Managing the Transition to Climate Stabilization

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Goal of this Study

To examine the relationship between the long-term climate goal and near-term policies.

- Long-term stabilization targets
- Policy Design
  - Coalition membership
  - Emissions reduction timetables
- Technology availability
MERGE 5.5 Model Overview

• Top-down economic model
• Intertemporal optimization through 2150
• Nine regions (USA, Western Europe, China, India, etc.)
• Process model of energy sector technology:
  – Electric Generation
  – Non-Electric Energy
• Prices of each GHG determined endogenously (no GWPs)
• Capable of representing a variety of greenhouse gas control scenarios
• Captures economy-wide impact of carbon policy
Structure of MERGE Model

INPUTS:
- Capital
- Labor
- Electric
- Non-Electric
- Technologies/Fuels

Production
- Investment
- Consumption

Energy Cost
- Welfare

Emissions
- Climate

= GDP
Overview of MERGE 5.5

- Intertemporal optimization model with 200 year timeframe
- Each region maximizes its own utility
- Prices of each GHG determined endogenously, i.e. no GWPs
- Top down model of economic growth and trade
- Process model of energy sector, with **new additions**:
  - CCS Technologies
    - Existing plants
    - New plants
  - Considers market *and* nonmarket costs of nuclear power
## Focus on Two Radiative Forcing Constraints

<table>
<thead>
<tr>
<th>U.S. CCSP Stabilization Level</th>
<th>Long-Term Radiative Forcing Limit (Wm⁻² relative to pre-industrial)</th>
<th>Approximate 2100 CO₂ Limit (ppmv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4</td>
<td>6.7</td>
<td>750</td>
</tr>
<tr>
<td>Level 3</td>
<td>5.8</td>
<td>650</td>
</tr>
<tr>
<td>Level 2</td>
<td>4.7</td>
<td>550</td>
</tr>
<tr>
<td>Level 1</td>
<td>3.4</td>
<td>450</td>
</tr>
</tbody>
</table>
Reference Case Radiative Forcing

Radiative Forcing (W/m^2)

- RF from OGG
- RF from CO2
- 4.7 Target
- 3.4 Target

Years: 2000 to 2100
Two Policy Scenarios

• “First Best” (1B):
  When and where flexibility

• “Third Best” (3B):
  Additional “Transition Constraints” Through 2050:
  - Near-term reduction timetables for Annex B countries
  - Non-Annex B does not participate

3B Designed to Reflect Realistic Policies
3B Transition Constraints for Annex B

- Post-transition emissions cannot increase

Historic Emissions (energy-related CO2)

Transition Constraints

Billion tons Carbon

USA

Kyoto Coalition

EEFSU
Two Technology Scenarios

• “Optimistic”: All technologies available

• “Pessimistic”: New nuclear and carbon capture and sequestration (CCS) are not available in electric sector
Global Energy-Related CO2 Emissions

- 1B
- 3B (Optimistic Technology)

Billion tons Carbon

BAU
4.7 RF
3.4 RF

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Emissions by Region with 3.4 RF Target

- **BAU**
- **1B**
- **3B**

**Non-Annex B**

**Annex B**

3B Transition Constraint

Billion tons Carbon

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Annex B Carbon Price with 3.4 RF Target

Transition: Non-Annex B OUT

OPTIMAL

Current EU-ETS price

0 500 1000 1500 2000 2500

2000$US per ton Carbon

2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

3B

1B

Optimistic

Pessimistic
3.4 RF Target Storyline

• Transition constraints on Annex B are *not* binding

• 3B policy costs are higher because Non-Annex B is out

• Carbon price rises quickly, driven by immediacy of target
Global Carbon Emissions

Billion tons Carbon

- 1B
- 3B
- BAU
- 4.7 RF
- 3.4 RF

(Optimistic Technology)
Emissions by Region with 4.7 RF Target

- BAU
- 1B
- 3B

3B Transition Constraint

Non-Annex B

Annex B
Annex B Carbon Price with 4.7 RF Target

Transition:
Annex B Constrained
Non-Annex B OUT

OPTIMAL

2000$US per ton Carbon

Current EU-ETS price

Optimistic
Pessimistic
4.7 RF Target Storyline

• Transition constraints on Annex B are binding

• 3B policy costs are higher because Annex B over-abates and because Non-Annex B is out

• Carbon price rises slowly in 1B, but quickly in 3B to satisfy transition constraints
U.S. Electric Generation, Pessimistic Technology

TWh per year

Reference  4.7 RF Target  3.4 RF Target (1B Policy)

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U.S. Electric Generation, Optimistic Technology

Reference

4.7 RF Target
(1B Policy)

3.4 RF Target

TWh per year


rnw-hc
rnw-lc
gas-ncs
gas-n
gas-r
coal-ncs
coal-n
coal-rcs
oil-r
nuc-n
nuc-r
hydro
USA GDP Loss from Reference with 3.4 RF Target

- Opt.
- Pess.

3B
1B
U.S. GDP Loss from Reference with 4.7 RF Target
Global Discounted Sum of Economic Cost
At 5% through 2200

2000$US Trillions

% GDP Loss from Reference

Optimistic

Pessimistic

1B
3B

4.7 Target

3.4 Target

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Insights from These Scenarios

• Target has greatest impact on stabilization cost

• Technology plays increasingly important role in managing cost

• Transition policy choice has smallest effect on overall cost, possibly large effect on cost distribution

Paper Available on AEI-Brookings website:

www.aei-brookings.org
Effect of Technology

• 3.4 RF Target: Technology does not have strong effect *at the margin* because backstop and conservation are required in both optimistic and pessimistic case

• 4.7 RF Target: Technology *does* have strong effect at the margin

• In both cases, technology impacts inframarginal costs of abatement
“Second Best” Policies

• Replace exogenous transition constraints with When Flexibility within Annex B

• Annex B chooses an optimal emissions path to achieve forcing level in 2050 equivalent to 3B scenario

• Non-Annex B remains outside coalition

• Long-term stabilization target still applies
Global Discounted Sum of Economic Cost
At 5% through 2200

2000$US Trillions

Optimistic

Pessimistic

4.7 Target

1B 2B 3B

3B 2B 1B

3B 2B 1B

Pessimistic 2B 3B

Optimistic 2B 3B

1B

3.4 Target

% GDP Loss from Reference

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Reference Case Radiative Forcing

![Graph showing radiative forcing from 2000 to 2100 with targets and projections for RF from OGG and RF from CO2.]
Reference *without* Annex B Emissions

![Graph showing radiative forcing (W/m²) from 2000 to 2100](image)

- **RF from OGG**
- **RF from CO2**
- **4.7 Target**
- **3.4 Target**

Radiative Forcing (W/m²)

2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

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Scenario Design

8 SCENARIOS

TARGET

3.4 RF

First Best

Policy

Third Best

Opt.

Pess.

TECHNOLOGY

4.7 RF

First Best

Third Best

Opt.

Pess.

Opt.

Pess.

Opt.