Carbon removal, net zero, and implications for Switzerland

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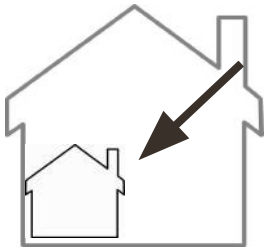
Carbon removal, including **carbon capture, utilization and storage (CCUS)** and negative emission technologies (NET), is an important but small part of climate action, unlikely to scale beyond 5-10% percent of current emissions, in the 2-3 critical decades we have to stabilize our climate and stop biodiversity loss.

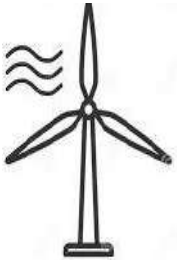
E4S White Paper, 2022 - xx DRAFT

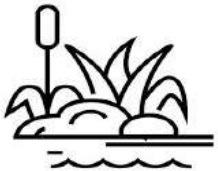
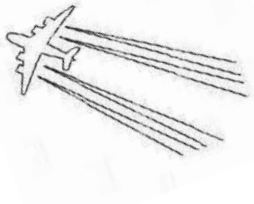
Swiss Negative Emissions Fund - getting to Net Zero

Authors: Sascha Nick, Philippe Thalmann

Typology of Climate Action






1 Sufficiency 2 Efficiency 3 Clean Energy 4 CCS 5 NET 6 SRM 7 Adaptation

Stabilize temperature

Stabilize CO_2 concentration

Reduce emissions

Adapt to changed climate

Mitigation (IPCC): reduce sources or enhance sinks

Adaptation: reduce harm

Concept

1. The priority is GHG emissions reduction
2. Rapid massive reduction of all emissions is excessively costly; costs can be lowered by proceeding gradually
3. On the way to deep decarbonization, there remain emissions
4. This is more easily acceptable if the emitter commits to eliminating these emissions through removal (clean-up)
5. Today, removal is very costly
6. Costs are expected to decrease as the practice develops
7. Hence, some removal should take place today, more later

Neutrality – Net zero

We can use the glossary of the IPCC SR15 Report:

- **Net zero carbon dioxide (CO_2) emissions** are achieved when anthropogenic CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period. Net zero CO_2 emissions are also referred to as **carbon neutrality**.
- **Net zero emissions** are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period.
- **Climate neutrality** is achieved when human activities result in no net effect on the climate system. Achieving such a state would require balancing of residual emissions with emission removal as well as accounting for regional or local biogeophysical effects of human activities that, for example, affect surface albedo or local climate.
- **Negative emissions**: Removal of greenhouse gases from the atmosphere by deliberate human activities, i.e., in addition to the removal that would occur via natural carbon cycle processes.

ipcc.ch/sr15/chapter/glossary

Options for negative emissions and costs

- Reforestation or afforestation is the only inexpensive method, usually well below $100 per ton CO_2
- Soil carbon, depending on method <$100/t
- Biochar, $8-300/t
- BECCS, $45-250/t
- DACS, around $1000/t in 2021, expected to fall slowly
  - EU REF2020 estimates €894 in 2030, and €495 ultimate
- Enhanced weathering, $40-1000/t

Two opposing effects of scaling-up:

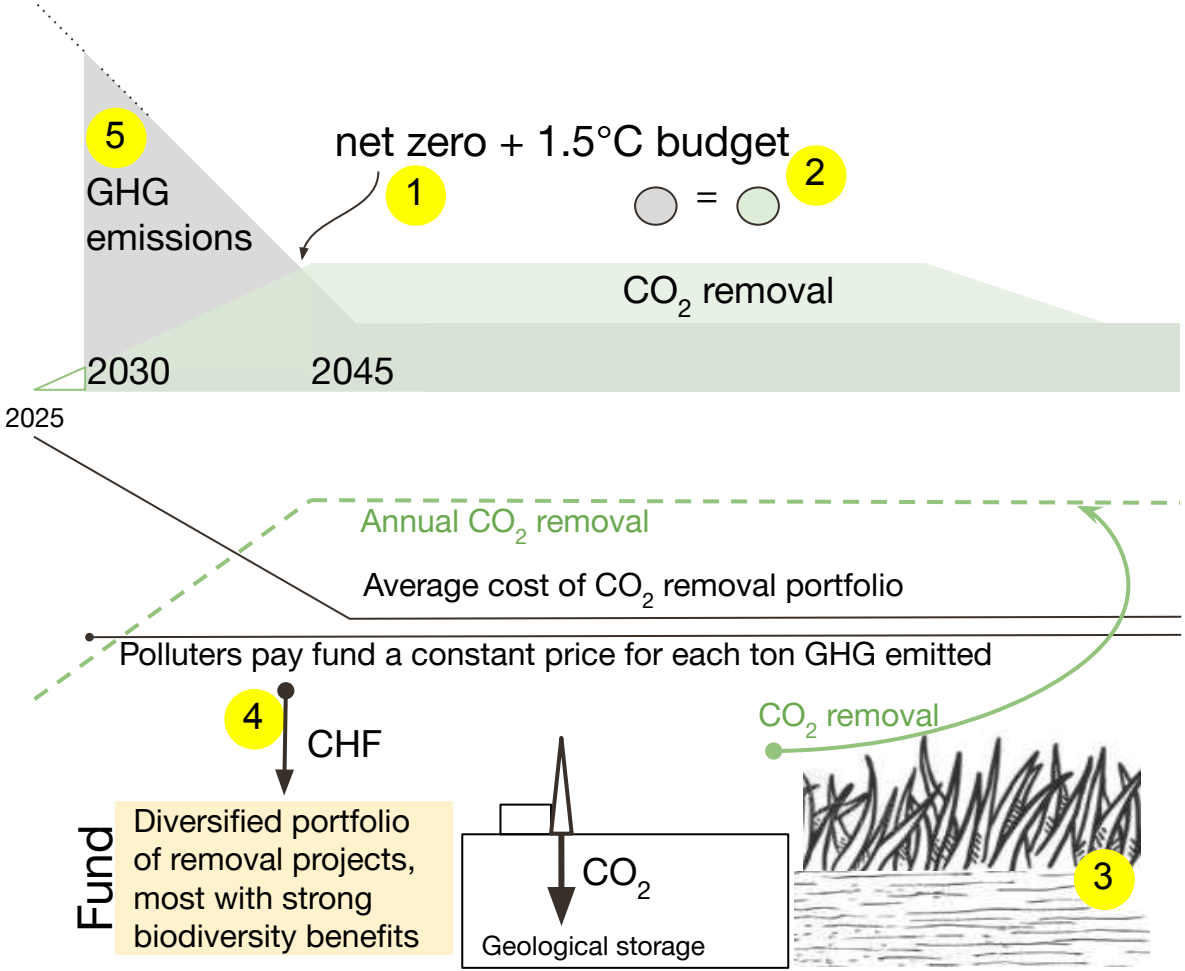
1) Falling costs along the learning curve
2) Rising costs as cheapest options are used up

S. Nick & P. Thalmann, Carbon removal, net zero, and implications for Switzerland, E4S White Paper, December 2021

Time is of the essence

- Today: high emissions, few costly removal options
- In a decade or two: low emissions, many affordable removal options
- Polluter pays principle: those responsible for today's emissions should pay for their future removal
- A Fund makes this possible: those responsible for today's emissions pay into the Fund, which pays for future removal
- By paying for some removal today, the Fund would kick-start technological improvement and cost reductions, build capacity, prepare the upscaling, promote method development and create the market

Swiss Negative Emissions Fund - concept



1.5°C climate action goals

1. Annual net zero ca. 2040
2. Climate neutrality from 2030
3. Biodiversity co-benefits
- Meet NDC commitment
- Social cushioning

1.5°C climate policy

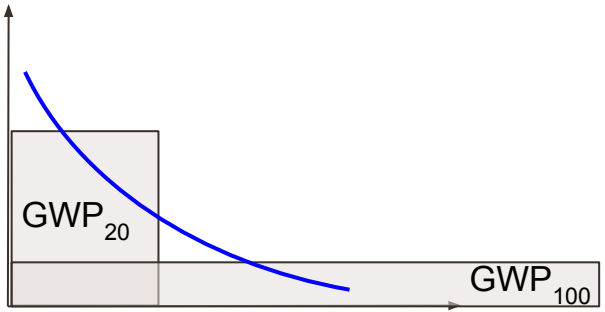
4. Fund: CO_2 price (incentive)
5. Regulation: GHG↓ by 2045
- Public investment
- Voluntary action

NETs enhancing

	Capture	Storage
Biological (fast natural carbon cycle)	Reforestation, Afforestation	
	Soil carbon restoration	
	Ecosystem restoration, especially wetlands	
		Biochar
		BECCS
Chemical (slow natural carbon cycle)	Enhanced weathering	
Artificial	DACS	

Short-lived and long-lived GHG, and the case of methane

GWP_{100} or **GWP_{20}** or **GWP*** ?



For short-lived GHG, especially methane

$CO_2e^* = (105 \bullet \Delta Em) + (7 \bullet Em)$

where Em are current methane emissions and ΔEm is the absolute change in methane emissions over 20 years

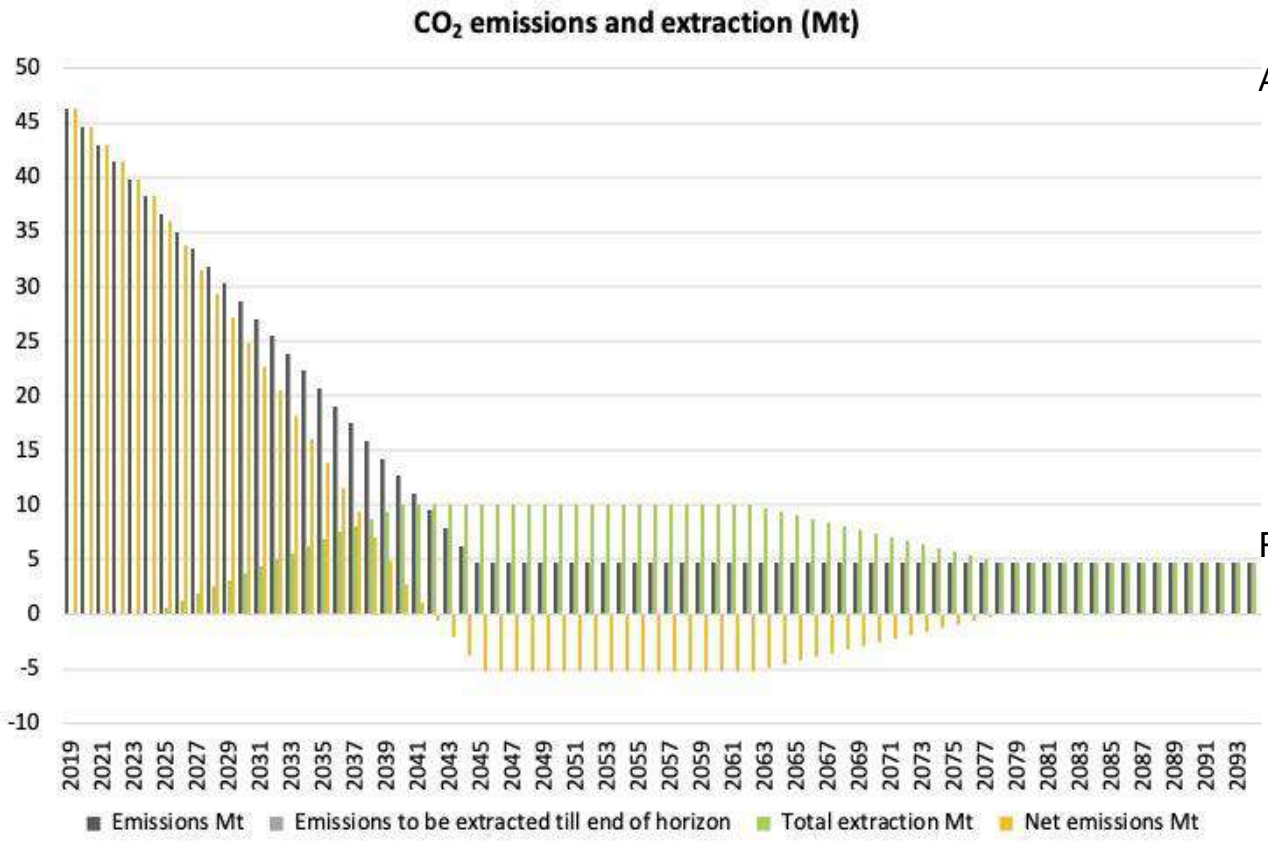
Example: For methane from Swiss agriculture, based on the 1999-2019 period, when emissions slightly decreased from 160 to 155 kt CH_4,

ΔEm is -5 kt CH_4, and equivalent CO2 emissions using GWP* are

105*(-5)+7*155 = 560 kt CO_2e

significantly less than the 155*28 = 4340 kt CO_2e obtained when using GWP_{100}

Baseline, adapted from Switzerland's long-term climate strategy



Assumptions

- Fund launch 2025
- Emissions decrease until 2045
- CO_2 price ramp-up to 2030
- NET ramp-up to 2040
- 2025 NET cost: CHF 800
- 2040 NET cost: CHF 350
- Interest rate: 2.5%
- 2025 GHG emissions: 36 Mt
- 2045 GHG emissions: 9.7 Mt
- 2045 GHG after CCS: 4.7 Mt

Results

- Net zero: 2042
- Excess CO_2 removed: 2077
- CO_2 price: CHF 279
- Peak NET: 10 Mt p.a.
- Peak payment: CHF 7.99 bn

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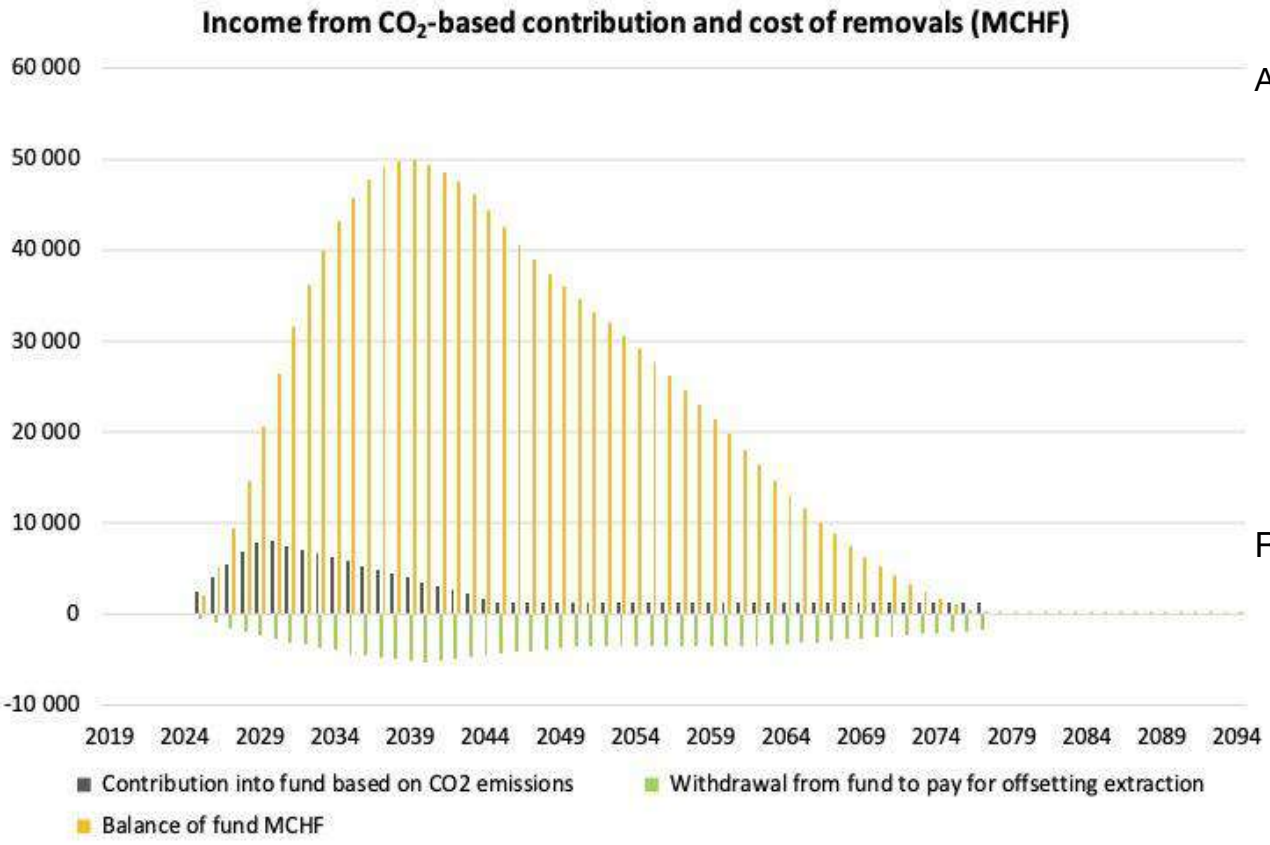

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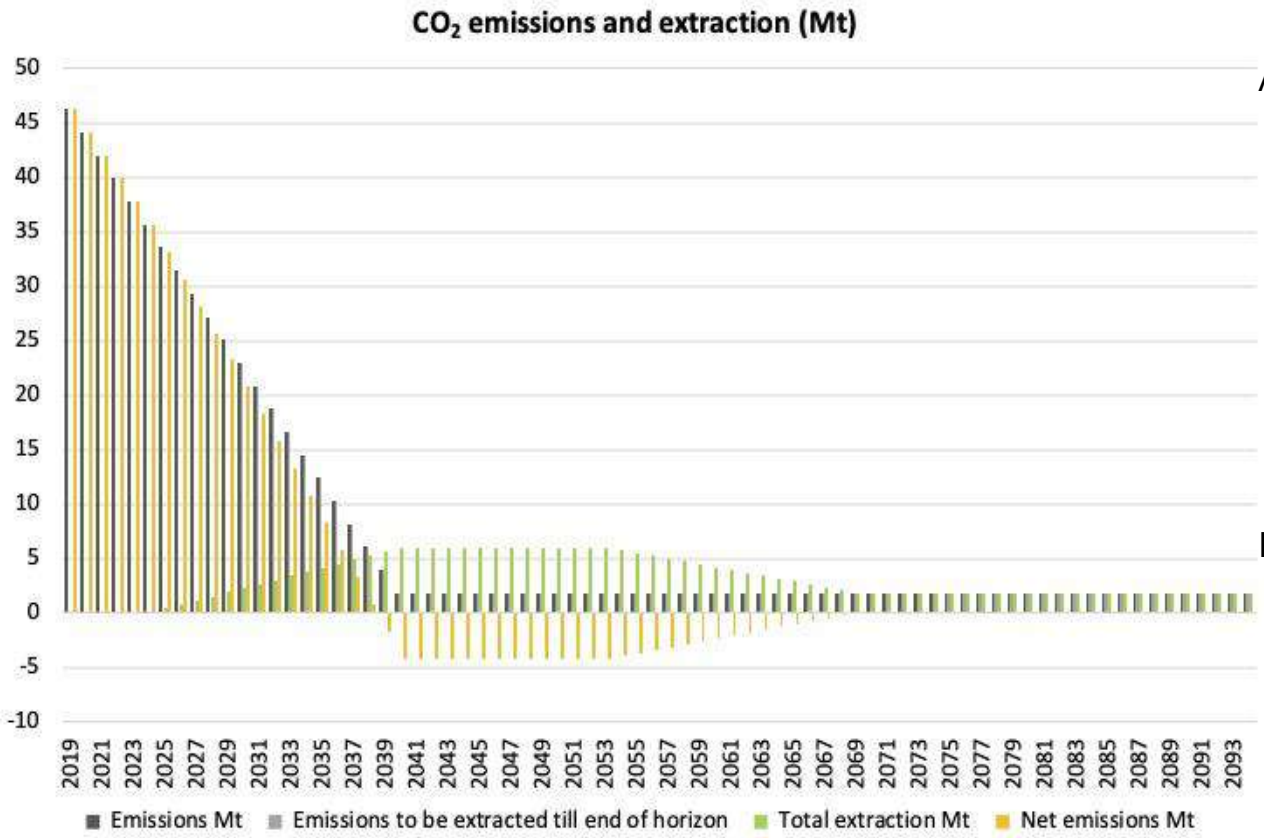
Simulation of a more ambitious climate policy



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- Net zero: 2039
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- CO_2 price: CHF 245
- Peak NET: 6 Mt p.a.
- Peak payment: CHF 5.75 bn

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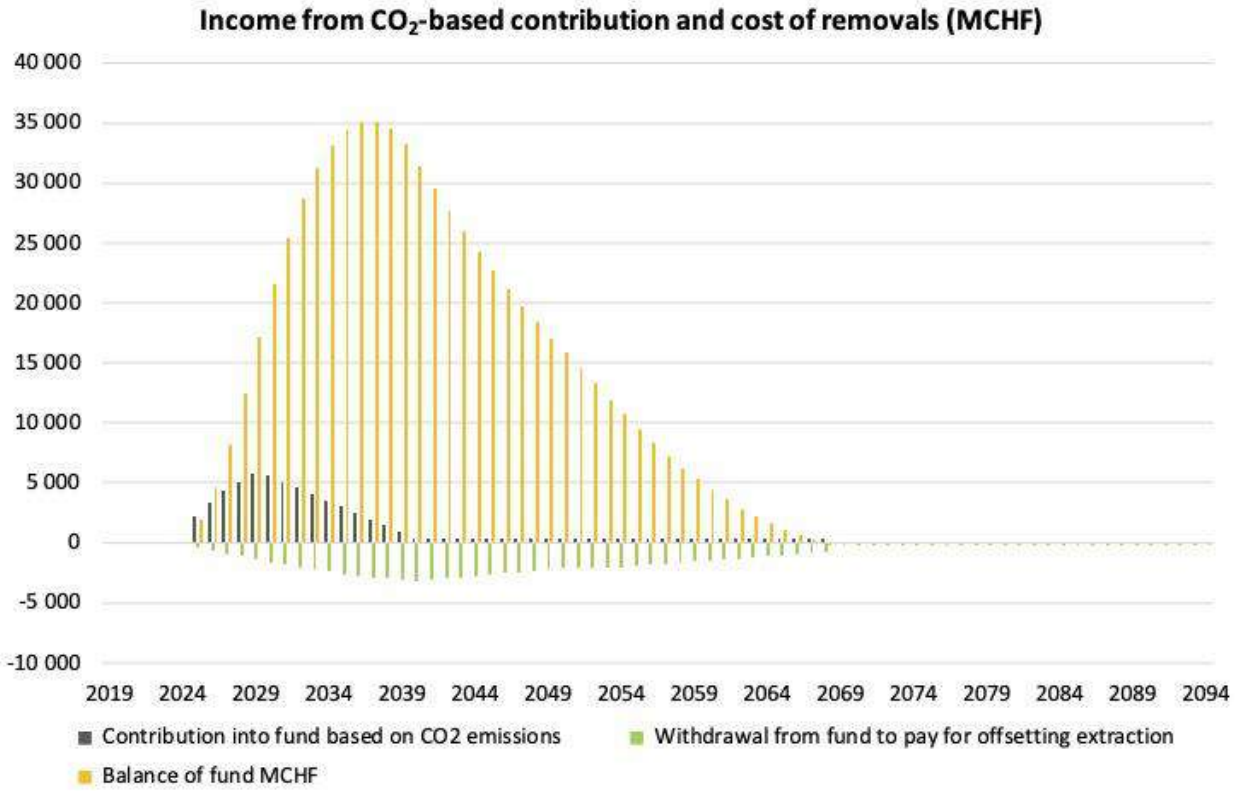

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Pilot fund proposal - a voluntary 3-year, 1%-scale test implementation

Diversified portfolio, including biological and geological projects, short-term carbon removal and longer-term learning - example of mix:

- Capture: 80% biological, 20% chemical
- Storage: 80% biological, 20% geological
- 80% short-term removal, <CHF 250/t, 20% long-term learning, >CHF 250/t
- Max 10% of annual investment (CHF 300k) on any single project
- Max 30% of annual investment on any single type of project

Each project must be attractive in its own right, but there is a strong benefit in ensuring a balanced portfolio.

Pilot fund proposal - a voluntary 3-year, 1%-scale test implementation

Hypothetical example of a balanced portfolio after one year:

- Three wetland restoration projects, total CHF 800k, CHF 200/t, 4000 t
- One forest restoration project, total CHF 100k, CHF 100/t, 1000 t
- One riverbed restoration project, total CHF 200k, CHF 200/t, 1000 t
- Five biochar and soil restoration projects, CHF 400k, CHF 500/t, 800 t
- One low-cost biochar project, temporary subsurface storage, CHF 200k, CHF 200/t, 1000 t
- One agroecology and soil restoration project, total CHF 100k, CHF 100/t, 1000 t
- One geological storage project, first year CHF 300k, CHF 1000/t, 300 t
- One enhanced weathering project, first year CHF 100k, CHF 500/t, 200t

Analysis of this hypothetical portfolio:

- Total 14 projects, total investment CHF 2200k, total CO_2 removed 9300 t, average cost CHF 236/t
- Reserve CHF 925k (29.6% of 3125k), CO_2 removed 74.4%
- Capture: 82% biological, 18% chemical
- Storage: 75% biological, 25% geological
- 64% short-term removal, <CHF 250/t, 36% long-term learning, >CHF 250/t
- Costs of monitoring each project are included in the project

If interested in the

Swiss Negative Emissions Fund, or the pilot fund

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