## B-54.1 Special Collaborative Studies for Evaluating Greenhouse Gas Mitigation Policies by Applying the Asian-Pacific Integrated Model (AIM) (Final Report)

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**Abstracts:** The AIM model based on the work of the past six years was applied to the assessments of emission scenarios, climatic change scenarios, climatic impact scenarios, mitigation costs, and new policy integration in order to respond to the various common research needs from international organizations, national governments, and non-governmental organizations. These assessments include new IPCC emission scenarios, mitigation scenarios for global climate stabilization, land use related mitigation scenarios, implication and economic impacts of Kyoto Protocol, effect of Clean Development Mechanism in competition with emission trading, potential of GHG reductions in Asian developing countries, and policy design for Asia-Pacific collaboration.

**Key Words** Asian-Pacific countries, Greenhouse gas mitigation policy, Emission scenario, Emission trading, Integrated assessment

### 1. Introduction

The development of AIM model was started in 1991. For first three years the basic structure of the model was developed and after that collaborations with developing countries was done for three years. During this time, there were requests from Asian countries and international organizations like IPCC, UNEP, Eco-Asia to apply AIM model for specific studies. This required further revision and development of the model and its applications to the specific requests hence this project was initiated. In this project, the main objectives were to study impacts of climate change policy on specific countries (Japan, China, India and Korea) as well as global impacts of such policies.

### 2. IPCC long-term emission scenarios

AIM model was selected by IPCC as one of the models for developing new long-term emission scenarios. The first set of scenarios, called IS92, was developed by IPCC in 1992. The new scenarios were developed to include the changes in understanding of driving forces of emissions and methodologies as recommended in an evaluation of these scenarios in 1995. These changes relate to, e.g., the carbon intensity of energy supply, the income gap between developed and developing countries and to sulfur emissions.

Four qualitative storylines yield four sets of scenarios called families: A1, A2, B1, and B2. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation

of local identities. The B1 storyline and scenario family describes a convergent world. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. These scenarios appear in the Special Report on Emission Scenarios by IPCC. Fig. 1 presents the classification of these scenarios.

These four storylines and scenarios are the basis for Business-as-Usual (BAU) scenarios. The major results are: CO2 emission is highest in A2 scenario and lowest in B1 sustainable development scenario among the four scenarios; Energy intensity improvement is highest in B1 scenario while carbon intensity reduction is highest in A1; Although energy intensity improvement is not steep in A1 due to adoption of carbon-free technologies the CO2 emissions reduction is significant; Compared to IS92 scenarios, which projected high growth of SO2 emissions, the new scenarios estimate SO2 emissions to drop after 2050 because of structural changes in the energy system as well as concerns about local and regional air pollution.

After making BAU projections various mitigation scenarios were developed with policies regarding energy conversion sector such as use of solar energy for electricity generation, biomass etc., energy efficient technologies in transportation sector, increase in plantation area, and so on. Different levels of stabilization of emissions such as 450 ppm, 550 ppm, 650 ppm were taken as constraints for mitigation policy scenarios. Fig. 2 depicts World CO2 emissions reduction in 550 ppm stabilization case for the four storylines. It shows that there is large potential in emission reduction and the amount of reduction depends on the socio-economic assumptions in various scenarios. The reductions turn out to be largest in A2 case.

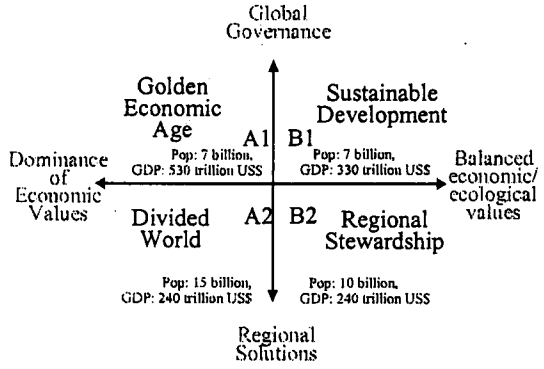


Fig. 1 Four different socio-economic trends of new IPCC emissions scenarios

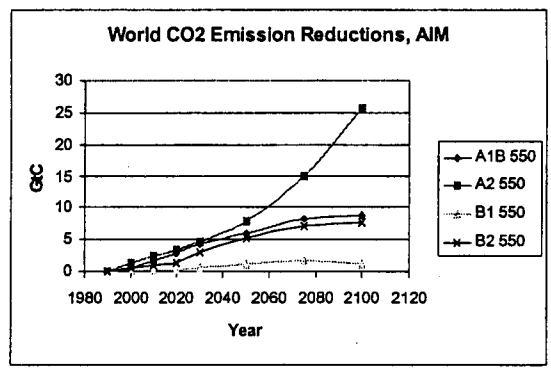


Fig. 2 World CO2 reductions in 550 ppm stabilization scenario

## 3. Implication of the Kyoto Protocol and its policy analysis

### 3.1. CO2 emission reduction possibilities in Japan

According to the Kyoto Protocol, Japan needs to reduce its emissions by 6% of 1990 level. AIM model was applied to analyze the possibilities for achieving this target. For this study GDP growth rate was assumed to be 0.6% for 1999, 1.0% for 2000 and 2% for 2001-2010. Other assumptions were: Oil price at US$30 per barrel in 2010; Exchange rate at

120yen/dollar; and Nuclear power generation in 2010 to be 56.2 million kWh.

Four cases were developed for estimation of CO2 emissions:

*Frozen case*: Technology share is frozen at 1998 level, only energy service demand is varied.

*Market case*: New technologies are introduced based on cost through market mechanism. The payback period for new technologies was assumed to be less than 3 years.

*Carbon tax case*: A tax of 30000 yen/ton of carbon is introduced from year 2000.

*Carbon tax plus subsidy case*: A tax of 3000 yen/ton of carbon is introduced and the revenue from this is used for subsidizing new technologies.

The timeframe for these simulations was from 1990 to 2010. The key result from the simulation is shown in Fig. 3.

In Frozen case, CO2 emissions in 2010 are 18% higher than 1990 level on the whole, though emissions in different sectors show variance. Emissions from Industry sector rise 4% while those from Residential sector rise 31%. Similarly, commercial sector emissions increase by 30%, transportation sector emissions increase by 38%, and emissions in energy conversion sector are 16% high. Market case has a 10% increase in CO2 emissions in 2010. In this case, industry sector decreases emissions by 3%, residential sector increases 17%, commercial rises 18%, while transportation sector is 37% high and energy conversion sector is 9% higher than the respective1990 levels.

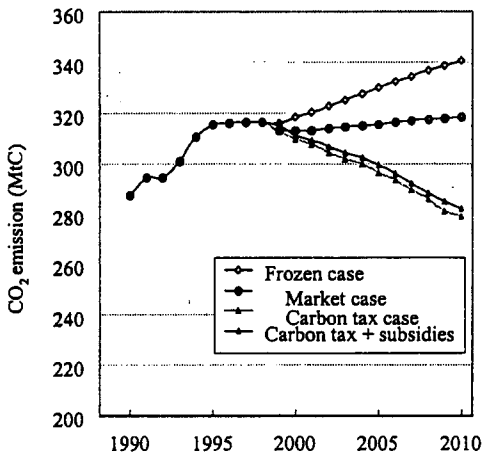


Fig. 3 CO2 emission forecast in Japan

Since emissions increase in both the above cases, we need to introduce policies to control this increase. In Carbon tax case, Industry and Residential sectors experience a decrease in emissions by 11% and 13% respectively while there is no change in emissions in commercial sector. On the other hand, transportation sector emissions increase by 22% and energy conversion sector emissions decrease by 5%. The overall effect of Carbon Tax case is a 3% decrease in emissions by 2010. In the last case, that is Carbon Tax plus Subsidy case, emissions reduced by 10% in industrial sector, reduced by 12% in Residential sector, increased by 1% in commercial sector, increased 22% in transportation sector and decrease by 5% in energy conversion sector. Overall emission reduction achieved in this case is 2%. The effect in this case is almost similar to that in pure tax case although the tax level is 10 times lower.

As it can be noticed, the above policy simulations show a maximum decrease of emissions by 3%, which means that in order to achieve 6% reduction as given in Kyoto

Protocol, we need to have some drastic policy initiatives.

3.2. Potential to reduce cost of emission reductions

While AIM technology model was applied to estimate the potential to achieve the Kyoto Protocol, to estimate the costs of emission reduction a general equilibrium model was applied. Fig. 4 shows comparison of reduction in costs by emission trading in 2010. Marginal costs of achieving Kyoto target domestically is higher than in case emission trading takes place. In case of domestic actions alone, the marginal cost faced by Japan is $234 in 2010 and is the highest compared with EU and US.

The total reduction cost in US is the highest because the total amount of emissions reduced is the largest. In case of Annex I emission trading, the marginal cost will become $65. In such a case US$4.8 billion will be saved in Japan, $7.9 billion in EU, and $8.9 billion in US.

Fig. 5 shows the amounts of emissions traded by various countries in World Trading case. The main exporters are former Soviet Union and Latin America in 2010 and importers are US, EU, Japan and Canada. As the former Soviet Union has so-called "hot-air", the trading between Asian countries is not accreted in 2010.

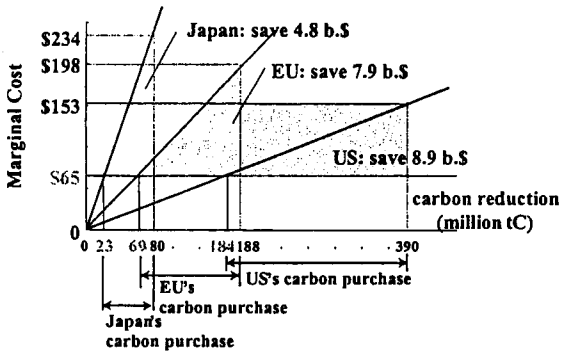


Fig. 4 Comparison of reduction costs by emission trading in 2010

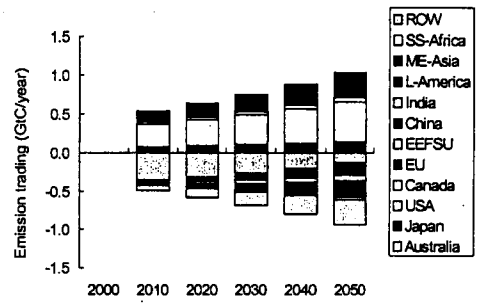


Fig. 5 Amounts of emission trading in world trading case

Fig. 6 shows the benefits of non-Annex I countries by Clean Development Mechanism (CDM). It shows that the benefits are not high before 2010, because the emission price in emission trading is low. After 2030, the benefits are significant.

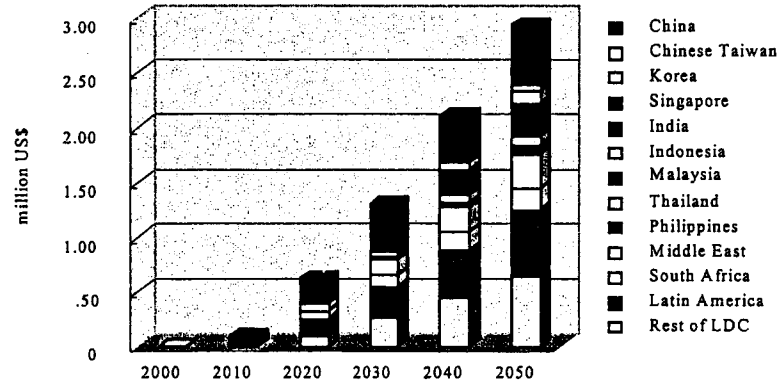


Fig. 6 Benefits of non-Annex I countries by Clean Development Mechanism

## 4. Analysis of the global warming policies in the Asian countries

According to the Kyoto Protocol, there are no emission targets for developing countries. However, it is recognized that the emissions in the developing countries are rapidly growing. We estimated greenhouse gas emissions in Asian countries, especially in China, India and Korea and analyzed various policy scenarios to reduce emissions. Following is a brief description of some of the analyses.

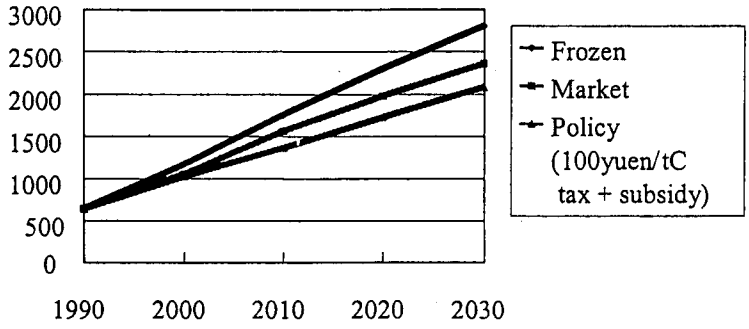


Fig. 7 Projection of CO2 emissions in China by scenarios

Fig. 7 shows CO2 emissions projections in three scenarios: Frozen, Market and Policy cases in China. It is expected that the CO2 emission in China will grow more than 2.5 GtC in Frozen case and 2 GtC in Policy case in 2030.

Fig. 8 shows CO2 emission projection in 2010 in various sectors in China for market and policy cases. About 13 % reduction is possible in policy case compared to market case. The reduction potential is high in the steel making industry, the rural residential sector and urban residential sector.

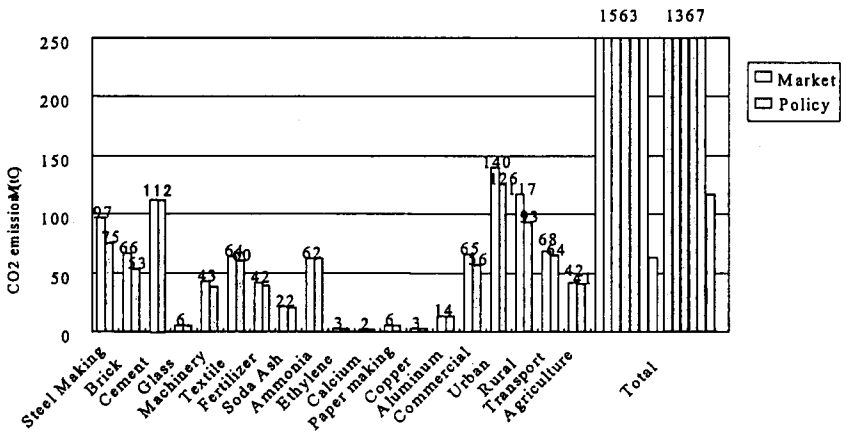


Fig.8 CO2 emission projection in 2010 in market and policy cases

CO2 emissions in India are also estimated based on several socio-economic scenarios and policy scenarios. Fig. 9 shows CO2 projections in India in 2010 under reference and high tax cases. In the high tax case, US$20/tC is assumed in 2010. There are possibilities to reduce emissions in the steel industry, transport and commercial sectors. Fig. 10 shows projections of CO2 emissions in the industry sector in India, under 4 cases: Reference, Low Tax, Medium Tax and High Tax cases. It shows that even under a Low Tax case, there is a possibility to reduce emissions in the industrial sector, but in order to reduce emissions by introducing energy saving technologies, especially in the transportation sector, tax rates needs to be increased

Based on the data of the 1995, the simulations are set up to the year of 2020 in Korea. Various scenarios on future energy consumption can be set up for the model simulation.

Four kinds of scenarios are used to analyze the policy effects: BaU, Frozen, Carbon tax (30,000 Won/tC from 2000) and Subsidy (same carbon tax and subsidy from 2001).

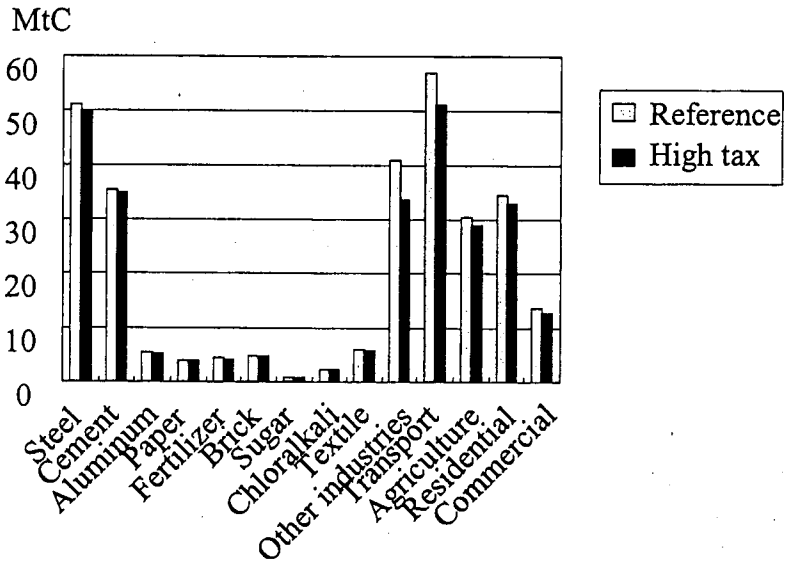


Fig. 9 CO2 emission projections in India in each sector in 2010

Fig. 11 shows the CO2 emissions by end-use sectors. The total CO2 emission in 1995 was 105 MtC, reaching 177.6 MtC in 2020 under BaU scenario. The share of residential sector keeps increasing from 17.4% in 1995 to 18.1% in 2020. The same trend is shown in commercial sector. In industrial sector, CO2 emissions are continuously increasing, but the share of this sector is decreasing due to the industrial structural changes to less carbon intensive industries.

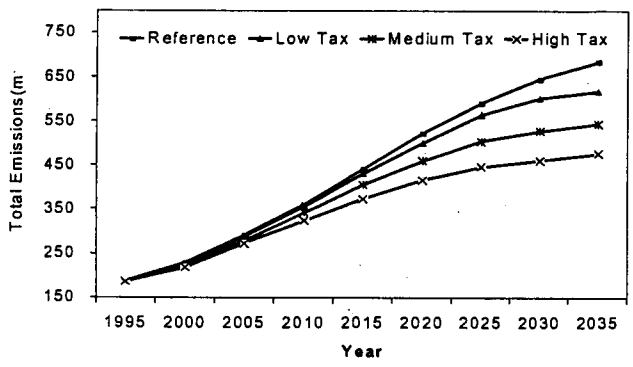


Fig.10 CO2 emission projections in India in industrial sector

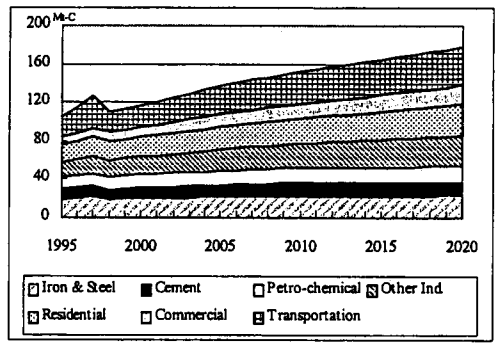


Fig. 11 CO2 emission forecasts in Korea by sectors

Fig. 12 shows CO2 emission projections in the residential sector. In BaU scenario, CO2 emissions in 1995 were 18.21 MtC and in 2020 they would be 32.16 MtC with the average annual growth rate of 2.3%. By imposing carbon tax of 30,000 Won/tC (about 25$/tC), it is not expect CO2 emission mitigation in this sector. If carbon tax of 30,000 Won/tC is imposed and recycled, further CO2 emissions reductions would be feasible, in which case, 2.3 MtC in 2010 and 7.4 MtC in 2020 would be possible. Hence, it is found that carbon tax recycle is very effective in this sector.

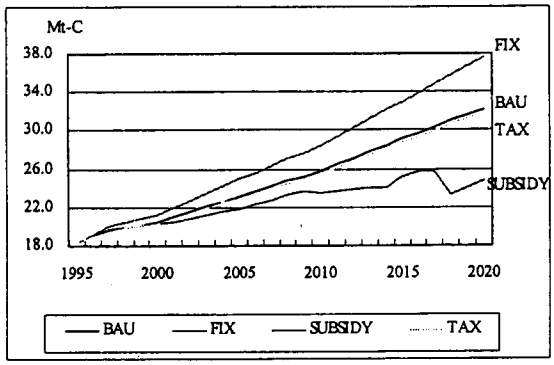


Fig. 12 CO2 emission prediction in Korea in residential sector

## 5. Concluding remarks

IPCC new long-term emission and mitigation scenarios have been developed. Also analyzed the economic impacts of the Kyoto Protocol and the CO2 reduction potential in Asian countries. These results have been referred to by several organizations such as the IPCC, Eco-Asia Project, and national governments.

Further studies are requested to evaluate policy options to stabilize global climate change from different perspectives of increasing economic activities and reducing local environmental problems. If efforts are made to reduce CO2 emissions even further than as mandated by the Kyoto Protocol, the necessary costs will certainly become larger. These are the costs that industry and households will have to bear. On the other hand, there will be an increase in effective demand for producers of energy-saving technologies. There is a high possibility that the indirect cost will become smaller through the activities of environmental industries. The business opportunities for environmental industries will also increase as projects to reduce CO2 emissions jointly with developing countries are implemented. Earlier investment in environmental industries will reduce the total cost in the long term. These studies will be conducted in collaboration with Asian research institutes.

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