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Global long-term greenhouse gas mitigation emission scenarios based on AIM

Kejun Jiang,[1] Tsuneyuki Morita,[2] Toshihiko Masui,[2] and Yuzuru Matsuoka[3]
[1] Center for Energy, Environment and Climate Change, Energy Research Institute, Zhansimenlu, Shahe, Changping County, Beijing 102206, China
[2] National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, Japan
[3] Faculty of Engineering, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto, Japan

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Abstract In order to respond to climate change, it is essential to describe possible future greenhouse gas (GHG) emission trajectories in both nonintervention and intervention terms. This paper analyzes long-term GHG mitigation emission scenarios according to alternative development paths in the world and major regions, based on the nonintervention emission scenarios quantified by the Asian-Pacific Integrated Model (AIM). AIM is revised and applied to the quantification of narrative storylines for scenarios of socioeconomic development, and GHG emissions from energy use, land-use change, and industrial production processes are simulated. A wide range of mitigation policies are adopted in this simulation as responses to the climate change. Several target stabilized levels—650, 550 and 450 ppmv—are analyzed. The results show that to achieve stabilization at a different GHG concentration level, a policy package is essential to reach the target concentration level, rather than a single policy. Energy efficiency improvement will be a key contributor to the reduction of GHG emissions as a result of the policy package. The mitigation cost could be at a medium level, without a large loss of economic growth. The developing world could significantly reduce GHG emissions compared with nonmitigation scenarios with sufficient knowledge transfer from developed countries.

Key words Climate change · Mitigation emission scenario · Integrated assessment model · Energy

1 Background

It is well understood that human society must respond to possible climate changes caused by increasing greenhouse gas (GHG) emissions from fossil fuel use and other sources. In order to describe future possible GHG emission trajectories in both of nonintervention and intervention terms and the costs of responses for GHG emission reduction, various emission scenarios must be analyzed to answer questions posed by researchers and policymakers. Over the next hundred years, global socioeconomic development may progress in various ways. The developing countries, with the majority of the world's population, may experience high economic growth, making them a major growth center in the global economy, which already occurred in the Asia-Pacific region. Many developing countries share problems that arise from rapid industrialization, population growth, and concentration of people in cities.

Future emission scenarios are mostly dependent on the regional development pattern, and each region has a wide range of development path options. This means that future GHG emissions may diverge depending on the future development path. Recognition of such divergent nonintervention and intervention scenarios is highly important in assessing policy options to respond to climate change, because the reduction level of GHG emissions is dependent not only on the target climate stabilization level but also on the baseline scenario of the nonintervention increase in GHG emissions.

Many emissions scenarios have already been quantified or published. The most popular scenarios are the IS92 scenarios published by IPCC in 1992 (Alcamo et al. 1995; Morita et al. 1994; Matsuoka et al. 1996). However, very few of these scenarios have been explicitly analyzed from the viewpoint of future alternative development path in developing regions (Parikh 1992; Zhou et al. 1997; Bruce et al. 1996). Only some scenarios have clarified the relationship between development patterns and emissions at the global level (Lashof et al. 1990; WEC 1993). Moreover, the analysis of intervention scenarios is limited. In order to contribute to the analysis for both nonintervention and intervention emission scenarios, we developed the AIM-Linkage model. A group of nonintervention emissions was quantified based on the IPCC Special Report on Emission Scenarios (SRES) and reported (Jiang et al. 2000). This paper discusses the quantification of intervention scenarios based on the non-intervention emission scenarios by the AIM-Linkage model.

2 Study framework

In order to quantify GHG emissions from various sources, a new linkage module of the integrated assessment model was developed and comprehensive storylines of development were established. Then, future projections were made by the integrated assessment model for energy use, energy production, industrial processes, land-use changes, agricultural production, livestock, etc. from 1990 to 2100 according to the storylines. These projections were finally converted to the GHG emission scenarios.

Based on the nonintervention emission scenarios, the Asian-Pacific Integrated Model (AIM) project team quantified selected target concentration levels (see Table 1). Descriptions of the nonintervention scenarios are given in other papers and reports (Jiang et al. 2000; IPCC SRES 2000).

A model framework called the AIM/emission linkage model was developed for this emission scenario study. It links several models to calibrate the data and perform scenario quantification. An important point to note is that the developing Asia-Pacific region's development pattern should be analyzed in relation to the global regime because international issues will strongly influence the region's

Table 1. Intervention emission scenarios by the AIM project team

Baseline scenario Stabilization level	A1B	A2	B1	B2
450 ppmv stabilization	✓			
550 ppmv stabilization	✓	✓	✓	✓
650 ppmv stabilization	✓			
Application of common robust policy set to all baseline scenarios	✓ (550 ppmv stabilization)	✓ (Non-stabilization)	✓ (Non-stabilization)	✓ (Non-stabilization)

future environment, economy, and energy activities. Scenarios for the developing Asia-Pacific region should also be closely related to scenarios for other regions. Hence, the model framework adopted was a global model divided into key regions.

Major emission sources including energy activities, industries, land use, agriculture, and forests can be simulated in the model framework. The structure of the AIM/emission linkage model is shown in Fig. 1.

The components of the model framework were adopted from previous studies. The energy sector top-down module was developed based on the Edmonds-Reilly-Barns (ERB) model (Edmonds et al. 1983; Edmonds et al. 1995; Edmonds et al. 1996), which is widely used for emission analysis; the end-use module was taken from the AIM/end-use model (AIM Project Team 1996; Hibino et al. 1996); and the land-use module was developed from the Global Trade Analysis Project (GTAP) model (Hertel 1997). This new model structure maximizes the ability to simulate a variety of inputs at a variety of levels, incorporating the strengths of both top-down and bottom-up approaches. A bottom-up model reproduces highly detailed processes of technology development related to energy supply and demand, in order to determine future improvement of end-use efficiency. A top-down model, on the other hand, estimates equilibrium of energy supply and demand, and then determines energy prices that reflect not only energy service demand, but also energy efficiency improvement.

The AIM/end-use model is part of the Asian-Pacific Integrated Model (AIM), which was developed by the National Institute for Environmental Studies (NIES) and Kyoto University. It is a bottom-up, energy-technology model. Based on detailed descriptions of energy services and technologies, it calculates the total energy consumption and production in a bottom-up manner. This model has been used to analyze several key countries in the Asian region including China, India, Indonesia, and Japan etc. The AIM/end-use models for key Asian developing countries have been constructed, and the results of analyses using this model have been reported (Jiang et al. 1998; Hu et al. 1996). Among the advantages of bottom-up models, the most important is that their results can be interpreted clearly because they are based on detailed descriptions of changes in human activities and technologies.

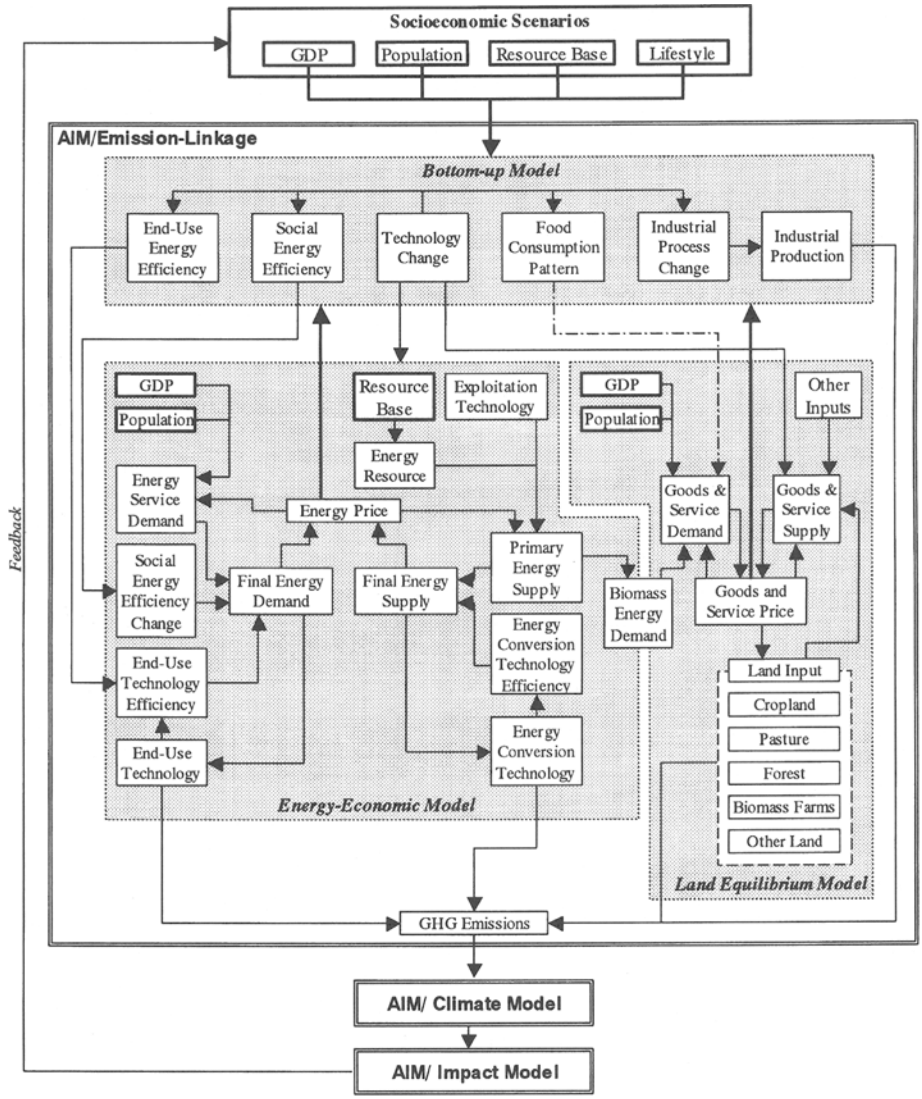


Fig. 1. Outline of the AIM-Linkage model

The top-down model for the energy sector provides a consistent, conditional representation of economic, demographic, technical, and policy factors as they affect energy use and production. It is a macroeconomic partial-equilibrium model that deals with energy activities and forecasts energy demand over the long term. It uses gross domestic product (GDP) and population as future development drivers, combined with other energy-related parameters to forecast energy demand based on the supply and demand balance. Three end-use sectors—industrial, residential and transportation—and one energy-conversion sector—power generation sector—are specified in the model. Energy efficiency is described by both technology efficiency and social efficiency improvements. A number of technologies in these four sectors are listed in the model to present different possibilities of technological progress. A link between the bottom-up energy model and the top-down energy model has been developed. A detailed energy-use analysis for the developing Asia-Pacific region from the bottom-up model drives the energy-use pathway before 2030, while a simplified linkage is presented for other regions in the model. The linked AIM/end-use model and the energy top-down model are composed of the energy model in the model framework.

The top-down land-use model is based on the Global Trade Analysis Project (GTAP), which was established in 1992 (Hertel 1997). This model is an applied general-equilibrium model that divides the world into multiple regions. For the sake of this analysis, the land uses for agriculture, livestock, and forests are considered, and the biomass energy demand is taken exogenously. It is designed to explicitly model agriculture and land use, endogenously determine emissions resulting from land-use changes, and explore the use of biomass as an element of a strategy for anthropogenic carbon emissions.

The AIM/emission linkage model combines these various components to calculate future GHG emissions in a relatively full-range analysis. For the purpose of the model, the world is divided into nine regions: USA, Western Europe OECD and Canada, Pacific OECD, Eastern Europe and the former Soviet Union, Central Planned Asia and China, South and East Asia, Middle East, Africa, and Central and South America. The model has a time horizon extending from 1990 to 2100. The time steps are in units of 5 years up to 2030, followed by time steps at 2050, 2075, and 2100. The GHGs covered in the nonintervention emission scenarios are CO_2, N_2O, CO, NOx, and CH_4. Because SO_2 has a strong influence on climate change and is an important pollutant in local areas (Gan 1998; Qi et al. 1995), it is also included. CO_2 emissions are analyzed in the intervention scenarios.

Regarding Fig. 1, the GHG emissions from energy consumption and energy production are simulated by the energy model. GHG emissions from land use are derived from the land-use model, while GHGs from other emission sources are calculated by simplified industry process models that describe the relationship between GDP per capita and industrial product outputs.

3 Narrative scenarios

A set of story-lines was formulated for the nonintervention scenarios by defining several key driving factors such as GDP growth, population, energy efficiency improvement, etc. The historical data on energy use and GHG emissions were taken from OECD statistics, FAO statistics, related papers on emissions, expert advice, and other sources. A special issue of the Journal of Technology

Forecasting and Social Change was published to introduce the development of nonintervention scenarios.

Seven different GHG emissions scenarios were developed with the AIM-linkage model. The same names were adopted for these scenarios as these described in other papers in the above special issue, that is: A1B, A1C, A1G&O, A1T, A2, B1 and B2. Mitigation scenarios by the AIM-Linkage model were developed based on these nonintervention emission scenarios. The following are the names of mitigation emission scenarios used in this paper:

A1B 450: AIM A1B scenario for stabilization at 450 ppmv by 2100
A1B 550: AIM A1B scenario for stabilization at 550 ppmv by 2100
A1B 650: AIM A1B scenario for stabilization at 650 ppmv by 2100
A2 550: AIM A2 scenario for stabilization at 550 ppmv by 2100
B1 550: AIM B1 scenario for stabilization at 550 ppmv by 2100
B2 550: AIM B2 scenario for stabilization at 550 ppmv by 2100

Key drivers for mitigation emission scenarios were reorganization of the harm of climate change and prevention of possible climate change. For example, accumulated CO_2 emissions by 2100 would be around 1500 GtC in AIM A1B, which may cause a 2.3°C temperature increase. A clear understanding of the impact caused by climate change will persuade people to act. In the A1B scenario, people desire a high standard of living, and try to avoid the loss of welfare from damage caused by climate change. High incomes provide full financial support to combat climate change. A common perspective on the environment is driven by the similar lifestyles in the developed world and developing world. The global response to climate change proceed through international negotiations. Knowledge transfers from developed countries to developing countries are well conducted. This can be expected to accelerate the response to climate change in developing countries.

Environmental awareness will lead to environmental friendly lifestyles and consumption patterns. Well-educated people pursue environmental conservation in their lives to avoid excessive exploitation of natural resources. People's welfare is balanced by limiting consumption that relies on natural resources, such as taking pleasure from the powerful recreational vehicles, while pleasure from a comfortable environment is emphasized.

The A1 world is described by a high level of technology progress, which will greatly support actions in response to climate change. Expanded economic activity may provide large amounts of investment in R&D. Energy supply technologies, energy end-use technologies, and other clean-production technologies will be developed to satisfy the demand for environmental preservation. In addition to rapid progress in realizing modern renewable energy-utilizing technologies, clean-production technologies will be developed over a wide range of fields. High efficiency end-use technologies are assumed in the A1B mitigation scenario to meet the need to respond to climate change. Because of the well-established world-wide trade system and knowledge transfer mechanism, environmentally friendly technologies are diffused in developed as well as developing countries.

Due to these changes in life-styles and technology progress, the economic loss caused by response to climate change is very limited. International collaboration with regard to climate change could be achieved between developed and developing countries. Developing countries may take action at an early stage upon receiving assistance from developed countries in the form of technology transfers. Such assistance may be on a commercial basis or provided through governmental assistant funds. Developing countries will not have to shoulder a heavy burden in taking action against climate change.

4 Intervention policy package design

The AIM stabilization scenarios were simulated to quantify the various pathways to reach the desired target for global GHG concentration by the end of 21st century. A policy package was designed for this quantification based on the diverging baseline scenarios.

The policy package used in the AIM stabilization scenarios is as follows:

— Improved transportation efficiency. Higher transportation technology efficiency, and introduction of advanced transport technologies such as electric vehicles and fuel cell vehicles are included.
— Social efficiency gains. Efficiency improvement from industrial structure changes, and lifestyle changes are considered.
— Improved power generation efficiency. More advanced power generation technologies are introduced.
— Improved end-use efficiency. Higher end-use technology efficiency improvement is adopted.
— Nuclear power progress. Advanced nuclear power generation technologies such as FBR are emphasized.
— Incentive for natural gas.
— Carbon tax. A carbon tax is levied at the base of carbon emissions.
— Renewable energy incentives. Solar, wind, geothermal, and ocean energy will be well developed.
— Synthesized fuel production.
— Commercial biomass: early introduction, larger share. Commercial biomass will have a low cost to bring to market.
— Preference for forests.

Population and GDP growth are not designed to be reduced for mitigation, although there will be some reduction of GDP due to the introduction of the above policies.

All these policies are incorporated in the AIM mitigation scenario analysis based on the merits of each baseline scenario. In the A1B baseline scenario, successful economic development, social prosperity, human equity, etc. are the key factors. Consequently end-use technology efficiency improvement, and social efficiency improvement are emphasized in the A1B stabilization scenario analysis. Intergenerational equity is considered in the A1 mitigation scenarios to avoid major pressure on CO_2 emission reduction after 2050. In the A2 scenario, failed economic development results in inequity and low technology efficiency improvement. Hence, technology efficiency improvement, commercial renewable energy utilization, and a nuclear technology incentive are adopted in the A2 mitigation scenario simulation. We maintain a neutral policy level for the mitigation scenario analysis of the B2 world because the B2 baseline scenario already includes an understanding of the importance of human welfare and inequity, and environmental solutions. There is no major pressure for policies in the AIM B1 mitigation scenario for 550 ppmv stabilization level analysis.

In the A1B mitigation scenario family, much more strict policies are required for 450 ppmv stabilization analysis. Wider range policies have to be introduced, and strong policies have to be considered in order to attain the large CO_2 emission reduction. Early reduction is essential to avoid large pressure on social development and technology progress in the latter part of 21st century. Investment in technology R&D will contribute to CO_2 emission reduction over the next several decades. High-level carbon tax rates must also be adopted at an early stage even in the developing countries.

By examining through all the policies adopted in the AIM mitigation scenario analyses, some policies such as carbon tax, end-use efficiency improvement, and renewable incentives are seen in all the mitigation scenario analyses. All these policies could be regarded as robust policies.

The quantified policies in this study are shown in Tables 2 and 3 based on the model parameters.

5 Results of mitigation scenarios

Figures 2 to 13 present the quantified results from AIM-Linkage for the mitigation scenarios.

Among the same target concentration level mitigation scenarios—for example, the 550 ppmv stabilization group—there is no significant difference in CO_2 emission trajectories (see Fig. 2). Rather, the CO_2 emission reductions differ because of the different baseline emission trajectories. They show that the CO_2 emission will increase first then start to decrease in the second half of the 21st century.

To achieve CO_2 stabilization at a given level, CO_2 abatement is mainly achieved through a mix of technology progress in the energy end use sector and supply sector, structural changes in the economy with a trend toward dematerialization and lifestyle changes. End-use technology efficiency improvement and lifestyle changes are favoured mitigation measure in the A1B baseline scenarios. In order to avoid possible damage from climate change to prevent a larger welfare loss, people may invest more in end-use technology R&D to attain higher efficiency improvement, and give up their energy-intensive consumption pattern. Advanced energy end-use technology could be introduced to save

Table 2. Policy option package for stabilization at 550 ppmv

Policy options	A1B	A2
Transport efficiency improvement	Vehicle fuel-use efficiency improvement rate will be 0.14% higher than BaU case for all regions, starting from 2000.	Vehicle fuel-use efficiency improvement rate will be 0.14% higher than BaU case for all regions, starting from 2000.
Power generation efficiency	0.13% higher efficiency improvement	0.15% higher efficiency improvement
Social efficiency improvement	0.3% higher energy efficiency improvement, additional 0.2% higher energy efficiency improvement in developing countries from 2030 to 2050.	0.3% higher energy efficiency improvement, additional 0.2% higher energy efficiency improvement in developing countries from 2030 to 2050.
Carbon tax	US$50/tC Annex 1 countries will start from 2000, non-Annex 1 countries will start from 2030.	US$80/tC Carbon tax will start from 2000.
Nuclear incentive		0.5% higher marginal production cost improvement rate
Natural gas incentive		0.4% higher marginal production cost improvement rate
Syn-oil	0.1% higher marginal production cost improvement rate	0.15% higher marginal production cost improvement rate
Syn-gas	0.1% higher marginal production cost improvement rate	0.16% higher marginal production cost improvement rate
Biomass incentive	0.1% higher marginal production cost improvement rate	0.2% higher marginal production cost improvement rate
Solar energy		0.4% higher marginal production cost improvement rate (3.5 cents/kWh)

energy, especially fossil fuels. In the A1B world, in order to reach the 450 ppmv stabilization level, early action to reduce GHG emissions becomes essential because of the large reduction needed. If the reduction of GHG emissions is delayed, there will be critical pressure for reductions in the latter half of the 21st century, which may cause social and economic losses. In the A2 baseline scenario, because of the energy resource limitation in the baseline scenarios, CO_2 abatement is mainly through zero carbon technology progress such as renewable energy utilization technology, nuclear power generation technology, etc. Fossil fuel use could be reduced because of the increase in renewable energy and nuclear energy production, when the cost of such technologies decrease as a

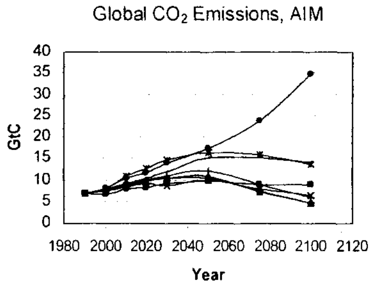
Table 2. Policy option package for stabilization at 550 ppmv (cont.)

Policy options	B1	B2
Transport efficiency improvement	Vehicle fuel-use efficiency improvement rate will be 0.1% higher than baseline case for all regions, starting from 2000.	Vehicle fuel-use efficiency improvement rate will be 0.1% higher than baseline case for all regions, starting from 2000.
Other end-use technology efficiency improvement	0.1% higher efficiency improvement	0.15% higher efficiency improvement
Power generation efficiency	0.1% higher efficiency improvement	0.1% higher efficiency improvement
Social efficiency improvement	0.1% higher energy efficiency improvement, starting from 2000; additional 0.1% higher energy efficiency improvement in developing countries from 2030 to 2075 (efficiency improvement rate will be 0.1% higher in 2000, 0.2% higher from 2030 to 2075, then 0.1% higher in 2100 in developing countries).	0.2% higher energy efficiency improvement, starting from 2000; additional 0.2% higher energy efficiency improvement in developing countries from 2030 to 2070.
Carbon tax	US$15/tC Annex 1 countries will start from 2000, non-Annex 1 countries will start from 2030.	US$60/tC Annex 1 countries will start from 2000, non-Annex 1 countries will start from 2030.
Nuclear incentive	0.1% higher marginal production cost improvement rate	0.2% higher marginal production cost improvement rate
Natural gas incentive		0.2% higher marginal production cost improvement rate
Syn-oil	0.1% higher marginal production cost improvement rate	0.15% higher marginal production cost improvement rate
Syn-gas	0.1% higher marginal production cost improvement rate	0.16% higher marginal production cost improvement rate
Biomass incentive	0.1% higher marginal production cost improvement rate	0.2% higher marginal production cost improvement rate
Solar energy		0.1% higher marginal production cost improvement rate

result of large demand for them. End-use technology efficiency improvement is also a key countermeasure for CO_2 abatement. The results show that in the A2 world, early GHG emission reduction is also essential. In the B1 baseline scenario, there is relatively small pressure for CO_2 emission reduction to reach the

Table 3. Policy option package for A1B 450ppmv and 650ppmv mitigation scenarios

Policy options		
	450	650
Transport efficiency improvement	Vehicle fuel-use efficiency improvement rate will be 0.14% higher than baseline case for all regions, starting from 2000.	Vehicle fuel-use efficiency improvement rate will be 0.1% higher than baseline case for all regions, starting from 2000.
Power generation efficiency	0.13% higher efficiency improvement	0.1% higher efficiency improvement
Social efficiency improvement	0.4% higher energy efficiency improvement, another 0.2% higher energy efficiency improvement in developing countries from 2030 to 2050.	0.2% higher energy efficiency improvement, another 0.1% higher energy efficiency improvement in developing countries from 2030 to 2075.
Carbon tax	US$100/tC	US$20/tC Annex 1 countries will start from 2000, non-Annex 1 countries will start from 2030.
Nuclear incentive	0.2% higher marginal production cost improvement rate	
Syn-oil	0.1% higher marginal production cost improvement rate	0.1% higher marginal production cost improvement rate
Syn-gas	0.1% higher marginal production cost improvement rate	0.1% higher marginal production cost improvement rate
Biomass incentive	0.3% higher marginal production cost improvement rate	0.1% higher marginal production cost improvement rate



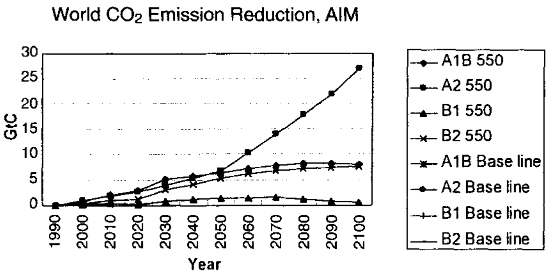
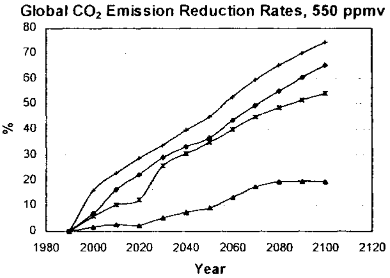


Fig. 2. Global CO_2 emissions
Fig. 3. Global CO_2 emission reductions for 550ppmv scenarios



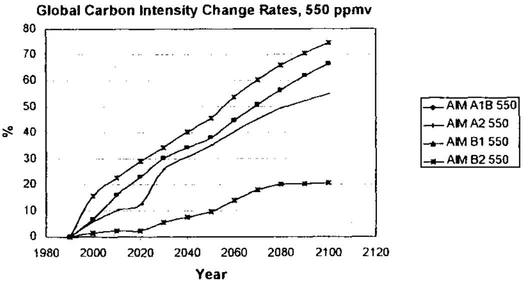
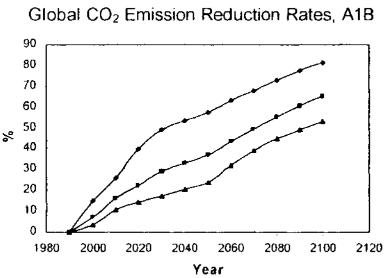


Fig. 4. Global CO_2 emission reduction rates for 550 ppmv scenarios
Fig. 5. Global carbon intensity change rates for 550 ppmv scenarios



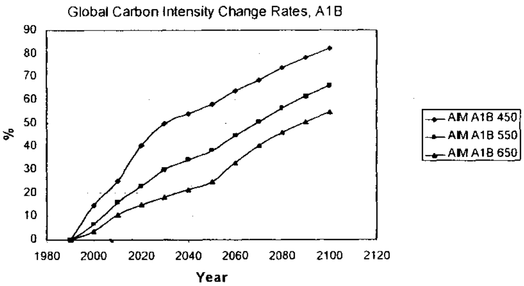
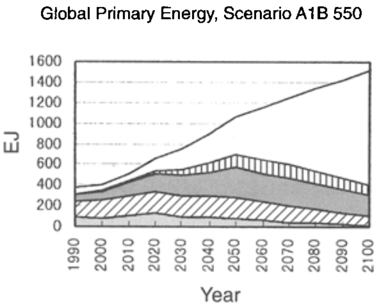


Fig. 6. Global CO_2 emission reduction rates for A1B family
Fig. 7. Global carbon intensity change rates for A1B family



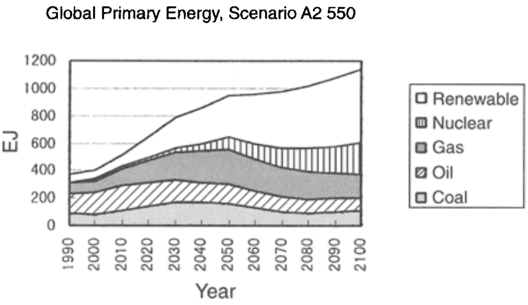


Fig. 8. Global primary energy for A1B 550 scenarios
Fig. 9. Global primary energy for A2 550 scenarios

550 ppmv stabilization level, so that the target could be reached by price incentive policies such as a carbon tax. In the B2 baseline scenario, progress in both energy end-use technology and energy supply technology is emphasized.

Technology progress is thus a key issue for CO_2 emission abatement in the AIM mitigation emission scenarios. This is because these scenarios embrace

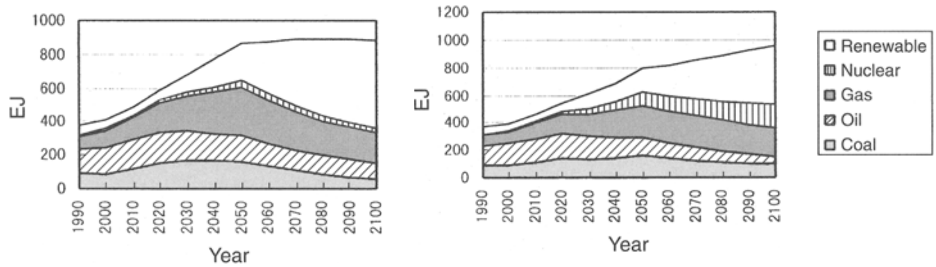


Fig. 10. Global primary energy for B1 550 scenarios
Fig. 11. Global primary energy for B2 550 scenarios

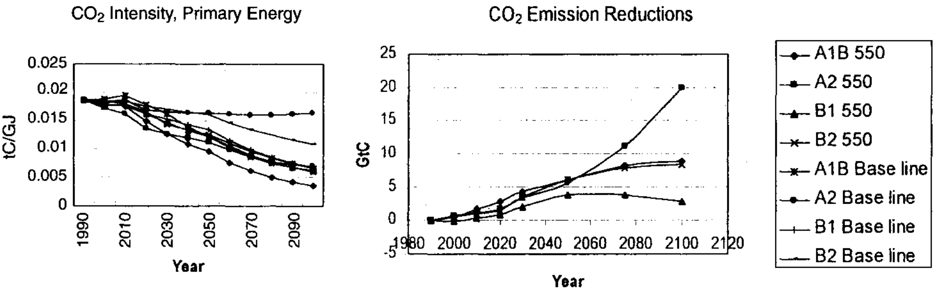


Fig. 12. Carbon energy intensity changes
Fig. 13. CO_2 emission reductions for robust policy

the perspective of induced technical change; i.e., an additional environmental constraint accelerates the rates of technological change already implicit in the scenario baseline.

Examining the policies used for emission reduction in this study, it is seen that some of them are not necessarily adopted in response to climate change, especially in developing countries. For example, technology efficiency improvements in both energy production and energy end use, social efficiency changes, and low carbon technology incentives (nuclear and renewable energy, etc.) are widely adopted in the pursuit of sustainable development, as has been the case in China.

As a result, primary energy will decrease with energy efficiency improvement and the introduction of energy price incentive policies, and the primary energy mix will tend to shift to low carbon energy sources such as natural gas, renewable energy, nuclear energy, etc. (see Figs. 8 to 11).

Cost analyses were simulated by the AIM-Linkage model. Table 4 shows the GDP loss for each mitigation scenario and different target level in 2050 and 2100.

Table 4. GDP loss for each scenario at different target levels

	2050	2100
A1B-550	1.0%	2.0%
A1B-650	0.6%	1.0%
A1B-450	3.2%	5.9%
A2-550	1.3%	3.2%
B1-550	0.3%	0.1%
B2-550	0.9%	1.2%

The results reveal that the GDP loss ranges from 0.1% to 5.9% across the scenarios. Obviously the costs rely on the target level and baseline emission trajectory. The largest loss occurs in the A1B-450 scenario, at 5.9%.

Applying the designed robust policies to different scenarios results in different CO_2 emissions (see Fig. 13). Some commonly used policies in the AIM mitigation scenarios could be recommended as essential countermeasures in response to climate change, while they also have benefits unrelated to the climate change concept. Policies such as technology progress in both end use and energy supply, social efficiency improvement, renewable energy incentives and carbon tax can be regarded as robust policies.

6 Conclusion

A set of mitigation scenarios was simulated by the AIM-Linkage model based on the nonintervention emission scenarios. Following the discussion and comparison given above, several key conclusions have been obtained from the results of our modeling as follows:

1. The targeted stabilization levels could be reached through the adoption of various policies. All the mitigation scenarios from AIM show a trend toward various stabilization level.
2. Wide-ranging policy packages are needed, rather than a single policy, in order to mitigate the difficulty of responding to climate change.
3. In the A1 and A2 world views as well as for 450 ppmv stabilization, early GHG reduction is essential to avoid serious pressure on social development and technological progress in the second half of the 21^{st} century.
4. Integration between global climate policies and domestic environment policies could effectively reduce GHG in developing regions for next two or three decades.
5. Technology progress and lower energy consumption play a very important role in stabilization.

6. Knowledge transfer to developing countries is a key issue that should be emphasized to motivate developing countries' participation in early CO_2 emission reduction.
7. Technology efficiency improvement for both energy use technology and energy supply technology, social efficiency improvement, renewable energy incentives and the introduction of energy price incentives such as a carbon tax can be regarded as robust policies.
8. Robust technology/policy measures are efficiency improvements in end-use technologies and social systems as well as the introduction of renewable energy.

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