



POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH

Rein in die Atmosphäre, raus aus der Atmosphäre? Die Bedeutung von CO₂-Entnahme aus der Atmosphäre für den Klimaschutz

Dr. Jessica Strefler

5. Dezember 2018

13. Master Class Course Conference Renewable Energies

Das Paris Abkommen

Nations Unies

Conférence sur les Changements Climatiques 2015

COP21/CMP11

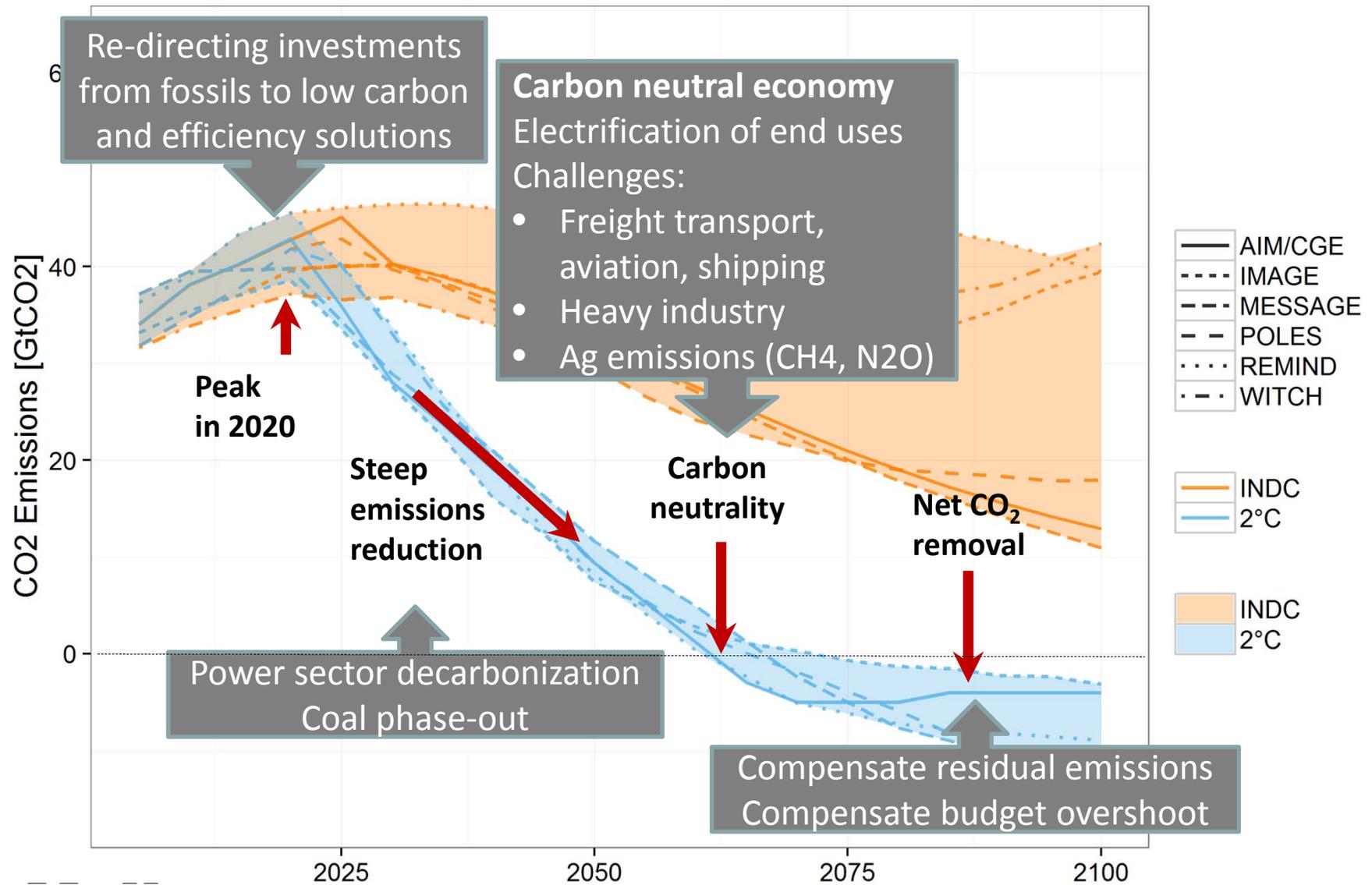
Paris France



Bis 2030: Nationale **CO₂ Minderung** (nationally determined contributions, **NDCs**)

Nach 2050: **CO₂-Entnahme** – Ausgleich unvermeidbarer Emissionen

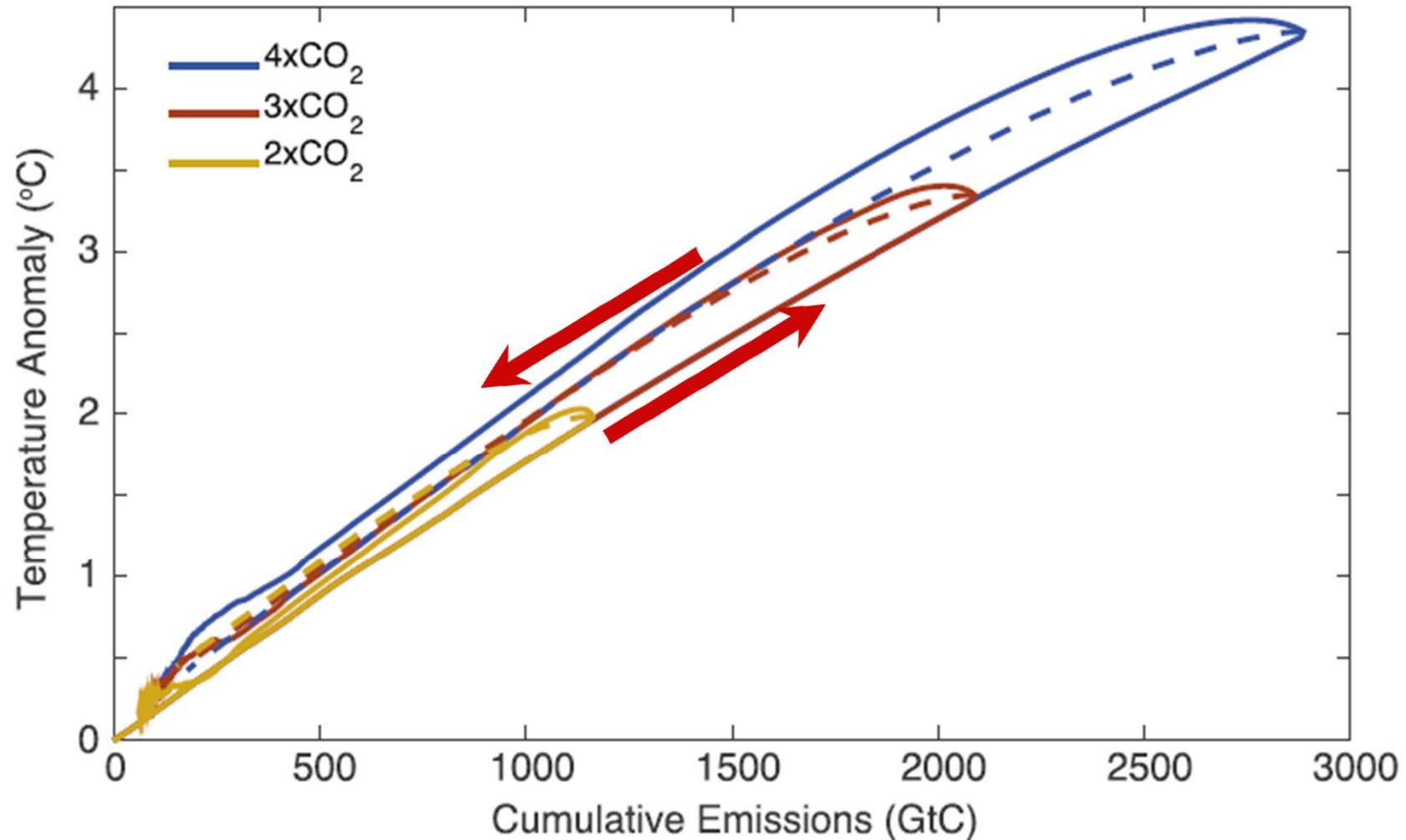
General Structure of Mitigation Pathways



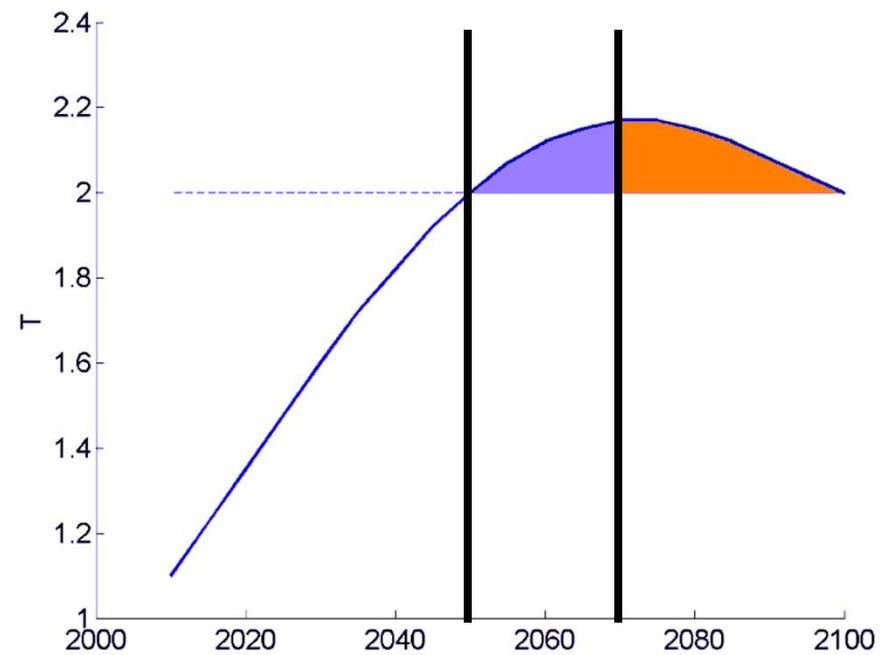
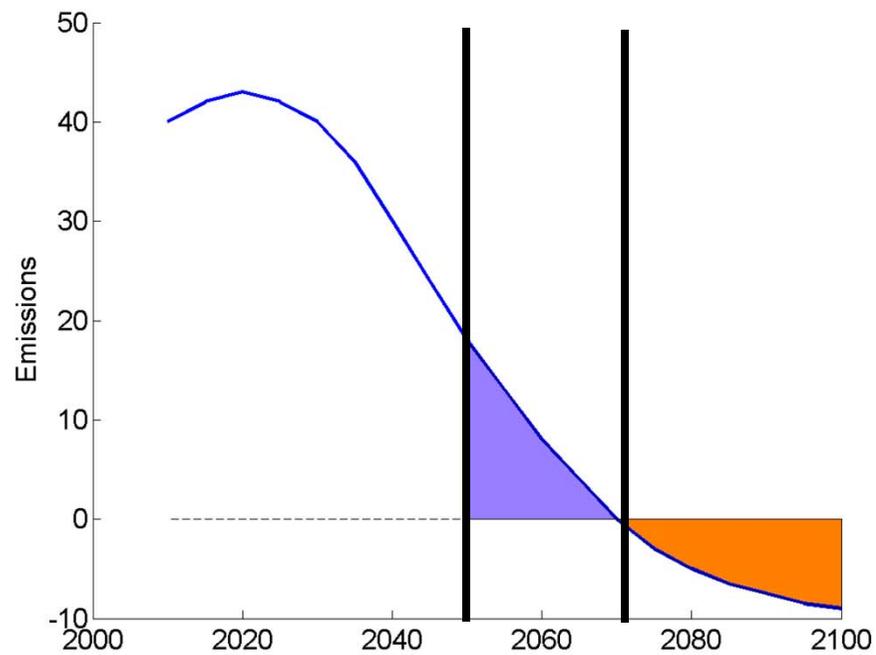
Jessica Strefler, PIK

Luderer et al. „Deep Decarbonization towards 1.5°C – 2°C stabilization: Policy findings from the ADVANCE project“, 2016.
 Luderer et al. „Residual fossil CO₂ in 1.5-2°C pathways“. NCC, in press.

Linearer Zusammenhang kumulative CO₂ Emissionen - Temperatur



Netto CO₂ Entnahme senkt die Temperatur!

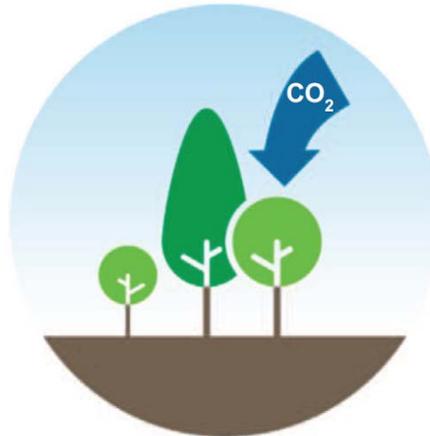


CDR Technologies

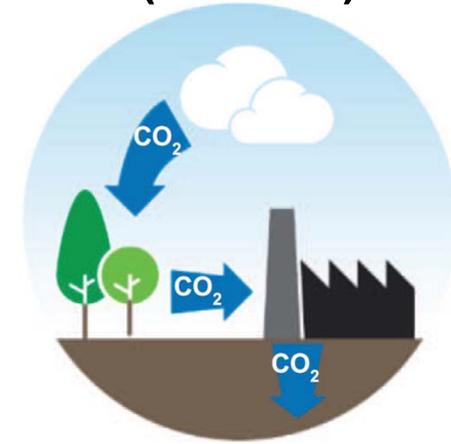
**Biochar + soil
carbon sequestration**



Afforestation



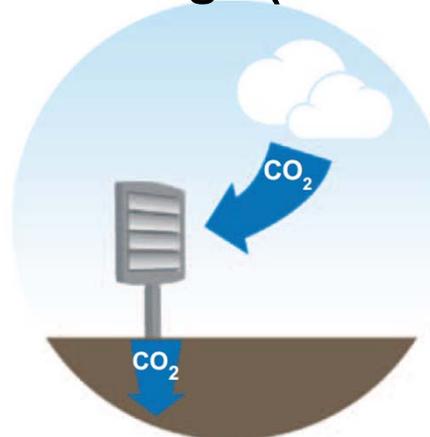
**Bioenergy + CCS
(BECCS)**



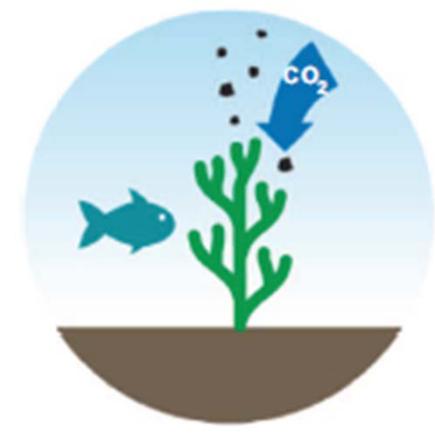
**Enhanced
Weathering of rocks**



**Direct Air Capture
+ Storage (DACs)**



**Ocean fertilization /
alkalinization**



CDR Technologies

PRO

Produces not only „negative“ CO₂ emissions, but also usable energy

Versatile energy carrier

- Electricity (but: many low-c alternatives)
- Synthetic liquids

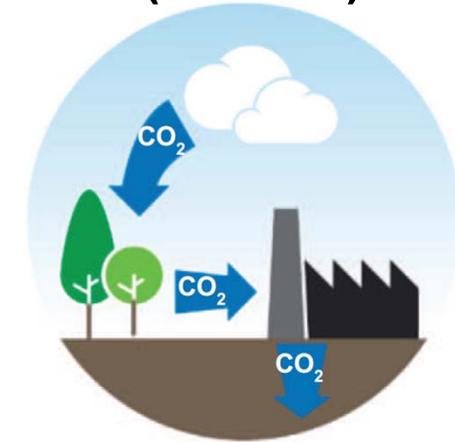
CON

Large land requirement
→ land competition with food crops

How much biomass can be grown sustainably?

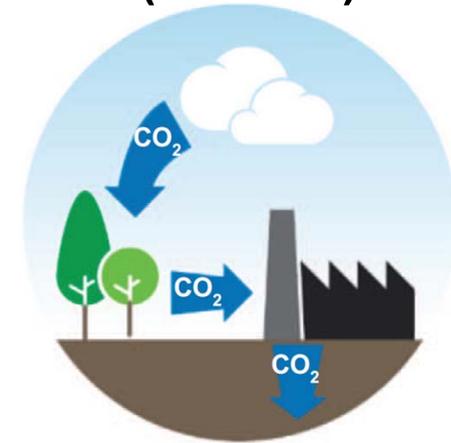
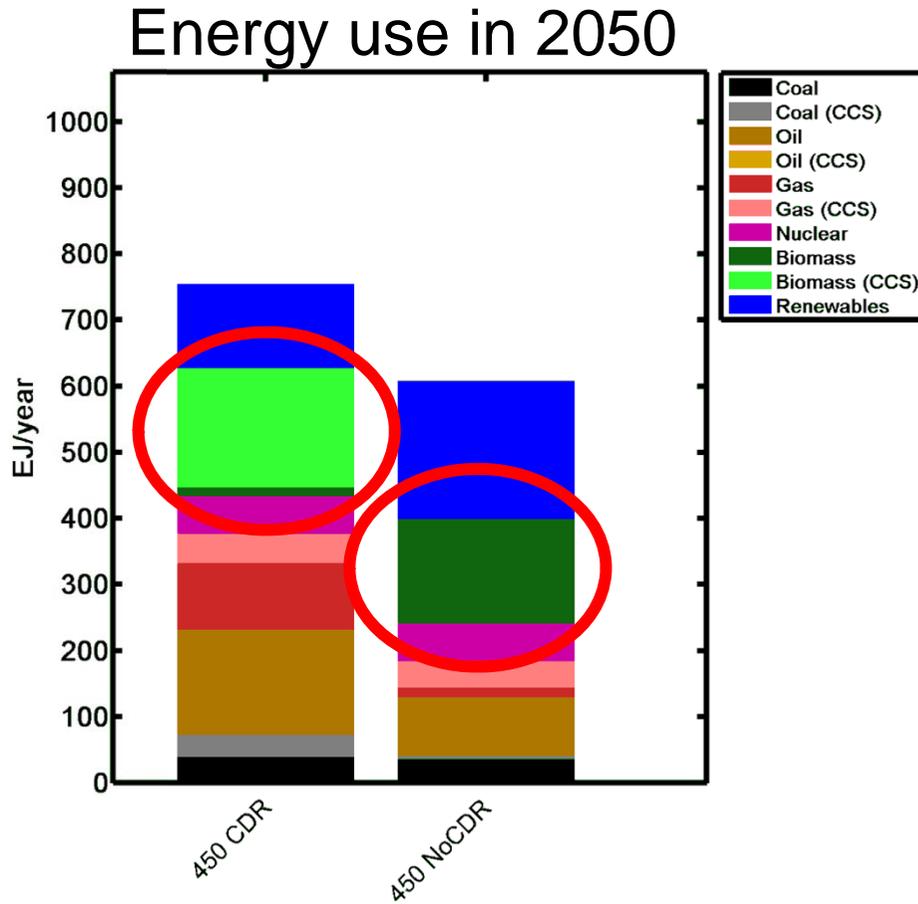
Geological storage required

Bioenergy + CCS (BECCS)



BECCS is not the driver of bioenergy use

Bioenergy + CCS (BECCS)



Afforestation



PRO

Easy, no new technologies involved

Cheap

CON

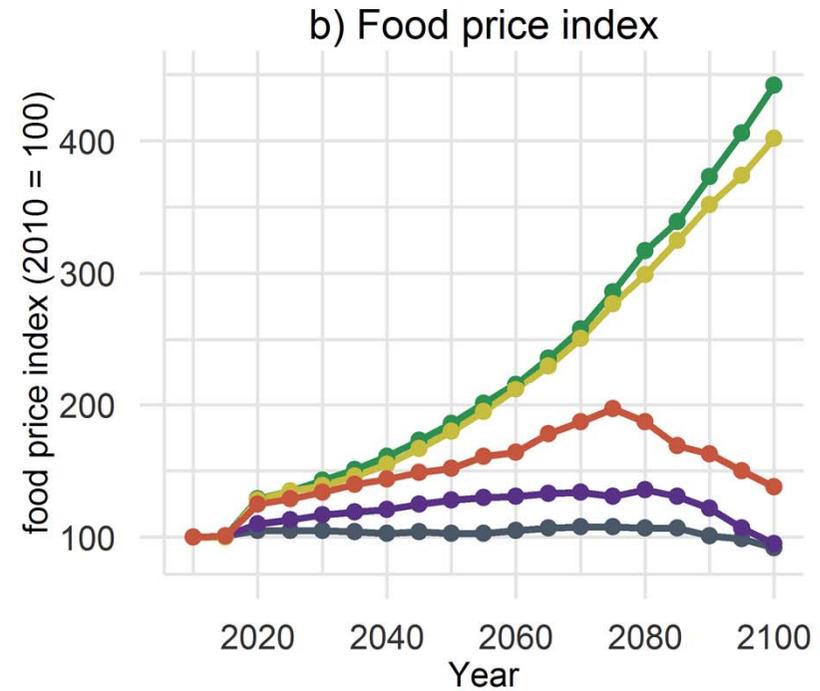
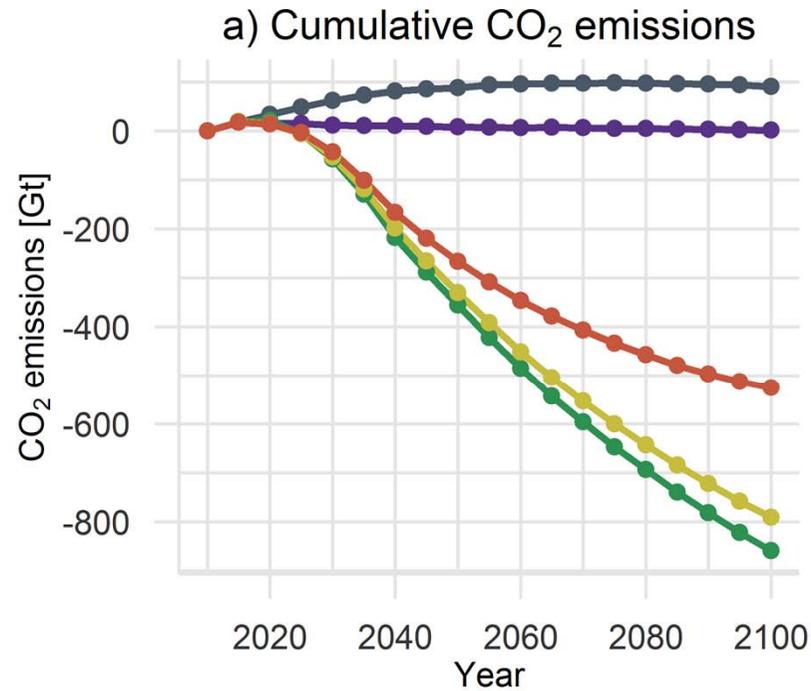
Large land requirement
→ land competition with food crops

Forest has to be protected, otherwise carbon is released again

Sink saturation

Albedo effect in boreal areas

Food price effects of afforestation



Scenario — BAU — avoided defor — unrestricted aff — no boreal aff — only tropical aff



CDR Technologies

Biochar + soil carbon sequestration



PRO

Improves soil quality

Cheap

CON

Carbon can easily be released again

Sink saturation

Beschleunigte Verwitterung



Natürliche Verwitterung bindet CO₂

Silikatgestein + CO₂ + Wasser
⇒ Lehm + Carbonat

Langsamer Prozess!

Kann man den Prozess beschleunigen?

- Oberfläche vergrößern - kleine Korngrößen
- Warme, feuchte Regionen

Enhanced weathering



PRO

Easy, no new technologies involved, natural process

Nutrient supply

Counteracts coastal acidification

CON

Environmental impacts of mining

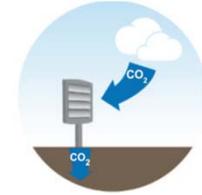
Large industry needed

→ 1 Gt CO₂ / yr ≈ 3 Gt st / yr

Health effects?

→ Grain size > 10 μm

Direct air capture



PRO

Low land requirements
75,000 km² /F one giant operation
(Johnston et al., 2003)

Can be built anywhere (e.g.
close to storage sites)

Large potential, mainly limited
by storage capacity.

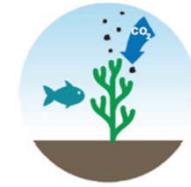
CON

High costs

High energy requirements

Geological storage required

Ocean alkalization



PRO

Counteracts ocean acidification

Carbon stored permanently

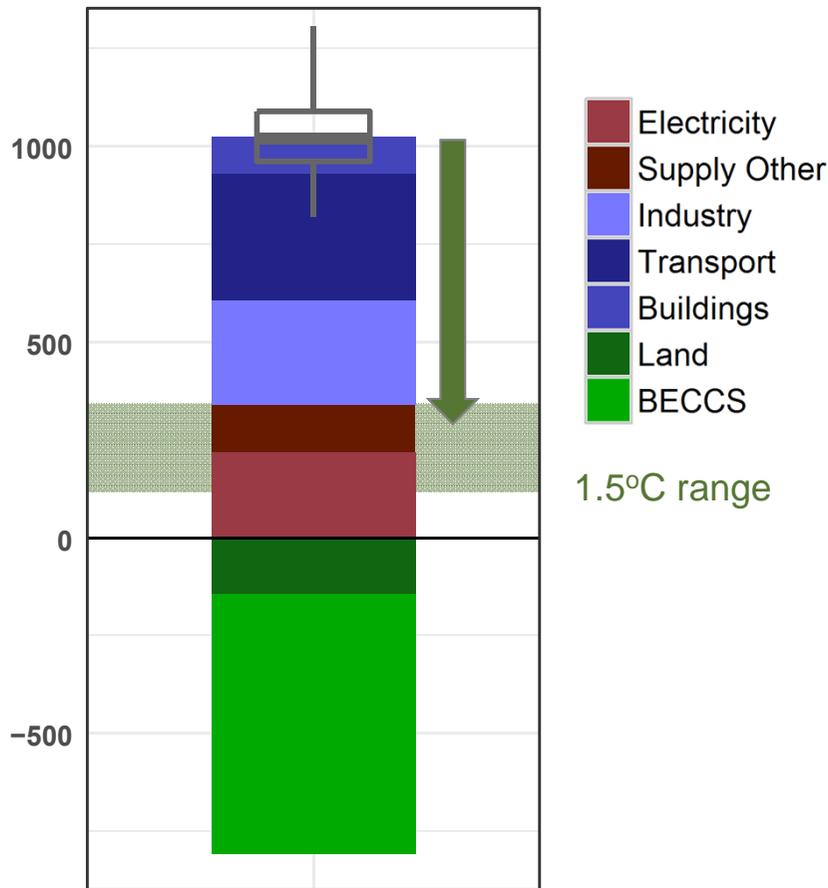
CON

Effects on marine ecosystem?

Technological feasibility?

Mining and production of large quantities of e.g. lime

How much CDR do we need?

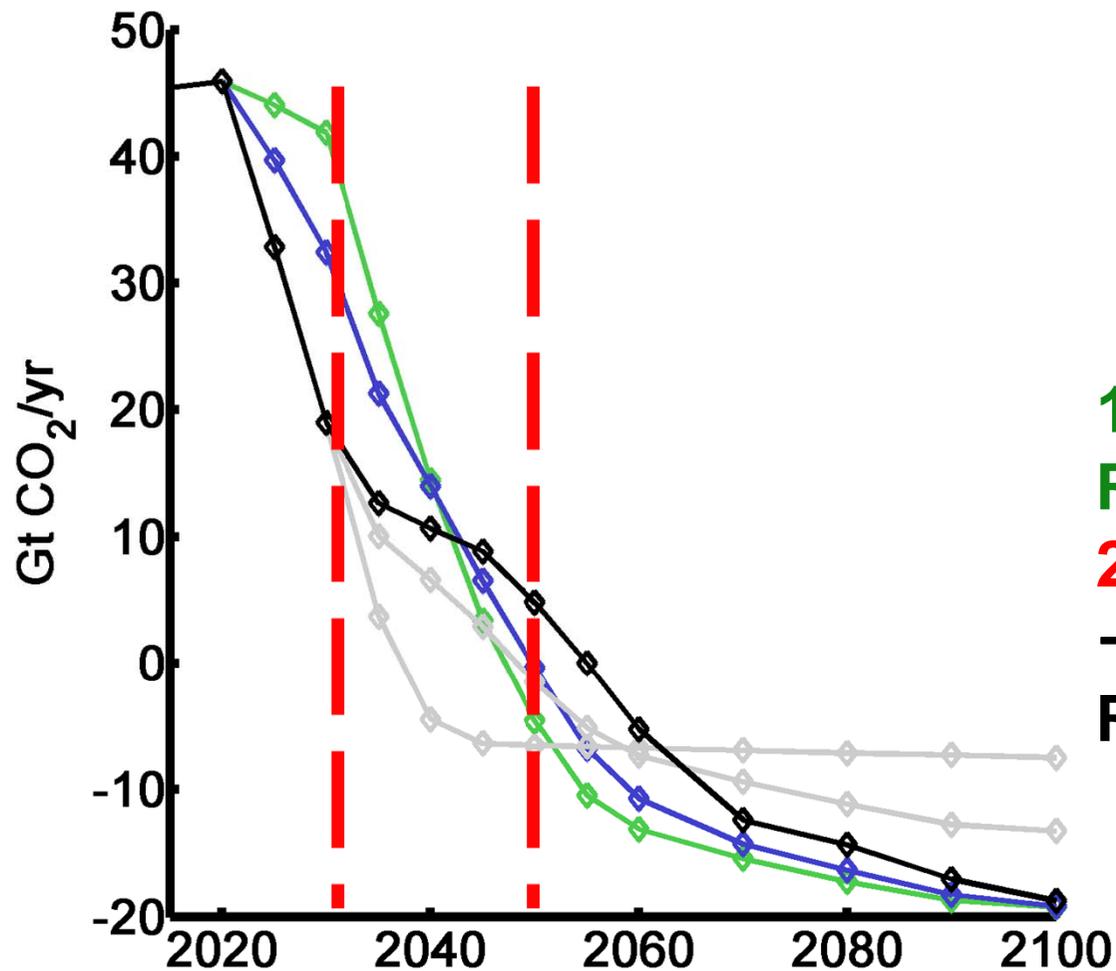


1000 Gt CO₂ residual emissions, even under very optimistic assumptions.

→ CO₂ budget determines minimum CDR requirements

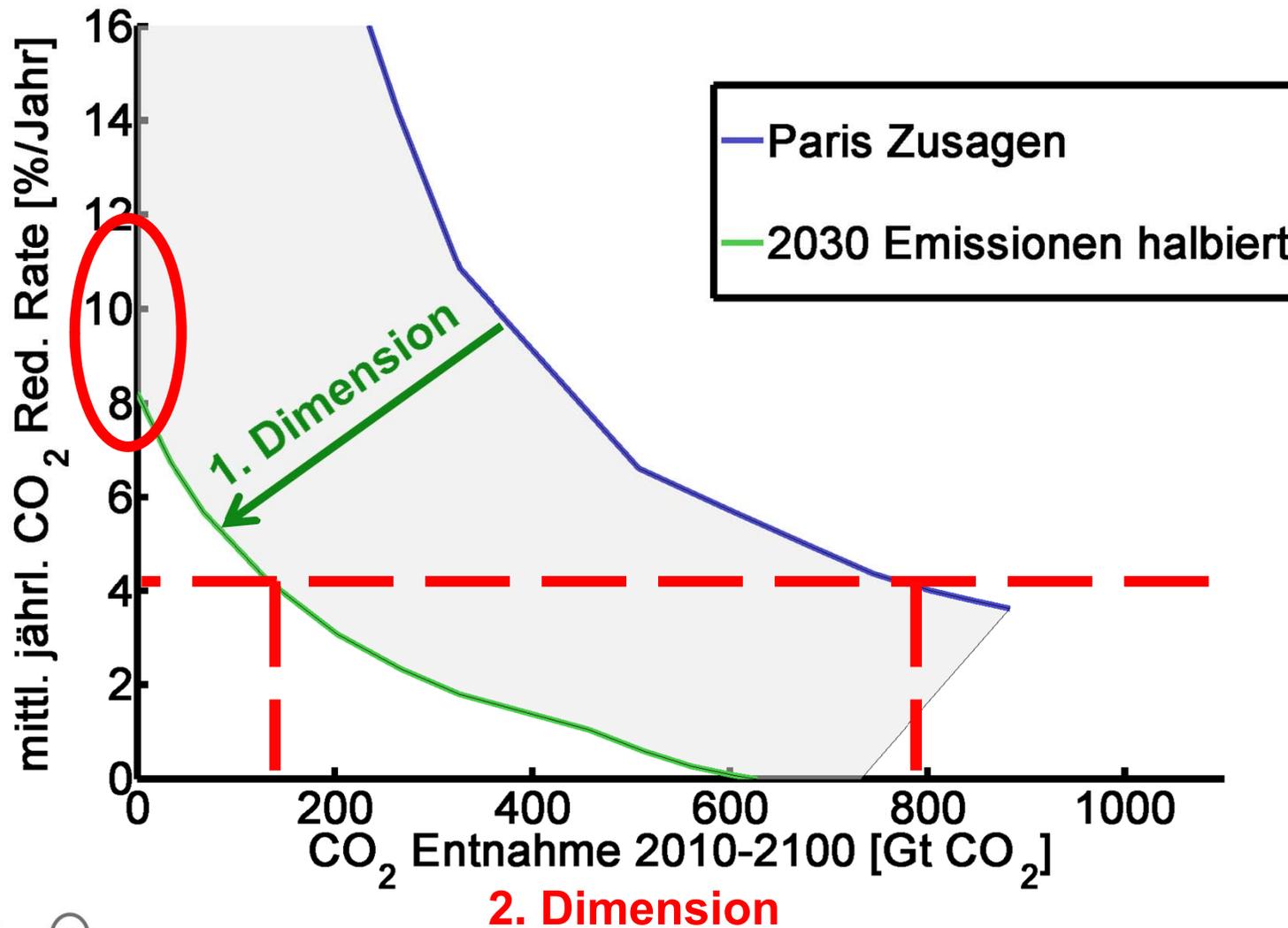
Based on Luderer et al., 2018 (NCC)

Viele CO₂-Emissionspfade führen zu 2°C



1. kurzfristige CO₂ Reduktion
2. CO₂ Entnahme
→ mittelfristige CO₂ Reduktionsrate

Minimaler Bedarf an CO₂-Entnahme

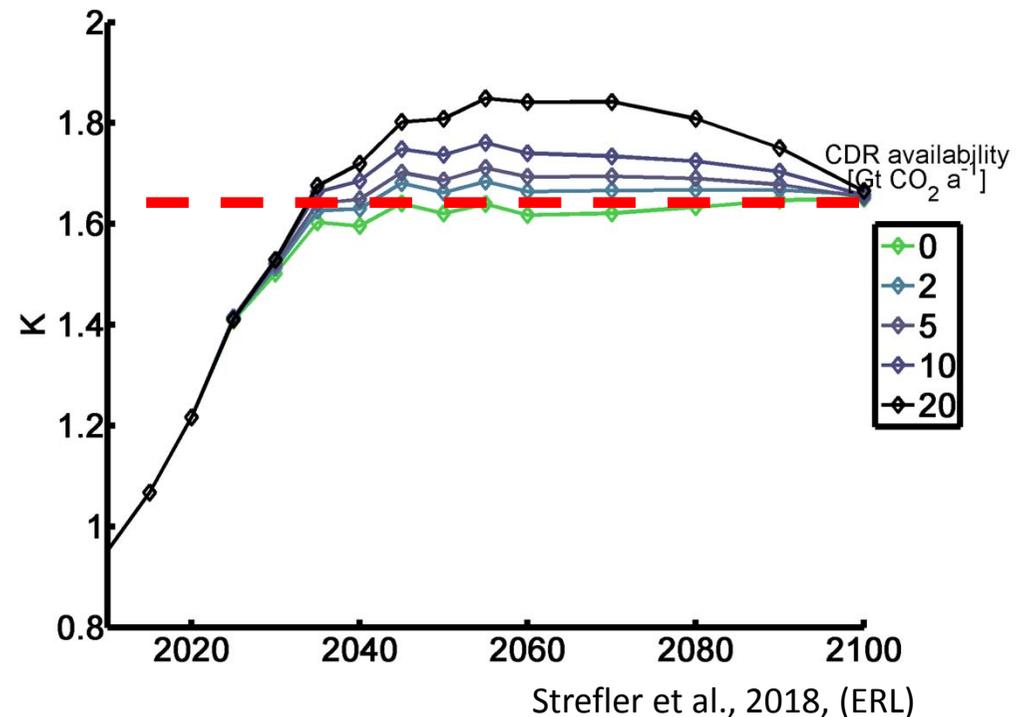


High CDR leads to high risks

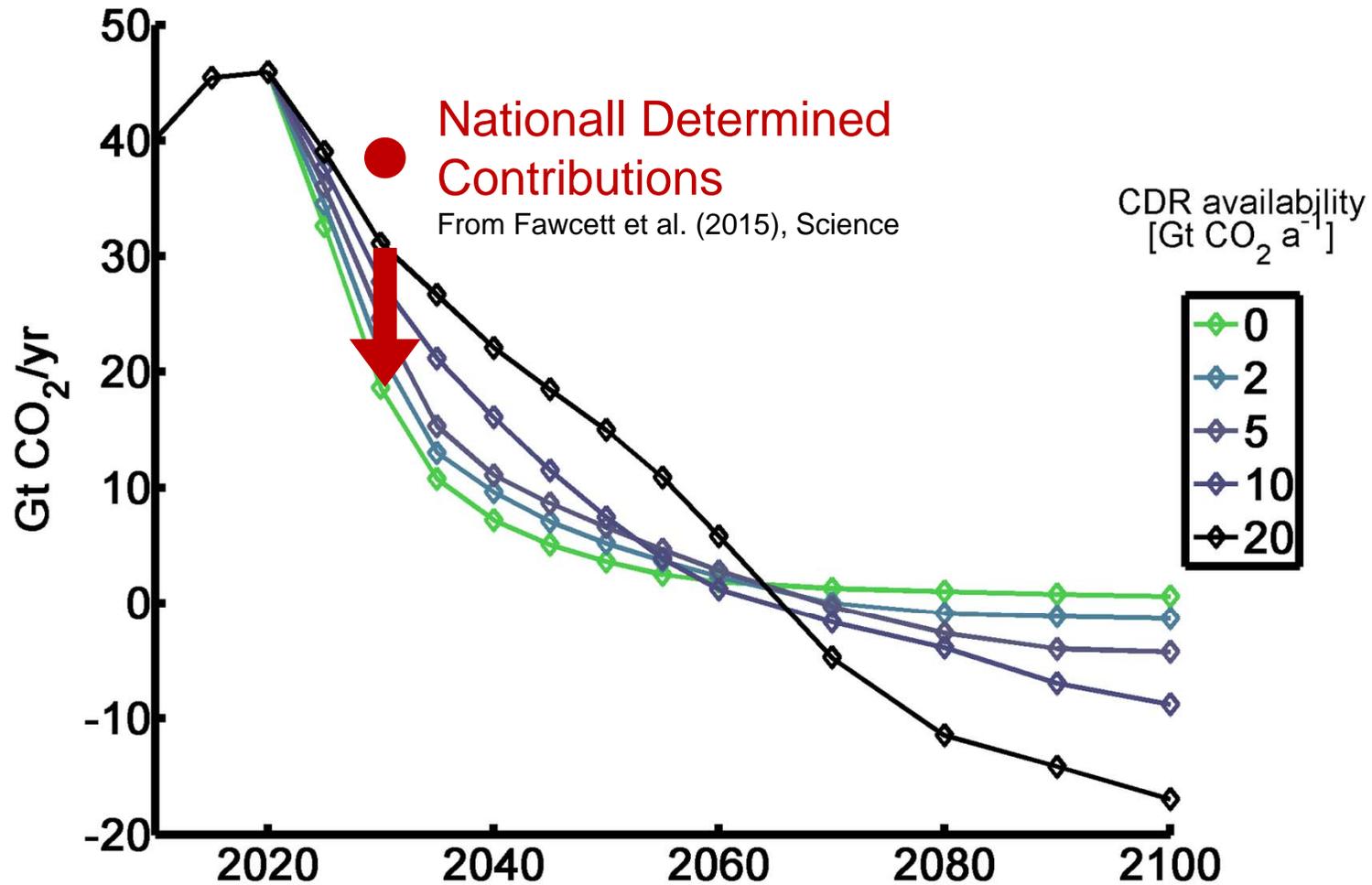
Trade-off between short-term costs, medium-term emission reductions, large-scale CDR deployment

High CDR increases

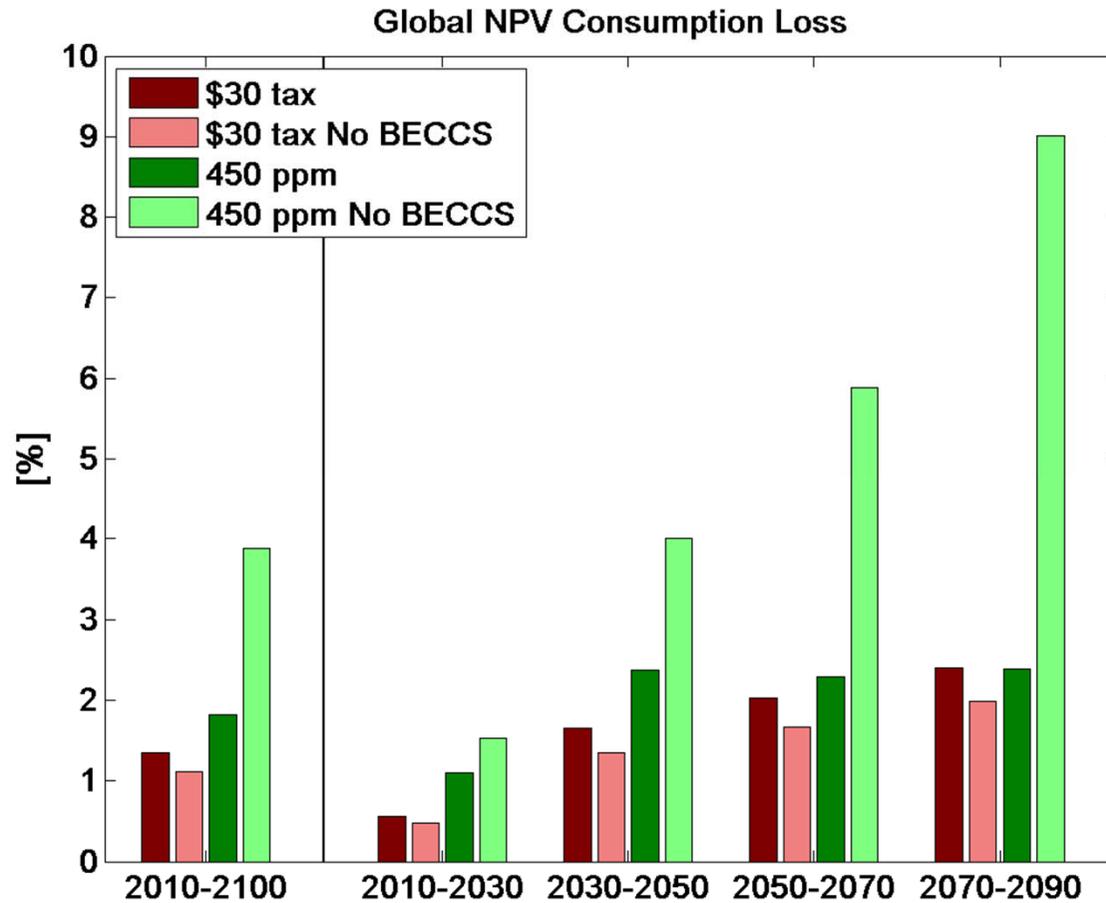
1. Technical risks
2. Adverse side-effects
3. Climate risks
4. Financial/governance



2030 emission reductions



Balancing Generational Mitigation Costs



Kriegler et al, 2013, Climatic Change 118:45-57



Summary

- **CDR plays a key role for achieving low stabilization**
- **Strategic value lies in compensating the emissions that are most expensive to reduce**
- **Different CDR technologies have different limiting factors**
- **Scale of deployment matters!**
- **Ambitious short-term mitigation reduces technical, governance, and climate risks. It can alleviate the trade-off between CDR deployment and transitional economic challenges, but substantial CDR requirements remain**
- **Challenge: find a level of effort that navigates between short-term costs, transitional challenges, and CDR deployment**

