Carbon management: What's the point of CCS, CCU, CCC?

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Global warming is roughly proportional to cumulative emissions

- There is a finite residual CO₂-budget ca. 800 GtCO₂ for well below 2°C, and ca. 200 GtCO₂ for 1.5°C
- Emissions have to be reduced to near-zero in the long-term

Gunnar Luderer et al., Limiting warming to 1.5-2°C
RD III: Sustainable Solutions
Sectoral breakdown

1.5°C Scenarios (average of models)

Cumulative Emissions 2016-2100 [GtCO2]

Buildings
Transport
Industry
Supply Other
Electricity

Luderer et al., NCC, (2018)
Sectoral breakdown

- Remaining fossil emissions of 1000 Gt CO₂, even with immediate and comprehensive climate action
- Major emissions from transport and industry
- Negative emissions required for 1.5°C limit
2050 emission reductions
electricity vs. demand side

- Electricity supply is much easier and faster to decarbonize
- Most of the incremental effort for 1.5°C over 2°C comes from demand side
How can demand-side emissions be limited?

2050

- Models
  - max
  - 84th
  - median
  - 16th
  - min

- Scenario
  - Med–2C
  - WB–2C
  - 1.5C–2100

- Reference
  - 84th
  - median
  - 16th

Total Demand
Res-FF-CO2 [Gt]

Efficiency  Electrification  Decarbonization
How can demand-side emissions be limited?

- Efficiency
- Electrification
- Decarbonization

Biomass, hydrogen, industry CCS, power-to-X
How can demand-side emissions be limited?

**Efficiency**

Direct electrification, e.g. freight transport, power-to-heat

**Electrification**

Biomass, hydrogen, industry CCS, power-to-X

**Decarbonization**

2050
Concluding thoughts on CCU

• Most important use cases
  - storage / long-range transportation of renewable electricity
  - non-electrifyable end uses (aviation, freight, industrial processes)
  - combination with biofuel production
  - Material use, e.g. plastics, carbon fibres in building materials

• Key issues:
  - Not climate neutral unless carbon is renewable-based
  - Very high efficiency penalty
  - Need to consider economics and life-cycle impacts
Thanks!

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References:
https://doi.org/10.1038/s41558-018-0198-6
Backup
How can demand-side emissions be limited?

I. Energy demand reductions (efficiency and sufficiency)

II. Reduction of combustible fuels (electrification)

III. Decarbonization of fuels (mostly biomass, hydrogen)
The role of bioenergy for climate protection

- (1) Substitution of fossil energy
- (2) Negative Emissions via combination with CCS (BECCS)
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2050 indicators
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