LOW CARBON SOCIETY SCENARIO
SEMARANG 2030
Research Model

The phenomenon of climate change in the last few decades has become one of the strategic issues for all over the world, including Indonesia. At the G20 Summit in Pittsburgh and COP15 in Copenhagen, Indonesia is committed to taking part in reducing greenhouse gases (GHG) by 26% with domestic resources and 41% with international assistance in 2020. The commitments are then followed up by the formulation of Presidential Regulation No. 61/2011 and No. 71/2011 on national action plans for GHG reduction. This regulation provides the basis for ministries, institutions and local governments to implement programs/activities aimed at reducing GHG emissions from key development sectors. The Presidential Regulation has mandated local governments to develop Local Action Plans for Greenhouse Gas Emission Reduction. Moreover, Indonesia has set unconditional reduction target of 29% and conditional reduction target up to 41 % of the business as usual scenario by 2030 in Intended Nationally Determined Contribution (INDC) in 2015.

Following up the Presidential Regulation 61/2011 and 71/2011, Semarang City as one of the cities in Indonesia has a liability in the GHG reduction activities. This research on the low carbon society (LCS) scenario for Semarang City are carried out aiming to contribution to promoting climate change actions and policies in the city. This study is one of the outcomes of the collaboration among Municipality of Semarang, Diponegoro University and Asia-Pacific Integrated Model (AIM) team in Japan.

The research are begun with collecting data and information related to socioeconomic parameters and energy consumption. A lot of domestic and international sources are used to estimate both current and future status of Semarang City. The entire data is processed with the help of Extended Snapshot (ExSS) tool. ExSS is applied for the projection of carbon dioxide (CO_2) emission and design of LCS scenario. This preliminary research focuses on energy-related CO_2 emission.

Semarang City's CO_2 emission is estimated to be 5,282 $ktCO_2e$ in 2015 based on collected data. The industry sector is a sector emitting the largest CO_2 in Semarang City. This sector accounts for nearly half of the total emission.

Two kinds of scenarios, namely Business as Usual (BaU) scenario and Countermeasure (CM) scenario, are prepared to analyze reduction potential of CO_2 emission in future. In BaU scenario, it is assumed that there is no policy or technology intervention to reduce carbon emission, while attempt to reduce carbon emission is assumed in CM scenario. In the CM scenario, Semarang City Government will promote five LCS actions and implement various LCS projects belonged to the actions. One of the action named "Sustainable Transport", which promotes energy efficient vehicle and modal shift, will contribute to the reduction of 4,220 $ktCO_2e$. These actions and projects help Semarang City to reduce total CO_2 emission in 2030 by 29% compared to BaU scenario. CO_2 emission per GDP, which is 39.4 tCO_2e/bil. Rp in 2015, will be decreased to 26.9 tCO_2e/bil. Rp in BaU scenario and to 19.2 tCO_2e/bil. Rp in CM scenario by 2030. Besides, CO_2 emission per capita is 3.3 tCO_2e/person in 2015 and will be increased by more than 3 times from 2015 to 2030 in BaU scenario. On the other hand, it will be reduced to 7.8 tCO_2e/person from BaU scenario in CM scenario.

In conclusion, Semarang City has a potential to reduce CO_2 emission corresponding to INDC of Indonesia. The city can be developed more effectively and efficiently with contribution to the mitigation of world climate change.

Table 1. CO_2 emission by sector

	2015	2030BaU	2030CM	2030BaU/2015	2030CM/2030BaU
CO_2 emission ($ktCO_2e$)	**5,282**	**22,409**	**16,009**	**4.24**	**0.71**
Industry	2,524	14,577	10,826	5.77	0.74
Commercial	571	4,042	2,665	7.08	0.66
Residential	748	1,174	862	1.57	0.73
Passenger transport	1,351	2,093	1,246	1.55	0.60
Freight transport	87	523	410	5.99	0,78
CO_2 emission per GDP (tCO_2e/bil. Rp)	39.4	26.9	19.2	0.68	0.71
CO_2 emission per capita (tCO_2e/person)	3.3	10.9	7.8	3.29	0.71

SOCIOECONOMIC VISION

Based on collected data of Semarang City in 2015 and information such as the national economic vision, "Masterplan for Acceleration and Expansion of Indonesia's Economic Development 2011-2025", socioeconomic indicators for 2030 has been projected as shown in Table 2. There will have been an increase in the number of each socioeconomic factor by 2030.

Table 2. Main socioeconomic indicators in Semarang City

	Unit	2015	2030	2030/2015
Population	persons	1,595,267	2,060,000	1.29
No. of households	households	471,327	686,667	1.46
GRDP per capita	mil. Rp	84	405	4.81
GRDP	bil. Rp	134,207	834,197	6.22
Primary industry		1,373	3,590	2.61
Secondary industry		73,340	440,906	6.01
Tertiary industry		59,493	389,701	6.55
Final consumption	bil. Rp	79,822	486,134	6.09
Gross capital formation	bil. Rp	99,697	607,179	6.09
Export	bil. Rp	37,563	228,772	6.09
Import	bil. Rp	114,672	690,811	6.02
Commercial floor area	thous. m^2	50,252	330,043	6.57
Transport demand				
Passenger transport	mil. pass-km	18,342	28,422	1.55
Freight transport	mil. ton-km	3,391	20,307	5.99

Population and Household

Population of Semarang City will grow by 464,733 people from 2015 to 2030 or 1.29 times as much as population in 2015. This situation is similar to the number of households in Semarang City. The number of households will also increase by 1.46 times compared to the number in 2015. Growth of the number of households is a little bit faster than population growth because household size will be-

Macro Economy

As described in Table 2, the increase of macroeconomic indicators occurred by 2030 is about 6 times as much as the value in 2015. There are three aspects underlying the macroeconomic conditions which are gross regional domestic product (GRDP), GRDP per capita and final consumption expenditure.

First, the value of GRDP in 2015, which amounted to 134,207 bil. Rp, will have increased to as big as 834,197 bil. Rp by 2030. Manufacturing of food, textile and transport equipment and Information and communication technology (ICT) industry will lead the economic growth of this area as written in the masterplan. The largest contributor to GRDP in Semarang City is the secondary sector. Table 3 and Figure 1 indicate the change of economic structure in Semarang City. GRDP of Semarang City in 2030 will still be dominated by the secondary sector, especially the construction industry, followed by the tertiary sector, and the last is the primary sector. Nevertheless, the increase in GRDP in the secondary sector is not greater than that of the tertiary sector. Growth rates of the primary, secondary and tertiary sectors between 2015 and 2030 are 2.61 times, 6.01 times and 6.55 times.

Table 3. GRDP by economic activity

	2015	2030	2030/2015
Primary industry	**1,373**	**3,590**	**2.61**
Secondary industry	**73,340**	**440,906**	**6.01**
Mining and quarrying	261	1,414	5.41
Foods, beverage and tobacco	17,885	110,507	6.18
Paper, paper products and printing	408	2,165	5.30
Chemicals and pharmaceuticals	6,785	35,783	5.27
Non-metal mineral products	459	1,490	3.24
Basic metals	2,840	17,264	6.08
Metal products, machinery and equipment	2,804	17,162	6.12
Other manufacturing	5,695	32,959	5.79
Construction	36,201	222,162	6.14
Tertiary industry	**59,493**	**389,701**	**6.55**
Electricity, gas, water and waste	250	1,658	6.62
Wholesale and retail trade	18,966	124,395	6.56
Transport and communications	14,669	99,352	6.77
Financial, real estate and company services	10,452	67,700	6.48
Other services	15,157	96,597	6.37
Total	**134,207**	**834,197**	**6.22**

Second is GRDP per capita. GRDP per capita in 2015 was 84 mil. Rp and will have reached to 405 mil. Rp by 2030. GRDP per capita will increase by 4.81 times compared with that in 2015.

As a result of population growth and income increase caused by economic growth, final consumption expenditure in the year 2030 will also have increased rapidly. The increase in the year 2030 equals to 6.09 times as large as that in 2015. There is a connection between consumption expenditure and GRDP, especially in the high increase in tertiary sectors, namely Transport and communications; Electricity, gas, water and waste; Wholesale and retail trade; and Financial, real estate and company services.

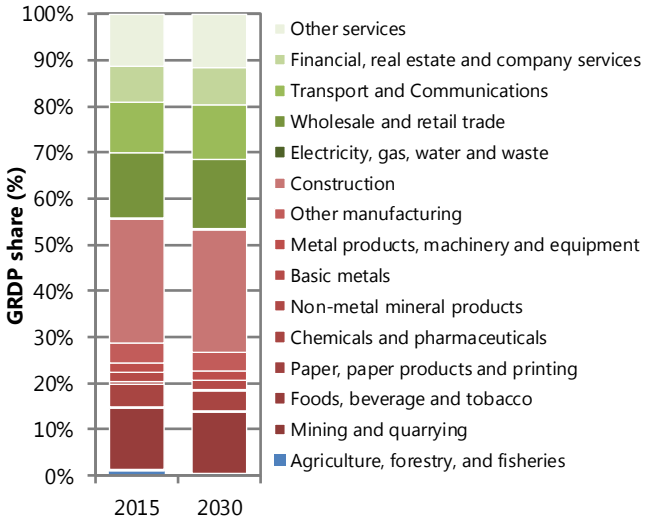

Figure 1. GRDP share by economic activity

Transportation

In connection with the increasing socioeconomic aspects of Semarang City, transport demand will also grow by 2030. Freight transport volume will increase by 5.99 times from 2015, while growth rate of passenger transport volume between 2015 and 2030 is 1.55. Freight transport demand will change rapidly leaded by the growing manufacturing output.

Figure 2 describes modal share in passenger transport . In BaU scenario, modal share is assumed not to be changed from 2015. On the other hand, modal shift from motorbikes and private cars to public transportation such us buses, bus rapid transits (BRTs) and railways are expected in CM scenario. Modal share of public transportation will have reached to 25% by 2030 in CM scenario.

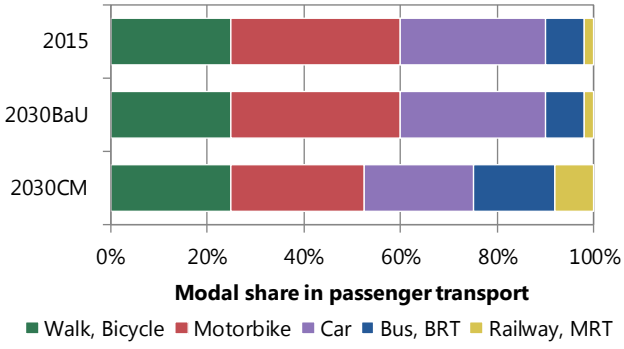

Figure 2. Modal share in passenger transport

ENERGY DEMAND AND SUPPLY

Under BaU scenario, final energy consumption will increase by 2,22 times in 2030 compared to 2015. The amount of energy consumed, which was 1,682.8 ktoe in 2015, will have increased to 6,149.6 ktoe in 2030. Table 4 describes that the industry sector will still be the highest energy consumer with the increase in 2030. However, the most rapid growth of energy consumption does not occur in the industry sector, but in the commercial sector instead. Energy consumption of the commercial sector in 2030 will be 7.08 times as much as that in 2015.

In contrast, energy consumption in CM scenario will be 27% lower than that in BaU scenario owing to implementation of LCS projects. Energy consumption will be reduced significantly in the passenger transport sector. The reduction rate compared with BaU scenario is 41%. According to Figure 3, oil will still dominate share of energy source in 2030, but it will have begun to switch from coal and oil to natural gas and electricity as a source of energy especially in CM scenario. Furthermore, use of solar energy will increase for heating water in the residential and commercial sector in CM scenario though the share in total energy demand is still small.

Regarding energy mix in power generation, share of renewable source such as solar, wind, geothermal and biomass energy will have increased to 17% in CM scenario as the national power development plan is implemented (Figure 4). CO_2 emission factor will be improved from 10.07 tCO_2/toe in 2015 to 7.74 tCO_2/toe in 2030 CM scenario.

Table 4. Final energy consumption by sector (ktoe)

Sector	2015	2030BaU	2030CM	BaU/2015	CM/BaU
Industry	731.6	4,139.9	3,483.6	5.66	0.84
Commercial	71.7	507.6	442.5	7.08	0.87
Residential	392.2	615.8	605.1	1.57	0.98
Passenger transport	457.7	709.2	421.0	1.55	0.59
Freight transport	29.6	177.2	138.8	5.99	0.78
Total	**1,682.8**	**6,149.6**	**5,091.0**	**3.65**	**0.83**

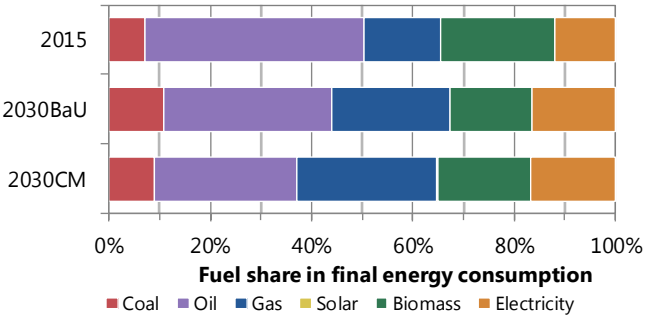

Figure 3. Fuel share in final energy demand

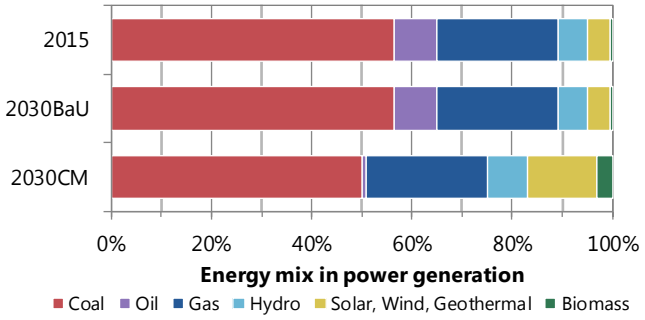

Figure 4. Energy mix in power generation

CO_2 EMISSION

Table 5 and Figure 5 describe estimated CO_2 emission. In BaU scenario, total CO_2 emission will increase by 4.24 times from 2015 and will have reached to 22,409 $ktCO_2e$ in 2030. On the other hand, CO_2 emission in CM scenario will become 16,009 $ktCO_2e$, which is equivalent to 29% reduction compared with BaU scenario.

The industry sector will still be the largest CO_2 emitter in both BaU and CM scenario. The biggest increase in CO_2 emission in BaU scenario will occur in the commercial sector, where CO_2 emission will have increased by 7.08 times compared to 2015, followed by the freight transport sector (5.99 times) and the industry sector (5.77 times).

In CM scenario, the passenger transport sector and the commercial sector will lead emission reduction. The passenger transport sector will have achieved 40% reduction of CO_2 emission compared with BaU scenario, while CO_2 emission will be reduced by 34% in the commercial sector.

Table 5. CO_2 emission by sector and fuel ($ktCO_2e$)

	Sector	Coal	Oil	Gas	Electricity	Total
2015	Industry	497.0	492.5	586.8	948.2	**2,524.5**
	Commercial	0.0	45.3	5.7	520.0	**571.0**
	Residential	0.0	173.5	0.3	574.2	**748.0**
	Passenger transport	0.0	1,350.7	0.0	0.0	**1,350.7**
	Freight transport	0.0	87.3	0.0	0.0	**87.3**
	Total	**497.0**	**2,149.3**	**592.7**	**2,042.5**	**5,281.5**
2030 BaU	Industry	2,738.9	2,820.5	3,322.9	5,694.5	**14,576.9**
	Commercial	0.0	320.8	40.3	3,680.7	**4,041.7**
	Residential	0.0	272.4	0.4	901.5	**1,174.4**
	Passenger transport	0.0	2,093.0	0.0	0.0	**2,093.0**
	Freight transport	0.0	522.8	0.0	0.0	**522.8**
	Total	**2,738.9**	**6,029.5**	**3,363.7**	**10,276.8**	**22,408.9**
2030 CM	Industry	1,905.2	2,140.8	3,137.6	3,642.7	**10,826.3**
	Commercial	0.0	208.9	105.7	2,350.8	**2,665.3**
	Residential	0.0	272.4	0.4	588.8	**861.7**
	Passenger transport	0.0	1,182.6	40.6	23.2	**1,246.3**
	Freight transport	0.0	409.7	0.0	0.0	**409.7**
	Total	**1,905.2**	**4,214.5**	**3,284.3**	**6,605.5**	**16,009.4**

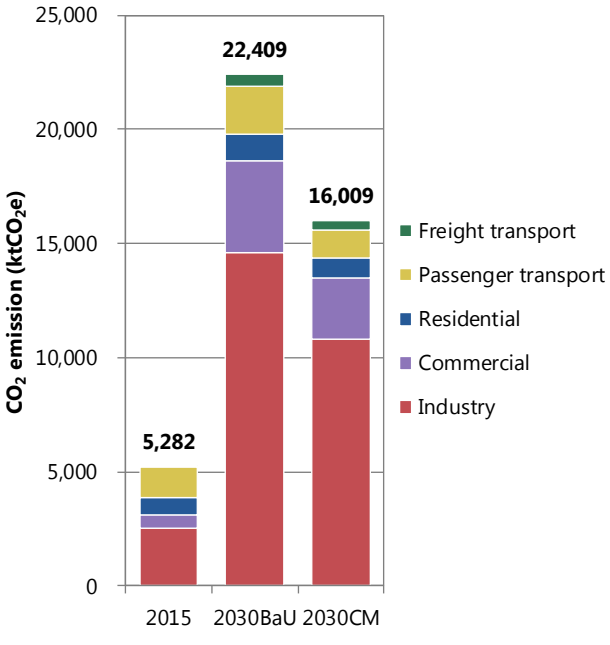

Figure 5. CO_2 emission

CO_2 EMISSION REDUCTION BY LCS ACTIONS/PROJECTS

A variety of LCS projects shown in Table 8 are assumed to be implemented to achieve CO_2 emission reduction in CM scenario. These projects are aggregated into five LCS actions from the perspective of fields and similarities. The actions are "Green Industry", "Smart Building", "Smart Device", Sustainable Transport" and "Green Energy". These actions can help to reduce CO_2 emission by 4,220.3 $ktCO_2e$. In addition, 2,179.3 $ktCO_2e$ of CO_2 emission are reduced by improvement of CO_2 emission factor of electricity due to the national power policy to promote switching from coal to renewable energy.

Action 1: Green Industry

Action 1 covers LCS projects for reducing energy consumption or CO_2 emission especially factories in industries. CO_2 emission reduction equivalent to 2,552.0 $ktCO_2e$ by this action is largest among all actions, because the industry sector emit more CO_2 than any other sectors and has large room to reduce emission. Energy saving support scheme such as energy service company (ESCO) projects is a dominant project in this action. This project contributes to reduce 964.6 $ktCO_2e$ of CO_2 emission.

Action 2: Smart Building

LCS projects related with housing and building are categorized in Action2. Reduction of CO_2 emission reaches 248.4 $ktCO_2e$ in Action 2. Not only energy saving technology like insulated materials applied to buildings but also installation of infrastructure for natural gas and solar water heater are main projects in the action. For instance, Introduction of solar water heater to houses and buildings can reduce CO_2 emission by 76.2 $ktCO_2e$.

Action 3: Smart Device

Action 3 is a group of LCS projects promoting energy efficient devices and equipment used in houses and offices. Total GHG emission reduction by projects of the action is 434.1 $ktCO_2e$. Projects for the commercial sector has a large potential to reduce CO_2 emission reduction. Energy saving support scheme is a project that reduce energy consumption and 150.6 $ktCO_2e$ of CO_2 emission.

Action 4: Sustainable Transport

LCS projects regarding transportation are included in Action 4. CO_2 emission reduction by the action amounts to 950.1 $ktCO_2e$. Modal shift to public transportation as well as promotion of fuel efficient vehicles are listed in this action. promoting high efficient motor bike is a project which have the largest potential to reduce CO_2 emission (452.3 $ktCO_2e$) in the action.

Action 5: Green Energy

Action 5 is a category for projects regarding electric power generation from renewable energy. 35.7 $ktCO_2e$ of emission can be reduced by photovoltaic power generation systems and small-scale hydropower generation facilities are introduced in Semarang City.

Table 6. Contribution to CO_2 emission reduction by action and sector ($ktCO_2e$)

	Industry	Commercial	Residential	Passenger Transport	Freight Transport	**Total**
Action 1: Green Industry Promotion of energy efficient equipment and fuel shift	2,552					**2,552**
Action 2: Smart Building Diffusion of low-energy building (Insulation, fuel shift)		215	33			**248**
Action 3: Smart Device Promotion of energy efficient device/appliance		357	77			**434**
Action 4: Sustainable Transport Energy efficient vehicle and modal shift				837	113	**950**
Action 5: Green Energy deployment of renewable electricity		26	10			**36**
Total	**2,552**	**598**	**120**	**837**	**113**	**4,220**

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Table 7. Main references of this research

	Source
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PROJECTS TO ACHIEVE LOW CARBON SOCIETY

Table 8. CO_2 emission reduction by project

Action		Project	Sector	Emission reduction ($ktCO_2e$)
1 Green Industry	1-01	Energy saving support scheme such as ESCO (Energy Saving Company) project for	Industry	964.6
	1-02	Installation high energy efficiency facilities	Industry	346.6
	1-03	Regional energy supply system	Industry	489.7
	1-04	Improvement of kiln and furnace technology	Industry	692.3
	1-05	Promotion of fuel shift of furnaces and boilers from coal to natural gas	Industry	58.8
		Total		**2,552.0**
2 Smart Building	2-01	Installation of insulated glasses to commercial buildings	Commercial	84.1
	2-02	Installation of insulated glasses to houses	Residential	12.2
	2-03	Introduction of incentive to low energy buildings	Commercial	15.9
	2-04	Introduction of insulating material to houses	Residential	7.0
	2-05	Energy efficiency technology applied to buildings	Commercial	35.8
	2-06	Shift to natural gas in buildings	Commercial	17.1
	2-07	Introduction of solar water heater to commercial buildings	Commercial	52.3
	2-08	Introduction of solar water heater to households	Residential	23.9
		Total		**248.4**
3 Smart Device	3-01	Energy saving support scheme such as ESCO (Energy Saving Company) project for	Commercial	150.6
	3-02	High efficiency lighting in commercial buildings	Commercial	66.5
	3-03	High efficiency lighting in households	Residential	22.8
	3-04	High efficiency air conditioners (such as air conditioners with inverter controllers)	Commercial	137.3
	3-05	High efficiency air conditioners (such as air conditioners with inverter controllers)	Residential	33.7
	3-06	Promotion of energy-efficient appliances	Residential	23.1
		Total		**434.1**
4 Sustainable Transport	4-01	Promotion of eco-driving with digital tachographs	Transport	7.2
	4-02	Wide-range traffic control	Transport	28.8
	4-03	Expansion of frequencies and routes of bus and BRT	Transport	96.2
	4-04	Development of public transportation like railway and MRT	Transport	98.6
	4-05	Shift to CNG bus	Transport	6.1
	4-06	Introduction of electric motorbikes	Transport	61.5
	4-07	Promotion of energy-efficient vehicles (cars for passenger)	Transport	452.3
	4-08	Promotion of energy-efficient vehicles (motorbikes)	Transport	86.7
	4-09	Promotion of energy-efficient vehicles (trucks)	Transport	112.8
		Total		**950.1**
5 Green Energy	5-01	Introduction of photovoltaic power generation to commercial buildings	Commercial	24.3
	5-02	Introduction of photovoltaic power generation to households	Residential	9.7
	5-03	Introduction of small-scale hydropower generation (at water distribution stations)	Commercial	1.7
		Total		**35.7**
Improvement of CO_2 emission factor of electricity				**2,179.1**
Total				**6,399.5**

METHODOLOGY

1. Start of the Story

First, we authorize a task force to develop LCS scenario and allocate human resource and budget for the research. We also make a schedule based on needs and situation of a local government.

2. Framework Setting

Background research is important to set an effective framework suited with the target region. We determine framework of the scenario (the target year, the base year, types of greenhouse gases, the target activities and the number of scenarios) by reference to the background. The base year should be decided with consideration for data availability. More than one scenarios such as BaU scenario and CM scenario should be set to analyze effects of LCS actions to reduce GHG emissions.

3. Data Preparation

Two kinds of data are needed. One is for the current status and the other is for the future vision. We collect data and information about population, No. of household, economic accounts, input-output tables, transport volume, energy balance tables and GHG emission. If some data are unavailable in the target region, it can be estimated based on other available regional and national data.

4. Design of LCS Projects and Projection of Future Scenario

Based on the collected information, GHG emission for the base year and BaU scenario are estimated by the quantification tool, ExSS. This model was developed by Kyoto University. We adopt both bottom-up approach and top-down to estimate CM scenario. First, we list LCS projects that can be implemented in the target region by the target year, and calculate GHG emission reduction by each project from bottom up based on assumption of degree of implementation. Then, ExSS is used again to estimate GHG emission and reduction from a macro perspective in CM scenario to remove duplication of GHG reduction among projects and to keep consistency.

5. Bridging the Output to Real World

We formulate actions by grouping projects according to themes and fields for implementation. The whole outputs are summarized to a brochure/report and reported to policy makers.

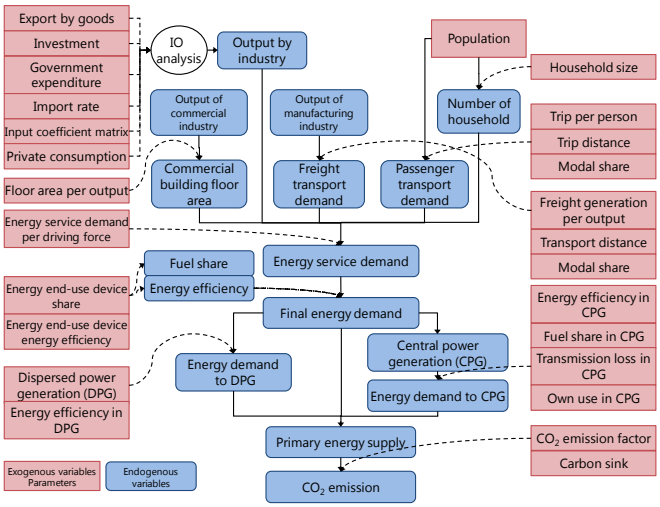

Figure 6. Structure of ExSS

ACRONYMS AND ABBREVIATIONS

AIM	Asia-Pacific Integrated Model
Bappeda	Development Planning Agency
BaU	Business as Usual
BRT	Bus Rapid Transit
CM	Countermeasure
CNG	Compressed Natural Gas
COP	Conference of the Parties
CPG	Central Power Generation
DPG	Dispersed Power Generation
ESCO	Energy Service Company
ExSS	Extended Snapshot Tool
G20	Group of Twenty
GHG	Greenhouse Gasses
GRDP	Gross Regional Domestic Product
LCS	Low Carbon Society
IEA	International Energy Agency
IGES	Institute for Global Environmental Strategies
INDC	Intended Nationally Determined Contribution
MRT	Mass Rapid Transit
NIES	National Institute for Environmental Studies, Japan
pass-km	Passenger-km
Rp	Rupiah
tCO_2e	Tons of Carbon Dioxide Equivalent
toe	Tons of Oil Equivalent

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