2008 MERGE Results

- Re-evaluated magnitude of developing country growth
- Much higher no-policy baseline for CO$_2$ emissions
- Major implications for stabilization with limited participation

**CO$_2$ Emissions in China: New Projections**

**Non-Annex B CO$_2$ Relative to Global Targets**

Joint work with Richard Richels and Thomas Rutherford
Progress in 2009

- Global Recession – what does it mean?

- Analysis of specific scenarios with delayed accession of developing countries (Energy Modeling Forum study)

- Insights into role of non-CO$_2$ gases

- Relationship between global emission pathways and policy proposals in US
Coalition Countries: Ready to Participate Now

Annex B
- USA
- Greater EU
- Japan
- Canada
- Aus/NZ

OECD
- Korea
- Mexico
- Turkey

Russia
Ukraine
### Non-Coalition Countries: Delayed Participation

<table>
<thead>
<tr>
<th>Medium-Term Transition:</th>
<th>Long-Term Transition:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>Rest of World</td>
</tr>
<tr>
<td>Russia</td>
<td>- Mid-income countries</td>
</tr>
<tr>
<td>India</td>
<td>(e.g. Korea, Mexico)</td>
</tr>
<tr>
<td>China</td>
<td>- OPEC countries</td>
</tr>
<tr>
<td></td>
<td>- Poor countries</td>
</tr>
<tr>
<td></td>
<td>(e.g. Sub-Saharan Africa)</td>
</tr>
</tbody>
</table>

“BRIC” Group

“ROW” Group
2007 Total CO₂ Emissions (Energy/Cement)

Billion tons CO₂

“BRIC” Group

Brazil
Russia
India
China

Rest of World

Rest of Coalition

USA

Indonesia
Saudi Arabia
South Africa
Mexico
Iran
Korea

© 2009 Electric Power Research Institute, Inc. All rights reserved.
Baseline Emissions Adjusted for Recession
What is possible, at what cost, if…

- Coalition countries begin abatement immediately

- BRIC Group (Brazil, Russia, India, China) begins abatement after 2030

- Rest of world (ROW) begins abatement after 2050

- MERGE model used to find least-cost stabilization pathway under these constraints
Projected 2010 Concentrations for Kyoto GHGs

- **CO₂**
  - 392,000 ppbv
  - (392 ppmv)

- **CH₄**
  - 1,830 ppbv

- **N₂O**
  - 325 ppbv

- **F-gases**
  - 0.1 ppbv

Scale reflects atmospheric volume

Extra-equilibrium stock leads to warming

© 2009 Electric Power Research Institute, Inc. All rights reserved.
Projected Radiative Forcing in 2010

Watts per square meter: Change in heat balance relative to pre-industrial

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

CO₂  CH₄  N₂O  F-gases (0.02 W/m²)

278 300 350 400 450 500 550 600 650

CO₂-equivalent concentration in ppmv CO₂-e

Target Levels
Stabilization Targets

CO₂ limits implied by “residual” emissions from non-CO₂ gases

<table>
<thead>
<tr>
<th></th>
<th>CO₂-e concentration (ppmv)</th>
<th>Radiative Forcing (W/m²)</th>
<th>RF from non-CO₂ gases (W/m²)</th>
<th>RF from CO₂</th>
<th>CO₂-only concentration (ppmv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Levels</td>
<td>448</td>
<td>2.55</td>
<td>0.72</td>
<td>1.83</td>
<td>392</td>
</tr>
<tr>
<td>Target 0</td>
<td>450</td>
<td>2.6</td>
<td>0.95 (minimum)</td>
<td>1.65</td>
<td>380</td>
</tr>
<tr>
<td>Target 1</td>
<td>550</td>
<td>3.7</td>
<td>0.95 (minimum)</td>
<td>2.75</td>
<td>465</td>
</tr>
<tr>
<td>Target 2</td>
<td>650</td>
<td>4.5</td>
<td>0.95 (minimum)</td>
<td>3.55</td>
<td>540</td>
</tr>
</tbody>
</table>
Global CO₂ in the Optimistic Baseline

Billion tons CO₂

1990 2000 2010 2020 2030 2040 2050

Coalition
BRIC
ROW
Optimal Global Stabilization Pathways

- Optimistic Baseline
- 540 ppmv CO₂
- 465 ppmv CO₂

Billion tons CO₂

Coalition
BRIC
ROW

© 2009 Electric Power Research Institute, Inc. All rights reserved.
“Locked-in” Emissions from Non-Participants

Optimistic Baseline

540 ppmv CO₂

465 ppmv CO₂

Infeasible
650 CO$_2$-e Target is Possible with Delay

- $30 /$ ton CO$_2$ in 2020
- 1% of Gross World Product by 2050
- 4% max

Optimistic Baseline

540 ppmv CO$_2$
Optimal Paths w/ Pessimistic Economic Growth

- Coalition
- BRIC
- ROW

Billion tons CO₂

Pessimistic Baseline

540 ppmv CO₂

465 ppmv CO₂

© 2009 Electric Power Research Institute, Inc. All rights reserved.
Now, 550 CO2-e Target is Possible with Delay
However, Requires Drastic Action in Coalition

- Pessimistic Baseline
- 540 ppmv CO₂
- 465 ppmv CO₂
- Coalition
- BRIC
- ROW

$300 / ton CO₂ in 2020
4% of Gross World Product by 2050
7% max
US CO₂ Emissions in Optimistic Case

Optimistic Baseline

650 CO₂-e with Full Participation

650 CO₂-e with Delayed Participation

Representative US Policies:
- dashed line: 50% below 1990 in 2050
- dotted line: 80% below 1990 in 2050

© 2009 Electric Power Research Institute, Inc. All rights reserved.
US CO₂ Emissions in Pessimistic Case

Representative US Policies:
- 50% below 1990 in 2050
- 80% below 1990 in 2050

Pessimistic Baseline

550 CO₂-e with Full Participation

550 CO₂-e with Delayed Participation
R&D is Still a Good Investment

- **Savings when CCS and nuclear are available**
- **Policy Cost for 650 CO2-e with delay**

**USA**
- No Recession: $1.1 T
- Mild Recession: $0.9 T
- Severe Recession: $1.0 T

**World**
- No Recession
- Mild Recession
- Severe Recession

US $ Trillions (discounted NPV through 2100)
Conclusions

• Recession has an impact but does not change fundamental realities of the stabilization challenge

• With delayed participation by developing countries, achieving stabilization at:
  – 650 CO2-e is reasonably possible
  – 550 CO2-e is extremely difficult
  – 450 CO2-e is in the rearview mirror

• Coalition benefits from incentives for earlier participation and technology adoption in developing world