GJ/t CO ₂]	7.2	7.0	6.7	6.5	6.2	6.0	5.9	5.7	5.6	5.4	5.3	5.1	5.0	4.8	4.7	4.5
CO ₂ storage [GJ/t CO ₂]	0.45	0.42	0.40			(2) CO ₂ storage [GJ/t CO ₂]	0.45	0.44	0.44	0.43	0.43	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.40	0.40	0.40
CCU chemicals [GJ/t CO ₂]	36.0	28.0	22.0			(3) CCU chemicals [GJ/t CO ₂]	36.0	34.4	32.8	31.2	29.6	28.0	27.4	26.8	26.2	25.6	25.0	24.4	23.8	23.2	22.6	22.0
CCU fuels [GJ/t CO ₂]	32.0	29.0	25.0			(4) CCU fuels [GJ/t CO ₂]	32.0	31.4	30.8	30.2	29.6	29.0	28.6	28.2	27.8	27.4	27.0	26.6	26.2	25.8	25.4	25.0
Assumed nPIL → kerosene	37.2%	41.7%	49.5%																			
CO ₂ flows						CO ₂ flows																
Point-source potential [kt CO ₂]						Domestic CO ₂ [Mt]						4.8										
Nature-based sinks [kt CO ₂]						Embodied CO ₂ [Mt]						36.9										
CCS: CH storage [kt CO ₂]						Point-source potential [kt CO ₂]						9000										
CCS: EU pipeline [kt CO ₂]						Point-source capture [kt CO ₂]						0										
CCU → chemicals [kt CO ₂]						Nature-based sinks [kt CO ₂]						0										
CCU → liquid fuels [kt CO ₂]						CCS: CH storage [kt CO ₂]						50										
CCU → kerosene [kt]						CCS: EU pipeline [kt CO ₂]						80										
DACS [kt CO ₂]						CCU → chemicals [kt CO ₂]						150										
						CCU → liquid fuels [kt CO ₂]						320										
						DACS [kt CO ₂]						200										
						Territorial CO ₂ [Mt]						34.2										
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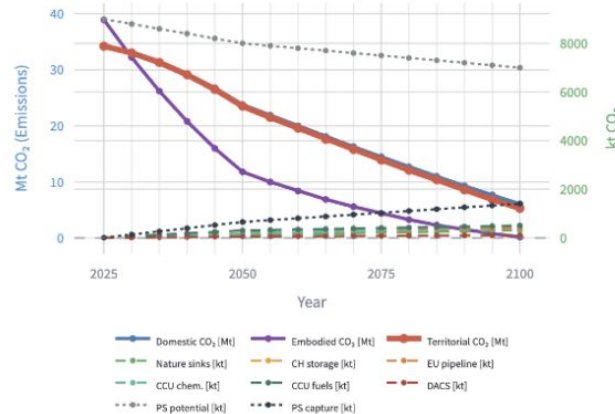
CO₂ flows



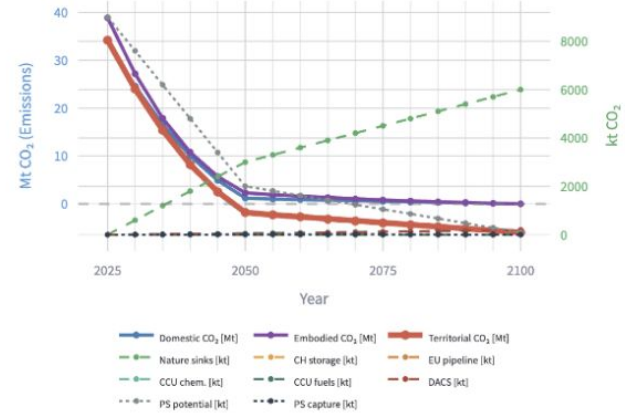
(a) Scenario 1 - CO₂ flows



(b) Scenario 2 - CO₂ flows



(c) Scenario 3 - CO₂ flows



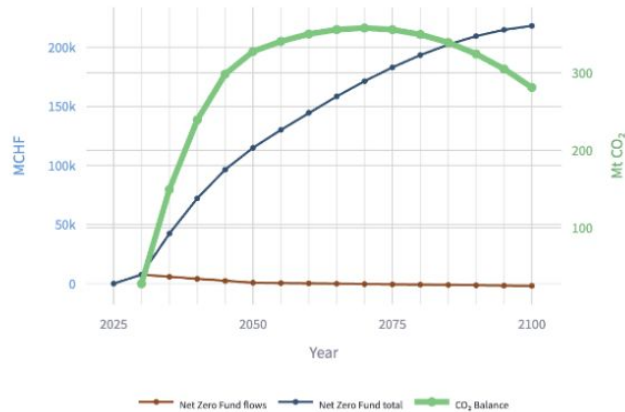
(d) Scenario 4 - CO₂ flows

Modeled scenarios

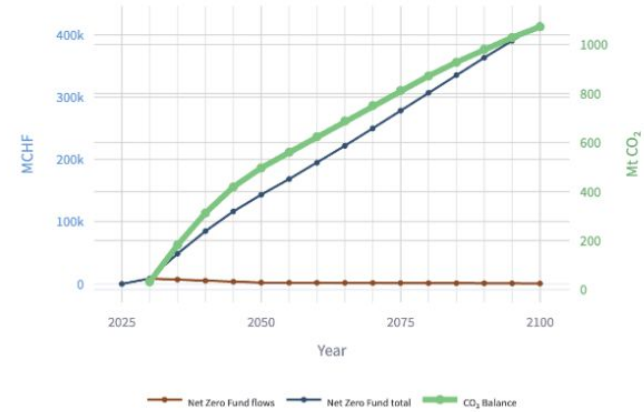
1. Full spectrum
2. Tech-driven
3. Fragmented futures
4. Commons focus

Net zero fund

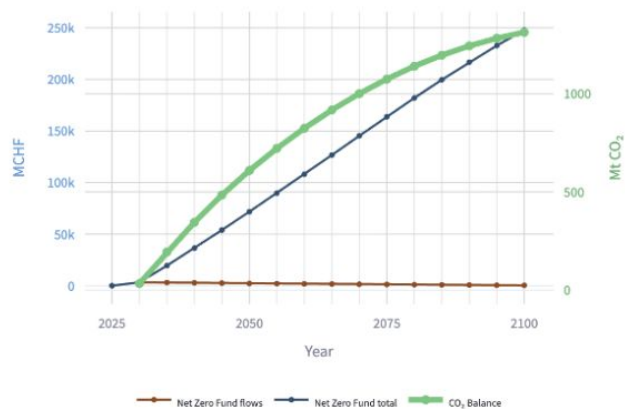
1.5°C carbon debt in 2100



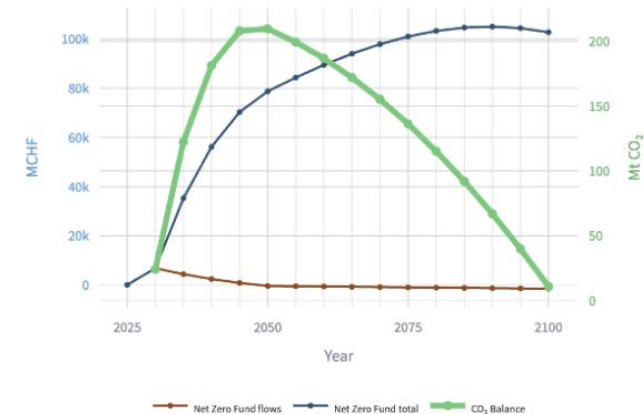
(a) Scenario 1 - Net Zero Fund (Polluter pays)



(b) Scenario 2 - Net Zero Fund (Polluter pays)



(c) Scenario 3 - Net Zero Fund (Polluter pays)



(d) Scenario 4 - Net Zero Fund (Polluter pays)

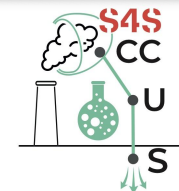
Modeled scenarios

1. Full spectrum
2. Tech-driven
3. Fragmented futures
4. Commons focus

2050 risk comparison

Modeled scenarios

1. Full spectrum
2. Tech-driven
3. Fragmented futures
4. Commons focus



Risk Indicator (2050)	Value
i Territorial CO ₂ 2050 [Mt]	2.9
i CO ₂ Overshoot 2025–2050 [%]	107%
i Tech deployment 2050 [Mt]	1.35
i CCUS energy burden [%]	1.7%
i EU storage dependency [%]	94%
i CCU energy cost [%]	70%
i Net Zero Fund coverage [%]	149%
i PAYG coverage (in/out) [%]	165%

(a) Scenario 1

Risk Indicator (2050)	Value
i Territorial CO ₂ 2050 [Mt]	12.6
i CO ₂ Overshoot 2025–2050 [%]	146%
i Tech deployment 2050 [Mt]	4.70
i CCUS energy burden [%]	4.4%
i EU storage dependency [%]	91%
i CCU energy cost [%]	87%
i Net Zero Fund coverage [%]	118%
i PAYG coverage (in/out) [%]	36%

(b) Scenario 2

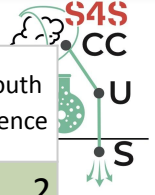
Risk Indicator (2050)	Value
i Territorial CO ₂ 2050 [Mt]	23.5
i CO ₂ Overshoot 2025–2050 [%]	173%
i Tech deployment 2050 [Mt]	0.75
i CCUS energy burden [%]	1.4%
i EU storage dependency [%]	80%
i CCU energy cost [%]	73%
i Net Zero Fund coverage [%]	41%
i PAYG coverage (in/out) [%]	72%

(c) Scenario 3

Risk Indicator (2050)	Value
i Territorial CO ₂ 2050 [Mt]	-1.8
i CO ₂ Overshoot 2025–2050 [%]	80%
i Tech deployment 2050 [Mt]	0.07
i CCUS energy burden [%]	0.4%
i EU storage dependency [%]	0%
i CCU energy cost [%]	58%
i Net Zero Fund coverage [%]	150%
i PAYG coverage (in/out) [%]	67%

(d) Scenario 4

Impact of policy packages on five principles



Policy package	Type	Wellbeing	Sufficiency	Reduced inequalities	Repurposing of the economy	North south convergence
P1. Broad sufficiency transformation	N	3	3	2	3	2
P2. Restrict high-carbon BAU	R	1	3	1	2	2
P3. Ecosystem restoration and land-use integrity	N+R	2	1	1	2	1
P4. Residual-first and selective CCUS deployment	R+C	1	2	1	2	1
P5. CCUS infrastructure and cross-border storage	C	1	-1	0	1	0
P6. Public-interest governance and anti-capture rules	N+R	1	1	3	3	1
P7. PAYG tax-and-support finance	C	0	0	-1	0	-1
P8. Polluter-pays reserve fund	R+C	1	1	2	1	1
P9. Damage-linked responsibility fund	R+C	1	2	3	2	2
P10. Binding adaptive review, deliberation, trigger points	T	2	2	2	1	1

Policy types: **No-regret (N)** policies are useful across most futures; **Contingent (C)** policies depend on specific conditions being met; **Restrictive (R)** policies limit lock-in, overuse, or capture; **Trigger-based (T)** policies are activated, paused, or revised when monitored thresholds are crossed

Policy sequencing and contingency triggers

Policy domain	2026–2034	2034–2042	2042–2050	2050+
Demand reduction and sufficiency	Launch sufficiency transformation in housing, mobility, food, materials, and shared infrastructure. [N]	Tighten high-carbon BAU restrictions if residual emissions remain high. [R/T1]	Prevent rebound in energy- and material-intensive sectors. [N/R/T1]	Keep demand within ecological and wellbeing limits. [N/R/T1]
Residual definitions and deployment rules	Define narrow residual categories and a mitigation hierarchy. [N/R]	Tighten residual definitions if excessive emissions are classified as hard-to-abate. [R/T1]	Restrict support to emissions remaining after sufficiency, efficiency, substitution, process change. [R/C/T1]	Reassess residual categories as technologies and social practices evolve. [T1/T2]
CCUS deployment	Support selective residual-sector pilots with public data sharing. [N/C]	Scale only where performance, energy, cost, legitimacy, and residual criteria are met. [C/T2/T5]	Deploy only for remaining residuals under public-interest conditions. [C/R]	Shift towards carbon-debt reduction and long-term stewardship. [C/T6]
Infrastructure and cross-border storage	Plan shared infrastructure, MRV, liability rules, and bilateral storage agreements. [N/C]	Build hubs and storage chains only where volumes and treaty integrity justify them. [C/T4]	Operate under access, integrity, liability, and public-interest rules. [C/R]	Maintain storage stewardship, monitoring, liability, and treaty review. [N/T4]
Governance and anti-capture	Establish transparency, lobbying, ownership, funding-cap, and public-interest rules. [N/R]	Audit rent extraction, subsidy dependence, concentration, and control of infrastructure. [R/T5]	Tighten controls if CCUS infrastructure or finance becomes concentrated. [R/T5]	Maintain oversight; tighten if concentration risks return. [N/T5]
Funding models	Start reserve accrual and damage-linked accounting; use PAYG only for pilots. [N/C]	Shift from PAYG toward reserve and responsibility-based funding. [N/C/T3]	Use reserve funding as backbone; strengthen damage-linked contributions if carbon debt remains high. [N/C/T3/T6]	Finance long-term stewardship, liability, and carbon-debt reduction. [N/T6]
Trigger legend		Policy-type notation		
T1 residual emissions too high		N = no-regret / robust		
T2 CCUS energy or cost burden too high		C = contingent		
T3 fund coverage too low		R = restrictive		
T4 storage access or treaty integrity unreliable		T = trigger-based		
T5 legitimacy, concentration, or anti-capture safeguards weak				
T6 1.5°C carbon debt remains high after reaching net zero				

Configurable Swiss Net Zero Model

☒ Extend to 2100 ☐ Dual graphs

Your Feedback

Reset

> Load other baseline values

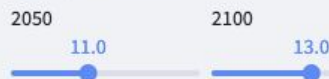
Scenario

Scenario 1 - Full Spectrum

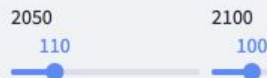
Start Challenge

Energy

Population [M]



Final energy/cap [GJ]



Tech →



Societal →

Territorial CO₂ at zero

2070

CO₂ Balance 2100

+281 Mt

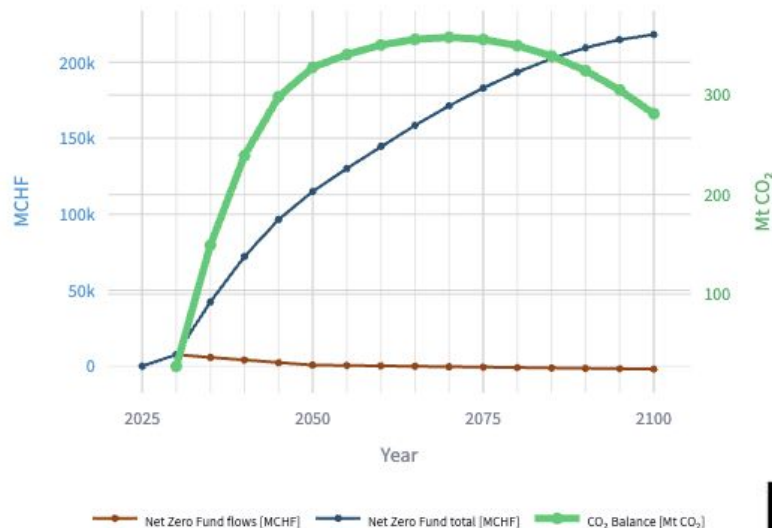
Scenario 1

All scenarios

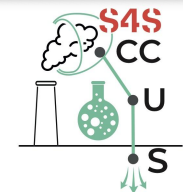
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CCU energy cost [%]	70%
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PAYG coverage (in/out) [%]	165%

Net Zero Fund (Polluter pays)

Results of other scenarios

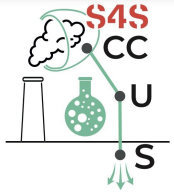


EPFL



ccusnz.epfl.ch

Adaptive CCUS governance without lock-in



Swiss CCUS policy should prepare credible options for residual emissions and durable removals, while limiting dependence on uncertain future conditions. Implications:

1. CCUS policy should be residual-first: deployment should follow from clearly justified remaining emissions.
2. Policy must be tested across multiple futures, because the same CCUS strategy can produce very different outcomes for CO₂ volumes, energy demand, risks, costs, and future obligations.
3. Governance should combine clear normative principles with adaptive mechanisms: monitoring, milestones, financing rules, liability provisions, and contingency triggers.

The goal is to build a policy approach that adapts as evidence, technologies, social choices, and climate constraints change.