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The potential role of CCS in electricity and liquid fuel production sectors

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Mitigation Cost Increases in Scenarios with Limited Availability of Technologies … Especially CCS

Table SPM.2 | Increase in global mitigation costs due to either limited availability of specific technologies or delays in additional mitigation [a] relative to cost-effective scenarios [b]. The increase in costs is given for the median estimate and the 16th to 84th percentile range of the scenarios (in parentheses) [c]. In addition, the sample size of each scenario set is provided in the coloured symbols. The colours of the symbols indicate the fraction of models from systematic model comparison exercises that could successfully reach the targeted concentration level. *{Table 3.2}*

	Mitigation cost increases in scenarios with limited availability of technologies [d] *[% increase in total discounted [e] mitigation costs (2015–2100) relative to default technology assumptions]*				**Mitigation cost increases due to delayed additional mitigation until 2030** *[% increase in mitigation costs relative to immediate mitigation]*	
2100 concentrations (ppm CO_2-eq)	no CCS	nuclear phase out	limited solar/wind	limited bioenergy	medium term costs (2030–2050)	long term costs (2050–2100)
450 (430 to 480)	138% (29 to 297%) 4	7% (4 to 18%) 8	6% (2 to 29%) 8	64% (44 to 78%) 8	44% (2 to 78%) 29	37% (16 to 82%) 29
500 (480 to 530)	not available (n.a.)	n.a.	n.a.	n.a.		
550 (530 to 580)	39% (18 to 78%) 11	13% (2 to 23%) 10	8% (5 to 15%) 10	18% (4 to 66%) 12	15% (3 to 32%)	16% (5 to 24%)
580 to 650	n.a.	n.a.	n.a.	n.a.		

Symbol legend—fraction of models successful in producing scenarios (numbers indicate the number of successful models)

: all models successful

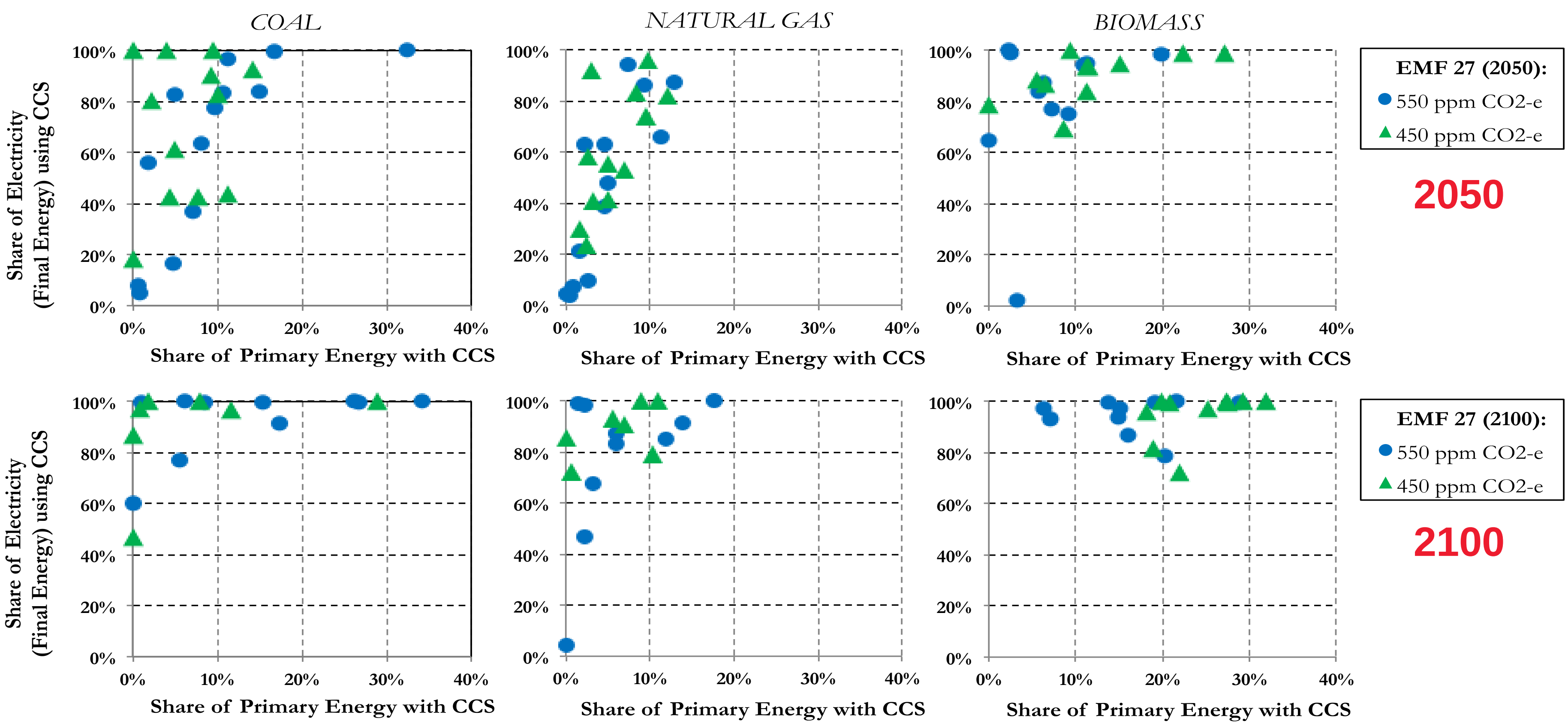
: between 80 and 100% of models successful

: between 50 and 80% of models successful

: less than 50% of models successful

Source: IPCC AR5 Synthesis Report, Table SPM.2 (2014)

Role of CCS Varies Across Integrated Assessment Models (IAMs)



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A Collaborative Study on CCS Assessment

A collaboration with researchers at:

- ExxonMobil Corporate Strategic Research: Haroon Kheshgi and Bryan Mignone
- Pacific Northwest National Lab: Matteo Muratori (now at NREL), Haewon McJeon, Leon Clarke and Jae Edmonds

Publications:

- M Muratori, H. Kheshgi, B. Mignone, L. Clarke, H. McJeon, J. Edmonds, "**Carbon Capture and Storage across Fuels and Sectors in Energy System Transformation Pathways**", *International Journal of Greenhouse Gas Control*, 56 (2017) 1–8.
- M Muratori, H. Kheshgi, B. Mignone, H. McJeon, L. Clarke, "**The future role of CCS in electricity and liquid fuel supply**", *Energy Procedia*, Forthcoming.

Research Question

What determines the role of CCS in climate change mitigation scenarios?

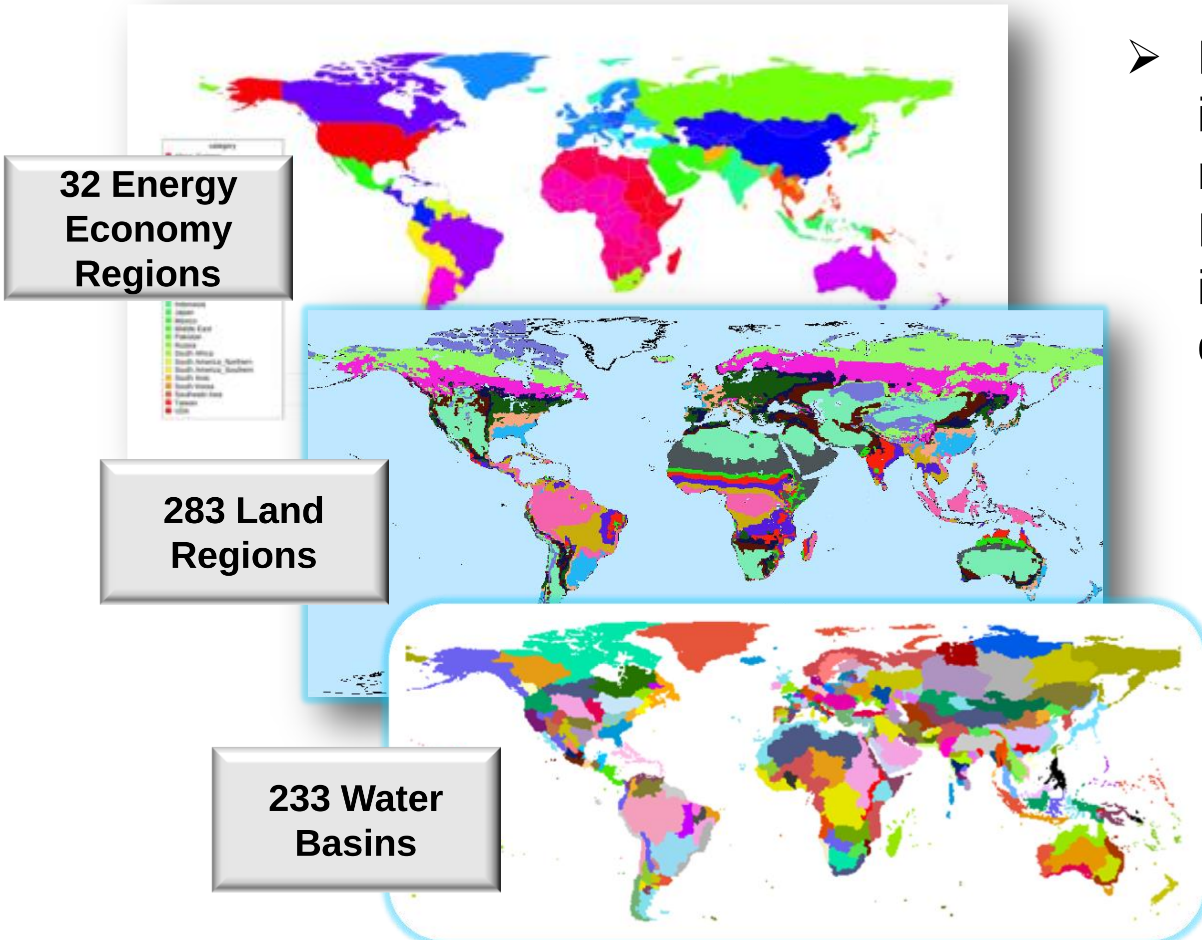
- Extent of CCS deployment across fuels and sectors?
- Sensitivity to assumptions?

Method

Examine role of CCS in the integrated assessment model GCAM (Global Change Assessment Model).

The Global Change Assessment Model (GCAM)

GCAM is a global long-term integrated assessment model



- For integrated, interdisciplinary research, modeling and analysis of Human-Earth systems to inform policy, strategy and decisions.

Includes:

- Many technology options
- 16 greenhouse gases and aerosols
- Extends through this century

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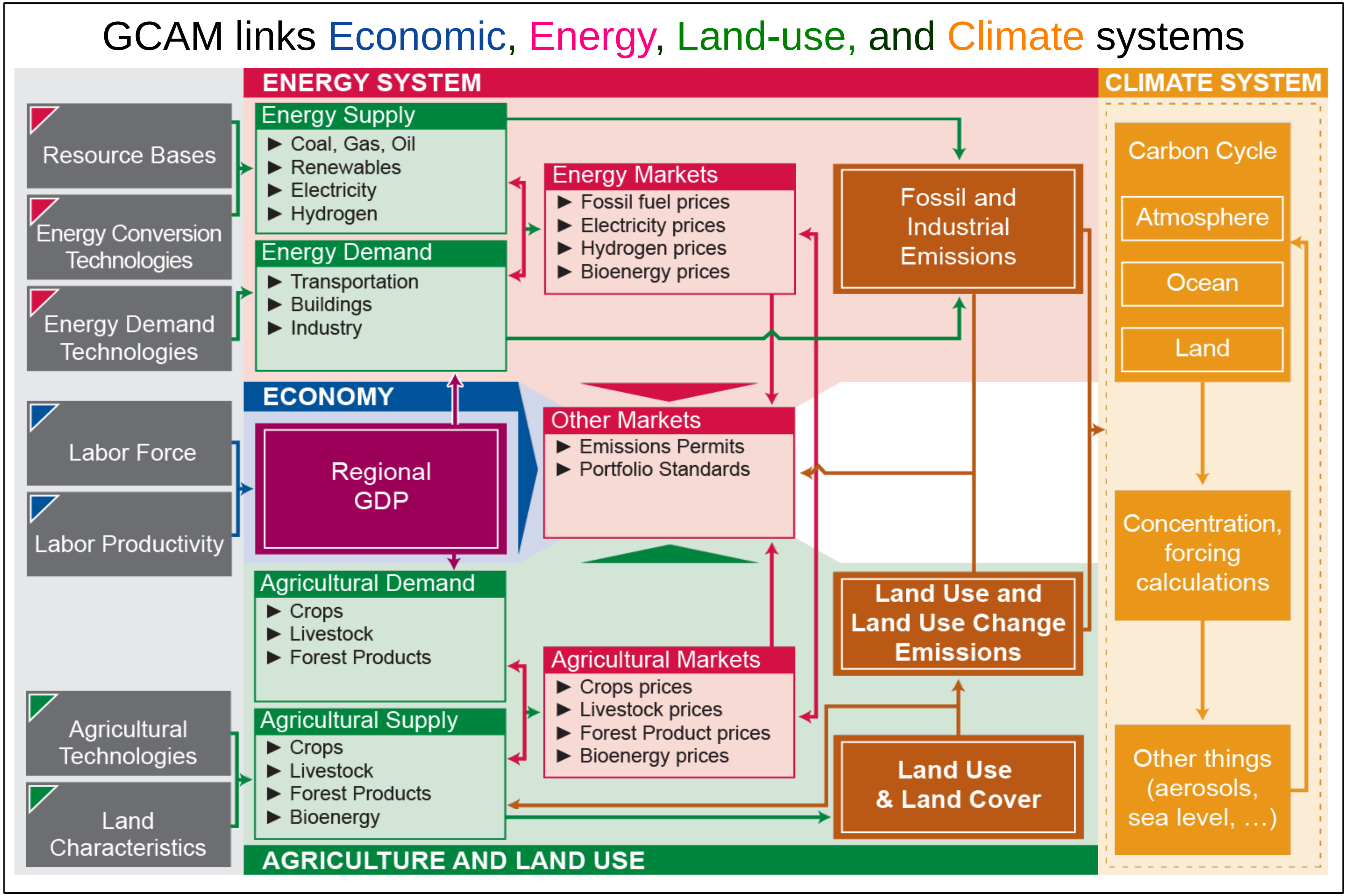
The Global Change Assessment Model (GCAM)



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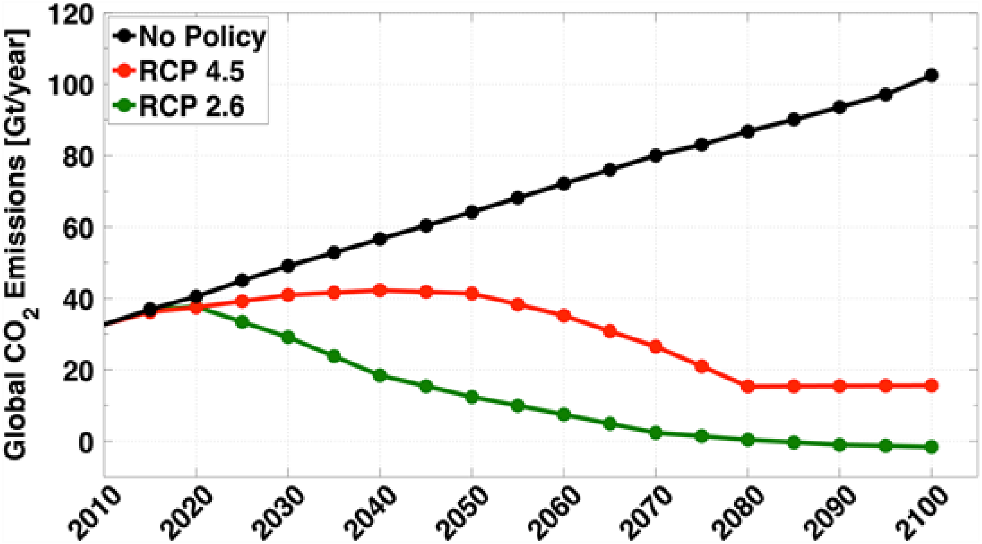
GCAM Mitigation Scenarios: Policy Assumptions

- Two emission pathways are prescribed to drive GCAM scenarios that we use to explore the roles of CCS:
  - The IPCC (2013) found that RCP 4.5 and 2.6 were modeled to lead to about 2.4°C and 1.6°C (*likely* below 2°C) temperature rise above pre-industrial by the end of the century.

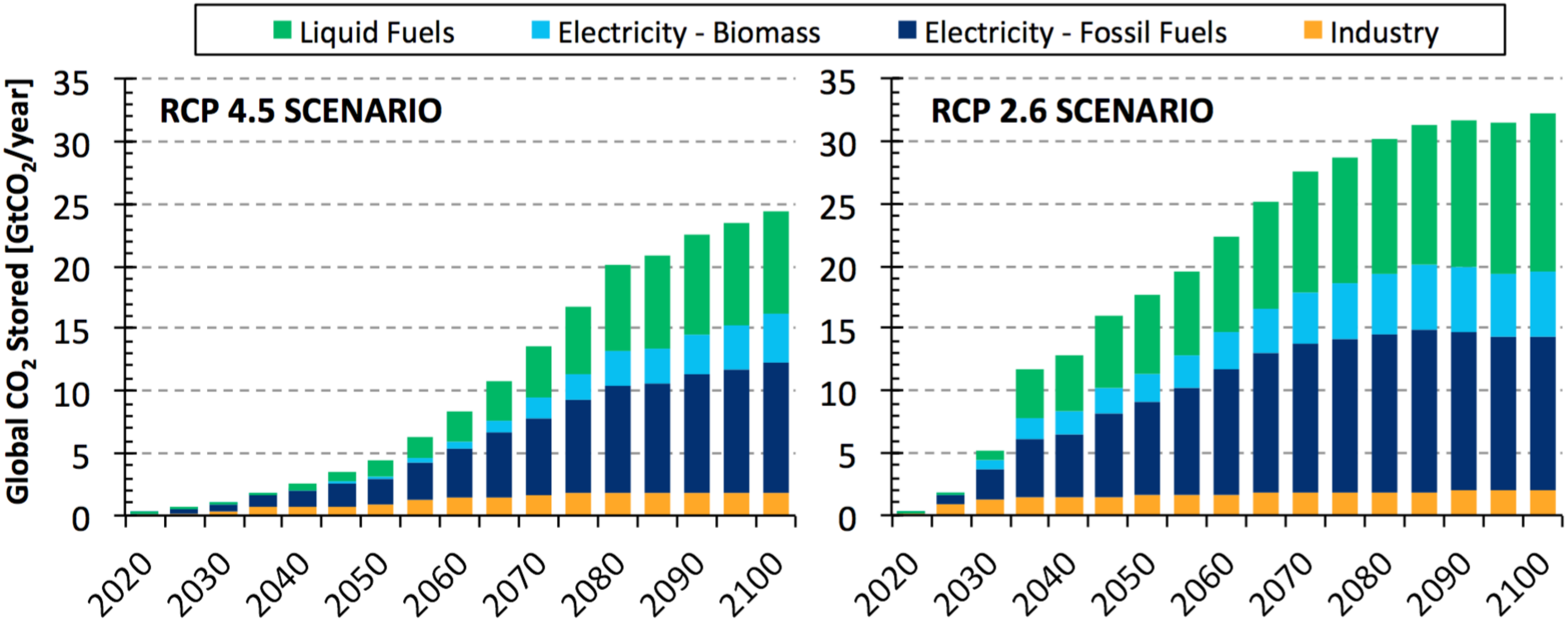


- GCAM applies a price on GHG emissions to achieve the prescribed emission reductions from the No Policy case.
  - Approximates a model least-cost scenario to reach emission pathway.

- Technologies deployed in GCAM scenarios are influenced by their relative economics.

GCAM Mitigation Scenarios: CO_2 Stored

- The scale of CCS deployment in GCAM depends on the stringency of the climate change mitigation policy.
- The deployment of CCS technologies is not limited to fossil fuels, nor to power plants, as suggested by some studies.



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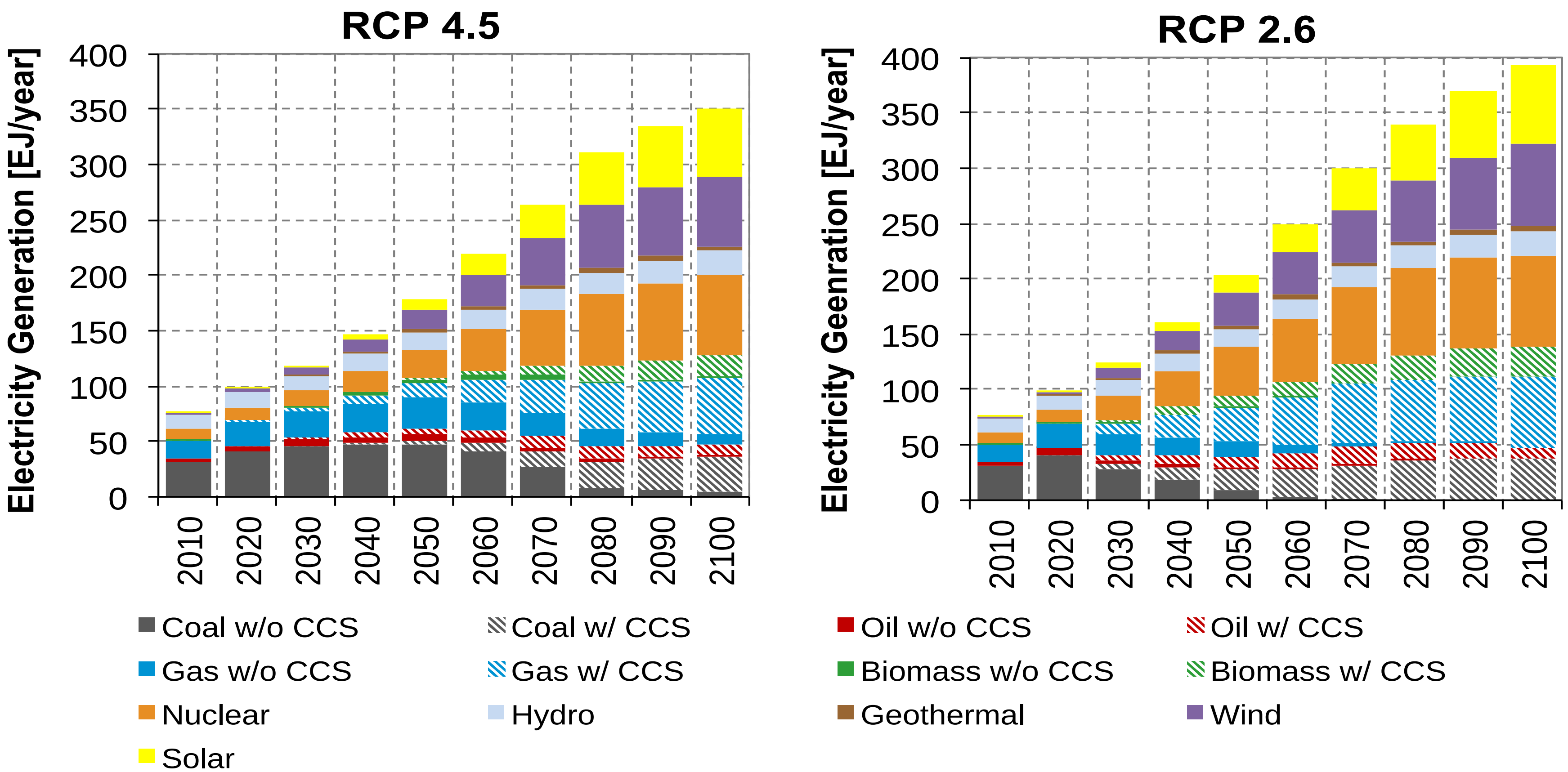
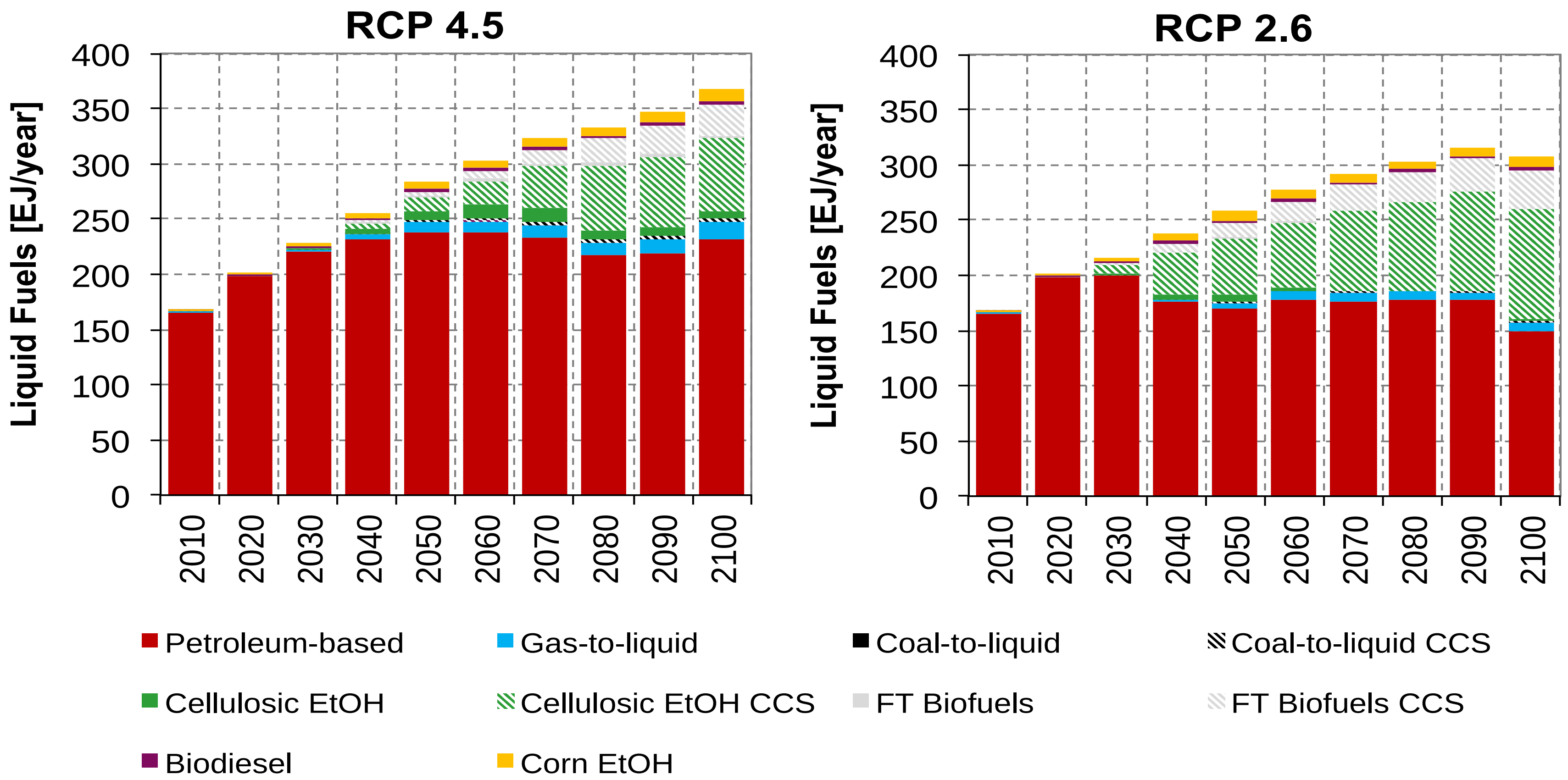
GCAM Mitigation Scenarios: Electricity



- Both CCS- and biomass-for-electricity are limited at present.
- Both gas & coal with CCS emerge over time; gas demand is robust.
- Nearly all biomass used for electricity includes CCS.

GCAM Mitigation Scenarios: Liquid Fuels



- Petroleum-based fuels currently dominate liquid fuels and continue throughout the century.
- Most bio-ethanol is produced with CCS, not without.

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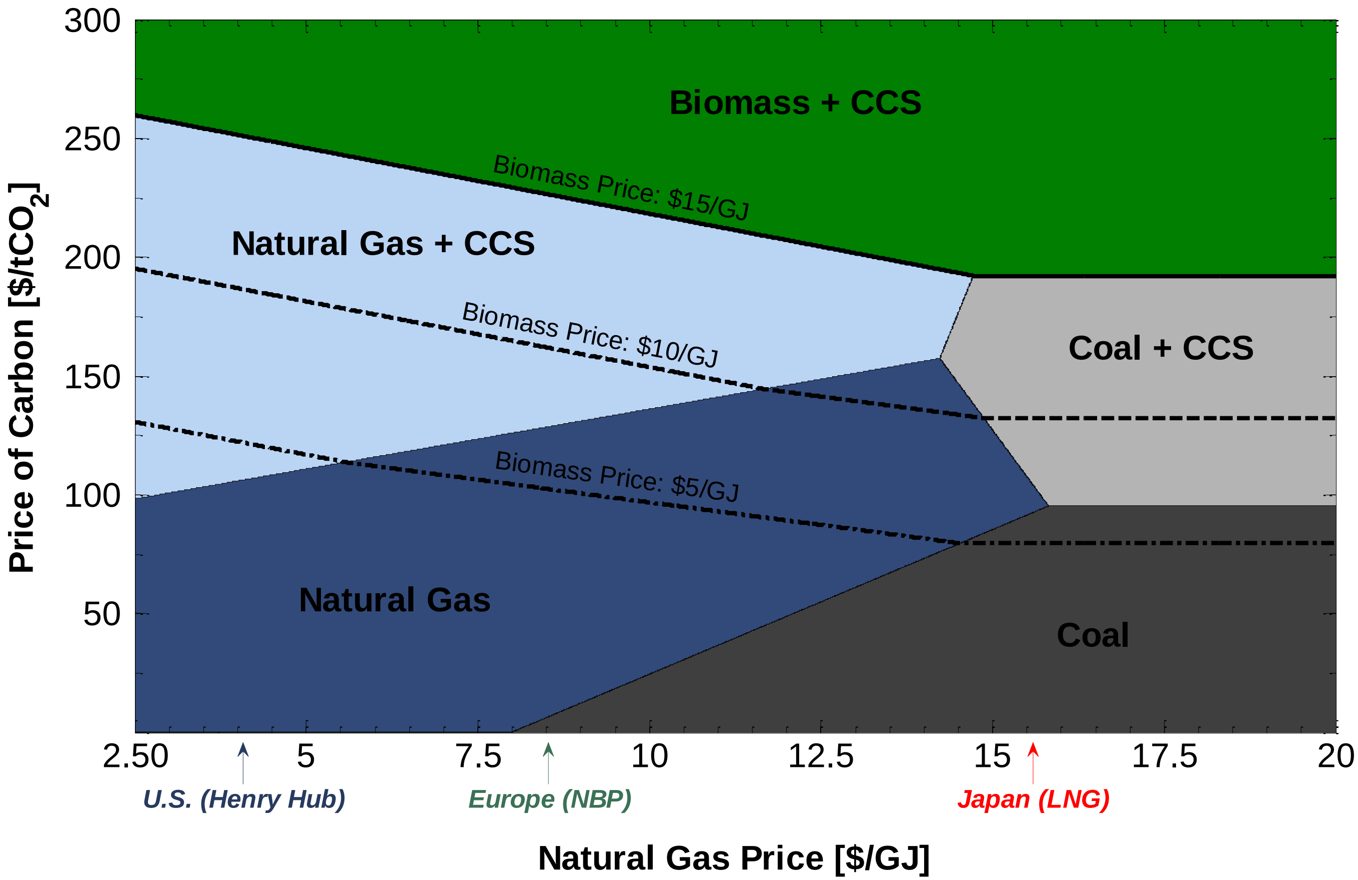
CCS in the Electricity Generation Sector

- The fuel choice for CCS applications in the electricity sector in GCAM is driven by the **levelized costs of electricity** (LCOE)
- CCS technologies become competitive at a **sufficiently high carbon prices**.



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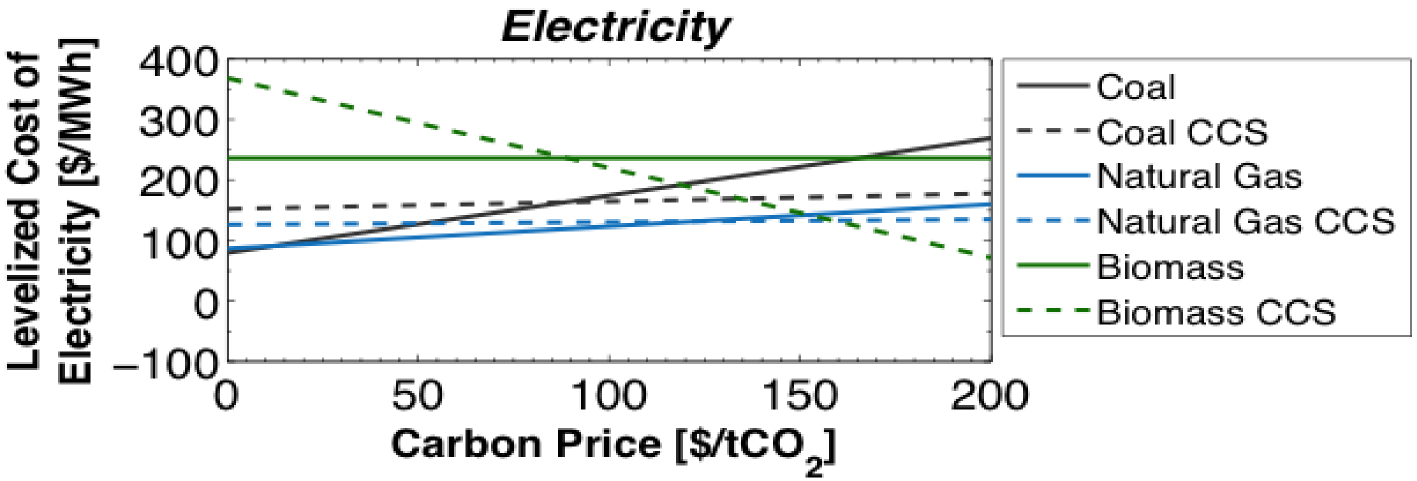
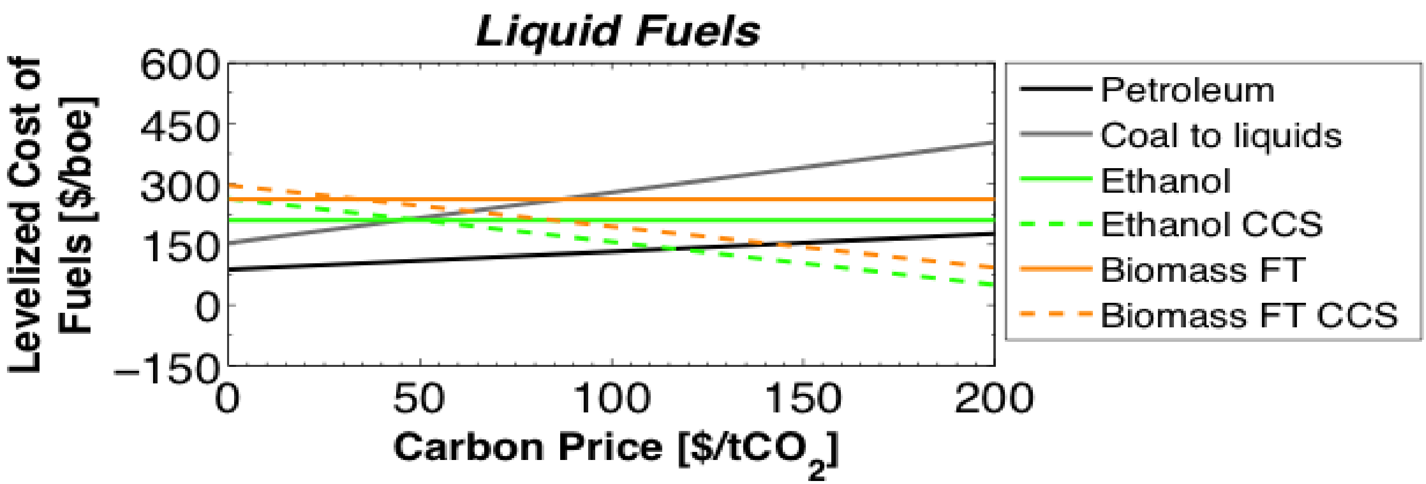
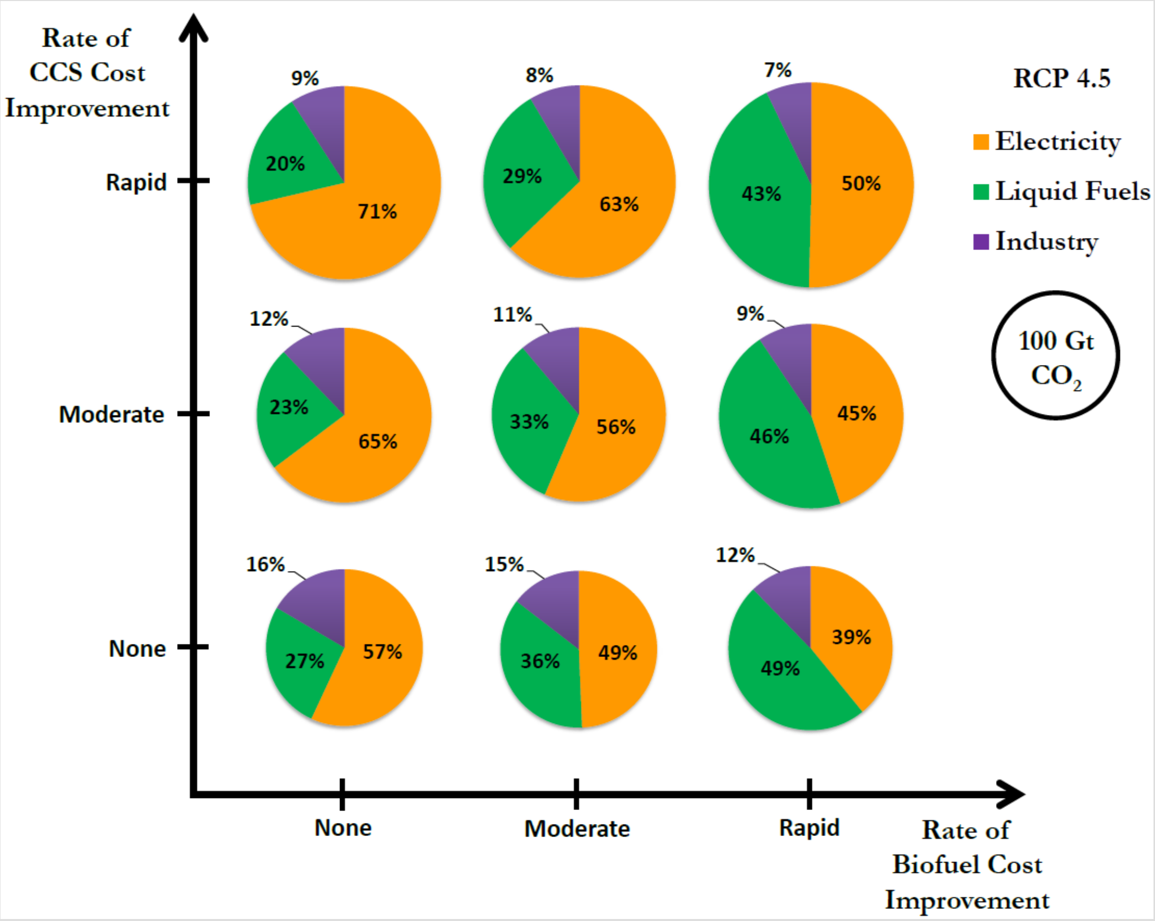
Illustrative Economics Shows Why BECCS is Favored when Carbon Price is High





CCS across Sectors

Sensitivity of Cumulative CO_2 Stored 2020-2100 to Technology Improvement Rates



- CCS cost improvement increases CCS use, particularly in Electricity Sector.
- Biofuel cost improvement increases CCS in Biofuels.

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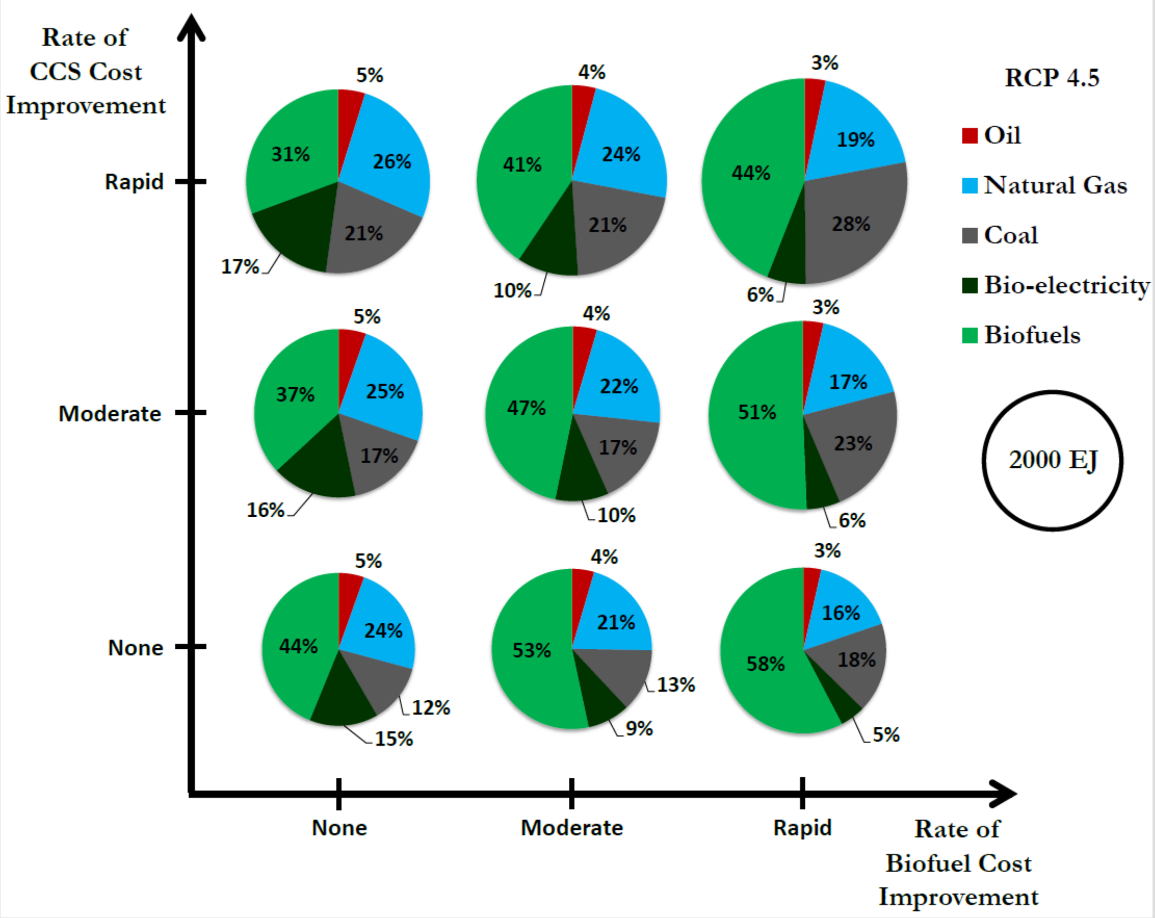
CCS across Fuels

Sensitivity of Cumulative Primary Energy 2020-2100 in CCS Applications to Technology Improvement Rates



- Biofuels with CCS an important option in the future, but not at this time.
- Natural gas with CCS important fossil source of electricity.

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Conclusions

- Role of CCS differs across mitigation scenarios of IAMs.
  - IAMs do not agree on overall CCS deployment and on which fuels or sectors CCS would be applied.
- GCAM scenarios can be explained based on underlying cost competition between technology options.
  - Little CCS when carbon price low.
  - Fossil fuel electricity and BECCS (for both electricity and biofuels) when carbon price high.
- Greater scrutiny of CCS cost assumptions and broader assumptions about practical barriers to CCS deployment (and BECCS in particular) is important to further refine scenarios of energy system transformation pathways.

Thank You