AIM/CGE for global and country analysis

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The 16th AIM Workshop
National Institute for Environmental Studies, Tsukuba, Japan
19 February 2011
Overall of AIM

- Emission Model
  - Account model
  - Enduse model
  - Economic model
    - mid-term target
    - low carbon scenario

- Impact/Adaptation Model
  - Sequential dynamics
  - Dynamic optimization

- Simple Climate Model
  - GHG emissions
  - temperature
  - IPCC/WG3
  - IPCC/WG2
  - IPCC/integrated scenario
  - IPCC/Impact Model

- Other Models
  - Population
  - Transportation
  - Residential
  - Burden share
  - Stock-flow
  - Accounting
  - IPCC/global
  - IPCC/national/local
  - Adaptation

- Future society
  - Agriculture
  - Water
  - Human health
CGE models development and their application

Main purposes of CGE models
- Consistency check of scenarios
- Quantification of economic impacts of GHG mitigation policies

Global model
- Long-term emission scenarios: RCP and SSP
- AME and EMF
- Contribution to other analyses such as LCS study (S-6; Env. research fund, MoE)

Country model
- Mid-long term GHG emission reduction target in Japan
- Application to China

New model development
- Global model: more detailed sectors and regions
- Country model: training workshop toward LCS study
Global Model
Features of present AIM/CGE [Global]

- Global general equilibrium model with recursive dynamics.
- Benchmark data of the economic activity is GTAP6 (the year 2001). IEA energy balance table is introduced for energy
  - Numbers of region: 24
  - Types of commodity: 21
  - Treated Gas: CO2, CH4, N2O, SOx, NOx, CO, NMVOC, BC, OC, NH3
- Production factor: capital, labor, resource and land
- Future scenarios
  - technology change (TFP, AEEI, material inputs, ...)
  - consumption pattern change
- Designed to link with the global technology selection (enduse type) model and country CGE model
## Region and commodity in AIM/CGE [Global]

<table>
<thead>
<tr>
<th>Region</th>
<th>Commodity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Agriculture, Livestock</td>
</tr>
<tr>
<td>China</td>
<td>Livestock, Forestry</td>
</tr>
<tr>
<td>Korea</td>
<td>Livestock, Fishing</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Mining (except fossil fuels)</td>
</tr>
<tr>
<td>India</td>
<td>Energy intensive products</td>
</tr>
<tr>
<td>Thailand</td>
<td>Metal and machinery</td>
</tr>
<tr>
<td>Other South-east Asia</td>
<td>Foods</td>
</tr>
<tr>
<td>Other South Asia</td>
<td>Other manufactures</td>
</tr>
<tr>
<td>Australia</td>
<td>Water</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Construction</td>
</tr>
<tr>
<td>Rest of Asia-Pacific</td>
<td>Transport</td>
</tr>
<tr>
<td>Canada</td>
<td>Communication</td>
</tr>
<tr>
<td>USA</td>
<td>Public service</td>
</tr>
<tr>
<td>EU-15 in Western Europe</td>
<td>Other service</td>
</tr>
<tr>
<td>EU-10 in Eastern Europe</td>
<td>Coal</td>
</tr>
<tr>
<td>Russia</td>
<td>Crude oil</td>
</tr>
<tr>
<td>Rest of Europe</td>
<td>Petroleum products</td>
</tr>
<tr>
<td>Brazil</td>
<td>Natural gas</td>
</tr>
<tr>
<td>Mexico</td>
<td>Gas manufacture distribution</td>
</tr>
<tr>
<td>Argentine</td>
<td>Electricity</td>
</tr>
<tr>
<td>Other Latin America</td>
<td>Coal fire*, Oil products fire*, Gas fire*</td>
</tr>
<tr>
<td>Middle East</td>
<td>Nuclear, Hydro, Biomass*</td>
</tr>
<tr>
<td>South Africa</td>
<td>Waste, Geothermal, Solar, Wind, and Other renewables</td>
</tr>
<tr>
<td>Other Africa</td>
<td>*: with/without CCS</td>
</tr>
</tbody>
</table>
RCP and SSP toward IPCC/AR5

- **RCP:** Representative Concentration Pathways
  - Inputs to climate models: Concentrations of GHGs, land use change, ...
  - Following model teams are contributing:
    - 2.6W/m² IMAGE
    - 4.5W/m² MiniCAM
    - 6.0W/m² AIM
    - 8.5W/m² MESSAGE
  - NIES (climate modeling team), JAMSTEC and Ibaraki Univ. support AIM team.
  - Emission forecasts and historical data for RCP: http://www.iiasa.ac.at/web-apps/tnt/RcpDb

- **SSP:** Shared Socio-economic Pathways
  - Inputs to impact models: Socio-economic activities
  - Different future directions: Adaptive Capacity and Mitigation Capacity
Results on RCP

Total CO2 emissions by scenarios

Electricity in 6W/m2

Electricity in reference
Asian Modeling Exercise

• Model comparison project

• Final goals
  1. Asian scenarios toward low carbon society (-2100)
     • Policy options and their costs in Asia
  2. Input outcomes to AR5

• Schedule
  – 1st meeting in Tsukuba, Sep 2009
  – 2nd meeting in Beijing, Mar 2010
  – 3rd meeting in Seoul, Sep 2010
  – Final data submission, Jan 2011
  – The 4th meeting in Xian, Mar 2011
  – Paper deadline: June 1st 2011
Results from AIM/CGE [Global]

- **Total CO2 emission (Mt CO2)**
  - China (BAU)
  - China (550ppm)
  - China (450ppm)
  - Japan (BAU)
  - Japan (550ppm)
  - Japan (450ppm)
  - India (BAU)
  - India (550ppm)
  - India (450ppm)

- **World carbon price (US$2005/t CO2)**
  - 550 ppm
  - 450 ppm

- **TPES/GDP (EJ/billion US$)**

- **CO2/GDP (Mt CO2/billion US$)**
Preliminary results for EMF24 (1st round)

Global GDP

Global CO2 emissions

Scenario 1 Base
Scenario 2 Base
Scenario 3 Base
Scenario 4 Base
Scenario 5 450 CO2e
Scenario 6 550 CO2e
Scenario 7 550 CO2e
Scenario 8 550 CO2e
Scenario 9 550 CO2e
Scenario 10 Idealized G8
Scenario 13 Muddling through
Scenario 14 Muddling through
2 approaches toward Low Carbon Society

Top-down approach: global model analysis
GHG emissions from Asia region corresponding to global target

Backcasting to estimate roadmap

Low Carbon Society

How to bridge “GAP”?

Bottom-up approach: country/local scenario development
Quantification of activity in the future achieving country/local GHG emission reduction target
Asia in scenario of global GHG emission reduction by half

CO2 emissions (bil. tCO2)

Primary energy supply (EJ)

Renewable energy supply (EJ)
Country Model
Linkage between AIM/Enduse [Japan] and AIM/CGE [Japan] (as of 21 December 2010)

This information estimated from AIM/Enduse [Japan] is input into AIM/CGE [Japan].
GDP and carbon price from AIM/CGE [Japan]
(as of 21 December 2010)

Within 10 years, GDP growth rate will slow down, but new industries related energy saving equipment and renewable energy will be activated.

<table>
<thead>
<tr>
<th></th>
<th>reference</th>
<th>▲15%</th>
<th>▲20%</th>
<th>▲25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP growth rate (2010-2020 ; %/year)</td>
<td>2.07%</td>
<td>1.96%</td>
<td>1.89%</td>
<td>1.77%</td>
</tr>
<tr>
<td>GDP change from reference in 2020 (%)</td>
<td>-1.11%</td>
<td>-1.78%</td>
<td>-2.94%</td>
<td></td>
</tr>
<tr>
<td>CO2 price (yen at 2000 price/tCO2)</td>
<td>14,643</td>
<td>21,198</td>
<td>41,446</td>
<td></td>
</tr>
</tbody>
</table>
China Dynamic CGE Model Features

◆ **Model**: Recursive dynamic CGE model, 41 sectors
◆ **Time period**: 2005-2050, 5 year step
◆ **Gas**: Energy related CO₂, Process CO₂, other GHGs
◆ **Technology**:
  - **12 power generation technologies**
    - 7 fossil and 5 non-fossil
  - **CCS technology in**:
    - Coal and gas fired electricity sectors, sectors of cement, chemistry, iron and steel.
China Dynamic CGE Model: Preliminary Results

GDP

CO₂

Carbon Price

Primary Energy in RS

Final Energy in RS

Power generation in RS

China
New model development
## Main features of a new Global CGE model

<table>
<thead>
<tr>
<th></th>
<th>New model</th>
<th>Present model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Region</strong></td>
<td>35 (Asian countries; 14)</td>
<td>24 (Asian countries; 8)</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td>38 (manufacture sector is disaggregated in detail)</td>
<td>20</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>CO2, CH4, N2O, NH3, SOx, NOx, BC, OC</td>
<td></td>
</tr>
<tr>
<td><strong>Institution</strong></td>
<td>Household, government, Enterprise</td>
<td>Representative household</td>
</tr>
<tr>
<td><strong>Dynamics</strong></td>
<td>Recursive dynamic (1 year step)</td>
<td>Recursive dynamic (10 year step)</td>
</tr>
<tr>
<td><strong>Base year</strong></td>
<td>2005</td>
<td>2001</td>
</tr>
<tr>
<td><strong>Base data</strong></td>
<td>Original energy balance and SAM (data reconciliation system)</td>
<td>GTAP and IEA energy balances</td>
</tr>
<tr>
<td><strong>Program</strong></td>
<td>GAMS / MCP</td>
<td>GAMS / MPSGE</td>
</tr>
</tbody>
</table>
Preliminary results of global CGE model

Global GHG emissions
- baU
- 550ppm
- 450ppm
- 450ppm-delay

Global GDP
- baU
- 550ppm
- 450ppm
- 450ppm-delay

Global power structure (450ppm-delay scenario)
- Other renewable
- Biomass w CCS
- Biomass wo CCS
- Hydro
- Nuclear
- Fired w CCS

GHG emission price
- China
- Korea
- USA
- India
- Indonesia
- Malaysia
- Japan
- Singapore
- Thailand
- Vietnam
- Philippine
- Rest of South Asia
- Rest of South east Asia
Country CGE model and example of the results
-a case of Japan-

• Most of the features are same as global model.
• Each national characteristic (e.g., renewable energy potential) should be considered.
• National governmental target and plan will be implemented in the scenario.
Training workshop on Country CGE model

- We will have a training workshop for development of country LCS scenario by using a CGE model.
  - Date; June 1 or 2 weeks (Tentative)
  - Location; NIES @ Tsukuba

- Required abilities to attend this training workshop
  - Basic knowledge about microeconomics, input-output analysis and GAMS
  - Experience to publish a peer-reviewed scientific paper
  - Enthusiasm to show the economic aspects of LCS