Modeling Post-2012 Climate Policy Scenarios

Interim Results

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Objectives

• To visualize alternative forms of a “multi-track” climate framework integrating different types of mitigation commitments

• To assess their:
  – **Environmental effectiveness**: Produce near/medium-term effort consistent with 450-600 ppmv CO₂?
  – **Economic efficiency**: Relative to an idealized case of full global cap+trade
  – **Fairness**: Achieve a reasonable distribution of costs?

• Scenarios are illustrative – not “proposals”
  – Real value is in insights, not numbers
The Model

- **O bjECTS-MiniCAM Model** developed and run by Joint Global Change Research Institute, Battelle/UMD

- **Partial equilibrium; Energy-Agriculture-Economy**
  - Explicit energy technologies, regional specifications
    - End-use sectors: buildings, industry, transportation
    - Supply sectors: fossil-fuels, biomass (traditional and modern), electricity, hydrogen, synthetic fuels
    - Integrated agriculture and land use model
  - CO$_2$ only
  - 13 Regions
  - Runs from 1990 to 2095 in 15-year time steps
Overview of MiniCAM
Regions in the Model

- Australia/New Zealand
- Canada
- Europe
- Former Soviet Union
- Japan
- United States
- Africa
- China
- India
- Latin America
- Middle East
- South Korea
- (Rest of) South & East Asia
Developing the Scenarios

- Policies in scenarios reflect:
  - What countries already doing (or discussing)
    - Specific domestic policies, specific sectors targeted
  - The world of commitment types
    - Being discussed in the UNFCCC and beyond

- Action/Commitment Types:
  - Targets
    - Economy wide targets
  - Policy-based commitments
    - National-level sectoral targets, efficiency standards
  - International sectoral agreements
    - Sector-specific targets or standards applied across regions
  - Funds for adaptation and technology
Differentiation within Scenarios

- Regional differentiation taking into account:
  - Regional emissions contexts
    - Fuel mix
    - Energy and GHG intensity and efficiency
  - Economic indicators
    - GDP, GDP/capita
    - Mitigation costs, cost as share of GDP
  - Emissions projections
    - Reference case
    - “Efficient” 450, 550, 650 ppmv stabilization scenarios

- Differentiation is illustrative, not formulaic
• Mix of approaches:
  – Full trading (initially or over time)
  – Policy crediting
  – Intra-sectoral trading
  – Different combinations of the above
Overview of Scenarios

• Baseline scenarios
  - Reference case: “business as usual” pathway
    • Based on CCSP MiniCAM Scenario (updated for 2008)
  - “Efficient” stabilization pathways to 450, 550, & 650 ppmv CO₂

• Six policy scenarios
  - 1A 550: Targets + limited policy commitments
  - 1A 450: Targets + limited policy commitments
  - 1B 450: Targets + broader policy commitments
  - 2 450: Targets + sectoral agreements
  - 3 550: Targets + policy commitments + sectoral agreements
  - 3 450: Targets + policy commitments + sectoral agreements

• It is assumed that world moves to a global trading regime after 2050, however...
  - The focus here is on the near-term
  - A theme of this research is that eventually there needs to be a move to broad coverage.
Scenario 1: Targets + Policies

- Absolute economy-wide targets
- Policy crediting
- Full emissions trading
- Policy-Based Commitments
- Absolute economy-wide targets

Developed Regions

Developing Regions

2005

2050
# Scenario 1A 550: Targets and Policies I

<table>
<thead>
<tr>
<th>Region</th>
<th>Electricity</th>
<th>Transportation</th>
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</tr>
</thead>
</table>
| Australia/New Zealand, Canada, Europe, Former Soviet Union, Japan, United States | **Economy-Wide Carbon Constraint**  
CO2 emissions relative to 2005  
(85%, 73%, 60%) | | | |
| Africa                    | **Power Sector Carbon Intensity**     | Relative to 2005  
(NA, 70%, 50%) | | |
| China                     | **Power Sector Carbon Intensity**     | Relative to 2005  
(70%, 50%, 35%) | **Biofuels Target**  
Share of refined liquids  
(5%, 7.5%, 10%) | **Industry Carbon Constraint**  
Reduction from BAU  
(NA, 50%, 80%) |
| India                     | **Power Sector Carbon Intensity**     | Relative to 2005  
(70%, 50%, 35%) | **Biofuels Target**  
Share of refined liquids  
(NA, 5%, 7.5%) | **Fuel Economy Standard**  
Increase in mpg over 2005  
(NA, 20%, 45%) |
| Korea                     | **Power Sector Carbon Intensity**     | Relative to 2005  
(70%, 50%, 35%) | **Biofuels Target**  
Share of refined liquids  
(NA, 5%, 7.5%) | **Industry Carbon Constraint**  
Reduction from BAU  
(30%, 50%, 80%) |
| Latin America             | **Power Sector Carbon Intensity**     | Relative to 2005  
(NA, 70%, 50%) | **Biofuels Target**  
Share of refined liquids  
(5%, 7.5%, 10%) | **Fuel Economy Standard**  
Increase in mpg over 2005  
(20%, 45%, 75%) |
| Middle East               | **Power Sector Carbon Intensity**     | Relative to 2005  
(70%, 50%, 35%) | **Fuel Economy Standard**  
Increase in mpg over 2005  
(20%, 45%, 75%) | | |
| Southeast Asia            | **Power Sector Carbon Intensity**     | Relative to 2005  
(70%, 50%, 35%) | **Biofuels Target**  
Share of refined liquids  
(NA, 5%, 7.5%) | **Fuel Economy Standard**  
Increase in mpg over 2005  
(NA, 20%, 45%) |
| Africa, China, India, Korea, Latin America, Middle East, Southeast Asia | | | | **Crediting**  
% of emissions reductions sold to developed world  
(50%, 25%, 0%) |
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<td>Building Energy Efficiency Constraint Increase over 2005 (NA, 20%, 80%)</td>
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<td>Industry Carbon Constraint Reduction from BAU (NA, NA, 65%)</td>
</tr>
</tbody>
</table>

**Crediting**

% of emissions reductions sold to developed world (50%, 25%, 0%)
Scenario 2: Targets and Sectoral Agreements

- Absolute economy-wide targets
- Sectoral agreements
- Funding commitments

Developed Regions

- Emissions trading within sectors, across regions

Developing Regions

- Policy-Based Commitments
- Absolute economy-wide targets

2050

Full emissions trading
### Scenario 2 450: Targets and Sectoral Agreements

<table>
<thead>
<tr>
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<td>CO2 emissions relative to 2005</td>
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<td>Africa</td>
<td>CCS Subsidy</td>
<td>Percent of incremental cost</td>
<td>(100%, 75%, 50%)</td>
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<td>Percent of electricity</td>
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<td>India</td>
<td>Biofuels Target</td>
<td>Share of refined liquids</td>
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<td>Korea</td>
<td>Fuel Economy Standard</td>
<td>Increase in mpg over 2005</td>
<td>(20%, 45%, 188%)</td>
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<td>Latin America</td>
<td>Industry Carbon Constraint</td>
<td>Reduction from BAU</td>
<td>(NA, 30%, 80%)</td>
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<td>Middle East</td>
<td>Building Energy Efficiency Constraint</td>
<td>Increase over 2005</td>
<td>(20%, 40%, 125%)</td>
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### ADAPTATION FUND

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<td>United States, Canada, Europe, Japan, Australia/New Zealand, Former Soviet Union</td>
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</table>

*Will be modeled in Phase II*
Scenario 3: Targets + Policies + Sectoral

- Absolute economy-wide targets
- Sectoral agreements
- Funding commitments

Developed Regions

Emissions trading within sector, across regions

Developing Regions

Policy-Based Commitments

Economy-wide absolute targets

2005

2050

Full emissions trading
### Scenario 3 550: Targets + Policies + Sectoral

<table>
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CO2 emissions relative to 2005  
(85%, 73%, 60%) | | |
| Africa | **Biofuels Target**  
Share of refined liquids  
(NA, NA, 5%) | | |
| | **Fuel Economy Standard**  
Increase in mpg over 2005  
(NA, NA, 20%) | | |
| China | **Biofuels Target**  
Share of refined liquids  
(5%, 7.5%, 10%) | | **Building Energy Efficiency Constraint**  
Increase over 2005  
(NA, 20%, 40%) |
| | **Fuel Economy Standard**  
Increase in mpg over 2005  
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Relative to 2005  
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Share of refined liquids  
(NA, 5%, 7.5%) | **Building Energy Efficiency Constraint**  
Increase over 2005  
(NA, 30%, 50%) |
| | **Fuel Economy Standard**  
Increase in mpg over 2005  
(NA, 20%, 45%) | **Industry Carbon Constraint**  
Reduction from BAU  
(NA, 30%, 50%) | |
| Korea | **Biofuels Target**  
Share of refined liquids  
(5%, 7.5%, 10%) | | **Building Energy Efficiency Constraint**  
Increase over 2005  
(20%, 40%, 50%) |
| | **Fuel Economy Standard**  
Increase in mpg over 2005  
(20%, 45%, 75%) | | |
| Latin America | **Biofuels Target**  
Share of refined liquids  
(5%, 7.5%, 10%) | | **Building Energy Efficiency Constraint**  
Increase over 2005  
(NA, 20%, 40%) |
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Increase in mpg over 2005  
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(NA, 20%, 40%) |
| Southeast Asia | **Biofuels Target**  
Share of refined liquids  
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Increase over 2005  
(NA, 20%, 40%) |
| | **Fuel Economy Standard**  
Increase in mpg over 2005  
(NA, 20%, 45%) | | |

### Adaptation Fund

**United States, Canada, Europe, Japan, Australia/New Zealand, Former Soviet Union**  
Contribute annually 0.25% value of emission allowances
## Scenario 3 450: Targets + Policies + Sectoral

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<td>Share of refined liquids</td>
<td>(NA, NA, 11%)</td>
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<td><strong>Fuel Economy Standard</strong></td>
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<td><strong>China</strong></td>
<td><strong>Biofuels Target</strong></td>
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<td><strong>Building Energy Efficiency Constraint</strong></td>
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<td>Share of refined liquids</td>
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<td>(5%, 7.5%, 23%)</td>
<td>(NA, 5%, 17%)</td>
<td>(NA, NA, 45%)</td>
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<td><strong>Fuel Economy Standard</strong></td>
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<td>Increase in mpg over 2005</td>
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<td>(20%, 50%, 169%)</td>
<td>(NA, 20%, 101%)</td>
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<td><strong>India</strong></td>
<td><strong>Power Sector Carbon Intensity</strong></td>
<td><strong>Biofuels Target</strong></td>
<td><strong>Building Energy Efficiency Constraint</strong></td>
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<td>Relative to 2005 (70%, 45%, 16%)</td>
<td>Share of refined liquids</td>
<td>Increase over 2005</td>
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<td><strong>Korea</strong></td>
<td><strong>Biofuels Target</strong></td>
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<td>Share of refined liquids</td>
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<td><strong>Latin America</strong></td>
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<td><strong>Middle East</strong></td>
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<td><strong>Southeast Asia</strong></td>
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### Adaptation Fund

**Fund**

United States, Canada, Europe, Japan, Australia/New Zealand, Former Soviet Union

Contribute annually 0.25% value of emission allowances
Background on the Reference Scenario
The reference scenario envisions a growing global economy with an evolution in the distribution of economic activity.
Overview of Technology Assumptions

- **Abundant fossil resources**
  - An eventual decline in conventional crude production accompanied by a gradual increase in production from unconventional sources

- **Nuclear competitive with fossil electricity sources**

- **CCS available at reasonable cost with no limits on deployment in most regions**

- **Wind competitive in the near-term, solar later; limits on wind supply, and backup requirements for solar and wind on the grid**

- **Roughly 1% annual improvement in end use efficiency globally**

Thinking About Pathways to 450 ppmv
Mitigation: A Long-Term Strategic Challenge

Stabilizing CO₂ concentrations at any level means that global CO₂ emissions must peak and then decline forever.
Mitigation in 2005-2050 is Just the Start

- The bulk of emissions reductions will need to take place beyond 2050.
- The tighter the concentration, the greater emissions reductions in the near-term.
- Ultimately, achieving large-scale future reductions will require that all countries and sectors participate in mitigation.
- These scenarios explore differing policy architectures on a transition toward a comprehensive long-term policy regime.

We are considering “transition” measures through 2050 on the path to 450 ppmv stabilization. What is a reasonable transition emissions pathway through 2050?

- **Global emissions consistent with fully-efficient pathways.**
  - Concentrations should be on a path to roughly 450 ppmv, and there should be some degree of economic balancing between near- and mid-term reductions.

- **Limited reliance on overshoot and negative emissions.**
  - A wide range of concentration levels are viable in the very long-term given the option for overshoot, particularly if bio&CCS is available. These scenarios will not be dramatically dependent on overshoot and/or negative emissions.

- **A smooth transition to fuller coverage and market-based mechanisms after 2050.**
  - The distribution of emissions among sectors and regions in 2050 should not deviate dramatically from distribution in efficient solution.
  - Global emissions through 2050 should roughly match efficient, long-term stabilization pathways.
There are multiple global emissions pathways to any long-term target.

Fossil and Industrial emissions pathway depends on (1) discount rate, (2) overshoot versus stabilization, (3) emissions drivers (e.g., population, GDP), (4) technology (e.g., bio&CCS), (5) coverage (e.g., is terrestrial carbon priced)
The emissions pathway we will be choosing will roughly fit a 450 ppmv scenario.
Overview of Results
To Keep in Mind in Interpreting the Results

- In each scenario, important to distinguish between broad architecture and stringency of assumed policies
  - Architecture: the mix of instruments (e.g., economy-wide caps)
  - Stringency: the numbers (e.g., the specific cap levels)
- Equity and efficiency (cost-effectiveness) interact but are not the same
  - It is feasible to have equitable distributions of costs that are not cost-effective and vice versa
- It is important to distinguish between costs with and without trading
- This analysis does not address the economic benefits of avoided climate impacts
Annual CO₂ Emissions through 2095

- Reference
- Efficient 650
- Efficient 550
- Efficient 450

Year: 2005, 2020, 2035, 2050, 2065, 2080, 2095

Emission Units: GtC/yr

Key:
- 1A 550
- 1A 450
- 1B 450
- 2 450
- 3 550
- 3 450
Annual CO₂ Emissions through 2050

- Reference
- Efficient 650
- Efficient 550
- Efficient 450
- 1A 550
- 1A 450
- 1B 450
- 2 450
- 3 550
- 3 450

GtC/yr

2005 2020 2035 2050
Note that different stringencies could lead to different efficiencies.
Global Emissions and Costs: 2035
Global Emissions and Costs: 2050

Emissions Reduction Costs (Fraction of GDP)

- Efficient 650
- Efficient 550
- Efficient 450
- IA 550
- IA 450
- IB 450
- 2 450
- 3 550
- 3 450
The Effect of the Increasing Challenge

Electric sector low-carbon standard not eliminating freely-emitting coal.

Coverage of policy commitments must apply to virtually all sectors in the developing regions.

All sectors covered, including CO2-based sectoral policies.

Without expanded policy coverage, limited coverage makes 2050 infeasible.
The Increasing Challenge

• The efficiency losses from the multi-track approaches explored in this analysis may be moderate in the near-term...

• But over time, as the abatement burden increases, they become increasingly acute.
Sectoral Emissions: 2035

Idealized stabilization scenarios

- Industry
- Buildings
- Transport
- Electricity
Sectoral Emissions: 2050

Sectoral Emissions: 2050

Idealized stabilization scenarios

GtC/yr

Industry
Buildings
Transport
Electricity

Reference Efficient 650 Efficient 550 Efficient 450 IA 550 3 550 IA 450 IB 450 2 450 3 450
Abatement by Region: 2035

With trading, emissions reductions are completed where they are least costly.
Abatement Cost by Region: 2035

With trading, emissions reductions are completed where they are least costly.
Policy approaches or sectoral approaches can lead to a different distribution of emissions reductions.
Policy approaches or sectoral approaches can lead to a different distribution of emissions reductions.
Regional Cost Distribution: 2035

Trading redistributes costs.
CCS Deployment Fund

Global Electricity Production, CCS Fund Recipients: 2035

CCS fund increases CCS fund in recipient nations; lowers cost of electricity, reducing impact on total demand.
Summary

- Ultimately, all sectors and regions must participate in emissions mitigation to achieve stabilization.
- These scenarios have explored near- and mid-term policy architectures in the context of long-term stabilization.
- A range of architectures could lead to emissions reductions in the near- and mid-term that are consistent with long-term stabilization at levels at roughly 450 ppmv.
  
  - But a transition toward broad coverage will be required toward mid-century to contain costs.
- The greater the overlap and intersections between policy approaches, the more difficult to predict the outcome.
- Deviations from full trading will reduce the absolute economic efficiency of any architecture; the degree of deviation depends on the mechanisms included in the architecture for trading.
- A variety of trading mechanisms can be used to redistribute costs among regions.
Concluding Thoughts

• Effectiveness
  – A range of policy mixes can produce a near/medium-term effort consistent with long-term stabilization

• Fairness
  – A range of policy mixes can produce a reasonable distribution of cost

• Efficiency
  – A transition to full global trading and coverage is key to economic efficiency in the long term
  – In the nearer term, can we tolerate some trade-off of efficiency to achieve the broad participation needed to put countries on track toward the long-term objective?
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