ASIA-PACIFIC INTEGRATED MODEL

Low Carbon Society Scenario Toward 2050

INDONESIA

Energy Sector

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Preface

This report presents the results of an academic research in developing option of roadmaps of energy sector toward low carbon society (LCS) of Indonesia in 2050, which is carried out as an extension activity of the Asia Pacific Integrated Model (AIM) Workshop 2009 “Designing Asian Scenarios Towards Low Carbon Society” held by NIES in August 2009 in Japan. The academic contributors of the roadmap development are Institut Teknologi Bandung (Indonesia), IGES (Japan), Kyoto University (Japan), NIES (Japan), and Mizuho Information and Research Institute (Japan).

The objective of this research is to obtain future visions and scenarios for achieving the goals of LCS in Indonesia, particularly within the context of energy sector. The energy sector covers supply side and demand side (industry, transportation, residential, and commercial sectors). The report provides an overview of scenarios of visions of Indonesian LCS in energy sector and related actions needed to achieve the LCS visions. The scenario of visions includes socio-economic development paths and the associated emissions. The discussion of actions to achieve LCS visions covers technology and policy options. The tool used in this research is ExSS (Extended Snap Shot) using GAMS (General Algebraic Modeling System) 23.3 supported by various technical, economic, and social parameters.

The report is prepared by Retno G Dewi (Institut Teknologi Bandung – Indonesia), Takuro Kobashi (IGES – Japan), Yuzuru Matsuoka and Kei Gomi (Kyoto University – Japan), Tomoki Ehara (Mizuho Information and Research Institute – Japan), Mikiko Kainuma and Junichi Fujino (NIES – Japan). We hope that the research results presented in this report could be used as a reference in further discussion on LCS in Indonesia. We thank the following individuals for their invaluable contributions in this research, i.e. Farida Z and M. Saleh Abdurrahman (Ministry of Energy and Mineral Resources), Elly A Sinaga (Ministry of Transportation), Rizaldi Boer (Institute of Agriculture Bogor – Indonesia), Ucok Siagian and M. Rozie (Institut Teknologi Bandung – Indonesia).

Bandung, November, 2010
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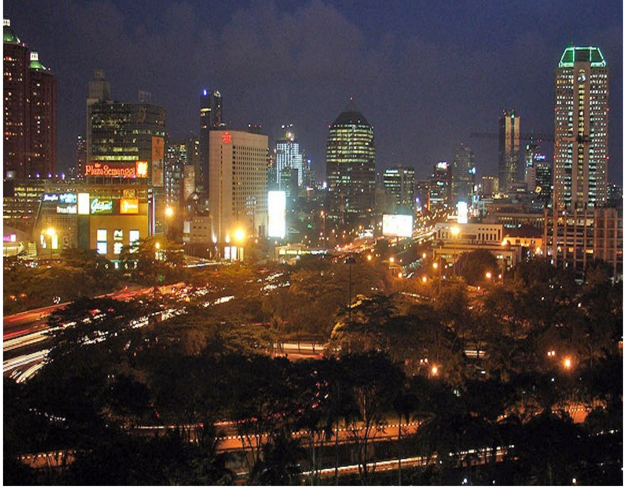

Abbreviations

AIM	Asia Pacific Integrated Model
BAU	Business as Usual
BPS	Biro Pusat Statistik (National Statistical Bureau)
CCS	Carbon Capture and Storage
CM1	Counter Measure 1
CM2	Counter Measure 2
CNG	Compressed Natural Gas
ExSS	Extended Snap Shot
GAMS	General Algebraic Modeling System
GHG	Green House Gas Emissions
GOI	Government of Indonesia
IGCC	Integrated Gasification Combined Cycle
IGES	Institute for Global Environmental Strategies
LPG	Liquefied Petroleum Gas
LCS	Loc Carbon Society
MMBOE	Million Barrels of Oil Equivalent
MEMR	Ministry of Energy and Mineral Resources
NIES	National Institute for Environmental Studies
PLN	National Electric Utility
PUSDATIN	Pusat Data dan Informasi (Center for Data and Information) - Ministry of Energy and Mineral Resources
RUPTL PLN	Rencana Umum Pengembangan Tenaga Listrik (General Plan of The Development of Electric Power)
Toe	Ton oil equivalent
Rp.	Rupiah

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Executive Summary

Low Carbon Society (LCS) is relatively new concept in Indonesia. Currently, there is no official document containing roadmaps to achieve LCS target. However, there are several government initiatives that are in line with and supportive to the LCS concept. This report presents the results of an academic research assessing scenarios of LCS visions 2050 in Indonesia especially in energy sector and associated actions and policies to achieve the LCS visions.

Three scenarios are developed to envision Indonesian development paths related to LCS including socio economic, energy, and associated carbon emissions. The first scenario is designated as business as usual (BAU) scenario, which assumes that the current development trend and society orientation will continue until 2050. What is meant by orientation is peoples' lifestyles and activities that has implication to the generation of CO_2 emissions.

The second scenario is designated as Countermeasure 1 (CM1), which assumes that economic development will be the same as BAU but the society is more efficient in energy utilizations compared to the BAU. The society is depicted as calmer, slower, and nature oriented. This scenario is regarded as moderate development path.

The third scenario is designated as Countermeasures 2 (CM2), which assumes that Indonesian economy will grow at much higher rate compared to those of the BAU but more efficient and less carbon energy systems. In addition, the scenario assumes that Indonesia is to reduce significant emission to comply with world's LCS target (0.5 ton-C per capita) in 2050. In this scenario, the society is depicted as more active, quick changing, and technology oriented. This scenario is regarded as high development path.

Indonesia's future energy and associated emissions projections (Table 1, Figure 1, 2) can be summarized:

- BAU, CO_2 emissions level is projected to increase substantially from 81 Mton-C in 2005 to 1184 Mton-C in 2050 (14.5 times).
- CM1, CO_2 emissions is projected to become 617 M ton-C (7.6 times higher than 2005) or it is 48% lower than the BAU.
- CM2: CO_2 emissions would become 183 Mton-C (85% less than BAU) despite higher economic size.

It should be noted that increases of energy demand in freight transport is significant because growth in freight transport is correlated directly with industrial export and commercial growths. Meanwhile the industrial and commercial sectors are assumed to grow significantly. Commercial sector also covers apartments that is expected to become a trend in Indonesia.

There are several actions considered to achieve LCS target in reducing CO_2 emission, which are grouped into 5 Actions:

Table 1. Estimation result of scenario quantification for base year (2005) and target year (2050)

Energy Emission Parameter	2005	2050		
	Base	BaU	CM1	CM2
Energy Demand, ktoe				
Passenger Transport	17,798	41,406	12,543	9,244
Freight Transport	6,562	126,510	45,623	42,056
Residential	42,832	69,761	38,710	66,971
Industry	39,224	569,325	471,039	543,266
Commercial	3,704	111,952	68,039	129,068
Total	110,120	918,953	635,954	790,605
Energy demand per capita, toe	0.50	2.81	1.95	2.42
Energy intensity, toe/million rupiah	61.6	24.8	17.2	11.6
CO_2 Emissions				
Total, million ton-C*	81	1,184	617	183
Per capita, ton-C	0.37	3.62	1.89	0.56
Total, million ton-CO_2	299	4,341	2,263	670
Per capita, ton-CO_2	1.4	13.3	6.9	2.0
Annual GDP Growth rate	-	6.9%	6.9%	8.3%
Annual energy demand growth rate	-	4.8%	4.0%	4.5%
Energy elasticity	-	0.70	0.57	0.54

(1) **Introducing Clean Energy**: utilization of renewable and less carbon emitting energy types and technology in residential/commercial sector;

(2) **Low Carbon Lifestyle**: efficiency improvement through appliances technology and society behavior in residential/commercial sector;

(3) **Low Carbon Electricity**: more renewable energy, efficient power generation (pulverized to sub-critical, supercritical, and integrated gasification combined cycle (IGCC) equipped with carbon capture and storage (CCS), and decreasing losses in T&D of electricity grids;

(4) **Low Carbon Fuels in Industry**: energy shift (toward renewable and less carbon emitting fuels), efficiency improvement of industrial processes, equipments, and appliances;

(5) **Sustainable transport**: transport modal shift (more mass rapid transport utilization), fuel shift (to renewable and less carbon emitting fuels), reducing trip generation and trip distance (improvement of infrastructure, telecommunication, and information access), traffic management, efficiency improvement of vehicles.

There are numerous energy-climate policy initiatives, regulations, and actions in energy sector that could result in CO_2 emission reduction. The latest policy initiative is non-binding emission reduction target of 26% lower than baseline in 2020 using domestic budget and further increased to 41% with international support. To implement non-binding commitment, GOI prepares National Actions Plan 2010 -2020 to Reduce CO_2 Emissions. In addition to the policy initiatives, most of the actions above will still need policy measures to support the implementations of these actions, i.e.:

(1) Increasing share of new/renewable energy and less carbon emitting fuels (include less carbon emitting technology) in energy supply mix to support implementation of Presidential Regulation 5/2006. On-going programs considered to meet energy supply mix target are power generation crash program I and II (which include clean coal and geothermal), kerosene to LPG, mandatory biofuel in power plant, transportation, industry (MEMR 32/2008) ;

(2) Increasing share of new/renewable (hydro, geothermal) and oil switch to natural gas as stated in the National Plan of Electricity Development (RUPTL) PLN 2008 - 2018;

(3) Regulations that lead to the formulation of national master plan on energy efficiency;

(4) Policies to support MRT (mass rapid transit) development, diversification of fuels (CNG/LPG, biofuel, electricity) in transportation, and emissions monitoring and control of local emission and combustion efficiency that has implication to the CO_2 emissions.

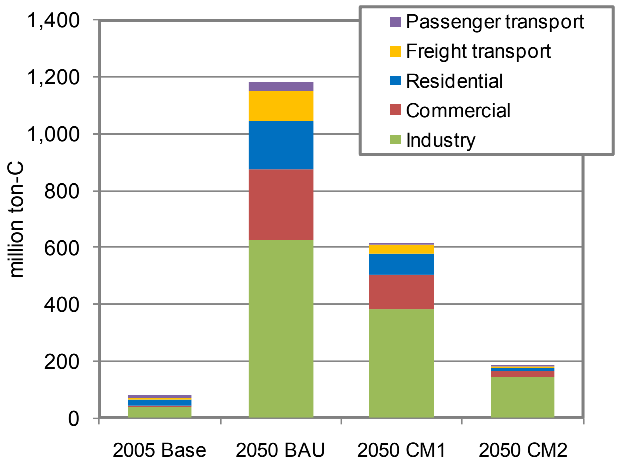


Figure 1. CO_2 emission by energy demand sector

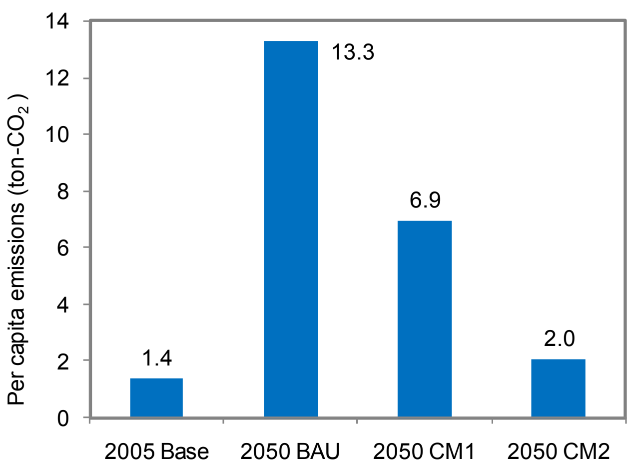


Figure 2. CO_2 emission per capita

Background

Geographical Features

Indonesia is located between 6°08' north latitude and 11°15' south latitude, from 94°45' to 141°05' east longitude. It is an archipelago with 5 big islands (Sumatera, Java, Kalimantan, Sulawesi, Papua) and 13.7 thousand small islands. Among the small islands, 56% are nameless and 7% are inhabited. Indonesia has 7.9 million-sq.km maritime area (81% total area, 1.86 million-sq. km land area, 81,000 km coastline, 0.220 million-sq.km arable land, 40% wet (rice fields), 40% dry, 15% shifting cultivation.

The country has two seasons: dry and rainy seasons with 3 rainfall peak patterns, namely monsoon (December), *local* (July-August), equatorial (March and October). Based on location , the pattern can be further categorized into two groups indicated by a clear distinction between dry and wet throughout the year, i.e. east part (East Nusa Tenggara) with drier and longer period and west part (Java, South Sumatra, South Sulawesi). In general, rainfall variation is larger in dry season (April-September) compared to those in wet (Oct-March).

Demography

According to BPS [2008], the population in 2005 is 219 millions with an average growth of 1.3% per annum (2000-2005). Indonesian population is divided into three age groups: 0-14 year old (28%), 14-65 year old (66%), and > 65 year old (5.5%). About 58% of the population lives in Java island, while the land area of Java is only 7% of total area of Indonesia. Most of these people (60%) live in rural area. The remaining 40% live in urban and urban peripheral. On average, member of a household is 3.65.

Economic Features and Trend

GDP of Indonesia in 2005 is 1786 trillion Rupiah. The GDP is structured by agriculture (13.6%), mining (11.0%), manufacturing and construction (35.2%), trade and services (40.1%). During 2000-2005, the GDP has grown at 5.6-6 % per year with inflation rate at 6-7% and income per capita in 2005 is 11 million Rupiah (1,300 USD). In the same year, Indonesia's export value was 607 trillion Rupiah (mainly oil, gas, coal, copper and textile) while its import value was 522 trillion Rupiah (mainly food, chemical and consumer goods).

Indonesian GHG Emissions

In Indonesia, the key sources of GHG emissions are Land Use, Land Use Change and Forestry (LULUCF) and peat fires, combustion of fuels and fugitives in energy sector, industrial processes, waste sector, agriculture sector. In 2005, the total CO_2 emissions of these sectors reached almost 1.99 Gton-CO_2e (0.55 Gton-C). Out of these emission, around 56% is from LUCF and peat fires and 18.5% is from energy sector. The rest are accounted by the previous mentioned remaining sectors.

Existing National Plan on Energy Sector and Climate Change Related Actions

In line with the world's commitment on climate change, Government of Indonesia (GOI) announced non-binding emission reduction target of 26% lower intensity than the baseline of 2020 using domestic budget. With international support, the reduction could be further increased to 41%. To meet this target, GOI is preparing National Action Plan on GHG Reduction (2010-2020). There are also several policy measures relevant to climate change, primarily in energy sector. The energy sector covered in the research study are power generation, industry, transportation, residential, and commercial sectors.

Share of renewable energy in the current mix of primary energy supply in Indonesia is still low. The supply still relies on oil, which accounts for 54.8% of total supply, followed by natural gas 22.2%, coal 16.7%, hydro 3.7%, and geothermal 2.49%. According to National Energy Policy (President Regulation No 5/2006), share of oil is to be decreased and substituted by coal, natural gas, and new/renewable energy. It is expected that in 2025 the energy supply mix will comprise coal (33%), gas (30%), oil (20%), and new/renewable (17%). Renewable include hydro, geothermal, and biofuel. New energy includes coal liquefaction, coal bed methane, and nuclear.

Ongoing programs considered to meet supply mix target are power generation crash program I (10,000 MW coal) and II (10,000 MW coal and geothermal), kerosene-to-LPG and biofuel. Share of biofuel in supply mix will be 5%.The primary consideration in setting the supply mix target is energy security but the achievement of the target will also has impact to the CO_2 emissions level. Current Indonesia power generation is dominated by coal, followed by natural gas, oil, and renewable. The fuel mix composition of power generation are coal 40.7%, oil 30.6%, natural gas 5.1%, hydro 8.4%, and geothermal 5.2% (2005). The share of other renewable energy is not significant. To achieve renewable energy target in the supply mix, GOI has passed several regulations, one of them is mandatory biofuel utilization in transportation, power generation, industry (MEMR -32/2008).

The fuel mix in power plant is expected to change in the future. According to national electricity generation plan 2008–2018 of State Electricity Enterprises (RUPTL PLN), the fuel mix in 2018 will become coal 63%, oil 2%, natural gas 17%, hydro 6%, wind 12%, and biomass 1%. After 2018, the fuel mix will be different, where the dominant fuel to be used in power plant is natural gas. Based on Blueprint National Energy Management Plan 2009, the fuel mix in power sector (2025) is as follows: gas 48% followed by coal 36%, oil 3%, geothermal 8%, and hydro 5%.

Energy conservation program is formally stated in Energy Law 30/2007, Presidential Regulation 5/2006 Presidential Instruction 10/2005, Ministerial Regulation 031/2005. These regulations lead to the formulation of national master plan on energy conservation, which state that there is 15-30% reduction potential. Based on Presidential Regulation, energy conservation is to be implemented so that in 2025 the energy elasticity (energy growth divided by GDP growth) will become less than 1.

There are several actions in transportation sector relevant to energy and climate change are to be implemented in Jakarta and other big cities, i.e. decreasing of traffic jam through the reduction of private vehicles by development of MRT (mass rapid transit) or BRT (bus rapid transit) in 6 cities, development of several new toll roads, application of transport demand management, electronic road pricing, and intelligent transport system. Other actions to be implemented are diversification of fuels such as CNG and LPG for taxi and bus-ways, biofuel for public as well as private car, and in the future, those are development of fuel cell, methanol and electricity in transportation. In addition, GOI implements emissions monitoring in transportation (mobile source) and industrial flue gas (stationery source) to control local emission as well as combustion efficiency in accordance to GHG emission.

Context of LCS scenario

During 2000-2005, GHG emissions in energy sector increased from 50.5 million ton-C (2000) to 67 million ton-C (2005). At this level, energy sector is the second contributor of national GHG emission after forestry and peat fires. On average, level of country's emission increased 5.9 % per year (2000-2005).

Concerning the CO_2 emission/capita, energy sector contributed 0.37 ton-C (1.4 ton-CO_2) per capita in 2005. Key sources of CO_2 emission are fuel combustions (90.3%) and fugitives from flaring/venting in oil and gas production facilities (9.7%). In fuel combustion activities, 33.2% of CO_2 emissions is accounted by energy transformation and losses in power generation and oil and gas processing, 25% manufacturing, 22.4% transportation, 15% residential and commercial, 4.3% agriculture, mining, construction.

LCS is a relatively new concept for Indonesia. All the above mentioned government action plans are not developed as roadmap to achieve Low Carbon Society (LCS) target of the country. However, all those action plans actually are in line with and supportive to the LCS concept.

In this report, a scenario of energy sector in Indonesia towards LCS was developed. The objective is to describe future visions for achieving the goals of LCS. In developing the roadmap, there are 5 important steps:

- Depicting socio economic visions of Indonesia toward 2050;
- Estimating current energy service demand-supply and resulting CO_2 emission that cover quantifying society behavior on energy utilization, analyzing the impact of city and transport infrastructure (include travel behavior) and industrial structure to energy consumption and resulting CO_2 emission;
- Exploring innovations for energy demand-supply;
- Estimating energy service demand and supply in BAU and two countemeasure scenarios and the amount of resulting CO_2 emissions; and
- Analysis of domestic potential to achieve energy-related CO_2 emission reduction.

Socio-economic scenarios in 2050

Depictive Scenario

Three scenarios are used to figure the direction of future socio economic visions for achieving LCS goals toward 2050, i.e. BAU (business as usual) and two countermeasure (CM) scenarios. BAU assumes that the existing society orientation will continue until 2050. The two countermeasures assume that there will be changes in society orientation in the future.

The CM1, which is regarded as a moderate scenario, assumes that the society behavior is depicted as calmer, slower, and nature oriented ones. The CM2 that is regarded as high growth scenario, assumes that the society is depicted as more active, quick changing, and technology oriented. This scenario has two long-term objectives, i.e. 'realizing full socio-economic potential of the country' and 'creating a sustainable LCS.

Estimated Socio Economic Indicators

All scenarios (BAU, CM1 and CM2) use the same estimate of population, 327 million in 2050. For number of household, BaU and CM1 assumed that population per household will not change from 2005 while CM2 assumed the size will be reduced to 3.00.

For future projection (Figure 4) in BaU and CM1 scenario, it is assumed that the GDP will grow with 5.5% (2005–2010), 6.6% (2010-2014), 7.2% (2015-2030), 6% (2030-2050). On average, the GDP growth in 2005-2050 will be 6.9% per year. At this rate, the GDP will be 36998 trillion rupiah in 2050 (20.7 times higher than 2005). The GDP per capita increases from 8 million (2005) to 113 million (2050) rupiah. For high growth scenario (CM2), GDP growth rate is assumed to be 5.5% (2005-2010), 7.0% (2011-2015), 9% (2016-2030), 8% (2030-2050). As a result, It is estimated that in 2050, the GDP will be 68252 trillion rupiah (40 times higher than 2005) and GDP per capita will increase from 8 million rupiah (2005) to 209 million rupiah (2050). As comparison, GDP projection developed by Bapenas is also presented in the Figure 4. Compared to Asian developed countries (Figure 5), the estimated GDP per capita in 2050 for BAU and CM1 scenarios is relatively low while in CM2 scenario the estimated of GDP per capita is as high as Hongkong.

As for the industrial structure, countries with high GDP per capita such as most developed countries in the world are usually has tertiary industry as the main contributor of the country's GDP while other countries with low GDP per capita will still rely on primary and secondary sector. The share of tertiary industry in most developed countries is around 70% while in countries with low GDP per capita only 40-50%. The

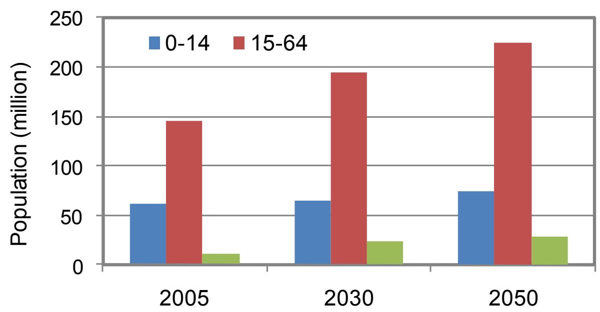


Figure 3. Projection of Indonesian Population

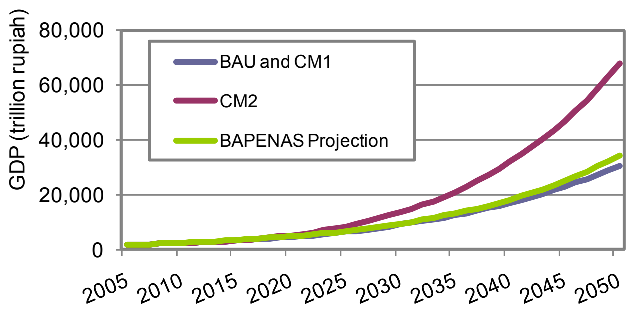


Figure 4. GDP projection 2005-2050

Table 2 Estimated socio economic indicators in the base year (2005) and the target year(2050)

Socio Economic Parameter	2005	2050			2050/2005		
		BaU	CM1	CM2	BaU	CM1	CM2
Population, Million	219	327	327	327	1.5	1.5	1.5
No. of households. Million	60	89	89	109	1.5	1.5	1.8
GDP, trillion rupiah	1,787	36,998	36,998	68,252	20.7	20.7	38.2
GDP per capita, million rupiah	8.2	113	113	209	13.9	13.9	25.6
Gross output, trillion rupiah	3,533	72,406	72,406	126,791	20.5	20.5	35.9
Primary	329	6,516	6,516	9,610	19.8	19.8	29.2
Secondary	1,953	37,505	37,505	39,625	19.2	19.2	20.3
Tertiary	1,251	28,384	28,384	77,556	22.7	22.7	62.0
P-transport demand, billion psg km	1,763	3,407	2,965	2,195	1.9	1.7	1.2
F-transport demand, million ton km	1.07	20.64	20.64	23.08	19.3	19.3	21.6

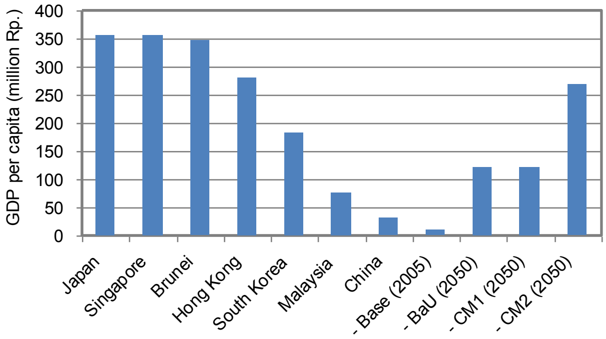


Figure 5. GDP per capita of Asian countries (2005) and Indonesian scenarios.

GDP per capita of BAU and CM1 scenarios (in 2050) is still relatively low, therefore, it is assumed that GDP structure of the scenarios in 2050 will slightly different compared to those in 2005. The share of tertiary industry is assumed to increase from 40 % to 45 % and share of other sectors are relatively similar with that in 2005. In CM2 scenario, share of tertiary industry is assumed to increase to 65% in 2050. Shift of share of industry in the GDP structure will determine energy consumption of the country since industry sector is the largest energy consumer in Indonesia.

In passenger transport, trip generation (number of trips per parson per day) is assumed constant in BaU (3.6), slightly decrease in CM1 (3.3) and CM2 (3.0) due to telecommunication. Though, in BaU scenario, it is assumed that the distance of one trip will be longer than 2005, and total passenger transport demand is about twice of the base year. In CM1 and CM2 case, trip distance is assumed shorter than BaU due to infra-structure development, and total passenger transport volume is reduced by 13% and 36% respectively. Structure of freight transport is assumed similar with base year, though, driven by growth of manufacturing industries (export oriented), transport volume is increased significantly in all scenarios.

In addition, floor space of commercial sector (including apartments) is increased by 23 times (BAU and CM1) and 62 times (CM2) compared to base year due to high growth of tertiary industry.

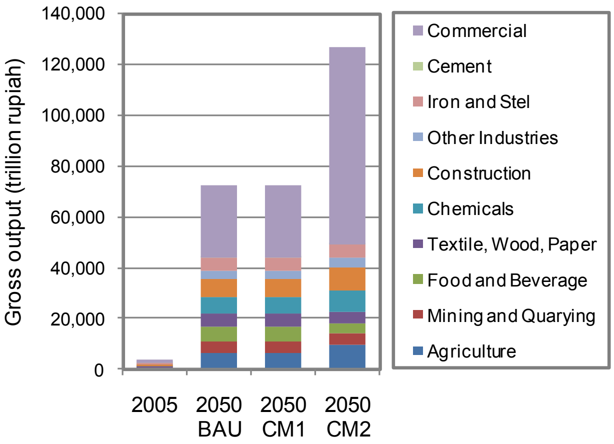


Figure 6. Economic structure of Indonesia in 2005 and 2050

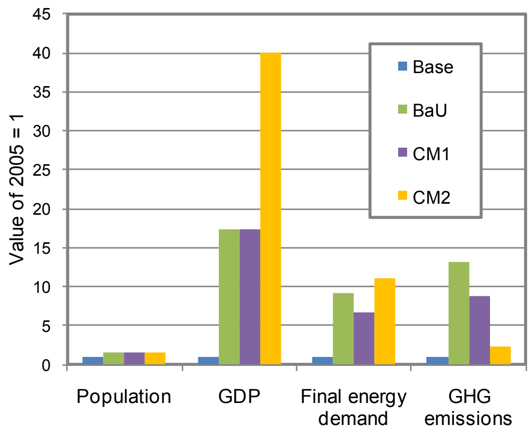


Figure 7. Economy, Energy, Emissions

Table 3 Quantitative assumptions of socio-economic indicators (input parameters to ExSS)

	2005 Base	2050 BaU	2050 CM1	2050 CM2
Population	219,204,700	326,933,718	326,933,718	326,933,718
Composition of population by age	0-14 (28%), 15-64 (67%) >65 (5%)	0-14 (23%) 15-64 (69%) >65 (9%)		
Number of population per house hold	3.68	3.68	3.68	3.00
Passenger Trip Generation (Ptg), trips	3.6	3.6	3.3	3.0
Final demand formation (trillion rupiah)				
- Export of Primary Industry	11	222	222	213
- Export of Secondary Industry	471	9,117	9,117	6,973
- Export of Tertiary Industry	125	3,113	3,113	4,791
- Private consumption	1,109	22,755	22,755	40,572
- Government consumption	140	2,867	2,867	15,336
- Private investment	453	9,294	9,294	16,572

GHG emissions & reductions

Energy demand

Future energy demand and the corresponding CO_2 emissions are estimated using socio-economic data described previously. Estimated energy demand is shown in Table 4 and Figure 8-10. Primary energy demand in BAU is expected to increase 10.6 times, from 120 to 1,273 million toe, while in CM1 and CM2 the demand will increase 6.5 and 10.9 times compared to 2005. In the BAU, final energy demand is projected to increase 8.3 times from 110 million toe (2005) to 919 million toe (2050) while CM1 and CM2 will increase 5.8 and 7.2 times. Share of industry sector will increase from 36% (2005) to 62% (2050 BaU). In countermeasure scenarios, share of final energy demand by type of fuel will shifts toward 'move away from oil'. Oil decreases from 39% (2005) to 20.8% (CM1) and 3% (CM2),

In CM1 scenario, which assumed socioeconomic structure will similar to BAU but considers low-carbon fuels and energy technology in line with the GOI energy planning. Final energy demand will be reduced to 636 million toe due to efficient energy system and mitigation measures as described later.

The CM2 has higher final energy demand (781 million toe) than CM1, but still lower than BaU despite its greater economic size. It occurs due to higher energy efficiency in CM2 with better financial availability.

CO_2 emissions

CO_2 emissions varied related to the economic size and the way energy system is structured (Figure 11). BAU has the largest CO_2 emission, i.e. 1,184 million ton-C in 2050 (14.4 times higher than in 2005). The second is CM1 i.e. 617 million ton-C (7.6 times higher than 2005 emission). Although the economic size of CM1 is similar with BAU, however, energy system is structured to be more energy efficient and low-carbon. CM2 result in the lowest emission (183 million tons

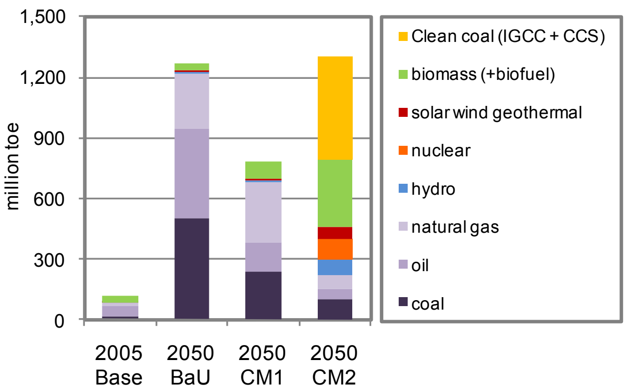


Figure 8 Primary energy demand by type of energy

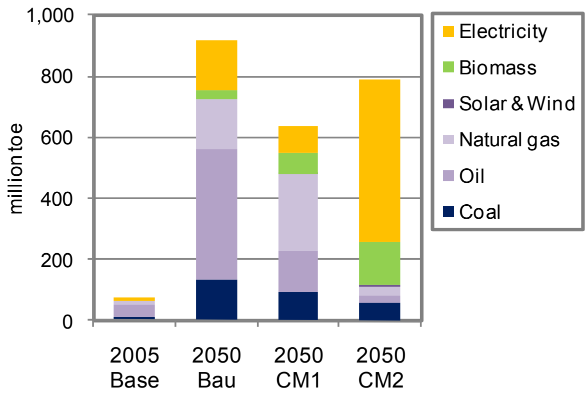


Figure 9 Final energy demand by type of energy

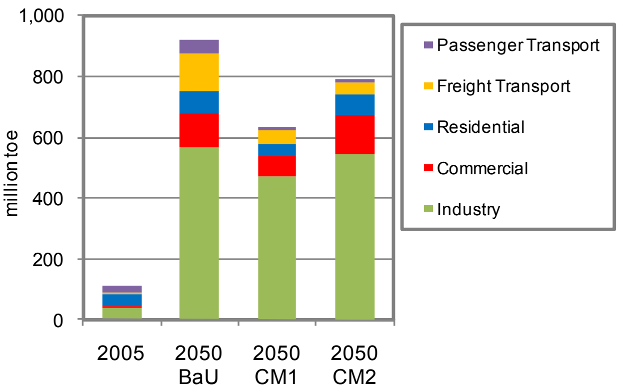


Figure 10 Final energy demand by sector

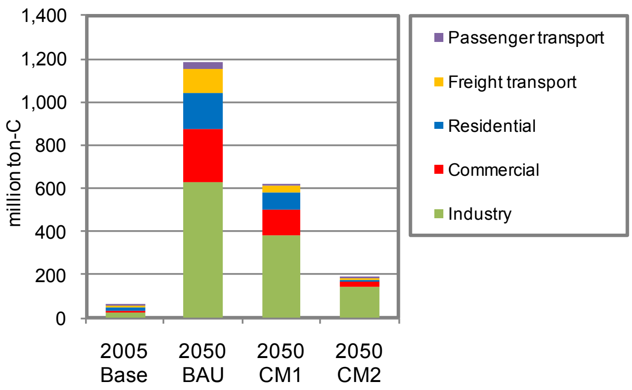


Figure 11 CO_2 emissions by sector, million ton-C carbon). The energy demand and CO_2 emission in this scenario are lower than in BAU. The emissions reductions from BAU emission are 48% and 85% respectively in CM1 and CM2 scenarios. Concerning future final energy demand, in CM1 and CM2, share of carbon intensive energy (coal, oil, and gas) in final energy demand is decreased. However, clean coal power generation (equipped with CCS) increases its share in CM2.

The CO_2 emission per capita (Figure 2) in BAU substantially increase from 0.37 ton-C (1.4 ton-CO_2) per capita (2005) to become 3.6 ton-C (13.3 ton-CO_2) per capita (2050). Emission per capita in CM1 is about half of BAU and in CM2 it is about one sixth of BAU. Owing to higher growth of the CM2, energy efficiency improves more than CM1 and fuel use are expected to shift toward more electricity, renewable, nuclear, clean coal power plant (IGCC) equipped with carbon capture sequestration (CCS). It covers exploration of appropriate combination of energy services demand, end-use technology, types of energy supply and technology.

The BAU projection is based on existing planning without mitigation actions for reducing CO_2 emissions, moderate projection (CM1) follows the existing plan of actions of the government, institutions, industries, association, etc. The above described results clearly demonstrate that with appropriate policy it is possible

Table 4. Final energy demand by sector, ktoe

	Coal	Oil	Gas	Solar, Wind, Hydrogen	Biomass	Electricity	**Total**
2005							
P-Transport	0	17,788	6	0	0	5	17,798
F-Transport	0	6,562	0	0	0	0	6,562
Residential	0	7,876	836	0	30,674	3,446	42,832
Industry	8,975	8,925	11,777	0	5,995	3,552	39,224
Commercial	0	1,223	207	0	193	2,081	3,704
Total	8,975	42,374	12,825	0	36,863	9,084	110,120
Share	8.2%	38.5%	11.6%	0.0%	33.5%	8.2%	100%
2050 BAU							
P-Transport	0	41,394	10	0	0	2	41,406
F-Transport	0	126,510	0	0	0	0	126,510
Residential	0	14,416	4,660	0	5,606	45,078	69,761
Industry	133,904	204,622	153,487	0	21,045	56,266	569,325
Commercial	0	39,561	4,689	0	4,385	63,317	111,952
Total	133,904	426,503	162,846	0	31,037	164,663	918,953
Share	14.6%	46.4%	17.7%	0.0%	3.4%	17.9%	100%
2050 CM1							
P-Transport	0	8,526	0	0	4,001	15	12,543
F-Transport	0	39,174	0	0	6,449	0	45,623
Residential	0	0	13,761	9	0	24,940	38,710
Industry	94,758	66,071	223,445	0	62,690	24,076	471,039
Commercial	0	18,603	14,265	0	0	35,171	68,039
Total	94,758	132,374	251,471	9	73,140	84,202	635,954
Share	14.9%	20.8%	39.5%	0.0%	11.5%	13.2%	100%
2050 CM2							
P-Transport	0	304	0	0	5,366	3,573	9,244
F-Transport	0	574	0	5,403	12,086	23,994	42,056
Residential	0	0	2,248	0	326	64,397	66,971
Industry	55,649	22,980	22,958	0	102,556	339,124	543,266
Commercial	0	0	4,872	0	20,121	104,075	129,068
Total	55,649	23,857	30,079	5,403	140,454	535,163	790,605
Share	7.0%	3.0%	3.8%	0.7%	17.8%	67.7%	100%

to direct the society toward low carbon development. CM2 shows that higher economic growth may not always mean higher emissions. It can apply more costly mitigation options and could reduce emission more than lower economic growth scenario like CM1.

CO_2 emission reductions potential

Figure 12 presents CO_2 emissions and reduction potential of energy demand side. CO_2 emission of BAU will be reduced in demand side by 488 million ton -C 2050 under the CM1 scenario and by 385 million ton-C in 2050 under the CM2 scenario. In both scenarios, largest reduction potential is found in industry sector.

. Figure 13 presents the breakdown of emission reduction potential of energy supply side (broke down by the sectors which consumes electricity). It is possible to reduce emissions by 195 million ton-C in CM1 with appropriate policies. Largest reduction comes from industry and commercial sector. The reduction potential of supply side is particularly high In CM2, 986 million ton-C in total, since large part of final energy demand is shifted to electricity and power sector assumes very advanced technology in the scenario. As a result, with higher efficiency and low carbon energy sources can be implemented and its CO_2 emissions can be 85% less than BAU despite its greater economic size.

Residential sector

Energy demand in the sector will increase in line with increasing population and GDP per capita. In 2050, it is assumed that energy service consumption per capita increase by 1.2 ~ 7 times (varies by energy service) compared to 2005 (BAU and CM1) and by 1.7 to 14 times in CM2. These assumptions are taken based on energy demand and GDP trend data of several countries. However, because of higher efficiency of equipments and more share of low-carbon fuels, CO_2 emissions from residential sector decreased by 54% (CM1) and 93% (in CM2) from BAU scenario.

Commercial sector

In BAU scenario, highest growth rate of CO_2 emissions is found in commercial sector, 34 times greater than year 2005. This is due to high growth of tertiary industry and more energy service demand per floor area of commercial buildings. Though, in CM1 scenario, the rate is reduced to 16 times and in CM2, only 2.8 times. In CM1, large part of emission reduction is contribution of energy efficiency improvement in buildings while in CM2 power supply sector has greater contribution as shown in Figure 13.

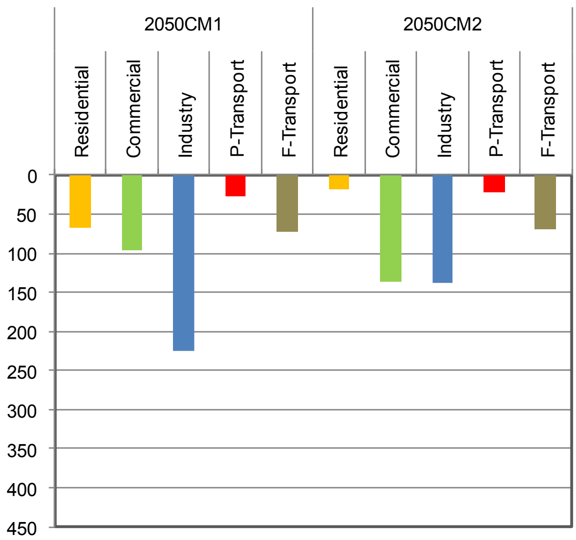


Figure12 Potential of GHG emission reduction of demand side by energy demand sector

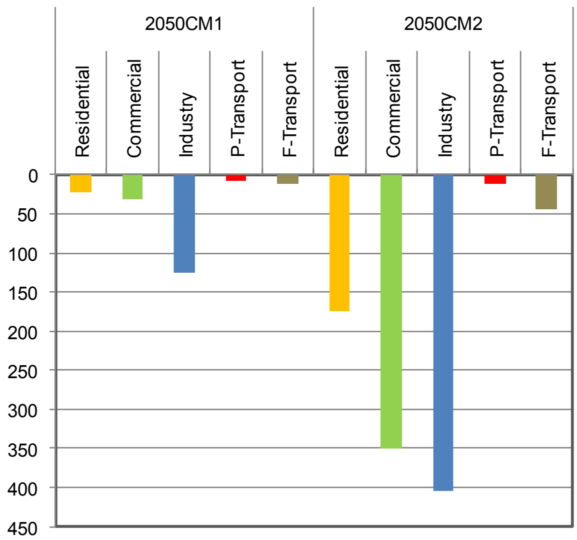


Figure13 Potential of GHG emission reduction of supply side by energy demand sector

Industry Sector

"Industry sector" in this report means primary and secondary industries as energy consumer. Currently It is the largest GHG emitter and also the highest contributor to Indonesia's GDP. In the future, energy consumption of this sector will be still higher compared to others. Energy demand of industry sector is expected to grow from 39 (2005) to 569 million toe (2050). Since energy consumed by the industry is mainly coal, oil and gas, this sector will remain the main contributors of CO_2 emission. However, the share of CO_2 emission of industry sector also changes substantially. The share of emissions from industry increase from 45% in 2005 to 53%, 62%, 80% in 2050 for BAU, CM1, and CM2, respectively.

Process technologies and types of equipments used in this sector determine the type and quantity of energy used by the sector and the amount of resulting CO_2 emissions. Energy technology intervention, good house keeping, changes of behavior and lifestyle of workers could be implemented to achieve the LCS target. Energy technology intervention is implemented through efficiency improvement (high efficient equipments and processes). Energy efficiency potential varies upon type of equipments and visions of each scenario (BAU, CM1, CM2). BAU assumes that existing low efficiency equipment and processes will continue to be used until 2050. Countermeasures scenarios assume that in 2050, there should be changes in technology processes orientation. CM1 (moderate scenario), assumes that the level of efficiency of most equipment and processes in the manufacturing sector is lower than those in CM2 (high growth scenario), which assumed that the behavior of the society is depicted as "technology oriented".

Transportation Sector

Transportation sector is the second largest (after industry) energy consumer in Indonesia. This sector consumes almost 80% of oil product in the country. CO_2 emissions of the transport sector is mainly from oil combustion. Reduction of CO_2 emission from fuel combustion activities could be achieved through efficient use of fuel and fuel change to less CO_2 emitting fuels. Efficient use of fuel can be achieved through efficient vehicles, efficient transportation system (increasing the share of mass transport mode, reducing transport distance, changing transport structure). Fuel change to less CO_2 emitting fuels could be implemented by introducing biofuel and natural gas to replace oil fuels.

Energy systems, both demand and supply side, in CM1 and CM2 are progressively efficient and more electrified. Central power systems utilize low carbon energy source such as renewable energy, nuclear, and other less CO_2 emitting fuels. Particularly the CM2, clean coal technology such as IGCC equipped with CCS is included.

Five “Actions” towards LCS

Based on the result of the scenarios, a set of actions in energy sector was developed (Figure 14). The countermeasures were grouped into following five actions.

1. Introducing Clean Energy: Utilizing clean energy in residential and commercial sector, for example, switch from oil to gas or electricity ;

2. Low Carbon Lifestyle: Promoting low carbon lifestyle in residential and commercial sectors through energy efficiency campaign (i.e. energy efficiency improvement of technology appliances and behavior change in buildings);

3. Low Carbon Electricity: Introducing low carbon electricity in power sector involves the use of new and renewable energy, efficient power generation, reduction of transmission and distribution (T&D) losses in electricity grids, and CCS (carbon capture and storage) technology in coal power plants;

4. Low Carbon Fuels in Industry: Introducing low carbon energy in industry, which covers energy shift to renewable and less carbon emitting fuels, energy efficiency improvement of processes, equipments, and appliances;

5. Sustainable Transport: Developing sustainable transportation, including modal shift (more public and mass transport), fuel shift to renewable and less-carbon-emitting energy, reducing trip generation and passenger trip distance through improvement of urban infrastructure, telecommunication, information access, transport demand management, and energy efficiency improvement of vehicles.

The implementation of those actions needs several policies and regulations to provide appropriate incentives. Several regulations and policy initiatives regarding energy and climate change related issues have been passed by the GOI (see page 8-9). To boost the implementation of those actions, more technical regulations and policies initiatives (i.e. economic incentives) are still needed.

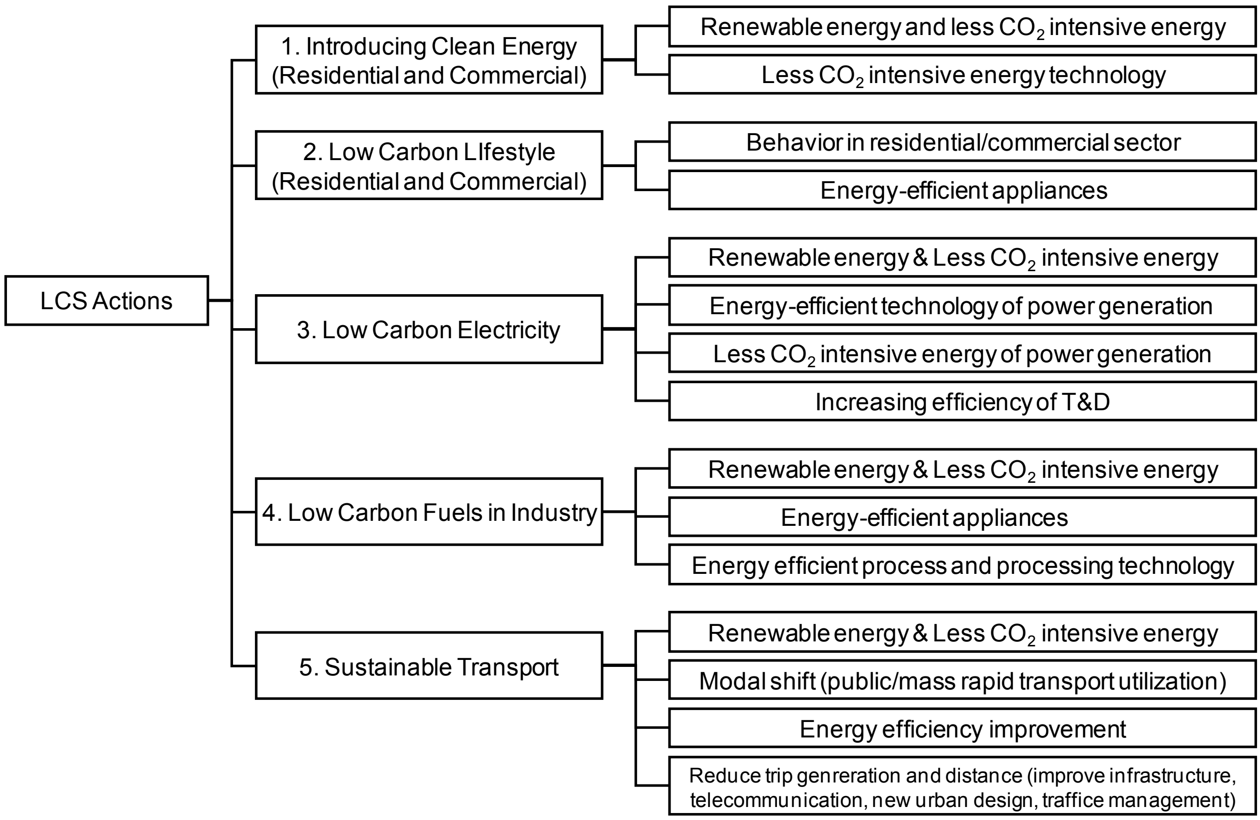
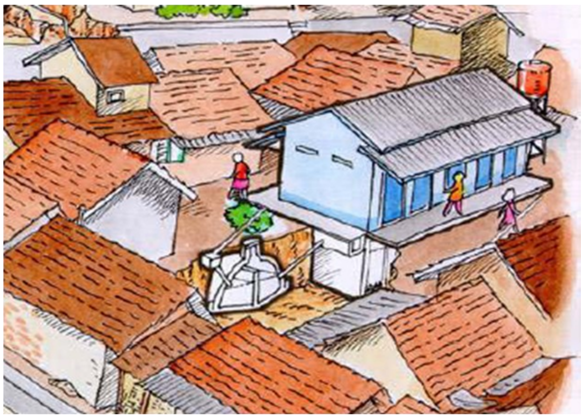


Figure 14 Integrated Chart of Five Options

Action1: Introducing Clean Energy

Utilization of renewable energy and less carbon emitting energy in residential and commercial (Figure 15) are considered as "Introducing clean energy". In CM1 and CM2 scenarios, the actions cover replacing oil products (kerosene and LPG, 17% in the base year) by increasing the utilization of electricity.



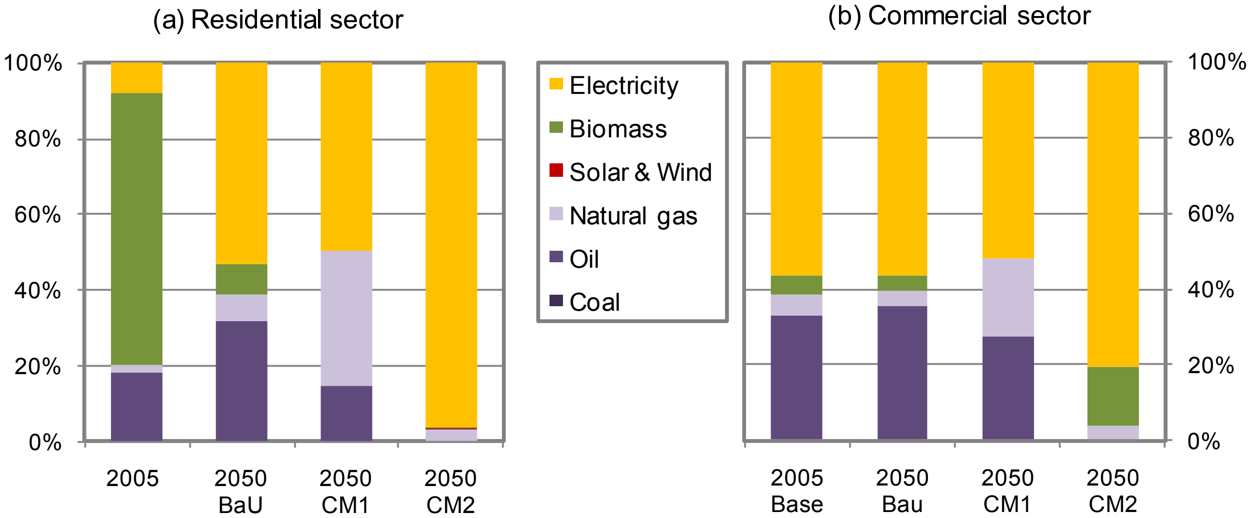


Figure 15 Share of energy in (a) residential and (b) commercial sectors

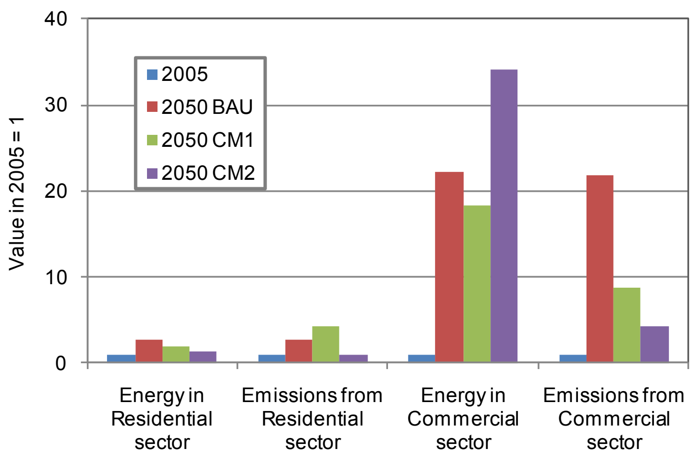


Figure 16 Energy demand and CO_2 emissions in residential and commercial sectors

Action 2: Low Carbon Lifestyle

"Low carbon lifestyle" is implemented through efficiency improvement of electric appliances and other devices in residential and commercial sectors and also behavior change in the buildings.

Assuming share and efficiency of the appliances in residential and commercial sectors, it was found that total energy demand of residential sector in BaU, CM1 and CM2 are 70, 39, 67 million toe, respectively. Those of commercial sector are 112, 68, 129million toe, respectively (Figure 17 and 18). Energy demand in CM2 is similar level with BaU because CM2 has greater economic size and therefore consumes more energy service. Emission form these sectors in CM2 is substantially reduced by supply side. (See Action 3).

Implementing actions on clean energy and low carbon lifestyle in residential and commercial sectors will need support from the government such as;

- ITax incentives for efficient electric appliances and other electric machines will reduce the price of this appliances and equipment and in turn will lead to reduction of energy use;
- Government regulations and policies that will encourage the development and utilization of energy efficient buildins;
- Reducing barriers to access information and installation of energy efficient appliances and equipments.

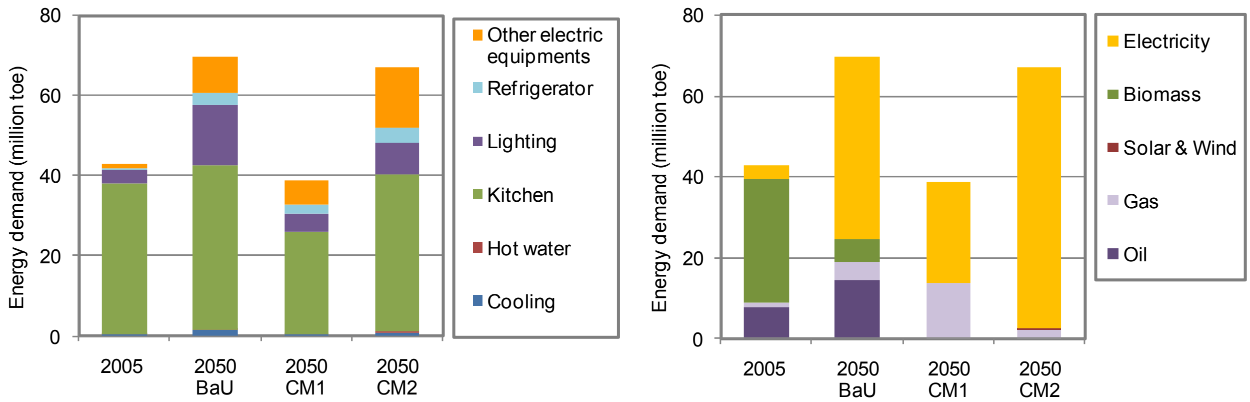


Figure 17 Final energy demand by service (left) and by fuel (right) in residential sector

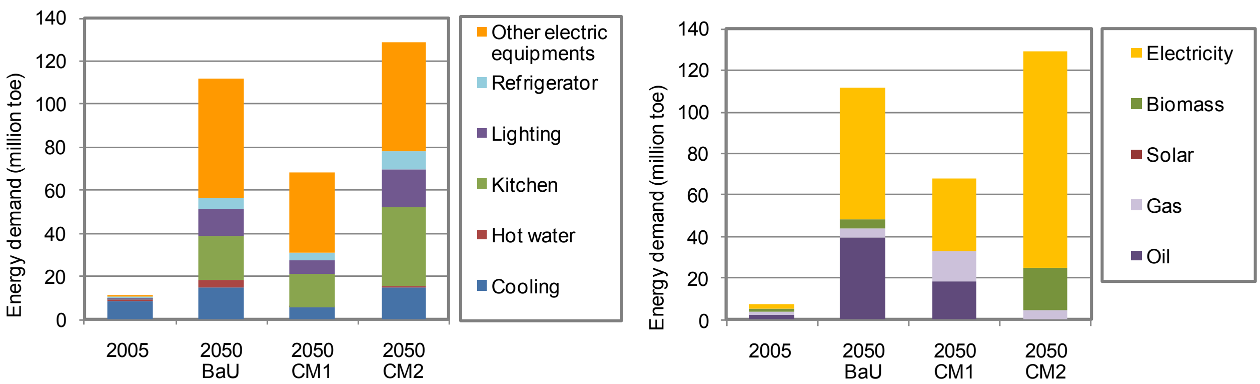


Figure 18 Final energy demand by service (left) and by fuel (right) in commercial sector

Action3: Low Carbon Electricity

"Low carbon electricity" can be implemented by increasing the use of renewable energy in energy supply mix of the power generation, developing more efficient power generation (from pulverized to supercritical or IGCC), reducing losses in transmission and distribution (T&D) of electricity grids, and CCS (carbon capture and storage) application.

Figure 19 presents energy efficiency level while Figure 20 presents share of the type of energy supply in power plant. In CM2, share of efficient power plant and more renewable energy (hydro, geothermal, etc) and less CO_2 emitting technology (clean coal, i.e. IGCC equipped with CCS and nuclear power plant) in CM2 is higher than those in CM1. Fuel consumption of power generation and CO_2 emission reduction is shown in Figure 21. For more detail of electricity supply , see Table 9 in page 19.

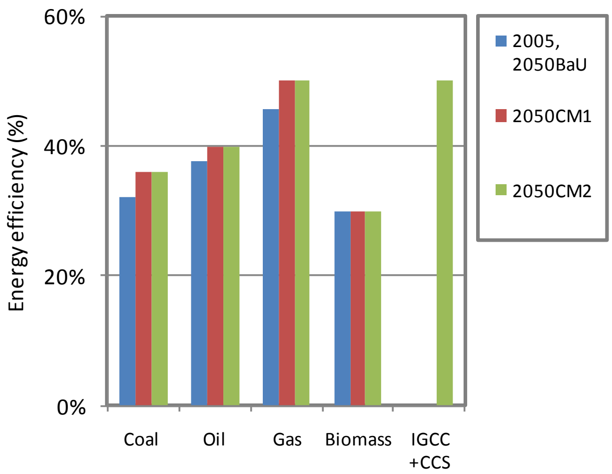


Figure 19 Energy efficiency level of power generation in each scenario

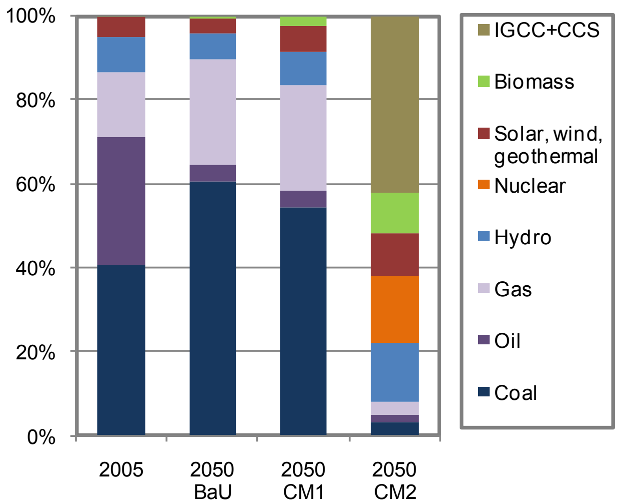


Figure 20 Share of power supply by energy type in each scenario

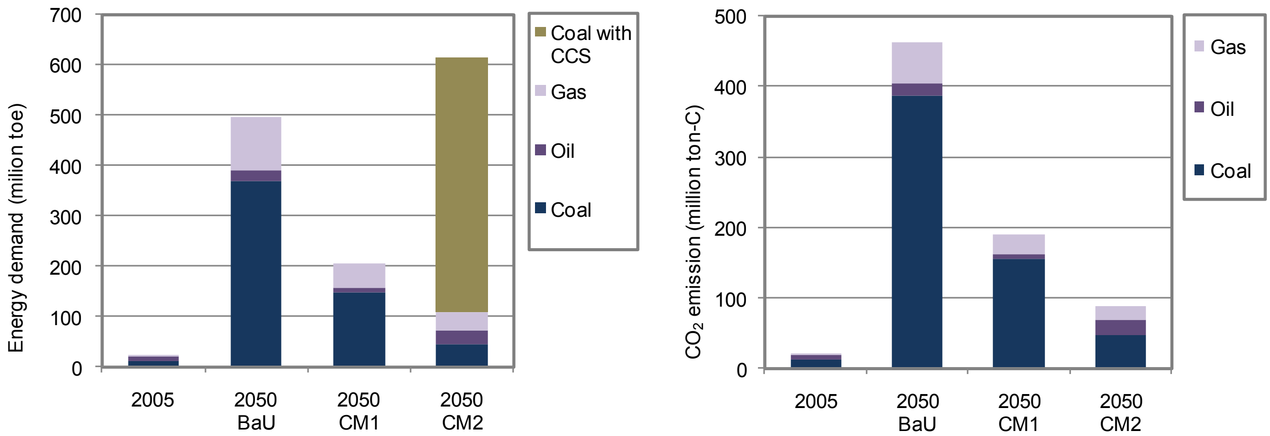


Figure 21 Fuel consumption and CO_2 emission of power generation sector in each scenario

Action4: Low Carbon Energy System in Industry

"Low carbon energy system in industry" can be implemented through utilization of more renewable and less carbon emitting fuels, efficiency improvement of processes, equipments, and appliances. Implementing low carbon fuels in industrial sector will reduce CO_2 emissions level significantly. Figure 22 presents CO_2 emission reduction potential of industry in CM1 and CM2 scenarios.

The level of emission and energy demand in both scenarios CM1 and CM2 is affected by economic conditions of each scenario. Figure 23 shows the impact of economic output to energy demand in industry sector of each scenario. Figure 24 and 25 present energy demand by service and by fuel.

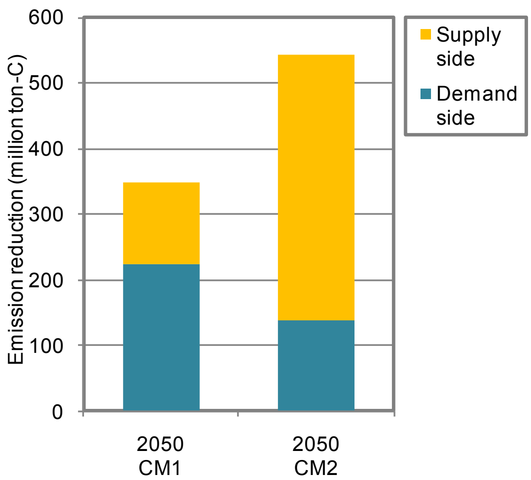


Figure 22 CO_2 emissions reduction potential in industrial sector by supply and demand side

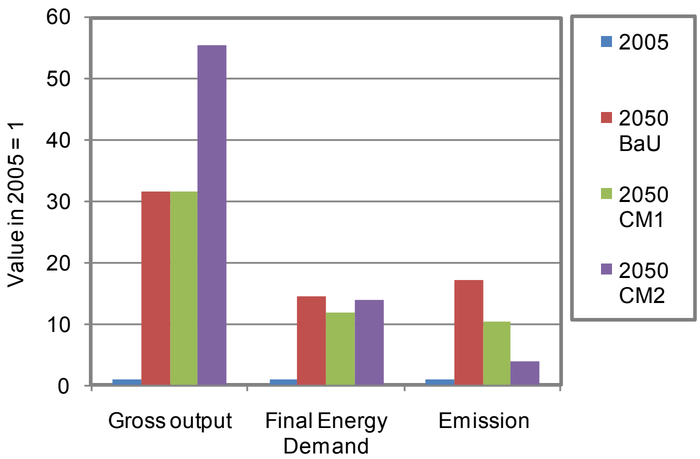


Figure 23 Impact of economic output to energy and CO_2 emissions in primary and secondary industry

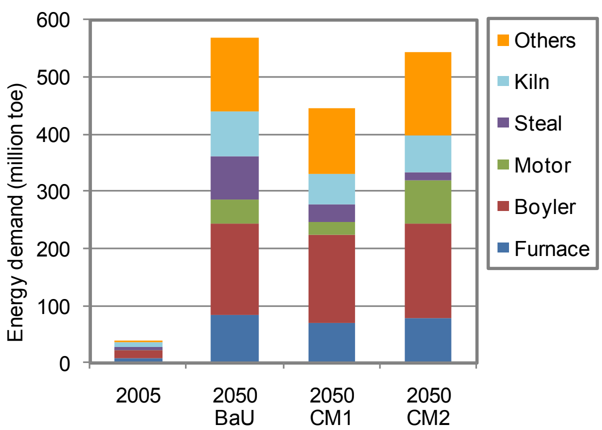


Figure 24 Energy demand in Industry by energy service

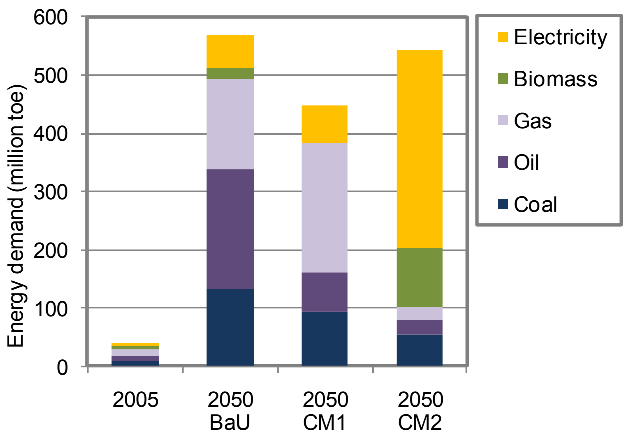


Figure 25 Energy demand in Industry by fuel

Action 5: Sustainable Transport

"Sustainable transport" is to be achieved through modal shift (more public and mass rapid transport), fuel switch (more renewable and less GHG emitting fuel), reducing trip generation and passenger trip distance through the improvement of city infrastructure, telecommunication, information access, traffic management, and energy efficiency improvement.

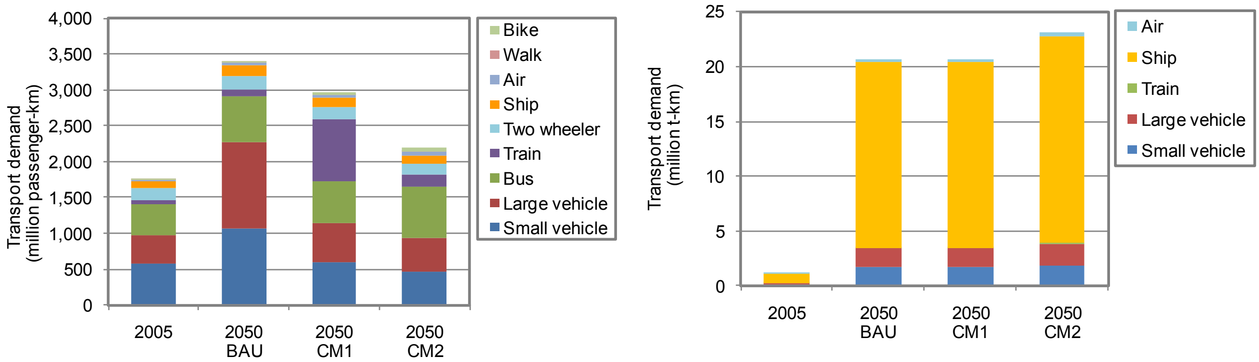


Figure 26 Transport demand by transport mode in passenger (right) and freight (left) transport

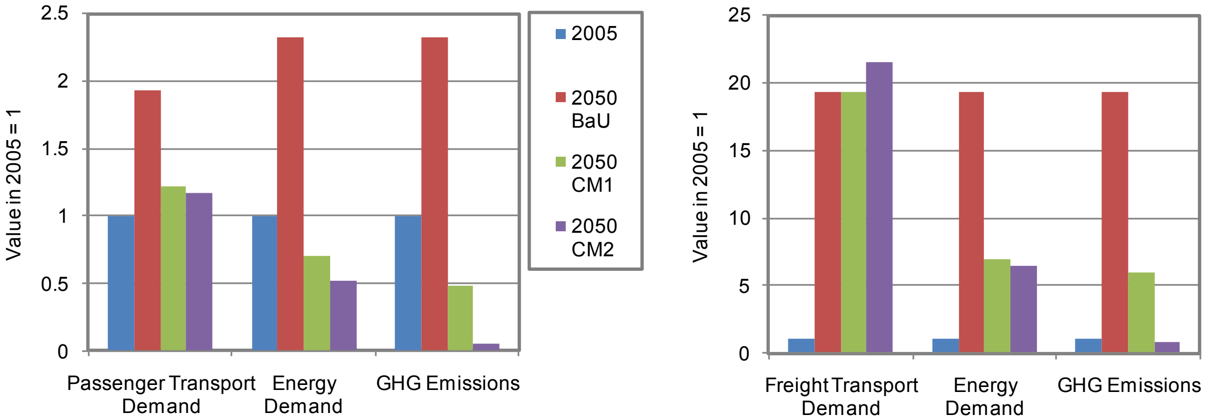


Figure 27 Effect of passenger and freight transport demand to energy demand and CO_2 emissions

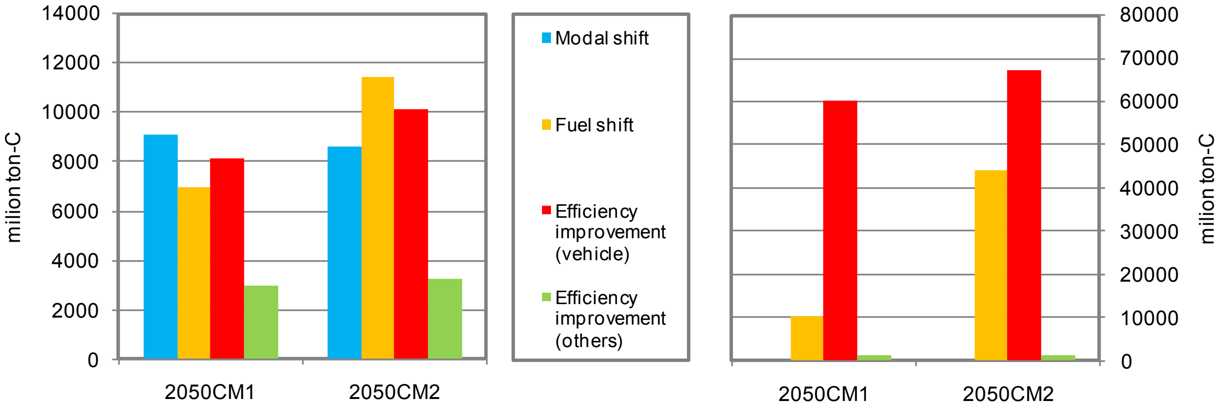


Figure 28 CO_2 emissions reduction potential by means in passenger (right) and freight (left) transport

Methodology

A Procedure to create a local LCS scenario

In order to create a local low-carbon society scenario, We developed a method based on the idea of "back casting", which sets a desirable goal first, and then seek the way to achieve it. Figure 28 shows overview of the method.

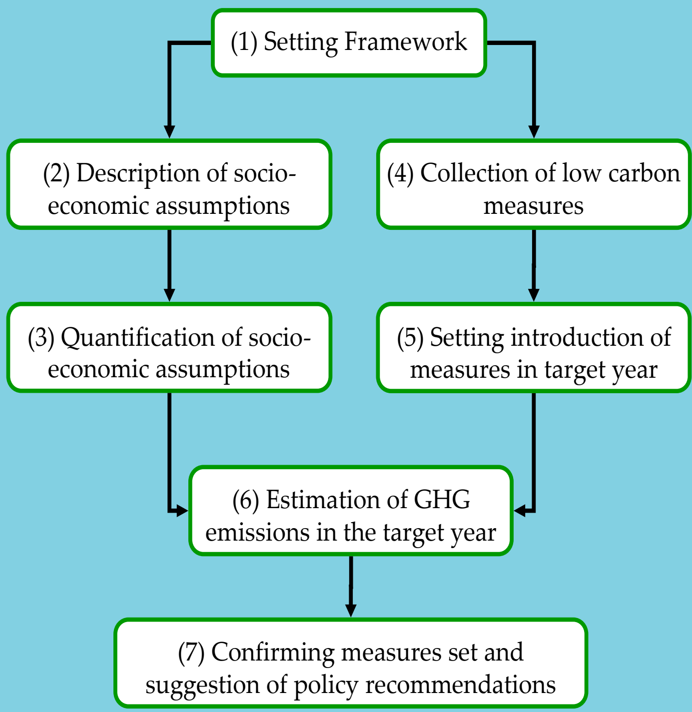


Figure 28. Procedure to create a local LCS scenario

(1) Setting framework

Framework of a LCS scenario includes; target area, base year, target year, environmental target, number of scenarios. Among them, the base year is compared with target year. The target year should be far enough to realize required change, and near enough to image the vision for the people in the region. In this study, we set the target year of Indonesia, 2050. This is also a suitable time span for a LCS study for the reasons above.

(2) Assumptions of socio-economic situations

Before conducting quantitative estimation, qualitative future image should be written. It is an image of lifestyle, economy and industry, land use and so on. We could use the assumptions showed in the CDP.

(3) Quantification of socio-economic assumptions

To estimate Snapshot based on future image of (2), values of exogenous variables and parameters are set. Using those input, ExSS calculates socio-economic indices of the target year such as population, GDP, output by industry, transport demand, and so on.

(4) Collection of low-carbon measures

To collect counter measures which are thought to be available in the target year. For example, high energy-efficiency devices, transport structure change such as public transport, use of renewable energy, energy saving behavior and carbon sink. Technical data is required to estimate their effect to reduce GHG emissions. In this research we employed the measure collected by AIM group in preceding studies.

(5)Setting introduction of counter measures

Technological parameters related to energy demand and CO_2 emissions, in short energy efficiency, are defined. Since there can be various portfolios of the measures, one must choose appropriate criteria. For example, cost minimization, acceptance to the stakeholders, or probability of technological development.

(6)Estimation of GHG emission in the target year

Based on socio-economic indices and assumption of measures' introduction, GHG emissions are calculated.

(7)Proposal of policies

Propose policy set to introduce the measures defined. Available policies depend on the situation of the municipality or the country which it belongs. ExSS can calculate emission reduction of each counter measure.

Therefore, it can show reduction potential of measures which especially needs local policy. It can also identify measures which have high reduction potential and therefore important.

Quantitative estimation tool "Extended Snapshot Tool"

Figure 29 shows the structure of the Extended Snapshot Tool (ExSS); seven blocks with input parameters, exogenous variables and variables between modules. ExSS is a system of simultaneous equations. Given a set of exogenous variables and parameters, solution is uniquely defined. In this simulation model, only CO_2 emission from energy consumption is calculated, even though, ExSS can be used to estimate other GHG and environmental loads such as air quality. In many LCS scenarios, exogenously fixed population data are used. However, people migrate more easily, when the target region is relatively a smaller area such as a state, district, city or town. Population is decided by demand from outside of the region, labor participation ratio, demographic composition and relationship of commuting with outside of the region. To determine output of industries, input-output approach with "export-base approach" is combined in line with the theory of regional economics.

Industries producing export goods are called "basic industry". Production of basic industries induces other industries i.e. non-basic industries, through demand of intermediate input and consumption of their employees. Number of workers must fulfill labor demand of those productions. Given assumptions of where those workers live and labor participation ratio, population living in the region is computed. This model enables us to consider viewpoints of regional economic development to estimate energy demand and CO_2 emissions. For future estimation, assumption of export value is especially important if the target region is thought to (or, desired to) develop led by particular industry, such as automotive manufacturing.

Passenger transport demand is estimated from the population and freight transport demand whereby it is a function of output by manufacturing industries. Floor area of commerce is determined from output of tertiary industries. Other than driving force, activity level of each sector, energy demand by fuels determined with three parameters. One is energy service demand per driving force, energy efficiency and fuel share. Diffusion of counter measures changes the value of these parameters, and so GHG emissions.

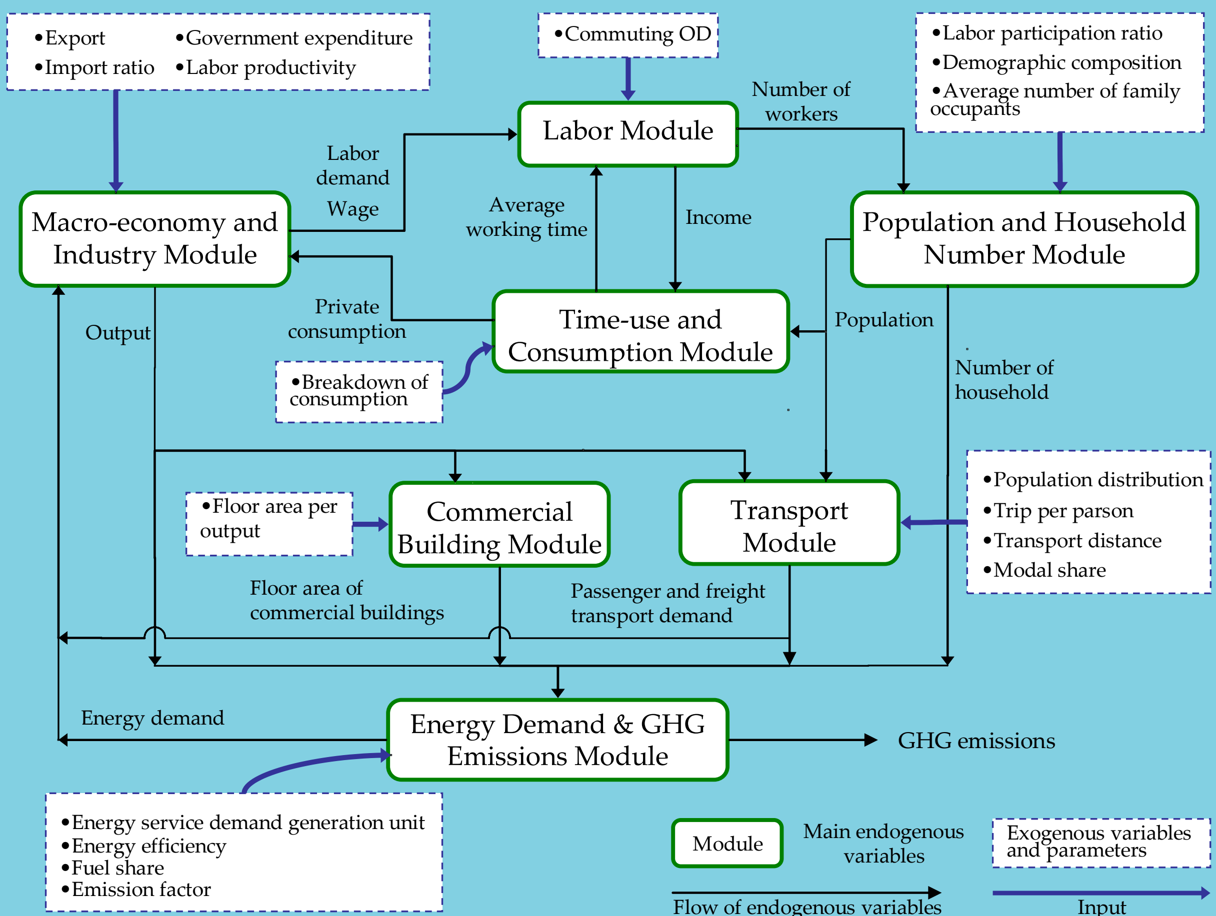


Figure 29. Overview of calculation system of Extended Snapshot Tool

Data tables

Table 5. Input-Output data in the base year (2005), trillion rupiah

	Agriculture	Mining and Quarying	Food and Beverage	Textile, Wood, and Paper	Chemicals	Construction	Other Industries	Iron and Stel	Cement	Commercial Services	Intermediate input	Private consumption	Government consumption	Fixed capital formation	Export	Import	Total final demand	Total output
Agriculture	32.0	0.0	104.9	14.2	13.8	5.7	0.5	0.0	0.0	34.4	206	131.4	0.0	-1.5	10.8	-17.6	123	329
Mining and Quarying	0.0	22.9	0.3	0.3	90.6	19.6	8.0	18.3	4.3	0.4	165	0.0	0.0	3.9	119.0	-47.2	76	240
Food and Beverage	13.7	0.0	54.6	0.9	1.1	0.0	0.0	0.0	0.0	34.8	105	199.6	0.0	-3.6	43.8	-28.9	211	316
Textile, Wood, Paper	0.5	0.2	3.3	70.8	2.5	14.1	1.1	2.5	0.2	26.0	121	54.0	0.0	5.5	96.7	-23.9	132	253
Chemicals	16.5	3.9	5.4	26.8	56.5	43.9	19.9	25.2	0.5	75.4	274	68.9	0.0	7.1	112.8	-123.4	65	339
Construction	2.7	2.5	0.1	0.4	0.4	0.4	0.6	0.5	0.1	23.1	31	0.0	0.0	328.5	0.0	0.0	328	359
Other Industries	0.4	0.2	1.1	5.6	2.4	0.6	44.9	5.9	1.1	43.2	105	73.2	0.0	21.0	16.8	-50.9	60	165
Iron and Stel	1.3	3.8	0.6	3.2	2.8	70.8	12.7	83.8	0.0	16.1	195	52.1	0.0	66.6	81.5	-130.4	70	265
Cement	0.0	0.0	0.6	0.0	0.4	12.3	0.0	0.0	0.0	0.0	13	0.0	0.0	0.0	0.5	-0.3	0	14
Commercial Services	18.7	10.1	35.8	36.2	25.0	63.3	17.3	42.2	1.5	280.4	530	529.7	139.7	25.3	124.8	-99.0	720	1251
Intermediate input	86	44	207	158	195	231	105	178	8	534	1746	1,109	140	453	607	-522	1786	3532
Compensation for employee	55.4	27.1	26.5	28.5	42.0	47.7	20.0	25.2	1.8	273.7	548							
Operating surplus	183.6	161.7	62.1	63.9	132.4	76.1	43.5	57.2	3.5	425.5	1209							
Subsidy & Indirect tax	3.9	8.2	20.7	2.7	-30.5	4.6	-3.1	4.0	0.7	17.7	29							
Total value added	243	197	109	95	144	128	60	86	6	717	1786							
Total Input	329	240	316	253	339	359	165	265	14	1251	3532							

Table 6. Input-Output data in the target year (2050), BAU and CM1 Scenarios, trillion rupiah

	Agriculture	Mining and Quarying	Food and Beverage	Textile, Wood, and Paper	Chemicals	Construction	Other Industries	Iron and Stel	Cement	Commercial Services	Intermediate input	Private consumption	Government consumption	Fixed capital formation	Export	Import	Total final demand	Total output
Agriculture	634.6	0.6	1895.5	272.8	269.0	113.6	10.5	0.1	0.0	779.9	3977	2696.5	0.0	-31.2	221.7	-347.6	2539	6516
Mining and Quarying	0.0	445.2	5.0	6.2	1770.7	387.4	152.3	352.8	84.0	10.2	3214	0.1	0.0	76.4	2303.5	-921.3	1459	4673
Food and Beverage	270.7	0.0	987.0	16.3	22.3	0.0	0.1	0.3	0.0	789.9	2087	3363.3	0.0	-69.7	847.7	-517.1	3624	5711
Textile, Wood, Paper	9.0	3.4	60.0	1355.7	48.7	277.8	21.8	48.7	3.0	590.2	2418	909.1	0.0	107.9	1870.6	-453.9	2434	4852
Chemicals	327.9	75.0	96.8	512.3	1104.0	868.7	380.2	484.6	10.4	1710.8	5571	1160.8	0.0	139.9	2182.6	-2422.6	1061	6631
Construction	53.4	48.4	2.0	7.0	6.9	7.2	12.1	10.1	1.2	524.4	673	0.0	0.0	6427.1	0.0	0.0	6427	7100
Other Industries	8.8	3.5	20.1	107.3	46.8	11.1	859.9	113.8	22.0	981.2	2175	1232.8	0.0	410.2	324.7	-974.2	993	3168
Iron and Stel	25.4	72.9	11.7	62.1	54.1	1399.5	242.3	1614.5	0.0	366.0	3848	877.2	0.0	1304.2	1577.9	-2505.9	1253	5102
Cement	0.0	0.0	11.7	0.0	7.9	243.2	0.2	0.1	0.5	0.0	264	0.0	0.0	0.3	10.2	-5.1	5	269
Commercial Services	370.1	196.6	646.3	692.2	488.2	1252.3	331.2	811.8	30.1	6363.9	11183	12515.1	2867.1	929.4	3113.0	-2222.8	17202	28384
Intermediate input	1700	846	3736	3032	3818	4561	2011	3437	151	12117	35408	22,755	2,867	9,294	12,452	-10,371	36998	72406
Compensation for employee	1098.4	526.9	478.5	545.6	821.3	943.7	382.3	485.8	35.8	6211.2	11529							
Operating surplus	3639.5	3141.7	1123.1	1222.6	2586.6	1503.5	833.9	1102.4	68.4	9654.9	24877							
Subsidy & Indirect tax	78.1	158.4	373.4	51.8	-595.1	91.9	-58.8	76.8	13.6	401.7	592							
Total value added	4816	3827	1975	1820	2813	2539	1157	1665	118	16268	36998							
Total Input	6516	4673	5711	4852	6631	7100	3168	5102	269	28384	72406							

Table 7. Input-Output data in the target year (2050), CM2 Scenarios, trillion rupiah

	Agriculture	Mining and Quarying	Food and Beverage	Textile, Wood, and Paper	Chemicals	Construction	Other Industries	Iron and Stel	Cement	Commercial Services	Intermediate input	Private consumption	Government consumption	Fixed capital formation	Export	Import	Total final demand	Total output
Agriculture	936.0	0.6	1352.7	264.2	318.6	148.2	12.6	0.1	0.0	2130.9	5164	4807.8	0.0	-55.7	213.3	-519.0	4446	9610
Mining and Quarying	0.0	428.6	3.6	6.0	2097.2	505.5	182.1	353.2	105.5	27.8	3709	0.0	0.0	91.0	1761.9	-1064.1	789	4498
Food and Beverage	399.3	0.0	704.3	15.8	26.4	0.0	0.2	0.3	0.0	2158.3	3305	569.8	0.0	-83.0	648.4	-364.4	771	4075
Textile, Wood, Paper	13.2	3.2	42.8	1313.1	57.7	362.4	26.0	48.8	3.8	1612.7	3484	154.0	0.0	128.5	1430.8	-497.7	1216	4699
Chemicals	483.6	72.2	69.1	496.2	1307.6	1133.5	454.6	485.1	13.1	4674.5	9189	196.7	0.0	166.6	1669.4	-3368.0	-1335	7854
Construction	78.7	46.6	1.4	6.7	8.2	9.4	14.5	10.1	1.5	1432.9	1610	0.0	0.0	7654.0	0.0	0.0	7654	9264
Other Industries	13.0	3.4	14.4	103.9	55.4	14.5	1028.2	113.9	27.6	2681.1	4056	208.9	0.0	488.5	248.3	-1212.8	-267	3788
Iron and Stel	37.5	70.2	8.3	60.2	64.0	1826.1	289.7	1616.2	0.0	1000.0	4972	148.6	0.0	1553.1	1206.9	-2773.6	135	5107
Cement	0.0	0.0	8.3	0.0	9.4	317.4	0.3	0.1	0.6	0.0	336	0.0	0.0	0.3	7.8	-6.5	2	338
Commercial Services	545.8	189.2	461.2	670.5	578.2	1634.0	396.0	812.7	37.7	17388.5	22714	34486.3	15336.0	6628.9	4791.1	-6400.3	54842	77556
Intermediate input	2507	814	2666	2937	4523	5951	2404	3441	190	33107	58539	40,572	15,336	16,572	11,978	-16,206	68252	126791
Compensation for employee	1620.0	507.3	341.4	528.4	972.7	1231.3	457.2	486.3	44.9	16971.2	23161							
Operating surplus	5367.8	3024.4	801.5	1184.2	3063.6	1961.8	997.2	1103.6	85.8	26380.5	43970							
Subsidy & Indirect tax	115.2	152.5	266.5	50.2	-704.9	119.9	-70.3	76.9	17.0	1097.5	1120							
Total value added	7103	3684	1409	1763	3331	3313	1384	1667	148	44449	68252							
Total Input	9610	4498	4075	4699	7854	9264	3788	5107	338	77556	126791							

Table 8 Final energy demand of base year (2005) and target year (2050BAU, CM1, CM2), ktoe

2005 Base	Coal	Oil	Natural gas	Solar & Wind	Hydrogen	Biomass	Electricity	total
Passenger Transport	0	17,788	6	0	0	0	5	17,798
Freight Transport	0	6,562	0	0	0	0	0	6,562
Residential	0	7,876	836	0	0	30,674	3,446	42,832
Agriculture	0	204	0	0	0	500	32	736
Mining and Quarying	0	901	500	0	0	150	350	1,901
Food and Beverage	0	321	2,500	0	0	300	150	3,271
Textile, Wood, Paper	1,068	1,122	1,500	0	0	2,650	800	7,140
Chemicals	17	650	3,000	0	0	0	500	4,167
Construction	0	210	0	0	0	150	50	410
Other Industries	4,461	2,256	1,277	0	0	745	470	9,209
Iron and Stel	254	1,510	1,500	0	0	0	700	3,964
Cement	3,175	1,750	1,500	0	0	1,500	500	8,425
Commercial	0	1,223	207	0	0	193	2,081	3,704
TOTAL	8,975	42,374	12,825	0	0	36,863	9,084	110,120

2050 BaU	Coal	Oil	Natural gas	Solar & Wind	Hydrogen	Biomass	Electricity	total
Passenger Transport	0	41,394	10	0	0	0	2	41,406
Freight Transport	0	126,510	0	0	0	0	0	126,510
Residential	0	14,416	4,660	0	0	5,606	45,078	69,761
Agriculture	0	11,453	421	0	0	0	4,811	16,686
Mining and Quarying	0	9,335	28,574	0	0	0	2,915	40,824
Food and Beverage	0	9,853	0	0	0	0	3,105	12,958
Textile, Wood, Paper	14,026	52,722	0	0	0	16,191	4,790	87,730
Chemicals	332	18,538	72,542	0	0	0	4,437	95,850
Construction	0	4,157	0	0	0	0	329	4,487
Other Industries	51,254	57,510	23,066	0	0	4,854	20,401	157,084
Iron and Stel	4,891	29,072	28,885	0	0	0	13,480	76,327
Cement	63,401	11,981	0	0	0	0	1,997	77,379
Commercial	0	39,561	4,689	0	0	4,385	63,317	111,952
TOTAL	133,904	426,503	162,846	0	0	31,037	164,663	918,953

2050 CM1	Coal	Oil	Natural gas	Solar & Wind	Hydrogen	Biomass	Electricity	total
Passenger Transport	0	8,526	0	0	0	4,001	15	12,543
Freight Transport	0	39,174	0	0	0	6,449	0	45,623
Residential	0	0	13,761	9	0	0	24,940	38,710
Agriculture	0	1,960	4,865	0	0	5,234	2,064	14,124
Mining and Quarying	2,141	6,351	22,753	0	0	4,313	1,657	37,214
Food and Beverage	682	1,670	3,313	0	0	2,503	2,825	10,993
Textile, Wood, Paper	4,422	6,835	44,617	0	0	25,728	1,057	82,660
Chemicals	1,023	15,606	65,168	0	0	3,741	596	86,134
Construction	0	917	582	0	0	1,584	329	3,411
Other Industries	12,409	20,751	82,146	0	0	19,586	13,551	148,443
Iron and Stel	31,247	0	0	0	0	0	0	31,247
Cement	42,835	11,981	0	0	0	0	1,997	56,813
Commercial	0	18,603	14,265	0	0	0	35,171	68,039
TOTAL	94,758	132,374	251,471	9	0	73,140	84,202	635,954

2050 CM2	Coal	Oil	Natural gas	Solar & Wind	Hydrogen	Biomass&H2	Electricity	total
Passenger Transport	0	304	0	0	0	5,366	3,573	9,244
Freight Transport	0	574	0	0	5,403	12,086	23,994	42,056
Residential	0	0	2,248	0	0	326	64,397	66,971
Agriculture	0	525	328	0	0	6,069	13,031	19,952
Mining and Quarying	627	1,168	2,426	0	0	5,579	26,186	35,985
Food and Beverage	77	246	417	0	0	1,349	6,247	8,335
Textile, Wood, Paper	0	1,460	4,660	0	0	16,209	59,662	81,990
Chemicals	0	3,826	6,249	0	0	21,112	69,561	100,748
Construction	0	289	289	0	0	686	4,512	5,776
Other Industries	0	3,618	8,591	0	0	51,552	146,746	210,507
Iron and Stel	1,996	0	0	0	0	0	11,205	13,202
Cement	52,948	11,848	0	0	0	0	1,975	66,771
Commercial	0	0	4,872	0	0	20,121	104,075	129,068
TOTAL	55,649	23,857	30,079	5,403	0	140,454	535,163	790,605

Table 9. Power supply table in Base year, BaU, CM1 and CM2 scenarios, ktoe

2005 Base	Coal (conventional)	Coal (IGCC with CCS)	Oil	Natural gas	Hydro	Nuclear	Solaer & wind	Biomass	Total
Fuel consumption	12,382	0	7,966	3,252	824	0	507	6	24,937
Power generation	3,979	0	2,992	1,481	824	0	507	2	9,785
Own use	166	0	125	62	34	0	21	0	407
Transmission loss	445	0	334	166	92	0	57	0	1,094
Power supply	3,368	0	2,533	1,254	697	0	429	1	8,284

2050 BaU	Coal (conventional)	Coal (IGCC with CCS)	Oil	Natural gas	Hydro	Nuclear	Solaer & wind	Biomass	Total
Fuel consumption	368,941	0	20,716	106,726	11,670	0	7,196	3,890	519,139
Power generation	118,061	0	7,780	48,625	11,670	0	7,196	1,167	194,499
Own use	4,915	0	324	2,024	486	0	300	49	8,097
Transmission loss	13,196	0	870	5,435	1,304	0	804	130	21,740
Power supply	99,950	0	6,587	41,166	9,880	0	6,093	988	164,663

2050 CM1	Coal (conventional)	Coal (IGCC with CCS)	Oil	Natural gas	Hydro	Nuclear	Solaer & wind	Biomass	Total
Fuel consumption	147,788	0	9,762	48,811	7,810	0	5,857	8,135	228,163
Power generation	53,204	0	3,905	24,405	7,810	0	5,857	2,441	97,622
Own use	2,215	0	163	1,016	325	0	244	102	4,064
Transmission loss	5,099	0	374	2,339	748	0	561	234	9,356
Power supply	45,890	0	3,368	21,050	6,736	0	5,052	2,105	84,202

2050 CM2	Coal (conventional)	Coal (IGCC with CCS)	Oil	Natural gas	Hydro	Nuclear	Solaer & wind	Biomass	Total
Fuel consumption	45,448	514,934	28,784	34,541	80,595	98,083	57,568	191,893	1,051,845
Power generation	17,270	257,467	11,514	17,270	80,595	98,083	57,568	57,568	597,335
Own use	719	25,747	479	719	3,355	9,808	2,396	2,396	45,620
Transmission loss	497	6,952	331	497	2,317	2,648	1,655	1,655	16,551
Power supply	16,055	224,769	10,703	16,055	74,923	85,626	53,516	53,516	535,163

Table 10. Sources for the statistical data

Statistics	Sources	Year
Indonesian Input-Output table	BPS-Indonesia	FY2000-2005
Indonesian population census	BPS-Indonesia	2005-2025
Indonesian population projection	UN statisitcs	2005-2050
Other indonesian economic data	Bank of Indonesia publications	
National energy balance	Pusdatin-MEMR	2000-2005
Energy balance table of several countries	US-department of energy	2005
Other energy information	DGEEU-MEMR publications	
Transportation statistics	Ministry of transportation	2005
Industrial statistics	BPS-Indonesia	2005

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