

Report on AIM/Enduse Model



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This report covers the basic guidelines about AIM/Enduse model and some examples of its application. The report is created based on the AIM/Enduse Model Manual provided from the National Institute for Environmental Studies (NIES) where I had training to learn the model as a visiting scholar. I would like to give special thanks to researchers at NIES for helping me learn to use the AIM/Enduse model.

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1. Overview of AIM/Enduse

AIM stands for the Asia-Pacific Integrated Model. The AIM/Enduse model is a bottom-up technology model to select the optimum technology systems in an economy when system cost is minimized under constraints such as satisfaction of service demand, availability of energy supplies and so on. System cost consists of fixed costs, the operating costs of technologies, energy costs, and other costs like taxes and subsidies. The AIM/Enduse model is useful for calculating set of technologies for the energy demand when total system cost is minimized based on the exogenously given energy price.

Objective function

Objective function of the AIM/Enduse model consists of the total annualized investment cost for recruitments in that year, total running cost, total cost of emission tax, and total cost of energy tax in that year.

Constraints

Although the details of the constraints in the AIM/Enduse model will not be explained in this report the objective function is minimized under the following constraints:

emission constraints, energy supply constraints, operating capacity constraints, service demand constraints, constraints for the internal service and internal energy balance, device share ratio constraints, share ratio constraints for group of devices, stock quantity constraints, recruitment quantity constraints, dynamic constraints on recruitment quantity, regional share constraints, and stock exchange constraints.

Steps to follow to conduct a certain policy scenario assessment

- 1) Building a conceptual model
- 2) Select the time horizon, units of money and energy, and units of service demand and devices
- 3) Collect data for the start year and estimate essential data needed for the assessment
- 4) Run the model and validate the dataset for the start year
- 5) Estimate the baseline data for the futures years

- 6) Run the model and validate the baseline data for the future years
- 7) Construct scenarios for policy analysis
- 8) Run model and compare the scenario results

To run the AIM/Enduse model all data need to be put into the “(file name) IN.xlsx” file and then run the Excel/VBA macro which creates the GAMS program files. Once the GAMS programs are created without errors you need to run the AIM_CMB.gms program. This program file produces the “(file name) PIVOT.xlsx” Excel file and the results will be shown in this file. The “(file name) PIVOT.xlsx” file shows the pivot table and this file can be used to see the pivot table as a figure.

2. Description of the software and its installation

Microsoft excel (2003 and 2007 versions) is used for the interface software for putting the data and showing the results. The General Algebraic Modeling System (GAMS) software is used to execute the program of AIM/Enduse. To install the GAMS program to your computer you need to follow the process below:

- 1) Make a folder “AIM_Enduse” in your local directory of your PC to install the AIM/Enduse Software.
- 2) Copy the folder “Src” and “inlib” to the folder “AIM_Enduse” you created under the local directory of your PC.
- 3) AIM/Enduse requires the CPLEX programming supplied in the GAMS so select CPLEX in your GAMS program.
- 4) You need to create the path environment variable for the GAMS program in your Windows OS.

3. Application for transportation, residential, and electricity generation sectors

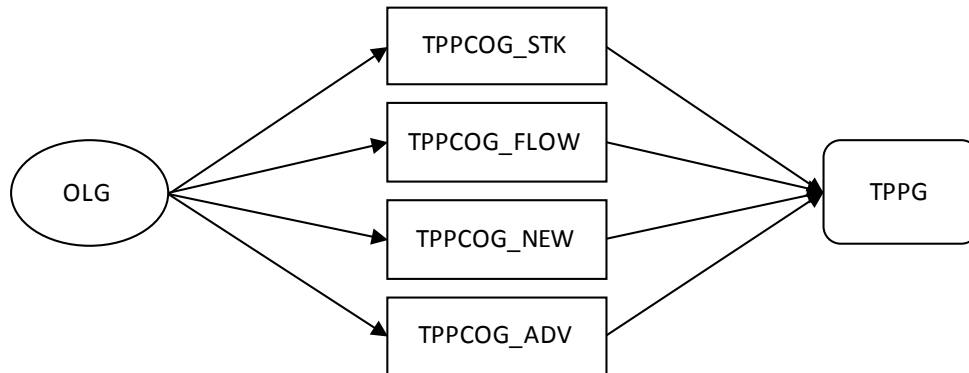
To show how the AIM/Enduse model can be used to estimate the level of CO₂ emission for a certain time in future and to see how that level will change under different scenarios, this report will provide some examples conducting the simulation for the transportation, residential, and electricity generation sectors.

3.1 Application for transportation sector

Here I would like to provide an example to find out the CO2 emission in 2030 for the transportation sector when basic data for the year 2005 for the transportation is given. The result will be compared with two scenarios. One scenario puts constraint on the maximum share of device in 2030 and the other one puts emission tax on the carbon price rate.

Figure 1 is the basic energy flow of this simulation. The sector and region used in this simulation was the “passenger gasoline car” and the “other South East Asia” region. In Figure 1, OLG (gasoline) is the type of energy used in this example, and TPPCOG_STK (Passenger gasoline car (stock average)), TPPCOG_FLOW (Passenger gasoline car (flow)), TPPCOG_NEW (High efficiency gasoline car), and TPPCOG_ADV (PRIUS (Hybrid gasoline car)) are the technologies or devices used to provide the service TPPG (Passenger gasoline car).

Figure 1.



Source: AIM Project Team, 2011

The simulation to find out the CO2 emission in 2030 for the transportation sector is conducted under the following assumptions (see AIM Project Team, 2011).

a. General setting of the simulation

Simulation start year	2005
Simulation end year	2030
Unit of price	1000\$US

Unit of Energy toe

b. Service demand of passenger gasoline car during 2005-2030 period

	2005	2020	2030
Passenger gasoline car demand (1000pkm)	120,000,000	200,000,000	300,000,000

c. Energy consumption of passenger gasoline car in 2005

2005	
Gasoline passenger car (toe)	3,000,000

d. Energy devices specification

	Stock in 2005	Efficiency (km/l)	Life time (Year)	Price (\$US)
Passenger gasoline car (stock average)	6,000,000	(estimation)	10	1,000
Passenger gasoline car (flow)	0	18	10	1,000
High efficiency gasoline car	0	26	10	1,500
PRIUS (Hybrid gasoline car)	0	38	10	1,800

e. Average usage characteristics per car

2005- 2030	
Average number of persons per car	2
Average km travel per car per year	10,000

f. Emission factor (kgCO2/kgoe)

2005-2030	
Gasoline	2.9

g. Energy price (\$US/kgoe)

	2005	2030
Gasoline	0.94	1.5

h. Maximum share of device in 2030 in each scenario

	Baseline	Counter-measure1	Counter-measure2
Passenger gasoline car (stock average)	0%	0%	0%
Passenger gasoline car (flow)	100%	100%	100%
High efficiency gasoline car	0%	100%	100%
PRIUS (Hybrid gasoline car)	0%	100%	100%

i. Emission tax and discount rate in each scenario from 2005 to 2030

	Baseline	Counter-measure1	Counter-measure2
Emission tax (\$US/kgCO ₂)	0	0	100
Energy tax (\$US/toe)	0	0	0
Discount rate (%)	33	33	33

j. Calorific values

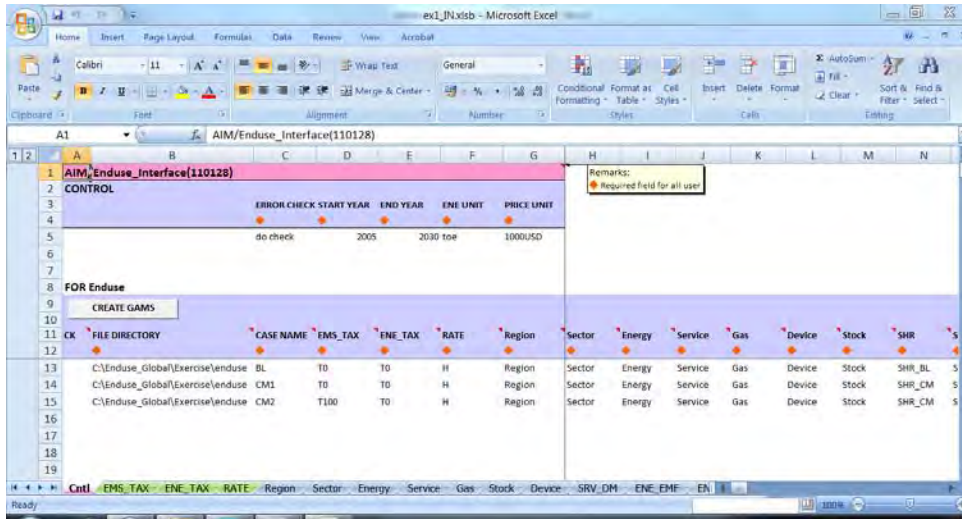
	Unit	Crude oil eq.(kl/Unit)	Tonnes of oil eq.(toe/Unit)
naphtha	1kl	0.88	0.81
kerosene	1kl	0.95	0.88
jet fuel	1kl	0.95	0.88
automobile gasoline	1kl	0.89	0.82
diesel	1kl	0.99	0.91
heavy fuel oil (A)	1kl	1.01	0.93
heavy fuel oil (C)	1kl	1.08	1.00
liquified petroleum gases (LPG)	1ton	1.30	1.20
liquified natural gases (LPG)	1ton	1.41	1.30
cooking coal	1ton	0.75*	0.69*

Note) *Varies by nation (ref) Energy Conservation Law, Japan, 2005; EDMC, 2007

These assumptions need to be put into the “(file name) IN.xlb” file under the Excel sheet and to conduct the simulation for this example the data need to be entered into the following sheets.

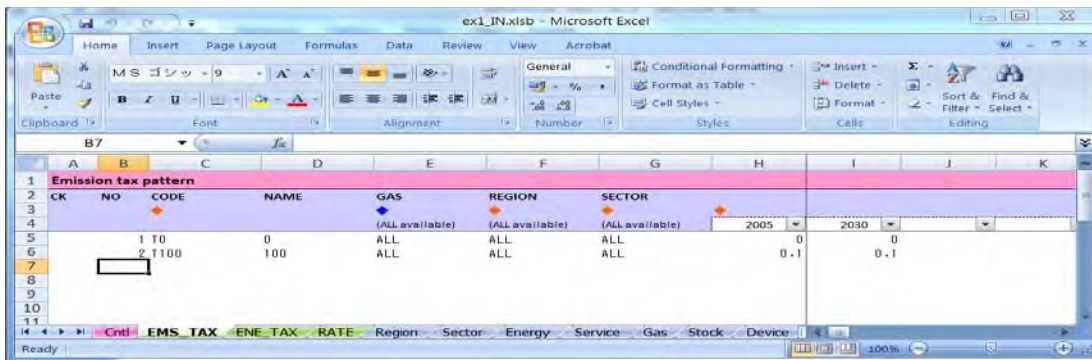
a. Cntl Sheet

This sheet is used to select the model type, time horizon and units of price and energy. It is also used to check which sheets are used for the simulation.



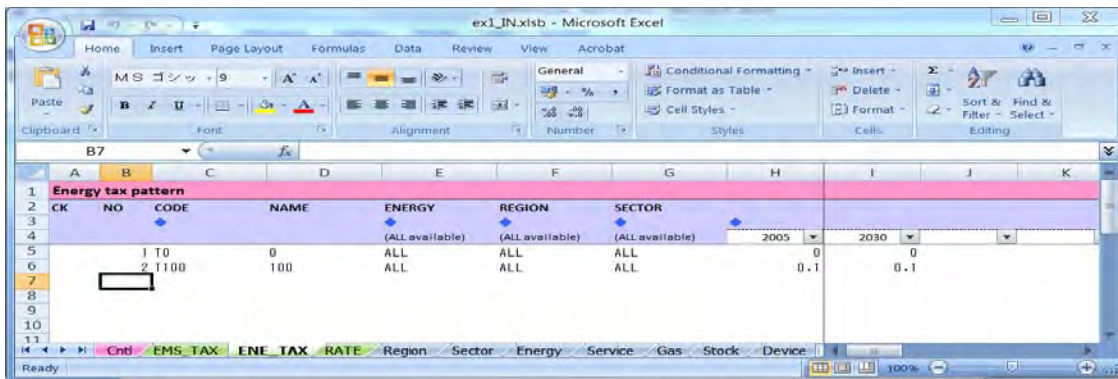
b. EMS_TAX Sheet

This sheet is used to set up the levels of carbon tax for the countermeasure scenarios. In this example the scenario of the countermeasure 2 puts 100 \$US/kgCO₂ of emission tax so you need to create a variable to represent this tax in this sheet (see below).



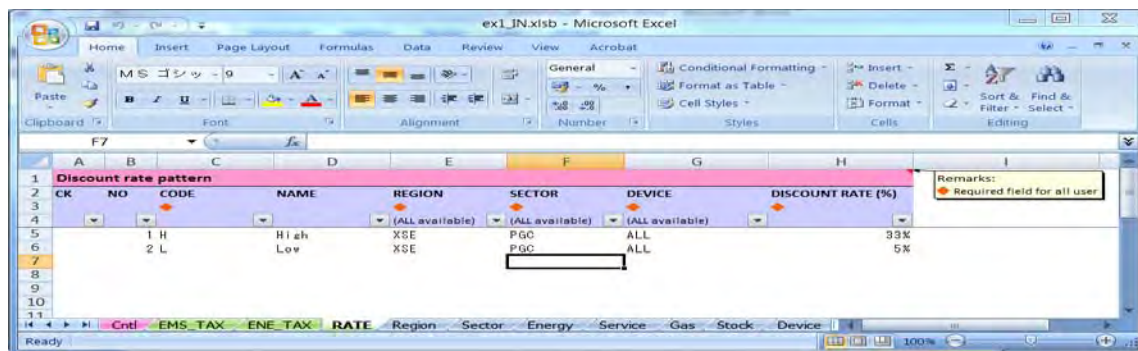
c. ENE_TAX Sheet

This sheet is used to set up the levels of energy tax for the counter-measure scenarios.



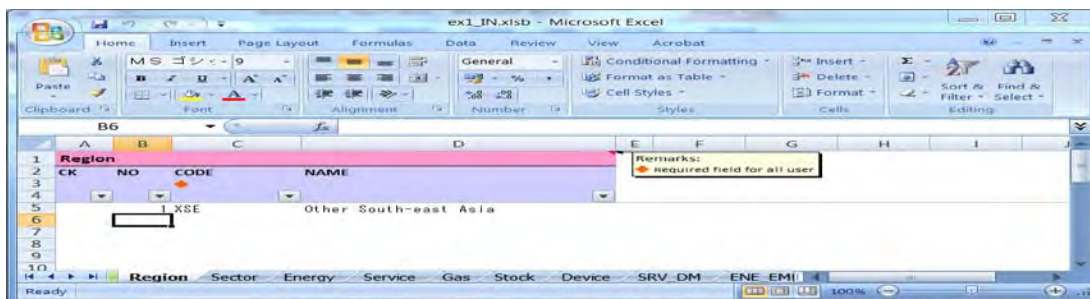
d. RATE sheet

This sheet is used to specify the discount rate pattern. Discount rate is used for economic criteria of technology selection considering the lifetime of technology options.



e. Region Sheet

This sheet is to state the name of the variable for the region. In this example the data for the simulation is the “Other South-east Asia” region so this information is put into this sheet.



k. Device sheet

This sheet is used to state the name of the code for each device and to set up the life time, initial cost, quantity of energy used, and type and quantity of service demand produced through the device. The energy device refers to the device which consumes energy and supply service in order to satisfy the service demand.

CK	NO	CODE	NAME	LIFE TIME	SHAPE PMT.	INITIAL COST	O&M COST	SECTOR	OUTI	OUTI
1	TPPCOG_STK		Passenger gasoline car (stock aver)	10	1	1.0	0	PGC	TPPG	1000pkm
2	TPPCOG_FLOW		Passenger gasoline car (flow)	10	1	1.0	0	PGC	TPPG	1000pkm
3	TPPCOG_NEF		High efficiency gasoline car	10	1	1.5	0	PGC	TPPG	1000pkm
4	TPPCOG_ADV		PRUIS	10	1	1.8	0	PGC	TPPG	1000pkm

CK	NO	CODE	NAME	LIFE TIME	SHAPE PMT.	INITIAL COST	O&M COST	INI	INI	UNIT	QNT	INE
1	TPPCOG_STK		Passenger gasoline car (stock aver)	10	1	1.0	0	OLG	flow	flow	0.50	
2	TPPCOG_FLOW		Passenger gasoline car (flow)	10	1	1.0	0	OLG	flow	flow	0.48	
3	TPPCOG_NEF		High efficiency gasoline car	10	1	1.5	0	OLG	flow	flow	0.32	
4	TPPCOG_ADV		PRUIS	10	1	1.8	0	OLG	flow	flow	0.22	

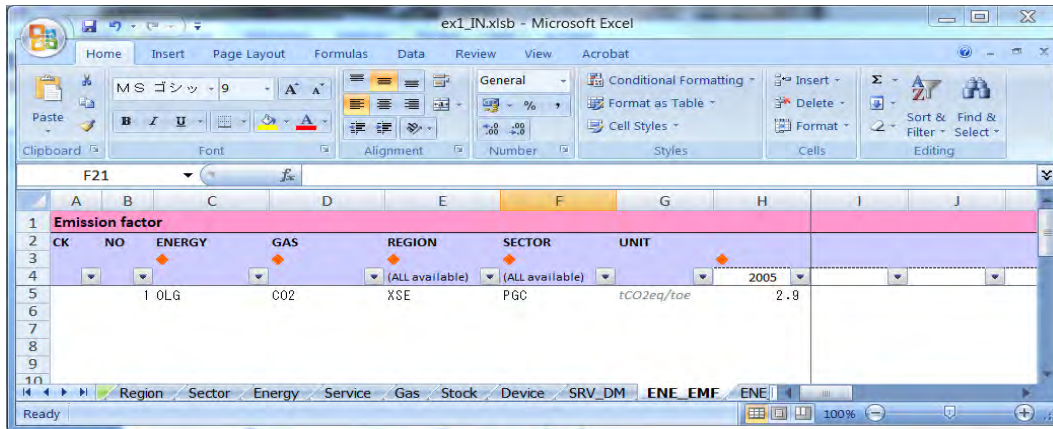
l. SRV_DM sheet

This sheet is to specify the volume of service demand in each service/region in the selected year. In this example the amount suggested in the assumption part is put into the sheet as below.

CK	NO	SERVICE	REGION	SECTOR	UNIT	2005	2020	2030
1	TPPG		XSE	PGC	1000pkm	120,000,000	200,000,000	300,000,000

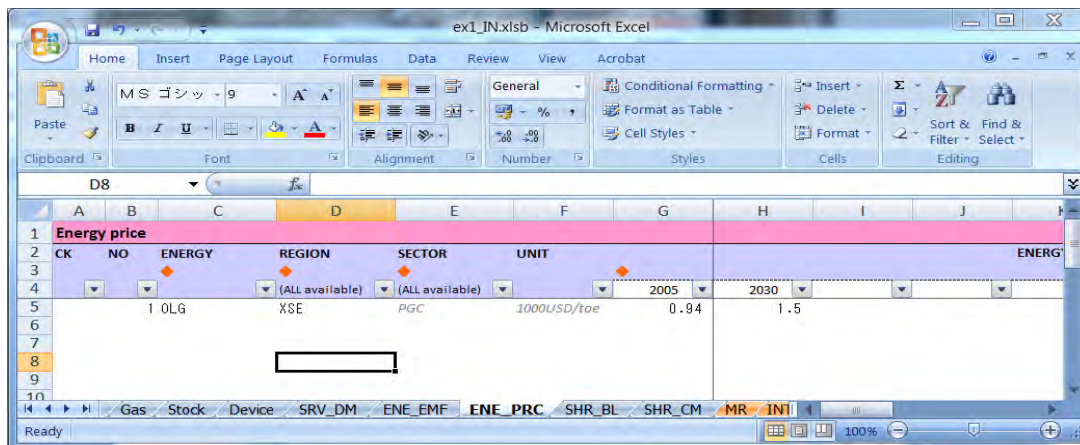
m. ENE_EMF sheet

This sheet is used to specify the value for the emission factor of the energy type. The Data for the emission factor should be obtained from reliable sources such as publications by ministries, government agencies, industry associations, and so on.



n. ENE_PRC sheet

This sheet is used to specify the value for the energy price of the energy type. Here too the data for the energy price should be obtained from reliable sources such as publications by ministries, government agencies, industry associations, and so on.



o. SHR sheet

This sheet is used to specify the maximum and minimum share for each energy device, which satisfies the service demand. The shares for the baseline scenario must be put in the SHR_BL sheet and that for the counter-measure scenario should be filled in the SHR_CM sheet as shown below.

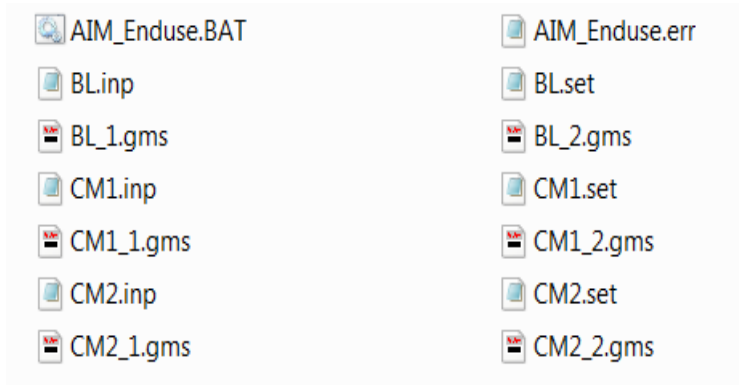
Sheet for the baseline scenario

CK	NO	DEVICE	SERVICE	REGION	SECTOR	2005		2030	
						MAX	MIN	MAX	MIN
	1	TPPCOG_STK	TPPG	XSE	PGC	100%	0%	0%	0%
	2	TPPCOG_FLOW	TPPG	XSE	PGC	0%	0%	100%	0%
	3	TPPCOG_NEW	TPPG	XSE	PGC	0%	0%	0%	0%
	4	TPPCOG_ADV	TPPG	XSE	PGC	0%	0%	0%	0%

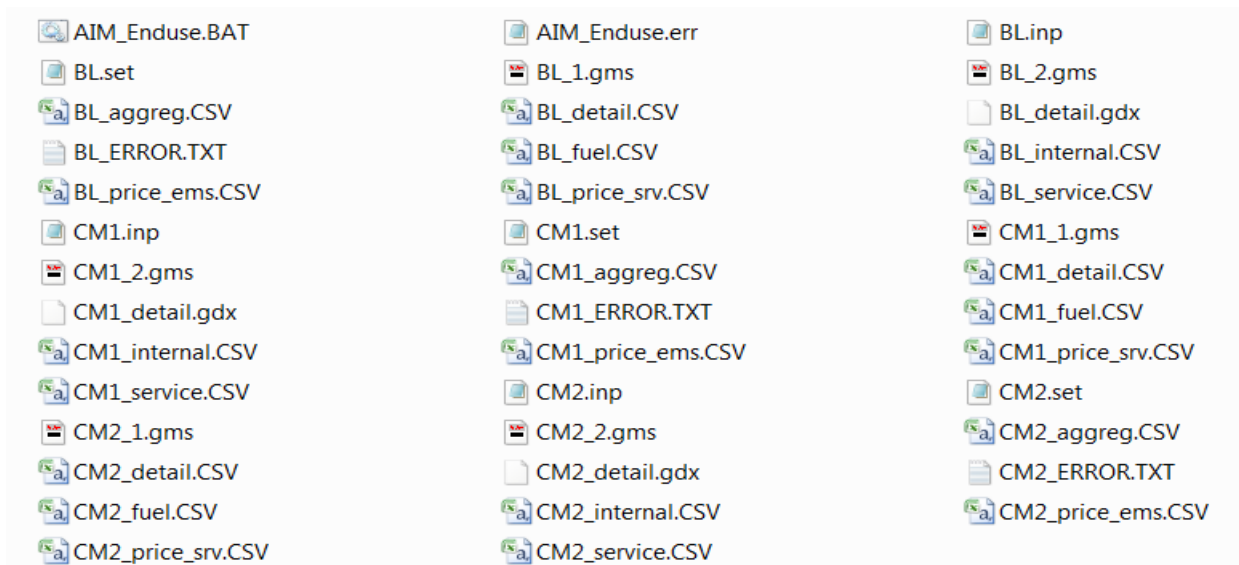
Sheet for the counter-measure scenario

CK	NO	DEVICE	SERVICE	REGION	SECTOR	2005		2030	
						MAX	MIN	MAX	MIN
	1	TPPCOG_STK	TPPG	XSE	PGC	100%	0%	0%	0%
	2	TPPCOG_FLOW	TPPG	XSE	PGC	0%	0%	100%	0%
	3	TPPCOG_NEW	TPPG	XSE	PGC	0%	0%	100%	0%
	4	TPPCOG_ADV	TPPG	XSE	PGC	0%	0%	100%	0%

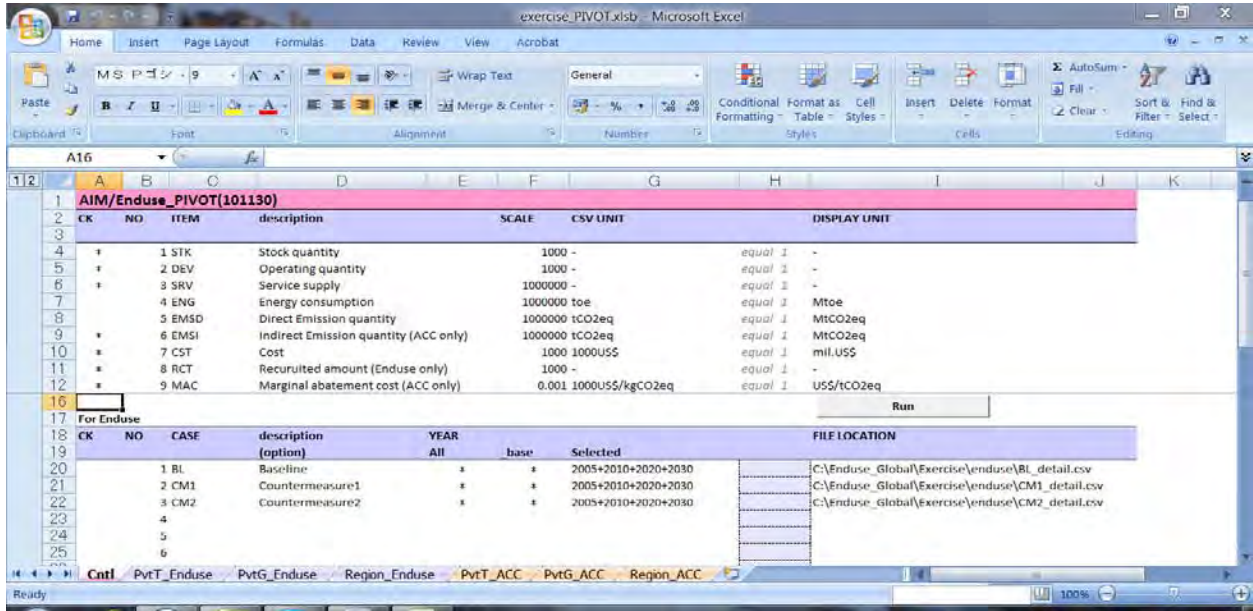
Once all the necessary data is filled in the sheets as shown above you need to run the Excel macro by clicking “CREATE GAMS” in the “Cntl” sheet and this will create the GAMS program to conduct the simulation. If there is any error in the data set you need to check the errors which can be found in the “(file name)_ERROR.TXT” file. When the macro runs successfully you should find the following files in the folder “AIM_Enduse” you created under your local directory.



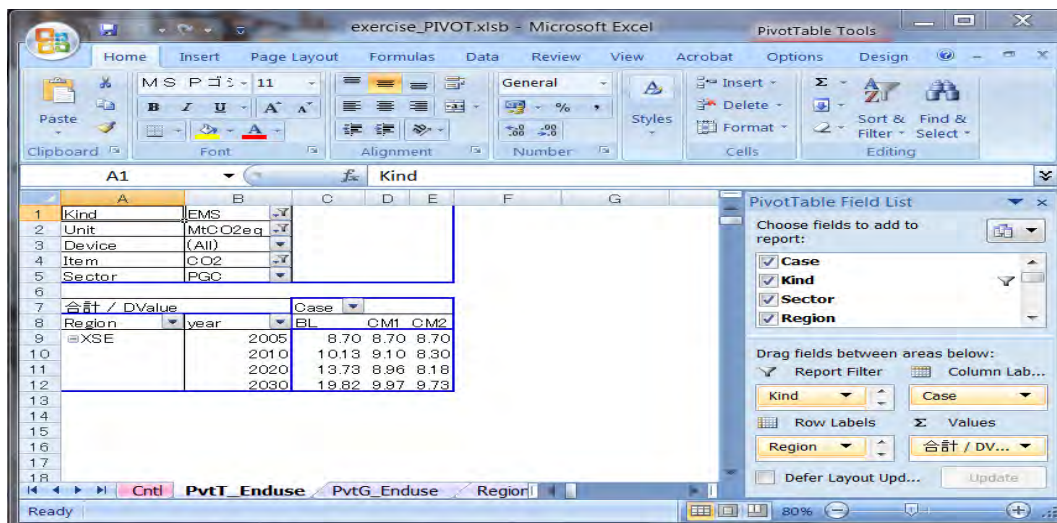
Then you need to run the “AIM_Enduse.BAT” file to run the GAMS program to get the results of the simulation. If the program runs without error, you should now see the following files created in the same folder of your local directory.

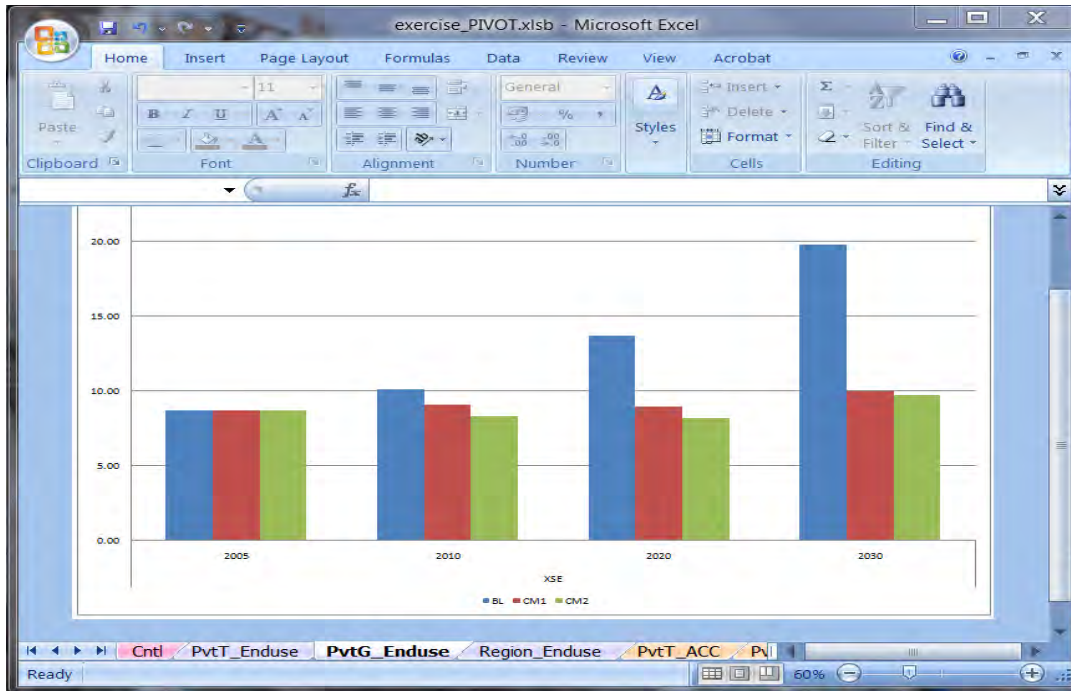


The “PIVOT.xlsb” file is used for checking the results. This file can be used to specify the results you want to see such as the result for the stock quantity, energy consumption, direct emission quantity, and so on. You need to make sure that the results file provided in CSV format is set in the correct file location. The asterisk “*” in the table below is used to exclude the variables to be estimated. So the example below only estimates the energy consumption (ENG) and direct emission quantity (EMSD).



Clicking the “Run” in the “Cntl” sheet of the PIVOT.xlsb” file will create the table and the figure of the results.





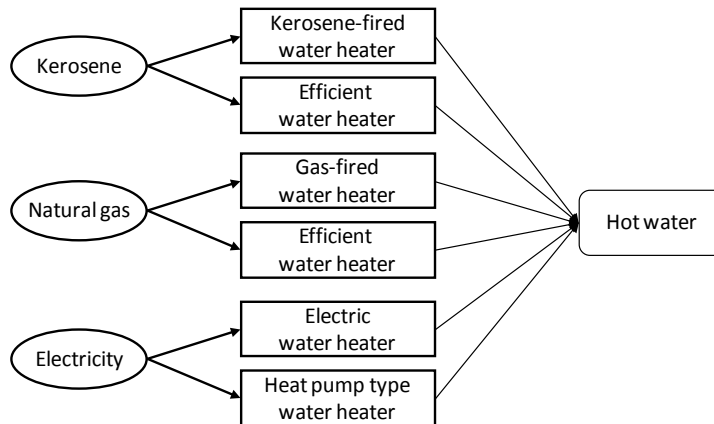
As shown in the table and figure above the simulated amount of CO2 emission in 2030 for the case of baseline, counter-measure 1, and counter-measure 2 became 19.82, 9.97, and 9.73.

3.2 Application for residential sector

As another example of AIM/Enduse model I would like to show a simulation to find out the CO2 emission in 2030 for the residential sector. As with the case for the transportation sector, the baseline scenario will be compared with two scenarios. One scenario puts constraint on the maximum share of device in 2030 and the other one puts emission tax on the carbon price rate in addition to the constraint on the maximum share.

Figure 2 illustrates the basic energy flow of this simulation. The sector used in this simulation was the residential sector and the region used was Japan. In Figure 2, kerosene, natural gas, and electricity are the type of energy source used in this example, and kerosene-fired water heater, efficient water heater for kerosene, gas-fired water heater, water heater for natural gas, electric water heater, and heat pump type water heater are the technologies or devices used to provide the service hot water.

Figure 2.



Source: AIM Project Team, 2011

The simulation to find out the CO₂ emission in 2030 for the residential sector is conducted under the following assumptions (AIM Project Team, 2011).

a. General setting of the simulation

Simulation start year	2005
Simulation end year	2030
Unit of price	1000\$US
Unit of Energy	toe

b. Number of households 2005-2030

	2005	2020	2030
Number of households (thousands)	50,000	51,000	49,000

c. Energy consumption for hot water supply in 2005

	Kerosene	Natural gas	Electricity
Energy consumption (ktoe)	5,000	5,000	800

d. Energy devices specification

	Stock in 2005	Efficiency (kgoe/kgoe)	Life time (Year)	Price (\$US)
Kerosene-fired water heater	24,000	0.75	10	3,360
Efficient kerosene water heater	0	0.9	10	3,600
Gas-fired water heater	24,000	0.75	10	3,360
Efficient gas water heater	0	0.9	10	3,600
Electric water heater	2,000	0.75	10	4,040
Heat pump type water heater	0	2.00	10	7,430

e. Energy specification

	Emission factor (kgCO2/kgoe)	Energy Price (\$US/kgoe)
Kerosene	2.8	0.86
Natural gas	2.1	1.37
Electricity	4.3	2.54

f. Maximum share of device in 2030 in each scenario

	Baseline	Counter- measure1	Counter- measure2
Kerosene water heater	40%	100%	100%
Efficient kerosene water heater	0%	100%	100%
Gas water heater	40%	100%	100%
Efficient gas water heater	0%	100%	100%
Electric water heater	20%	100%	100%
Heat pump type water heater	0%	100%	100%

g. Maximum share of each technology group in 2005, 2020, 2030

	2005	2020	2030
Group1: kerosene-type water heater	46%	40%	40%
Group2: gas-type water heater	46%	40%	40%
Group3: electricity-type water heater	7%	20%	20%

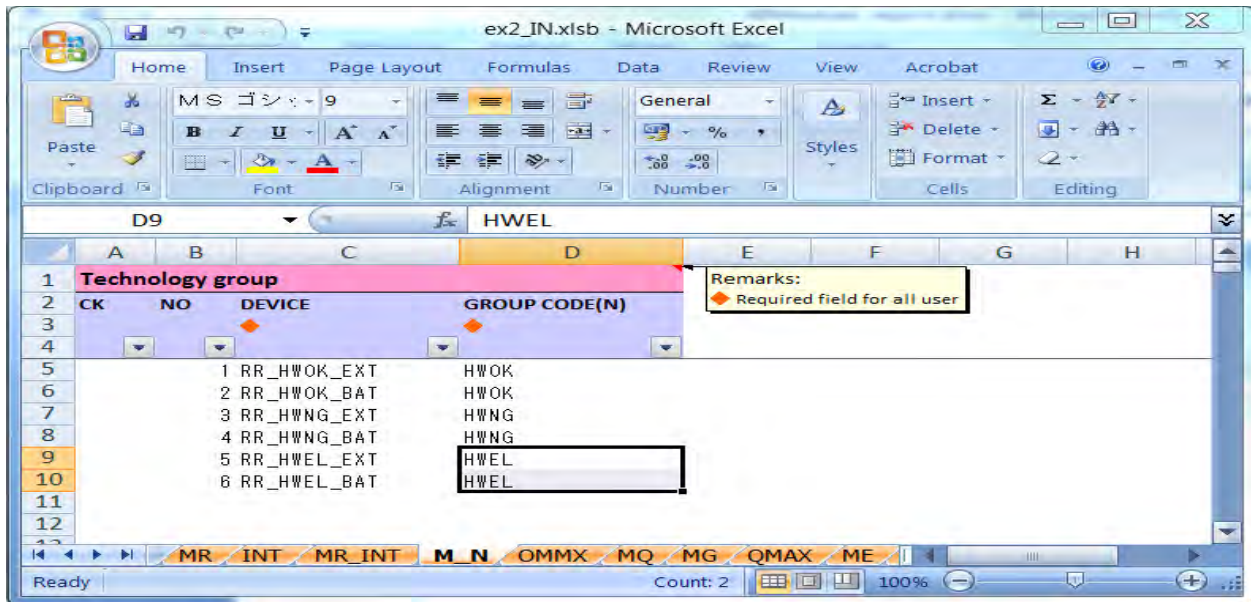
h. Emission tax and discount rate in each scenario from 2005 to 2030

	Baseline	Counter-measure1	Counter-measure2
Emission tax (\$US/kgCO ₂)	0	0	100
Energy tax (\$US/toe)	0	0	0
Discount rate (%)	33	33	33

The difference of this simulation from the example of the transportation sector is that here you need to specify the maximum share of each technology group for certain years. So besides putting the data into the same sheets as explained in the example for the transportation sector, you will also need to create a technology group variable using the M_N sheet in the “(file name) IN.xlsb” file and also specify the share of technology group using the OMMX sheet.

M_N Sheet

This sheet is used to create a code to specify the technology group. In this example for the residential sector the six technologies kerosene-fired water heater (HWOK_EXT), efficient water heater for kerosene (HWOK_BAT), gas-fired water heater (HWNG_EXT), efficient gas water heater (HWNG_BAT), electric water heater (HWEL_EXT), and heat pump type water heater (HWEL_BAT) are formed into three technology groups (kerosene-type water heater (HWOK), gas-type water heater (HWNG), and electricity-type water heater (HWEL)).



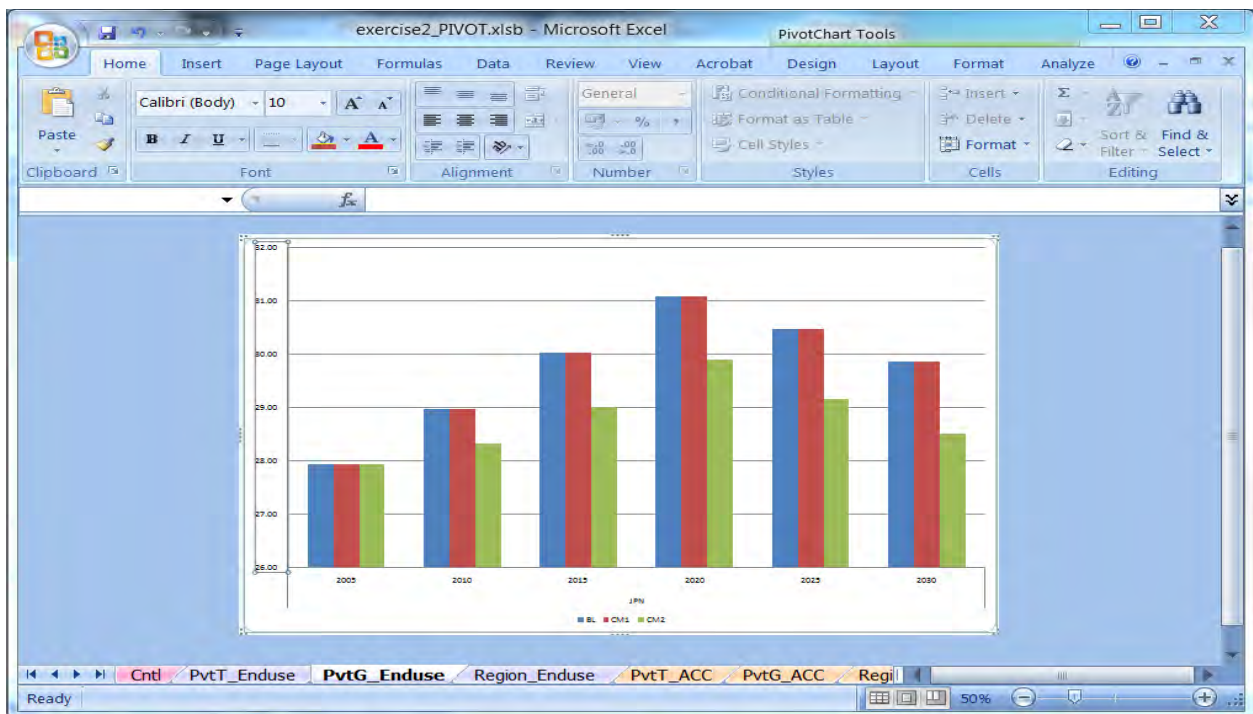
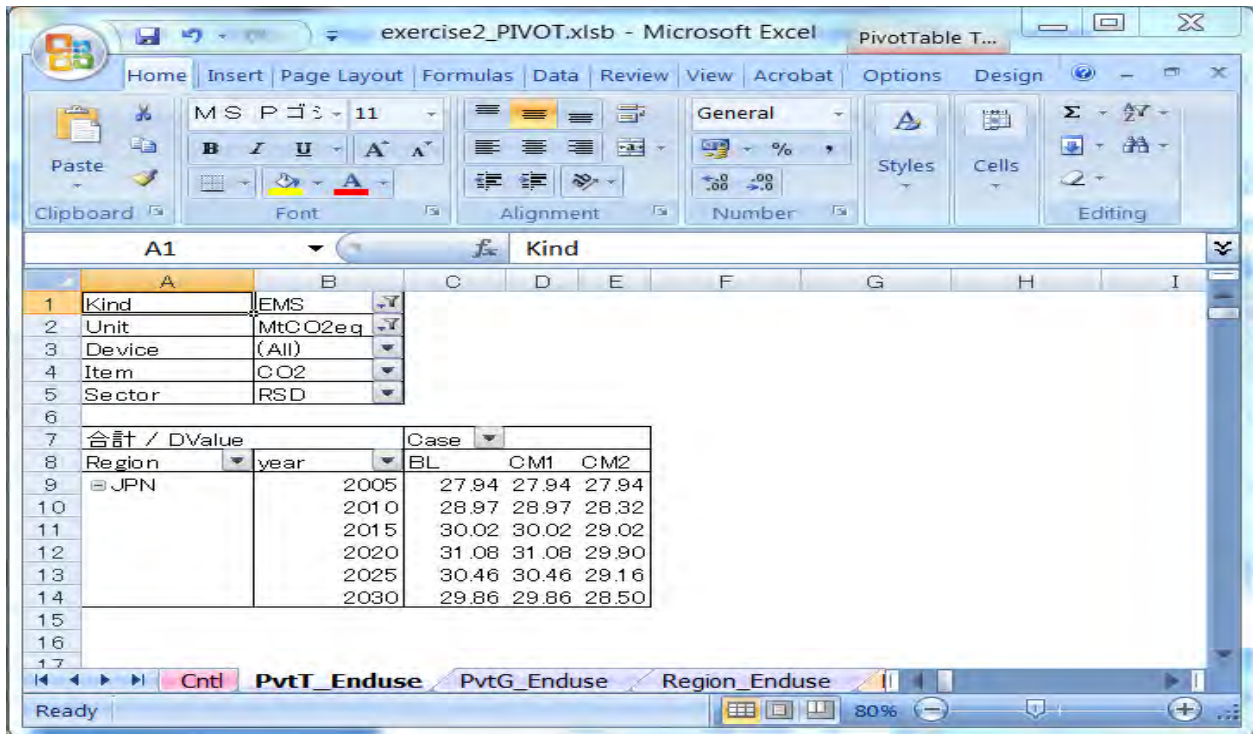
OMMX sheet

This sheet is used to specify the values for maximum or minimum allowable service share of technology groups. In this example for the residential sector, the assumptions provided for the three technology groups (kerosene-type water heater, gas-type water heater, and electricity-type water heater) for the years 2005, 2020, 2030 are entered into this sheet as below.

CK	NO	GROUP(N)	REGION	SECTOR	SERVICE	MAX/MIN	2005	2020	2030
	1	HWOK	JPN	RSD	RHW	MAX	46%	40%	40%
	2	HWNG	JPN	RSD	RHW	MAX	46%	40%	40%
	3	HWEL	JPN	RSD	RHW	MAX	7%	20%	20%

Once all the necessary data is filled in the “(file name) IN.xlsx” file, you need to run the Excel macro provided in the “Cntl” sheet by clicking “CREATE GAMS.” This will create the GAMS program to conduct the simulation. Once again if there is any error in the data set you need to check the errors which can be found in the “(file name)_ERROR.TXT” file. When the macro runs successfully you should find the GAMS program created in the “AIM_Enduse” folder you created under your local directory. Then you need to run the “AIM_Enduse.BAT,” which is the GAMS program, to get the results of the simulation. If the program runs without error you should now be able to see the results.

As shown in the case for the transportation sector the “PIVOT.xlsx” file is used for checking the results. Clicking the “Run” in the “Cntl” sheet of the PIVOT.xlsx” file will create the table and the figure of the results.

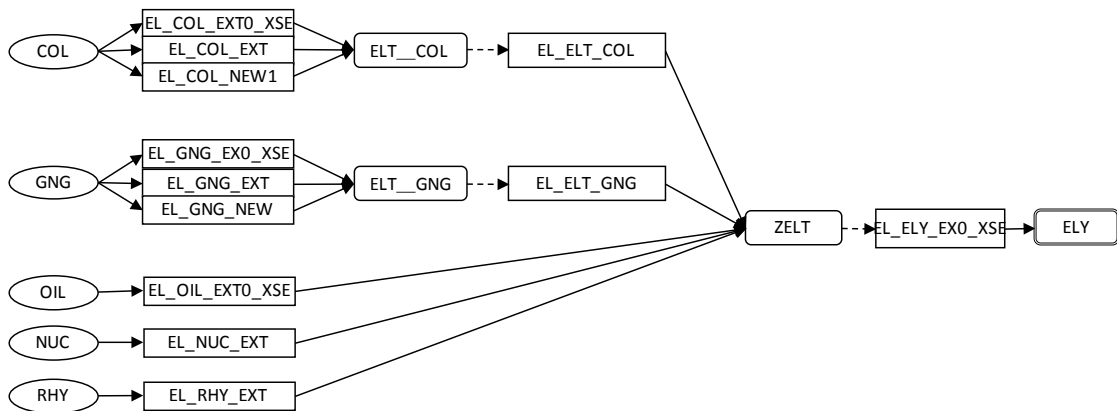


The table and figure above show the simulated amount of CO2 emission for 2010 through 2030 for the case of baseline, counter-measure 1, and counter-measure 2. The CO2 emission for 2030 for the three cases became 29.86, 29.86, and 28.50.

3.3 Application for electricity generation sector

Finally, I will show an example of the use of AIM/Enduse model conducted on the electricity generation sector. Here too the baseline scenario will be compared with the scenario putting constraint on the maximum share of device for 2030, and the scenario imposing emission tax on the carbon price rate in addition to the constraint on the maximum share. The basic energy flow for this simulation is summarized in Figure 3. In the figure below COL (coal), GNG (gas), OIL (oil), NUC (nuclear), and RHY (hydro) are the types of energy used in this example, and EL_COL_EXT0_XSE (transmission Loss), EL_COL_EXT (inefficient coal), EL_COL_New (efficient coal), EL_GNG_EXT0_XSE (stock for gas), EL_GNG_EXT (inefficient gas), EL_GNG_New (efficient gas), EL_OIL_EXT0_XSE (stock for oil), EL_NUC_EXT (nuclear power), and EL_RHY_EXT (hydro power) are the technologies or devices used to provide the final service ELY (electricity). There are also internal energy or service in this example: ELT_COL (electricity produced from coal), ELT_GNG (electricity produced from gas), and ZELT (internal service that combines energy produced from various types of electricity sources). The internal service or energy is any energy or material that is produced or consumed within the model.

Figure 3.



Source: AIM Project Team, 2011

The assumptions used for this simulation example to find out the CO2 emission in 2030 for the electricity generation are the followings (AIM Project Team, 2011).

a. General setting of the simulation

Simulation start year	2005
Simulation end year	2030
Unit of price	1000\$US
Unit of Energy	toe

b. Electricity demand projection 2005-2030 (GWh)

	2005	2020	2030
Value (GWh)	95,000	150,000	200,000

c. Net electricity production in 2005 (GWh)

	Coal	Oil	Gas	Nuclear	Hydro
Value (GWh)	30,000	9,000	26,000	30,000	5,000

d. Fuel consumption in electricity generation sector in 2005 (ktoe)

	Coal	Oil	Gas
Value (ktoe)	10,320	2,580	5,590

e. Energy device specification (power plant)

	Stock in 2005(MW)	Efficiency (%)	Life time (Year)	Price (\$US/KW)	Operating rate(%)
Coal-fired power plant (stock average)	4,892	(estimation)	40	2,500	70
Coal-fired power plant, Inefficient	0	28	40	2,500	70
Coal-fired power plant, Efficient	0	35	40	2,800	70
Gas-fired power plant (stock average)	4,240	(estimation)	40	2,000	70
Gas-fired power plant, Inefficient	0	42	40	2,000	70
Gas-fired power plant, Efficient	0	45	40	2,300	70
Oil-fired power plant (stock average)	1,468	(estimation)	40	2,700	70
Nuclear power generation	4,892	33	30	3,000	70
Hydro power generation	2,283	100	30	7,000	25

f. Energy device specification (transmission loss)

	Stock in 2005(toe)	Efficiency (%)	Life time (Year)	Price (\$US/toe)	Operating rate(%)
Transmission loss	8,170	95	30	0.001	100

g. Emission factor (kgCO2/kgoe)

	Coal	Oil	Gas
Value (kgCO2/kgoe)	4.0	3.2	2.3

h. Energy price (\$US/kgoe)

	2005	2030
Coal	0.071	0.119
Oil	0.512	0.811
Gas	0.262	0.579

i. Maximum share of device in each energy type in 2030 in each scenario

	Energy Type	Baseline	Counter-measure1	Counter-measure2
Coal-fired power plant (stock average)	Coal	37.5%	37.5%	37.5%
Coal-fired power plant, Inefficient	Coal	100%	100%	100%
Coal-fired power plant, Efficient	Coal	0%	100%	100%
Gas-fired power plant (stock average)	Gas	37.5%	37.5%	37.5%
Gas-fired power plant, Inefficient	Gas	100%	100%	100%
Gas-fired power plant, Efficient	Gas	0%	100%	100%
Oil-fired power plant (stock average)	Oil	100%	100%	100%
Nuclear power generation	Nuclear	100%	100%	100%
Hydro power generation	Hydro	100%	100%	100%
Transmission loss	-	100%	100%	100%

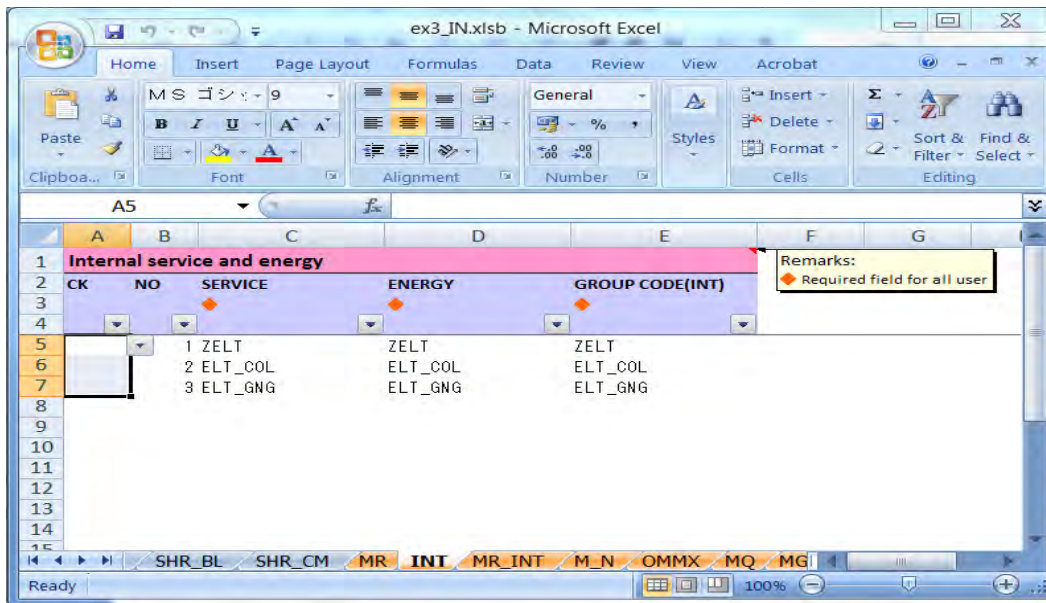
j. Emission tax and discount rate in each scenario from 2005 to 2030

	Baseline	Counter-measure1	Counter-measure2
Emission tax (\$US/kgCO2)	0	0	100
Energy tax (\$US/toe)	0	0	0
Discount rate (%)	33	33	33

Similar to the examples of the transportation and the residential sectors, the following sheets have to be initially filled in with the data based on the above assumptions: “Cntl” sheet, “EMS_TAX” sheet, “ENE_TAX” sheet, “RATE” sheet, “Region” sheet, “Sector” sheet, “Energy” sheet, “Service” sheet, “Gas” sheet, “Stock” sheet, “Device” sheet, “SRV_DM” sheet, “ENE_EMF” sheet, “ENE_PRC” sheet, and “SHR” sheet. In addition to these sheets the “INT”, “MR_INT”, and “GAM” sheets are also used in this example.

INT Sheet

This sheet is used to specify the relationship between the internal energy and service. This sheet needs to be set when a certain device consumes input of energy or service that is an output from another device.



MR_INT sheet

This sheet is used to link the internal service and energy groups with the region code.

CK	NO	GROUP(INT)	REGION, GROUP(MR)
	1	ZELT	XSE
	2	ELT_COL	XSE
	3	ELT_GNG	XSE

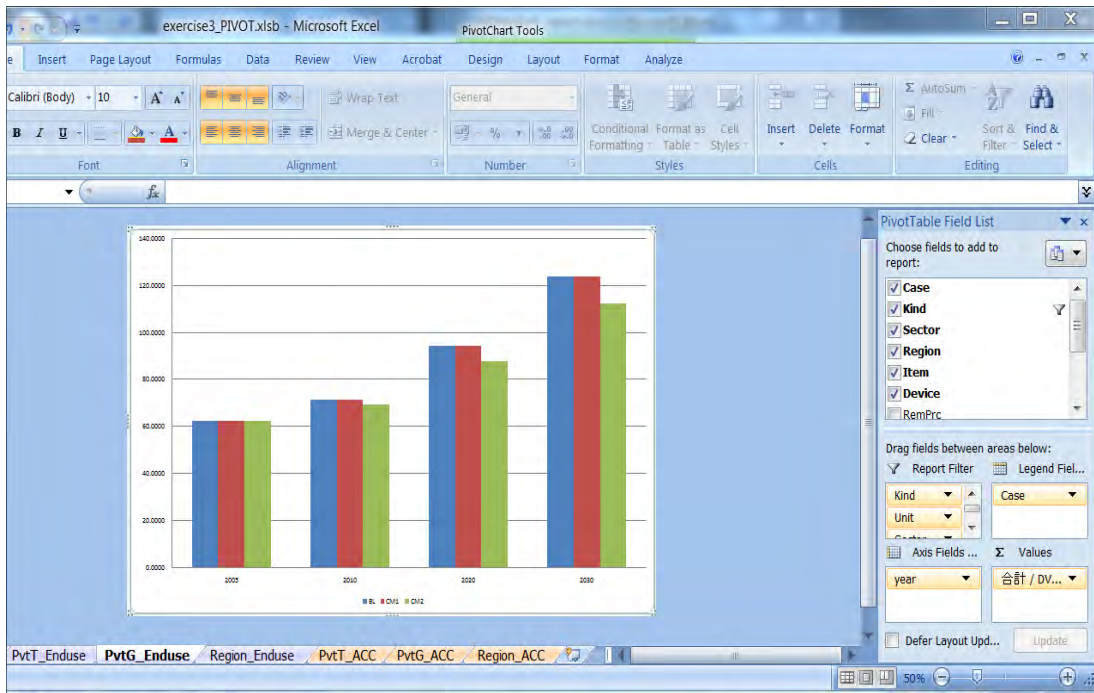
GAM sheet

This sheet is used to specify the operating efficiency improvement of a device. In this example this sheet is filled in by using the operation rate of the device which was provided in the assumption.

CK	NO	REGION	SECTOR	DEVICE	IMPRO
	1	XSE	ELE	EL_ELY_EXT0_XS	100%
	2	XSE	ELE	EL_ELT_COL	70%
	3	XSE	ELE	EL_ELT_GNG	70%
	4	XSE	ELE	EL_COL_EXT0_XS	70%
	5	XSE	ELE	EL_COL_EXT	70%
	6	XSE	ELE	EL_COL_NEW	70%
	7	XSE	ELE	EL_GNG_EXT0_XS	70%
	8	XSE	ELE	EL_GNG_EXT	70%
	9	XSE	ELE	EL_GNG_NEW	70%
	10	XSE	ELE	EL_OIL_EXT0_XS	70%
	11	XSE	ELE	EL_NUC_EXT	70%
	12	XSE	ELE	EL_RHY_EXT	25%

When all the sheets in the “(file name) IN.xlb” file are filled in with the necessary data, you need to run the Excel macro provided in the “Cntl” sheet by clicking “CREATE GAMS.” This creates the GAMS program and when you succeed running the program without error, you should find the GAMS file “AIM_Enduse.BAT.” Running this file provides you the results of the simulation. The table and the figure below is the simulation result of this example.

合計 / DValue	Case			
year	BL	CM1	CM2	
2005	62.3930	62.3930	62.3930	
2010	71.4812	71.4812	69.5412	
2020	94.2291	94.2291	87.7609	
2030	123.5979	123.5979	112.0935	



The table and figure above show the simulated amount of CO₂ emission for 2010 through 2030 for the case of baseline, counter-measure 1, and counter-measure 2. The CO₂ emission for 2030 for the three cases became 123.6, 123.6, and 112.1.

References

AIM Project Team. 2011. *AIM/Enduse Model Manual Ver3*. National Institute for Environmental Studies (NIES).

Kainuma, M., Matsuoka, Y., and Morita, T., eds. 2002. *Climate Policy Assessment: Asia-Pacific Integrated Modeling*. Springer, Berlin.