AIM/CGE modeling activity 2013

- Development of a CGE Model Coupled with Energy End-use Technology -

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National Institute for Environmental Studies
Presented at the international AIM workshop
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AIM ASIA-PACIFIC INTEGRATED MODEL

Overview

AIM/CGE modeling activity in 2013 (1)

International activities

- AgMIP (Agricultural economic model inter-comparison project) (Hasegawa)
- ADVANCE (one of the IAM intercomparison but not like EMF) (Diego and Dai)
- SSP quantification processes
  - A set of socioeconomic scenarios for the next generation of climate change research

Domestic or Asian activities

- Asian low carbon society project (S-6)
  - Global model application
  - Individual country model applications; 10 countries (Namazu, Tu and Panida)
- Next coming projects relevant to individual Asian countries' analysis (in preparation)
  - Indonesia
  - Thailand

Prof. Matsuoka, Masui-san and Takahashi-san organize and support CGE activities.

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Overview

AIM/CGE modeling activity in 2013 (2)

Original activities

- Agriculture, land, bioenergy and climate change impacts research
  - Cooperating with GAEZ model (Takahashi and Tanaka)
  - Integrated assessment of mitigation, impact and adaptation (Hasegawa)
- Resource assessment
  - Cooperating with variable renewable energy assessment (Diego and Dai)
  - Biomass potential considering water (Hanasaki)

Model development

- Integrating agriculture, land, and biomass (mostly done in the last year)
- Integrating energy end-use technology information and improve its representation.
- Building platforms for multi model developers and applications

Prof. Matsuoka, Masui-san and Takahashi-san organize and support CGE activities.

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Global Low-Carbon Society Scenario Analysis based on Two Representative Socioeconomic Scenarios

Shinichiro FUJIMORI[1*], Toshihiko MASUI[1] and Yuzuru MATSUOKA[2]

Feasibility of Low-Carbon Development in China

Michiko NAMAZU[*1], Shinichiro FUJIMORI[2], Kejun JIANG[3] and Yuzuru MATSUOKA[1]

Two Low-Carbon Development Pathways in India

Michiko NAMAZU[*1], Shinichiro FUJIMORI[2],
Priyadarshi Ramprasad SHUKLA[3] and Yuzuru MATSUOKA[1]

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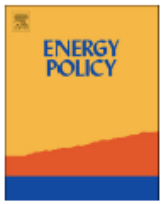

Thailand's Low-Carbon Scenario 2050: The AIM/CGE analyses of CO_2 mitigation measures

Panida Thepkhun [a], Bundit Limmeechokchai [a,*], Shinichiro Fujimori [b], Toshihiko Masui [b], Ram M. Shrestha [c]

AIM ASIA-PACIFIC INTEGRATED MODEL

Overview

Development of a CGE Model Coupled with Energy End-use Technology

- Introduction
  - Previous studies trials of Top-down (TD) and bottom-up (BU) model
- Methodology
  - Model structure
  - Scenarios
- Results
  - GDP losses
  - How emissions are reduced
- Discussions

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Two types of models in IAMs

- Two types of models have been used for the assessment of climate change mitigation policy.
  - TD model (such as AIM/CGE)
    - Adv; Entire economic goods and production factors are covered
    - Disadv; technological details are not described
  - BU model (such as AIM/Enduse)
    - Adv; technological details are represented
    - Disadv; macro economic feedback is outside of the model
- There are several trials
  - Exchanging information each other
    - MESSAGE-MACRO, IMACRIM-R (WEM and CGE), CIMS
  - Dealing with detailed technological representation partly
    - SGM (electricity and steel), EPPA (transport)

Objectives

Integrating bottom-up to top-down CGE

Develop fully coupled CGE model with detailed energy end-use representation

- Perfectly consistent solution (energy end-use and macro economy)
- More realistic model for the CGE models.

- This study aims to show
  - How the energy end-use is represented in the newly developed model
  - What are the characteristics of the model

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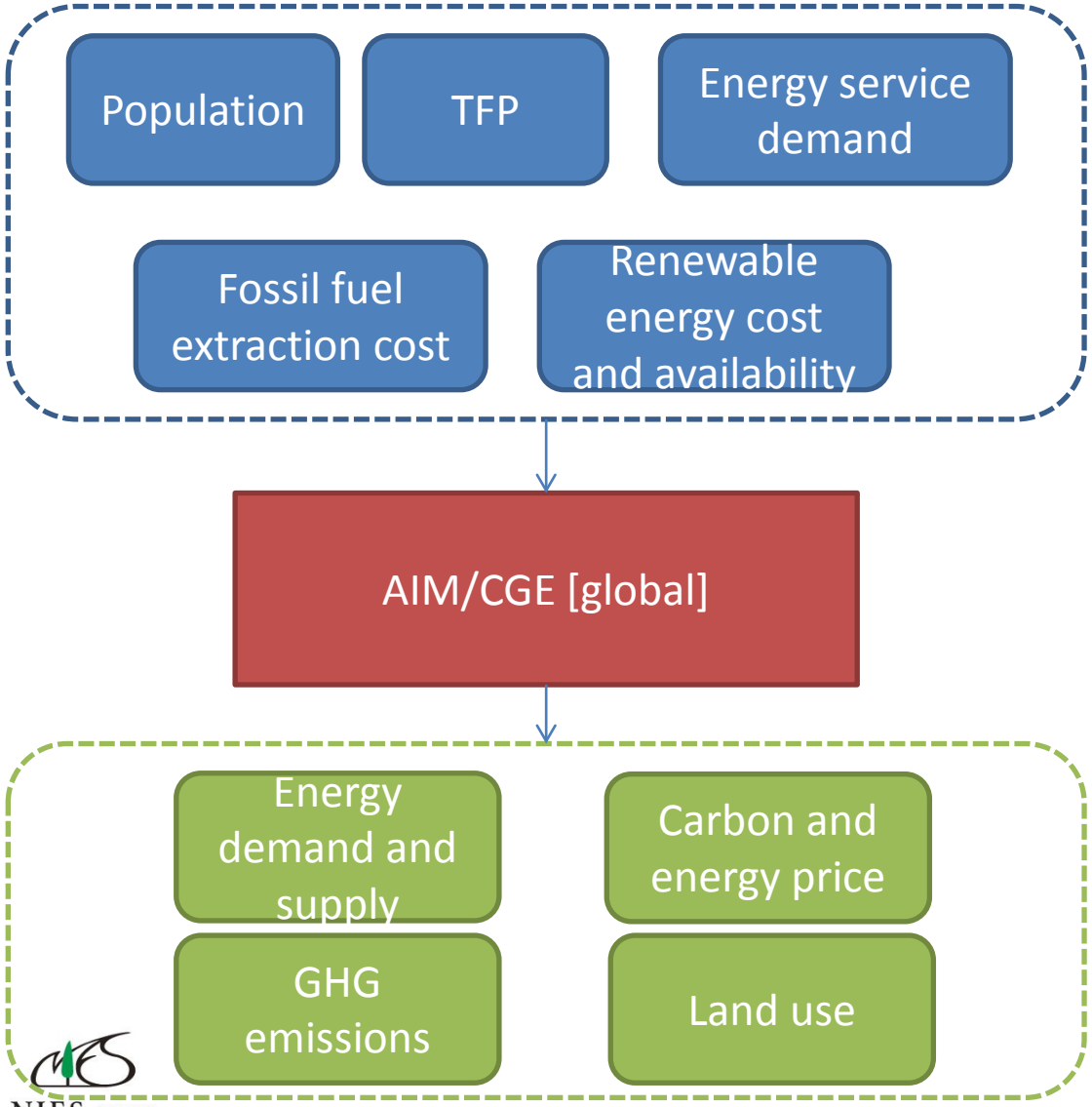
Method

Model structure (previous model)



- Electricity has detailed resolution combined with Logit formulation
- Land use and agriculture are dealt with as a physical volume
- Energy end-use is represented by CES nested production function or LES consumption function.

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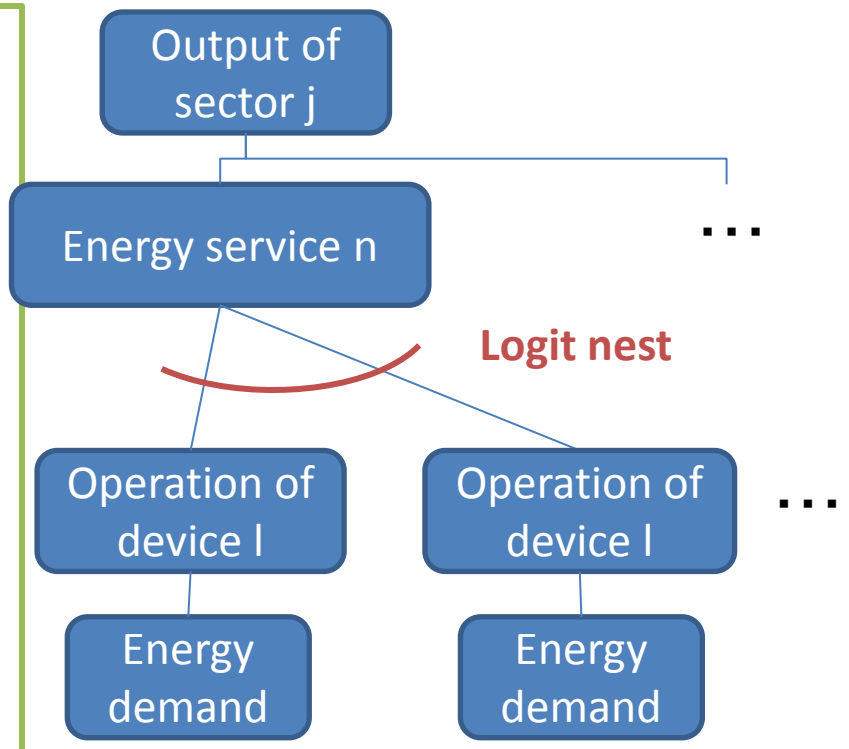
Method

How to determine energy end-use

- Using technology information from the AIM / Enduse database
- The technological selection is made under CGE framework.
- Sector inputs several kinds of energy services
  - Cooling, warming, …
  - Furnace, electric, machine …
- The operating share of technologies is determined under logit function with cost of the device investment and operation cost.



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Method

List of main end-use services and energy use

Sector	Transport	Industry	Services	Residents
Definition of service	Passenger gasoline car Passenger diesel car Passenger bus Passenger electricity rail Passenger domestic air Passenger industrial air Freight small truck Freight large truck Freight electricity rail Freight domestic ship Freight international ship Freight domestic air Pipeline	Boiler as intermediate input Heat as intermediate input Machine as intermediate input Other electric technology as intermediate input Other non-electric technology as intermediate input	Warming (Heating) Cooling Hot water Cooking Lighting Office tools	Warming (Heating) Cooling Hot water Cooking Lighting Refrigerator Television Others
Total	13	5	6	8
Energy use	Electricity, Fuel-cell, Gasoline, Natural gas, Diesel, Coal, Jet fuel, Heavy fuel oil, Crude oil, Oil	Coal, Oil, Natural gas, Biomass, Electricity, Heat	Coal, Kerosene, LPG, Natural gas, Heat, Geothermal, Electricity, Biomass, Oil (Kerosene)	Coal, Kerosene, LPG, Natural gas, Heat, Geothermal, Electricity, Solar thermal, Fuel-cell, Biomass, Oil (Kerosene)

- AIM/Enduse is the basis of the information
- Total of main services: 32

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Method

List of main end-use devices

Sector	Transport	Industry	Services	Residents
Definition of device	Passenger car	Boiler	Boiler for space heating	Stove for space heating
	Hybric passenger car	Electrict boiler	Stove for space heating	Heat supply for space heating
	Plug-in hybrid car	Heat pump	Adsorption heat pump	Geothermal supply for space heating
	Bus	Heat boiler	Heat supply for space heating	Air conditioner for warming
	Hybrid bus	Furnace	Geothermal supply for space heating	Air conditioner for cooling
	Passenger rail	Biomass furnace	Air conditioner for warming	Water heater
	Aircraft for domestic flight (passenger)	Electricc furnace	Heat pump for cooling	Electric water heater
	Aircraft for international flight	Heat furnace	Air conditioner for cooling	Heat pump type water heater
	Small-size truck	Motor	Water heater	Cooking equipment
	Small-size fuel-cell truck	Heat motor	Heat pump type water heater	Electric cooking equipment
	Small-size hybrid truck	Electrochemistry technology	Cooking equipment	IH cooking heater
	Large-size truck	Other technology	Electric cooking equipment	Incandecent lamp
	Large-size fuel-cell truck		IH cooking heater	Compact fluorescent lamp
	Large-size hybrid truck		Incandecent lamp	Fluorescent lamp
	Freight rail		Compact fluorescent lamp	Refrigerator
	Ship for domestic transport		Fluorescent lamp	Television
	Ship for international transport		Other electric equipment	Other electric equipment
	Aircraft for domestic flight (freight)			
	Pipeline transport			
Main	19	12	17	17
Detail	**76**	**59**	**120**	**110**

Devices are divided into different levels and energy types:
- Total of main devices: 65
- Total of detail devices: 365

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Method

Scenario framework and assumptions

		Model type	
		Aggregated CES and LES [AGG]	Detailed BU information [BU]
Mitigation policy	No policy [BaU]	AGG_BaU	BU_BaU
	Mitigation [MIT]	AGG_MIT	BU_MIT

- Socioeconomic assumptions; middle of the road (SSP2)

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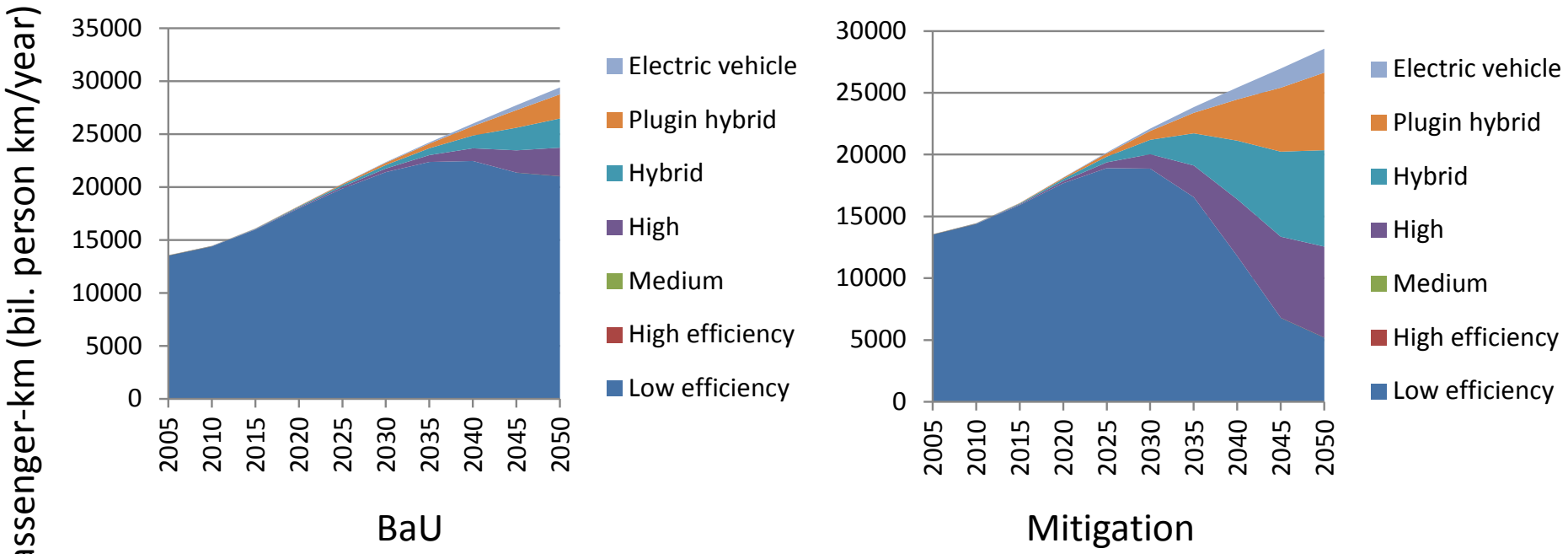
Results

Example of the end-use technology selection



Technology breakdown of global passenger car service

- This is just an example to show the endogenously determined within the CGE model in conjunction with BU information.

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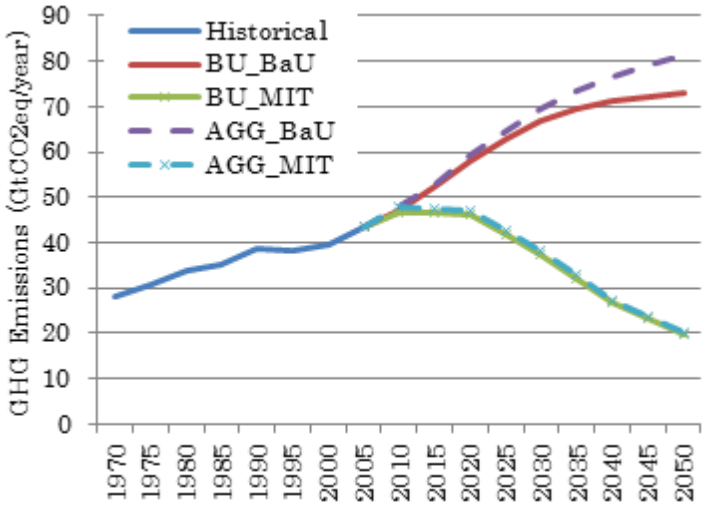
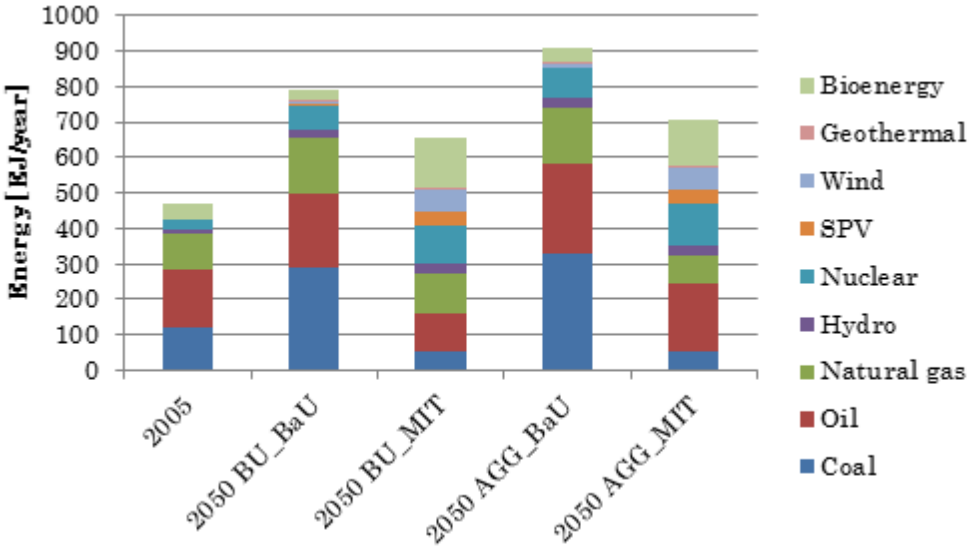
Results

Emissions and energy supply



GHG emissions



Primary energy supply

- AGG model is slightly higher emissions in BaU
- MIT scenarios are same
- Primary energy supply is not so quite different in BaU
- Those of mitigation scenarios are different “oil”.
  - The transport sector is one of the key sectors. AGG model is relatively hard to reduce the oil consumptions

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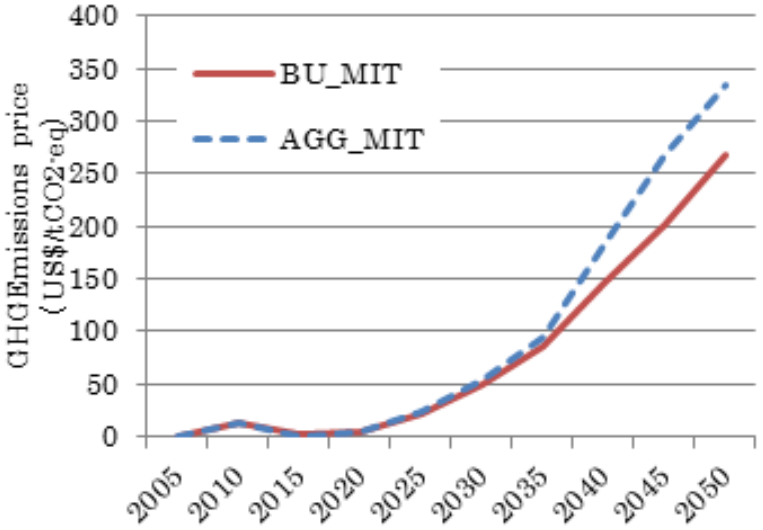
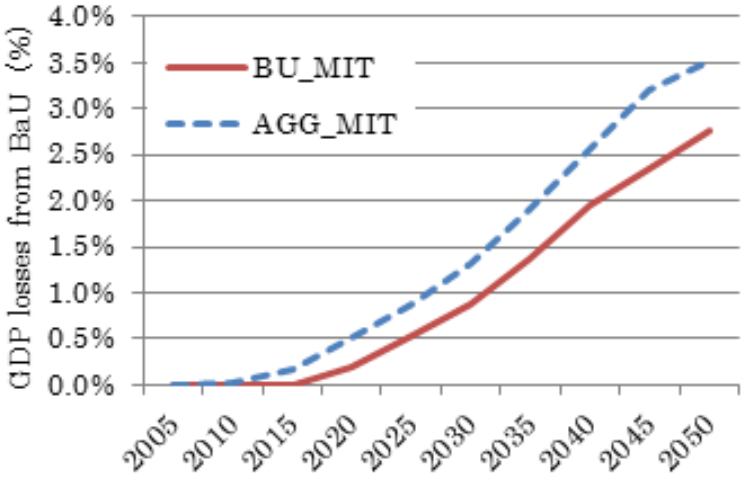
Policy cost; carbon price and GDP losses



Carbon price



GDP losses due to the climate mitigation

- Carbon price is higher in AGG
  - It would be due to the BaU emissions difference and mitigation possibility but hard to identify
- GDP losses are also high in AGG

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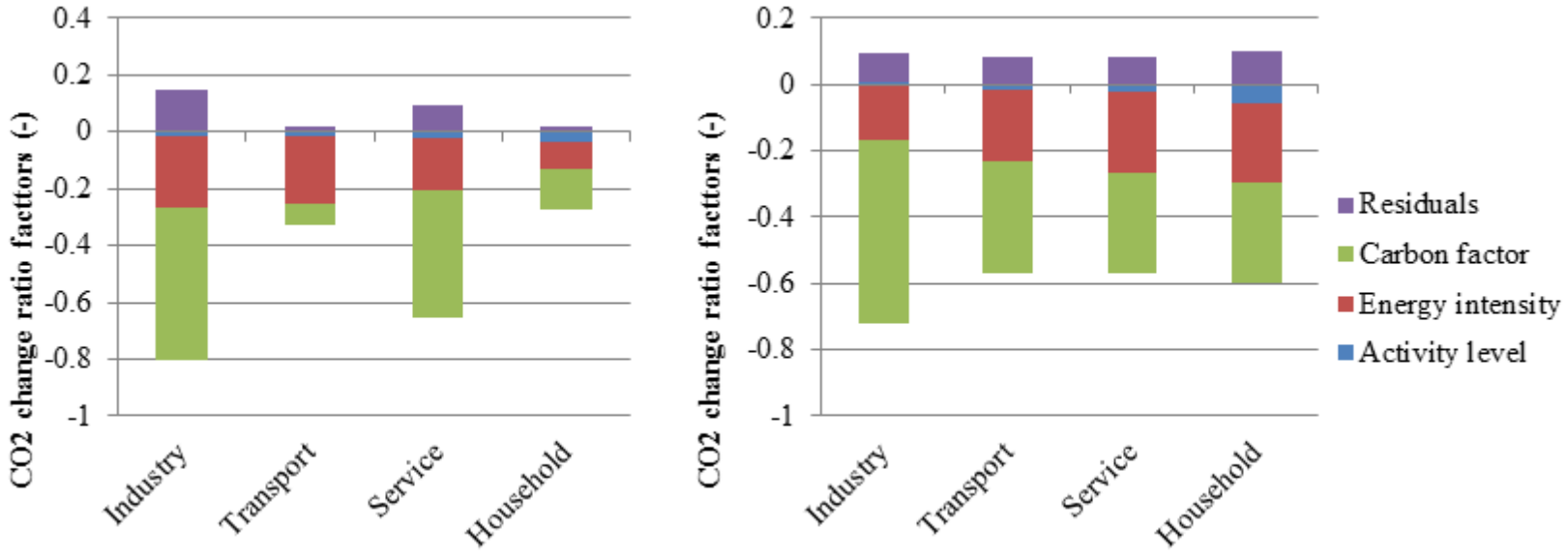
Results

CO2 emissions decomposition analysis



AGG model

BU model

- Activity level change is a small factor in all sectors of both models
- AGG model has less emission reduction in transport and household
  - The carbon factor reduction in transport is small in BU
  - The energy intensity improvement and carbon factor reduction in household are small in AGG
    - Biofuel and electric vehicle availability
    - The typical Household demand function is not so stylized for the energy assessment

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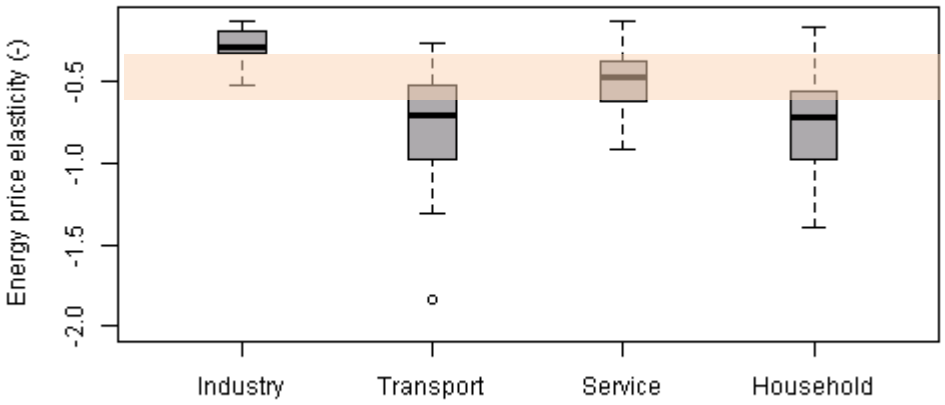
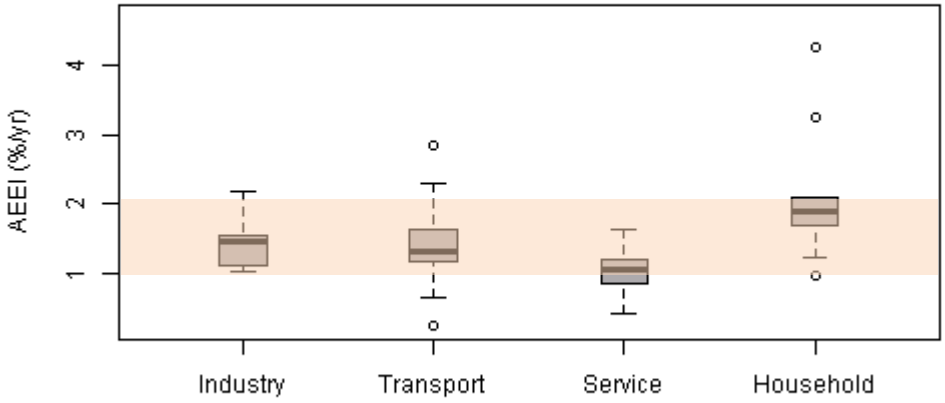
Results

Energy price elasticity and AEEI-





Energy price elasticity

Autonomous energy efficiency improvement

Energy intensity change = Price effect + Autonomous efficiency improvement

- Regression analysis of the BU model energy end-use response
- Both are heterogeneous across regions and sectors whereas single parameter is typically used in previous work.
- Some are an outside range of previous work's assumptions particularly in price elasticity.

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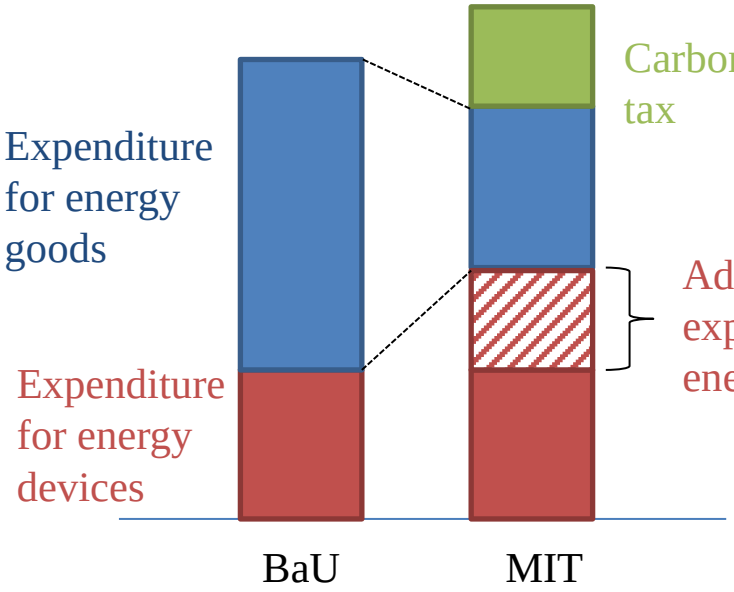
Discussions

GDP losses and how to account the energy device expenditure



Indicators	GDP			Household consumption		
Model type	BU		AGG	BU		AGG
Additional energy device cost in household	w/	w/o	-	w/	w/o	-
World	2.8	3.4	3.5	3.9	4.8	4.8
OECD	1.9	2.9	2.9	1.7	2.9	3.3
Asia	4.0	4.3	4.1	5.3	5.7	5.8
Reforming Economies	7.0	7.8	12.5	11.7	12.7	17.0
Middle East and Africa	2.0	2.3	2.7	8.3	8.7	5.4
Latin America	1.7	2.3	1.5	2.8	3.5	2.7

- Additional expenditure for energy device never contributes welfare so it would be excluded?
- Global losses in BU become closer to AGG.
- Regional differences are heterogeneous.
- BU model enables to distinguish the household additional expenditure for energy device and to show how the way of accounting matter with the macroeconomic indicators.
- But it does not mean that if the additional energy device expenditure in household is excluded, the macroeconomic losses are supposed to be always same as AGG model.

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Discussions

Sectoral energy and emission responses to mitigation

- The energy demand differences would be due to the difference of the function form.
- The aggregated model relies on the base year calibration but BU model is free from that.
  - The electric vehicle is never calibrated but expected in the future. BU model can deal with.
  - One of the advantages of the BU model

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Findings

- We developed a CGE model coupled with detailed energy end-use technology representation.
- Key results
  - Macro level impressions of the results are not so quite different.
  - Macroeconomic loss caused by mitigation is slightly less than previous models but how we account the household expenditure makes different results and interpretations.
  - The energy price elasticity and AEEI derived from the results are heterogeneous across regions and sectors.
  - The way how transport and household sectors reduce CO2 emissions are different and the proposed model showed high energy efficiency improvement and carbon factor reduction in particularly household sector
- The application of this model to individual Asian countries is desirable.

Limitations

- Parameters incorporated in the Logit function is arbitrarily assumed. It strongly requires behavioral studies or investigation.
- Energy service demand determination is also quite simplified.
- Energy end-use cost is actually part of the energy cost and infrastructure would substantially affect to the energy choices.