



Mercator Research Institute on
Global Commons and Climate Change



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Centre for Climate

Options for Carbon Dioxide Removal

Jan C. Minx

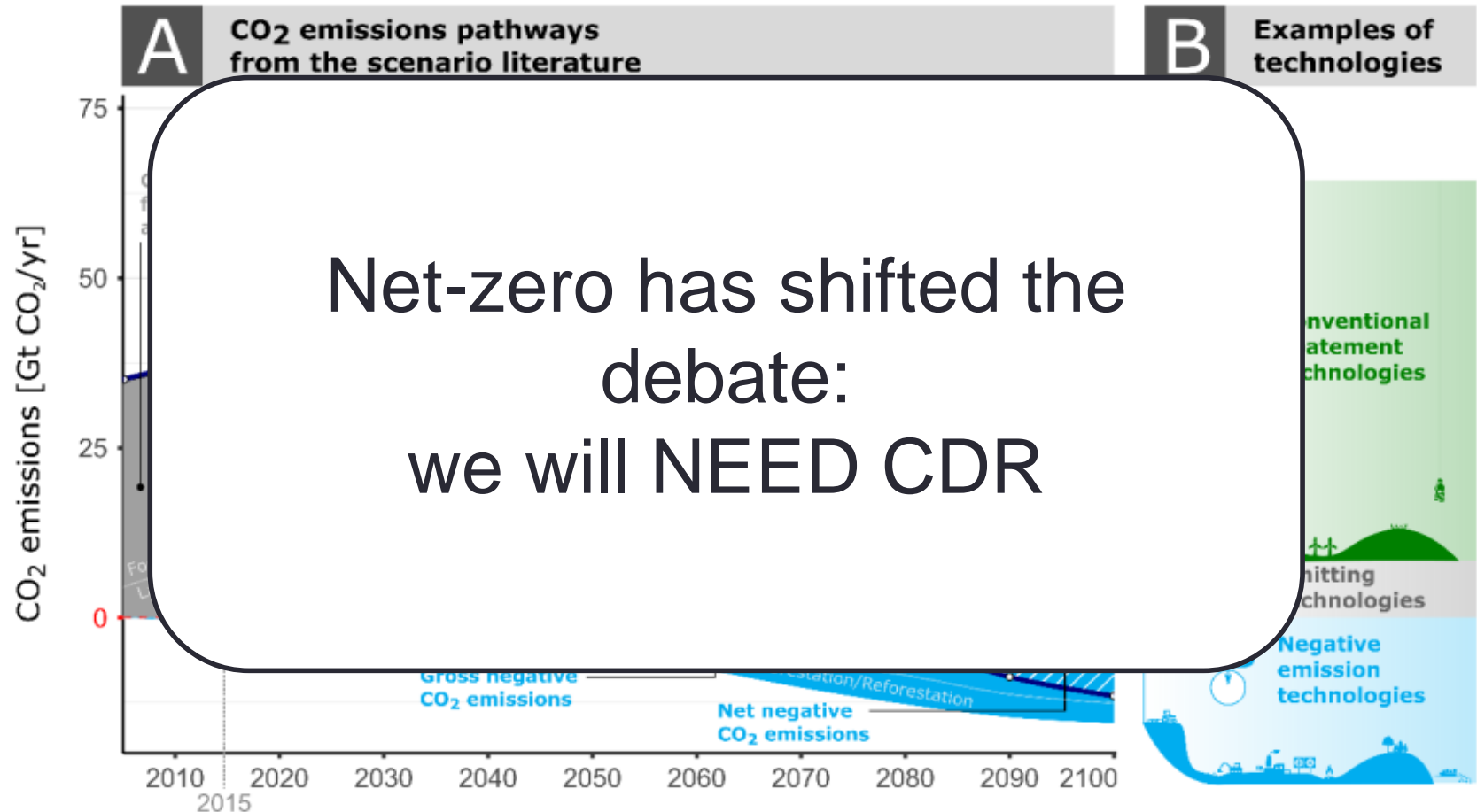
Final Symposium – BMBF-PEP1.5

PIK Potsdam

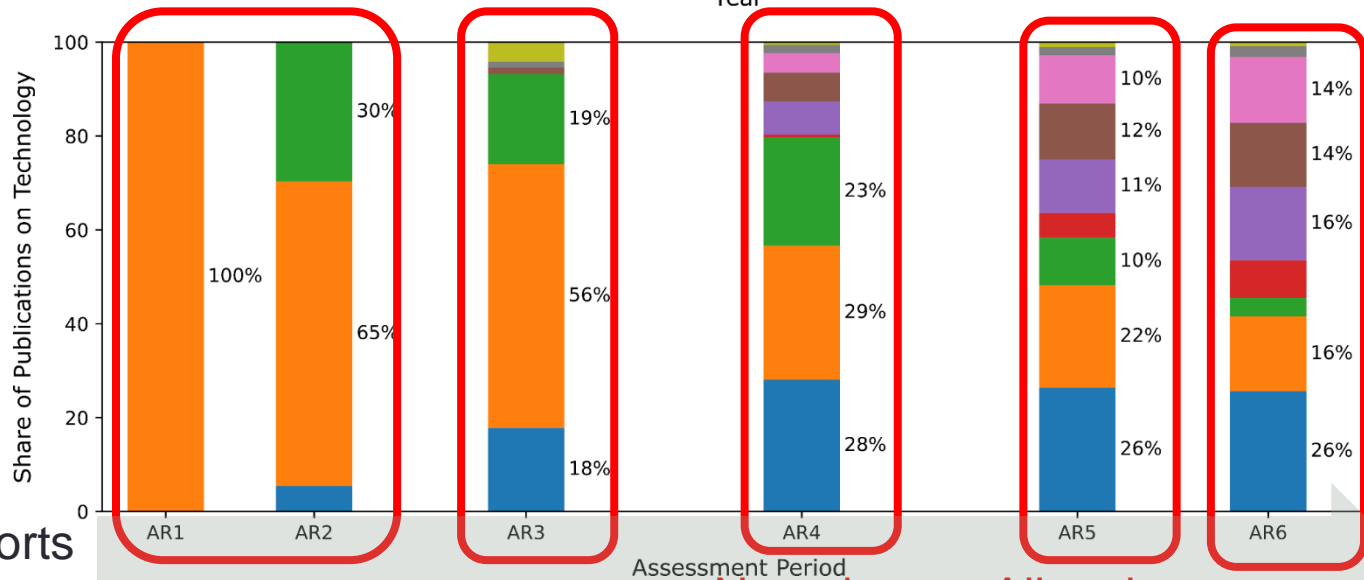
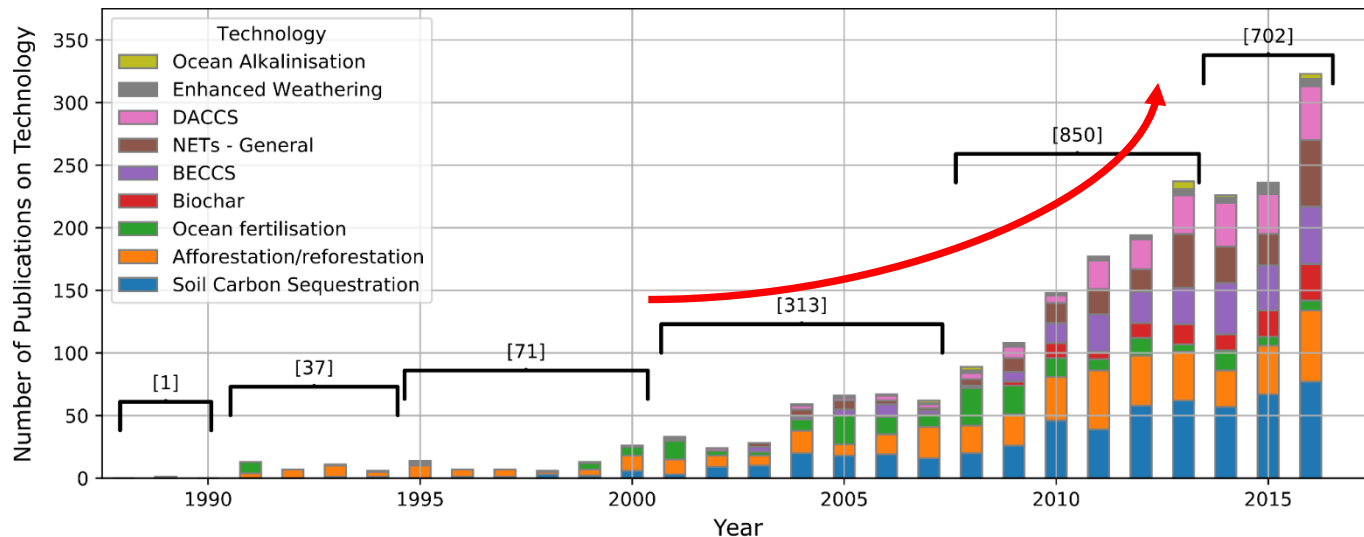
03.09.2019



Net-zero emissions & carbon dioxide removal



From discussions of individual CDR options towards portfolios



AR & OF sink enhancement Biological Negative emissions All major CDR options ?

Minx et al. (2018), Negative Emissions – Part 1: Research landscape and synthesis, *Environ Res Lett.*

IPCC Reports

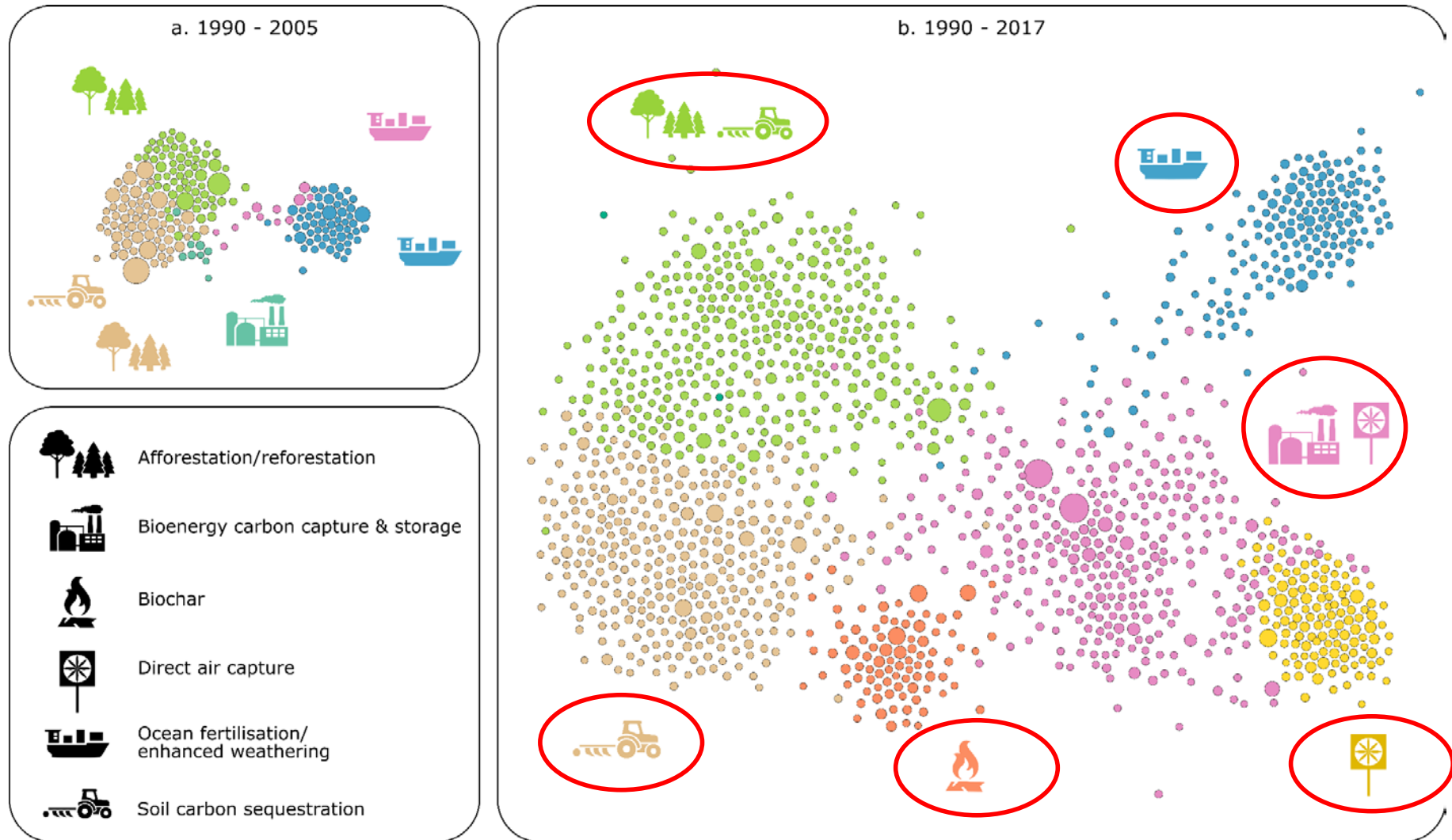


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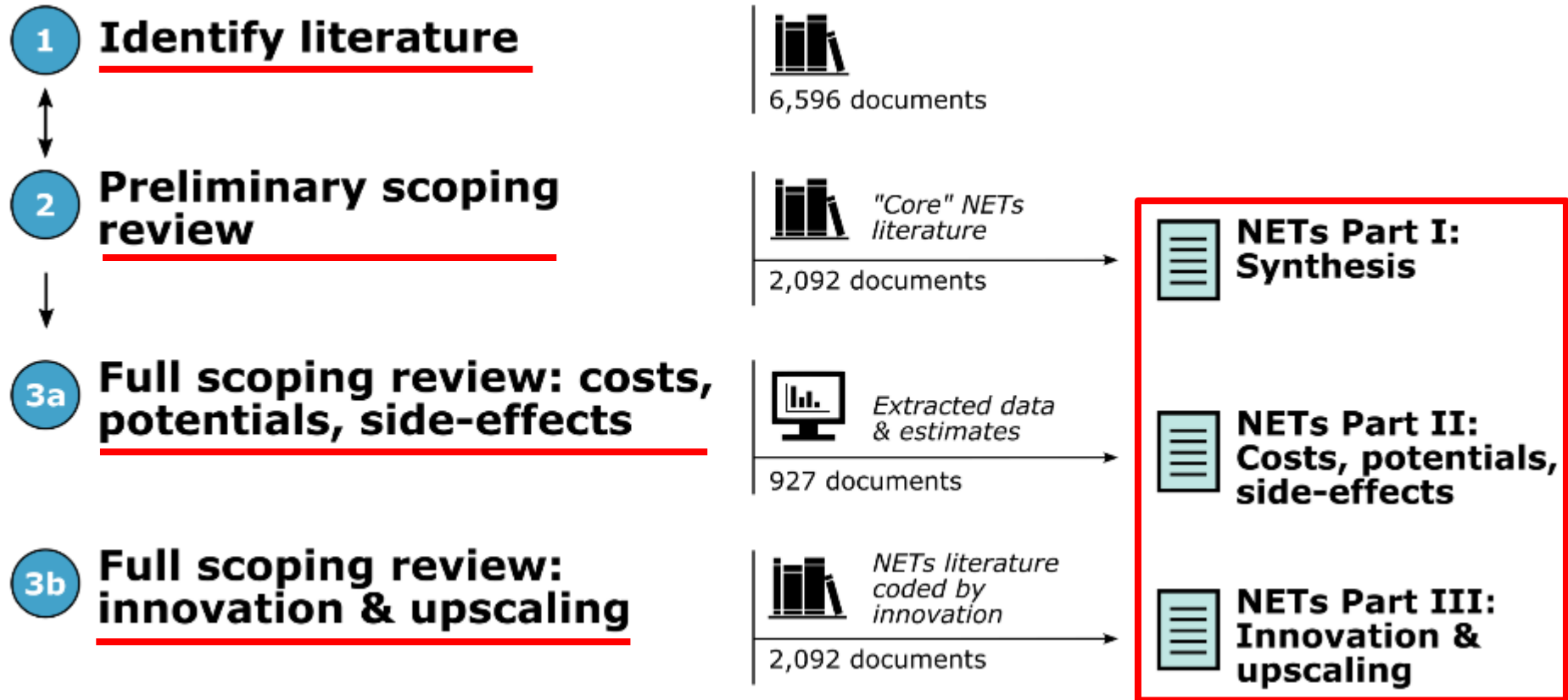
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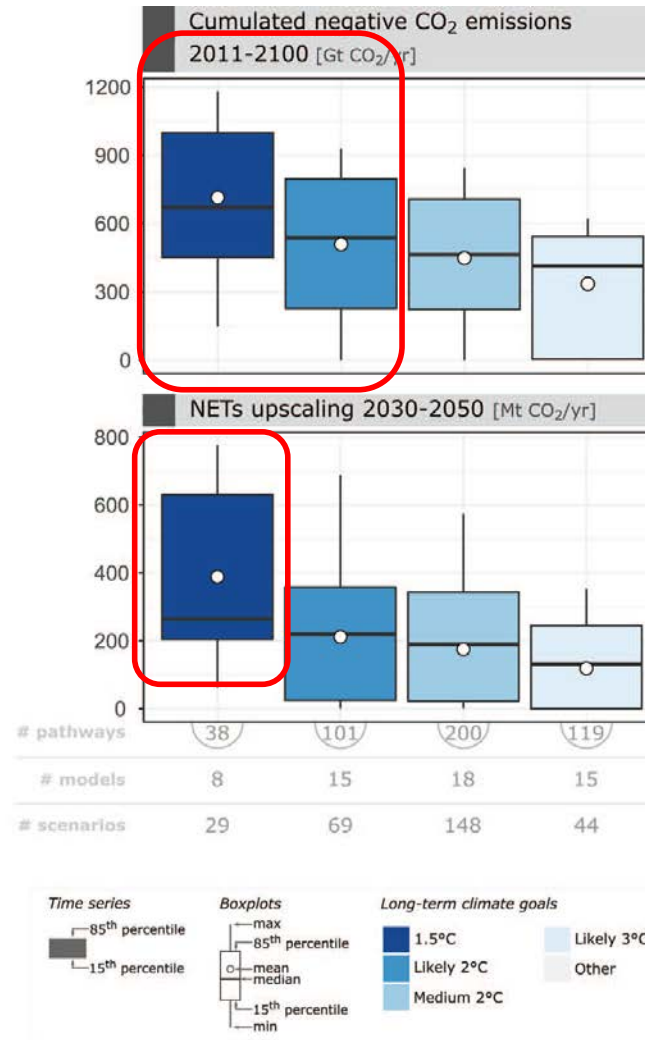
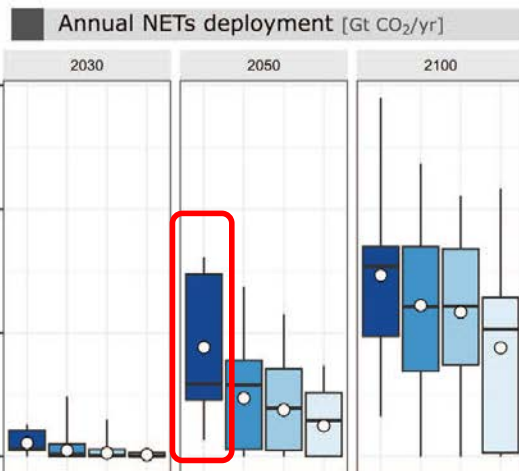
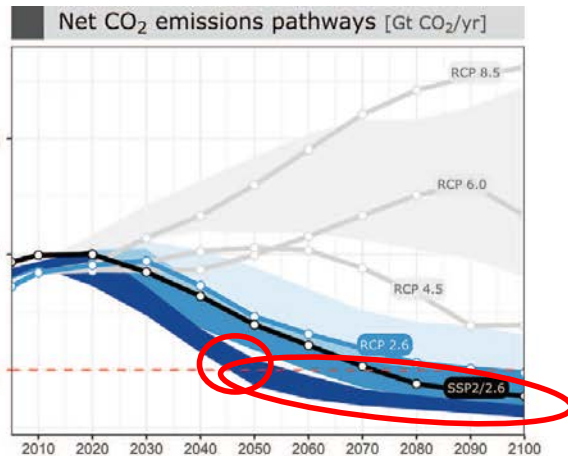
Matured clusters of scientific research around the various CDR options



Assessing the CDR space – linking bottom-up and top-down



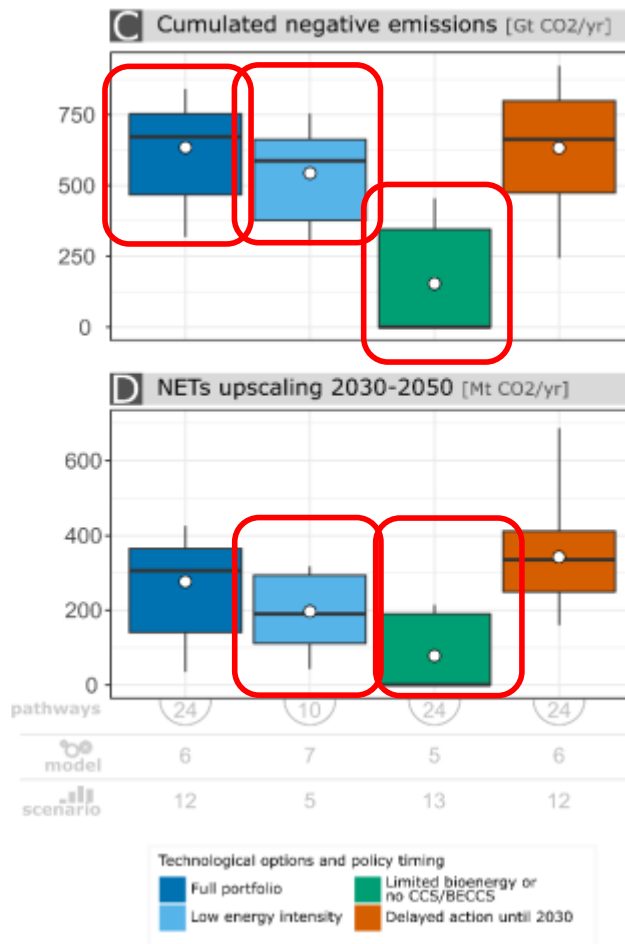
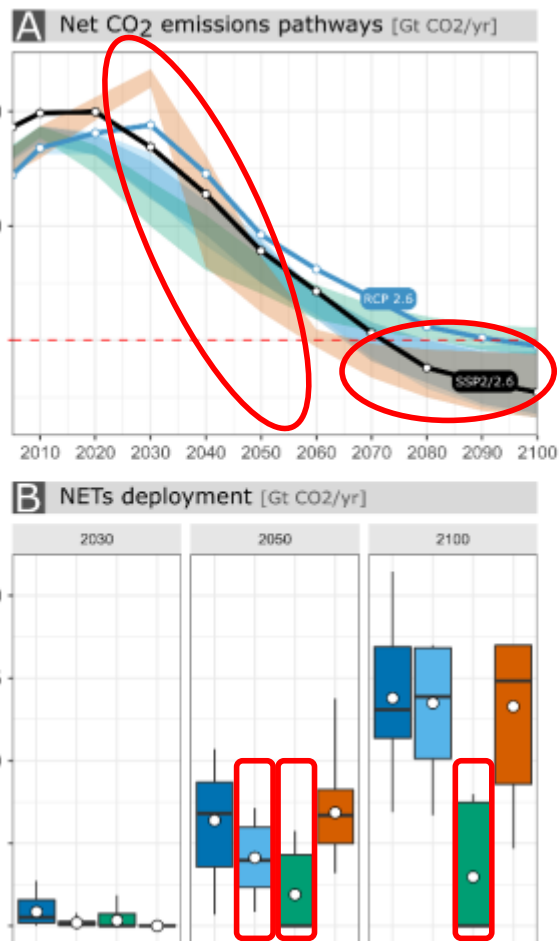
While 1.5°C fundamentally depend on CO₂ removal, this is not the case for 2°C scenarios



- Carbon budget for 1.5°C is small and finite
- Fully decarbonized world economy by 2050 (sharp emissions reductions)
- Sustained period of deep net negative emissions thereafter
- Up to 15Gt of NETs deployment in 2050
- Near-term upscaling substantially faster in 1.5°C scenarios
- All 1.5°C scenario require NETs – not the case for 2°C



NDC trajectory leads to similar dependence on CO₂ removal in 2030 like for 1.5°C limit today

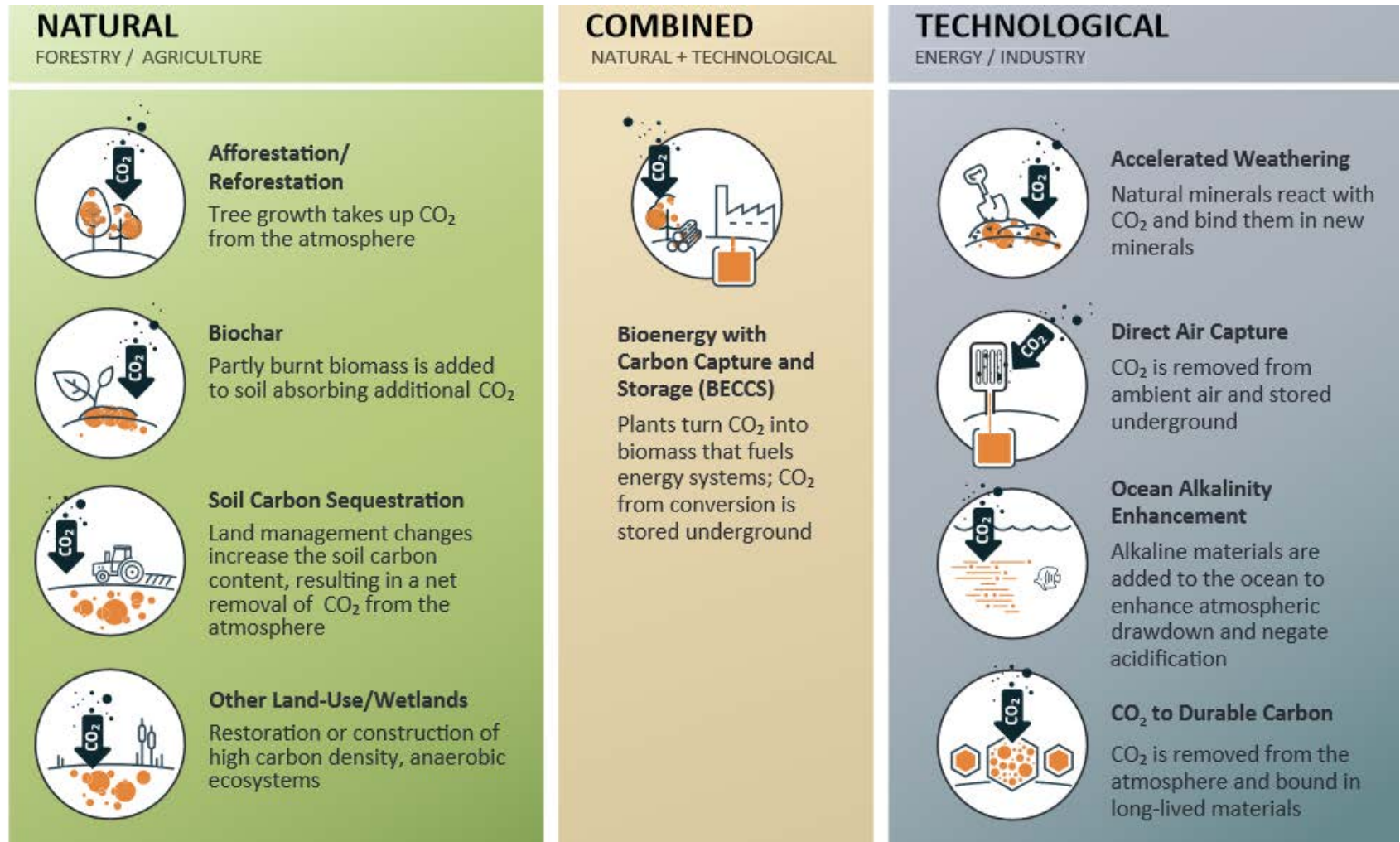


Role of NETs varies in 2°C scenarios, but can still be limited:

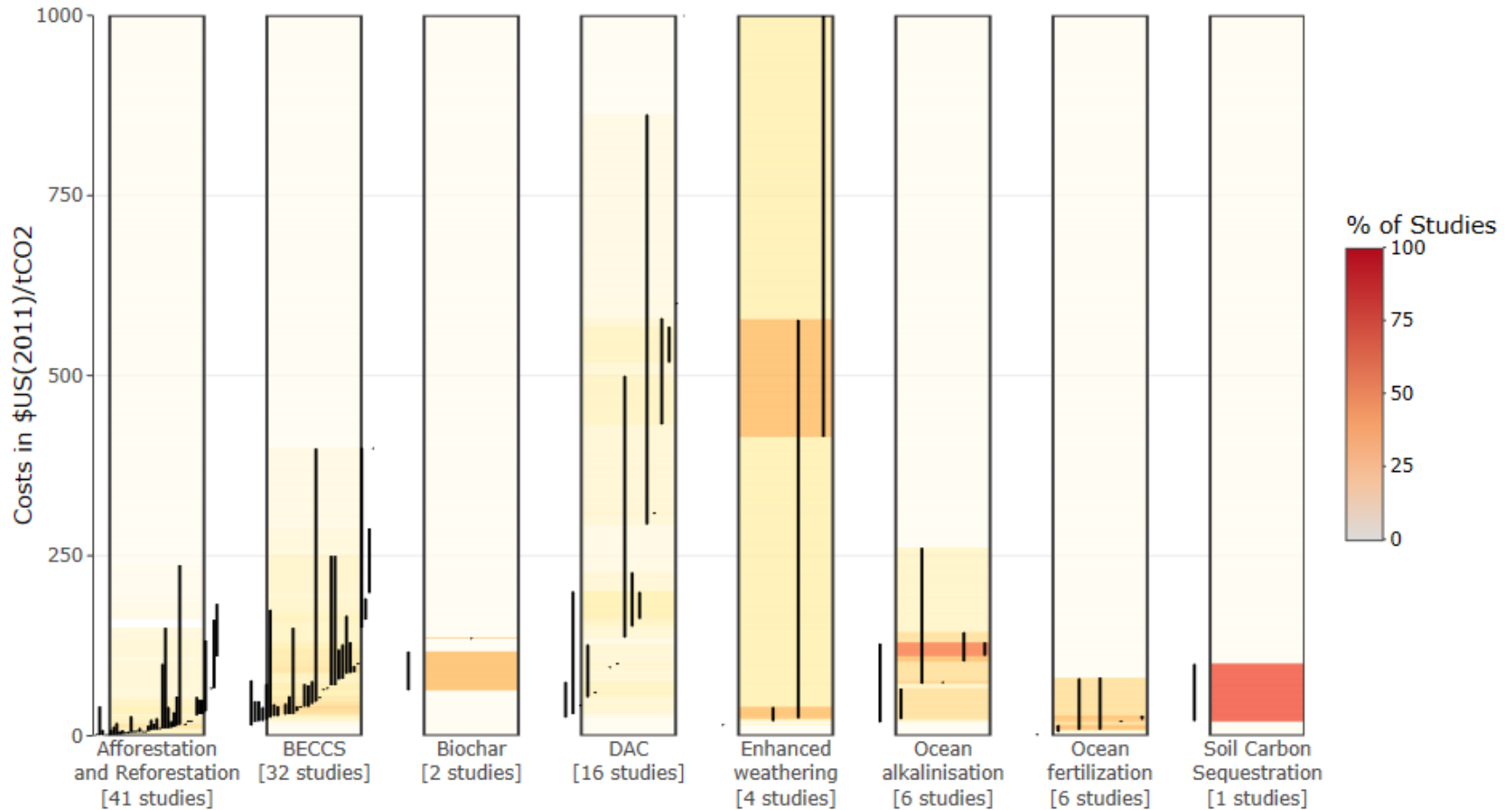
- Full tech, immediate action scenarios feature large-scale NETs deployment
- There are scenarios without or limited NETs deployment
- Low energy demand pathway provide additional flexibility for NETs deployment



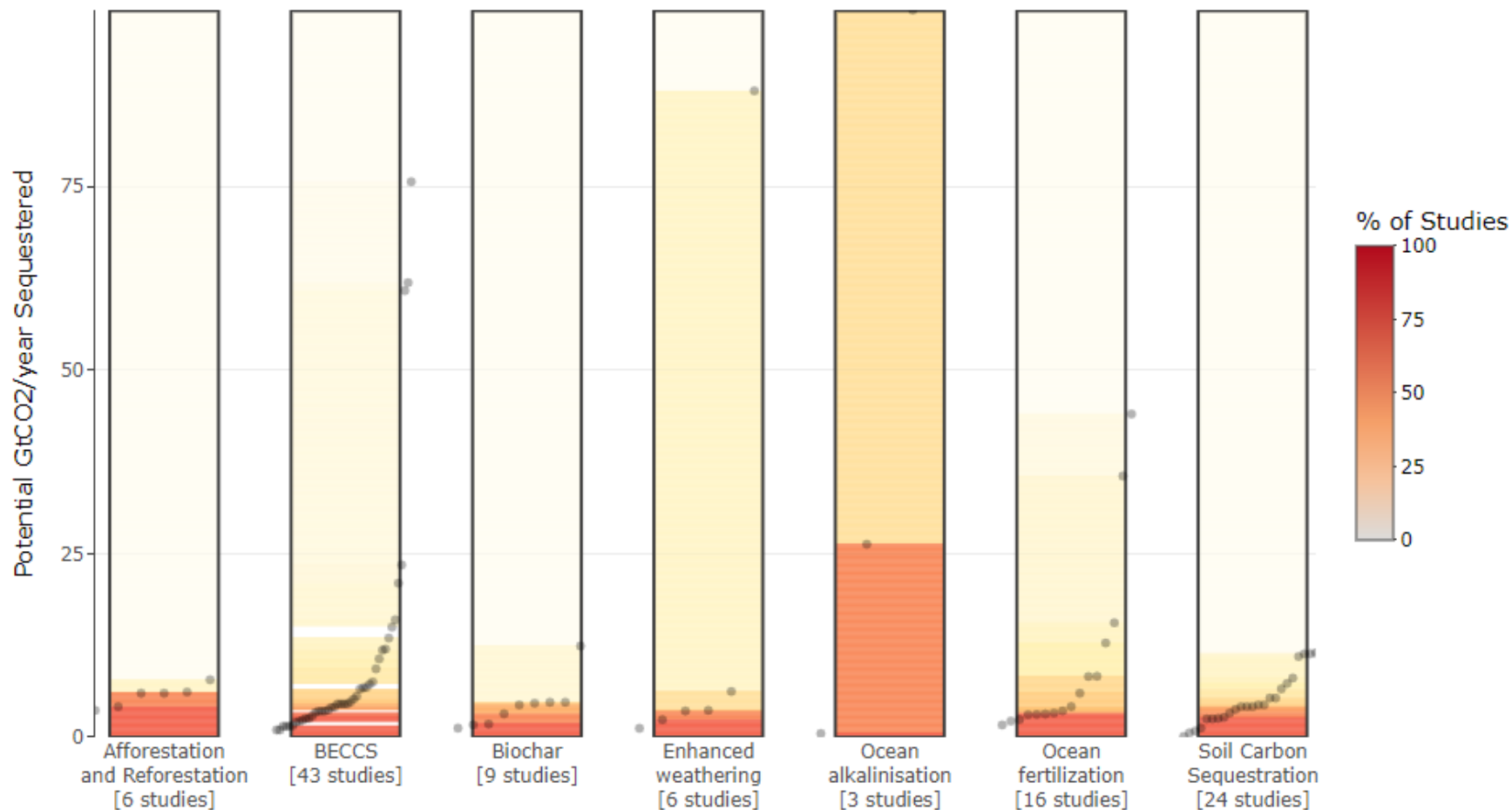
While the recent discussions have mainly focussed on BECCS, the spectrum of options is large



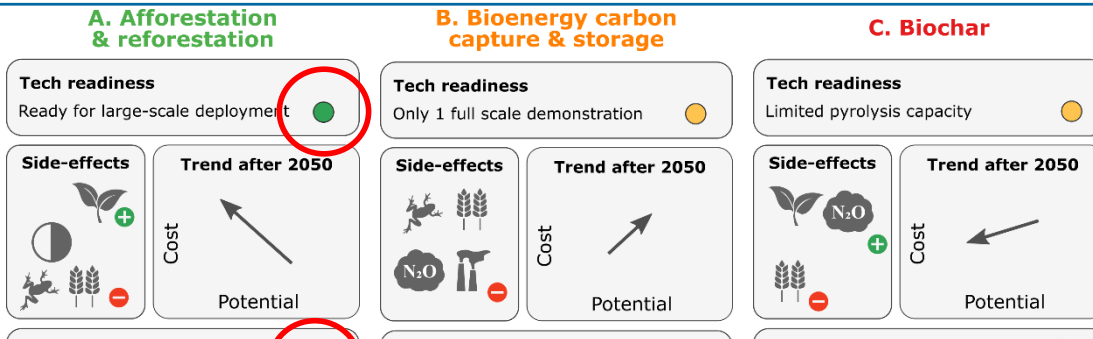
Costs (US\$/ton CO₂ in 2050)



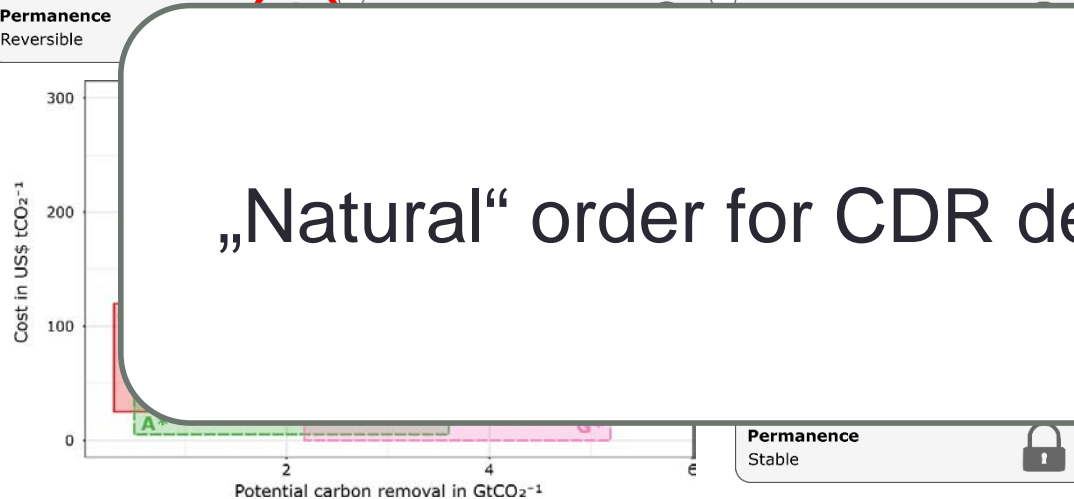
Non-additive potentials (Gt CO₂/year in 2050)



Most CDR options show relevant potentials, but all have limits

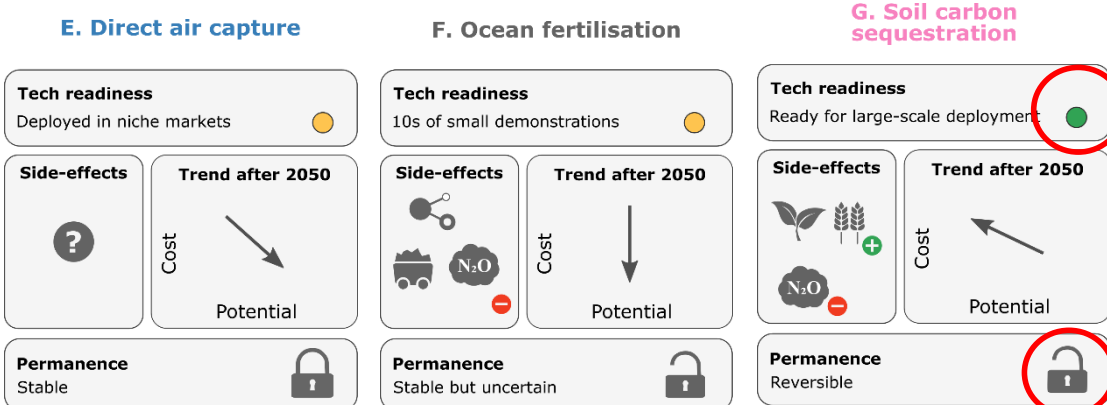


- Relevant potentials for all CDR options, except ocean fertilization
- Potentials are all constrained by bio-



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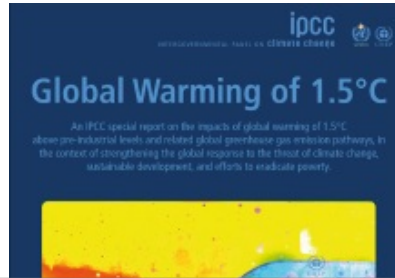
options, each deployed at modest scales can hedge risks and seem more realistic



- Important differences in development status and secure CO₂ storage

Evidence synthesis is a lot of work - but it is worth it!

- Prominently picked up by recent climate change assessments
- A series of scientific assessments
- Large public request for evidence synthesis by Government, Commons, Royal Society, German NGOs, etc.
- Wide media-coverage
- Triggered German Roundtable on Negative Emissions



Need to organise synthesis process for AR6!

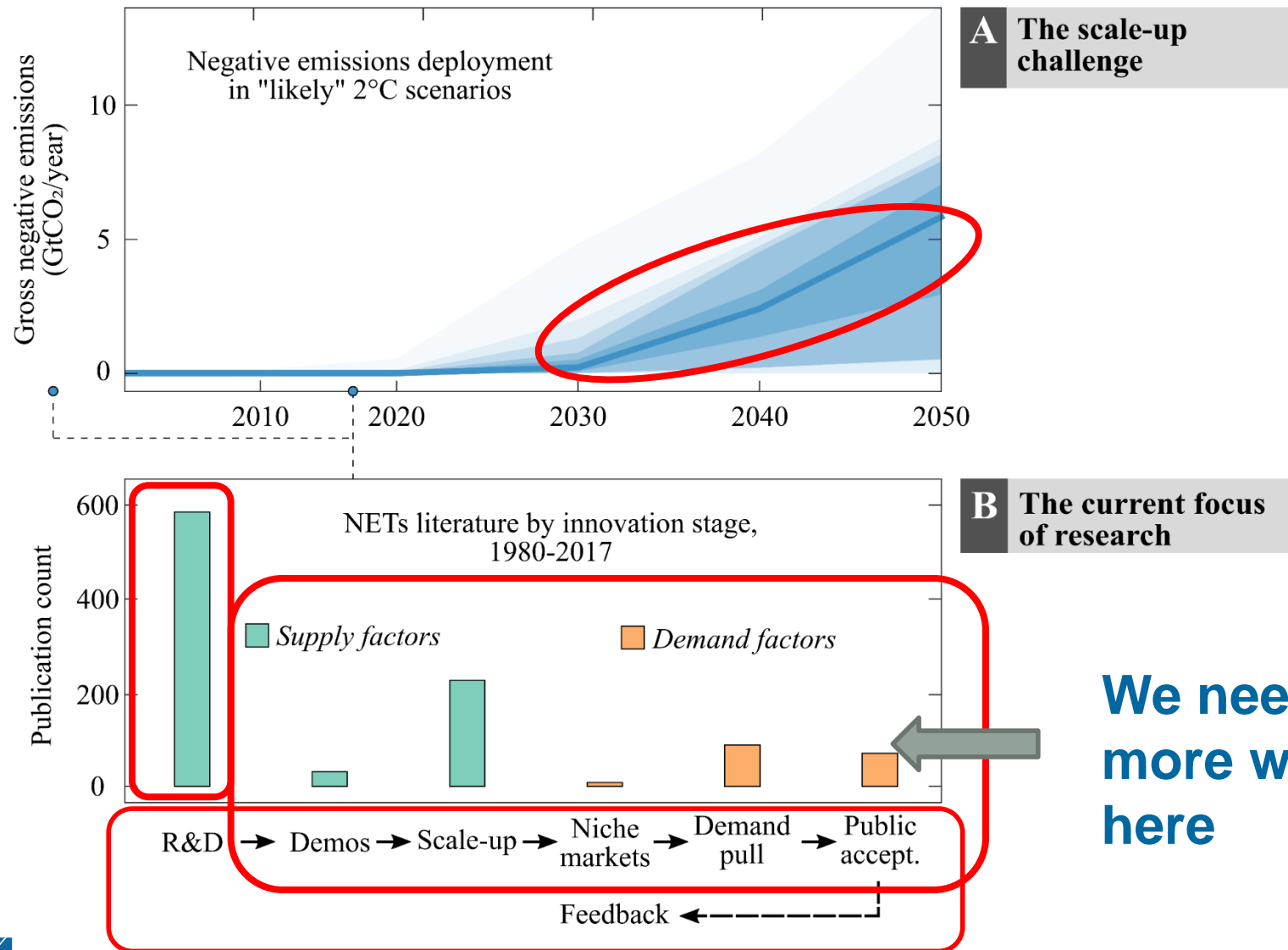


Weigh the ethics of plans to mop up carbon dioxide
Pinning climate hopes on negative emissions technologies is dangerous and demands reflection on the social aspects, warn Dominic Lavelle and colleagues.

As the Intergovernmental Panel on Climate Change (IPCC) releases its special report on keeping global temperature rise within 1.5°C above pre-industrial levels, governments are being urged to consider the ethical implications of the technologies that would be required to reach net-zero emissions by 2050. The report, which is the first of its kind, outlines the need for negative emissions technologies (NETs) to be deployed at scale. However, it also warns that the deployment of NETs could be socially and ethically challenging, particularly if it involves large-scale land use changes or the capture and storage of carbon in geological formations. The report calls for a 'just transition' to net-zero, one that takes account of the needs of all people and communities, and that is based on equity, justice and the principles of sustainable development.



Technological transitions often take time! Urgency in developing CDR portfolios

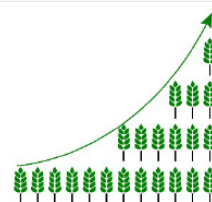
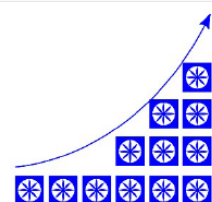
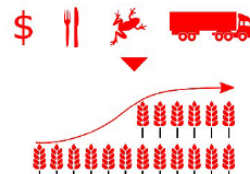



The need for acceleration in innovation and diffusion of CDR technologies



Minx and Nemet (2018), The inconvenient truth about carbon capture, *Washington Post*;
Figure by William Lamb (MCC)

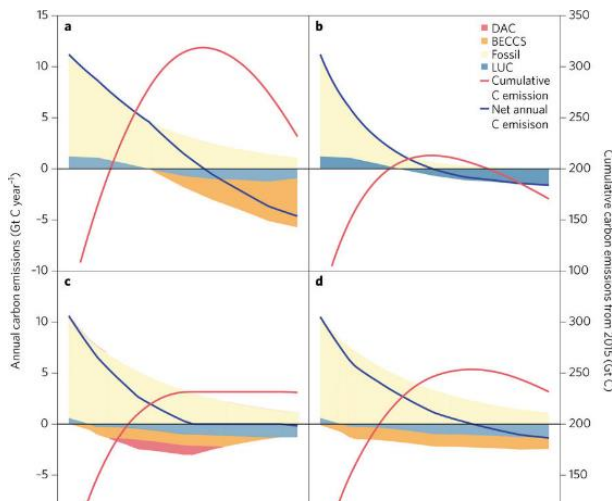
Requirement to spell out development paths

Innovation archetype	Technology role model	CDR analogue	BECCS	DACCS
High-tech, iterative disruptive	PV	DAC	 <p>Yields</p> <p>Efficient BECCS plants are powered by very high yield biomass with limited land footprint and algae options. Competition with food and/or biodiversity is avoided, via synthetic food routes, high-yield C4 plants, and/or humanity giving up on biodiversity.</p>	 <p>Innovation</p> <p>Considerable innovation in DACCS leads to reduce investment cost, and higher potential in low-cost locations/logistics. The energy demand of DACCS can be matched by a low-cost energy system based on PV and storage technologies for electricity and/or heat.</p>
Low-tech, small, distributed	Green revolution	Soil carbon sequestration	 <p>Land</p> <p>The technological development of BECCS remains slow because of the high costs of land and logistics. Land competition with food, biodiversity and human settlements emerges as a key barrier, resulting in high land prices.</p>	 <p>Energy</p> <p>DACCS innovation ramps up only slowly, and so does demand for this technology. Logistical issues, high and costly energy demand and technological costs prevent DACCS from falling below \$200 even after many innovation phases.</p>
Large, system integration intensive	Chemical plants	BECCS		



Nemet (2019), How solar energy became cheap, Routledge; Creutzig et al. (2019), The mutual dependence of negative emissions technologies and energy systems, *Energy Environ Sci*

Major avenues for research



- Closing the innovation gap – accelerating development and diffusion
 - Models of innovation for CDR
 - Public perceptions
 - Policy design & instruments
- Learning about the CDR policies & governance
 - Evidence synthesis
 - Ex-post policy assessments
 - Policy design & instruments
 - Governance
- CDR portfolios & pathways and their risks
 - Scenario analysis from differ
 - Political economy & socio-technical transitions
 - Evidence synthesis: co-benefits & risks

Take away messages

- **CDR has arrived in policy - growing understanding that CDR is essential for meeting climate goals – net zero fundamental**
- **There are more technologies available than BECCS with relevant potentials.**
 - Potentials are all constrained by bio-physical or economic limits.
 - Any single CDR option unlikely to provide the potentials observed in many scenarios sustainably: Portfolios of multiple NETs, each deployed at modest scales seem more realistic.
- **There is a large gap between CDR upscaling in scenarios and in reality.**
 - Limiting dependence on CDR through a rapid scale-up of short-term action
- **Concerted, community driven research agenda needed around policy, governance and innovation and linkage to scenarios work**



Thanks!



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the Potsdam Institute for Climate Impact Research



Things to work towards in AR6

- Clear home for CDR synthesis & common approach across chapters (sound top-down/ bottom-up link)
- Clear conceptual framing around net-zero that takes into account related discourses such as committed carbon



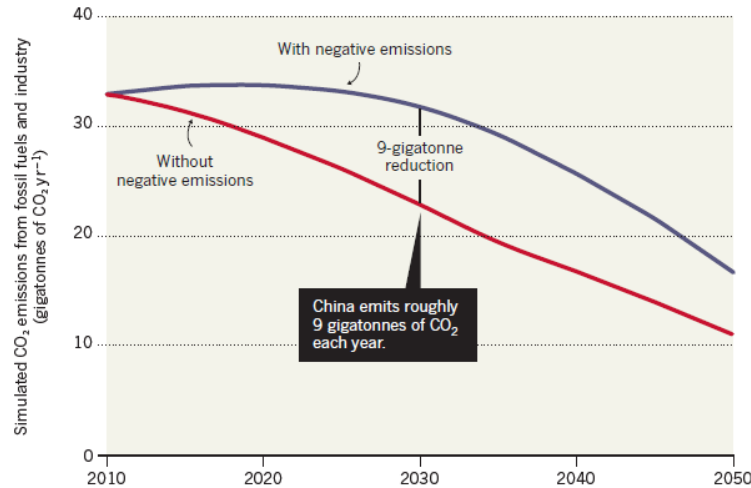
Insufficient ethical discussion around CO₂ removal

THREE-FOLD FOLLY

Technologies that capture carbon dioxide on a planetary scale might help to avert dangerous levels of climate warming, but they are risky.

COULD DELAY CUTS

Policy makers and industry could delay the reduction of emissions in the belief that these can be clawed back later with negative emissions.



REQUIRES STEEP SCALE-UP

Designing climate policy around technologies that might never sufficiently scale up is a gamble.

□ = 100 biomass power plants with carbon capture and storage

Future generations would bear the burden of failure to scale up negative emissions.

3 demonstration plants exist today

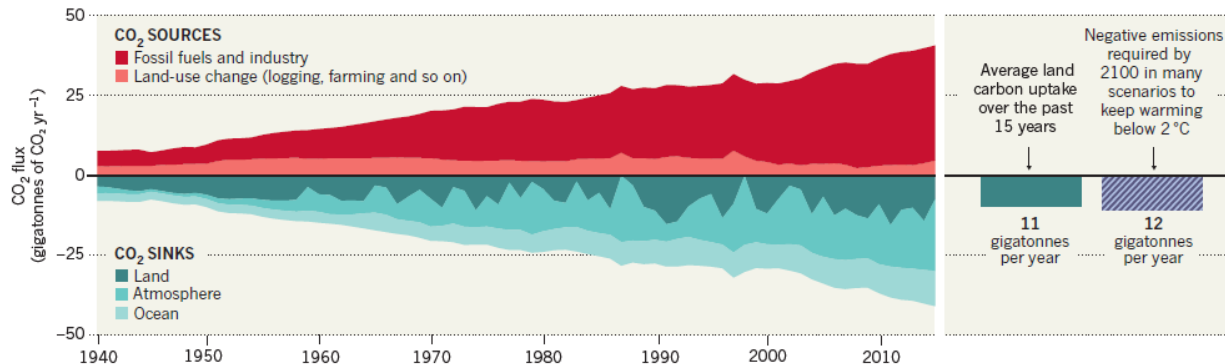
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16,000

DEMANDS UNPRECEDENTED SINK

The scale of negative emissions required in many scenarios would mean controlling a massive carbon sink (purple bar) — larger than the entire current natural land sink.



Lenzi et al. (2018), Weigh the ethics of plans to mop up carbon dioxide, *Nature*