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# The need & greed of CCS

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**samfunnsvitenskap og $CO_2$ håndtering** (7/03/2018, Forskningsrådet)

# Outline

- Why do we need CCS (and $CO_2$ removal)
- How much do we need?
- Why do models love CCS?

# Why do we need CCS and $CO_2$ removal?

# Why we need CCS?

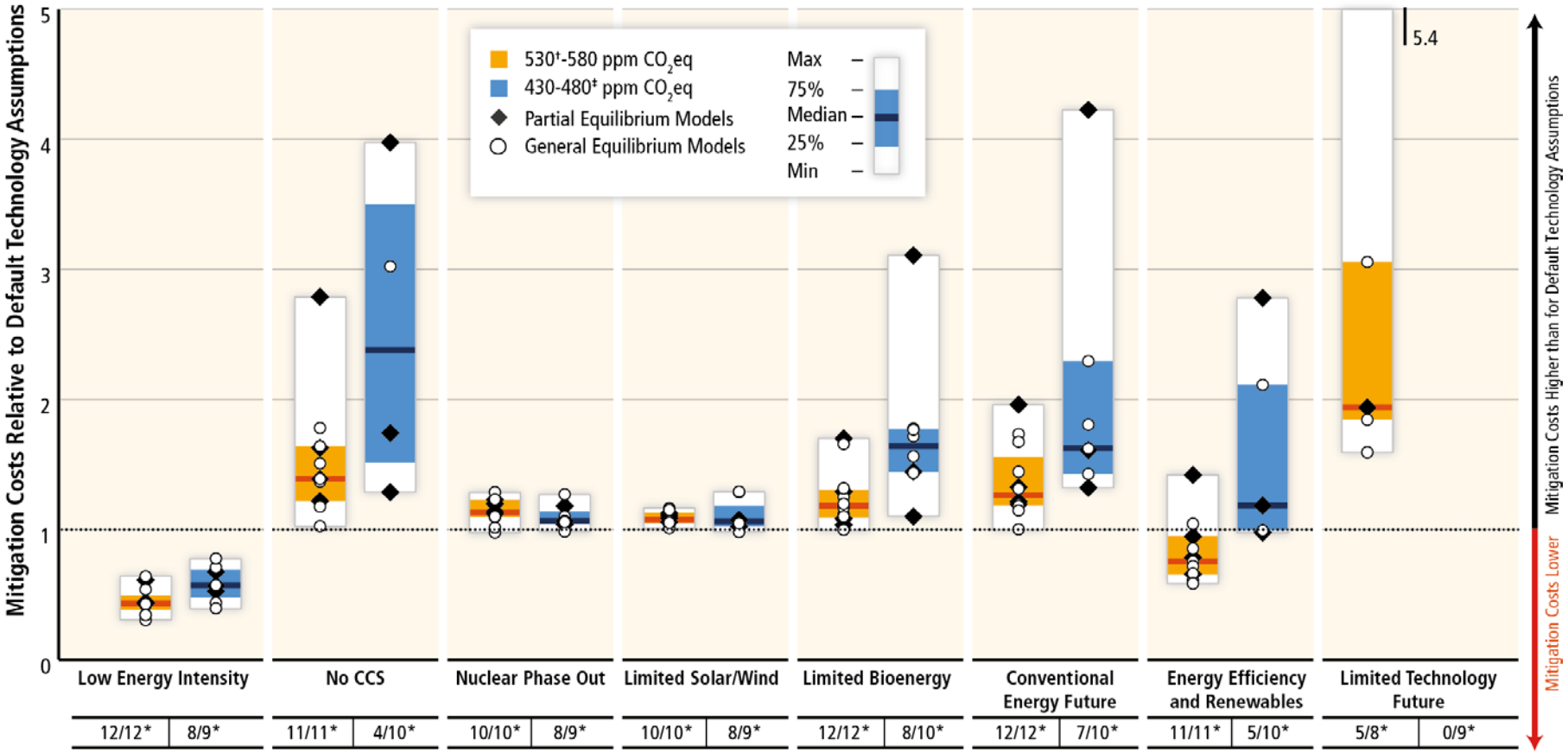
- It may be the cheapest form of mitigation in some sectors
  - Metals, cement, …
- We may allow some sectors or countries to emit
  - Poor countries
  - Some parts of transport, agriculture, or industry, …
- We have already emitted too much
  - Offset earlier emissions
  - Future CCS is “cheaper” than deep mitigation now



Source: Peters (2017), Love it or hate it, three reasons why we still need CCS

# Without CCS, costs go up

(In ~2010) Only 4 of 10 models IAMs could get below 2C without CCS, probably the most important technology. Though, models are poor on energy efficiency, and maybe lost opportunity.




† Scenarios from one model reach concentration levels in 2100 that are slightly below the 530-580 ppm $CO_2$eq category

‡ Scenarios from two models reach concentration levels in 2100 that are slightly above the 430-480 ppm $CO_2$eq category.

* Number of models successfully vs. number of models attempting running the respective technology variation scenario

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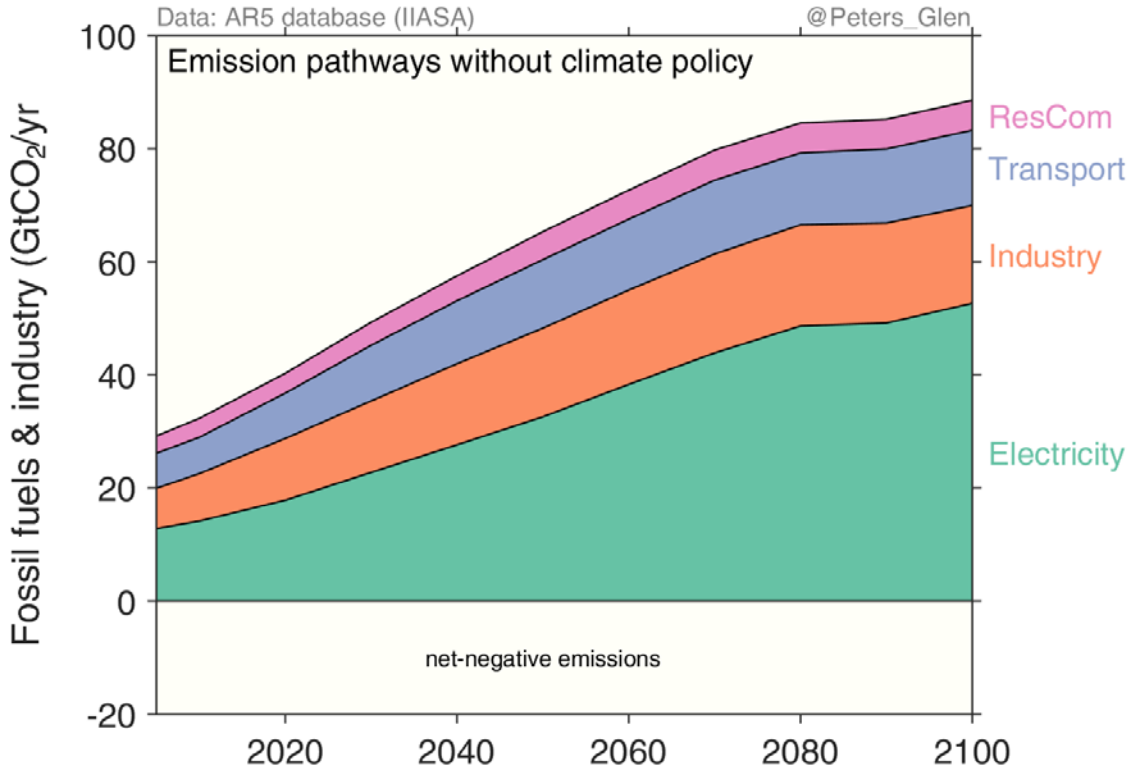
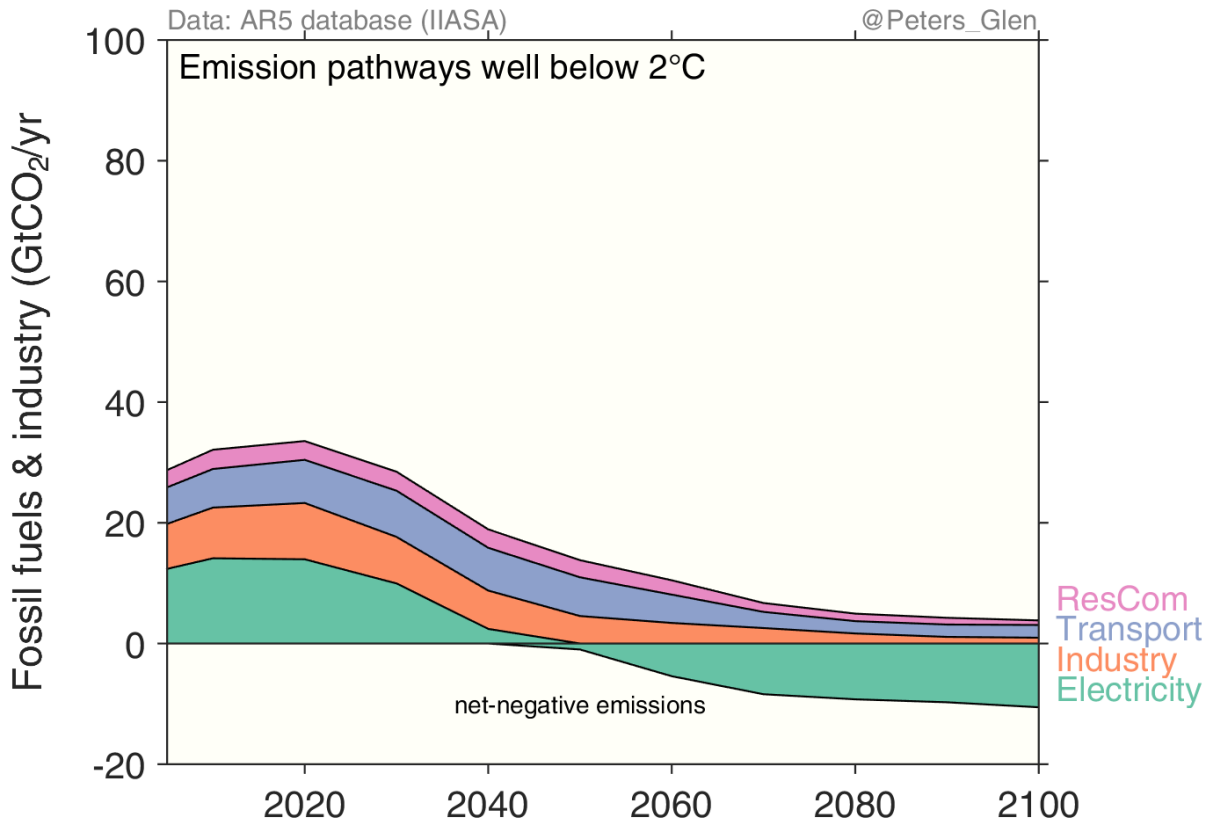
Source: IPCC AR5 WGIII Figure 6.24

# All sectors go down, electricity negative

Electricity generation dominates emissions, then industry, transport, and residential & commercial
Transport emissions persist the longest, and electricity generation removes carbon from the atmosphere

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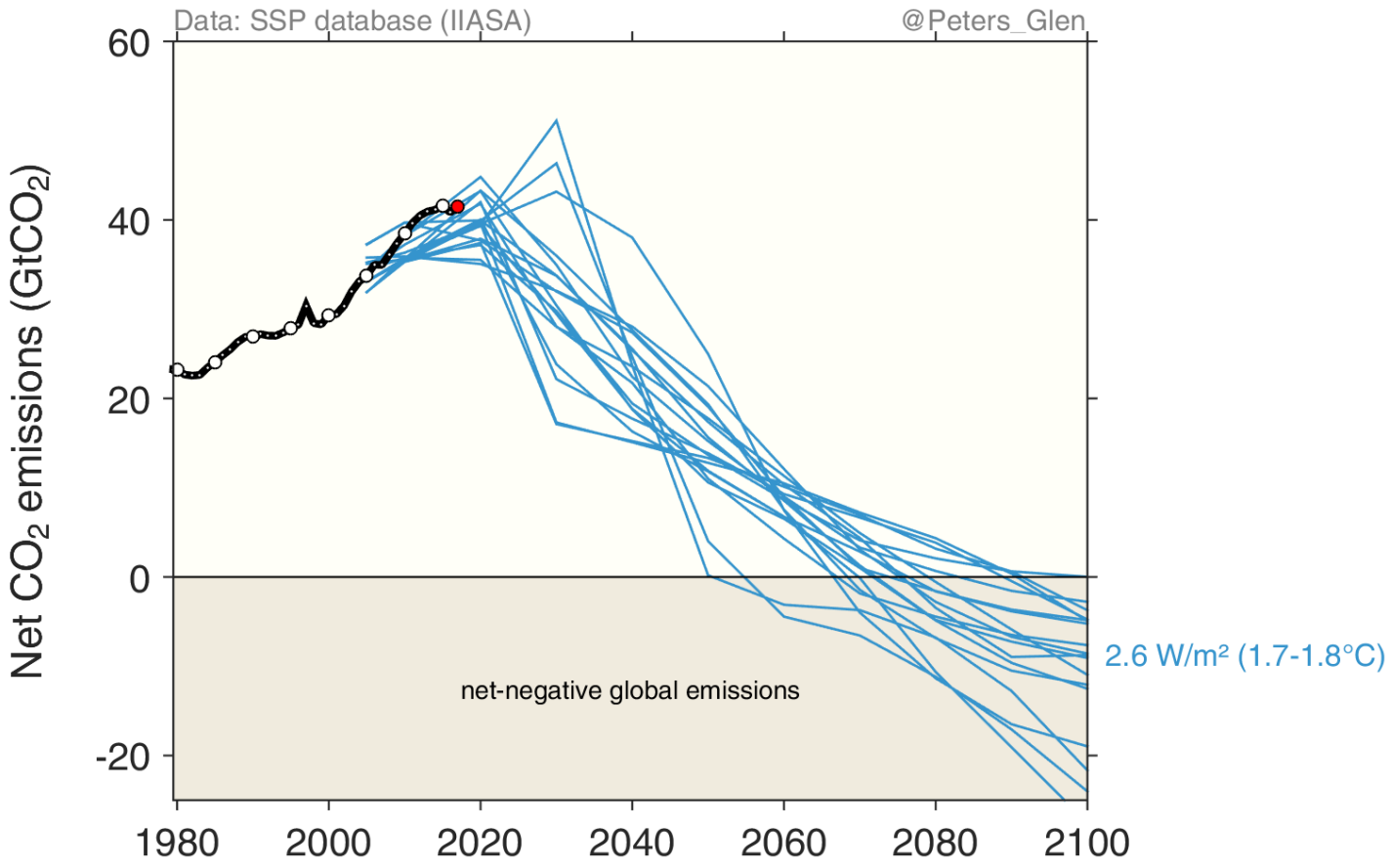
Source: IIASA AR5 Scenario Database (own calculations)

# Scenarios

The future is uncertain, and we use scenarios to explore these uncertainties

# Carbon dioxide pathways to 2°C

There are many ways to get to 2°C, depending on socioeconomic and modelling assumptions
All 2°C scenarios require rapid decarbonization, zero emissions around 2070, and negative emissions thereafter

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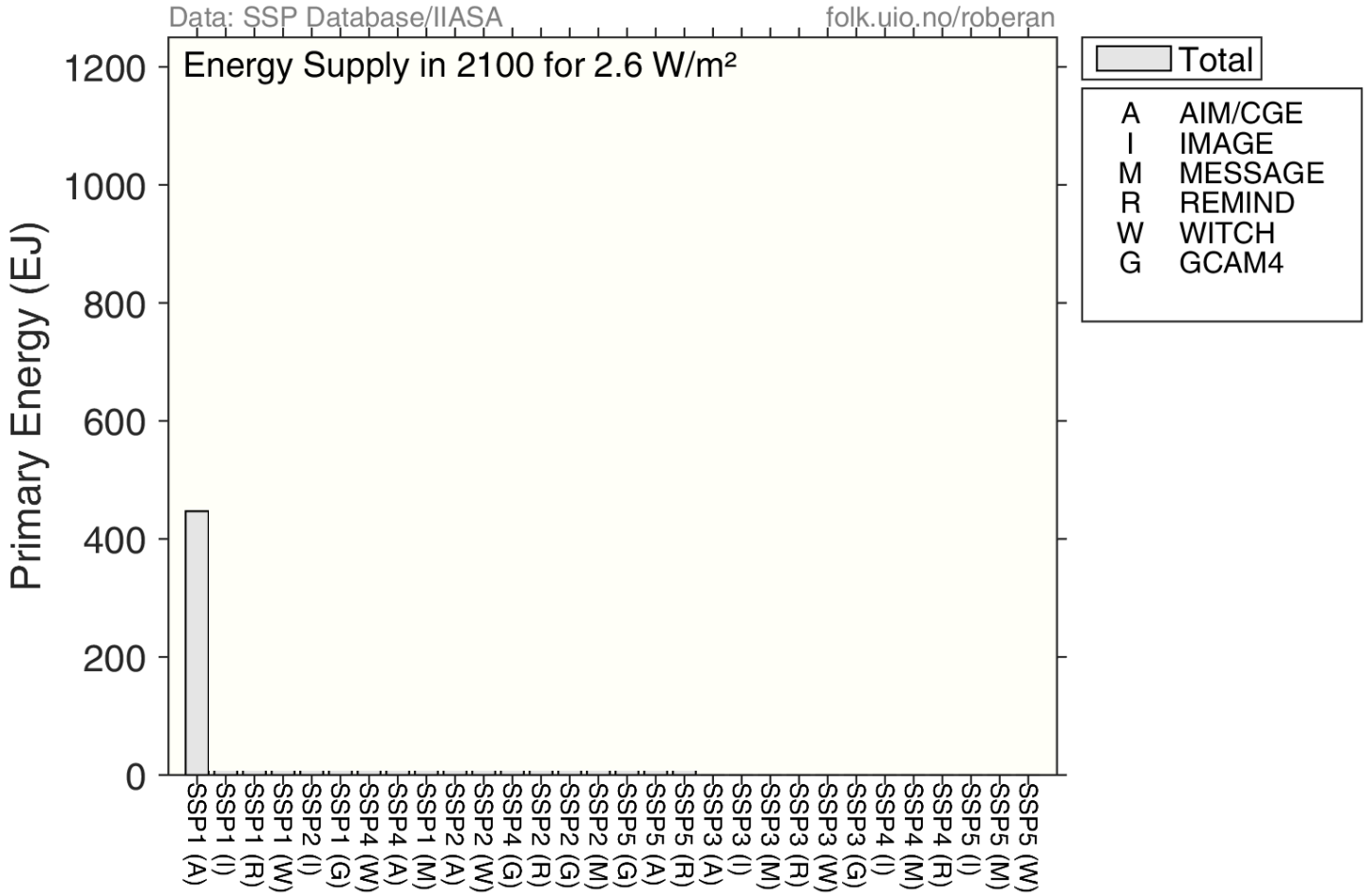
Source: IIASA SSP Database

# Energy system pathways to 2°C

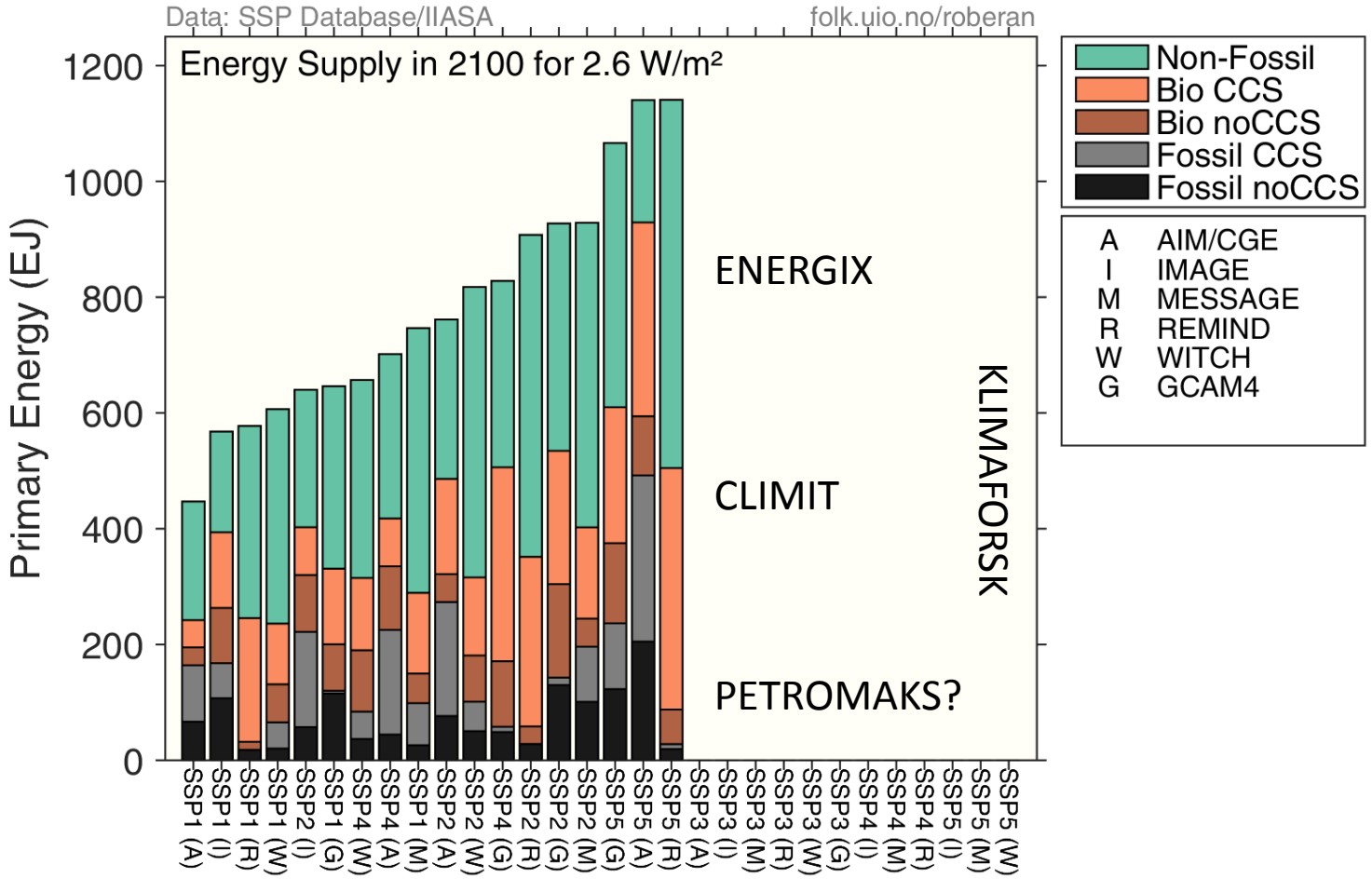
While there is little flexibility in the carbon dioxide pathways to 2°C, there is a big variation in energy consumption
Here are 18 scenarios consistent with 2°C, the “missing scenarios” are assumptions that could not keep below 2°C




SSPs represent different socioeconomic pathways (five in total), different models are abbreviated in brackets)
Source: IIASA SSP Database

# Energy system pathways to 2°C

… and very different energy mixes. It is possible to have high energy consumption with no fossil fuels, low energy consumption with lots of fossil fuels, and everything in between. There is no single pathway to 2100.

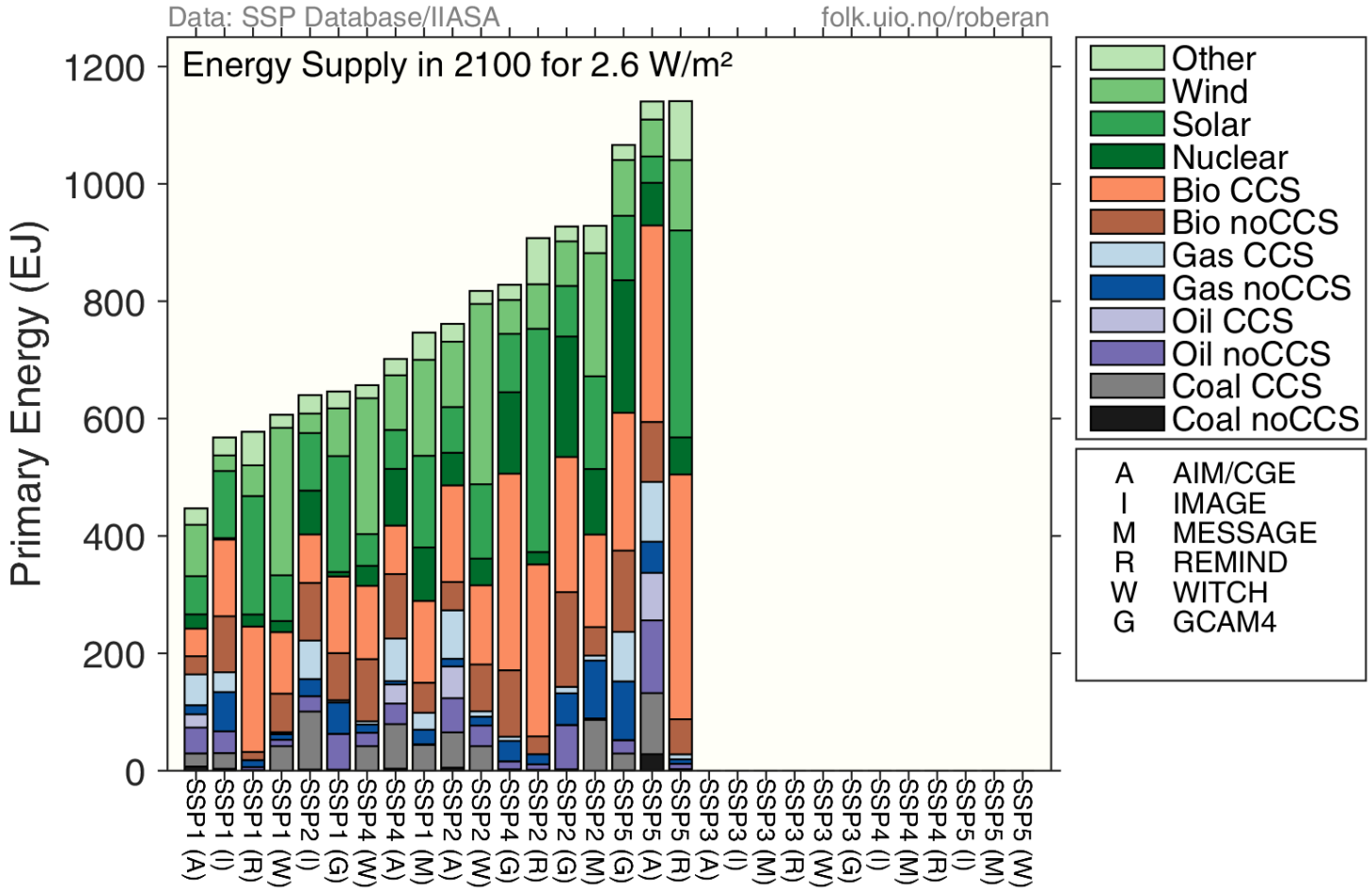



SSPs represent different socioeconomic pathways (five in total), different models are abbreviated in brackets)

Source: IIASA SSP Database

# Energy system pathways to 2°C

At the detailed level, there are many different energy systems that can be consistent with 2°C. E.g., it is not possible to categorically say 2°C is consistent with low fossil fuel consumption, as it depends on CCS assumptions

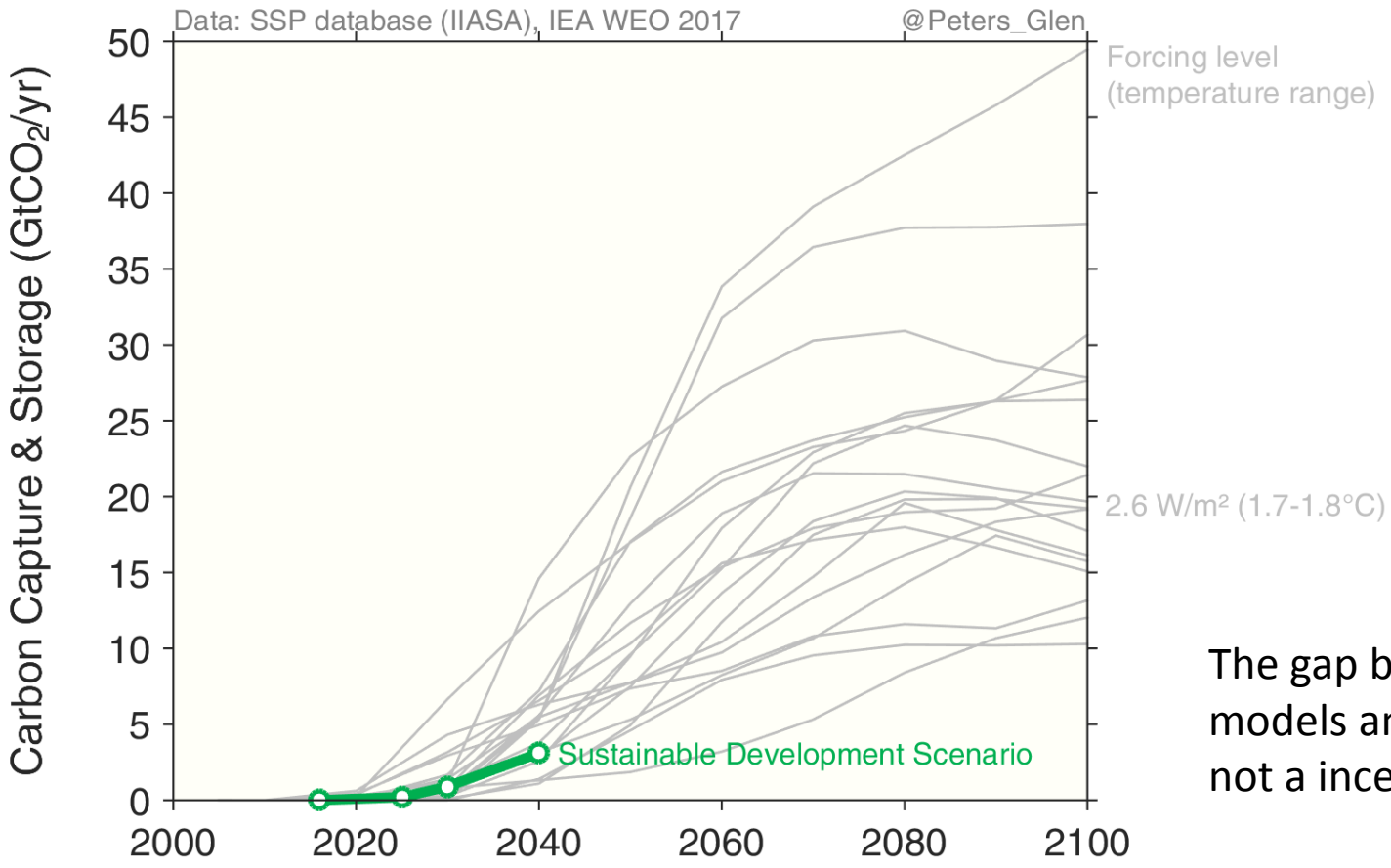



SSPs represent different socioeconomic pathways (five in total), different models are abbreviated in brackets)

Source: IIASA SSP Database

# Building block: Carbon capture & storage

Different scenarios have very different levels of CCS, hence very different risks on fossil resources
IEA World Energy Outlook has relatively low CCS (about 1500 facilities in 2040), others can have 15,000!




The gap between models and reality is not a incentives gap

3.0GtCO$_2$/yr is approximately 150 Sleipner size fields per year, or 3 fields per week
CCS volumes are estimated on energy consumption data and a capture rate of 90%
Source: IIASA SSP Database; World Energy Outlook (2017)

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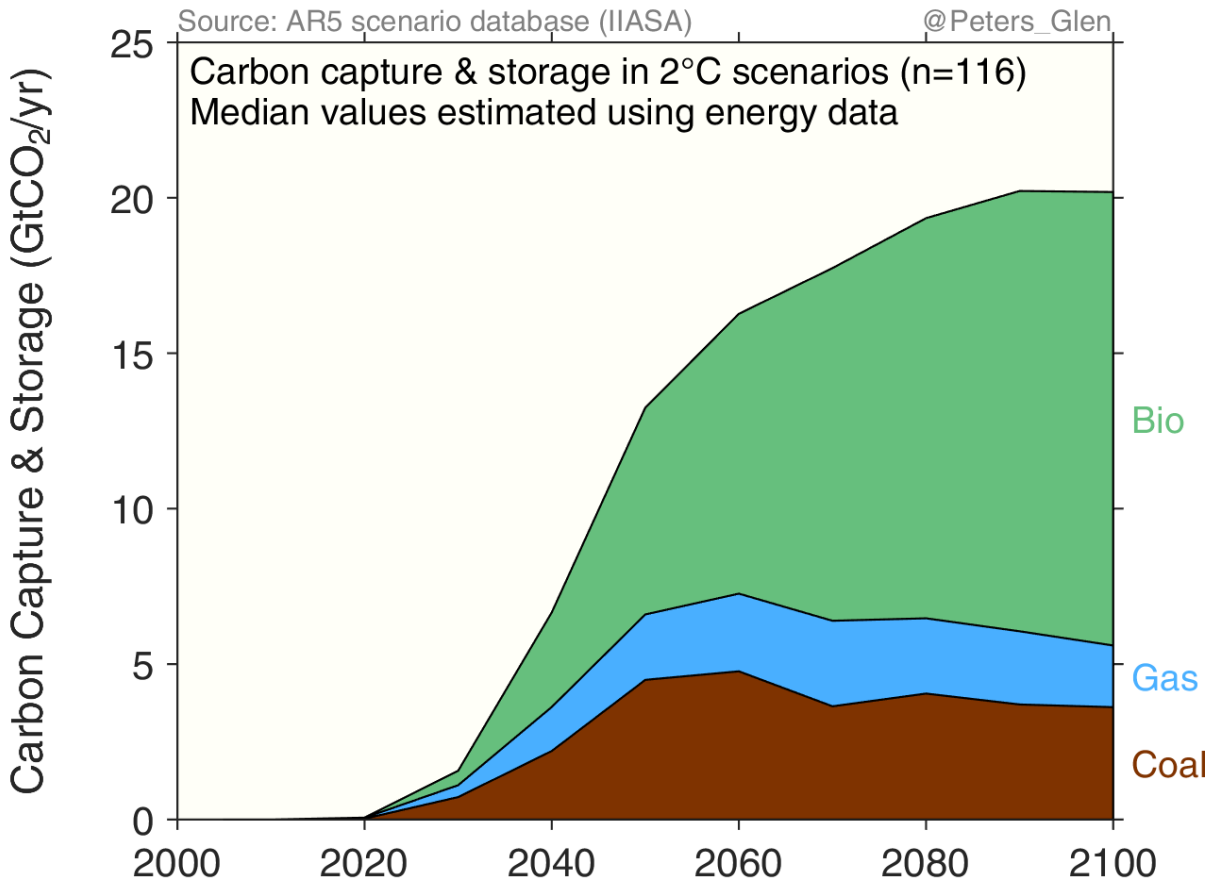
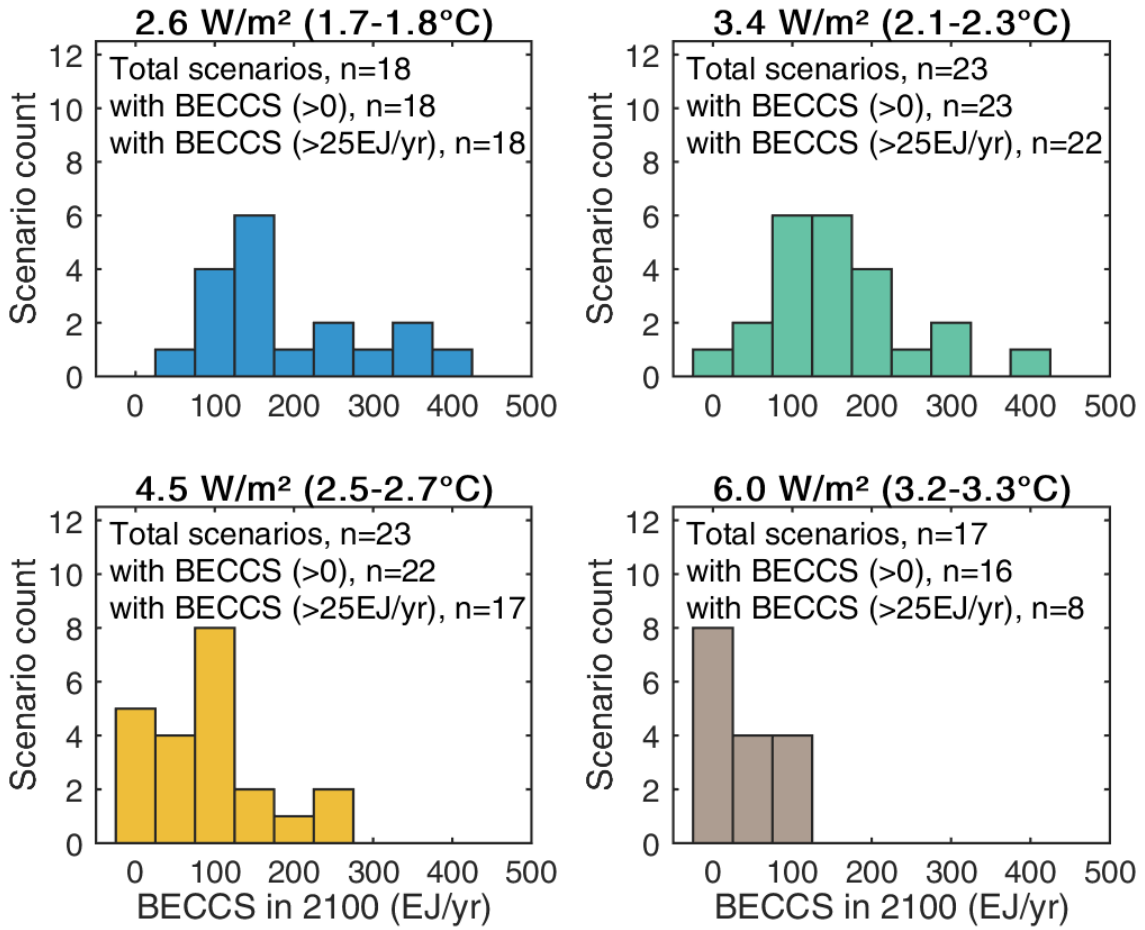
# Most CCS goes to bioenergy



# Building block: $CO_2$ removal

To stabilize global average temperature must have net-zero emissions, which means negative emissions.
Why? a) some sectors hard to mitigation, b) may allow some to emit longer, c) easier to shift problem later

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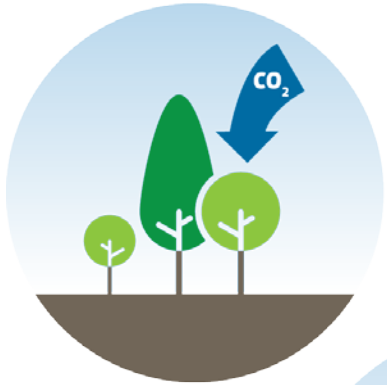
Source: Riahi et al. 2016; IIASA SSP Database

# What is $CO_2$ removal?

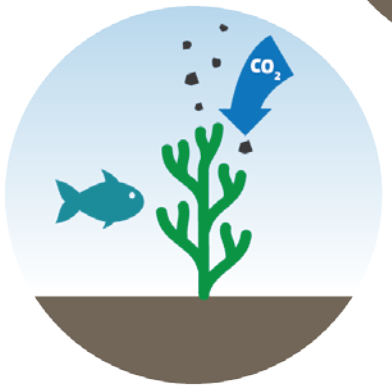



**Afforestation and reforestation**

Tree growth takes up $CO_2$ from the atmosphere.


**Biochar**

Partly burnt biomass is added to soils absorbing additional $CO_2$.




**Ocean fertilization**

Iron or other nutrients are applied to the ocean increasing $CO_2$-absorption by algae growth.

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Source: MCC 2016

# Why do models love CCS?

# Why do models love CCS?

- Van Vuuren et al (2015), report to Miljødirektoratet:
  - IAMs indicate rapid short-term reductions more expensive than cost of negative emissions in the long-term (given parameters)
  - (I think model structure is also important)
- Koelbl et al (2014), model comparison of CCS
  - Large variation in results cannot be explained by model assumptions
  - CCS complex interplay of several factors in each model
  - (basically, no one knows)
- Is validation even possible with complex models?

# Summary

# Summary

- We need CCS, but we don’t know how much
- Insufficient knowledge of low-CCS pathways
- Insufficient knowledge on *interactions*
- *Huge gap between scenarios and reality*
  - How to bridge the gaps (not necessarily incentives)
  - Modelling approaches, philosophy, community dynamics, …
- There will continue to be a large-gap between models and reality unless we invest in understanding the “gap”

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