Cover Sheet of Paper 1

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Long-term Emissions Scenarios and Short-term Targets

~ Application of AIM model ~

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Abstract

A dynamic optimization model as a family of the Asia Pacific Integrated model (AIM) was developed to provide global greenhouse gas emissions paths under different socioeconomic scenarios with constraints on multiple greenhouse gas emissions, temperature increases, rates of temperature increases and sea level rises. It identifies the short-term mitigation targets under different long-term goals. Stabilization of GHG concentrations at 500ppmv is required in order to limit any temperature increase as close as possible to 2^{o}C in 2150 relative to the 1990 level. The GHG reductions required to achieve such a 500ppmv cap on total GHG concentrations are 7.1 Gt-CO_2eq/y in 2020 and 19.0 Gt-$C0_2$eq/y in 2030 compared to the BaU case.

1. Introduction

It has been acknowledged that climate change is one of the important issues facing humanity in the present century and needs to be studied over a long-term horizon. The effects of climate change are already visible in different areas of the world. Analysis of climate data observed in last century and projected by climate models toward the end of this century have shown that much higher drastic changes in climate change indicators like annual mean temperature and precipitation is expected over the next century than that witnessed in the past century. These changes are likely to adversely impact the ecosystems in the region and have been a major concern in both the developed and the developing countries. We have so far developed an integrated assessment model (AIM) to analyze long-term emissions and short-term target as well as climate change impacts and risk. To analyze stabilization, impacts and emission, we are now developing a new module of the AIM. In this paper, we introduce a concept of this model and some preliminary results.

1.1 The Asia-Pacific Integrated Model (AIM)

The Asia-Pacific Integrated Model (AIM) is one of the main tools of developing policy options for the Asia-Pacific region. It is a set of integrated computer simulation models used to assess policy options for sustainable development in this region. It started as a tool to evaluate policy options to mitigate climate change and its impacts, and extended its function to analyze other environmental issues such as air pollution control, water resources management, land use management, and environmental industry encouragement. More than 20 modules have been developed so far, and models to evaluate climate policy options are classified into emission models, climate models and impact models from the viewpoints of climate policy assessment. These models have been used as single models or in combination depending on the policy needs[1].

1.2 AIM/Impact [policy]

AIM/Impact [policy] is a sub model of the AIM which provides a framework for evaluating climate change impacts management under stabilization strategies for GHG emission, concentration and temperature. The objectives of model development are

(1) to provide a platform to integrate past impacts studies of climate change on several sectors and analyze climate change impacts on dangerous level, economical damage and adaptation strategy comprehensively, and

(2) to provide a platform to investigate GHG emission reduction strategies for achieving climate stabilization goals and to analyze the effects of burden sharing scheme and flexibility scheme for GHG emission reduction.

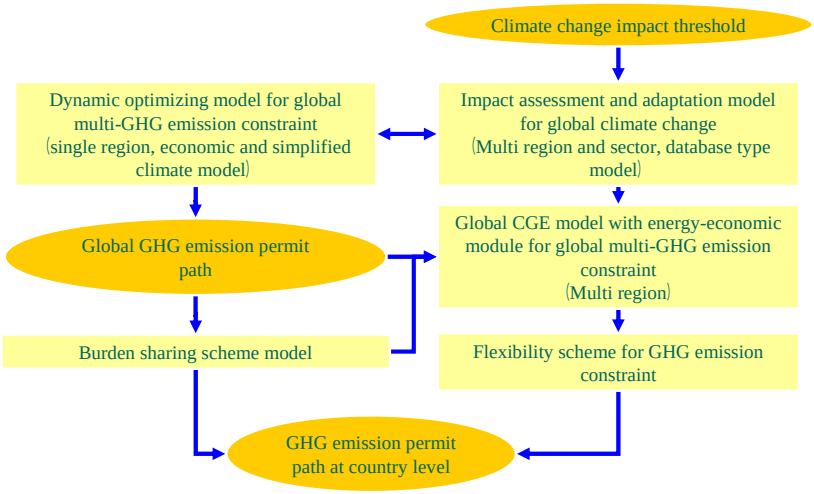

Figure 1 Framework of AIM/Impact[Policy]

This model consists of a series of linked sub models representing the major processes of GHG emission and climate change impacts (Fig. 1). The GHG emission part includes four sub models. The dynamic optimizing model is used to analyze global GHG emission path under different socio-economic scenarios and reduction constraint strategies of multi GHGs. In this model, the world is treated as single region and economic and simplified climate modules are incorporated. The burden sharing scheme model provides quantitative information on burden of GHG reduction at country level. Input data of global GHG reduction volume on various scenarios are provided by the dynamic optimizing model. This scheme

includes several types of burden sharing approach, e.g. Contraction and Convergence, Brazilian Proposal. Multi-stage, etc. The global CGE model is a recursive dynamic equilibrium model of world economy at regional and country level. This model enables quantitative evaluation of economic damages caused by GHG reduction and climate change impacts. The flexibility scheme is incorporated in the global CGE model and enables to evaluate range of emission reduction effects utilizing emission trading and carbon tax scheme. Climate change impacts part include one sub model, impact assessment and adaptation model for global climate change. This model is composed of database of pre-simulated results provided by process models. Results of external impact research group as well as the results of AIM/Impact are contained in the impact database. Country-averaged impacts on several sectors are estimated with combining (1) changes in country-averaged annual mean temperature and precipitation supplied by AO-GCM simulation results, and (2) sensitivity coefficient of several indices affected by climate change. This model indicates the sector-wise severity of the impacts based on the relationship among socio-economic scenario, adaptation capacity and sector-wise potential impacts.

2.Global GHG Emissions Paths

The dynamic optimization model included in AIM/Impact[policy] provides global greenhouse gas emissions paths under different socioeconomic scenarios with various constraints on multiple greenhouse gas emissions, temperature increases, rates of temperature increases and sea level rises. The model incorporates four sub-models: economic-energy model, simplified climate model, sea level rise model, and GHG emissions model. The world is treated as a single region. The time periods are the decades from 1990 through 2200. In this model, the focus is on several greenhouse gases: CO_2, CH_4, N_2O, SO_2, CFCs, PFCs, SF_6, BC, and O_3.

2.1 Simulation Cases

This model provides a framework to assist policymakers in their decisions on meeting the UNFCCC's ultimate objective; "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." To discuss the time frame and volume of GHG reductions, this study took six cases into consideration as follows:

- Simulation cases (reference Scenario: SRES B2)
  - ✓ Case 1: Business as usual (BaU)
  - ✓ Case 2: 450ppmv cap on CO_2 concentration
  - ✓ Case 3: 550ppmv cap on CO_2 concentration
  - ✓ Case 4: 650ppmv cap on CO_2 concentration
  - ✓ Case 5: 500ppmv cap on total GHG concentrations

- ✓ Case 6: 550ppmv cap on total GHG concentrations

With respect to Cases 2 to 6, constraint optimization calculations were carried out in which CO_2 or total GHG concentrations do not exceed the constraint levels from 1990 to 2200. Total GHG concentrations were calculated based on their global warming potential as reported by the IPCC. Figure 2 compares carbon emissions for the six cases. Figure 3 indicates CO_2 concentrations. These concentrations indicate CO_2 itself, not converted CO_2 concentrations from the total for GHGs. Figure 4 shows the results of global mean temperature changes from 1990 for the six cases. Under the business as usual case, CO_2 emissions continue to rise up to 2050 and in 2150 the CO_2 concentration is almost double the 1990 level. The temperature increases by nearly 2ºC in 2060 and by 4.2ºC in 2150.

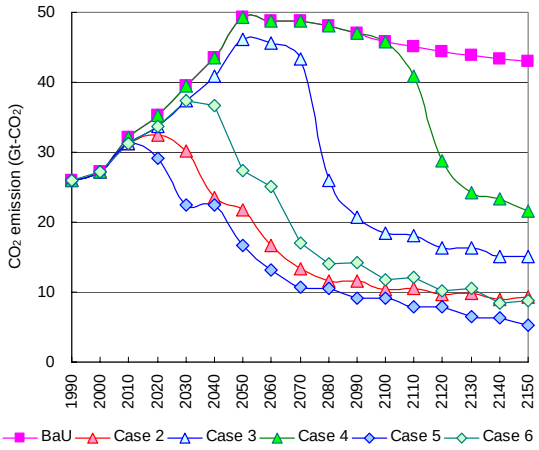

Figure 2: Global CO_2 emissions

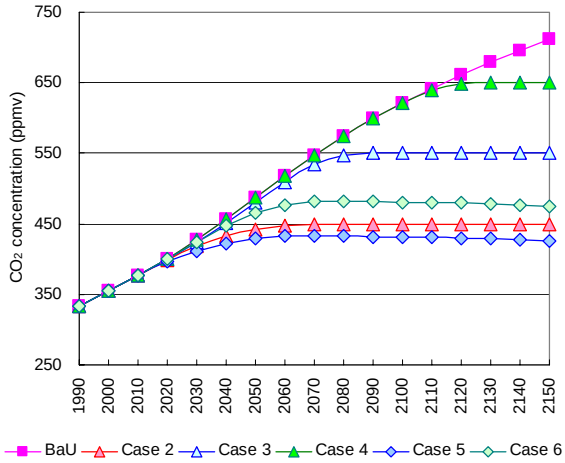

Figure 3: CO_2 concentrations

2.2 Required GHG reductions to achieve a 500 ppmv stabilization of GHG concentrations

In investigating the temperature increases for Cases 2 to 4, in which the maximum CO_2 concentrations are restricted, in each case the increases surpass 2ºC in 2150. This is because there are no constraints on the emissions of other GHGs except for CO_2. In Case 2, which represents the most severe constraint, the temperature increases by 3.1ºC in 2150.

In the case of constraints on GHG concentrations, Case 5 (500ppmv stabilization of

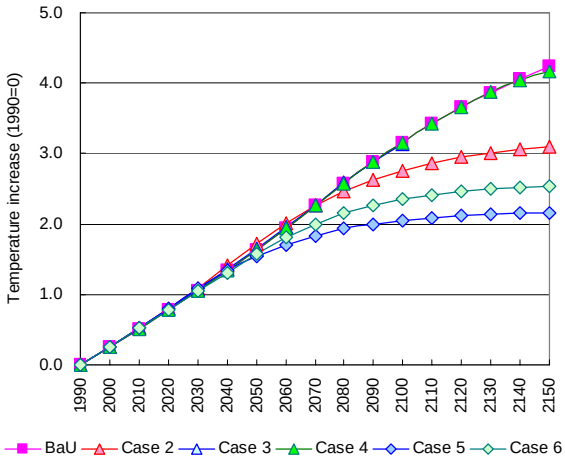

Figure 4: Global mean temperature changes

GHG concentrations) indicates a temperature increase of around 2ºC relative to 1990 in 2150 (2.2ºC). The GHG reductions required to achieve a 500ppmv cap on total GHG concentrations are 7.1 Gt-CO_2eq/y (CO_2 reduction: 6.1 Gt-CO_2/y) in 2020 and 19.0 Gt-CO_2eq/y (CO_2 reduction: 17.0 Gt-CO_2/y) in 2030, compared to the BaU case.

3. Research on Japanese climate policy scenarios toward 2050

In parallel, a new research project was initiated in April, 2004 to make feasible scenarios of future low carbon society. The goal of this research project is to explore the possible paths to low carbon society in Japan toward 2050 (Figure 5). Major output is the GHG emission scenarios, but it should be built on various related research works. These are: How should we set policy target? (stabilization target, international burden sharing, sustainable development,,) What technological and societal changes need to be introduced, and how? (Options, Policy and Measures) What implications these scenarios pose to future Japanese economy and society? (Evaluation of policies). In this project, AIM/Impact[Policy] model is utilized as identifying stabilization target.

References

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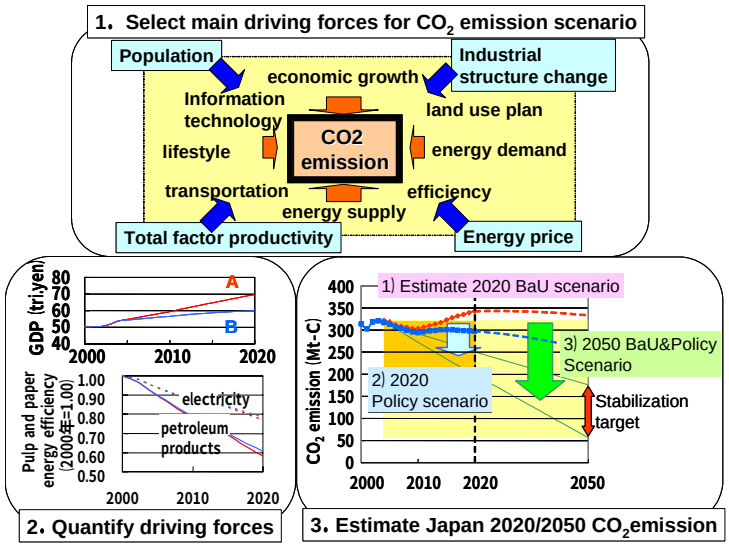

Figure 5 Outline of the project on low carbon society in Japan