Negative-emissions technology portfolios to meet the 1.5 °C target

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Negative-emissions technology framework

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PCF Dialogue 2: Avoiding Permafrost Thaw: Managing Temperature
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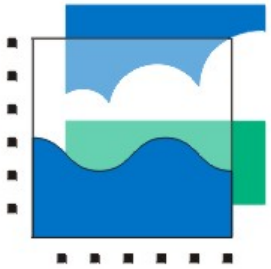
Universiteit Leiden
The Netherlands



CML
Institute of Environmental Sciences

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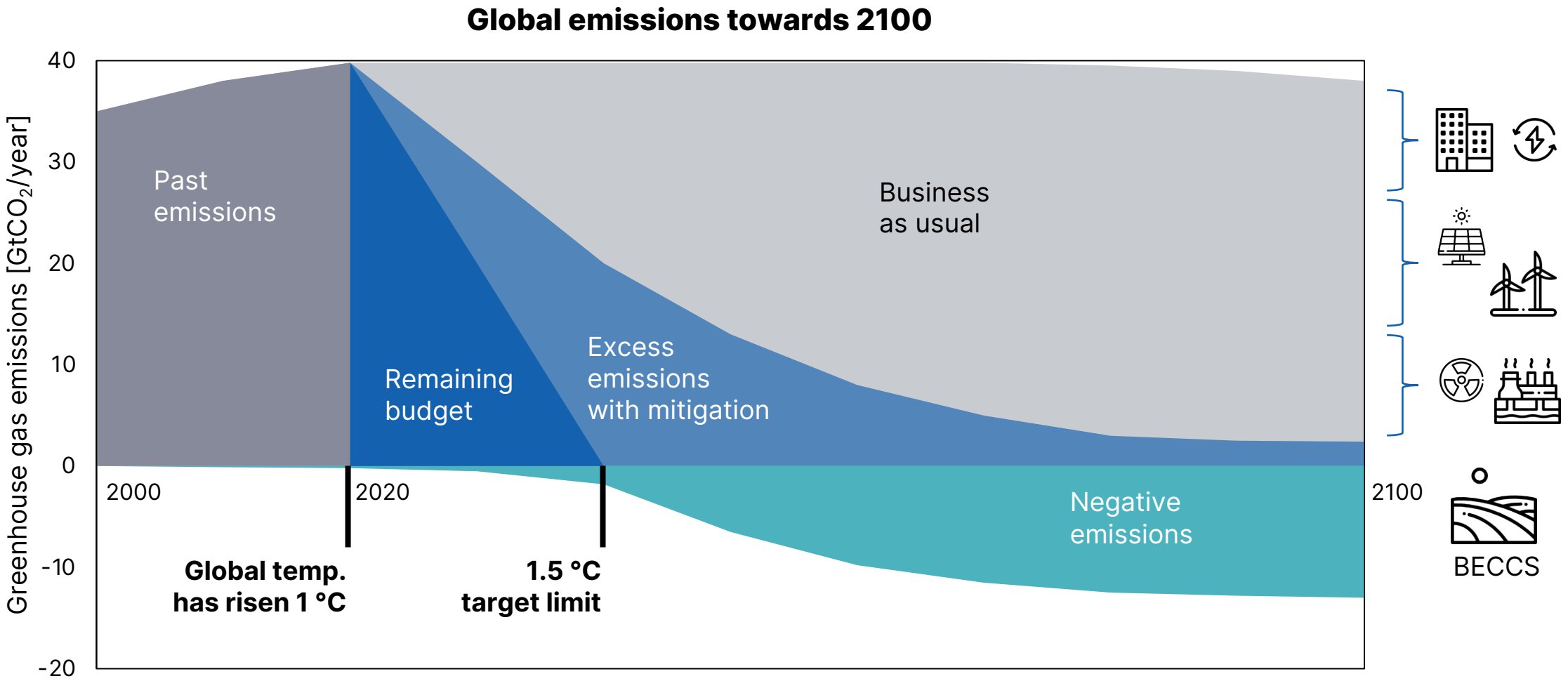
With a dwindling emissions budget, we need negative emissions to stabilize the climate.



The graph shows a plausible scenario without accurate values.
The icons were made by Freepik from flaticon.com.

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Many expect BECCS to deliver most of the negative emissions needed, but it is far from an ideal solution.

BECCS has a **large potential** to deliver **baseload, low-carbon energy**

Its **potential** to achieve sustainable **negative emissions** could be **limited**

Large-scale BECCS **can compromise biodiversity** and **food security**

BECCS could take a secondary role in negative-emissions portfolios

Photo by Edmarjr

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Afforestation and reforestation: a sustainable, low-tech, and low-cost solution with limited potential

Photo by Olena Sergienko on Unsplash

AR can help **improve biodiversity and ecosystem services**.

Its **potential is limited and vulnerable** to disturbances.

AR is **already late** to deliver its full potential this century.

Its **implementation** can be **challenging**.

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Soil carbon sequestration is a no-regrets climate solution with negative-costs opportunities.

SCS side impacts – improved resilience and production – **justify its adoption**.

Soil sinks **saturate very quickly and are reversible** if management practice ceases.

SCS **impact is vulnerable** and difficult to measure.

Its **potential is limited** but we can harness it **in the short to mid term**.

Photo by Immo Wegmann on Unsplash

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Biochar: carbonize biomass to store carbon and improve soil health

Biochar can have **positive side impacts** like increasing crop productivity and reducing drought.

It can **compete for biomass** resources.

Its effect and **impacts** remain **uncertain.** It has **not** been **implemented at a large scale.**

Biochar is **not as cheap** as afforestation or soil carbon sequestration.

Photo from Titan Biochar

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Enhanced weathering: an engineered solution with a large but uncertain potential worth further exploring

Terrestrial EW can have a large **cost-effective potential by 2050.**

In oceans (ocean alkalinity), its effect and impacts remain **highly uncertain.**

EW **permanence** of storage can be the **highest** among NETs (up to 10^6 years).

More field experiments can clarify potential, impacts, and feasibility.

Photo by jez s

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Direct air capture: once it becomes viable at scale, it can be the most effective NET to mitigate climate change.

Carbon Engineering

Global Thermostat

climeworks

Photo by Carbon Engineering

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Direct air capture: once it becomes viable at scale, it can be the most effective NET to mitigate climate change.

DAC has seemingly **unlimited potential** but **scaling it up is challenging.**

Its **accountability** and **controllability** are the highest among NETs.

It can become **cost-effective under 1.5°C climate policies.**

Photo by Carbon Engineering

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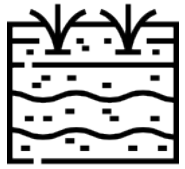
Several promising negative-emissions solutions can make up a diversified technology mix.

Natural solutions

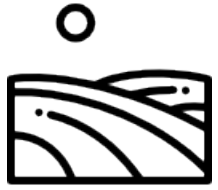
Afforestation & reforestation

Biochar

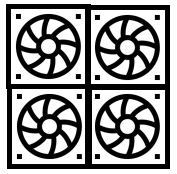


Soil carbon sequestration

Engineered solutions



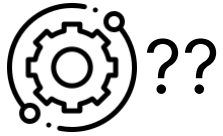
Bioenergy with CCS



Direct air capture

Enhanced weathering

$$$$



Icons from flaticon.com. The “check mark” was made by Becris; the rest, by Freepik.

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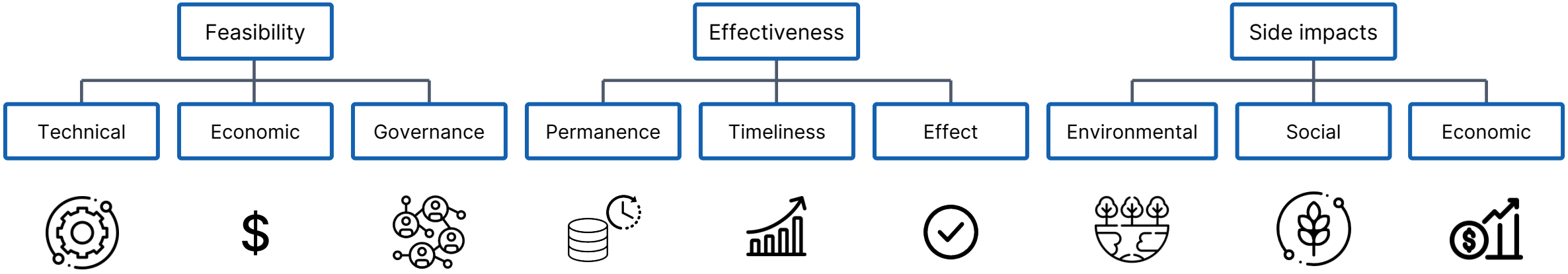
An intuitive and comprehensive framework helped evaluate alternatives and define sound portfolios.

Evaluation criteria



1-9 TRL

$/ton$CO_2$ in 2050

Principles of Good Gov.

From 10^2 to >10^4 years

Time to max cap.

Consensus of scientific bodies

THE ROYAL SOCIETY

ROYAL ACADEMY OF ENGINEERING

MCC Mercator Research Institute on Global Commons and Climate Change

Main sources considered for the side impacts evaluation: Fuss et al., 2018; Minx et al., 2018; Shepherd, 2009; Royal Society and Royal Academy of Engineering, 2018

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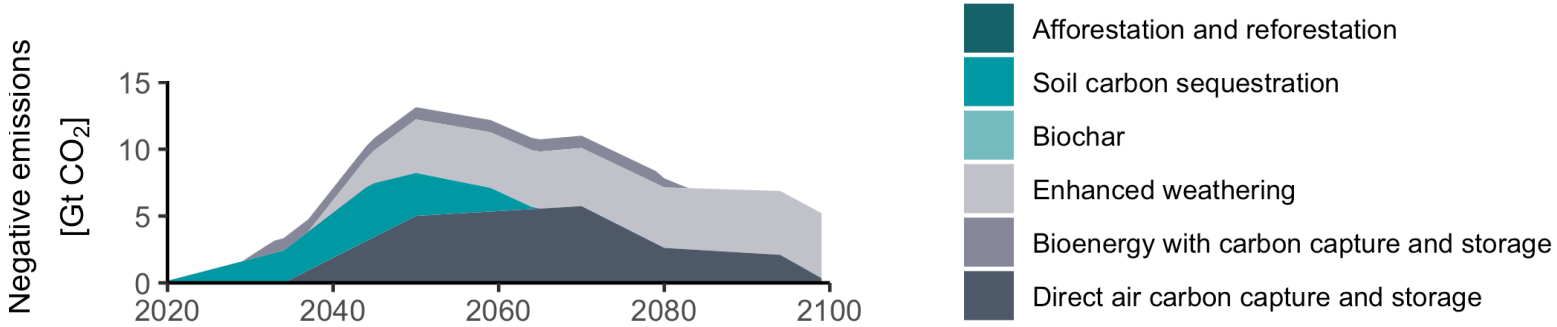
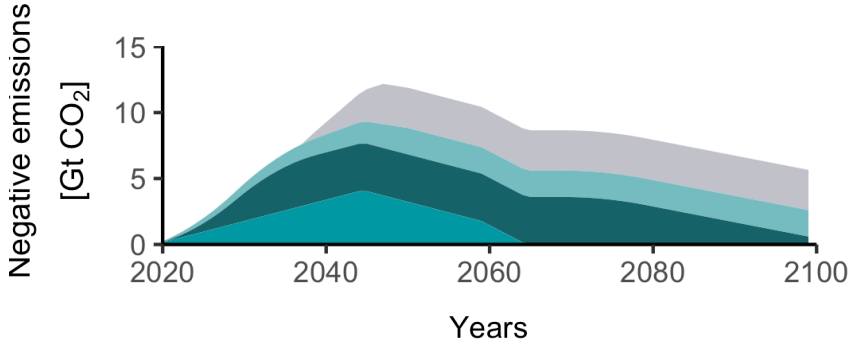
Balanced portfolio



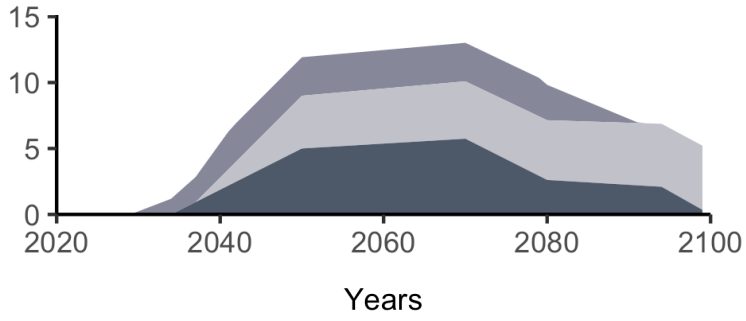
Medium-need estimate for negative emissions (i.e., under SSP2)

Total: 620 $GtCO_2$

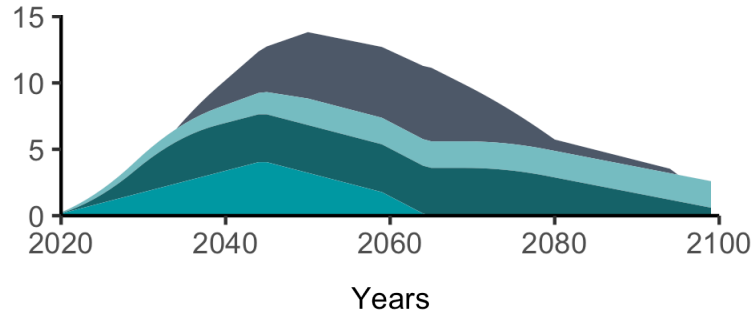
Most affordable portfolio



Most effective portfolio



Most sustainable portfolio



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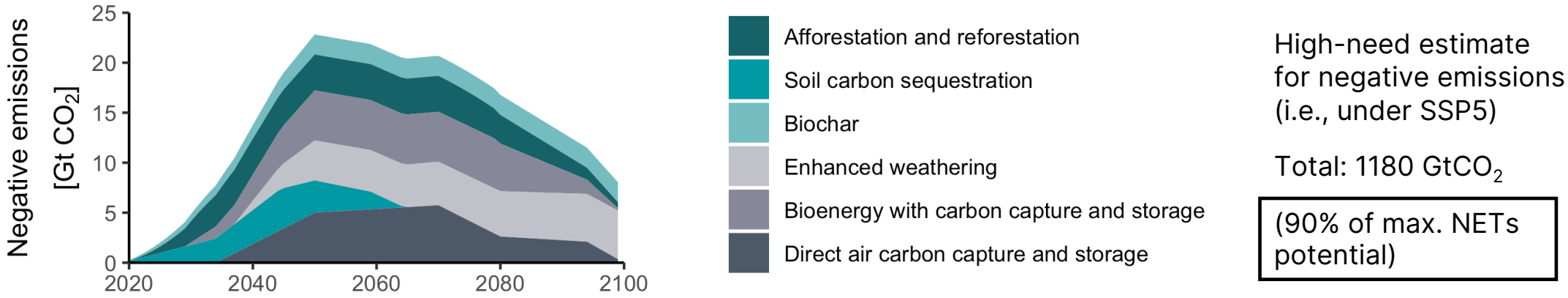
A high need for negative emissions requires all NETs potential.

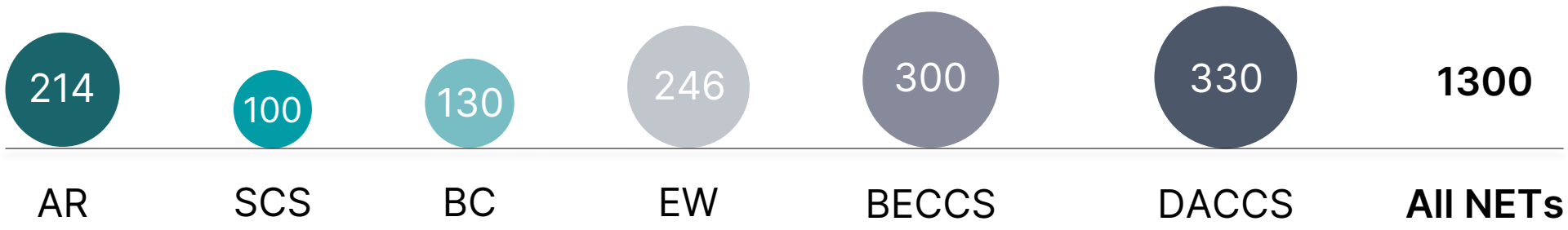


High-need estimate for negative emissions (i.e., under SSP5)

Total: 1180 $GtCO_2$

(90% of max. NETs potential)

Maximum potential [$GtCO_2$] for the period 2021-2100



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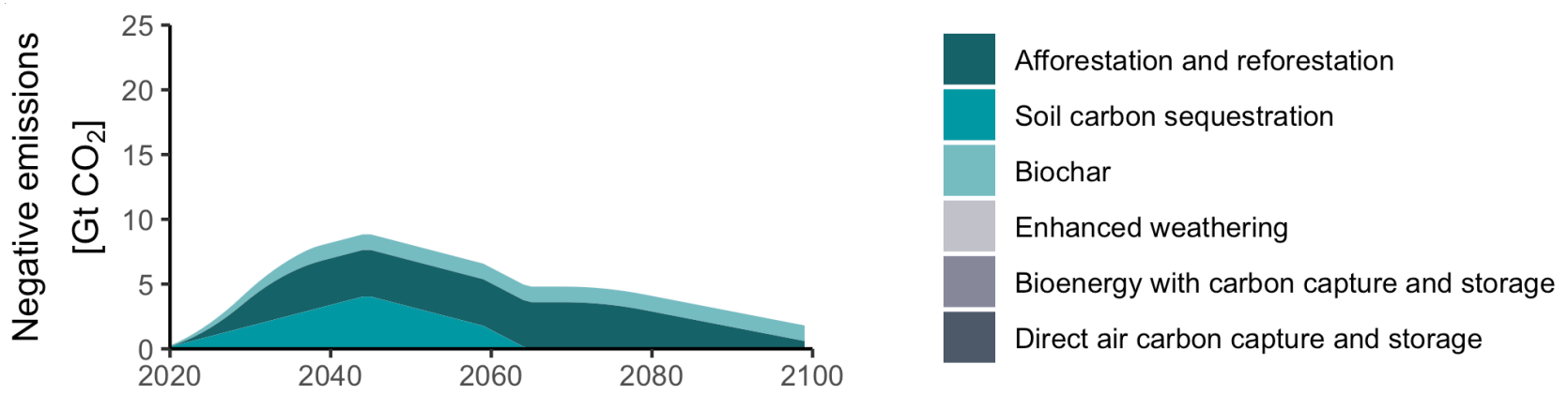
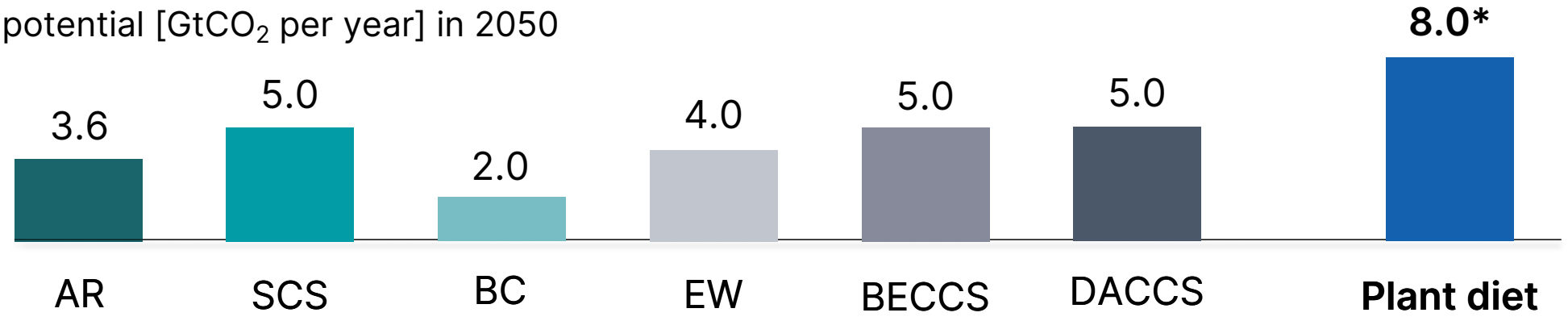
Systemic changes can minimize – for free – our reliance on negative emissions.



*IPCC estimates that adopting plant-based diets globally would reduce emissions by 8 $GtCO_2$ per year

Maximum potential [$GtCO_2$ per year] in 2050



Maximum potentials, according to review on NETs by Fuss et al., 2018
*IPCC, 2019: Special Report on Climate Change and Land

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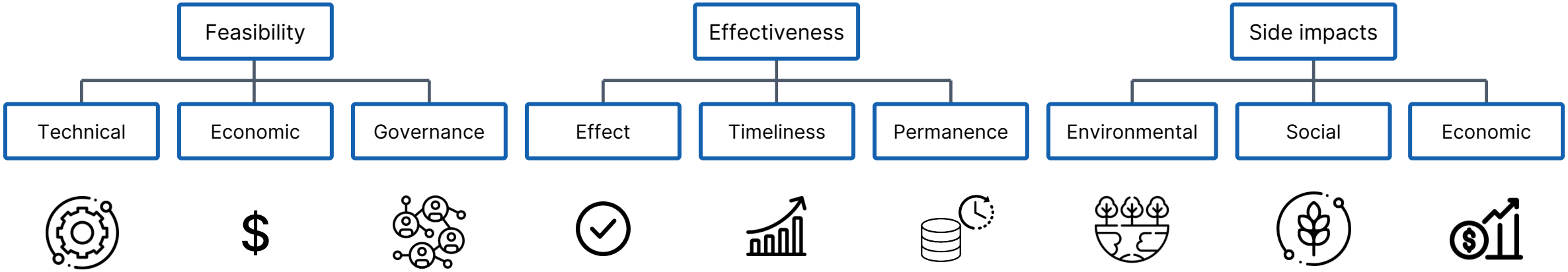
NETs tackle global warming's root cause, but they have a small window of opportunity.

SRM methods can provide a valuable temporary solution



Stratospheric aerosols, compared to direct air capture, can have a faster but riskier effect

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Performance of stratospheric aerosols in comparison to direct air capture is based on the assessment made by Shepherd, 2009.

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