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Independent Administrative Institution
National Institute for Environmental Studies

TECHNICAL SUMMARY

IEA

Integrated Environmental Assessment

Asia **P**acific **E**nvironmental **I**nnovation **S**trategy project

APEIS

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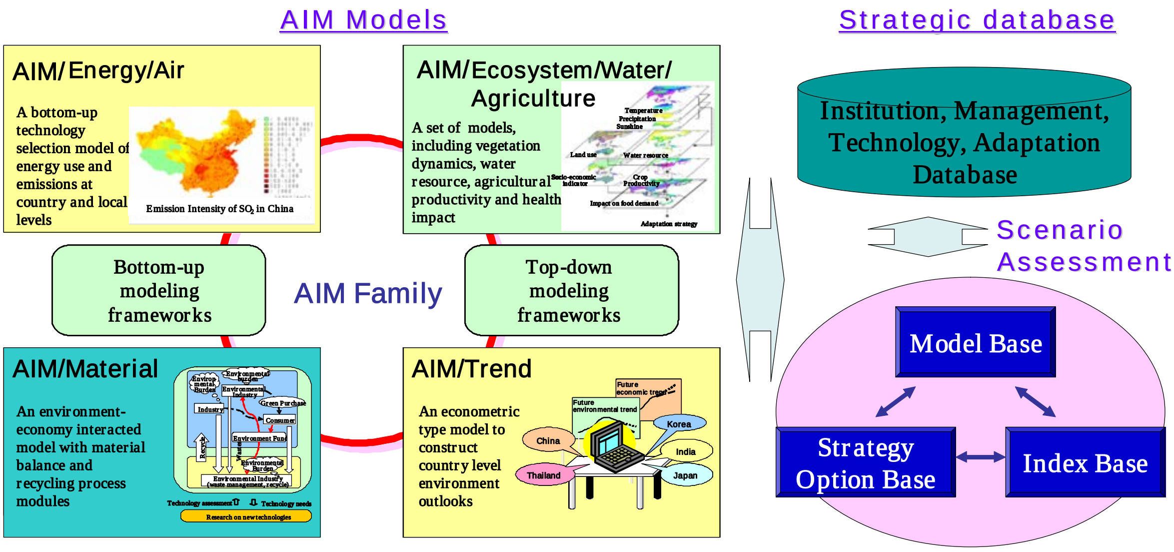
APEIS-IEA Technical Summary

1. What is APEIS-IEA?

The Integrated Environmental Assessment (IEA) sub-project of APEIS has the following objectives:

- Development of IEA tools. IEA tools comprise several models and a strategic database (SDB) developed for the purpose of assessing innovative options for managing environmental problems.
- Diffusion of IEA tools to selected Asia-Pacific countries. IEA tools are passed to researchers and policy makers in selected Asia-Pacific countries, such as China, India, Thailand and Korea, via research collaborations and capacity-building workshops.
- Development of quantitative innovation scenarios. IEA tools are used to develop short- and long-term quantified scenarios in various Asia-Pacific countries and regions for the purpose of assessing environmental innovation options.

A set of IEA tools has been developed to enable comprehensive analyses of environmental problems in the Asia-Pacific region. The tools include (i) the SDB, (ii) the AIM/Material model, (iii) the AIM/Energy and AIM/Air models, (iv) the AIM/Trend model, and (v) the AIM/Ecosystem, AIM/Water and AIM/Agriculture models. Figure 1 shows the connections between these tools. They have distinct utilities and are used in particular combinations depending on the specific environmental issues being assessed and their spatial scope.



Key Messages:

- Environmental stress is substantial in the absence of innovative strategies
- Innovations in technologies, institutions, and management systems are critical to resolving conflict between environment and development
- Environmental actions need mainstreaming within development decisions

Figure 1. IEA Tools: AIM Models and SDB

The SDB is used to store data relating to innovative options for technological, institutional, and behavioral systems in various sectors of a particular country or region. It is also used to assess the potential of such options for reducing emissions or mitigating other environmental problems. AIM/Material is a top-down model of economy–environment–energy linkages. It is used for analyzing macro-economic effects of environmental interventions and impacts of economy-wide policies on the environment. It can effectively assess environmental investments and recycling. AIM/Energy is a bottom-up optimization model of technology–energy–environment systems. It is used for assessing emission mitigation and technology options. AIM/Trend is an econometric model that simulates relationships between emissions and socio-economic indicators. It is used to project future socio-economic and environmental trends. The set of AIM/Ecosystem, AIM/Water and AIM/Agriculture models is used to assess impacts on water, agriculture, vegetation, and health. AIM/Air, a model for simulating air pollutant distribution within a city, takes emission forecasts from AIM/Energy as input. It is used together with AIM/Water to assess health impacts. Table 1 summarizes the characteristics and scope of IEA tools.

Table 1. Characteristics and scope of IEA tools

IEA Tool	Characteristics	Scope
SDB	Innovative options database	Innovative technology, institutional and management options
AIM/Trend	Econometric projection model	Socio-economic framework
AIM/Material	Combination of national economic model and material balance model	Macro-economy, environmental investments and material recycling
AIM/Water	Process-type water use and supply model	Water
AIM/Energy	Bottom-up-type energy-emission model	Energy
AIM/Air, AIM/Water	Process-type models	Health
AIM/Agriculture	Process-type crop productivity model	Agriculture
AIM/Ecosystem	Combination of process-type eco-service model and national-scale economic model	Biodiversity

The motivation behind the IEA sub-project is to assess the potential for innovative strategies to resolve pressing environmental problems and simultaneously circumvent the trade-offs between economic development and environmental improvement. Conventional approaches assume rigid trade-offs, as shown in the left panel of Figure 2. These approaches are based on the belief that any action toward environmental improvement has a cost to the economy, and conversely, strategies toward economic development will necessarily affect the environment adversely. The alternative approach, however, begins by looking at innovative strategic options that can overcome the trade-offs and result in win–win solutions for both the environment and the economy. It is rooted in the proposition that innovative strategies, by definition, push the frontiers of technological, institutional or behavioral systems, and enable the crossover to a superior economy–environment relationship. Thus, they offer improvement in both dimensions simultaneously.

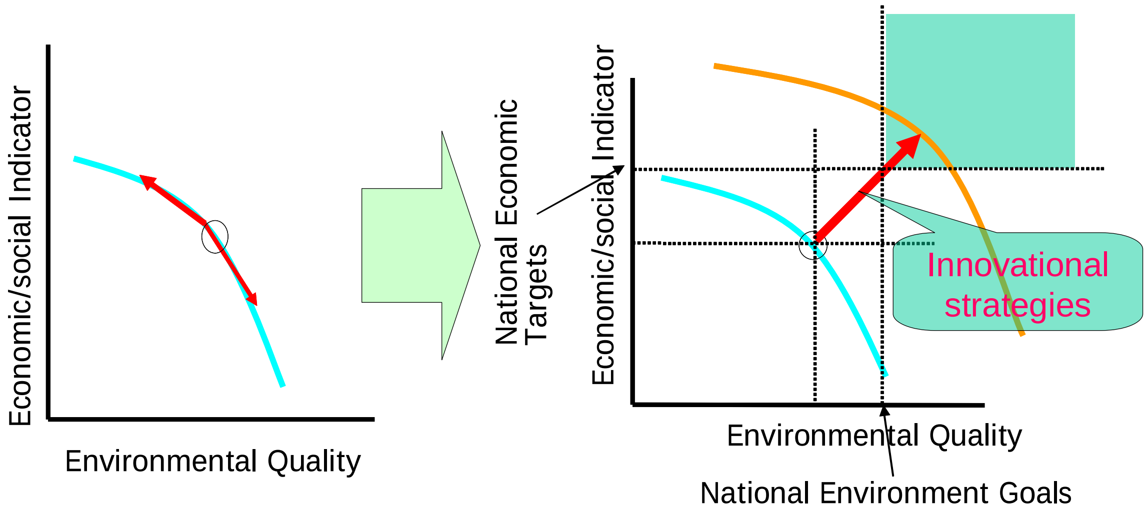


Figure 2. Circumventing economy–environment trade-off with innovative strategies

The IEA sub-project identifies and analyses such innovative options to manage local, regional, and global environmental problems. Problems relating to climate change, local air pollution, waste, water, health, and other issues have been analyzed. Such problems are complex by virtue of having multiple interlinkages among themselves as well as with the larger economic, institutional, societal, and technological systems. They also have a temporal dimension that makes them dynamic and gives them several uncertainties. The combinations of IEA tools have proved effective in dealing with such complexities.

2. What has APEIS-IEA achieved?

2.1 Enhancement and application of IEA tools

The SDB has been enhanced as a tool to comprehensively assess environmental innovations. It is now an advanced interactive tool that (i) stores an extensive database of country-level inventories of existing and new innovative countermeasures in technological, social, institutional, and management systems, and (ii) assesses the cost and environmental effectiveness of specific innovations. It provides a framework that allows policy makers and other stakeholders to conveniently build scenarios and evaluate options.

The SDB involves the setting up of an innovational countermeasures database and a country-specific database in continuous collaboration with stakeholders such as policy makers and research institutions. Development of the SDB is an iterative process that involves identification of innovative options; simulation, assessment, and design of environmental innovation strategies; development of quantitative countermeasure scenarios; and revision of the set of innovative options for assessment (Figure 3).

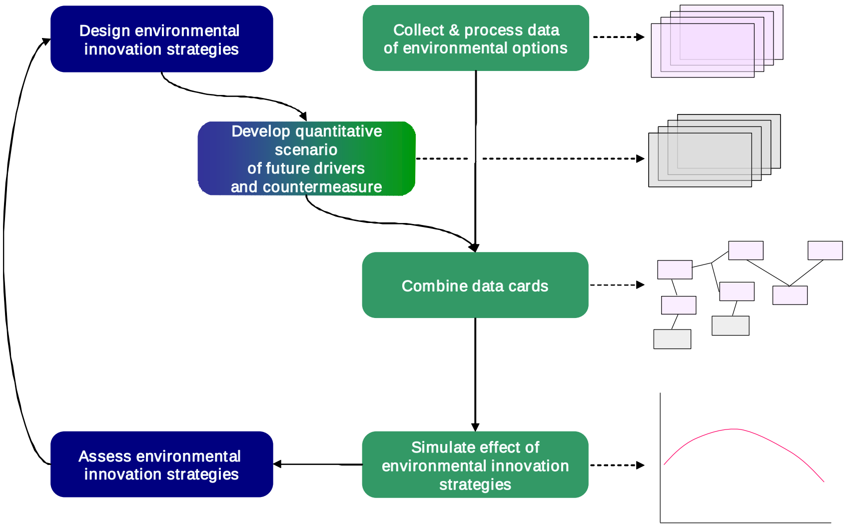


Figure 3. Process of development of the SDB

Figure 4 shows the SDB flow diagram developed for the transportation sector. Several options in the realms of technology, institutions, and management have been identified. These options have been quantified and used for environmental assessment. The SDB has also been used in a complementary relationship with the AIM/Material model to enable more integrative assessments. The development and use of the Water Management Model, explained in Section 2.3, is such an example.

The bottom-up modeling framework of IEA has been enriched by the development of AIM/Air, which takes emissions forecasts from the AIM/Energy model as input and simulates the extremely disaggregated distribution of air pollutants within a city. For instance, it can estimate the impact of road traffic on air quality through a mathematical simulation using a GIS framework that considers disaggregated factors such as land use and distribution of traffic on roads.

Specific combinations of IEA tools have been used for integrated studies of various issues of environment, energy, health, and sustainability in selected Asia-Pacific countries, as summarized in Table 2. The following sections discuss some of these applications and their results.

Table 2. Issues addressed using IEA tools

Issues Considered	IEA Tools	Examples
Integration of millennium development goals, global environmental problems, and sustainability	AIM/Material AIM/Energy AIM/Agriculture	India's assessment of innovative options for meeting both millennium development goals and climate change objectives
MDG, water, and sanitation	AIM/Water AIM/Material SDB	Asia-Pacific countries' water and sanitation developments and national health improvements
Renewable energy, rural electrification, and municipal solid waste management	AIM/Energy AIM/Trend SDB	Thailand's and Korea's environmentally sound energy innovations
City air pollution management	AIM/Air	Beijing city air management

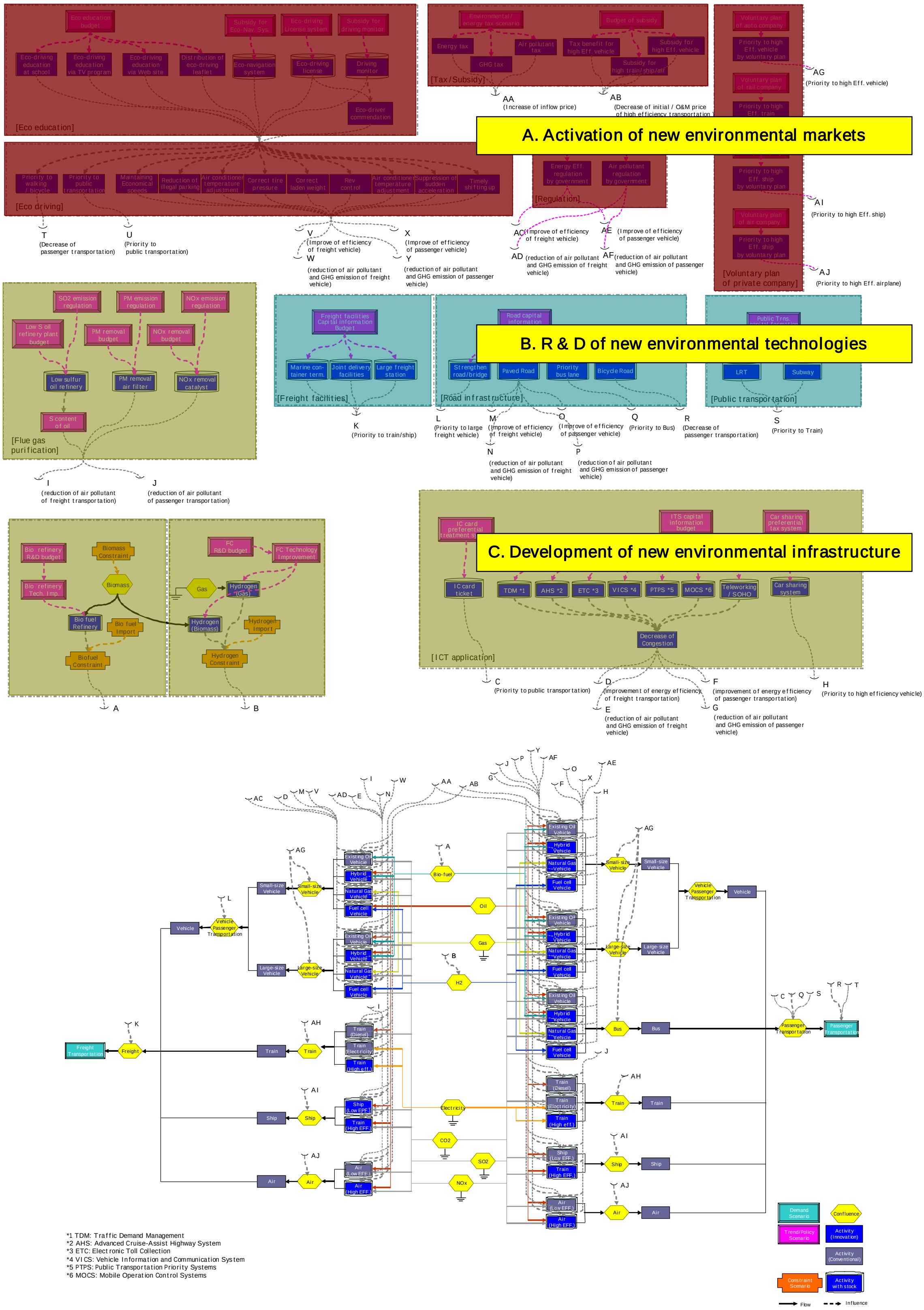


Figure 4. SDB flow diagram for the transportation sector

2.2 Assessment of innovative options for meeting both millennium development goals and climate change objectives

Millennium development goals (MDGs) comprise eight socio-economic developmental goals which all 191 United Nations member states have pledged to meet by the year 2015. United Nations Development Programme (UNDP) links and coordinates global and national efforts to reach these goals. It helps countries integrate the MDGs into their national development frameworks. Global and national MDGs have direct implications for the environment and climate change, since they involve changes in the drivers of socio-economic development and sustainability. Table 3 illustrates these relationships for India. IEA tools are being used to carry out analyses of such interactions to assess the impacts of MDGs on the environment and, conversely, the potential for meeting MDGs under various scenarios.

Table 3. Illustration of linkages among MDGs, India's national targets, and climate change

MDGs and global targets	India's national plan targets	Interface with climate change
Goal 1: Eradicate extreme poverty and hunger Targets: Halve, between 1990 and 2015, the proportion of people with income below $1 a day and those who suffer from hunger.	Double the per capita income by 2012. Reduce the proportion of people with income below $1 a day by 15% by 2012. Contain total population growth between 2001 and 2011 to 16.2%.	Income effect would enhance choices for cleaner fuels and adaptive capacity. GHG emissions would be reduced due to lower population.
Goal 7: Ensure environmental sustainability Targets: Integrate sustainable development principles in country policies and programs to reverse loss of environmental resources. Target: Halve by 2015 the proportion of people without sustainable access to safe drinking water.	Increase forest cover to 25% by 2007 and 33% by 2012 (from 23% in 2001). Enable sustained access to potable drinking water to all villages by 2007. Electrify 80,000 additional villages by 2012 via decentralized sources. Clean all major polluted rivers by 2007 and other notified stretches by 2012.	Enhanced sink capacity; reduced GHG and local emissions; reduced fossil fuel imports; reduced pressure on land, resources, and ecosystems. Higher adaptive capacity from enhanced supply of water, health, and education in rural areas.

Figure 5 illustrates such an analysis at global and country (India) scales. Global emissions scenarios developed for the purpose of climate change analysis are used as references in analyzing the potential for meeting global MDGs. For instance, the IPCC's A2 scenario will not leave reasonable scope for meeting the MDG of the number of people suffering from hunger in 2012. This target can be met under the B2 scenario, but only with additional economic support for hunger alleviation programs. Different emissions scenarios, translated for India, signify different trajectories for water consumption and other parameters critical for MDG. Since different emissions scenarios correspond to different socio-economic developmental pathways, this implies that the future development path of a country determines the scope and effort required for meeting MDGs and environmental and climate targets. Thus, environmental improvement actions need to be integrated within the development decisions of various countries. Elements of innovative strategies, such as financial budgeting or investment plans, must be designed for multiple dividends to development and the environment.

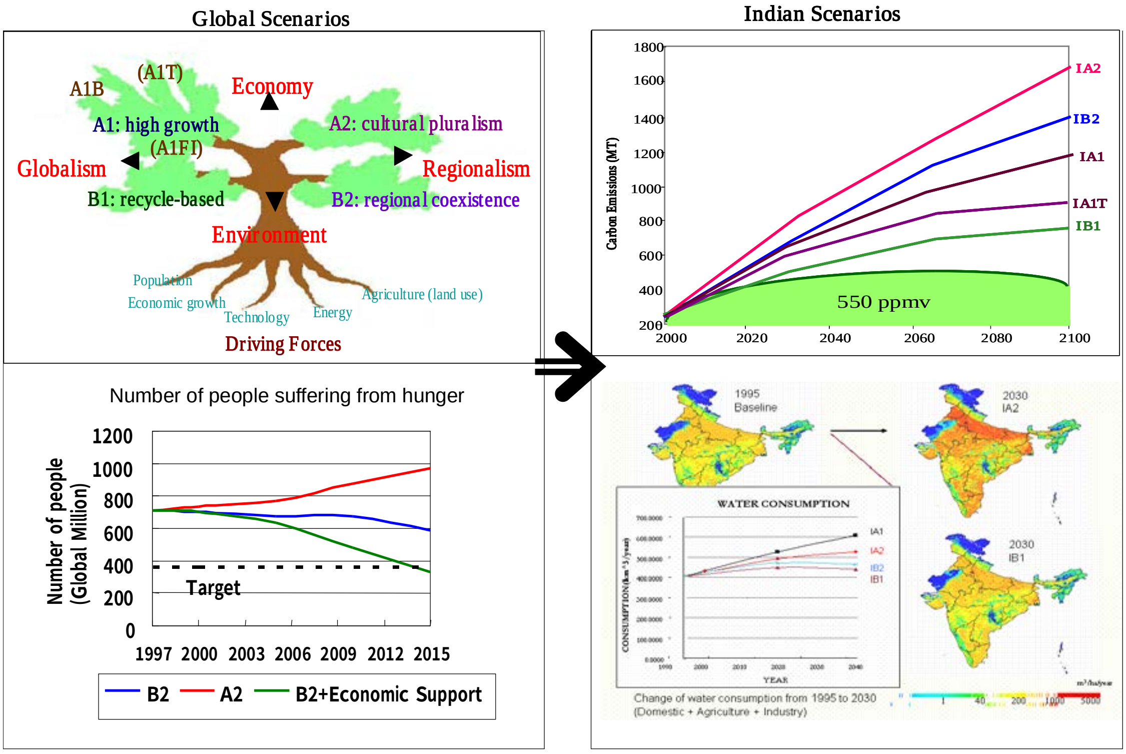


Figure 5. Linking global scenarios, Indian scenarios, and MDGs

2.3 Water management model linking the SDB and AIM/Material

The water management model has been developed within a framework that externally links the SDB and the AIM/Material model (Figure 6). Salient features of this framework are as follows:

- Water demand is estimated in the SDB on the basis of water supply and sanitation conditions
- Services with a safe piped water supply are distinguished from those without a safe water supply
- Services with sanitation are distinguished from those without sanitation
- Unaccounted for water and efficiency of water management are distinguished from actual water use by households and commercial users served by piped water
- A decision to install facilities for improved water supply and sanitation is linked to investment by government and households in the AIM/Material model
- Dynamics of inter-temporal decisions, such as investments, are considered
- Urban and rural areas are treated separately
- Potential health impacts and impacts on costs of strategies to increase water supply, improve sanitation, reduce unaccounted for water, and improve water management efficiency can be estimated using the SDB

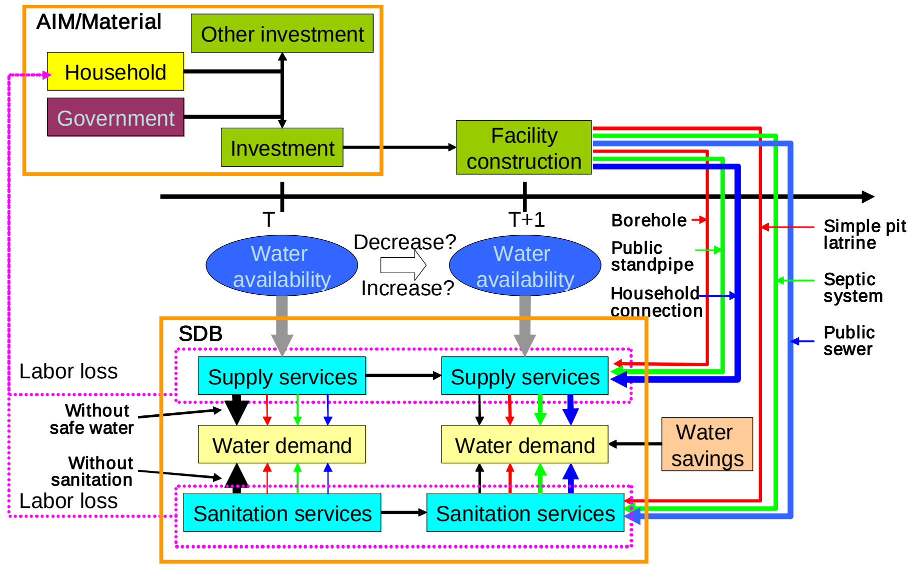


Figure 6. Water management model linking the SDB and AIM/Material

The water management model has been applied to India, China, and Thailand. Figures 7 and 8 show some of the results. For all three countries, the greatest decline in the relative risk of diarrhea mortality over the 2000–2025 period will come when all households are supplied with safe piped water and have a centralized sewer connection (Case 2). However, the increase in the annual cost of supplying water and sanitation is the highest in this case. For Case 3, where water is supplied to new households by cheap options such as wells, ponds, or boreholes, and cheap sanitation options are provided, such as ventilated improved pits (VIP) or simple pit latrines, annual costs will be lower but the risk of diarrhea mortality will decline less than in Case 1, where there is no change in the technology mix of water supply and sanitation systems. Thailand is not expected to witness any decline in diarrhea mortality risk in Case 3. This is because its population is not likely to increase significantly from 2000 to 2025, and almost all of its existing households have septic tank systems for treating waste water that have a similar impact on diarrhea mortality as cheaper sanitation options (Figure 7).

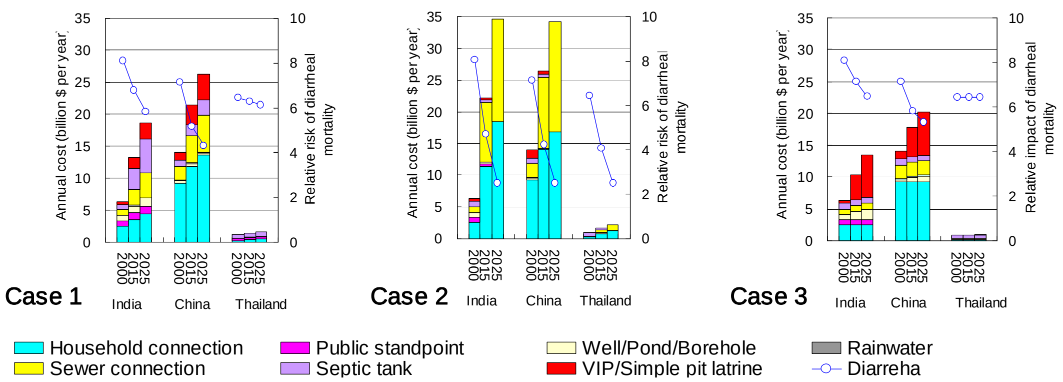


Figure 7. Annual cost of water supply and health risk in 2000, 2015, and 2025 in India, China, and Thailand under three scenarios

(Case 1: No change in technology mix. Case 2: Piped water and sewer connection to all households in 2025. Case 3: Provision of cheap water/sanitation technologies to new households from 2000 onwards.)

For India, the annual cost of providing a centralized connection of piped water to households is expected to decline more by improvement to the efficiency of water supply management than by reduction of unaccounted for water. However, it is the other way round for Thailand. This is because the existing manpower cost of supplying 1 m^3 of piped water and the existing proportion of unaccounted for water are both very high in India, whereas in Thailand, the former is very low and the latter is high. For the same reason, the reduction in annual volume of piped water is expected to be higher in India than in Thailand in scenarios where unaccounted for water is reduced. China is expected to witness a very low decline in both annual cost of connected systems and annual volume of piped water supply because of its existing low unit cost of piped water supply and low proportion of unaccounted for water (Figure 8).

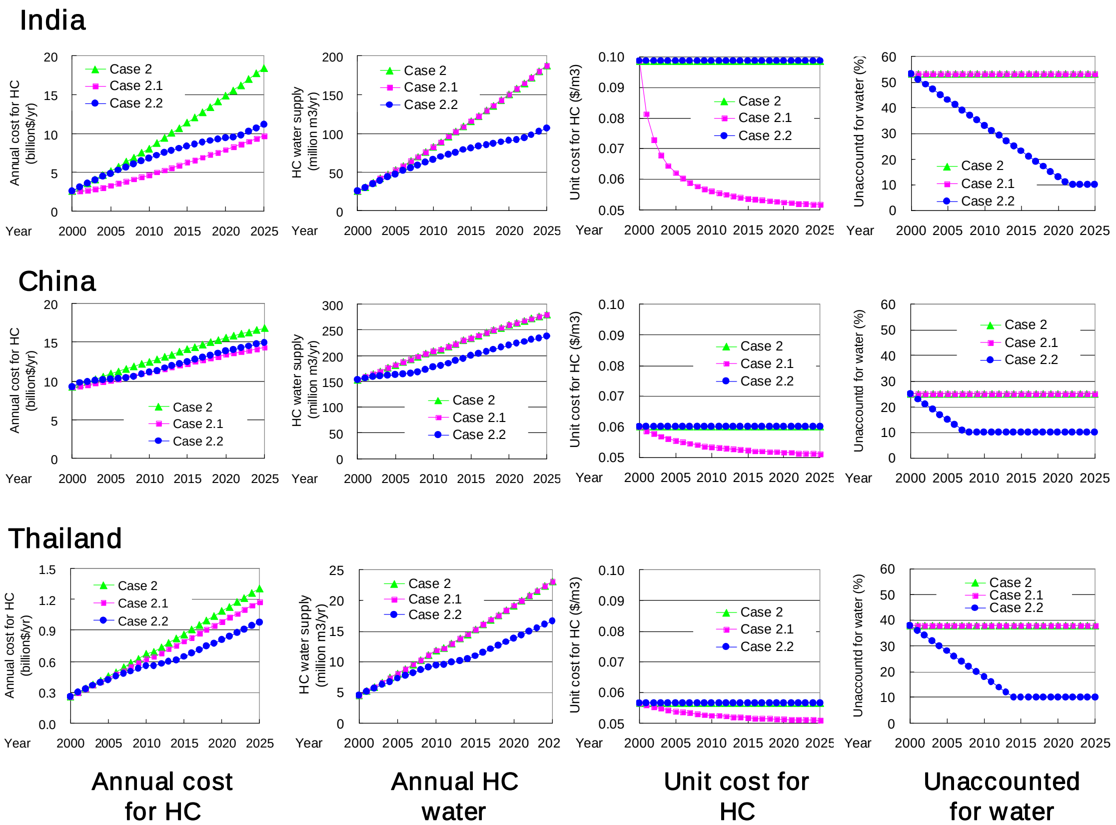


Figure 8. Comparison of three water management scenarios in India, China, and Thailand
(Case 2: Same as Case 2 in Fig. 7. Case 2.1: Improved water supply efficiency over Case 2 as measured by an increase in manpower productivity of 5% per year. Case 2.2: Reduction in unaccounted for water of 3% per year over Case 2 due to improved management, up to a minimum limit of 10% of total water supply. HC: Household connection of centralized piped water and sewer system.)

2.4 Use of the SDB to assess innovative options in Thailand and Korea

The SDB has been used extensively to assess multiple innovation options in the transportation, residential, and commercial sectors of Thailand and Korea. Figure 9 illustrates the concepts of innovations considered in various sectors, and the interlinkages among them, for urban Thailand. The SDB was used to analyze the biofuel program in Thailand, covering bio-diesel and gasohol options (Figure 10). It was found that bio-diesel is competitive in road transport but not in water transport in Thailand. Gasohol is not competitive at current production costs. At existing costs, the biofuel program in Thailand has the potential for reducing CO_2

emissions by 1.6 Mt and SO_2 by 1.9 kt in 2011. With additional policy and institutional support, its impact could be significant.

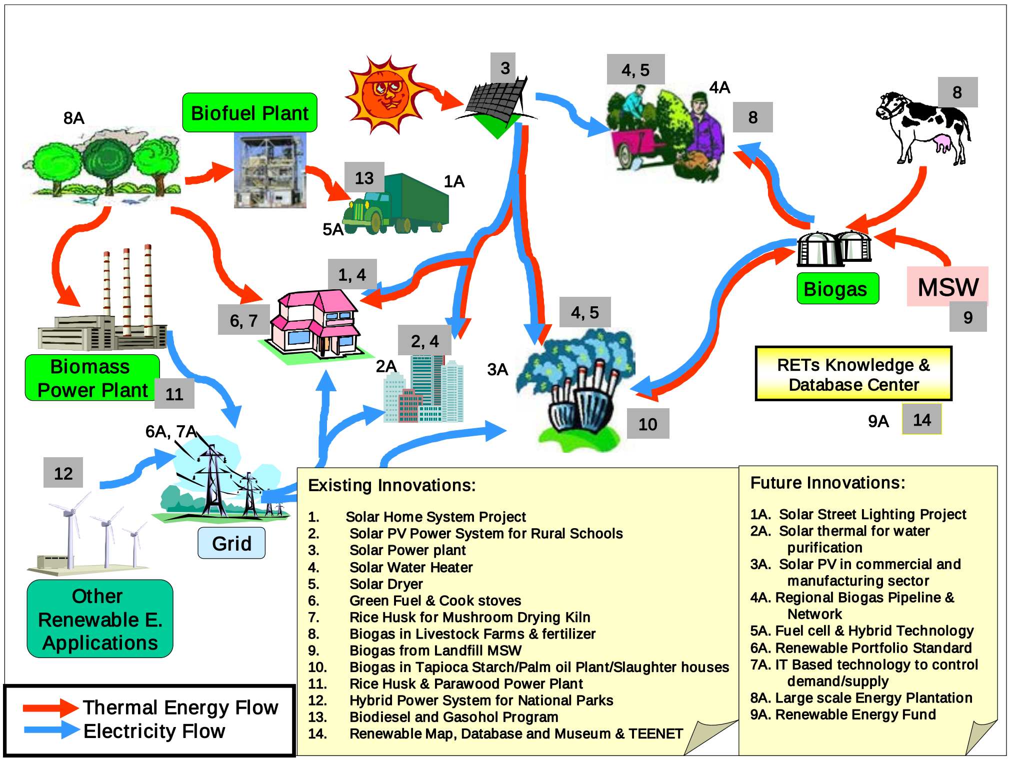


Figure 9. Existing and future innovations assessed in SDB for Thailand

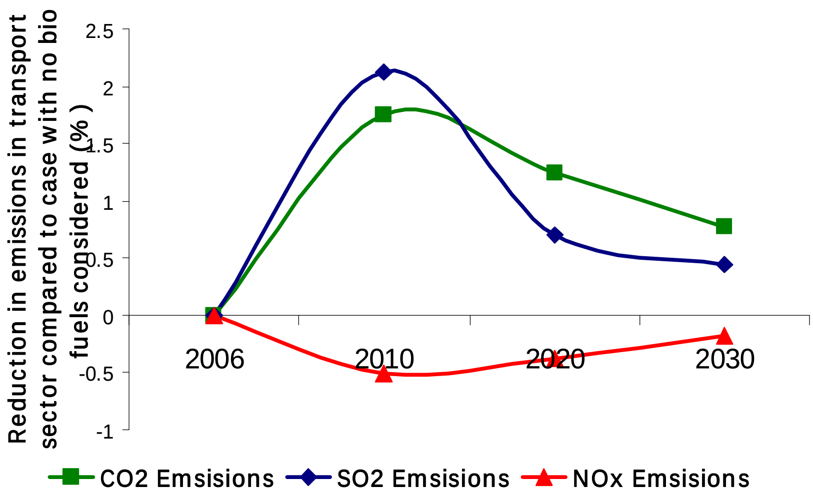


Figure 10. Assessment of the Thai biofuel program with the SDB

Several innovations have been analyzed using the SDB for the residential and transport sectors of Korea. Figure 11 shows the SDB card and result of a scenario where green roofs are installed on 30% of Korean houses. Green roof is a light weight roof garden system involving layers of volcanic stone mulching, artificial lighting soil, filtration non-woven fabric, drain insulating bricks, PVC water proof sheet, slope control EPS panel and insulating board. The green roof technology saves about 9.8% of the energy requirement of a house. This scenario is expected to result in an approximately 2.5% reduction in energy consumption in Korea.

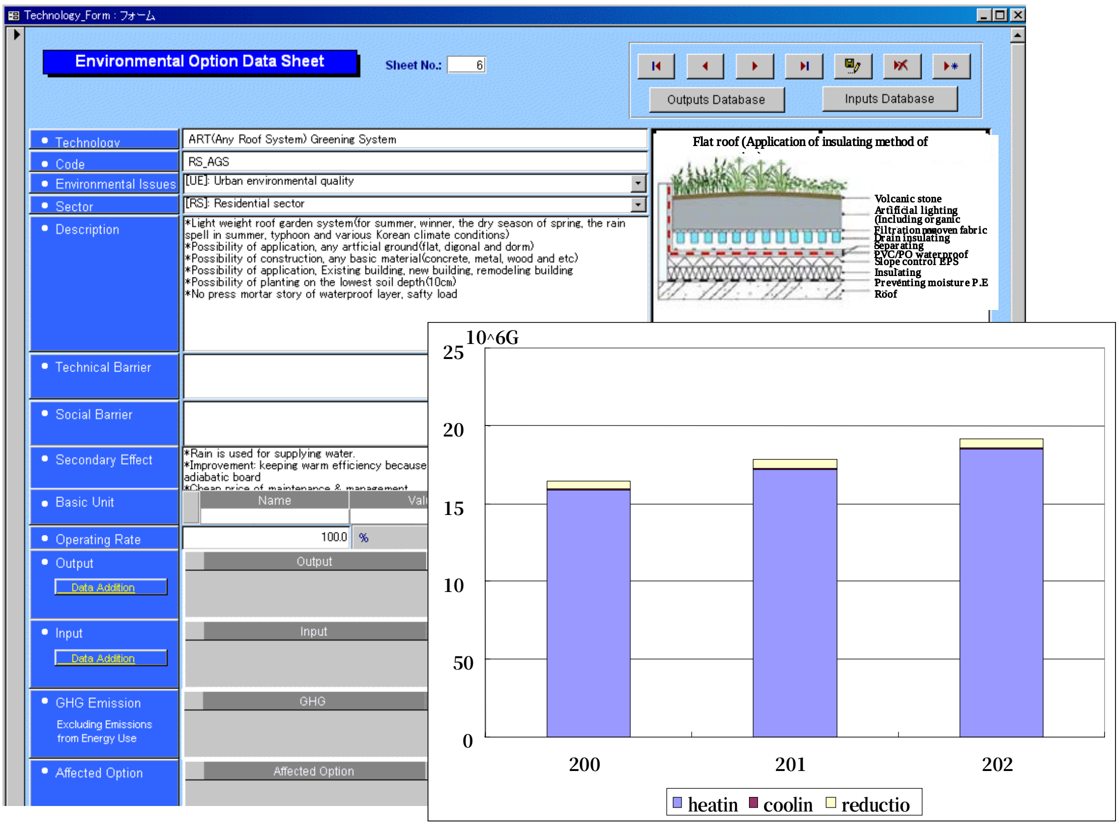


Figure 11. Assessment of a green roof scenario in Korea with the SDB

2.5 Application of AIM/Air to China

The AIM/Air model has been used to simulate air pollution from various sources in Beijing. Figure 12 shows the distribution of PM concentration estimated from the distribution of traffic volume in a winter night. Significant seasonal variation was observed in the concentrations of SO_2 and NO_x, with very high concentrations occurring in winter. On 63 days in a year, the SO_2 concentration in Beijing was above the 24-hour standard of 0.15 mg/m^3 for residential areas, and on 35 days it was above the standard of 0.25 mg/m^3 for industrial areas. The NO_x concentration crossed the residential area standard of 0.10 mg/m^3 on 64 days, and the industrial area standard of 0.15 mg/m^3 on 11 days. Although the commercial and power sectors were the main contributors of SO_2, the power sector alone was primarily responsible for most of the NO_x emissions (Figure 13).

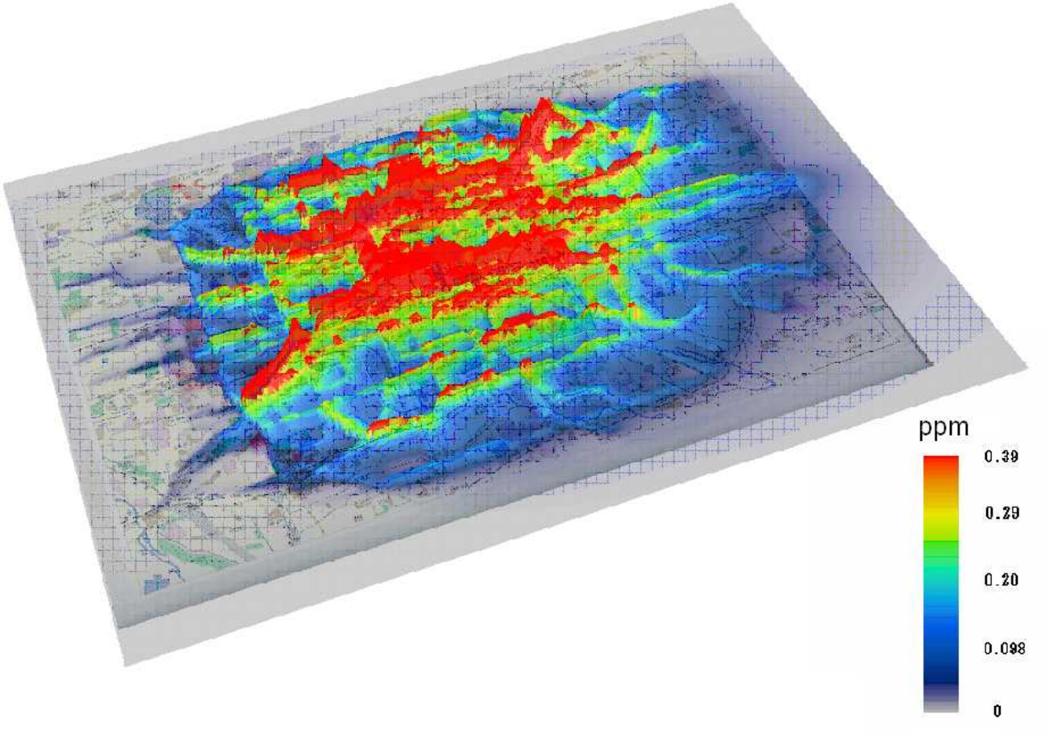


Figure 12. Simulation of PM concentration caused by traffic emission in Beijing in a winter night

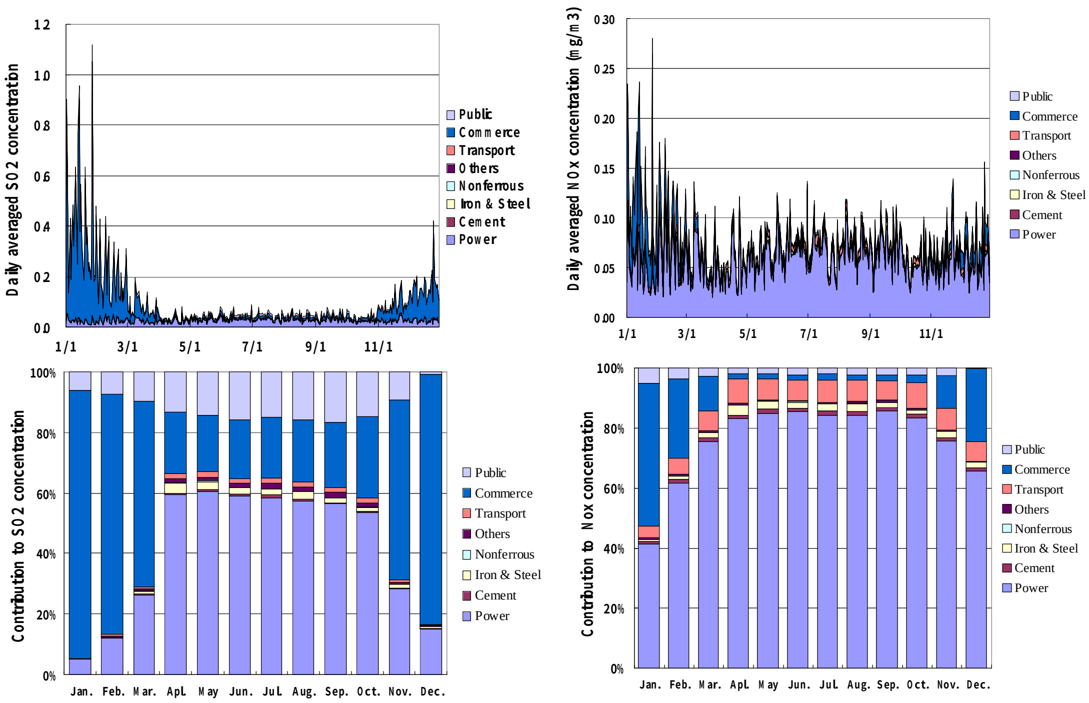


Figure 13. Seasonal variations in SO_2 and NO_x concentrations in Beijing

2.6 Capacity-building initiatives by the IEA sub-project in selected Asian countries

A capacity-building workshop was held in November 2004 to train researchers from China, India, and Thailand in the use of the AIM/Material model for environmental policy analysis at the country level. After the workshop, a team from each country carried out analysis using the model and presented its results. Figure 14 shows a result from the application of the AIM/Material model to China. Four scenarios to assess the impacts of SO_2 policies were developed — business as usual with no special SO_2 policy (BAU), investment and sulfur tax imposition (INV), investment and emission cap imposition (INV+CAP), and enhanced investment and emission cap imposition (EINV+CAP). For the majority of economic sectors, the minimum decline in output is expected to occur under the last scenario involving enhanced investment and a cap on SO_2 emissions. SO_2 emissions are expected to decline more under the last two scenarios (i.e., the ones involving investment together with an emission cap) than under the scenario with investment and sulfur tax. This shows that an innovative policy involving a combination of regulations imposing a limit on emissions together with enhanced supply-side investments in various sectors can achieve the dual objectives of mitigating emissions and economic costs.

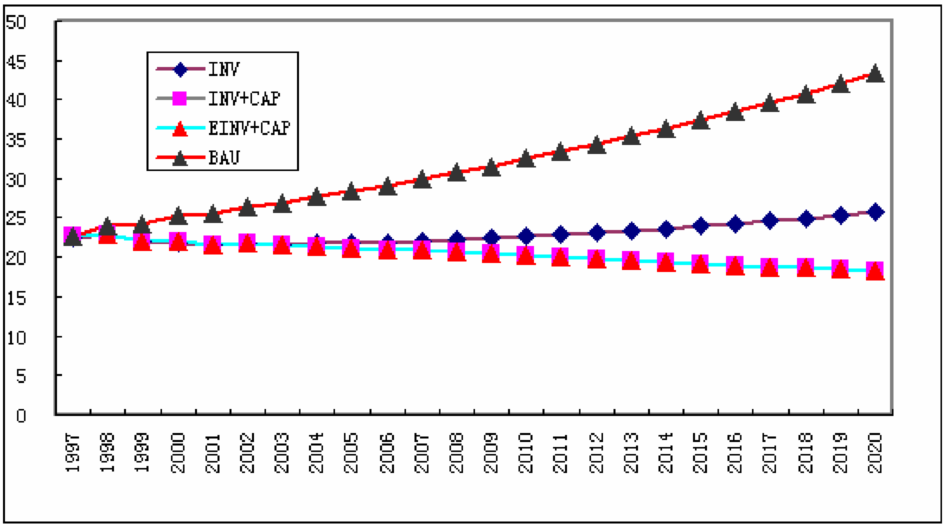


Figure 14. Assessment of SO_2 policies in China using AIM/Material

3. Application of APEIS-IEA activities

3.1 How can the APEIS-IEA products be used for policy formulation / implementation work?

APEIS-IEA tools have been directly used for providing input to policy analysis and implementation in selected Asia-Pacific countries. For instance, the use of IEA tools to analyze Beijing's air pollution contributed to the National Report on Climate Change in China. Local air pollution analyses carried out by IEA collaborating teams in India and Thailand have also been providing inputs to their national policy forums.

Another key area in which IEA tools have contributed to policy is the assessment of clean development mechanisms (CDM). CDM is one of the flexibility mechanisms of Kyoto Protocol that allows emission trading reduction projects creating sustainable development in developing countries to generate certified emission reductions for use by the investors. Analysis using IEA tools by collaborating teams in China, India, Thailand, and Korea has provided robust estimates of marginal costs of mitigation in various sectors in those countries. These estimates have been useful in deciding benchmarks for CDM projects.

3.2 What has APEIS contributed to the scientific community?

Each of the IEA tools is a new model developed to assess certain environmental issues and answer a specific set of policy questions. These tools have been designed to be used both independently and complementarily. Various combinations of these tools provide a comprehensive framework to assess multiple dimensions of environmental problems. Such dimensions could include technologies, institutions, policy instruments, regional scope, time horizon, GHG emissions and other environmental pollutants. For instance, the SDB and AIM/Material can be used together to design business-as-usual and intervention scenarios and assess their impacts on emissions of various gases, costs, macro-economic indicators such as changes in GDP and capital formation, health and other developmental indicators. The AIM/Energy and AIM/Material models can be used together to assess impacts of policy measures such as emission constraints, carbon taxes, or permit trading, on technology mix, fuel mix, and macro-economic indicators. Such analyses can be undertaken over short or long runs and at the level of city, country, or region.

The IEA models and database are especially suitable for application to developing countries where, on the one hand, collecting extensive and reliable data is difficult but, on the other hand, innovative options are expected to play an extremely critical role, since those countries are witnessing rapid socio-economic transitions. IEA tools are designed to facilitate estimation, storage, and use of relevant data for environmental assessment in such contexts. This characteristic is not adequately present in other existing models. This is one of the reasons why IEA tools are already being extensively used by researchers in major developing countries of the Asia-Pacific region, such as China, India, and Thailand, and are providing inputs to their policy discussions. IEA tools have helped in the scenario development processes in these countries.

3.3 Cooperation with international organizations

The APEIS-IEA sub-project has been actively contributing to several international projects, such as CAPaBLE, UNEP/SEFII, and UNEP/GEO3 & GEO4. APEIS-IEA tools are providing useful analyses in the CAPaBLE project for assessing mitigation options and sustainable development opportunities in developing countries. In the UNEP/SEFII Great Mekong project, IEA tools such as the SDB/Water Management Model and AIM/Air are proving useful for contributing to the database and for analysis of countermeasures for assessing regional environmental problems of water, air, waste, and forests. IEA tools have also contributed to the construction of future scenarios for emissions of CO_2, SO_2, and NO_x and generation of municipal solid waste in the UNEP/GEO3 project. Figure 15 shows the APEIS session in progress at the CAPaBLE Workshop at Asian Institute of Technology, Bangkok, in 2004, and the participants of the UNEP/SEFII Workshop held in Hanoi in 2005.

Figure 15. The APEIS session at the CAPaBLE Workshop (top), and participants at the UNEP/SEFII Workshop (bottom)

APEIS-IEA has been continuously collaborating with a network of organizations in the Asia-Pacific region in order to develop tools to suit the diverse social, institutional, and economic contexts of the region, and to carry out assessments useful to its policy making processes. The list of participating organizations and details on the Asia-Pacific Integrated Model can be accessed at http://www-iam.nies.go.jp/aim/.

Plan of APEIS-IEA Phase II

In APEIS phase II, the IEA sub-project aims to continue its work of enhancing tools and their application to environmental assessment in the Asia-Pacific region. New work on tool enhancement and application is expected to include:

(i) Building a comprehensive inventory of innovative institutional and management options in the SDB.
(ii) Development of country-specific innovation scenarios supported by the SDB.
(iii) Extension of AIM/Material and other AIM tools to assess land use, material stock balance, and options to achieve national environmental and developmental goals.
(iv) Enhancement of feedback linkages between the SDB and AIM/Material for more integrative assessment of environmental and national development goals.
(v) Development of feedback between the SDB and other IEA models in order to make the models more interactive and relevant for policy making processes in Asia-Pacific countries.
(vi) Extensive capacity building though use of IEA tools and making them accessible to researchers and policy makers in the Asia-Pacific countries.
(vii) Continuation of contribution to international activities such as UNEP/GEO4, IPCC, and UNEP/SEFII.

Figure 16 shows the proposed interlinkages among the SDB, AIM/Material, and other IEA models to be developed in APEIS phase II. The SDB engine will be developed to interface with other IEA models. For instance, service demand drivers for SDB will be provided directly by AIM/Material. AIM/Material will, in turn, take relevant data from other IEA tools, such as efficiency, emissions, and cost parameters from the SDB and the rate of technological improvement from AIM/Energy. The SDB engine will supply basic technology characteristics and estimates of technology shares to AIM/Energy for calculation of optimal investment trajectories in various sectors. Thus, the new interface enhancements will enable all IEA tools to be used together for a more integrative environmental assessment and scenario development for a country.

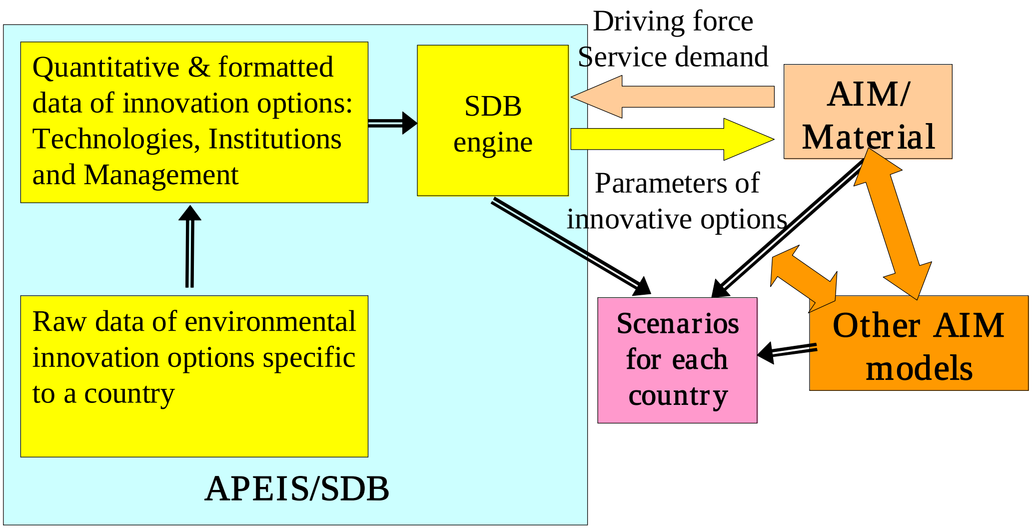


Figure 16. Proposed interlinkages between the SDB, AIM/Material model, and other IEA tools