Overview of AIM and model use for Cambodia

April 22nd, 2013

Reported by

Y. Matsuoka (Kyoto University)

IGES Institute for Global Environment 公益財団法人 地球環境戦略研究機関

AIM ASIA-PACIFIC INTEGRATED MODEL

KYOTO UNIVERSITY FOUNDED 1897

MIZUHO

A brief introduction of AIM

- AIM(Asian Pacific Integrated Models) is a group of computer models developed by a team composed of NIES(National Institute for Environmental Studies), Kyoto University, Japan, and several research institutes in the Asian-Pacific region.
- The objective of AIM is to design and assess policy options for stabilizing the global climate, particularly in the Asian-Pacific region.
- Internationally, AIM have been used as core tools for developing IPCC scenarios conducted by UN. Many members of AIM team have been deeply involved to IPCC process, as CLA or LAs.
- Also, the assessments conducted by AIM gave influential impacts on the real world processes;
  1) to determine national GHG reduction targets and support implementation process, in Japan,
  2) to assess national and regional reduction potential of GHG emissions in China, India, and several local regions in Asian countries.

Overview of the Activity(1)

◆Overarching objective

Supporting the development of Cambodian Low-carbon strategy and roadmap by collaborations with domestic researchers and Japanese experts

◆ Three time horizon of the analysis

Short Term: (2016-2020)

Medium Term: (2020-2030)

Long Term: (2030-2050)

Overview of the Activity (2)

◆Targets and outcomes

1. **To support developing a Systematic and Quantitative Design of Low Carbon Development Plan for Cambodia**

2. **To find out how the identified low carbon technologies would be contributed for implementing Cambodian Low Carbon Development Strategy**

3. **To enhance the capacity development and research networking with the methodologies using GHG emission reduction models developed through the study.**

Overview of the Activity (3)

◆ Expected activities

1. - **Collect information and organize database;**

   - Introduce visions and scenarios towards the Low Carbon Growth of Cambodia;

   - Provide the policies and technologies' roadmap;

   - Develop and adjust the tools for supporting and managing the visions, scenarios, and roadmaps to Low Carbon Development;

2. **- Identify effective technologies for Low Carbon Growth;**

   - Determine emission reduction potential of the country, which also stimulate economic and social development.

3. **- Provide guidance which summarize the approaches of Cambodian Low Carbon Development Strategy**

Overview of the Activity (4)

- **The covered sectors/dimensions of the analysis are: Energy, AFOLU, Industrial, and waste sectors, and also on social, economic, educational and technological dimensions.**

- **Two types of national level quantification models and a group of LCS policy supporting tools are planned to use. They are:**
  - **Extended Snapshot model (ExSS) and AFOLUA: To design Low Carbon Society vision and quantify the GHG reduction potentials;**
  - **Bottom-up type end-use model (AIM/enduse): To identify effective technologies and necessary financial policies for Low Carbon Development.**
  - **Quantification Tools for Low Carbon Strategies and Roadmaps (LCSR) making**

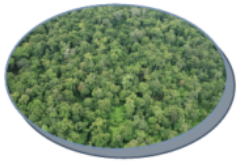
In the Morning Session, Mr. Hak Mao identified
four tangible polices for low carbon development plan and a dozen strategies to reach the policies.

Four Policies and a Dozen Strategies

Policy 1: Green Environment

Sustainable forest management strategy

- Effective forest concession management through implementing effective law enforcement against illegal logging
- Promotion and implementation of REDD+
- Increasing carbon sequestration via forest restoration and replantation
- Forest ecosystem conservation and management

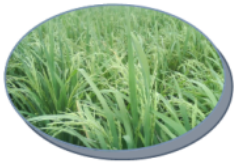


Sustainable waste management strategy

- Development of environmentally sound technology landfill sites through waste management strategy/plan, waste collection and segregation
- Minimization of waste and by-products and maximum use of renewable resources by implementing 3R principle and promote waste-to-energy technologies
- Environmentally sound waste management through allocation of waste deposal/storage and proper control of second hand goods import
- Promotion of local level self-governance and leadership to improve de-centralized coordination of waste management and segregation

Green agriculture management strategy

- Promotion of climate-smart agriculture which increases productivity, resilience (adaptation), and reduces/removes greenhouse gases (mitigation) while enhancing national food security
- Promotion of Eco-agriculture through the use of organic fertilizer such as biomass waste, bio -slurry, compost and livestock manure
- Introduction and implementation of system of rice intensification (SRI) to increase yield of rice without purchased inputs
- Introduction and implementation of integrated farming system (IFS)
- Sustainable land use and land management for agriculture purpose



Policy 2: Harmonization of Green Economy, Society, and Culture

Green transport management strategy

- Promotion of public transport in major cities by intensive urban math transit facilities, better traffic management and development of non-motorized transport infrastructure
- Green belt development by planting trees along the roads and parks
- Freight modal shift for long-distance shipment
- Introduction of low-emission and energy-efficient vehicles
- Improvement of public transport service in the rural areas with the development of infrastructure for bus with reliable and affordable price

Green energy management strategy

- Encouraging the use of renewable energy through construction of hydro power plants and private sector participation with solar, wind, mini-hydro, tidal, and biogas/biomass, etc.
- Encouraging the use of smart appliance and home automation system including energy saving appliance, power control devise, and fire protection and electricity appliance maintenance
- Encouraging all institutions and households to save energy

Green tourism management strategy

- Promotion and implementation of clean city, clean resort and good services
- Promotion of tourist attraction through introducing cultural heritages and natural tourism (eco-tourism)- Cambodia-Kingdom of Wonder
- Promotion of group tour with comfortable public transport
- Promotion of green flag competition and green award
- Encouraging tourists to recycle waste and to reduce emission

Green Good Governance and human resource development strategy

- Integrating green concept into curriculum from primary education to higher one as well as vocational and training
- Introducing and improving the green institutional management and arrangement
- Implementing green management initiatives and intellectual capital and green job
- Introducing and encouraging green concept into local communities to seek their participation for natural resource management
- Increasing human resource development throughout the country considering youth and gender participation for low carbon society

Green technology and investment strategy

- Promotion of green industries and industrial ecology
- Implementation of transfer of green technologies such as cleaner production, sustainable product innovation, renewable energy utilization
- Encouraging and incentivizing the investment in effective environmental protection and natural resource management
- Promotion of green business competition and green credit

Green financial mobilization strategy

- Green financial incentives including green tax and subsidy
- Adoption of green budget reform
- Implementing Payment for Environmental Services based on polluter pays principle to promote the internalization of environmental costs
- Conducting fund mobilization from development partners for green development
- Development of a sound market-based financial system to support resource mobilization, effective financial resource allocation

Policy 3: Blue Economy

Green merchant marine and sustainable coastal zone management strategy

- Introduction of emission standard in maritime transport through inspection and maintenance system
- Promotion of integrated coastal zone management
- Development and enforcement of the ballast water management to control marine invasive species

Policy 4: Eco-Village

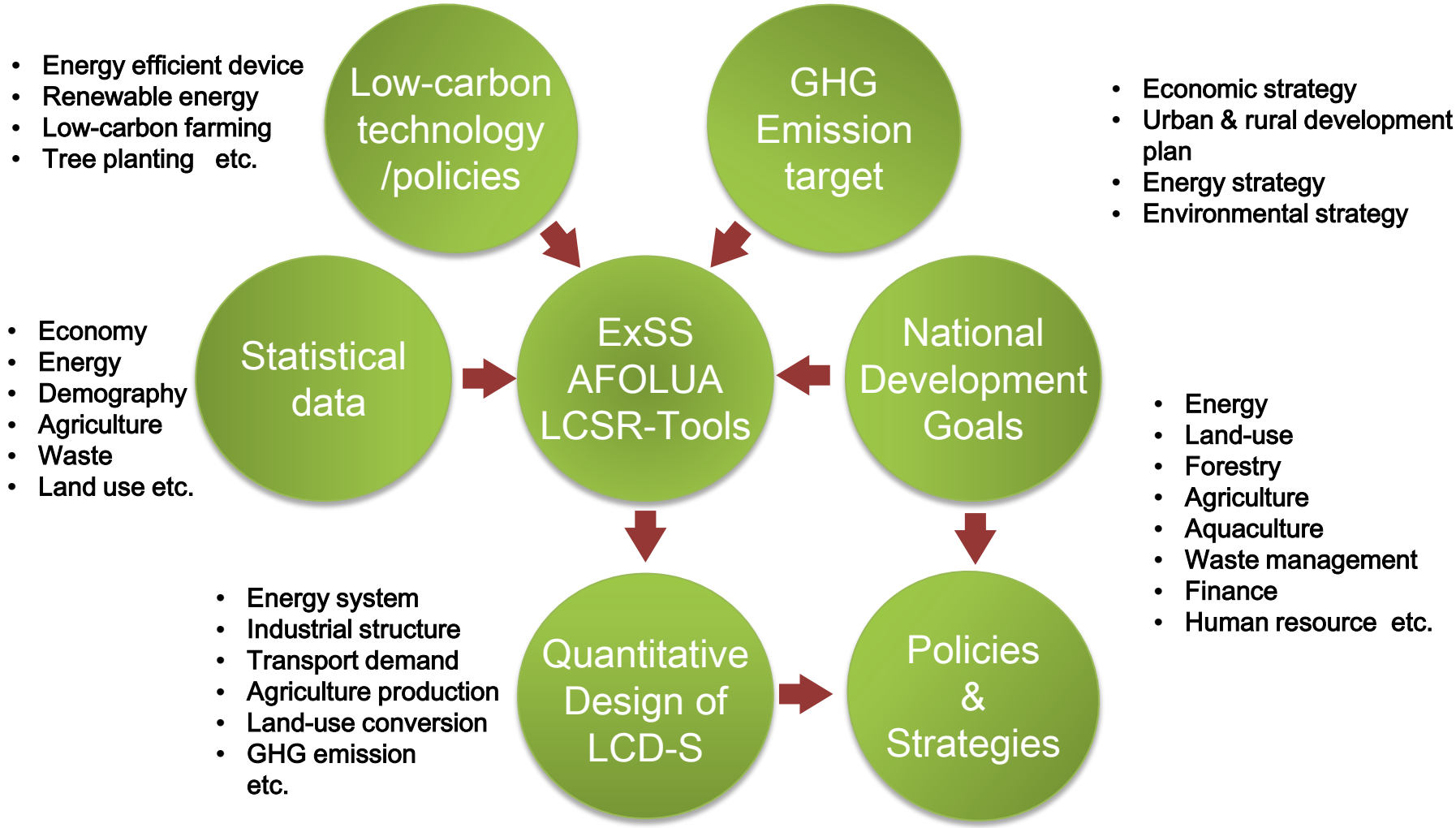
Low carbon infrastructure development strategy

- Implementation of decentralized management system for a sustainable urban environment and better mobility
- Construction and rehabilitation of rural roads to facilitate local transportation, and making transit point to improve connection from one village to another
- Designing walkable city through providing comfortable and safe pavement
- Designing a standard road facility to differentiate between vehicle, motorist, and cyclist lane to avoid road accident and traffic congestion

Green building design and construction strategy

- Promotion and implementation of green building designs and constructions through encouraging the use of energy efficient materials
- Increasing the use of wood for climate smart buildings and encouraging tree planting
- Encouraging embedding renewable energy and energy saving appliance in the building design

Methodology



In order to conduct quantitative analysis of the strategies, a couple of tools and models: ExSS, AFOLUA and LCSR-Tools are used. They are coupled with national development goals, and identify measures to be implemented in order to achieve the relevant targets

Coupling of LCD-strategies and models/tools

Policies	Strategies	Sectors	Element models	Integration
Green Environment	Sustainable forest management strategy	Forrestry and Land-use	AFOLUA	**ExSS and LCD-Strategies Tools**
	Sustainable waste management strategy	Waste	ExSS/Waste	
	Green agriculture management strategy	Agliculture/Livestock	AFOLUA	
Harmonization of Green Economy, Society, and Culture	Green transport management strategy	Transpotation	AIM/enduse	
	Green energy management strategy	Energy	AIM/enduse	
	Green tourism management strategy	Commercial/Transport	(ExSS)	
	Green Good Governance and human resource development strategy	Education Capacity Development	(ExSS)	
	Green technology and investment strategy	Technology	AIM/enduse	
	Green financial mobilization strategy	Industry/Commercial		
Blue Economy	Green merchant marine and sustainable coastal zone management strategy	Transportation and Land-use	AIM/enduse AFOLUA	
Eco-Village	Low carbon infrastructure development strategy	Construction	ExSS, AIM/enduse	
	Green building design and construction strategy	Residential/Commercial /Construction	ExSS, AIM/enduse	

Four models and tools expected using in the study

- **ExSS**
  Extended Snapshot tool

- **AIM/Enduse model**
  Energy enduse oriented bottom-up model

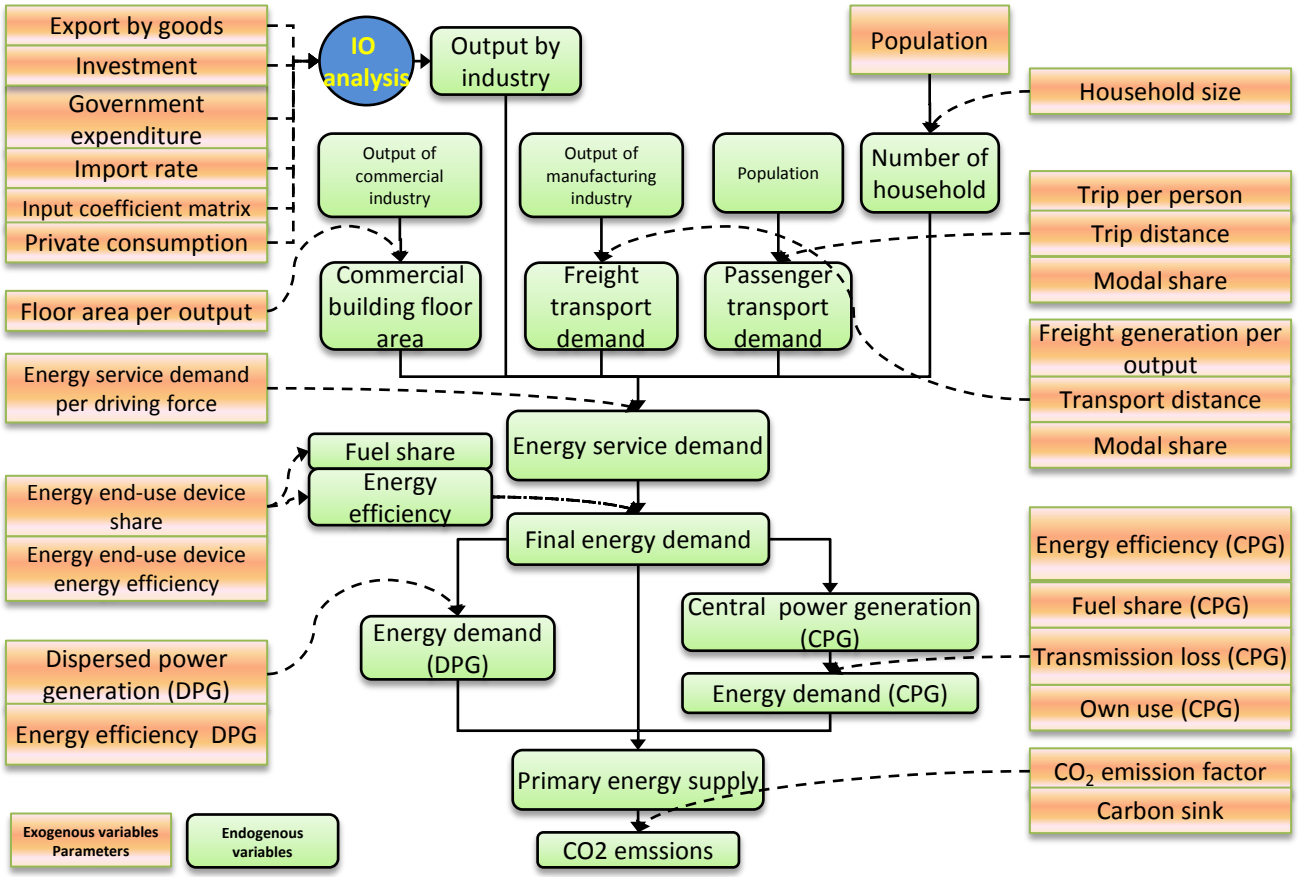
- **AFOLUA model**
  Agriculture, Forestry and Other Land-use Activity model

- **LCSR Tools**
  Tools for designing and managing Low Carbon Strategy and Roadmap and connecting models' output quantitatively with LCD strategies

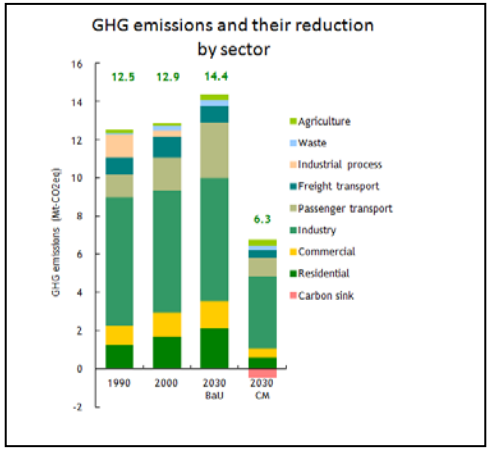
Extended Snapshot Tool (ExSS) (1)

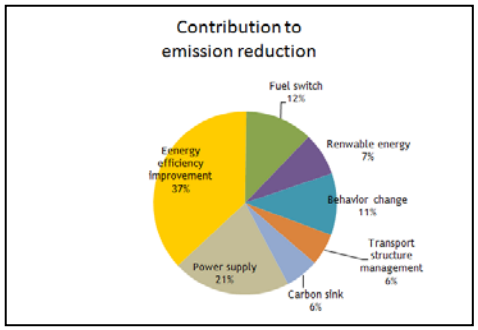
- ExSS is a tool to design and assess future energy consumption, power generation, technology diffusion, transportation, industrial outputs, residential and commercial activities, waste generation and GHG emissions, coupling with prescribed socio-economic, industrial and demographic scenarios in a particular future year.
- ExSS is an “input-output” type model consists of simultaneous equations with around 6000 variables.
- ExSS is based on the idea of “back-casting” approach and used to “Design” a future society as a Low Carbon Society in a consistent and quantitative manner.
- ExSS has been used for development of Low Carbon Strategy and Roadmap in many nations and regions in Asia.
- It is a GAMS linear/non-linear program operated on MS-Windows

Extended Snapshot Tool (ExSS) (2)



Model structure of ExSS



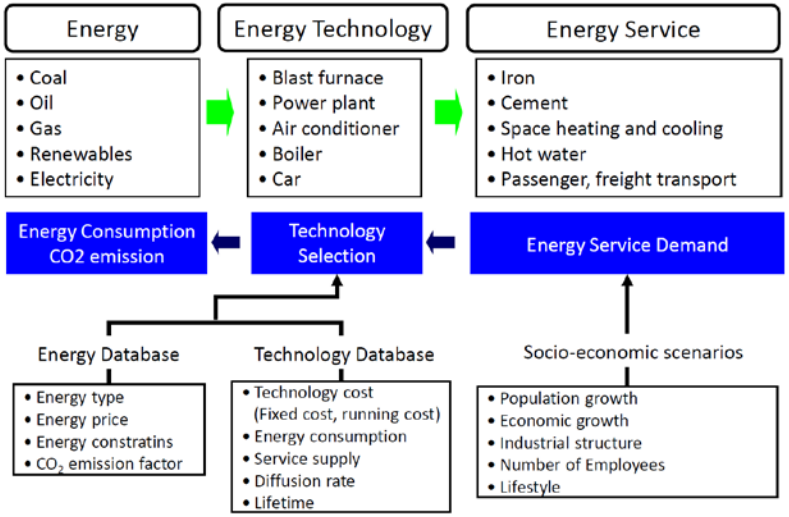


An example of ExSS outputs: (Shiga LCS study, Japan)

AIM/Enduse model (1)

- AIM/Enduse is a model to project energy demand and supply coupling with energy technology developments and energy policies.
- The model focuses on energy service generation, and on detail technology selection framework considering individual technologies characteristics and costs.
- The model assesses energy technological transition over time, Energy consumption, GHG emissions, Cost of policy actions.
- The model covers;
  Energy demand sectors, such as Industry, Building, Transport, …,
  Energy suply and transformation sectors, such as Power generation, Oil refinery, Gas transformation, …
- The model were extended to cover F-gas consumption/emission, and AFOLU activities
- The model was applied many times to Japan's climate policy making, and also China, India, Thailand, Indonesia,....
- It is a GAMS linear program operated on MS-Windows

AIM/Enduse model (2)



Concept of AIM/Enduse

GHGs, Sectors and services in AIM/Enduse

GHG	Sector	Sectors and Services
CO_2, CH_4, N_2O	Power generation	Coal power plant, Oil power plant, Gas power plant, Renewable (Wind, Biomass, PV)
	Industry	Iron and steel, Cement Other industries (Boiler, motor etc)
	Transportation	Passenger vehicle, Truck, Bus, Ship, Aircraft, Passenger train, Freight train (except for pipeline transport and international transport)
	Residential and & Commercial	Cooling, Heating, Hot-water, Cooking, Lighting, Refrigerator, TV
CH_4, N_2O	Agriculture	Livestock rumination, Manure management, Paddy field, Cropland
	MSW	Municipal solid waste
CH_4	Fugitive	Fugitive emission from fuel
HFCs, PFCs, SF_6	Fgas emissions	By-product of HCFC-22, Refrigerant, Aerosol, Foams, Solvent, Etching, Aluminum production, Insulation gas, others.

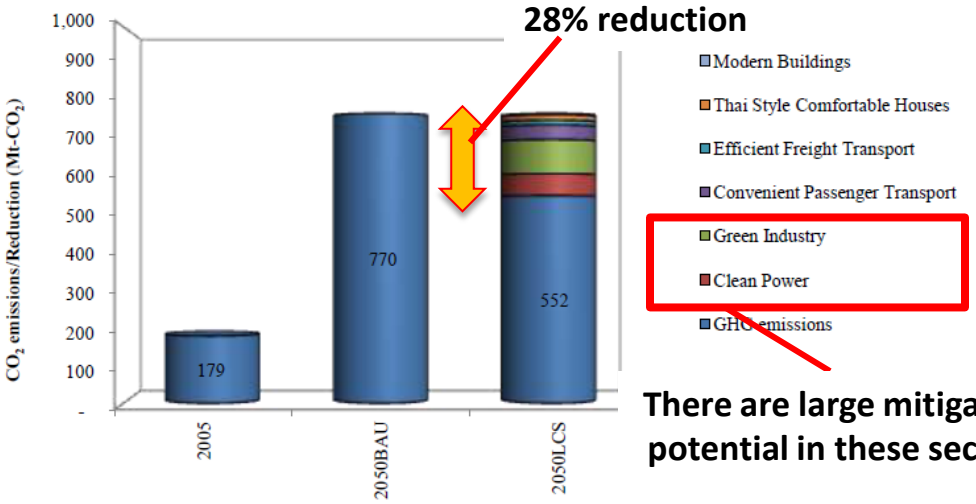
Typical technologies in AIM/Enduse

Sector	Category	Technology options
Power generation	Coal power plant	Efficient coal power plant, PFBC (Pressurized fluidized bed combustion), IGCC (Integrated Gasification Combined Cycle)
	Gas power plant	Efficient gas power plant, ACC (Advanced Combined Cycle)
	Renewables	Wind power, Photovoltaics, Biomass power plant
Industry	Steel	Coke oven (Coke gas recovery, Automatic combustion, Coal wet adjustment , Coke dry type quenching, COG latent heat recovery, Next generation coke oven), Sinter furnace (Automatic igniter, Cooler waste heat recovery, Mainly waste heat recovery, Efficient igniter), Blast furnace(Large size blast furnace, Blast furnace gas recovery, Wet top pressure recovery turbine, Dry top pressure recovery turbine, Heat recovery of hot blast stove, Coal injection, Dry top pressure gas recovery), Basic oxygen furnace(LDG recovery, LDG latent heat recovery), Casting & rolling (Continuous caster, Hot charge rolling, Hot direct rolling, Efficient heating furnace, Heat furnace with regenerative burner, Continuous annealing lines), Electric furnace(DC electric furnace, Scrap pre-heat)
	Cement	Mill (Tube mill, Vertical mill), Kiln (Wet kiln, Semi-wet kiln, Dry long kiln, Dry shaft kiln, SP/NSP)
	Other industries	Boiler (Efficient boiler [coal, oil, gas], Boiler with combustion control [coal, oil, gas], Cogeneration [coal, oil, gas], Regenerative gas boiler), Process heat (Efficient industrial furnace [oil, gas]), Moters (Motor with Inverter control, Efficient motor)
Building	Cooling	Efficient cooler (sold average in developed countries in 2005, top runner, highest performance)
	Warming	Efficient air conditioner (sold average in developed countries in 2005, top runner, highest performance), Insulation (Wall insulation, Double-glazed glass with Low-e)
	Hot water	Efficient water heater [kerosene, LPG, gas, coal], CO_2 refrigerant water heater, Solar thermal water heater
	Cooking	Efficient cooking stove [kerosene, LPG, gas, coal, electricity]
	Lighting	Fluorescent of incandescent type, Fluorescent with energy saving stabilizer, Inverter type fluorescent, Hf Inverter type fluorescent
	Refrigerator	Efficient refrigerator (sold average in developed countries in 2005, top runner, highest performance)
	TV	Efficiency TV (sold average in developed countries in 2000, top runner, highest performance)
	Others	Efficient other devices
Transport	Passenger car	Efficient gasoline passenger car (Variable valve control, Cylinder deactivation, Direct injection, Engine friction reduction, Rolling resistance reduction, Aluminum body, Lightweight Chassis, Aluminum Block, CVT), Hybrid passenger gasoline car, Plug-in hybrid gasoline car, Efficient diesel passenger car (Engine friction reduction, Rolling resistance reduction, Direct injection, Common-rail, Aluminum body, Lightweight Chassis, Aluminum Block, CVT), Hybrid passenger diesel car, Plug-in hybrid diesel car, Electric passenger car, Fuel-cell passenger car,
	Truck	Efficient small-sized truck (Rolling resistance reduction, Engine improvement), Efficient large-sized truck (Rolling resistance reduction, Engine improvement)
	Passenger bus	Efficient bus (Rolling resistance reduction, Engine improvement), Hybrid bus
	Ship	Efficient ship
	Aircraft	Efficient aircraft (Engine Improvement, Weight reduction, Drag reduction)

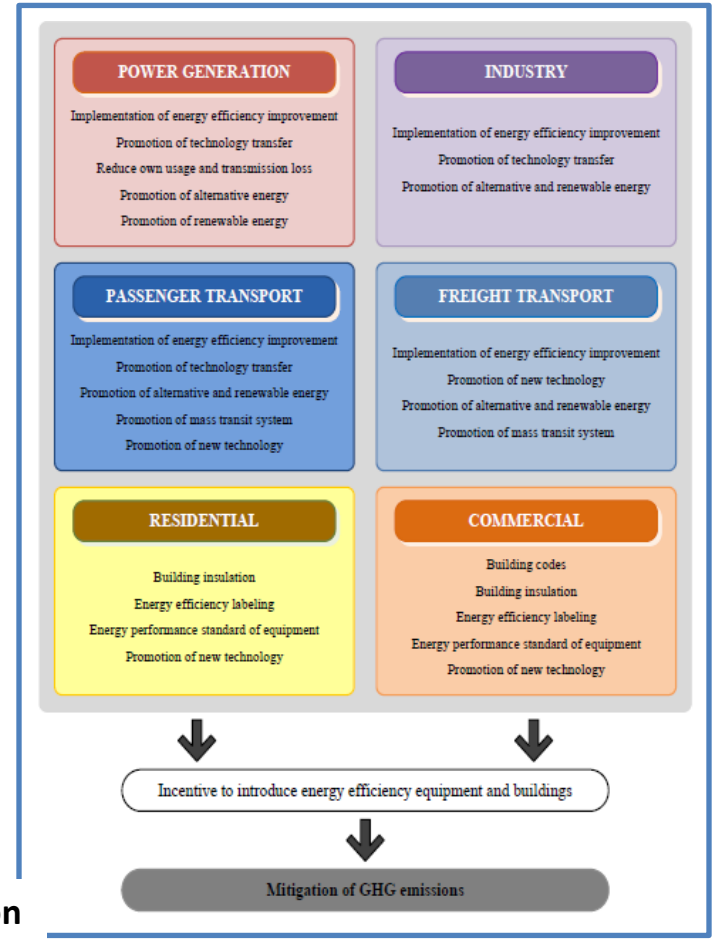
AIM/Enduse model (3)

An example of AIM/Enduse model outputs for developing Thailand Low Carbon Roadmap

- 28% reduction in 2050 compared to BAU case
- Found large mitigation potential in industry sector and power sector.
- Summarize the analysis to a Policy package to realize low carbon Thailand



There are large mitigation potential in these sectors

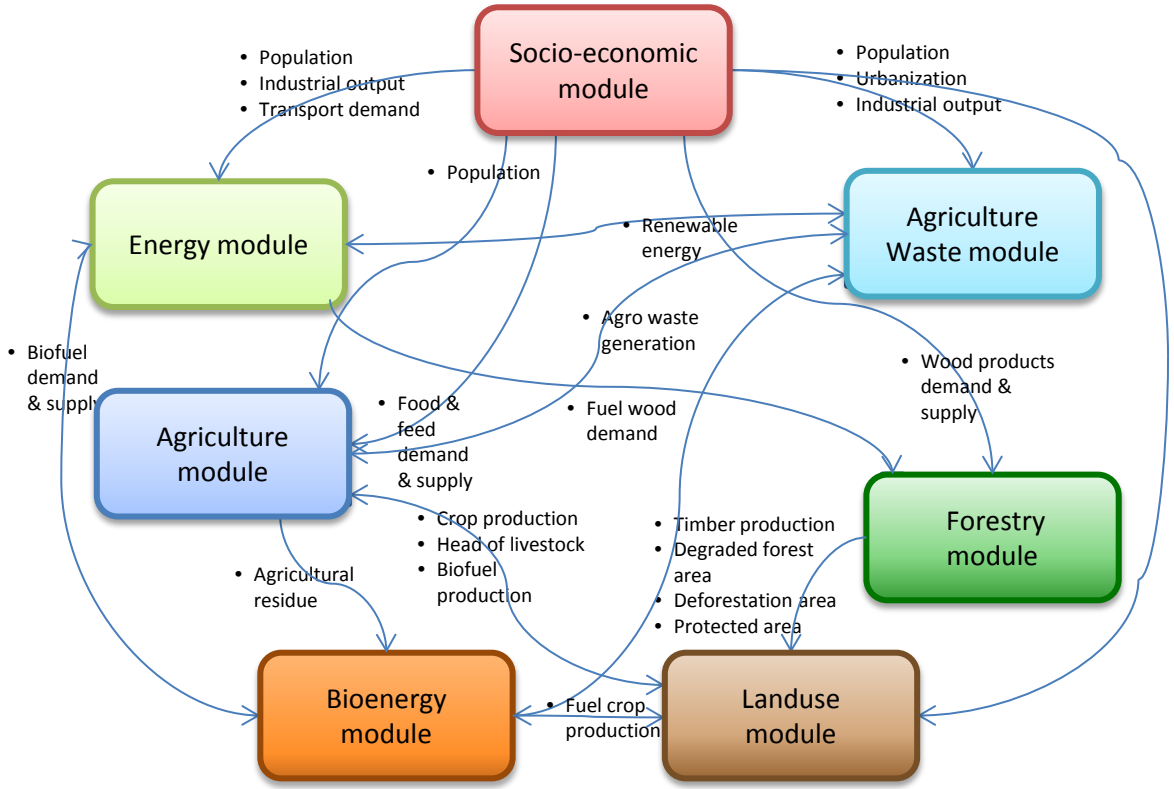


Policy package in various sectors

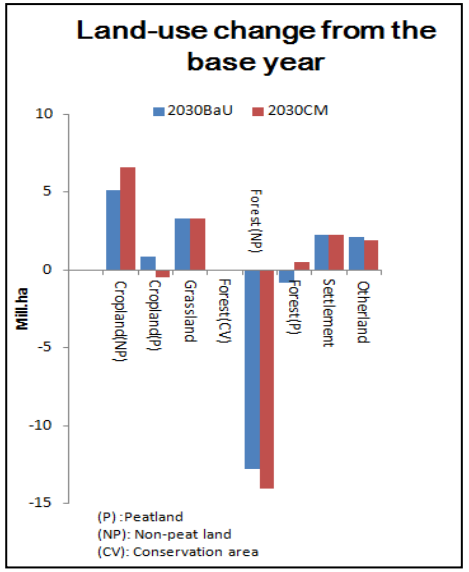
AFOLUA model (1)

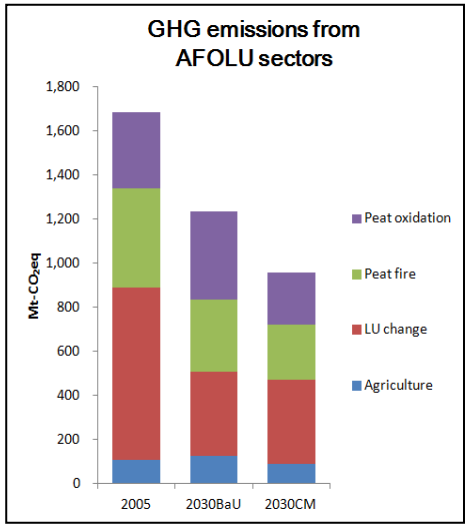
- AFOLUA (Agriculture, Forestry and Other Land-use Activity) is a model for projecting activity levels of AFOLU sectors and GHG emissions from these sectors.
- Simple accounting type tool, based on land use accounting table, food balance table and biomass balance table.
- Socio-economic variables are adjusted and consistent with other models, i.e. ExSS, CGE.
- The model considers production, consumption, import and export of forestry and agriculture products including bio-energy crops.
- It is a GAMS linear/non-linear program operated on MS-Windows.
- This model was applied to Vietnam, Indonesia and Malaysia

AFOLUA model(2)



Model Frame of AFOLUA





An example of AFOLUA outputs:
(Indonesian Low-Carbon Strategy and Roadmap study)

LCSR (Low Carbon Strategies and Roadmaps) Tools

- LCSR tools are tools for connecting models with LCSR making process quantitatively, and support designing, monitoring and managing the Low Carbon Strategy progress
- The tools are composed of
  - LCSR Work Breakdown Structures (LCSR-WBS)
  - LCSR Specification Cards (LCSR-SPEC)
  - LCSR Design Structure Matrix (LCSR-DSM)

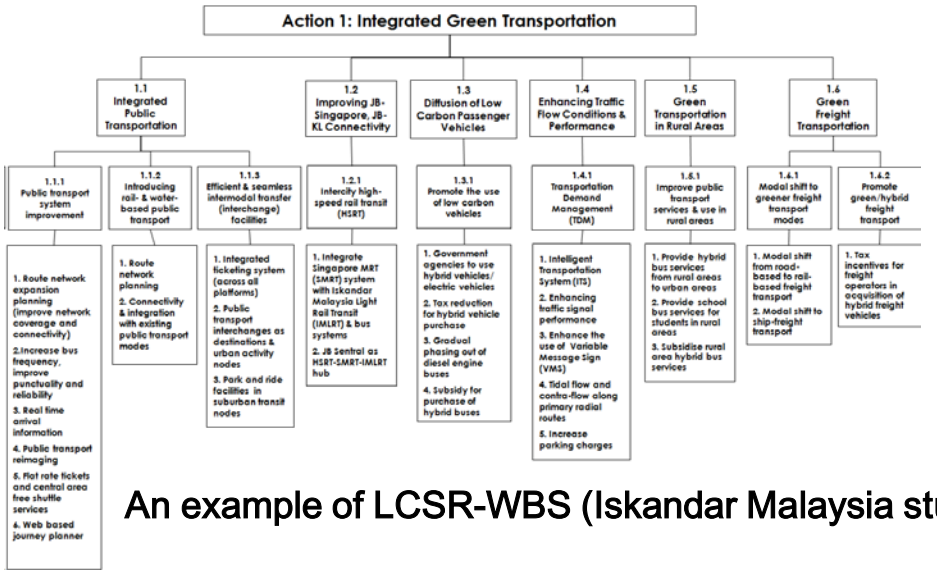
- These tools are now applying to a Malaysian regional study.

Low Carbon Strategies and Roadmap (LCS)

- LCSR is a deliverable-oriented grouping of elementally programs that organizes and totals the scope of the LC Policies.
- Overall structure of LCSR is shown with its Work Breakdown Structure (LCSR-WBS)
- LCSR-WBS is a graphical format of hierarchically displaying deliverable measures and projects, which are further broken down into more detailed deliverables.

An example of LCSR (IsKandar Malaysia study)

	Action Names	Themes
1	Integrated Green Transportation	GREEN ECONOMY
2	Green Industry	
3	Low Carbon Urban Governance	
4	Green Building & Construction	
5	Green Energy System & Renewable Energy	
6	Low Carbon Lifestyle	GREEN COMMUNITY
7	Community Engagement & Consensus Building	
8	Walkable, Safe, Livable City Design	GREEN ENVIRONMENT
9	Smart Growth	
10	Green and Blue Infrastructure & Rural Resources	
11	Sustainable Waste Management	
12	Green and Clean Environment	



An example of LCSR-WBS (Iskandar Malaysia study)

LCSR Specification Cards (LCSR-SPEC)

- LCSR Specification Cards (LCSR-SPEC) describes the Scope statement, Workflow, Timeline of implementation, Required resource, Costing, Implementation organization, Stakeholders, SWOT* analysis, and Current status
- It is used for discussing/analyzing the Design details, Progress management, Sharing and communicating the relevant information among research groups, implementation agencies and stockholders

Program 1.1.1 (1): Street tree planting for shades

Measure 1.1.1: Providing Comfortable Walkways

Sub-action 1.1: Designing Walkable City Centres & Neighbourhoods

Description

Objective

Time Line of Implementation

Sub-action		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1.1	Street tree planting for shades														

(Describe how this Sub-action will be implemented within this timeline)

Prerequisites of Implementation

Action		Program	Comments
1			
2			

Effects of this Action

Emission Reduction

GHG Emission Reduction
(Chart & Explaination)

Other Effects

Example:
Employment
Identification of Co-benefit

Existing Documentations

Document Name		Chapter	Page	Content
1	Comprehensive Development Plan			
2	Transportation Blue Print			

Stakeholders involved in Implementing

1	Iskandar Regional Development Authority	
2	The Local Authorities within the five (5) Flagship zones in	

SWOT Analysis

Strength	Weakness
Describe how this Program will be a benefit to IM	*What is the weakness of this program.– how will it be a negetive point for IM*
Opportunities	**Threats**
What kind of opportunity/ positive features of this Program	Negative points

Template of LCSR-SPEC using Iskandar Malaysia study

* SWOT: Strengths, Weaknesses, Opportunities, and Threats

LCSR Design Structure Matrix (LCSR DSM)

- LCSR DSM*1 is a matrix which shows relations and interactions among programs in LCSR-WBS and crucial parameters/variables/ performance measure which influence the quantified targets of LCSRs, with compact, easily scalable, and intuitively readable representation.

- LCSR DSM has a structure of MDM*2 with four domains*3 , i.e. Actors/ Stackholders, Programs/Actions, Performance measures/Crucial parameters, and Quantified targets .

*1 DSM (Design Structure Matrix) is a network modeling tool to represent the elements comprising a system and their interactions.

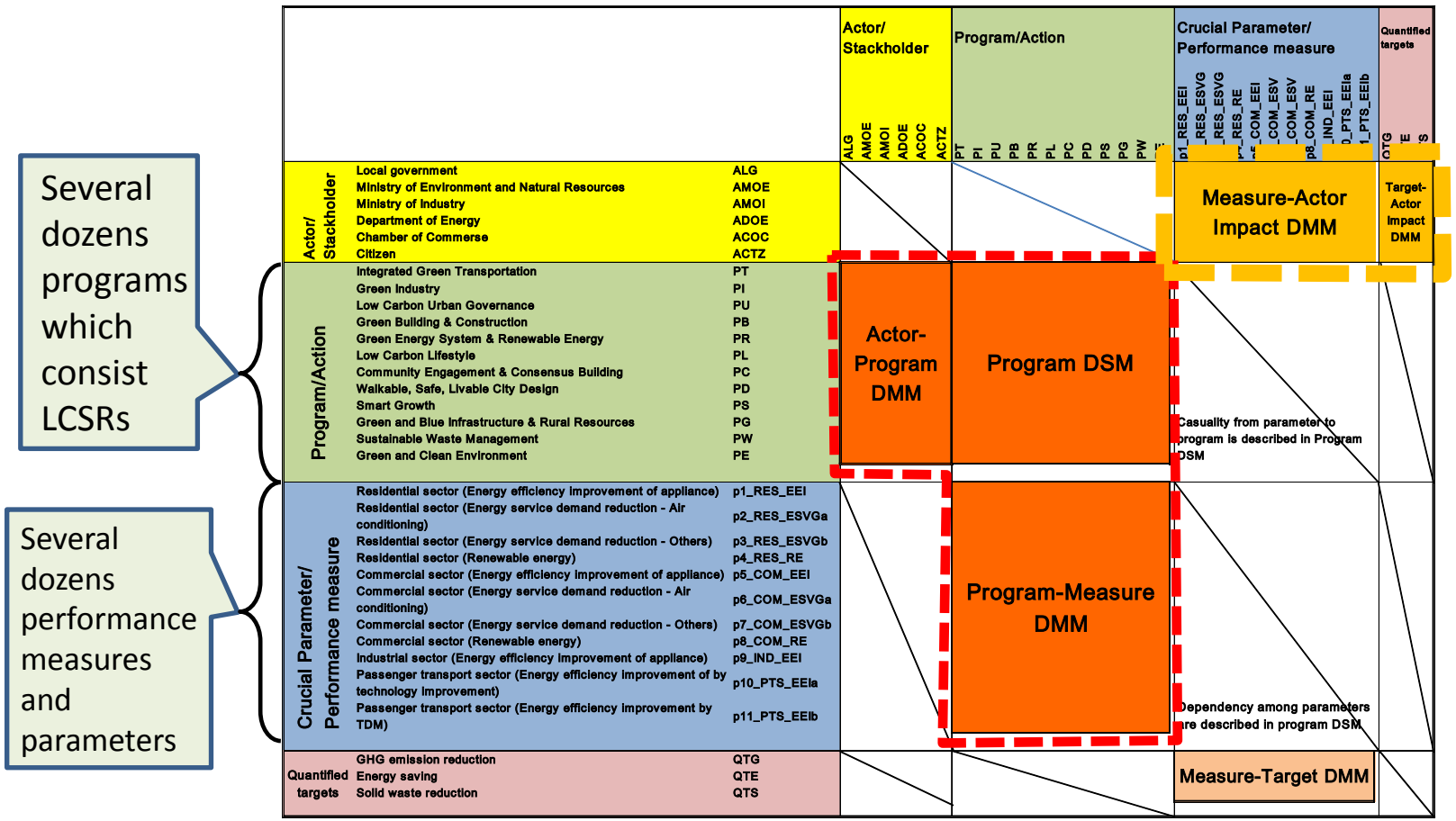
*2 MDM(Multidomain Matrix) is an extension of DSM modeling in which two or more DSM models in different domains are represented simultaneously.

*3 Domain is a realm of the elements comprising a DSM model of a system (e.g., product, process, organization, etc.).

Terminology defined in Eppinger, D. and Browning, T., Design Structure Matrix Methods and Applications, MIT Press, 2012

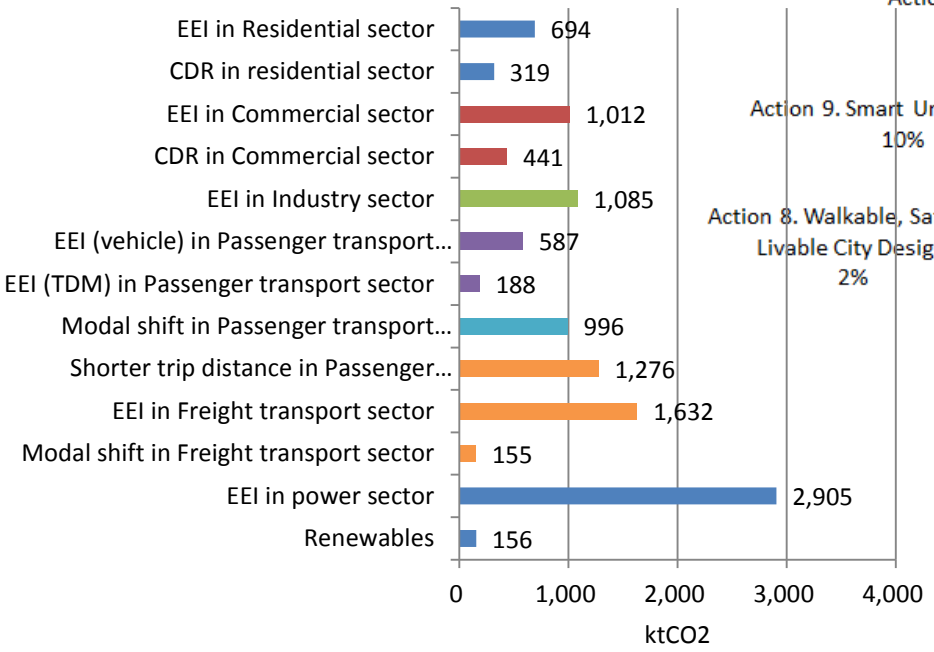
An example of LCSR-DSM

- Column elements act to row elements, i.e. column elements cause effects to row elements
- Elements of matrix denote relation between column elements and row elements

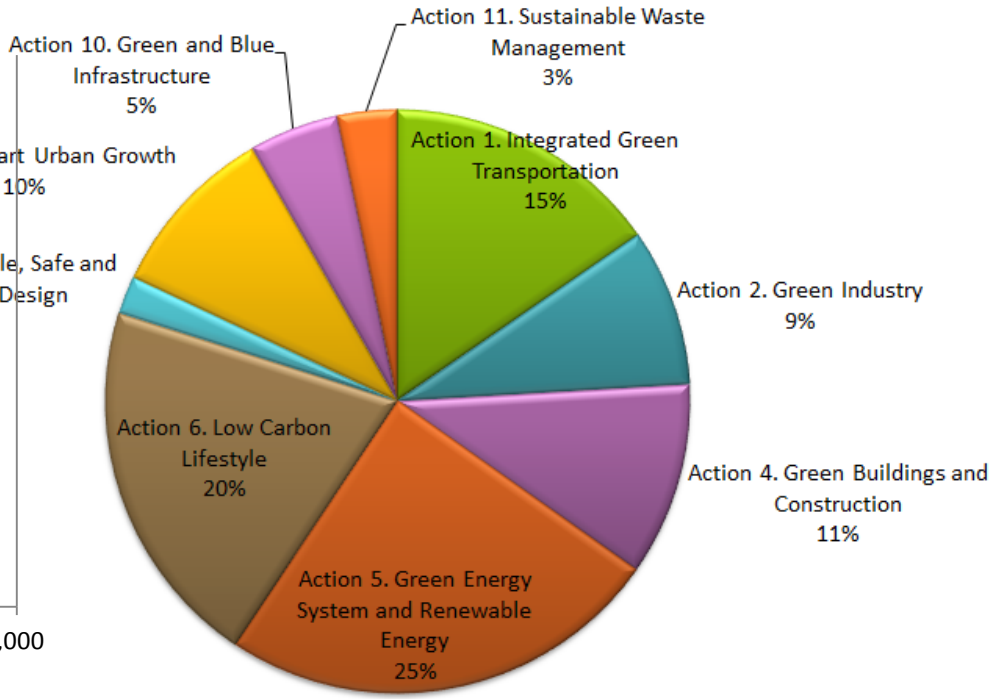


An example of evaluation of effectiveness of Low Carbon Strategies (Actions) to GHG emission reduction (Iskandar Malaysia study)

Green Economy: 59%
Green Community: 21%
Green Environment: 20%



Contribution of Emission reduction by sector/counter-measure



Contributions of Emission reduction by LCSR

Role of Japan's members

1. Support the development of Low Carbon Developing Strategies and identification of technologies which is useful for realizing the strategies:
   KU (ExSS, AFOLUA, LCSR tools) , NIES (AIM/Enduse) and MHIR (AIM/Enduse)

2. Support capacity development and conduct training workshops : **MHIR and NIES**

3. Organize policy dialogue for Implementation/Workshops and Reporting: **IGES and NIES**

KU: Kyoto University, NIES: National Institute for Environmental Studies, IGES: Institute for Global Environmental Strategies, MHIR: Mizuho Information & Research Institute, Inc.