Distinguishing Time-Varying Regional Stabilization Sensitivities in GCAM

Jon Lamontagne & Patrick Reed
Cornell University, Civil Engineering

JGCRI Collaborators:
R. Link, H. McJeon, & L. Clark

Penn State Collaborator:
Klaus Keller
Summary of Recent Efforts

2. Training in statistical diagnostics and HPC
3. GCAM port to Cornell HPC systems with JGCRI support
4. Verification of parallel GCAM simulations and developing data processing for ensembles
5. Update/Replication of McJeon et al. 2011*

Stabilization target: 550 PPM CO$_2$ Concentration
3 Tech Paths for 5 Energy Technologies

Solar

PV Solar w/ Storage Tech. Scenarios

Generation Capital Cost (1975$/kW)

Year

Low-Tech
Reference
High-Tech
3 Tech Paths for 5 Energy Technologies

Solar

Wind

PV Solar w/ Storage Tech. Scenarios

Wind w/ Storage Tech. Scenarios
3 Tech Paths for 5 Energy Technologies

Solar

Wind

Nuclear

PV Solar w/ Storage Tech. Scenarios

Wind w/ Storage Tech. Scenarios

Gen III Nuclear Tech. Scenarios

No Gen III in Low-Tech
3 Tech Paths for 5 Energy Technologies

Solar
Wind
Nuclear

Also, Carbon Capture and Sequestration (CCS) and Geothermal electricity.
Full Factorial Design: Ensemble of Stabilization Scenarios

![Diagram showing the relationship between 2005-2095 NPV of Stabilization Cost (1990 Trillions of Dollars) and 2005-2095 Cumulative Primary Energy Consumption (Thousands EJ of Fossil Energy Equivalent).]
Full Factorial Design: Ensemble of Stabilization Scenarios

![Graph showing relationship between 2005-2095 cumulative primary energy consumption and 2005-2095 NPV of stabilization cost. Higher cost corresponds to lower productivity, while lower cost corresponds to greater productivity.](image-url)
No CCS and no Gen III nuclear lead to high stabilization costs and low productivity.

Largest costs associated w/ no CCS and no Gen III Nuclear
Measuring the Speed of Energy Transition by Mid-Century

Measure percent change in primary energy cons. across 10 energy sources:

\[ T = \| X_{\downarrow 2010} - X_{\downarrow 2050} \| \]

where \( X_{\downarrow 2010} \) and \( X_{\downarrow 2050} \) are vectors of percent primary energy cons. by source in 2010 and 2050 respectively.
Measuring the Magnitude of Energy Transition by Mid-Century

Measure percent change in primary energy cons. across 10 energy sources:

\[ T = \| X_{\downarrow 2010} - X_{\downarrow 2050} \| \]

where \( X_{\downarrow 2010} \) and \( X_{\downarrow 2050} \) are vectors of percent primary energy cons. by source in 2010 and 2050 respectively.

For example in 3D:
Global Energy Transition @ Mid-Century

Larger energy changes associated with no CCS.

CCS provides a buffer against rapid shift from fossil fuels.
Global Aggregate vs. Regional Policy Costs

Global aggregate dominated by USA, China, and India

But, we’re interested in exploring regional dynamics
USA Stabilization Burden
Expensive (1.2>\%GDP) or Big Energy Transition (>22%)

Expensive outcomes and large energy transitions result when NO new CCS and NO new Gen III Nuclear.
Regional Impact of Stabilization: USA vs. South Africa

By USA thresholds, ALL scenarios poor for South Africa
South Africa Policy Cost: Relatively Small Energy Transitions (<31%)

Small energy transitions with expensive wind and available CCS.

CCS allows continued coal consumption. Wind is a major competitor to coal.
South Africa Policy Cost: Expensive (>6 GDP%)
South Africa Policy Cost: Expensive (>6 GDP%)
South Africa Policy Cost: Expensive (>6 GDP%)

Expensive outcomes associated with **no CCS** and **no new Gen III nuclear**
Benefits of technology not shared equally

Red = Larger benefit from technology
Blue = Smaller benefit from technology
Goals for the Next Year

1. Expand analysis to population & GDP assumptions.
2. Explore stabilization sensitivities to policy participation, tech timing.
3. Scale work to leadership class NSF HPC resources.

TACC
Questions?