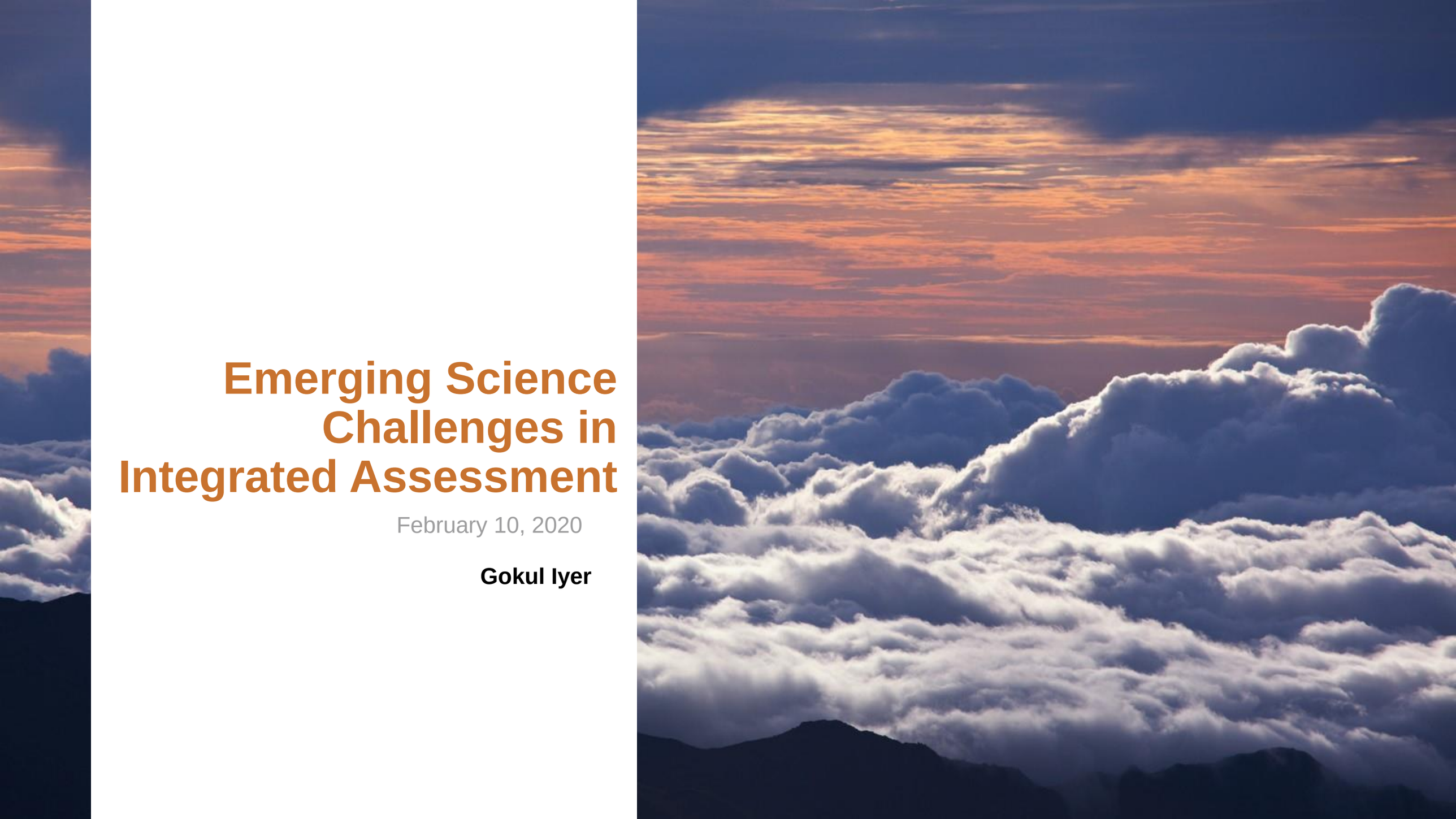
Emerging Science Challenges in Integrated Assessment

February 10, 2020

Gokul Iyer



Three main challenges (in turn, research opportunities) and a few examples of first steps

- Account for subnational forcers and policies in emissions mitigation analyses.
- Improve representations of financial and non-financial behavioral aspects in models.
- Improve representations of multi-sector interactions including those that cut across geographic boundaries (e.g. trade).

Account for subnational forcers and policies in emissions mitigation analyses

Motivation to account for subnational forcers and policies in emissions mitigation analyses

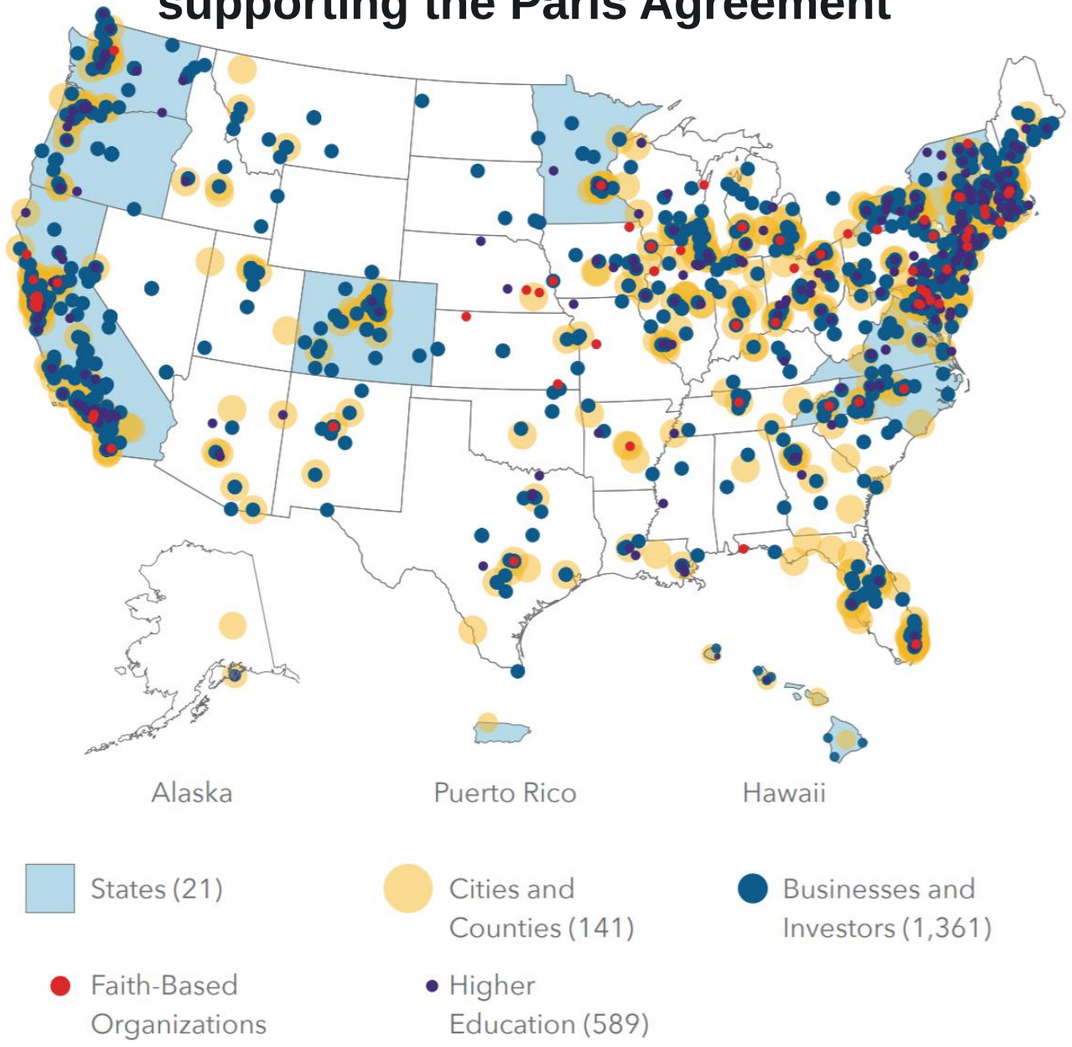
- Climate strategies are increasingly being designed at subnational scales with states, cities, and firms playing an important role.
  - About 12,500 of subnational efforts have been registered with the UNFCCC globally.

Example of subnational modeling: America's Pledge

- The study focuses on non-federal government actors in the U.S.: states cities, and businesses.

- Research Question: **Do their efforts add up to 26-28% reduction in economy-wide GHG emissions by 2025 relative to 2005 (the U.S. NDC**

U.S. States, cities, and businesses supporting the Paris Agreement

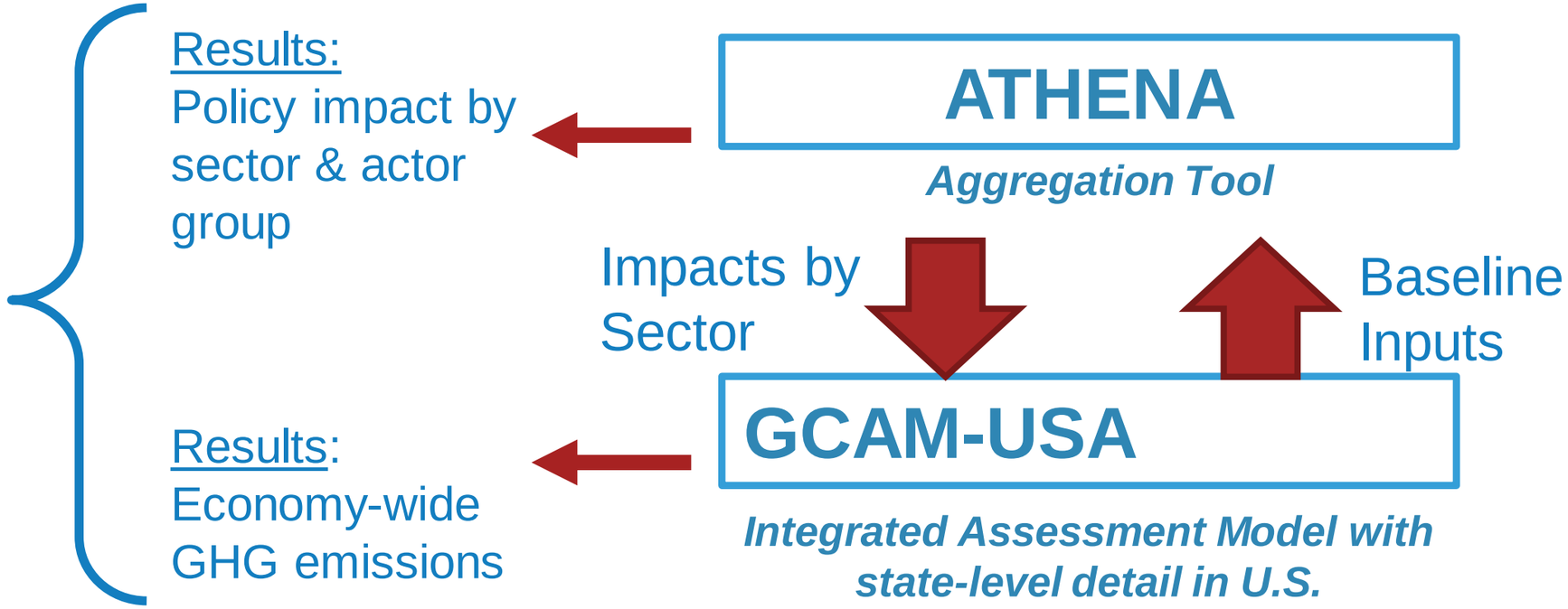


Source: Fulfilling America's Pledge, https://www.bbhub.io/dotorg/sites/28/2018/09/Fulfilling-Americas-Pledge-2018.pdf

The study used GCAM-USA to aggregate subnational efforts to the national scale

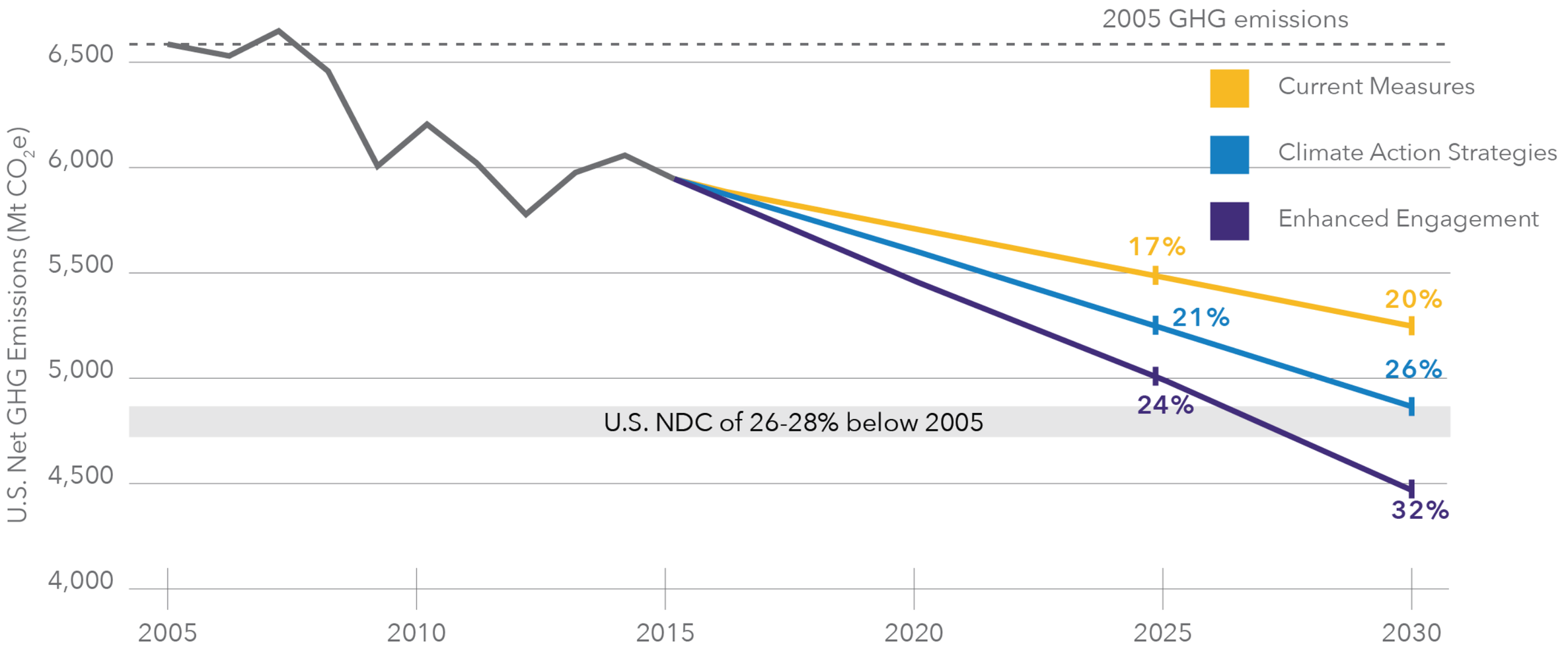
Three Scenarios:

- **Current Measures**
- **Ten Climate Action Strategies** *
- **Enhanced Ambition**



** Includes redoubling commitments to renewable energy targets, accelerating retirement of coal power, encouraging residential and commercial building retrofits, electrifying building energy use, accelerating electric vehicle adoption, phasing down super-polluting HFCs*

Bottom-up efforts could get the U.S. pretty close to the NDC and set the stage for deeper reductions in the future

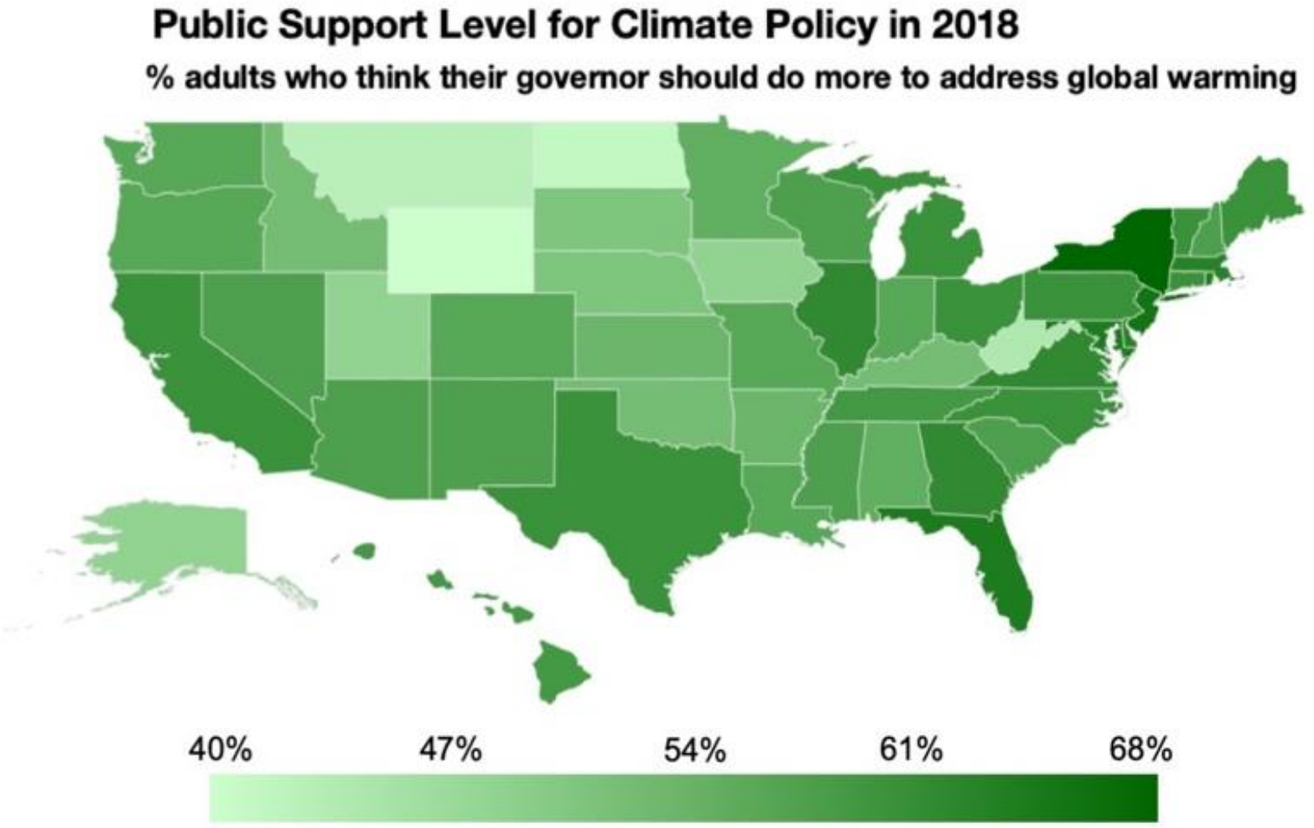


How much more expensive is decentralized bottom-up efforts?

- Wei et al. are representing the variation in state-level public support for climate action and thus plausible variation in the stringency of state-led climate policy in GCAM-USA.

- Research Question: **How much more does a *Decentralized*, state-driven approach cost compared to a *Uniform*, federally driven strategy in the longer-term?**

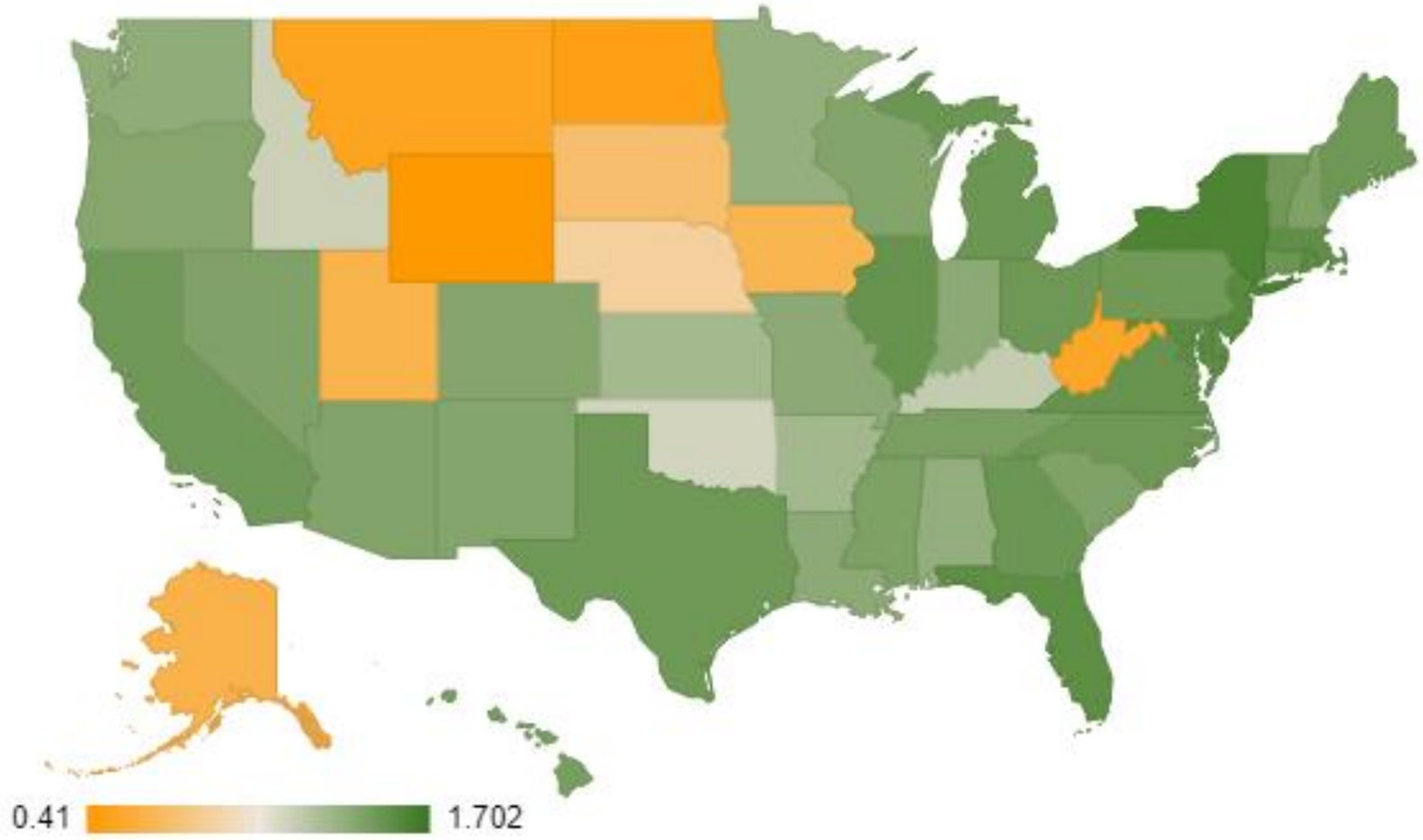
Source: Wei et al., Under preparation



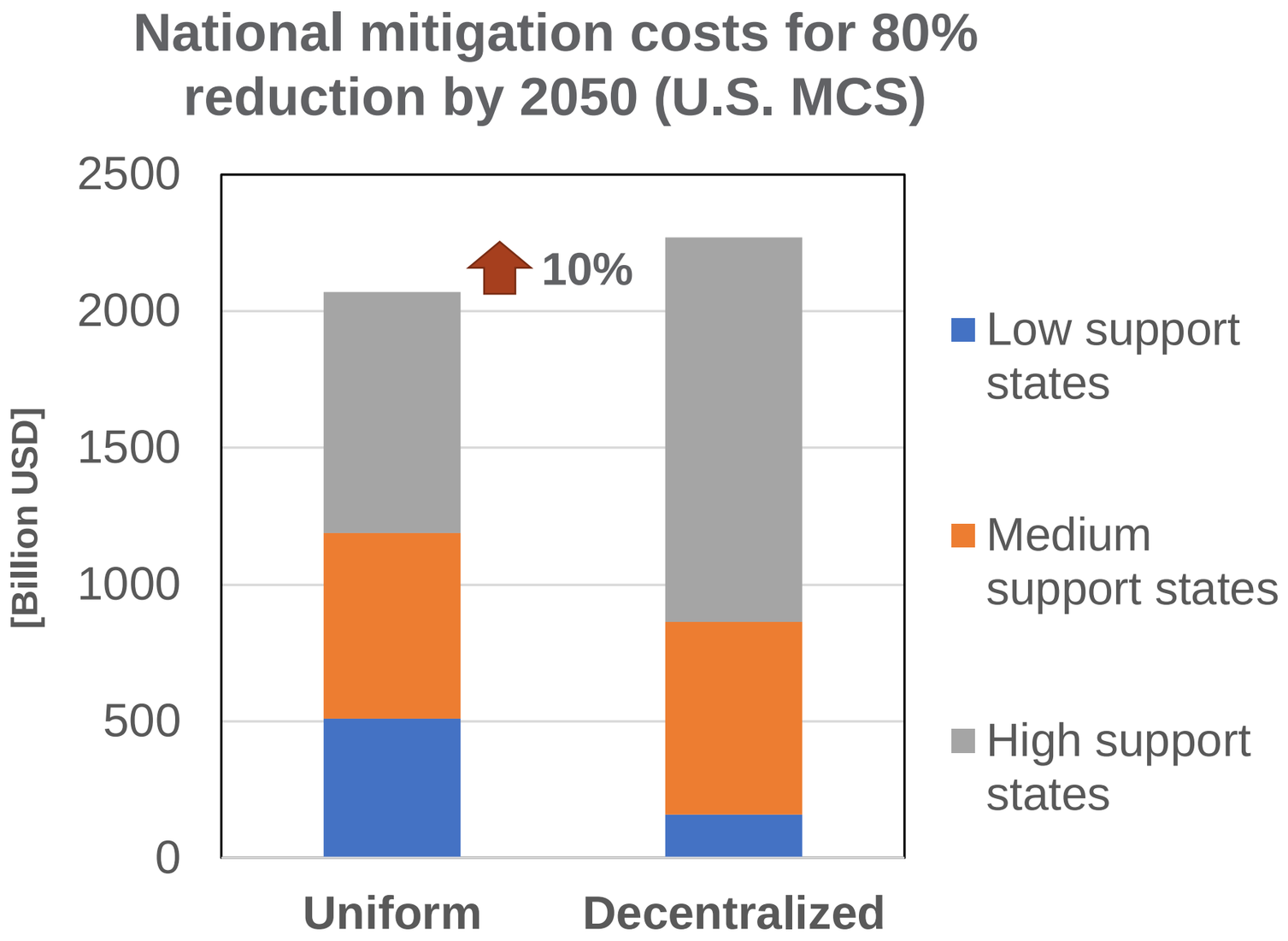
Source: Howe, et al. A. Geographic variation in opinions on climate change at state and local scales in the USA. Nature Climate Change.

The study translates variation in public support across states into marginal abatement costs

Ratio of state marginal abatement costs in the *Decentralized* scenario to the cost in the median-voter state



The decentralized approach is not all that more expensive nationally



- Because achieving the 80% goal is really hard either way requiring:
  - Decarbonization of the power sector
  - Deployment of bioenergy and biofuels
  - Electrification of end-use sectors
  - Energy efficiency

Improve representations of financial and non-financial behavioral aspects in models

Motivation

- Improving representations of financial as well as non-financial characteristics in models is important to answer questions about investments and stranded assets.

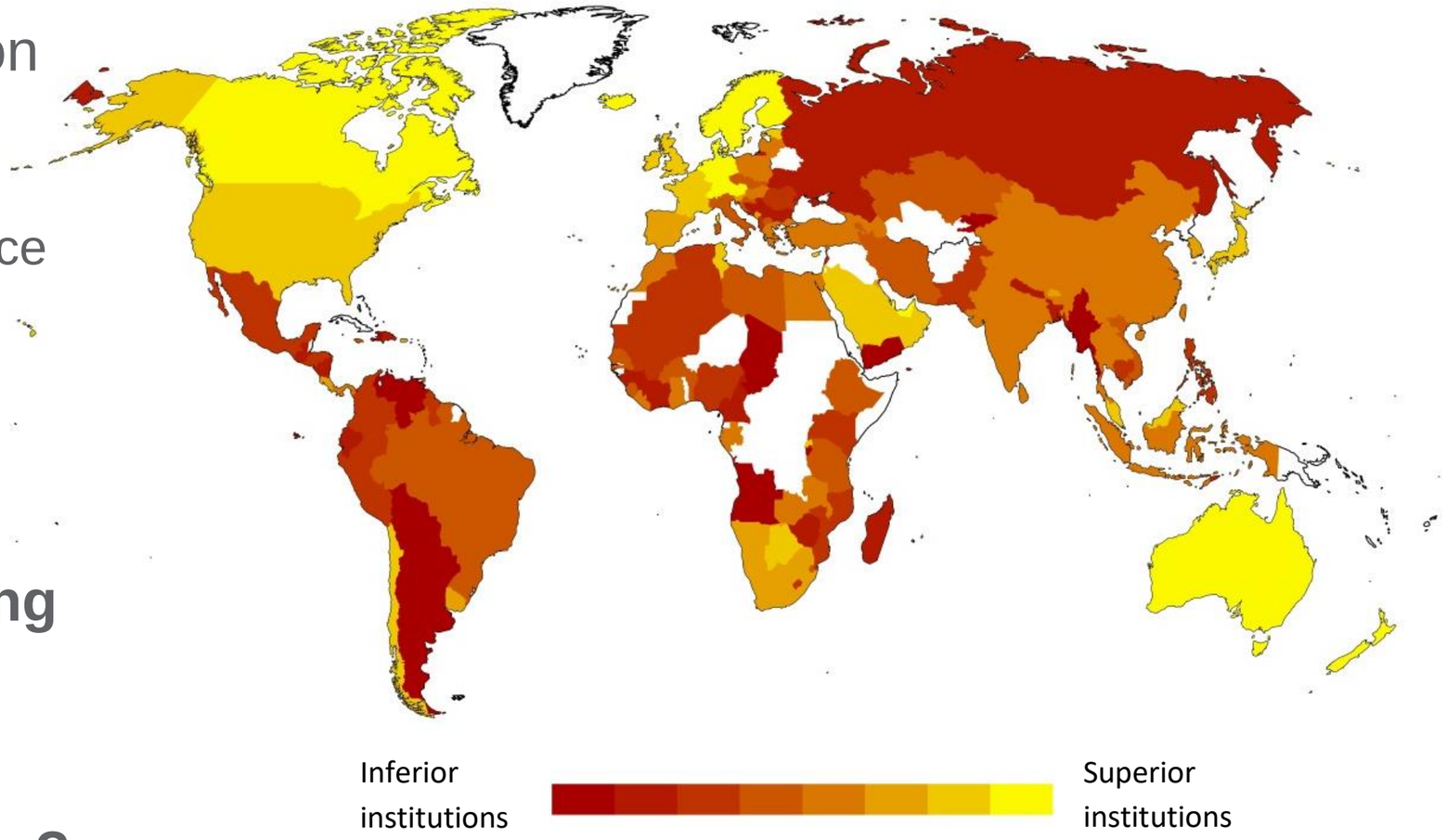
TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

https://www.greenbiz.com/article/state-green-business-stranded-assets

Example of incorporating improved financial considerations: investors' risk perceptions

- There is wide variation in investors' perceptions of risk
  - Variation across space
  - Variation across technologies

- Research Question: **How does accounting for this variation affect costs and distribution of emissions mitigation?**

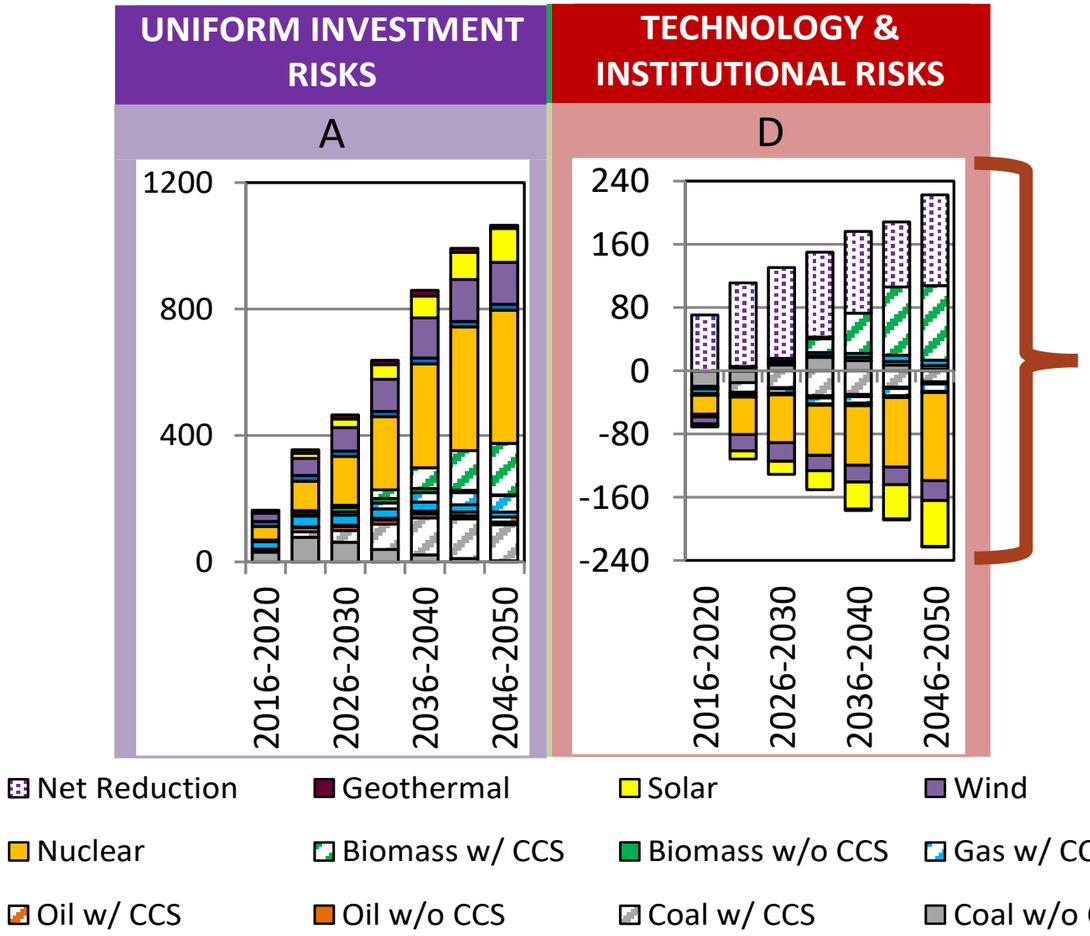


Source: Iyer et al. 2015 Improved representation of investment decisions in assessments of CO2 mitigation. Nature Climate Change, 5(5), p.436

Incorporating risk perceptions into cost of capital assumptions in GCAM results in three effects

- Reduced investments in high risk low-carbon technologies (e.g. nuclear) and increased investments in BECCS and energy efficiency.
- Shift of investments from developing to developed world.*
- Higher costs for meeting a given emissions goal
  - About 40% higher carbon price for a 50% reduction in CO2 emissions by 2050.

Investments in electricity for 50% reduction in CO2 emissions by 2050 (Billion 2012 USD per year)



Changes relative to uniform investment risks

**Under a cost-effective burden-sharing regime*

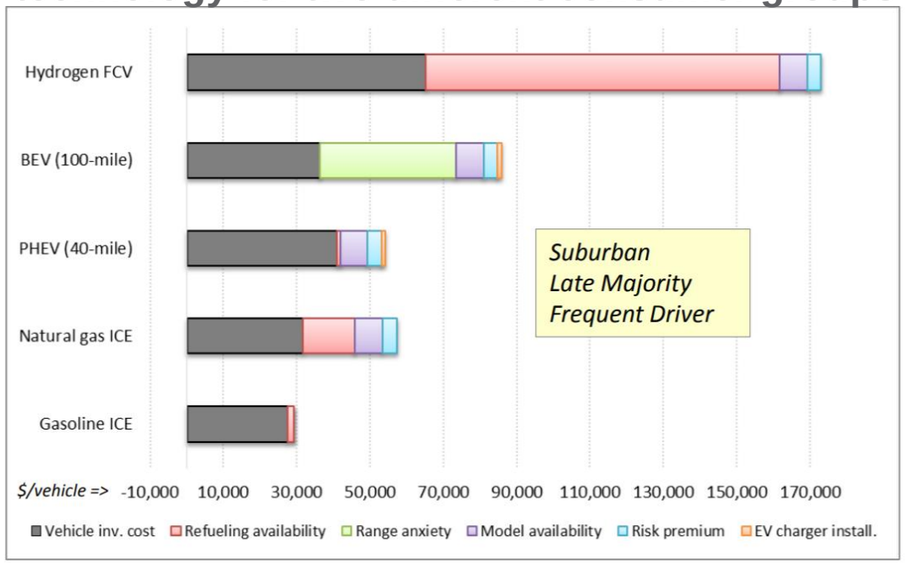
Source: Iyer et al. 2015 Improved representation of investment decisions in assessments of CO 2 mitigation. Nature Climate Change.

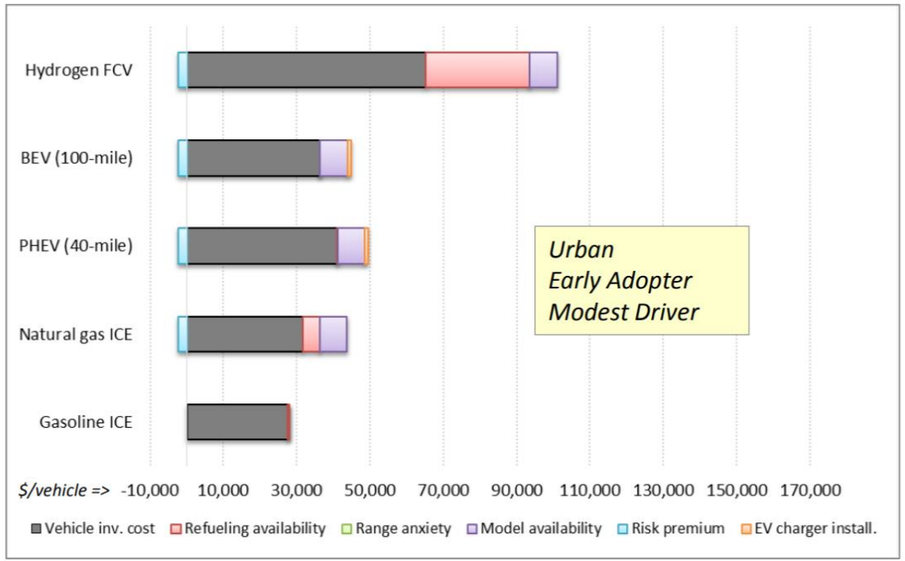
Example of improved behavioral considerations in models

- The study incorporated different consumer groups and non-financial attributes of vehicle choice in LDV sector of major IAMs.

- Research Question: **How will deployment of alternative fuel vehicles (electric, hydrogen) be influenced by behavioral changes of consumers?**

(Dis)utility cost assumptions in 2020, by technology for two different consumer groups





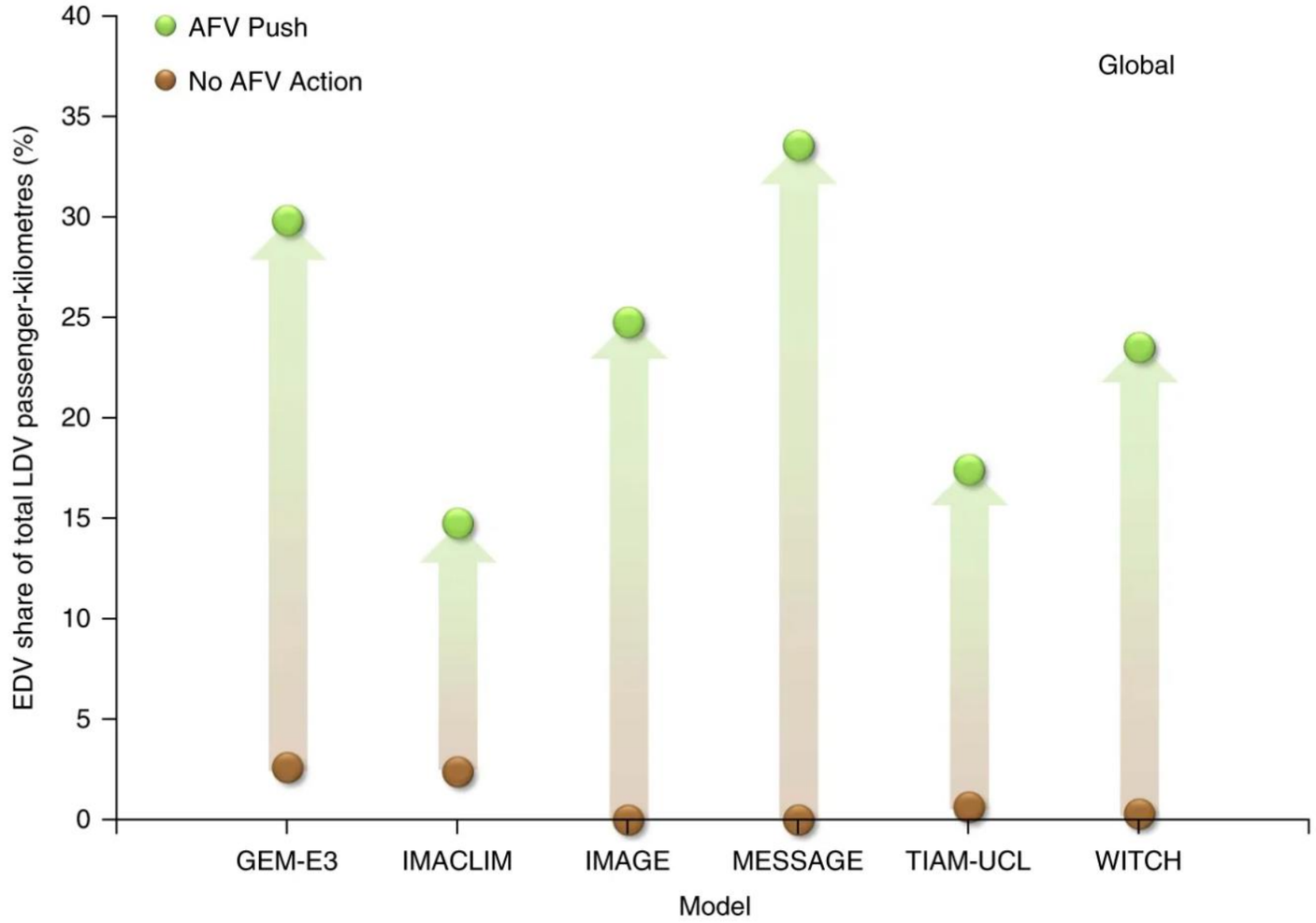
Source: McCollum et al. 2018. Nature Energy

Concerted actions to address non-financial aspects of consumers' preferences are critical to increase deployment of alternative vehicles

- Financial incentives influencing fuel prices (such as carbon pricing) may have a supporting role, but they may not be sufficient.

**The AFV Push scenario envisions a major shift in consumer perceptions of the non-financial attributes of AFVs (risk-aversion declines and range anxiety concerns are reduced)*

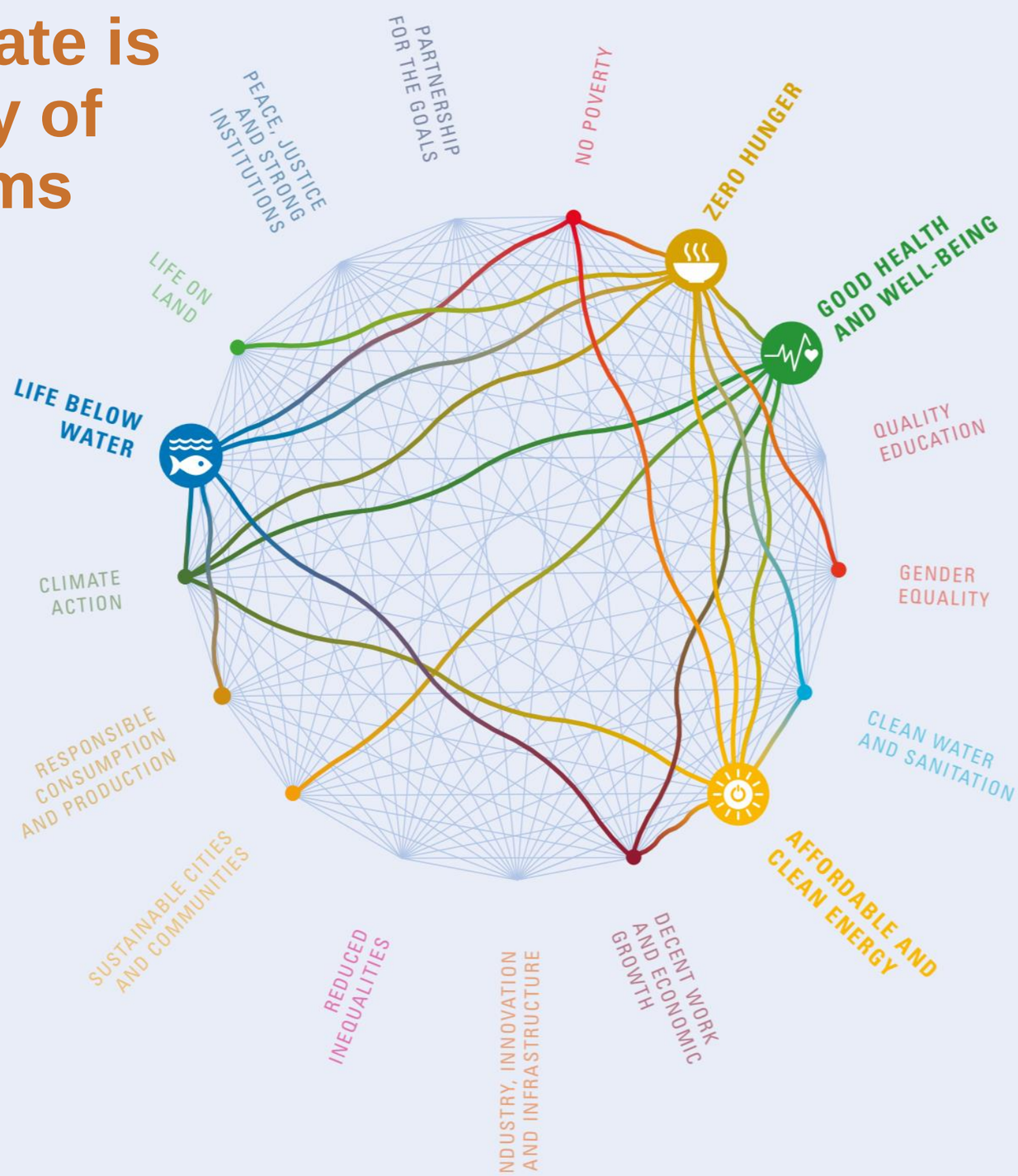
Share of all-electric, plug-in hybrid-electric and fuel cell vehicles in total light-duty vehicle passenger-kilometres in 2050



Improve multi-sector multi-scale interactions

Motivation: Climate is one among many of society's problems

- It is important to view the climate – sustainability interactions from an integrated perspective to:
  - Account for transboundary impacts
  - Avoid unintended negative implications for non-prioritized goals



Source: A guide to SDG interactions: from science to implementation. *https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf*

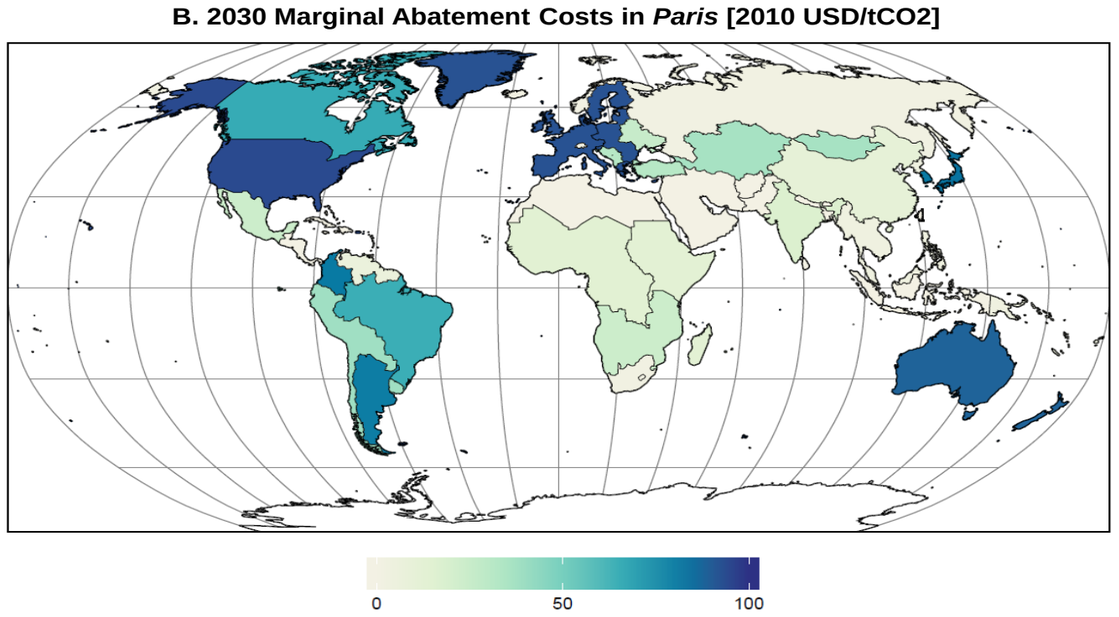
Example: Implications of sustainability considerations for comparability of effort

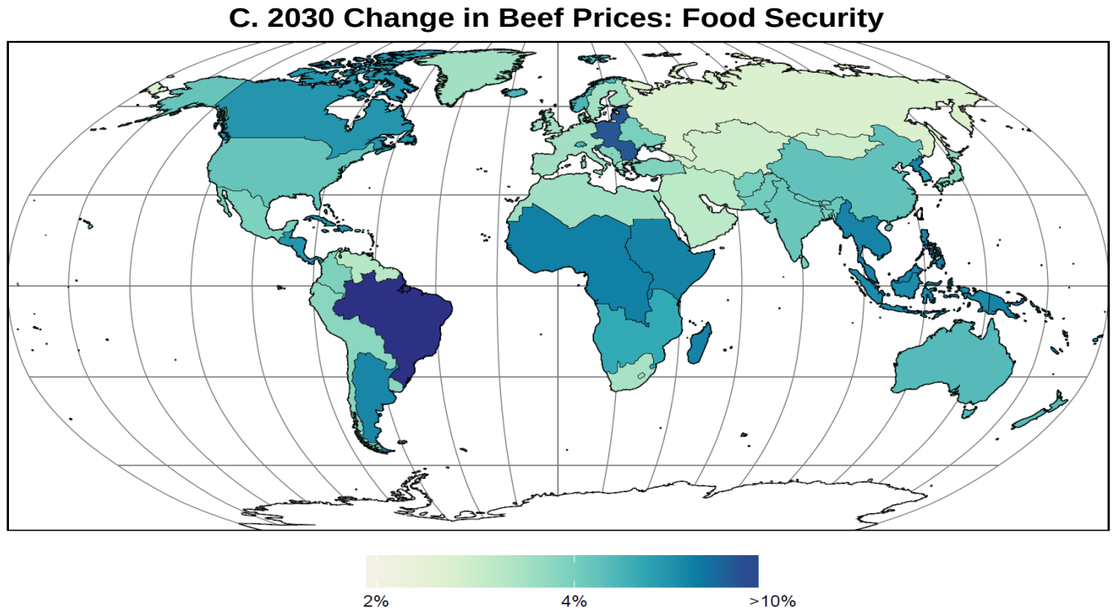

- Research Question: ***How do inter-linkages of climate mitigation with broader societal objectives influence comparability of effort across the NDCs?***

Source: Iyer et al. 2018. Nature Climate Change.

Example implications of the NDCs for food prices

- Canada and Brazil have similar carbon prices (shadow price of the NDCs) but different implications for beef prices.
- Brazilian beef is mainly pasture-fed whereas Canadian beef is fed using crops as well.
- Under NDCs, pasture prices increase because of competition for land.
  - 20% in Brazil and 13% in Canada.
- This results in a large change in beef prices in Brazil because of the dependence on pasture.





Accounting for implications of NDCs for other societal goals could affect perceptions of comparability of effort

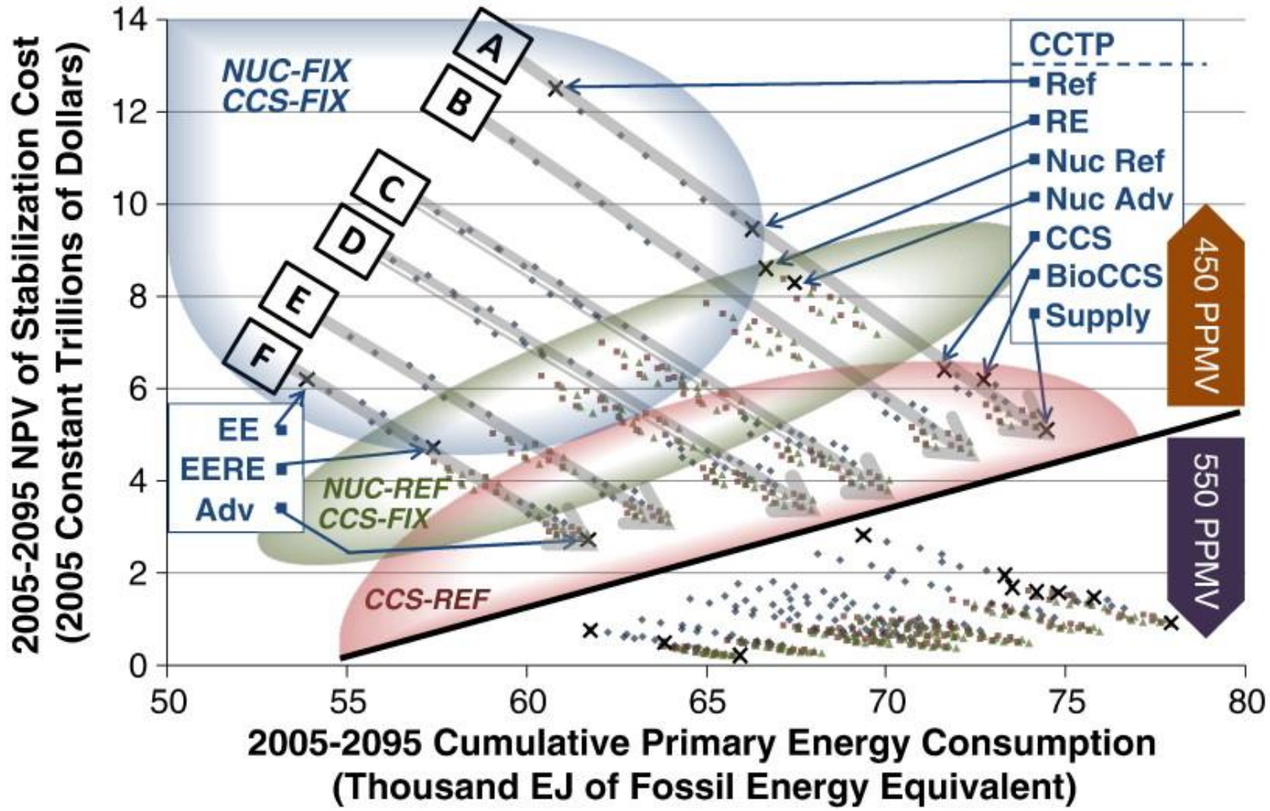
Contributions to climate change (blue) and consequences for other sustainability goals (green → positive consequence; yellow → negative consequence)

Country/ Region	CONTRIBUTION TO CLIMATE CHANGE MITIGATION					CONSEQUENCES FOR OTHER SOCIETAL GOALS																					
						AIR QUALITY		ENERGY SECURITY			OCN. HLTH.	ECONOMIC DEVELOPMENT				ENERGY ACCESS					FOOD SECURITY				LAND USE CHANGE	
	CAT's NDC assessment	GHG Emissions	GHG Emissions per capita	GHG Emissions per GDP	Marginal abatement costs	NOx emissions	SO2 emissions	Coal imports	Oil imports	Gas imports	Ocean pH	Coal exports	Oil exports	Gas exports	Miitgation Costs	Oil Prices	Natural Gas prices	Electricity Prices	Traditional Biomass consumption	Per capita electricity consumption	Wheat Prices	Corn Prices	Beef Prices	Dairy Prices	Biomass Land	Unmanaged Forest Land
		Percent reduction relative to Reference	tCO2e/person	Percent reduction relative to 2005	2010 USD/tCO2e	Percent reduction relative to Reference	Percent reduction relative to Reference	Percent reduction relative to Reference	Percent reduction relative to Reference	Percent reduction relative to Reference	Increase relative to Reference	Percent reduction relative to Reference	Percent reduction relative to Reference	Percent reduction relative to Reference	Percentage of GDP	Percent increase relative to Reference	Percent increase relative to Reference	Percent increase relative to Reference	Increase relative to Reference as a share of 2010 building energy consumption	Percent reduction relative to Reference	Percent increase relative to Reference	Percent increase relative to Reference	Percent increase relative to Reference	Percent increase relative to Reference	Increase relative to Reference as a share of total land cover	Decrease relative to Reference as a share of total land cover
USA	Medium																									
Brazil	Medium																									
EU-15	Medium																									
EU-12	Medium																									
Australia_NZ	Low																									
Canada	Low																									
South Korea	Low																									
Argentina	Low																									
Japan	Low																									
Colombia	NA																									
India	Medium																									
Russia	Low																									
China	Low																									
Africa_Northern	NA																									
Mexico	Medium																									
South Africa	Low																									
Middle East	NA																									
Indonesia	Low																									
Southeast Asia	NA																									

**Cells in each column are color coded according to the rank of the respective country or region in terms of the outcomes for the corresponding metric*

Discussion: Further thoughts

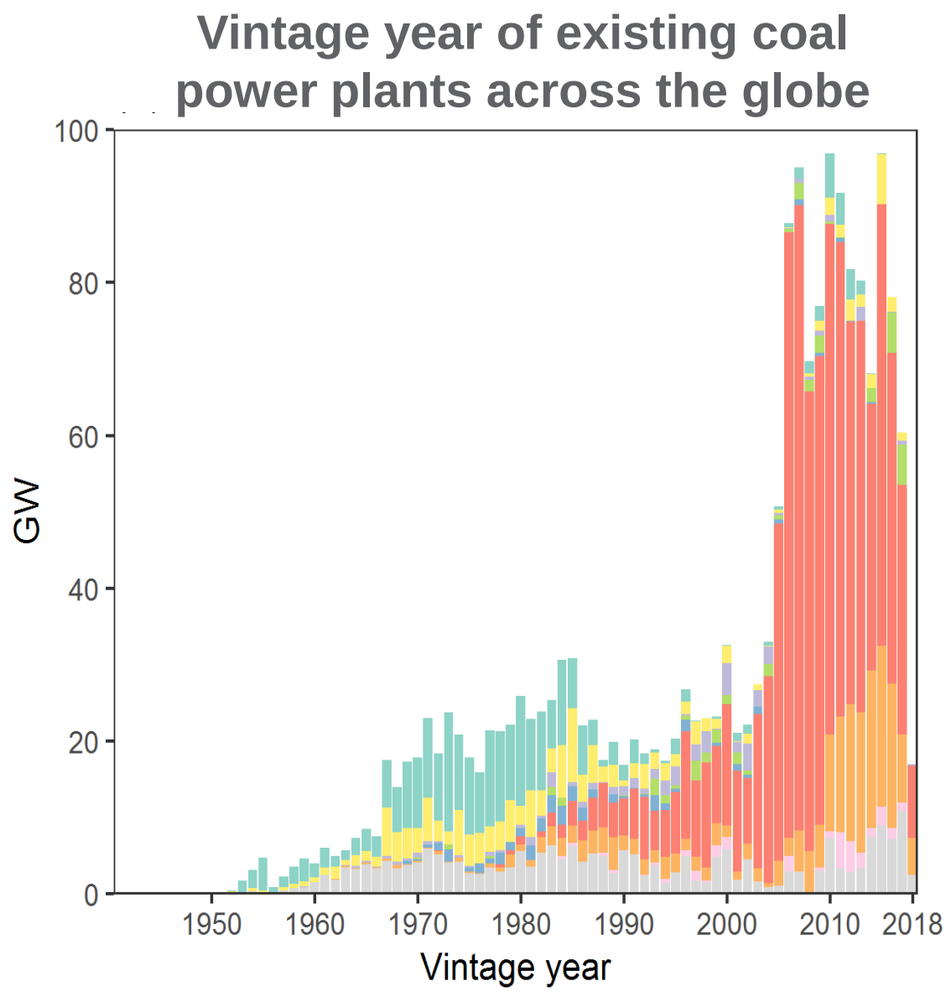
- Uncertainty characterization, especially in the context of multi-sector multi-scale research.



Source: McJeon, et al. 2011. Technology interactions among low-carbon energy technologies: what can we learn from a large number of scenarios?. Energy Economics.

Discussion: Further thoughts

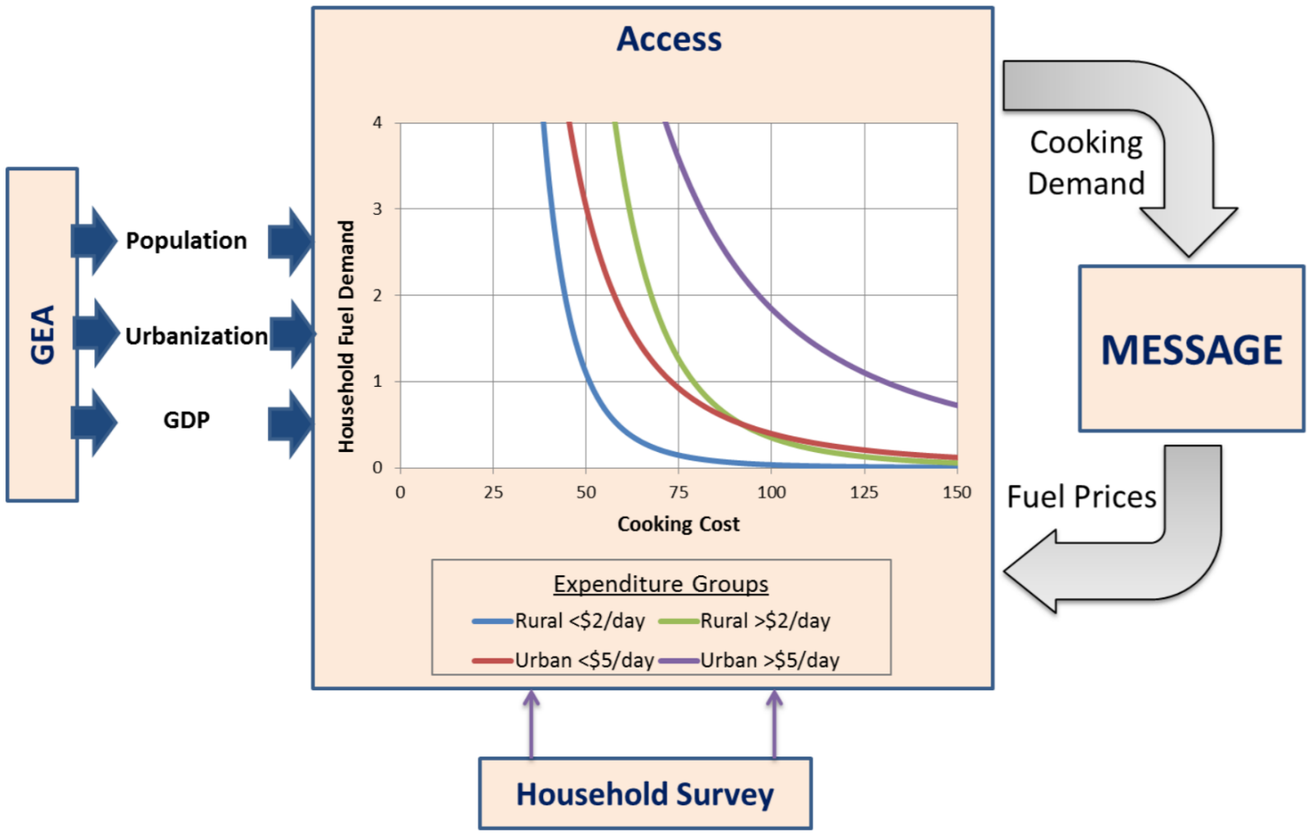
- Uncertainty characterization, especially in the context of multi-sector multi-scale research.
- Represent technology details (e.g. vintage structure).



Source: Cui et al. under review.

Discussion: Further thoughts

- Uncertainty characterization, especially in the context of multi-sector multi-scale research.
- Represent technology details (e.g. vintage structure).
- Explore avenues to couple with other detailed tools.



Source: Cameron et al. 2015. Nature Energy

Thank You