Decarbonization and the Expanding Focus of Energy Security

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MIT Joint Program on the Science and Policy of Global Change

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Image: Claudine Hellmuth/E&E News

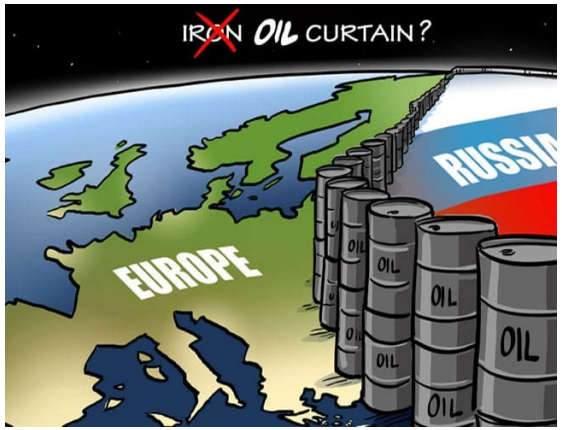
Based on work with: Angelo Gurgel, Sergey Paltsev, Howard Herzog, John Reilly, Adam Schlosser, Bryan Mignone, Haroon Kheshgi, Lucas Desport, Steve Rose

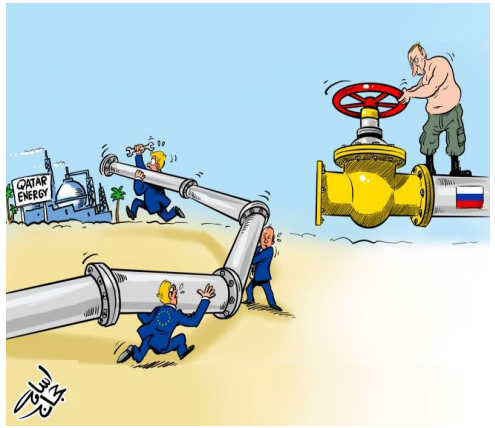
Original Focus of Energy Security

Stability of supply... of fossil fuels

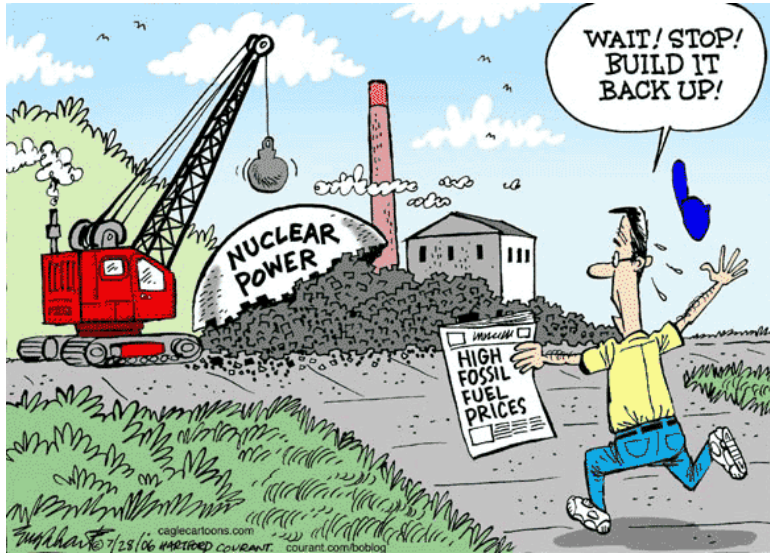
- Imports: amount; stability and diversity of suppliers
- Geopolitical disruptions
- High price spikes / price volatility
- Domestic production, reserves and energy independence

→ Still relevant





Expanding Focus of Energy Security



Reduce fossil fuel use

- Increase energy efficiency
- Diversify energy mix
    - Expand domestic low-carbon energy sources

Availability, Accessibility, Affordability, Acceptability

Risk and Resilience

→ Not just risk of geopolitical disruptions, but disruptions from natural disasters/ extreme weather events, (cyber)terrorism, pandemics, aging infrastructure, changing climate, societal transitions…

Main Decarbonization Pathway

1) Decarbonize electricity, with heavy focus on **renewables**

2) **Electrify** as much of the economy as possible

Domestic strategy that reduces energy security concerns regarding fossil fuels

BUT new energy security challenges…

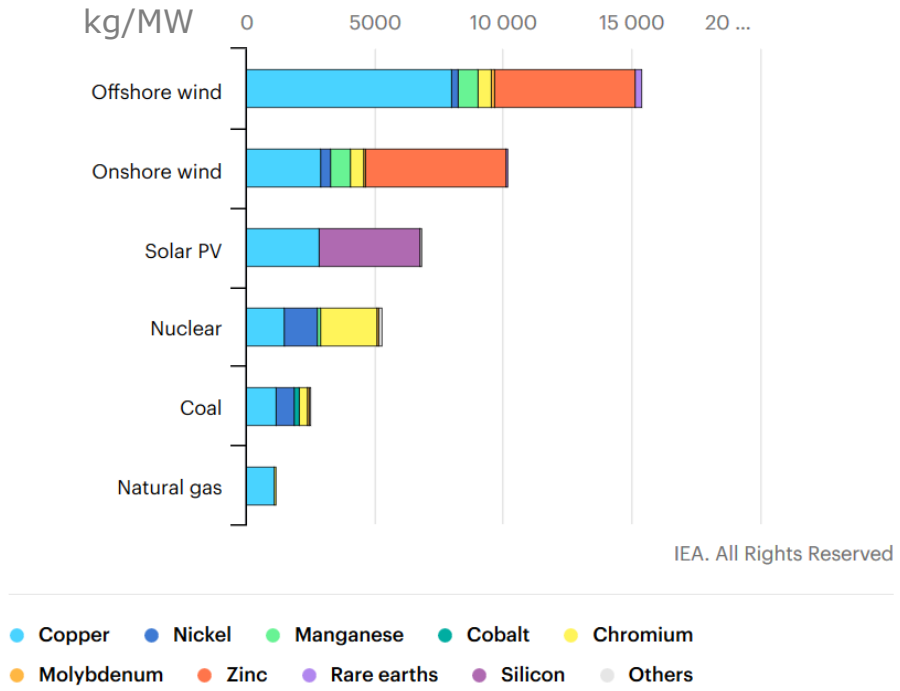
Variability of renewables

Image: https://sympower.net/what-is-electrification-definition-and-examples/

Expanding Focus of Energy Security

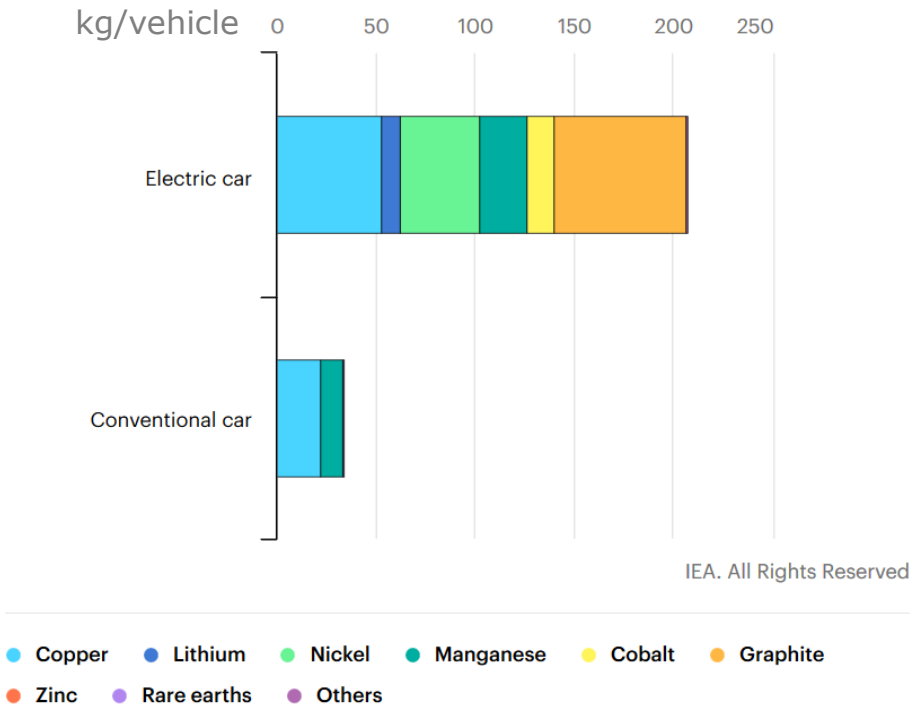
Stability of supply... of critical minerals

Materials Used in Low-Carbon vs. Fossil Generation Technologies



An offshore wind plant requires 13x the mineral resources of a similarly sized gas-fired power plant

Materials Used in EVs vs. ICEs



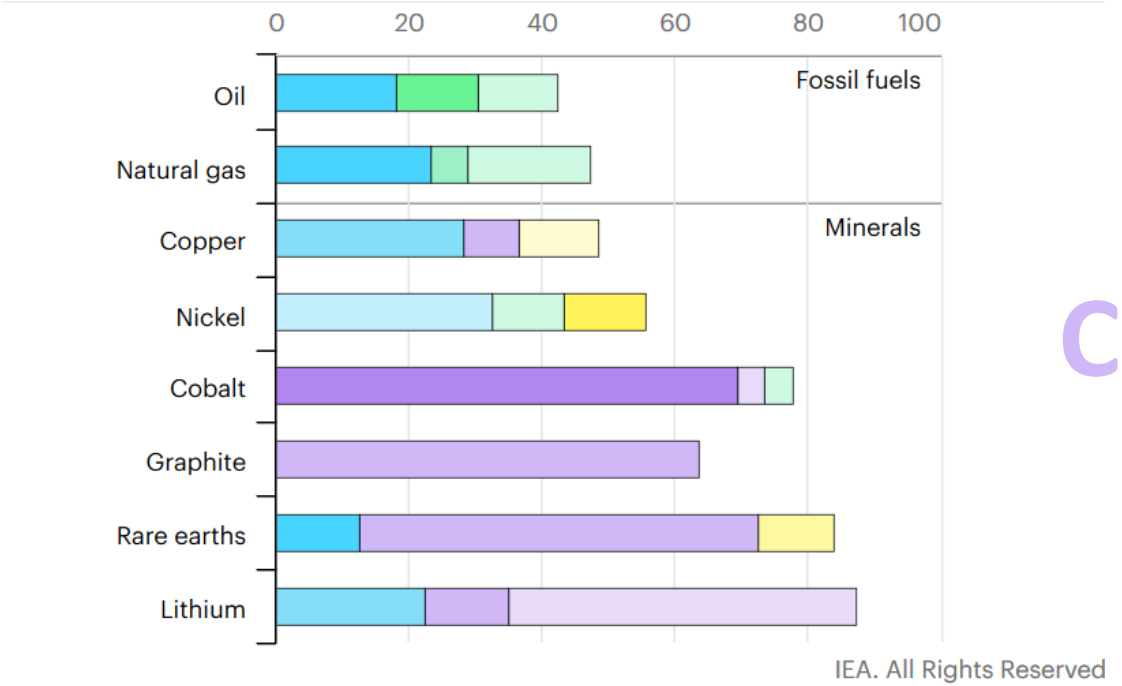
A typical electric car requires 6x the mineral resources of a conventional car

Source: IEA (2021)

Expanding Focus of Energy Security

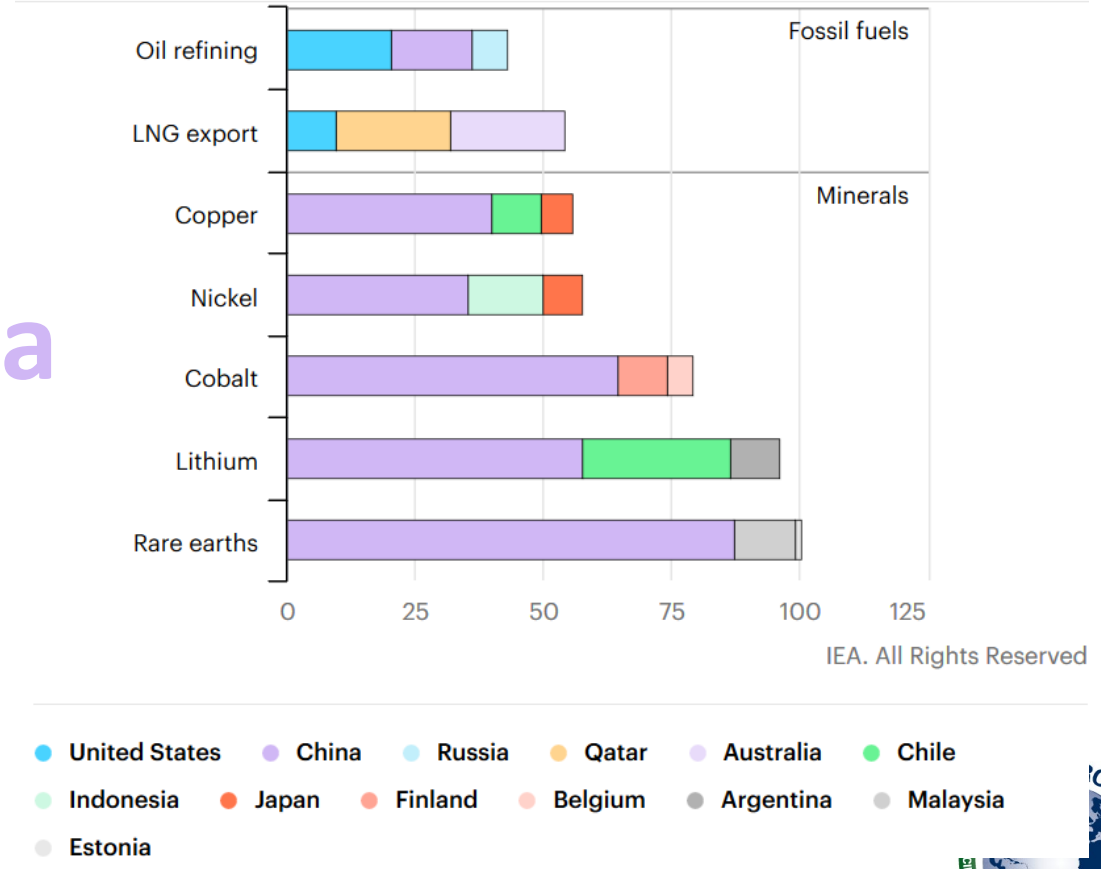
Stability of supply... of critical minerals

Share of top three producing countries in extraction (2019)



China

Share of top three producing countries in processing (2019)



Source: IEA (2021)

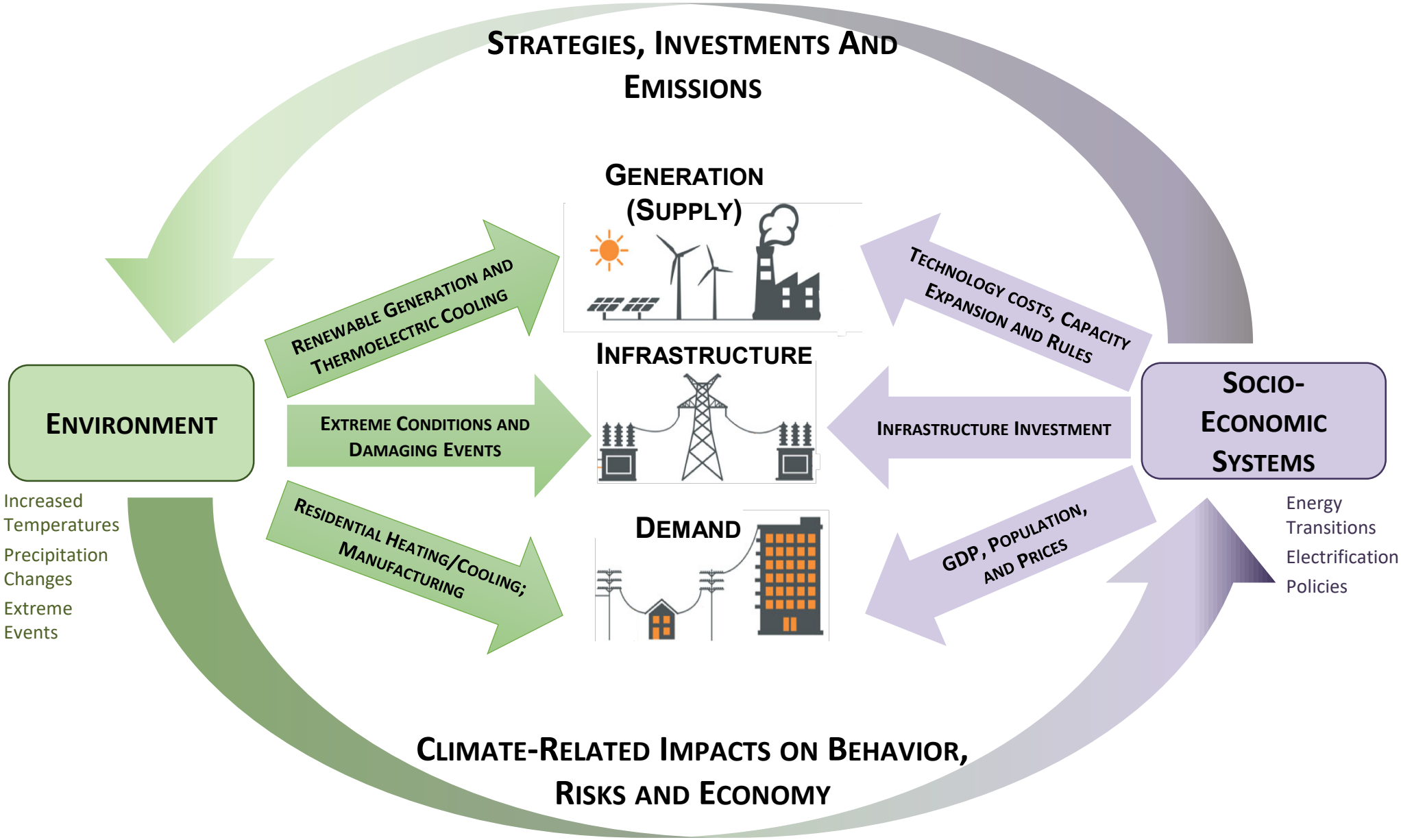
Expanding Focus of Energy Security

Heavy Dependence on Electricity

- Low diversity of energy mix
- Huge increase in electricity demand
    - Electrification
    - Green hydrogen
    - DAC
- Enormous infrastructure requirement
- Growing stressors threatening reliability and resilience of electricity system

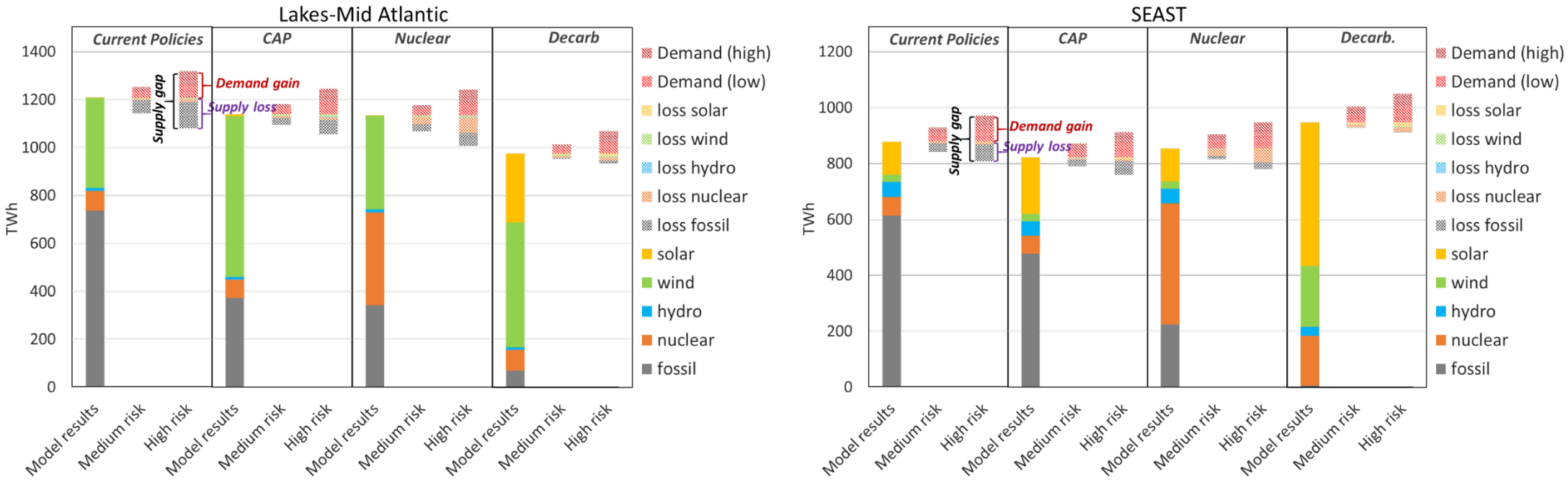
Credit: peterschreiber.media

Electricity System under Multiple and Compounding Stressors



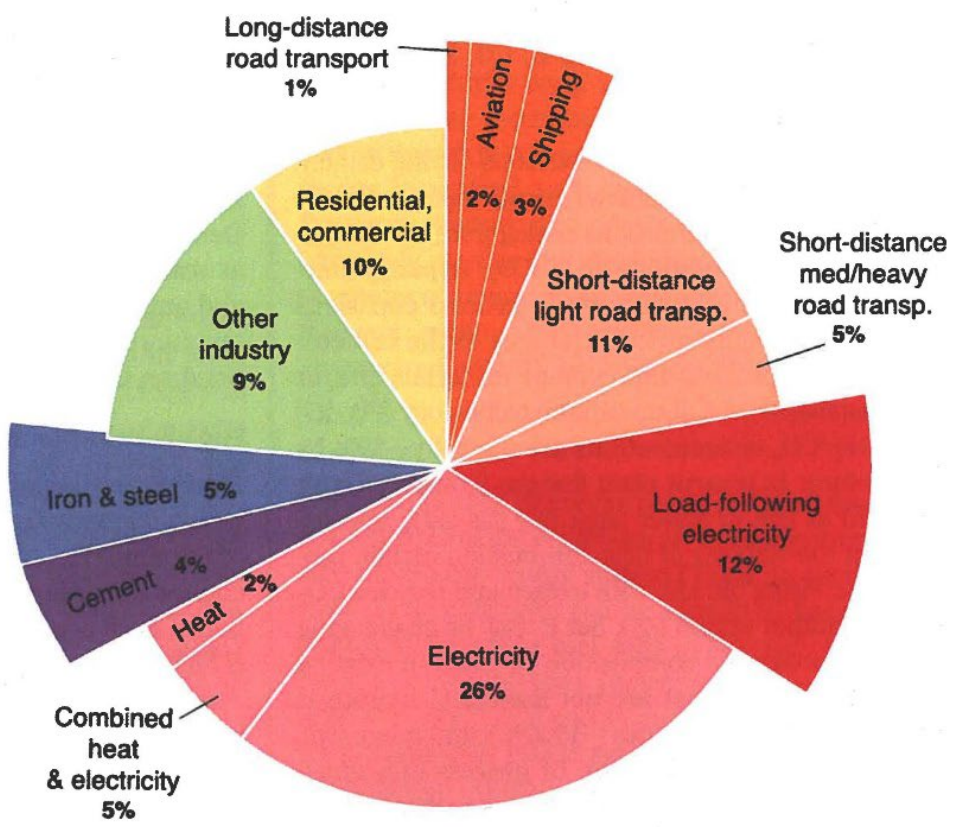
Supply gaps estimated based on climate impacts on generation technologies and electricity demand

DOE Project

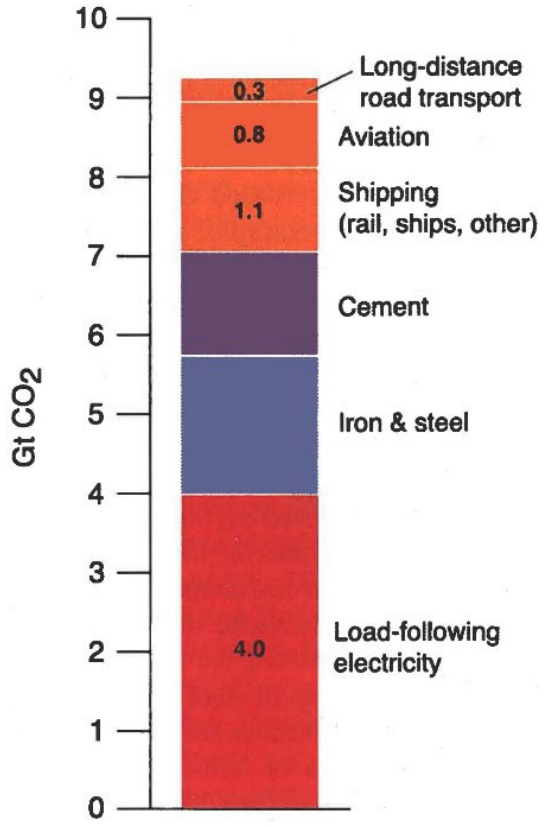


- "Medium risk" assumes RCP4.5 climate impacts: supply gaps of **6-9%** in Lakes-Mid Atlantic; **8-10%** in SEAST
- "High risk" assumes RCP8.5 climate impacts: supply gaps of **14-21%** in Lakes-Mid Atlantic; **15-19%** in SEAST
- Additional electricity demand from climate impacts has a greater effect than losses in energy supply
- Scenarios relying more on renewables are subject to lower supply gaps
- Annual supply and demand vs. extreme events

Decarbonizing Hard-to-Abate Sectors



A Global fossil fuel & industry emissions, 2014 (33.9 Gt CO_2)



B Difficult-to-eliminate emissions, 2014 (9.2 Gt CO_2)

+

Difficult-to-eliminate GHG emissions from other sectors (e.g., agriculture)

Total non-CO_2 GHGs in 2020 ~3 Gt CO_2e

Source: Davis et al., Science 360 1419 (2018)

Need Negative Emissions

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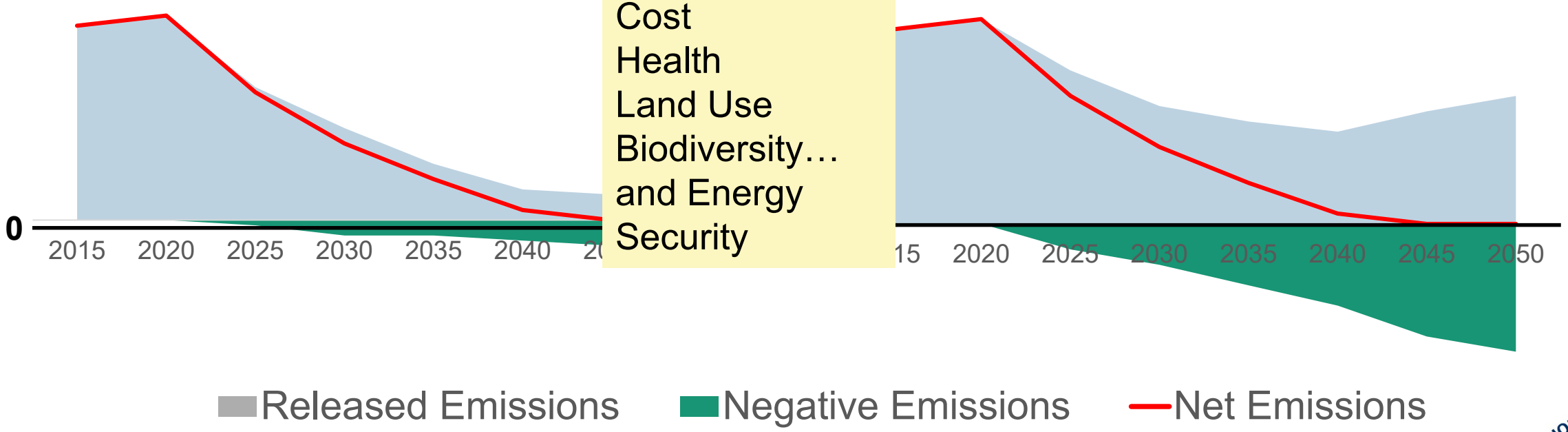
How balance released emissions vs. negative emissions?

Reduce emissions as much as possible and offset remaining difficult-to-eliminate emissions with negative emissions

Continue to release, and offset, any emissions with marginal abatement cost > cost per ton negative emissions

Implications for:
Technologies
Cost
Health
Land Use
Biodiversity…
and Energy
Security

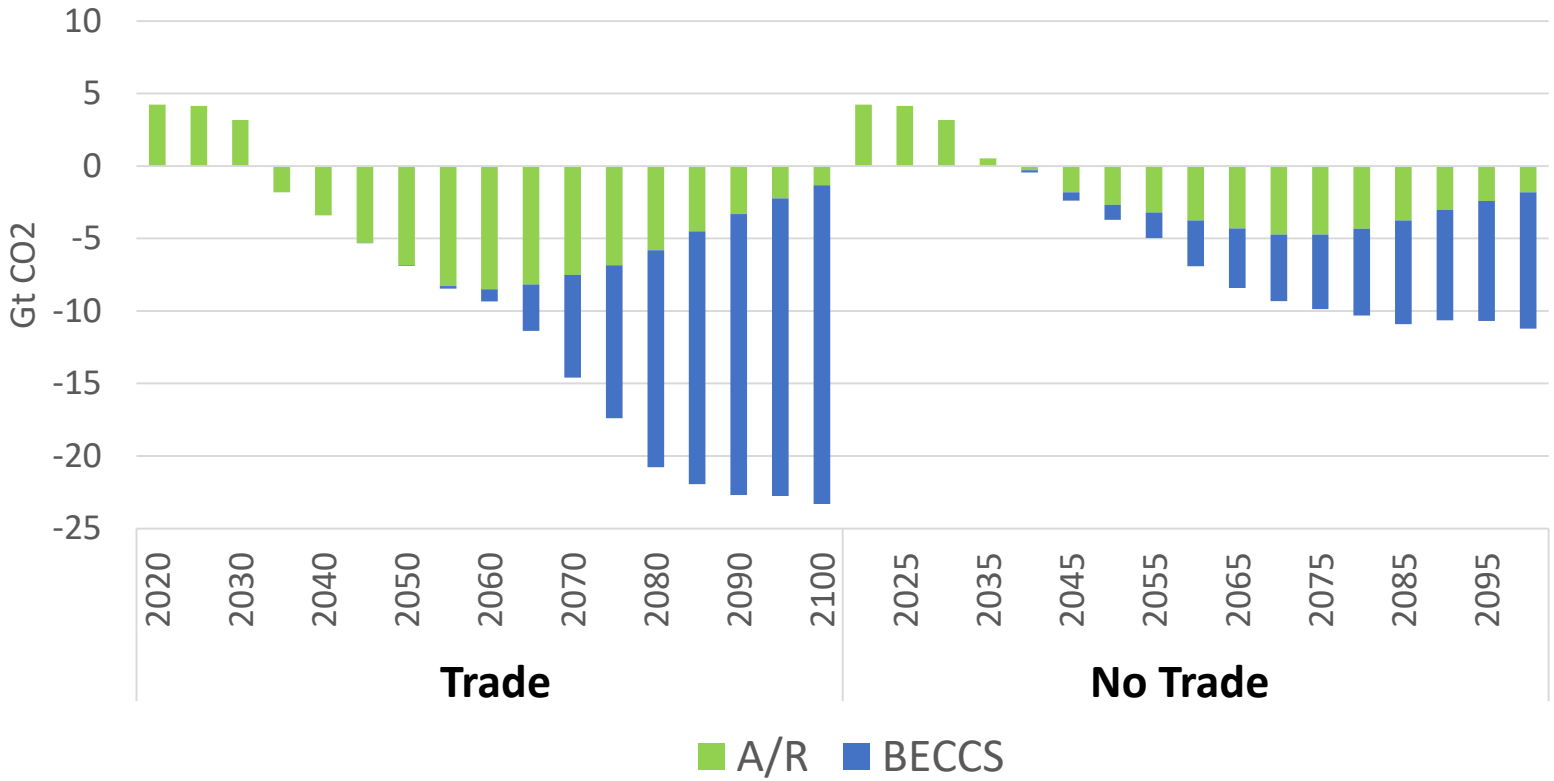


Role of Land-Based CDR

Project with ExxonMobil

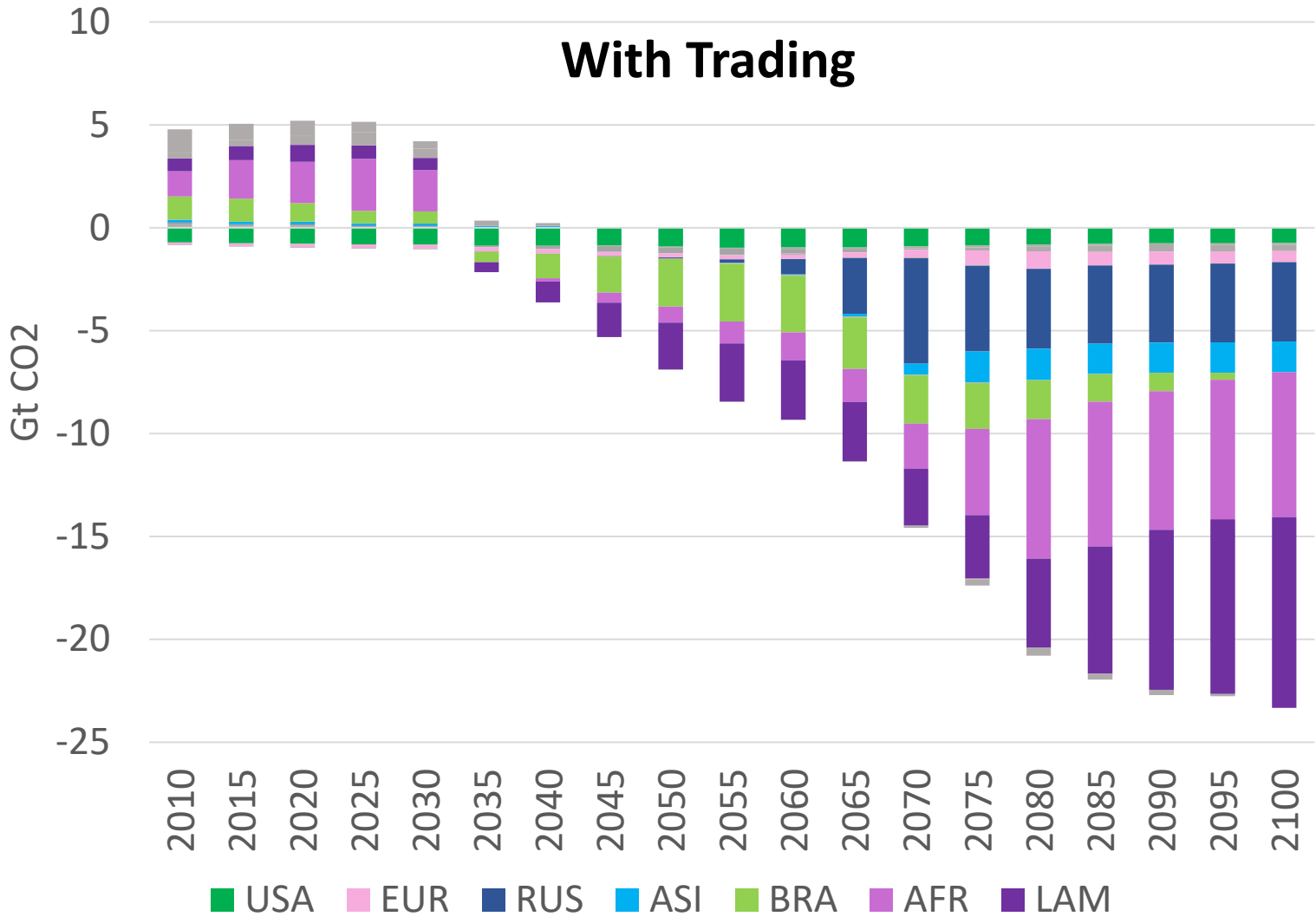
Work with
Bryan Mignone
Haroon Kheshgi

- 2C scenarios exploring different combinations of availability of:
  - **Afforestation/reforestation (A/R) offsets**
  - **BECCS**
  - **International emissions trading**



Preliminary results

Where Is Land-Based CDR Happening?



USA: A/R

Europe: BECCS + A/R

Russia: BECCS

Dynamic SE Asia: BECCS

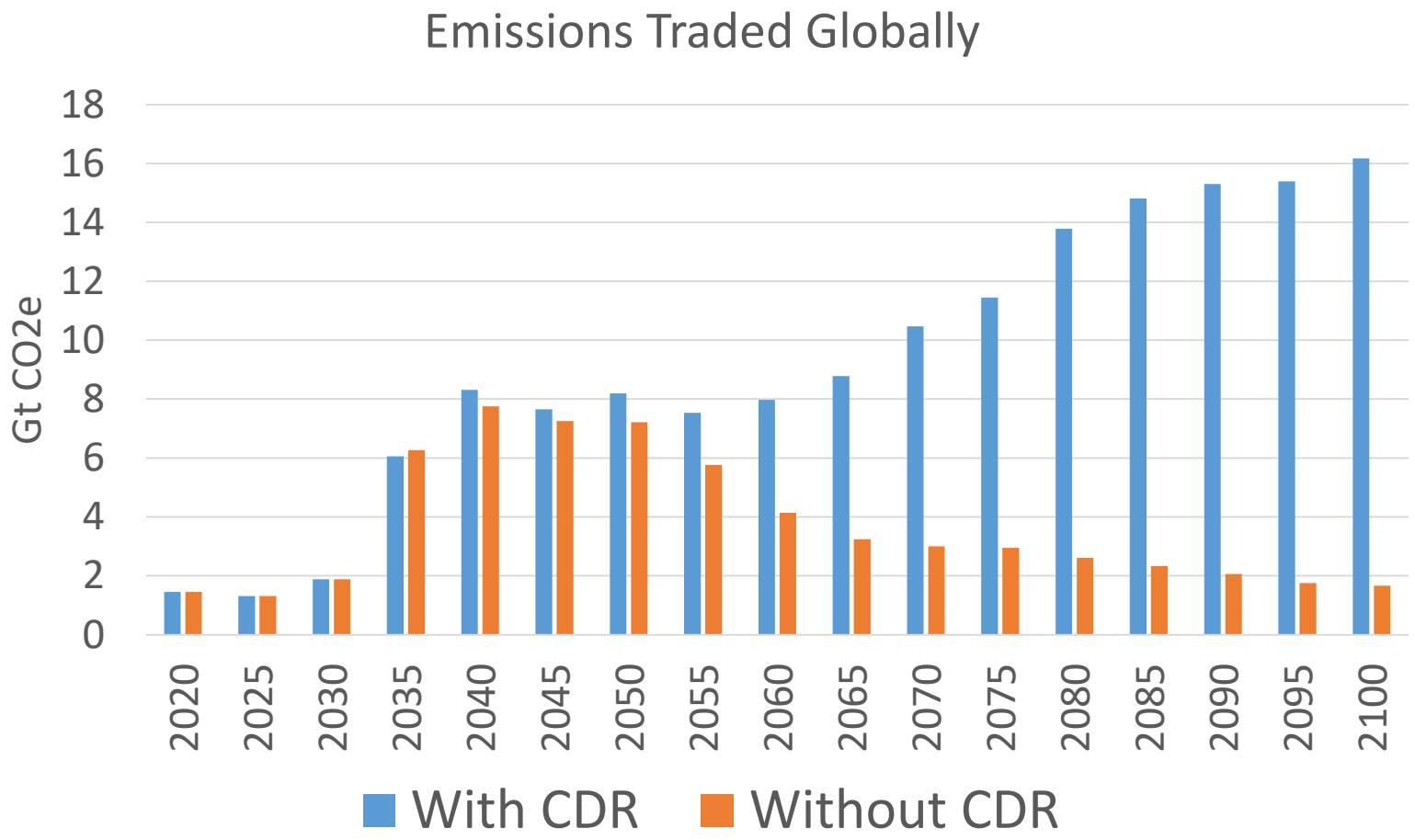
Brazil: A/R

Africa: BECCS + A/R

Latin America: BECCS + A/R

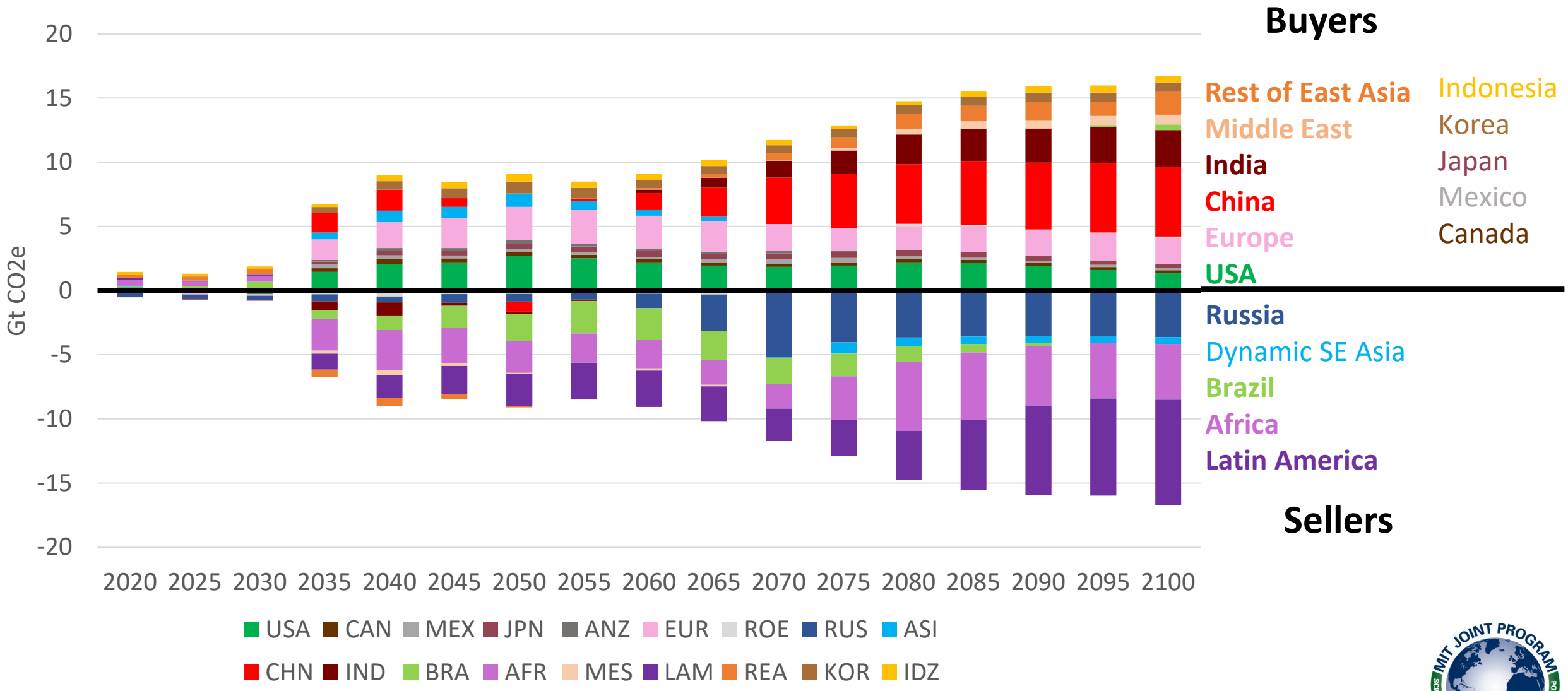
Preliminary results

Scale of Offset Trading



Preliminary results

Who's Buying the Offsets?



Preliminary results

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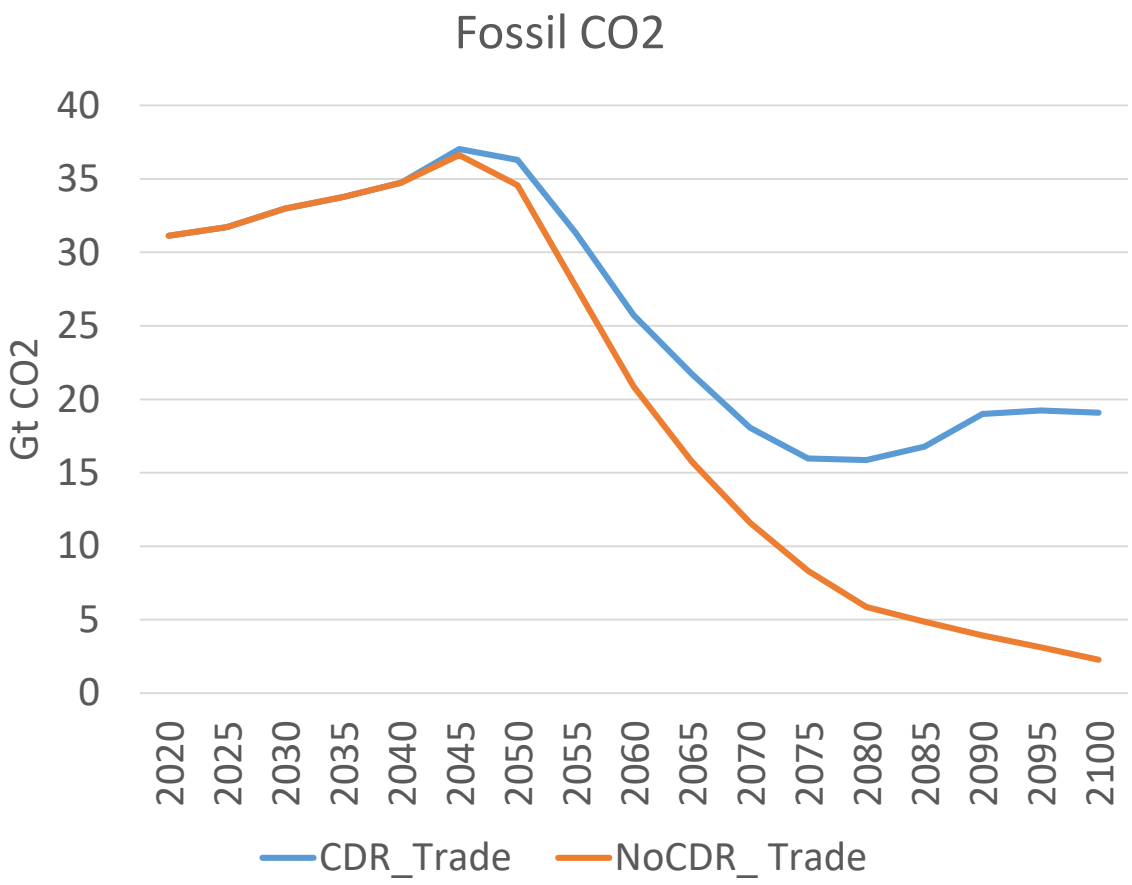
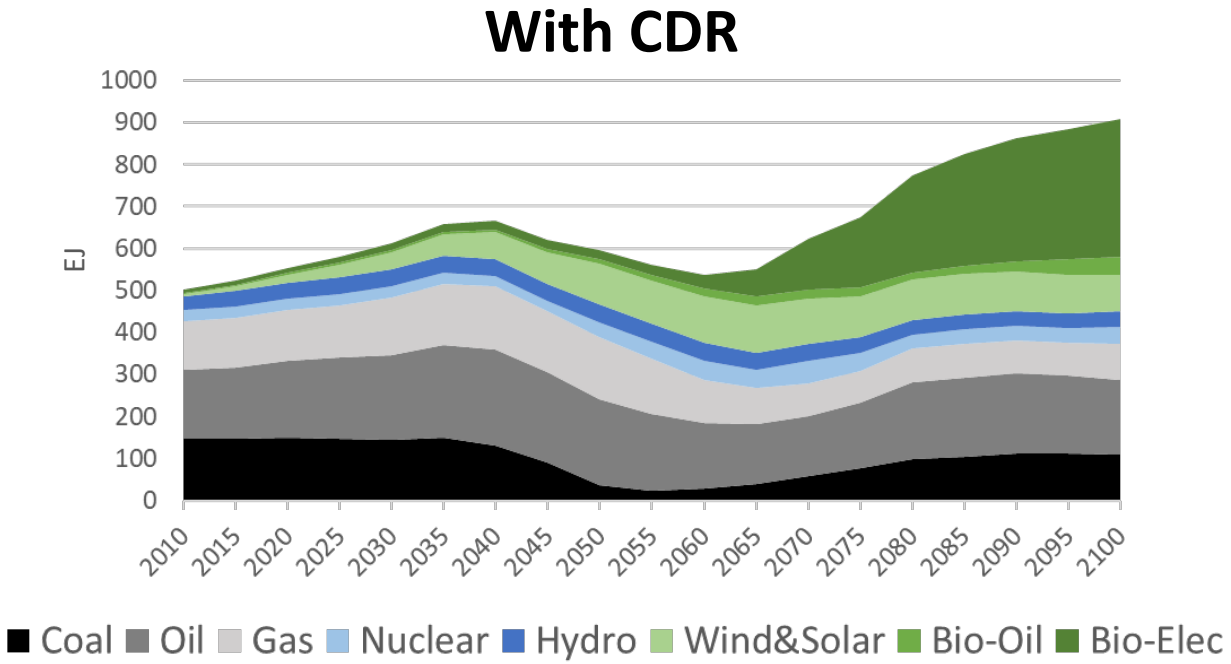
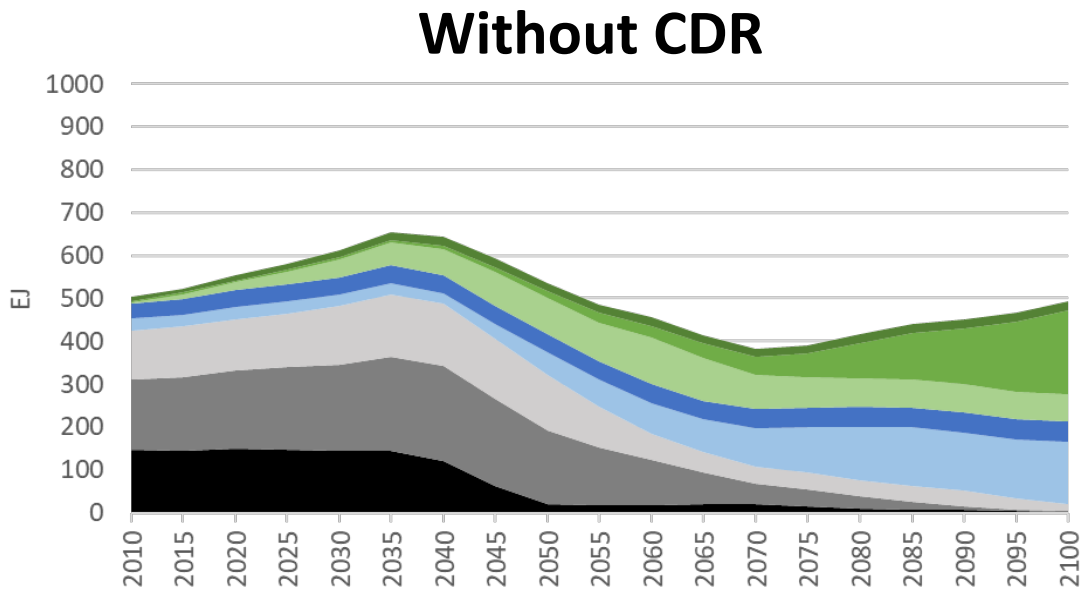
Expanding Focus of Energy Security

Stability of supply... of offsets







Preliminary results

Expanding Focus of Energy Security

Stability of supply... of land

Stability of supply... of water

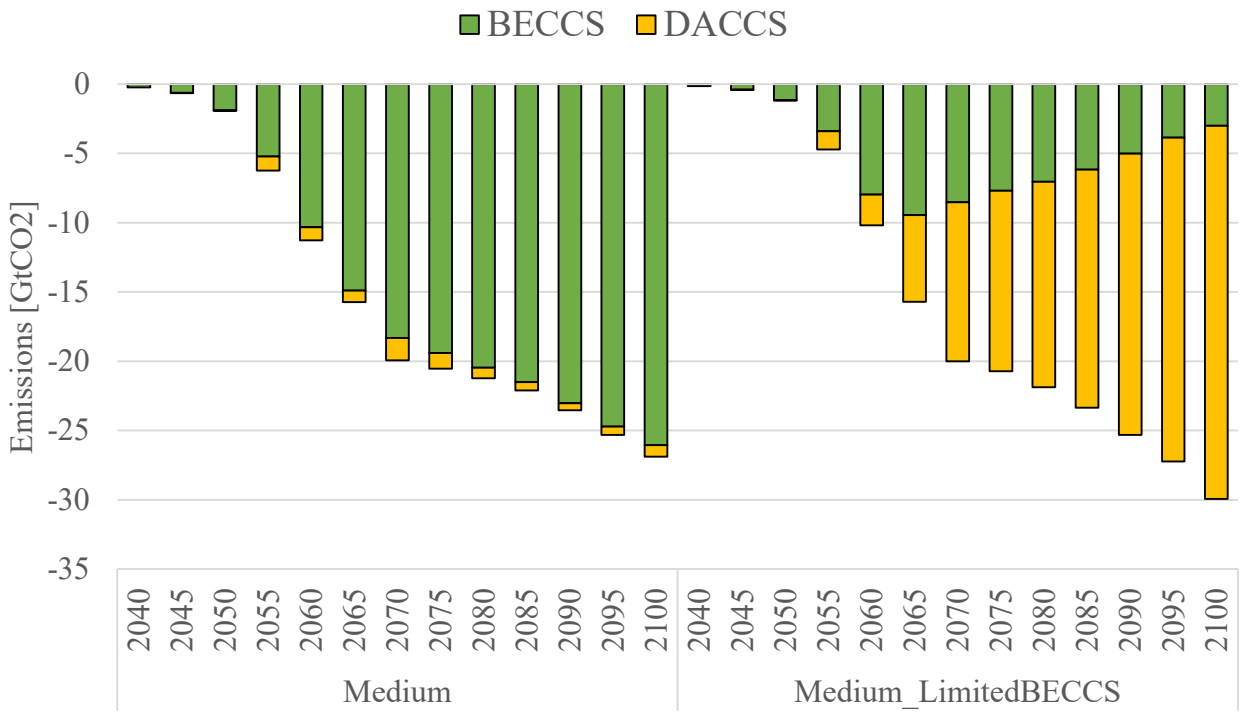
Stability of supply... of biomass

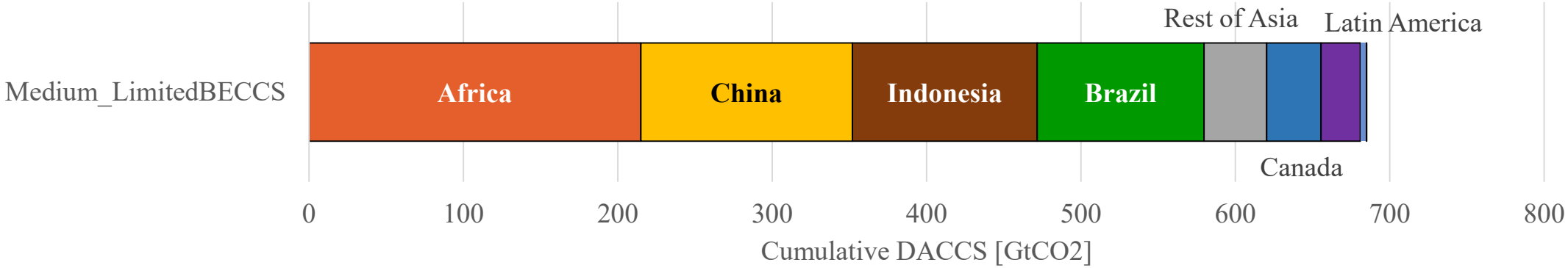
Stability of supply... of CO2 Storage locations

Role of DACCS

Project with TotalEnergies

Work by Lucas Desport





Stability of supply... of offsets

Preliminary results

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What about DACCU?

Project with FAA

- Potential pathway to produce valuable low-carbon fuels, chemicals, or building materials to help decarbonize hard-to-abate sectors

- Potential for **sustainable aviation fuels**

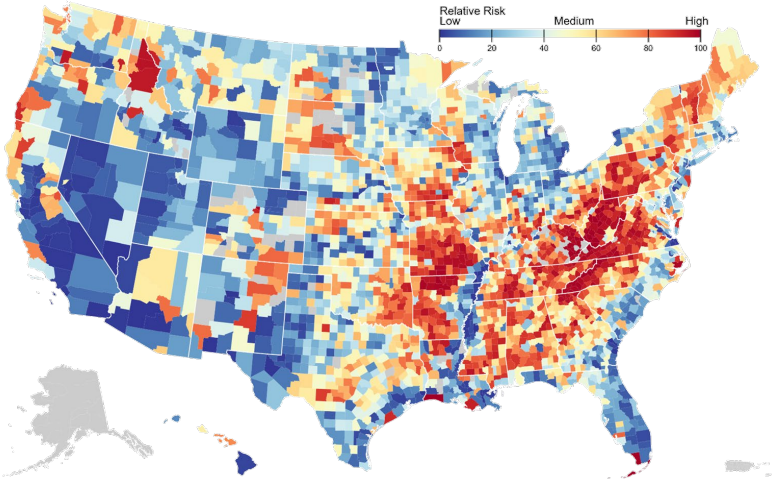
Stability of supply... of captured CO2

Image: https://airlines.iata.org/analysis/realizing-the-potential-of-sustainable-aviation-fuel

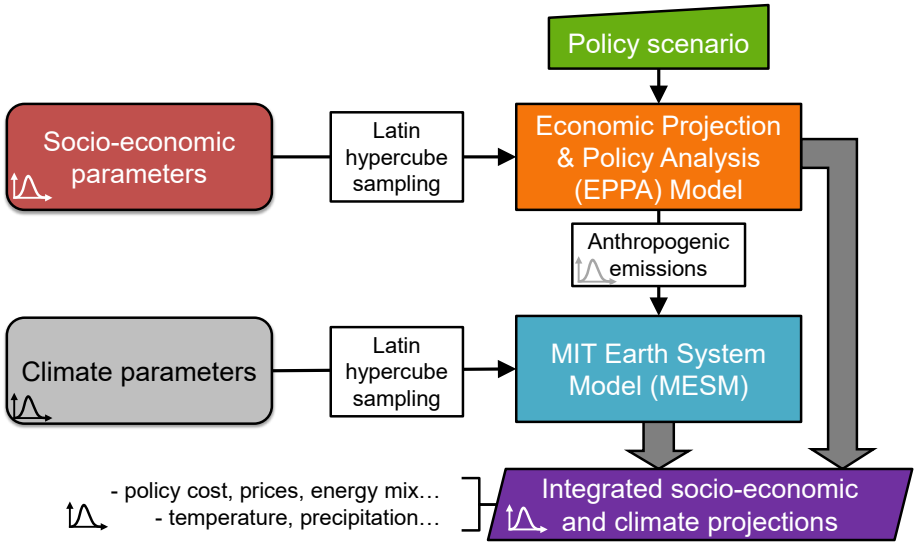
Expanding Focus of Energy Security

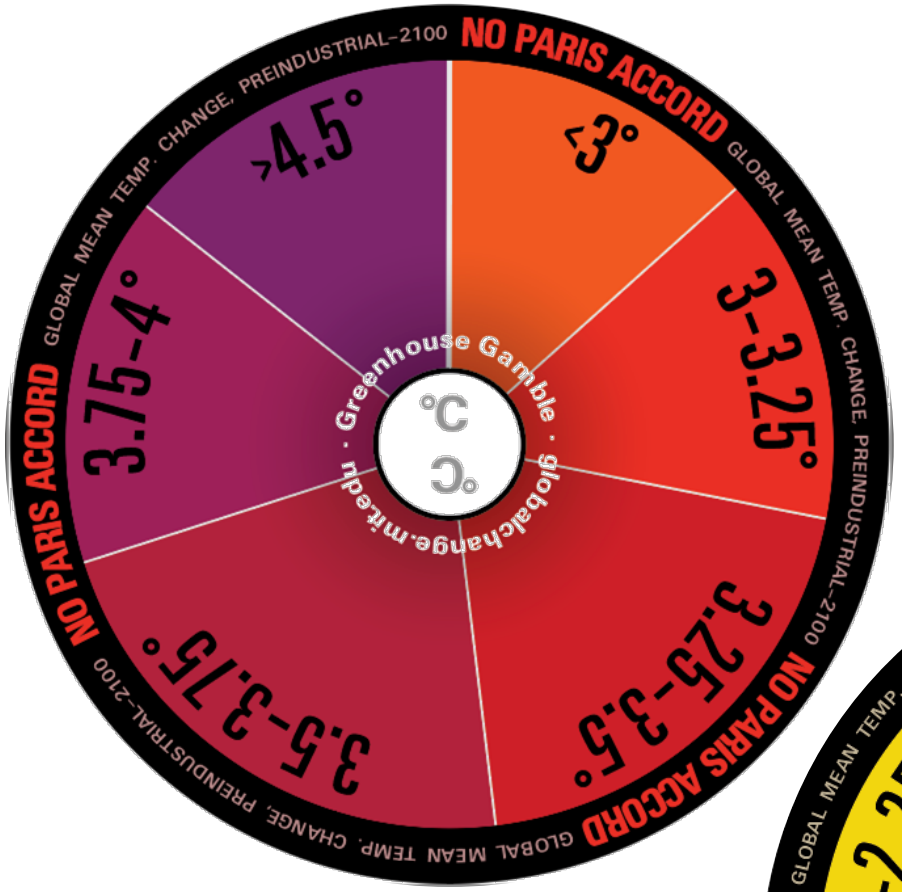
- Growing focus on affordability, accessibility and acceptability
- Decarbonization broadens scope of availability concerns and highlights multi-sector considerations
- Blurring lines between energy security and resilience of energy systems
  - Growing need to focus on wide range of stressors, uncertainties and risks

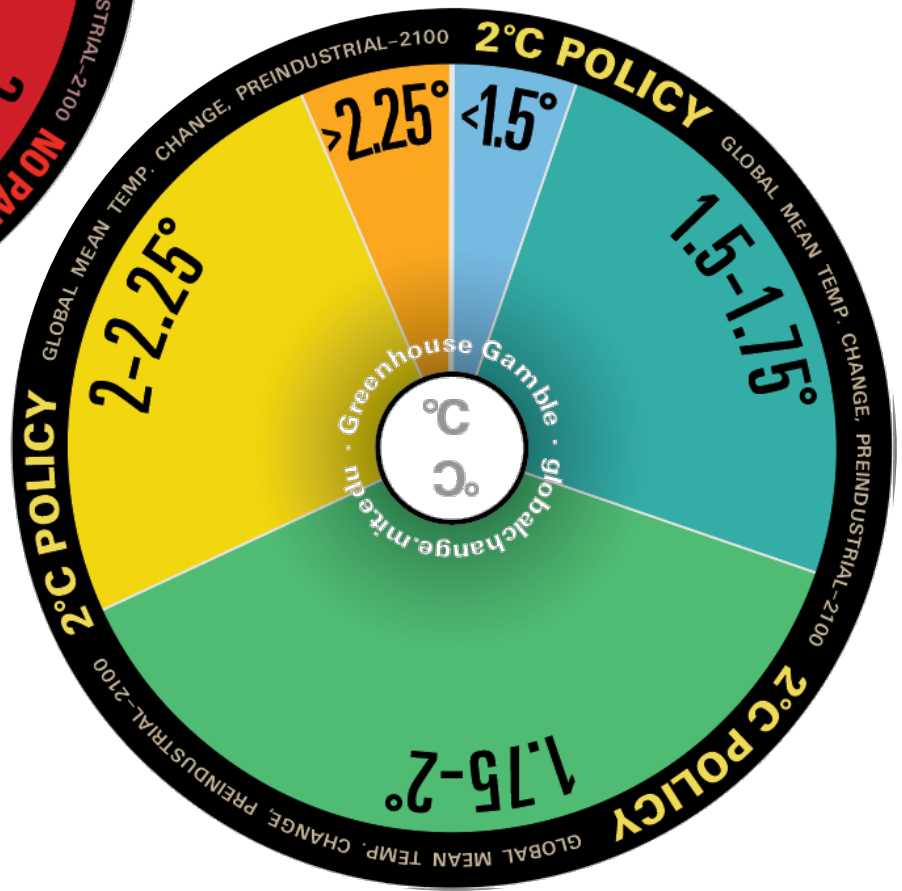
MIT Socio-Environmental Risk Triage (SERT) Platform



MIT Uncertainty Framework







Uncertainty is unavoidable… but we can quantify where possible and make decisions accordingly

Thank you!

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