Preliminary Study

LONG TERM STRATEGY To Achieve DKI Jakarta's Low Carbon Society 2050

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AIM
ASIA-PACIFIC INTEGRATED MODEL

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EXECUTIVE SUMMARY

In the context of global climate change mitigation, there is a need to cut GHG (Greenhouse Gases) emissions to limit global temperature increase of 2°C in the mid of the century. In December 2015, under the Paris Agreement, the world has reached an agreement that outlined the contribution of each country in combating climate change, which is called Indonesia NDC (Nationally Determined Contribution). In addition to NDC, the Paris Agreement also mandated that each country submit its long-term strategy in contributing to the world efforts in achieving 1.5 C target at the mid of the century. Within this context, Indonesia begins to prepare a long-term GHG emissions reduction target (2050), which is commonly called Long Term Strategy (LTS). In line with this National LTS, DKI Jakarta is preparing its Provincial LTS aiming to establish the Low Carbon Development Strategy (LCDS) for achieving the Low Carbon Society (LCS). In conjunction with this DKI Jakarta LCDS preparation, a study concerning low carbon development scenario toward 2050 has been conducted. Part of the results of the study, which covers the energy, power, waste, and AFOLU sectors are presented in this summary.

The tool used in this research is non-linear programming model ExSS using GAMS v 23.3 supported by various technical, economic and social parameters. The method based on back casting approach is developed with sets of desirable goal first and then seek the way to achieve it, namely (i) setting of framework: base year (2010) and target year (2030 and 2050), environmental target, target area, and number of scenarios; (ii) collection of the base year information i.e., socio-economic assumptions; (iii) collection of LC (Low Carbon) measure information; (iv) estimation of snapshots without LC measures; and (v) estimation of snapshots with LC measures. Projection scenarios developed in this study are business as usual (BaU) and mitigation scenarios. The BaU scenario envisions development paths and the associated GHG emissions without considering mitigation effort. The mitigation scenario is developed to envision the development paths to achieve low carbon city. The study assumes that in 2010-2050 the GDP of DKI Jakarta would grow, on average, 5.7% per year.

Key Findings

Under the BaU scenario, GHG emissions associated with energy used will increase from 28.249 Mton CO_2e (2010) to 165.274 Mton CO_2e (2050). While, under the CM scenario, the GHG emissions level will be reduced to 121.804 Mton CO_2e (2050), which is equivalent to 43.470 Mton CO_2e (22.95%) reduction compared with DKI Jakarta BaU scenario. The reduction is achieved under CM scenario as the end-user efficiency improvement measures, fuel switching, change of transport mode, deployment of advanced technology such as electric vehicle fueled using renewable source, and promotion of solar PV system.

The level of GHG emissions in waste sector is determined by the amount of waste treated and the type of technology used. For BAU scenario, GHG emissions is estimated increase from 2.447 Mton CO_2e (2010) to 5.241 Mton CO_2e (2050). The mitigation efforts implemented in CM scenario will result in a reduction of GHG emissions by 2.691 Mton CO_2e (2050) which is equivalent to 1.44% reduction compared with DKI Jakarta BaU scenario. The major reduction would come from mitigation action in the treatment of domestic solid waste (98% of total reduction from waste sector). The mitigation actions include i) Composting of solid organic waste, including food waste and garden waste, ii) 3R (reduce, reuse, recycle) activities, iii) Landfill gas recovery for electricity generation, and iv) power generation by waste.

The base year used in the AFOLU sector is 2018 due to data limitations. Under baseline calculation (BaU), the GHG emission removal by sinks reach 59.8 tons of CO_2e, with the area of urban forest vegetation that still active is 111.22 Ha for 2018-2030. Assuming the area of urban forest vegetation in 2010 and 2018 is similar, therefore GHG emission removal in 2010 as same as 2018. The mitigation action was taken from the Forestry Strategic Plan for 2017-2022. The selected mitigation activity is the development of forest green open space and limited to planting activities only. Therefore, forest green open space development outside of planting activities is not included in the mitigation activities. The additional forest green open space of DKI Jakarta for 2017 -2022 is 3 ha/year. The data for 2023-2030 are obtained from the regression result of green open space development in the Forestry Strategic Plan for 2017-2022. Under mitigation (CM), the GHG emissions removal by sinks are 79.13 tons of CO_2e in 2030 or increase by 32.4% compared with BaU level in 2018. The GHG emissions removal achieved from AFOLU sector is 19.35 tons of CO_2e in 2030.

In the context of global climate change mitigation, there is a need to cut GHG (Greenhouse Gases) emissions to limit global temperature increase of 2°C in the mid of the century. In December 2015, under the Paris Agreement, the world has reached an agreement that outlined the contribution of each country in combating climate change, which is called Indonesia NDC (Nationally Determined Contribution). Indonesia has ratified the Paris Agreement (PA) through Law No. 16/2016. Through its NDC, the Government of Indonesia (GOI) is committed to reduce the national GHG emissions level by 29% below its baseline emissions in 2030 (unconditional) and further up to 41% (conditional) if there are international supports.

This NDC has been translated into the implementation road map. In order to contribute to GHG emissions reduction of 29% (unconditional target) and 41% (conditional target) below the baseline, the energy sector should reduce its GHG emissions level in 2030 by 314 Mton CO_2e and 398 Mton CO_2e [Indonesia NDC, 2016]. At this GHG emissions reduction, the GHG emissions is estimated become 5.63 ton CO_2e per capita in 2030, in which the GHG emissions in 2010 is 1.90 ton CO_2e per capita. Longer-term studies show that Indonesia has the potential to deeply reduce GHG emissions in the energy sector down to 1.31 ton CO_2e per capita in 2050 [Siagian, 2015]. In support of the national GHG emissions reduction, many provincial governments are actively attempting to reduce their GHG emissions, including DKI Jakarta.

DKI Jakarta is the capital city of Indonesia with high economic activity. The city is marked by a very dense city's population (with 1% population growth) and more than 10.5 million population living in 662 km^2 of land area and 6,977 km^2 of sea area, having high motorized vehicle density (cars and motorcycles), and limited public transport infrastructure. Regarding the population, it should be noted that the analysis of this study also includes unregistered residents and commuters, which in total is 15% of the total Jakarta population [BPS 2018].

Economically, the city significantly contributes to the national economy. With the city's GDP level at around 396 trillion Rupiah (at constant price 2000) in 2010, DKI Jakarta accounts for 17% of national GDP. The population growth, economic characteristics, and transportation condition has to lead climate change issues with GHG emissions level. DKI Jakarta has already set its emissions reduction target in 2030 through the Governor Regulation RAD-GRK DKI Jakarta No. 131/2012. This regulation is being revised to respond to the latest development in the national as well as regional level, particularly, which are related to the GHG Emissions. In line with this regulation, DKI Jakarta accelerating the implementation of air quality control through the seven-point of Governor instructions No. 66/2019.

In addition to the 2030 target, Indonesia begins to prepare a long-term GHG emissions reduction target (2050), which is commonly called Long Term Strategy (LTS). In line with this National LTS, DKI Jakarta is preparing its Provincial LTS aiming to establish the Low Carbon Development Strategy (LCDS) for achieving the Low Carbon Society (LCS). In conjunction with this DKI Jakarta LCDS preparation, a study concerning low carbon development scenario toward 2050 has been conducted. Part of the results of the study, which covers the energy, power, waste, and AFOLU sectors are presented in this brochure

The Importance of Low Carbon Development for DKI Jakarta

It is important to understand the Low Carbon Development for a city, particularly city such as DKI Jakarta, one of the megacities in Indonesia. The city's population, economic characteristics, and transportation condition of DKI Jakarta has to lead climate change issues with GHG emissions level of 37.540 Mton CO_2e or 3.43 ton CO_2e per capita in 2010 and significantly increase up to 56.306 Mton CO_2e or 4.78 ton CO_2e per capita in 2018 (BaU) as shown in Figure 1. As a comparison, the national GHG emissions is 4.37 ton CO_2e per capita in 2018.

Table 1 The projection of CO_2 emissions and Its reduction potential

		2010	2030		2050		% Reduction	
			BaU	CM	BaU	CM	2030	2050
CO_2 emissions ($Mton\ CO_2e$) by sector	Energy (final)	28.249	83.237	61.548	165.274	121.804	**20.37%**	**22.95%**
	Power	7.213	19.029	9.844	19.029	9.817	**8.62%**	**4.86%**
	Waste	2.447	4.233	2.804	5.241	2.518	**1.34%**	**1.44%**
	AFOLU	$5.98\ 10^{-5}$	$5.98\ 10^{-5}$	$7.91\ 10^{-5}$	n.a	n.a		
Total CO_2 emissions ($Mton\ CO_2e$)		37.908	106.499	74.196	189.544	134.139	**30.33%**	**29.23%**
CO_2 emissions per GDP (tCO_{2e}/mil. Rp)		35.239	34.654	24.143	19.231	13.609		
CO_2 emissions per capita (tCO_{2e}/person)		3.431	8.188	5.705	13.833	9.790		
C emissions per capita (tC/person)		0.936	2.233	1.556	3.773	2.670		

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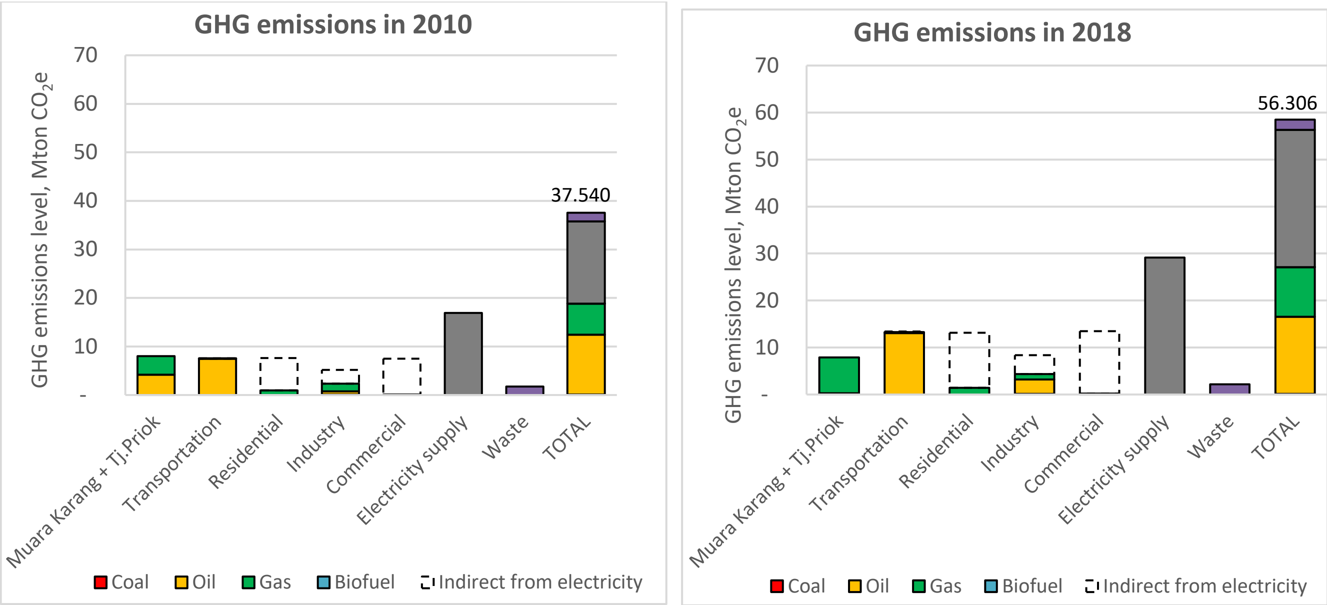

Figure 1. GHG emissions level in 2010 and 2018

Low Carbon Development Pathway of DKI Jakarta

Low Carbon Scenario of DKI Jakarta is developed using non-linear programming ExSS (Extended Snap Shot) using GAMS (General Algebraic Modeling System) as a tool for developing energy development paths and assessing the mitigation potential of the associated GHG emissions. ExSS supported by various current technical, economic, and social parameter.

As presented in Figure 2, exSS shows snapshots of energy demand (electricity and non-electricity) and the associated GHG emissions (electricity and non-electricity) for base year and target year. The snapshots of parameters are presented as a ratio of its future values 2030 and 2050 as compared to the level of the base year (2010).

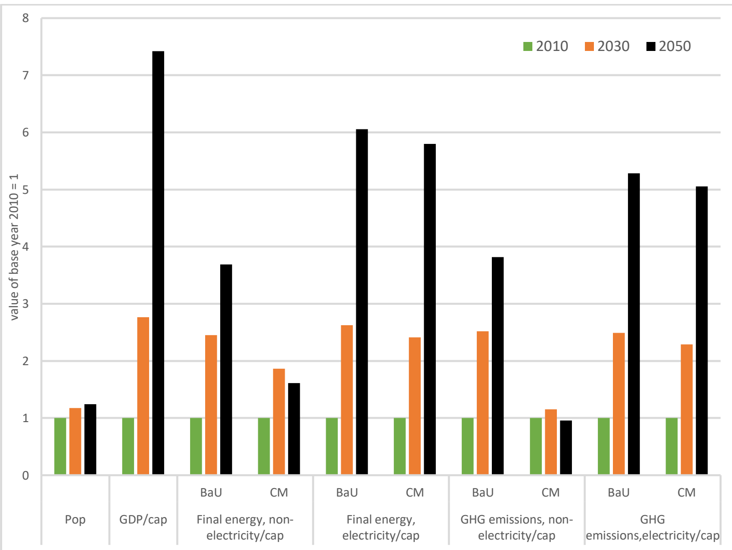

Figure 2. Projection of population, GDP, final energy, GHG emissions for base year (2010), 2030, and 2050

Two projection scenarios are developed, i.e., business as usual (BaU) and countermeasure (CM). The BaU scenario envisions the energy sector development path without considering mitigation actions and policies or regulations that lead to the reduction of GHG emissions while the CM scenario is developed to envision the low carbon development. The base year for both scenarios is 2010, and the target year is 2030 (NDC) and 2050 (Long Term Strategy).

The result of this study shows that under the BaU scenario, final energy consumption in DKI Jakarta is estimated to increase 2.96 times from 5.743 Mtoe to 16.989 Mtoe (2030) and 5.62 times to 32.260 Mtoe (2050). The GHG emissions is estimated to increase from 27.908 Mton CO_2e (2010) to 106.499 Mton CO_2e (2030) and 189.544 Mton CO_2e (2050).

Under the CM scenario, final energy demand during 2010-2050 is estimated to slightly low increase if compared with the BaU scenario, i.e., 2.96 times from 5.743 Mtoe to 16.989 Mtoe (2030) and 5.62 times to 32.260 Mtoe (2050). The mitigation actions in this scenario has energy-saving potential of 3.062 Mtoe (2030) and more ambitious energy-saving to 10.153 Mtoe (2050), which is equivalent to 18.02% and 31.57% reduction compared with BaU scenario. The GHG emissions level of DKI Jakarta will be potentially reduced for 30.33% (from 106.499 Mton CO_2e in the BaU scenario to 74.196 Mton CO_2e in the CM scenario) in 2030 and 29.23% (from 198.993 Mton CO_2e in the BaU scenario to 134.139 Mton CO_2e in the CM scenario) in 2050.

It should be noted that the GHG emissions reduction for both target 2030 and 2050 include emissions reduction from mitigation actions in Muara Karang and Tanjung Priok power plants. Although these power plants are located in the DKI Jakarta area, however, the mitigation actions in these plants are not under control of DKI Jakarta. The power plants are under the authority of PLN (national electricity company) as these plants are grid-connected (JAMALI grid). Although mitigation actions in both plants are classified as NPS (Non-Party Stakeholder), these efforts can be used to meet the Government of Indonesia/Party Stakeholder (PS) commitments.

Mitigation scenario (CM) in energy development path of DKI Jakarta is expected will bring DKI Jakarta to become Low

Carbon City in the future. The detail of GHG emissions reduction from each mitigation measure is summarized in Figure 3 and Figure 4. As can be seen from Figure 3 and Figure 4, GHG emissions reductions are resulted from implementing (i) end use energy efficiency measures in transportation, commercial building, industry, and residential sectors, (ii) fuel switching (diesel oil to biofuel) in transportation, industry, and commercial building, (iii) the use of gas in industry, (iv) transport mode shift to public transport (BRT, MRT & LRT, and Electric train) where the BRT will use electricity and biofuel, (v) non-motorized (pedestrian & bicycle track), the use of electric vehicle (vi) Public LED lighting and public lighting solar PV system, (vii) efficiency technology in power plant, (vii) fuel switching (oil to gas) in power plant, (viii) power generation by renewable fuel, (ix) solid waste treatment, and the last is (x) wastewater treatment.

In conclusion, DKI Jakarta has potential to reduce GHG emissions corresponding to the Indonesia NDC. Therefore, the development of DKI Jakarta will be in line with low carbon development path.

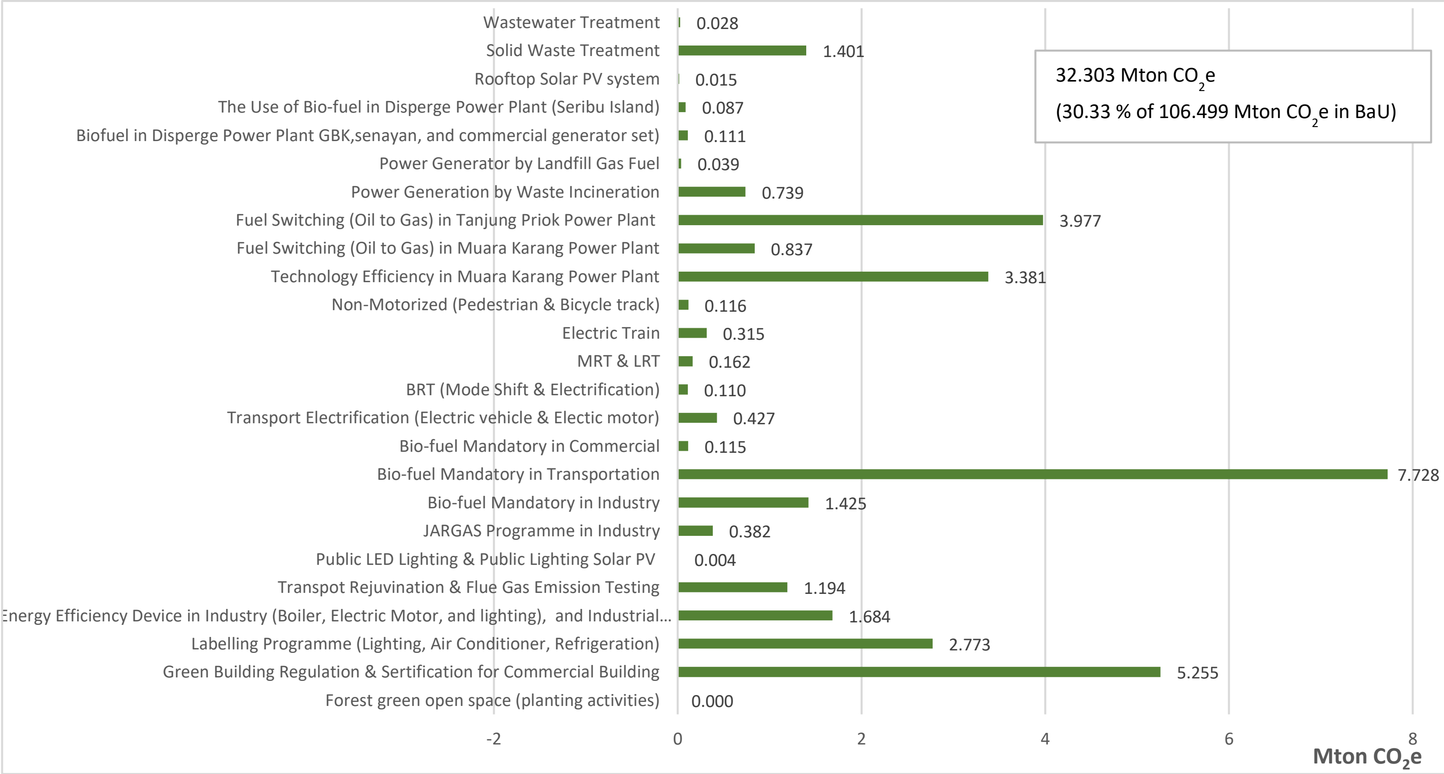

Figure 3. Breakdown of GHG emissions reduction target in 2030

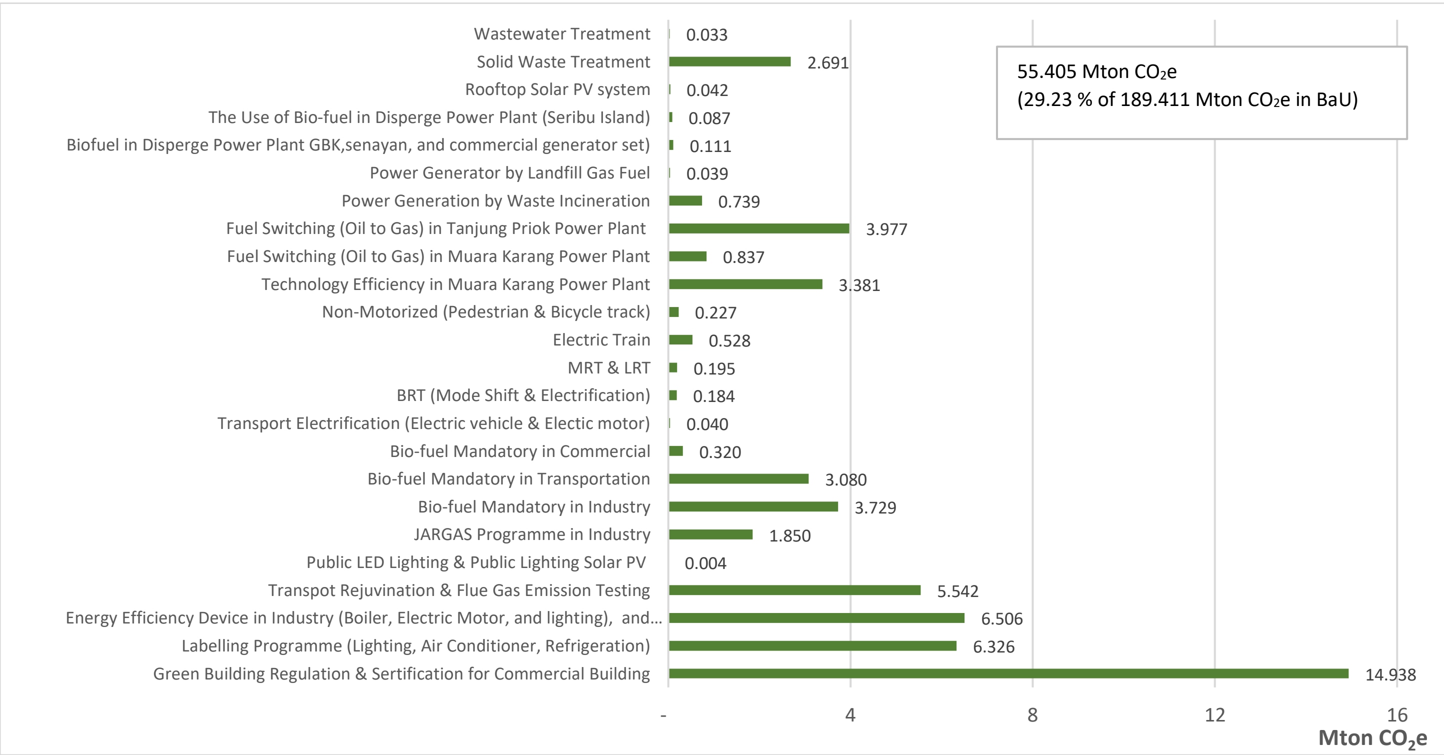

Figure 4. Breakdown of GHG emissions reduction target in 2050

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SOCIO-ECONOMIC VISION

Scenarios are used to envision the direction of future socio-economic visions for achieving LCS goals toward 2050, i.e., BAU scenario and CM scenario. The projection for both scenarios uses the same socio-economic indicator assumptions, as shown in Table 2. There will have been an increase in the number of each socio-economic factor by 2030 and 2050. All of these parameters are eventually will affect the projection of energy demand and the associated GHG emissions.

Population and Household

The city's population projection (2010-2050) uses the assumption that the population will continue to grow at the same rate (1% p.a). As can be seen in Table 2, the city's population increases 1.17 times and 1,24 times in 2030 and 2050, respectively. This situation is similar to the number of households in DKI Jakarta City. The number of households will also increase by 1.17 times (2030) and 1.30 times (2050) compared to the number in 2010. Growth of the number of households is a little bit faster than population growth because the household size will become smaller from the present to 2050

Table 2. Socio-economic indicators in DKI Jakarta (input parameters to ExSS Modeling)

	Unit	2010	2030	2050	2030/2010	2050/2010
Population	Persons	9,640,400	11,310,000	11,914,751	1.17	1.24
No. of households	Households	2,416,000	2,834,000	3,135,000	1.17	1.30
GDP	mil. Rp	1,075,761	3,073,233	9,856,274	2.86	9.16
Gross output	Bil.Rp	2,309	6,608	21,193	2.86	9.18
Primary industry		70.481	194.860	624.944	2.77	8.86
Secondary industry		958.496	2,737	8,777	2.85	9.16
Tertiary industry		1,280	3,676	11,791	2.87	9.21
Gross capital formation	mil. Rp	136,947	418,655	1,342,683	3.06	9.80
Export	mil. Rp	473,891	1,135,113	3,640,460	2.39	7.68
Import	mil. Rp	704,743	2,166,537	6,948,378	3.07	9.86
Transport demand						
Passenger transport	bil. Pass -km	84.328	259.360	303.704	3.08	3.60
Freight transport	bil. Ton-km	2.943	13.440	43.104	4.57	14.65

Macro Economy

As described in Table 2, the increase of macroeconomic indicators occurred is about 3 times (2030) and 9 times (2050) as much as the value in 2010. Two aspects are underlying the macroeconomic conditions, which are gross output and GDP.

First, the value of gross output in 2010 and its projection in 2030 and 2050 is presented in Figure 5. It can be seen from Figure 5, the main contributor to the city's economy is tertiary industry (commercial) followed by secondary industry (especially the manufacture and construction industry), and the last is the primary sector. Economic activity in these sectors will affect the demand for transportation infrastructure and also the energy consumption of the transport sector as well as the associated GHG emissions from the utilization of energy. However, economic activity in tertiary industry has a relatively low level of energy consumption.

Second is GDP per capita. GDP in 2010 was 1,076 bil. Rp and will have reached to 2,073 bil. Rp (2030) then increased rapidly to 9,856 bil. Rp (2050). GDP will increase by 2.86 times and 9.16 by 2030 and 2050, respectively, compared with that in base year (2010).

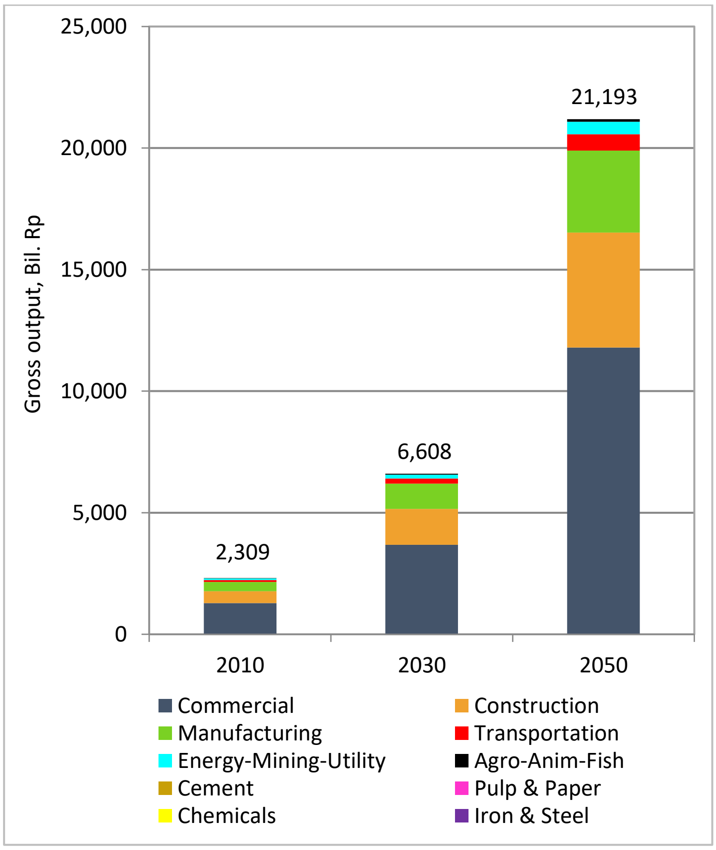

Figure 5. Projection of gross output for base year (2010), 2030, and 2050

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METHODOLOGY

The tool used in this research is non-linear programming model ExSS using GAMS v 23.3 supported by various technical, economic and social parameters. Figure 6 shows structure of the ExSS tool including input parameters, exogenous variables and variables between modules. As can be seen in the figure that population and economic developments are the main driving force of energy demand and, correspondingly GHG emissions. Scenario of development and choice of technology and type of fuel will determine the magnitude of energy demand and the associated GHG emissions.

The method based on back casting approach is developed with sets of desirable goal first and then seek the way to achieve it, namely (i) setting of framework: base year (2010) and target year (2030 and 2050), environmental target, target area, and number of scenarios; (ii) collection of the base year information i.e., socio-economic assumptions; (iii) collection of LC (Low Carbon) meassure information; (iv) estimation of snapshots without LC measures; and (v) estimation of snapshots with LC measures.

Projection scenarios developed in this study are business as usual (BaU) and mitigation scenarios. The BaU scenario envisions development paths and the associated GHG emissions without considering mitigation effort. The mitigation scenario is developed to envision the development paths to achieve low carbon city. The relationship between economic activity and energy sector development is shown in Figure 7. Projection scenario for both, BaU scenario and mitigation scenario, uses the same socio-economic indicator assumptions (see Table 2).

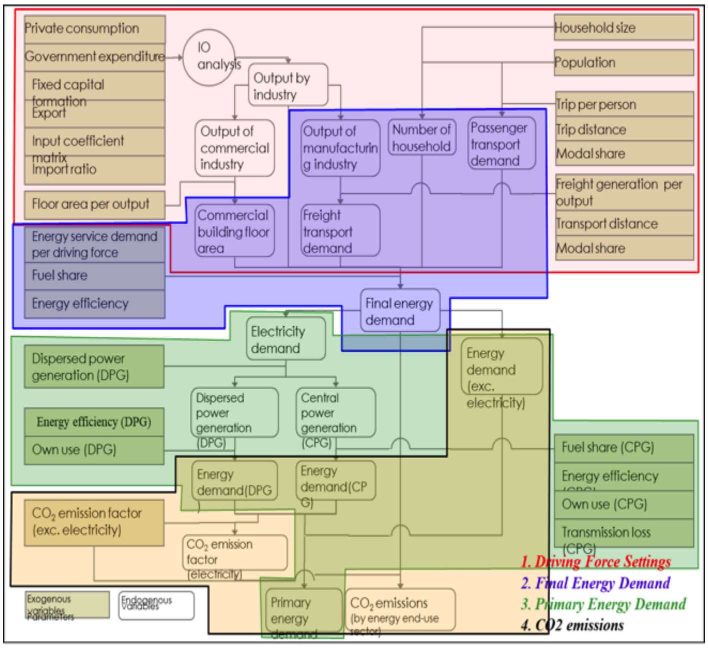


Figure 6. Overview of calculation system of ExSS

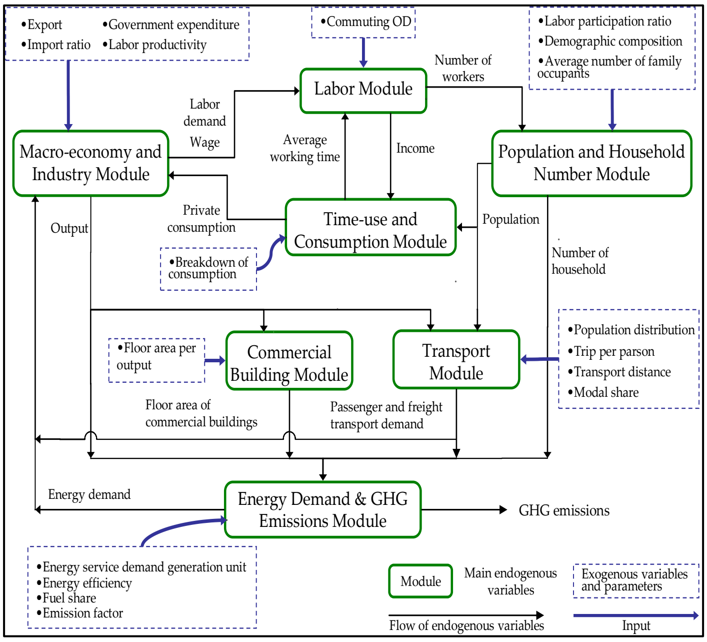


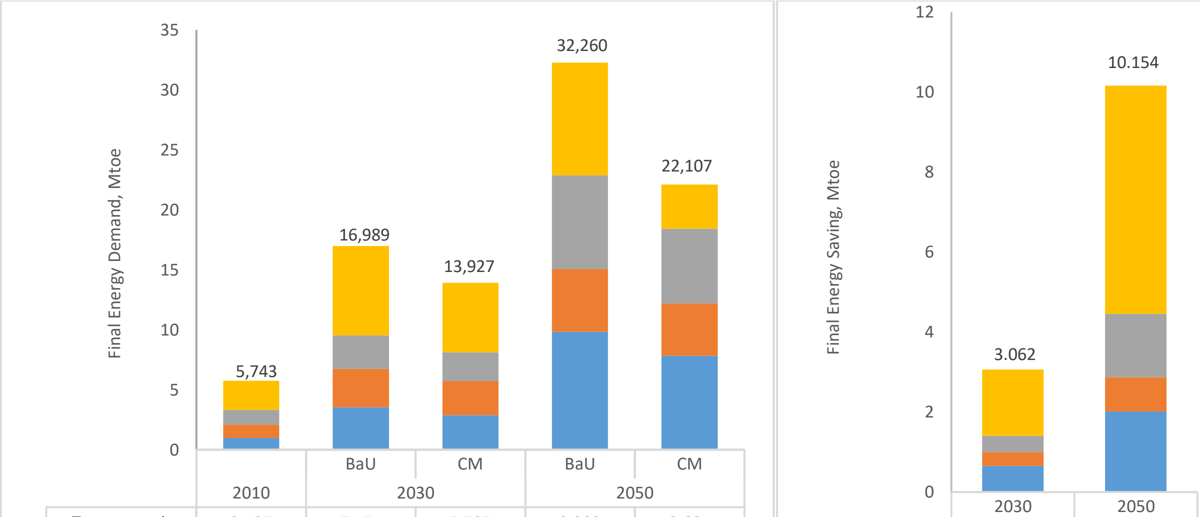
Figure 7. Relationship between economic development and energy sector developme

ENERGY DEMAND

Energy demand is expected to grow accordingly in line with increasing economic and population growth. Figure 8 shows the final energy demand projection in DKI Jakarta under BaU and CM scenarios for the base year (2010), 2030, and 2050. It can be seen from the figure that final energy demand under BaU scenario is estimated to increase 2.96 times and 5.62 times from 5.743 Mtoe to 16.989 Mtoe and 32.260 Mtoe in 2030 and 2050, respectively. In the same period, final energy demand under mitigation scenario (CM) is estimated to increase 2.43 times and 3.85 times from 5.74 Mtoe to 13.927 Mtoe (2030) and 22.107 Mtoe (2050). This result shows that the implementation of LCS projects in CM scenario provides energy-saving potential by 18.02% and 31.57% than that in energy sector BaU scenario, respectively, in 2030 and 2050.

In the base year (2010), the share transportation energy demand is significantly higher than the energy demand from industry, commercial, and residential sub-sector. This situation is expected to change in 2050, where the energy demand from the commercial activity will be comparable with the share of energy demand from transportation sub-sector.

By sub-sectors, the transportation sector will give the highest energy saving potential, and this sector accounts for 5.700 Mtoe followed by commercial (2.017 Mtoe), industry (1.583 Mtoe) and the last is residential (0.854Mtoe) compared with BaU level in 2050 (see right-hand side of Figure 8).

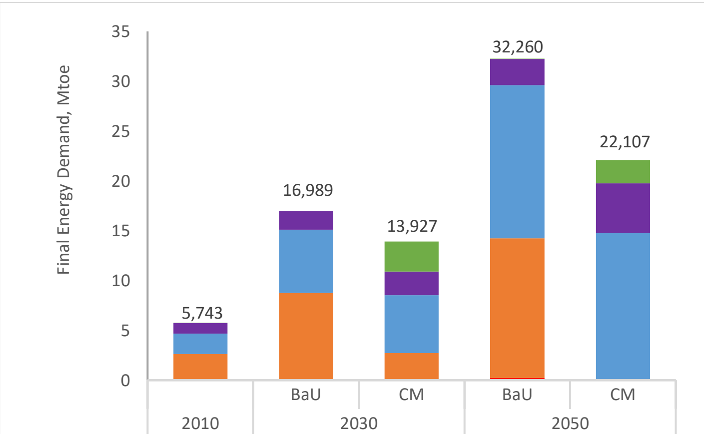


	2010	2030 BaU	2030 CM	2050 BaU	2050 CM
Transportation	2.427	7.451	5.795	9.382	3.681
Industry	1.205	2.809	2.401	7.816	6.233
Residential	1.145	3.192	2.848	5.220	4.366
Commercial	0.966	3.538	2.883	9.843	7.826

	2030	2050
Transportation	1.656	5.700
Industry	0.408	1.583
Residential	0.344	0.854
Commercial	0.654	2.017

Figure 8. Final energy demand of DKI Jakarta by type of sub-sector

The energy demand in DKI Jakarta is to be satisfied by different types of primary energy supply includes coal, oil, electricity, natural gas, and biofuel.

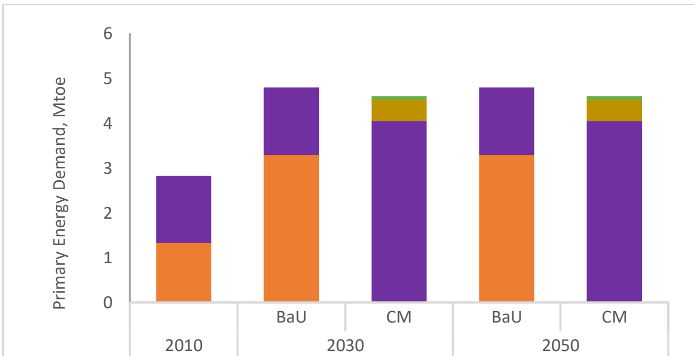


	2010	2030 BaU	2030 CM	2050 BaU	2050 CM
biofuel	0.023	0.023	3.037	0.023	2.344
gas	1.041	1.877	2.359	2.654	5.004
electricity	2.045	6.324	5.810	15.357	14.701
biomass	-	-	-	-	-
oil	2.613	8.689	2.652	14.014	0.058
coal	0.019	0.076	0.068	0.212	-

Figure 9. Final energy demand of DKI Jakarta by type of energy

Figure 9 presents the share of final energy demand by type of energy for the base year (2010), 2030, and 2050. It shows that at the base year, the energy supply is highly dominated by oil (accounts for 45.5% of the total energy supply, and the remaining 54.5% is shared by electricity 35.6%, natural gas 18.17%, biofuel 0.4%, and coal 0.33%). Under BAU scenario, this situation is projected to change in 2030 where the share of electricity and natural gas would become comparable with oil share. Then, the share of electricity will be significantly increased than others in 2050. This occurs because the growth of electricity demand is higher than the demand growth of transport (mostly supplied by oil). Under CM scenario, there is a shift energy use by type, from oil fuel to less GHG emitting fuels such as biofuel and natural gas. As can be seen in Figure 9, the share of oil will significantly decrease to 0.058 Mtoe while the share of biofuel and natural gas will increase to 2.344 Mtoe and 5.004 Mtoe, respectively, in 2050.

The primary energy in the power plant that used to supply energy demand includes coal, oil, natural gas, and renewable energy (waste, biofuel). The projection of primary energy supply in BaU scenario and CM scenario for base year (2010), 2030, and 2050 is shown in Figure 10. Under BAU scenario, the dominant fuel type is oil followed by gas. This situation is expected to change under CM scenario, the share of oil will significantly decrease from 3.285 Mtoe to 0.007 Mtoe while the share of gas will increase from 1.506 Mtoe to 4.036 Mtoe, waste from 0 Mtoe to 0.460 Mtoe, and biofuel from 0 Mtoe to 0.093 Mtoe in 2030 and 2050.



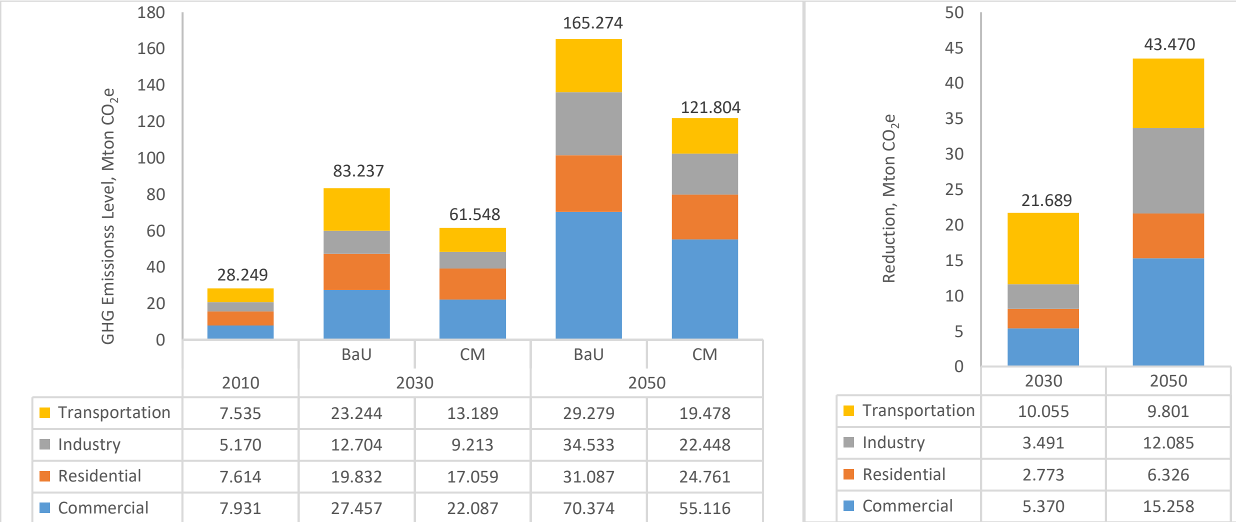
	2010	2030 BaU	2030 CM	2050 BaU	2050 CM
biofuel	-	-	0.093	-	0.093
waste		-	0.460	-	0.460
gas	1.506	1.506	4.036	1.506	4.036
oil	1.321	3.285	0.007	3.285	0.007
coal	-	-	-	-	-

Figure 10. Primary energy demand of DKI Jakarta by type of energy

GHG EMISSIONS

The level of the future GHG emissions from the energy sector is determined by fossil fuel combustion activities and indirect GHG emissions from electricity consumption in transportation, industry, commercial, and residential sub-sectors. Figure 11 presents the projection of GHG emissions and GHG emissions reduction achieved in 2030 and 2050. Under the BaU scenario, GHG emissions associated with energy used will increase from 28.249 Mton CO_2e (2010) to 83.237 Mton CO_2e (2030) and 165.274 Mton CO_2e (2050). While, under the CM scenario, the GHG emissions level will be reduced to 61.548 Mton CO_2e (2030) and 121.804 Mton CO_2e (2050), which is equivalent to 21.689 Mton CO_2e (20.37%) and 43.470 Mton CO_2e (22.95%) reduction compared with DKI Jakarta BaU scenario. The reduction is achieved under CM scenario as the end-user efficiency improvement measures, fuel switching, change of transport mode, deployment of advanced technology such as electric vehicle fueled using renewable source, and promotion of solar PV system.

As described in Figure 11, in the base year (2010) GHG emissions levels relatively similar to all sub-sectors. Under BaU scenario for 2030 and 2050, the commercial sub-sector is the major GHG emitter followed by industry, residential, and transportation. Therefore, under the CM scenario for 2030, the most significant GHG emissions reduction achieved by transportation (46.36%) followed by commercial (24.76%), industry (16.1%), and the remaining 12.78% from residential. This condition is expected to change in 2050, where the commercial and industry sub-sectors will be significantly reducing GHG emissions up to 35.1% and 27.8%, respectively.

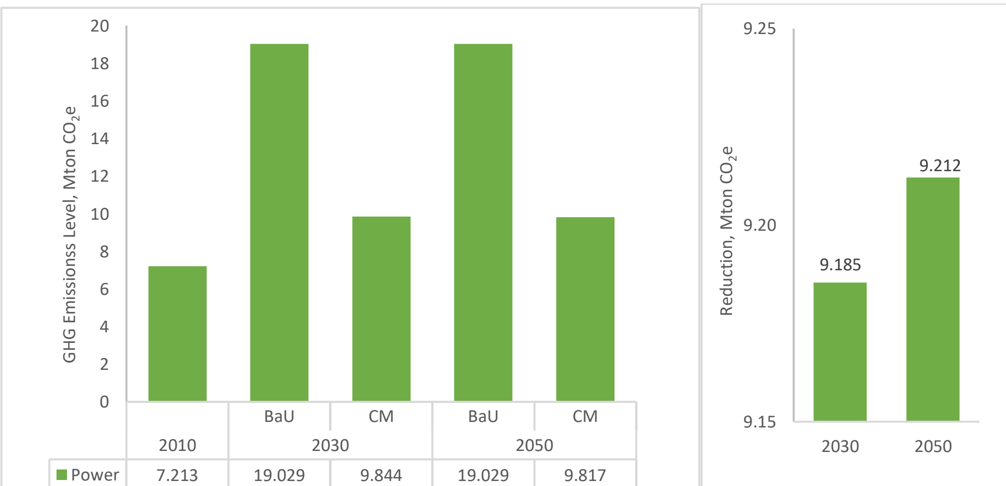


	2010	2030 BaU	2030 CM	2050 BaU	2050 CM
Transportation	7.535	23.244	13.189	29.279	19.478
Industry	5.170	12.704	9.213	34.533	22.448
Residential	7.614	19.832	17.059	31.087	24.761
Commercial	7.931	27.457	22.087	70.374	55.116

	2030	2050
Transportation	10.055	9.801
Industry	3.491	12.085
Residential	2.773	6.326
Commercial	5.370	15.258

Figure 11. GHG emissions level and GHG emissions reduction of DKI Jakarta from energy sector

In the context of GHG emissions inventory and mitigation actions, the power plant is beyond the authority of DKI Jakarta. However, some of power plants (Muara Karang and Tanjung Priok) are located in DKI Jakarta and these plants are integrated with other power generations that supplied to the regional grid (JAMALI). Therefore, GHG emissions due to electricity consumption of the city is calculated using off grid emissions factor. As can be seen in Figure 12, between 2010-2050, under BAU scenario, GHG emissions from power generation is projected to grow 2.64 times from 7.213 Mton CO_2e to 19.029 Mton CO_2e. in the CM scenario, GHG emissions level will be able to reduce by 9.185 Mton CO_2e (8.62%) and 9.212 Mton CO_2e (4.86%) in 2030 and 2050, respectively, compared with DKI Jakarta BaU scenario.



	2010	2030 BaU	2030 CM	2050 BaU	2050 CM
Power	7.213	19.029	9.844	19.029	9.817

Figure 12. GHG emissions level and GHG emissions reduction of DKI Jakarta from power plant

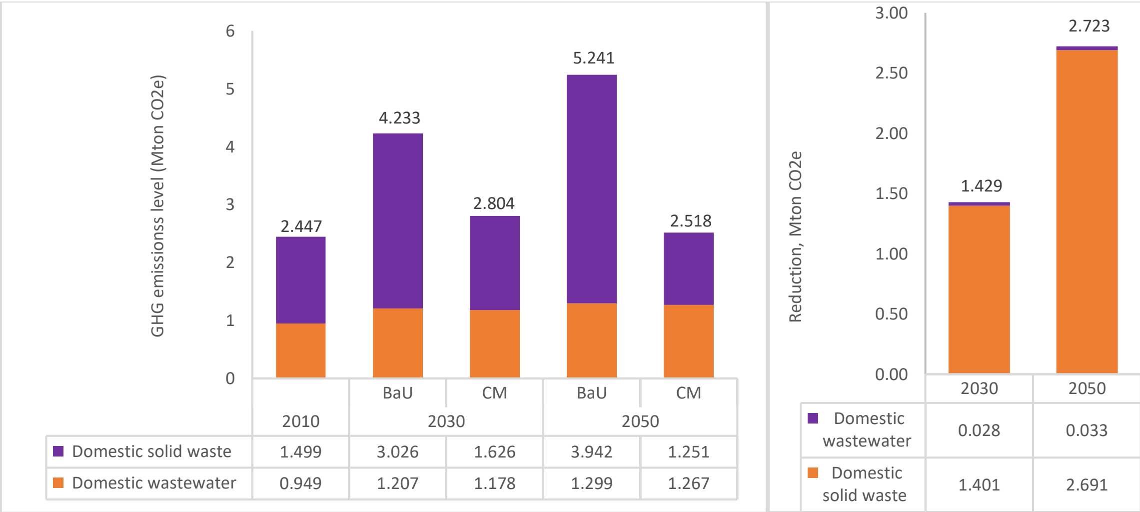


Figure 13. GHG emissions reduction potential of DKI Jakarta from waste sector

The level of GHG emissions in waste sector is determined by the amount of waste treated and the type of technology used. Figure 13 shows the projection of GHG emissions from waste sector under BaU and CM scenario for base year (2010), 2030, and 2050. It can be seen for BAU scenario, GHG emissions is estimated increase 1.73 times from 2.447 Mton CO_2e to 4.233 Mton CO_2e (2030) and 2.14 times to 5.241 Mton CO_2e (2050). The mitigation efforts implemented in CM scenario will result in a reduction of GHG emissions by 1.429 Mton CO_2e (2030) and 2.724 Mton CO_2e (2050) which is equivalent to 1.34% and 1.44% reduction compared with DKI Jakarta BaU scenario. As presented in the right-hand side of Figure 13, significant reduction is obtained from domestic solid waste (98.05%) of total reduction from waste sector.

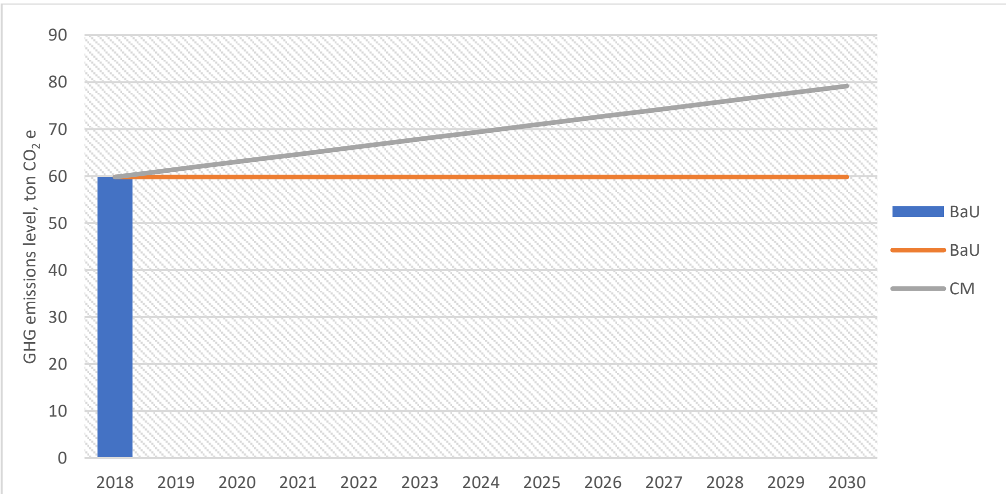


Figure 14. GHG removal potential from the Agriculture, Forestry and Other Land Use (AFOLU) Sector

The base year used in the AFOLU sector is 2018 due to data limitations. As described in Figure 14 under baseline calculation (BaU), the GHG emission removal by sinks reach 59.8 tons of CO_2e, with the area of urban forest vegetation that still active is 111.22 Ha for 2018-2030. Assuming the area of urban forest vegetation in 2010 and 2018 is similar, therefore GHG emission removal in 2010 as same as 2018.

The mitigation action was taken from the Forestry Strategic Plan for 2017-2022. The selected mitigation activity is the development of forest green open space and limited to planting activities only. Therefore, forest green open space development outside of planting activities is not included in the mitigation activities. The additional forest green open space of DKI Jakarta for 2017 -2022 is 3 ha/year. The data for 2023-2030 are obtained from the regression result of green open space development in the Forestry Strategic Plan for 2017-2022. Under mitigation (CM), the GHG emissions removal by sinks are 79.13 tons of CO_2e in 2030 or increase by 32.4% compared with BaU level in 2018. The GHG emissions removal achieved from AFOLU sector is 19.35 tons of CO_2e in 2030.

MITIGATION ACTIONS TOWARD LCS

A variety of mitigation actions is developed to achieve low carbon society in DKI Jakarta by 2050. The actions are assumed to be implemented to reduce GHG emissions in CM scenario. By implementing various mitigation measures of GHG emissions in energy, power, and waste sectors; GHG emissions will decrease to 32.303 Mton CO_2e and 56.866 Mton CO_2e in 2030 and 2050, respectively. The detail of GHG emissions reduction allocation from each mitigation meassure is summarized in Figure 15 to Figure 17.

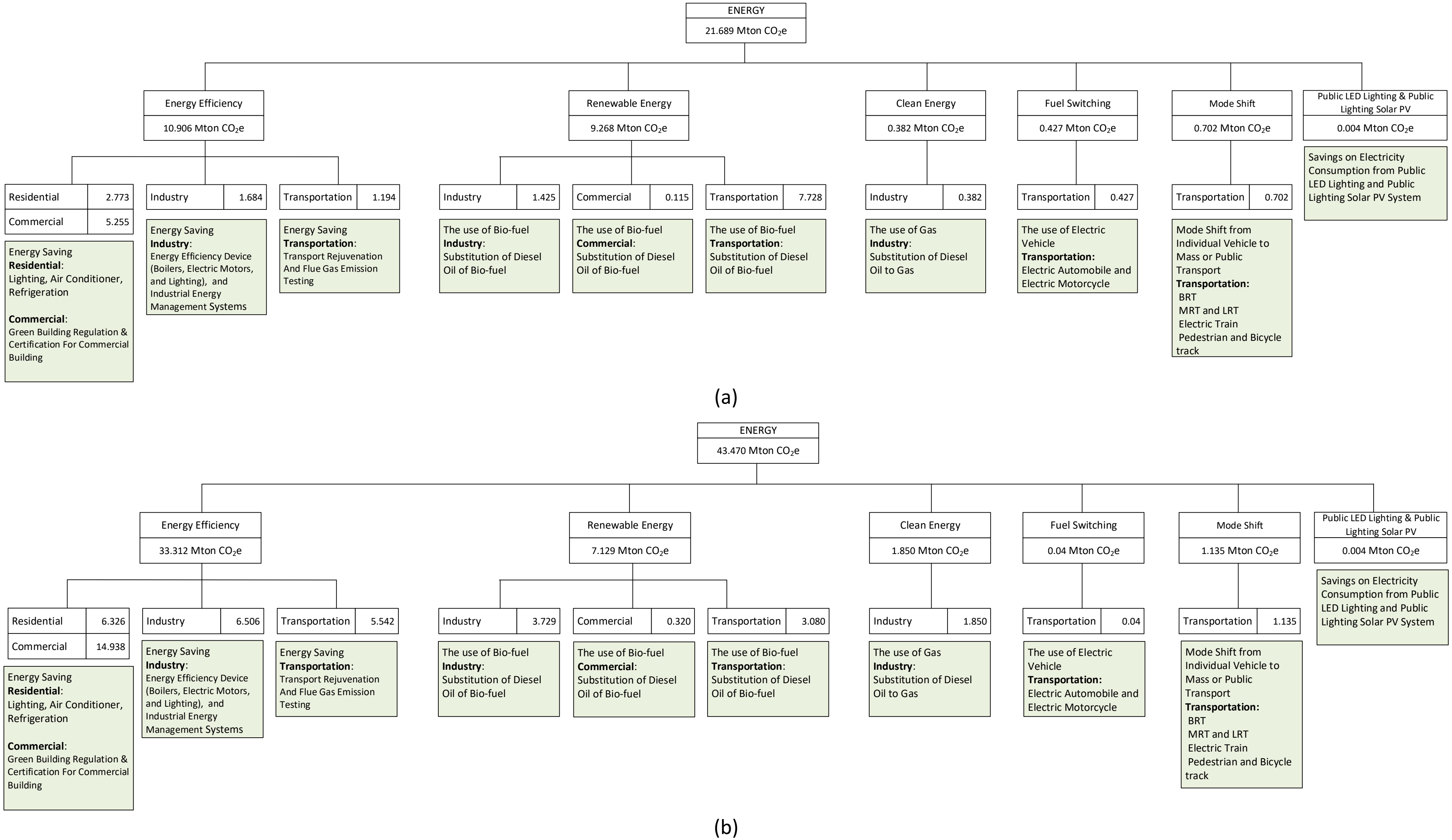


Figure 15. GHG emissions reduction target allocation from energy sector in (a) 2030 (b) 2050

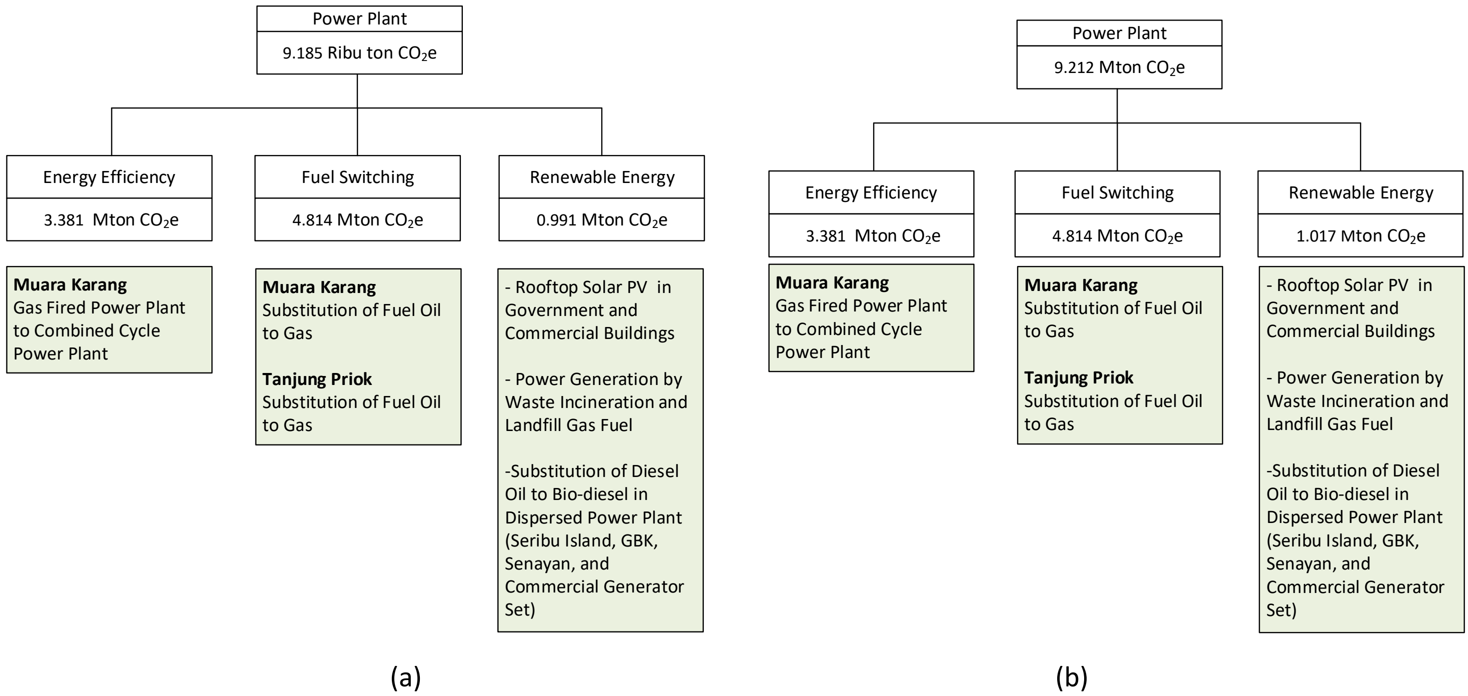


Figure 16. GHG emissions reduction target allocation from power sector in (a) 2030 (b) 2050

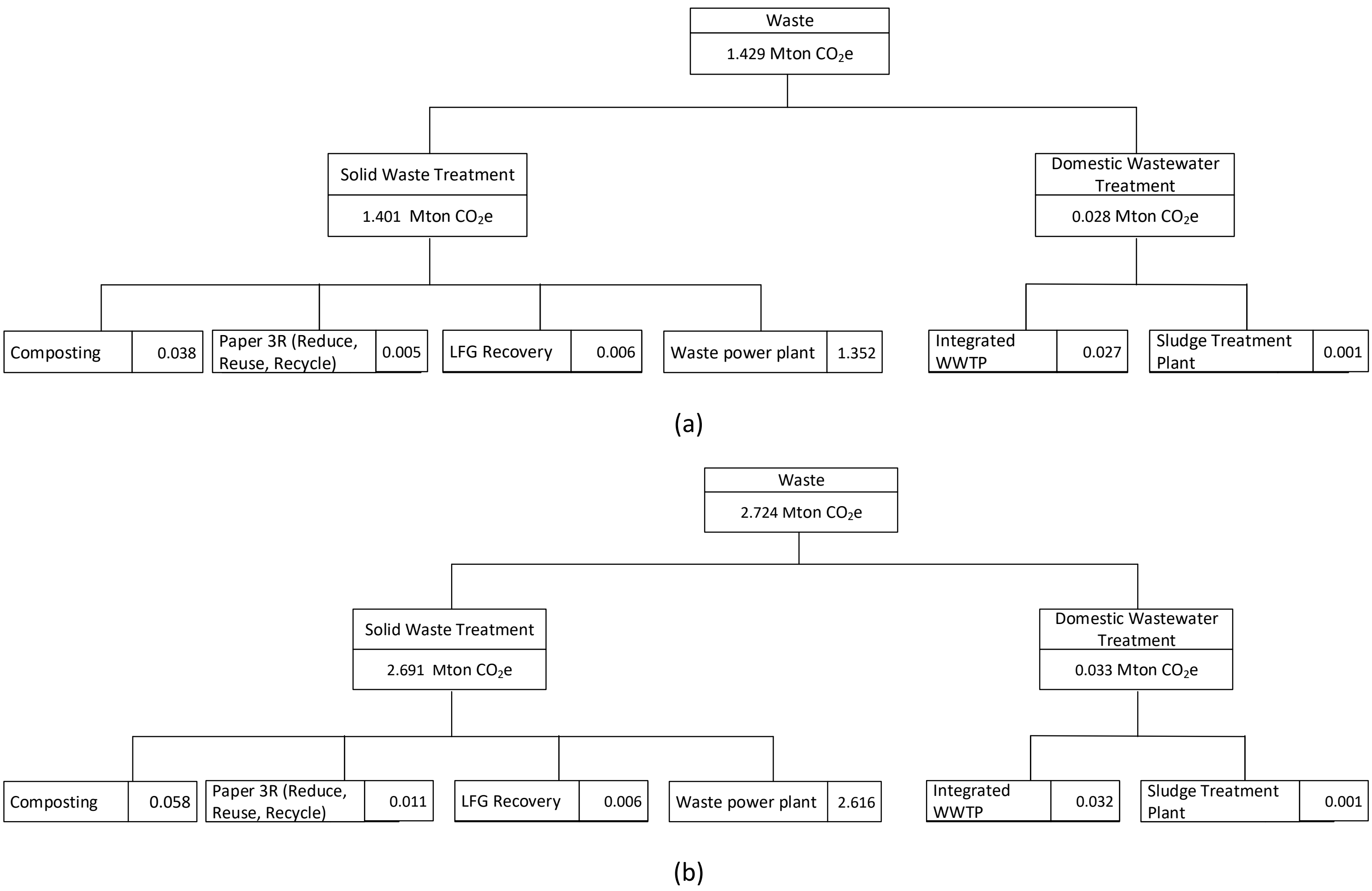


Figure 17. GHG emissions reduction target allocation from waste sector in (a) 2030 (b) 2050

Energy Sector

In the energy sector, there are 6 (six) mitigation actions carried out to achieve low carbon society in DKI Jakarta by 2050. Refers to the figure 15, these efforts will enable GHG emissions to be reduced by 21.689 Mton CO_2e and 43.470 Mton CO_2e in 2030 and 2050, respectively. Based on the result of the GHG emissions reduction achieved from energy sector, shows that the most significant emissions reduction can be made by energy efficiency action. In more detail, these mitigation activities are discussed in the following section.

Action 1: **Energy Efficiency**

The action of "Efficiency energy" measures at the end-user sides, and this action is targeted to reduce GHG emissions by 10.906 Mton CO_2e and 33.312 Mton CO_2e compared with BaU level in 2030 and 2050, respectively. This action of comprises of four main action measures; i) Energy efficiency in transportation sub-sector by management system transportation, public transport rejuvenation, and flue gas emissions testing, ii) Energy efficiency in industry sub-sector by implementation more efficient equipment (heat/furnace, electric motor, and lighting), and industrial energy management (energy audits and energy mandatory managers), iii) Energy efficiency in commercial sub-sector by increased equipment efficiency (air conditioner, water heater, lighting, refrigeration, and energy user equipment), commercial building energy management system (green building program), energy monitoring and appreciation of energy saving efforts, and energy saving behavior campaigns, iv) Energy efficiency in residential sub-sector by labelling programme to encourage the increasing of energy efficiency in electrical equipment (air conditioner, water heater, lighting, refrigeration), efficiency of energy user equipment, LED lighting, and energy audit.

Figure 18. Flue gas emissions testing and public transport rejuvenation (docs. of DLHK & PT. Transjakarta)

The level of efficiency measures is expressed in terms of share of the penetration of best available technology (BAT) within the technology (device) of end-user sides. The efficiency improvement varies depending on the type of device as presented in table 3.

Table 3. End-user energy efficiency measures, applied in "energy efficiency" mitigation action

Sub-sector		Penetration share of BAT		Energy saving (ktoe)	
		2030	2050	2030	2050
Transportation	Transport rejuvenation	18%	75%	382	1,772
Industry	Heat/furnace, electric motor, and lighting	50%	75%	344	854
Commercial	Air conditioner	84%	100%	408	1,583
	Water heater	20%	75%		
	energy user equipment	20%	75%		
	LED lighting	100%	100%		
	refrigeration	68%	100%		
	Others	20%	75%		
Residential	Air conditioner	84%	100%	652	2,017
	Water heater	18%	75%		
	energy user equipment	18%	75%		
	LED lighting	100%	100%		
	Refrigeration	68%	100%		
	Others	18%	75%		

Action 2: Renerwable Energy

Comprehensive use of renewable energy is carried out by substituting diesel oil to biofuel in transportation, industry, and commercial sub-sector.

The increasing of biofuel usage is a mandatory biofuel policy implementation as an effort to encourage greater use of biofuel, which establishes B30 (ratio 30:70; biofuel : diesel oil) to be implemented in early 2020 and then B50 (ratio 50:50; biofuel:diesel oil) at the end of 2020. Therefore, the estimation target of biofuel usage in 2030 and 2050 is B-100 (ratio 100:0; biofuel : diesel oil), shown in Table 4.

Table 4. Implementation target of biofuel in 2030 and 2050

Sector	Action	Implementation		Oil fuel saving (ktoe)	
		2030	2050	2030	2050
Transportation	The use of Biofuel	B100	B100*	2,512	1,001
Industry	The use of Biofuel	B100	B100	464	1,215
Commercial	The use of Biofuel	B100	B100	37	104

* Substitution 60% of diesel to B100 and the remaining use an electric vehicle (EV)

Action 3: Clean Energy

Clean energy mitigation action can be implemented by substitution of oil fuel to less carbon emitting-fuels (gas) on JARGAS (Jaringan Gas) programme. Substitution oil fuel to gas target in industry sub-sector shown in table 5. This mitigation action will be able to reduce GHG emissions by 0.382 Mton CO_2e (2030) and 1.850 Mton CO_2e (2050) as presented in Figure 15.

Table 5. Implementation target of gas subtitution in 2030 and 2050

Sub-sector	Action	Implementation Unit	Implementation 2030	Implementation 2050	Result Unit	Result 2030	Result 2050
Industry	Substitution of oil fuel to gas	% oil fuel	56	66	Gas (ktoe)	579	2,512

Action 4: Fuel Switching

As shown in table 6, the implementation of electric vehicles will be able to reduce GHG emissions up to 0.427 Mton CO_2e and 0.040 Mton CO_2e in 2030 and 2050, respectively. It should be noted that insignificant reduction in 2050 is caused by electric vehicle replace an efficient vehicle (High penetration share of BAT by 75%). While in 2030, efficient vehicles are still lower (18%). Therefore, the majority of vehicles replaced by electric vehicles are not yet efficient

Table 6. Implementation target of electric vehicle for public and private transportation in 2030 and 2050

Sub-sector	Action	Implementation Unit	Implementation 2030	Implementation 2050	Result Unit	Result 2030	Result 2050
Transportation	Electric vehicles for public and private transportation	%	17	100	Oil fuel saving (ktoe)	1,439	5,824

The use of electric vehicles for public transportation in DKI Jakarta has been implemented in 2019 as shown in the figure below.

Figure 19. Electric bus in dki jakarta (docs. of the government of DKI Jakarta)

Action 5: Mode Shift

The mode shift from owned automobiles that use fossil fuel to the use of public transportation by the general public targeted to reduce GHG emissions by 0.702 Mton CO_2e and 1.135 Mton CO_2e in 2030 and 2050, respectively (see Figure 15), This action needed to be implemented by promoting an urban design that prioritizes public transport and non-motorized.

Table 7. Implementation target of biofuel in 2030 and 2050

Sub-sector	Action	Implementation Unit	Implementation 2030	Implementation 2050	Result Unit	Result 2030	Result 2050
Transportation	BRT	Mil.pass-km	2.236	5.582	Oil fuel saving (ktoe)	58	126
	MRT & LRT	Mil.pass-km	5.921	8.371		156	189
	Electric train	Mil.pass-km	6.839	13.574		180	306
	Non-motorized (pedestrian & bicycle track)	%	0.5	1		37	73

The development of passenger mode shift distribution and oil fuel savings obtained DKI Jakarta city (2010-2050) is presented in table 7. It shows that there was a transport mode shift from individual vehicles to mass public transport i.e., mass rapid transit (MRT), light rail transit (LRT), bus rapid transit (BRT), electric train, and non-motorized to form an effective and efficient public transportation system

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(i) MRT (ii) LRT (iii) Electric Train (iv) BRT

Figure 20. Public transportation in dki jakarta (docs. of MRT & LRT Jakarta, commuter line, and PT. Transjakarta)

The action of non-motorized measure design to bring about a shift from the use of privately owned automobiles (It is assumed 50% of private cars and 50% of private motorbikes) to the pedestrian and bicycle track. The sidewalks and bicycle track along the city center will be widened to secure a comfortable pedestrian space and promote a mode shift on the part of the general public. The use of pedestrian and bicycle track by 0.5% demand transport or 1,059 million passenger-km (2030); 1% demand transport (2050) will enable GHG emissions to be reduced by 0.116 Mton CO_2e and 0.227 Mton CO_2e in 2030 and 2050, respectively.

Figure 21. Non-motorized (pedestrian and bicycle track) (docs. of the government of DKI Jakarta and Dishub Jakarta)

Action 6: Public LED Lighting & Public Lighting Solar PV

The mitigation action of public LED lighting is part of the city lighting quality and quantity improvement program, and the energy resources diversification program by the Department of Industry and Energy. LED lighting more efficient than conventional lighting technologies, thus making it possible to saving electricity consumption and reduce GHG emissions.

Public lighting solar PV mitigation action is separated from calculations on other solar PV usage activities such as in communal power plants or solar home systems (SHS) due to different scope of the calculation. In the Public lighting solar PV, the electricity generated is in a closed system, which only used for lighting. Public LED lighting and public lighting solar PV effort will be able to reduce GHG emissions by 0.004 Mton CO_2e in 2030 and 2050

Power

Mitigation actions in DKI Jakarta through energy efficiency activities and fuel switching at the Muara Karang power plant and Tanjung Priok power plant can be used to fulfill the Government of Indonesia/party stakeholder (PS) commitment since the management and operation of both plants are the authority of the Central Government.

Refers to the figure 16, GHG emissions reduction resulted from fuel switching is the most significant than others. This action accounts for 4.814 Mton CO_2e followed by energy efficiency 3.381 Mton CO_2e, and residential 1.017 Mton CO_2e in 2050. In more detail, these mitigation activities are discussed in the following section.

Action 1. Energy efficiency

Energy efficiency activities are carried out by the implementation of new technologies/systems that are more efficient, such as the combined cycle technology. Based on the roadmap of operating plan in the table 8, the efficiency of Muara Karang Power Plant is improved from 17.84% (2010) to 40.22% (2030 and 2050) would reduce the level of energy consumption and would lead to reduction of GHG emissions by 3.381 Mton CO_2e.

Table 8. Roadmap of operating plan in Muara Karang and Tanjung Priok

Plant		Unit	2030	2050
Muara Karang	MFO	TJ	0	0
	HSD	TJ	61	61
	IDO	TJ	0	0
	Gas	TJ	89,300	89,300
	Total	TJ	89,361	89,361
	Production	MWh	9,983,216	9,983,216
	Efficiency	%	40.22%	40.22%
	Own used	MWh	186,300	186,300
	Capacity	MW	2,100	2,100
Tanjung Priok	MFO	TJ	0	0
	HSD	TJ	230	230
	IDO	TJ	0	0
	Gas	TJ	79,674	79,674
	Total	TJ	79,903	79,903
	Production	MWh	9,148,271	9,148,271
	Efficiency	%	41.22%	41.22%
	Own used	MWh	190,525	190,525
	Capacity	MW	2,723	2,723

Action 2. Fuel switching

The action of "Fuel switching" is generally done by substituting diesel fuel (IDO/MFO/HSD) into the gas at the Muara Karang and Tanjung Priok power plants. increased use of gas to replace diesel fuel in both power plants (see table 8). GHG emissions reduction in 2030 and 2050 presented in figure 16

Action 3. Renewable Energy

The mitigation of "Renewable energy" shown in figure 16 is divided into several actions as describe below:

a. Rooftop solar PV system

Figure 22. Rooftop solar PV in commercial building

Solar photovoltaics (PV) is one of the most dynamic renewable power generation technologies, with improvements in technology, and increases in the scale of manufacturing will enable to driving down costs. The installed rooftop Solar PV capacity in commercial buildings and subtituted electricity shown in table 9. There are some activities to support implentation of solar PV in DKI Jakarta: i) arranged policy on facilitate access of renewable energy, ii) renewable energy campaign on the official dki jakarta platform, iii) increased investment for renewable energy, iv) training on renewable energy technology.

Table 9. The roadmap of power generation by waste in 2030 and 2050

Sector	Action	Implementation			Unit	Result	
		Unit	2030	2050		2030	2050
Commercial	The installed rooftop Solar PV capacity in commercial buildings	MW	10	20	substituted electricity (ktoe)	1.9	5.6

b. Biofuel in disperge power plant

Fuel shift from diesel oil to biofuel in disperge power plant includes: i) (Seribu island) and disperge power plant; ii) GBK, the capacity of 16 MW, iii) Senayan, the capacity of 100 MW, and iv) commercial generator set.

c. Power generation by waste

The burning process of waste through an incinerator will produce hot flue gases that can be recovered to generate electricity. Electricity generated is used to substitute electricity from JAMALI grid. Beside that, waste is processed into RDF (refuse derived fuel), RDF can be used as fuel to subtitute coal in power plant. The roadmap of power generation by waste and RDF utilization in DKI Jakarta presented in table 10 and table 11.

Table 10. The roadmap of power generation by waste in 2030 and 2050

Energy Type		Unit	2030	2050
Sunter	Waste (2300 ton/day)	MW	43	43
Cakung	Waste (1300 ton/day)	MW	24	24
Rawa Buaya	Waste (1200 ton/day)	MW	24	24
Cilincing	Waste (1200 ton/day)	MW	24	24
Production capacity (Utilization of 0.8)		MW	2115	2115
Bantar Gebang	RDF (100 ton/day)			
Production capacity (Utilization of 0.8)		MW	7	7
Total capacity			122	122
Electricity generation/year		MWh	1,070,667	1,070,667

Table 11. The roadmap of waste to RDF in 2030 and 2050

		Unit	2030	2050
Bantar Gebang	RDF for cement industry	ton/day	3000	4000

d. Power generation by landfill gas fuel

Landfill gas (CH_4) produced by a pile of garbage is recovered as a fuel for electricity generation. The roadmap of power generation by landfill gas fuel in DKI Jakarta presented in table 12

Table 12. The roadmap of power generation by landfill gas fuel in 2030 and 2050

LFG Recovery	Unit	2030	2050
Capacity	MW	2 x 4MW	2x 6 MW
Electricity production	MWh	56,064	105,120

Electricity generated from landfill gas will reduce electricity supply from JAMALI grid. GHG emissions reductions achieved from the landfill gas recovery action is 0.039 Mton CO_2e in 2030 and 2050.

Waste Sector

According to the figure 17 (a), GHG emissions reductions of 1.401 Mton CO_2e (2030) and 2.691 Mton CO_2e (2050) was obtained from domestic solid waste treatment in DKI Jakarta resulted by implementing i) Composting of solid organic waste, including food waste and garden waste, ii) 3R (reduce, reuse, recycle) activity, covers paper waste recycling, eco-friendly packaging innovation, Regulation of single-use plastic disposal, using items that can be used repeatedly to reduce plastic waste, iii) Landfill gas recovery, methane gas mainly from the anaerobic decomposition process of degradable organic components contained in solid waste is recovered as a fuel for electricity generation, and iv) power generation by waste.

Composting

waste sorting (3R activity)

Waste bank in DKI Jakarta (3R activity)

Landfill gas recovery

Figure 23.Solid waste treatment (Documentation from DLHK Jakarta)

Mitigation action on domestic wastewater treatment by integrated WWTP (Waste Water Treatment Plant) and sludge treatment plant, which includes self-management (e.g., septic tanks), treated system (centralized anaerobic treatment), and untreated system (rivers/sea or land discharge). These actions from domestic wastewater treatment totally reduce GHG emissions by 0.028 Mton CO_2e and 0.036 Mton CO_2e in 2030 and 2050, respectively. GHG emissions level and reduction determined by the total waste treated and the type of technology that shown in Figure 26 and 27. As presented in Figure 26, Solid waste handled in landfill is 70% of the total waste generation in 2010, and the other 30% entered the river or disappeared from the resident. Under the BaU scenario, solid waste treated in landfills up to 95% and 99% of the total waste generation in 2030 and 2050, respectively. Therefore, in the CM scenario for 2030 and 2050, power generation by waste, composting, and 3R mitigation actions increased to reduce waste in landfill.

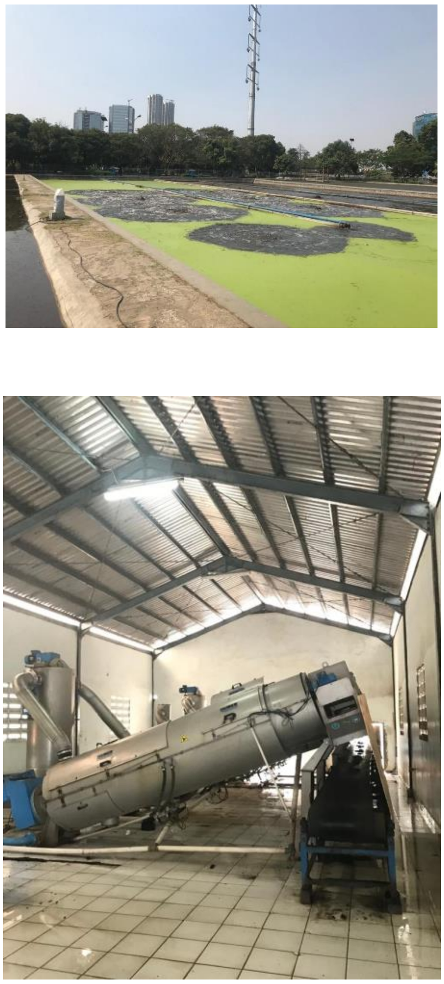


Figure 24. sludge treatment plant

Figure 25. integrated WWTP (Waste Water Treatment Plant)

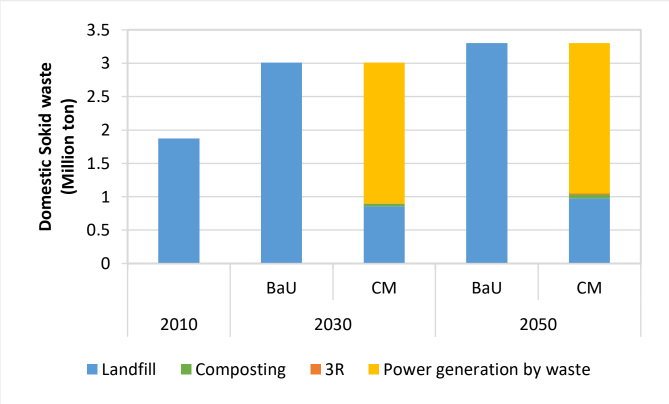


Figure 26. Projection of domestic solid waste treatment in DKI Jakarta by technology

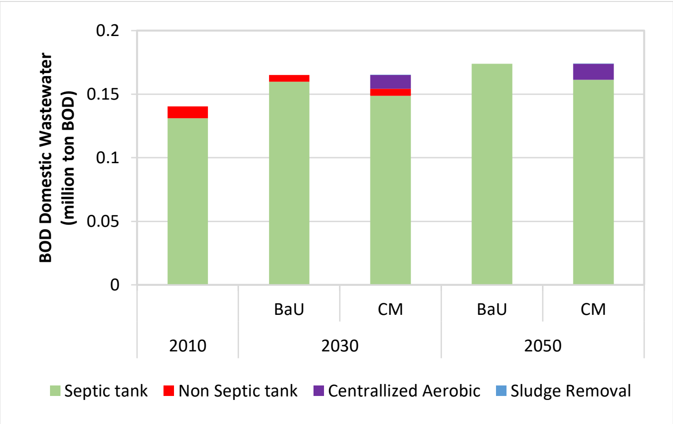
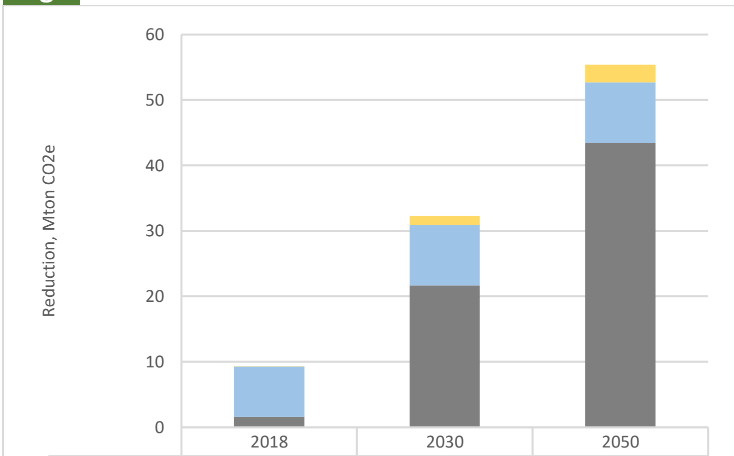


Figure 27. Projection of domestic wastewater treatment in DKI Jakarta by technology

GHG emissions reduction achieved in 2018 vs emissions target



	2018	2030	2050
Waste Sector	0.069	1.429	2.723
Power Sector	7.675	9.185	9.212
Energy Sector	1.598	21.689	43.470

Figure 28. GHG emissions reduction achieved in 2018 and reduction target in (2030 and 2050)

Figure 28 shown the GHG emissions reduction achieved in 2018 is 9.342 Mton CO_2e, which is equivalent to 28.9% of 32.203 Mton CO_2e (emissions target in 2030). The largest GHG emissions reduction achsieved in 2018 is power sector followed by energy and waste. While projection of GHG emissions reduction target in 2030 and 2050 indicate that there are still rooms for improvement on mitigation action from energy sector and waste sector. While GHG emissions target from power sector is relatively unchange in 2030 and 2050.

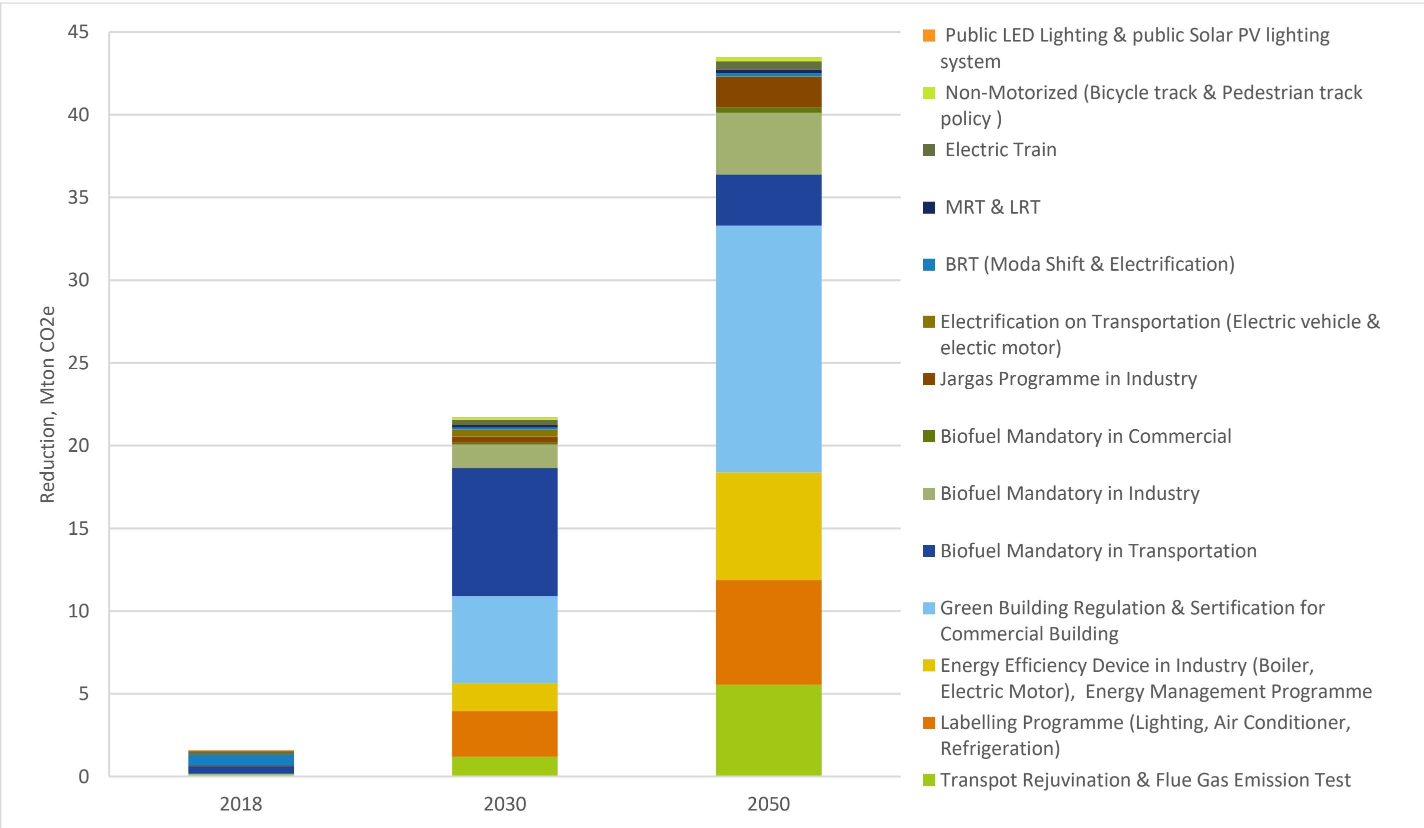


Figure 29. GHG emissions reduction achieved in 2018 and reduction target in (2030 and 2050) from energy sector

GHG emissions reduction achieved in 2018 and reduction target (2030,2050) from energy sector presents in Figure 29. The figure shows that GHG emissions reduction target from energy sector is 21.689 Mton CO_2e (67.35% of total reduction target in 2030). However, GHG emissions reduction achieved in 2018 is relatively lower than reduction target from sector energy in 2030 (1.598 Mton CO_2e or equivalent to 7.37% of 21.689 Mton CO_2e)

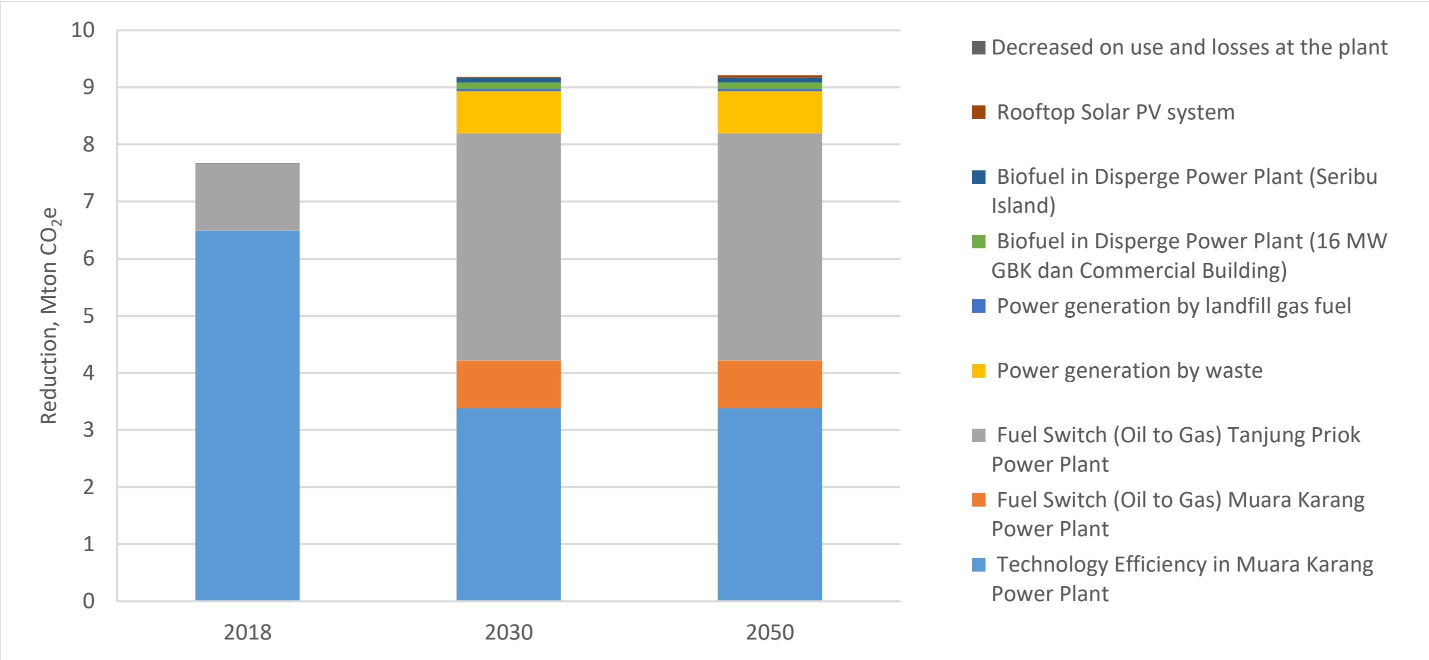


Figure 30. GHG emissions reduction achieved in 2018 and reduction target in (2030 and 2050) from power sector

Figure 30 shows that the GHG emissions reduction achieved in 2018 is 7.675 Mton CO_2e or equivalent with 83.56% of GHG emissions reduction target from power sector in 2030 (9.185 Mton CO_2e). Reduction achieved in 2018 is high considering that the reduction target in 2030 and 2050 is relatively unchange in 2030 and 2050.

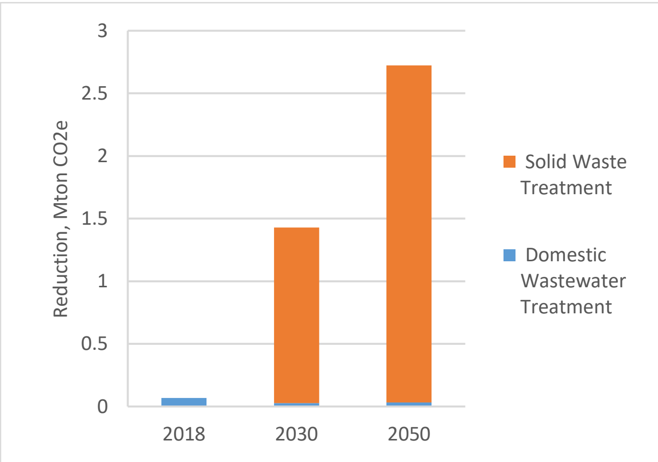


Figure 31. GHG emissions reduction achieved in 2018 and reduction target in (2030 and 2050) from waste sector

Figure 31 shows the GHG emissions reduction achieved in 2018 and reduction target in (2030 and 2050) from waste sector. Based on the results of the GHG emissions reduction from waste sector, shows that the most significant GHG emissions reduction is solid waste treatment in both reductions (reduction achieved in 2018 and reduction target). The GHG emissions reduction achieved in 2018 is 0.069 Mton CO_2e or equivalent with 4.83% of GHG emissions reduction target from power sector in 2030 (1.429 Mton CO_2e). It shown that there are still rooms for improvement on mitigation action and the potential of GHG Emissionss reduction from waste sector for long-term (2050) need further discussion.

References:

	Source
Population and Household	▪ Statistics of Indonesia: Provinsi DKI Jakarta dalam Angka,2018
Macro economy	▪ Statistics of DKI Jakarta province (website): DKI Jakarta Province GRDP at Current Prices by Type of Expenditure Component (Million Rupiahs), 2010-2018
Transport	▪ Department of Transportation, DKI Jakarta Province: Data of Public Transport Data, Environmental Transport Data (Bajaj BBG), Smart Driving Training, 2010-2018 ▪ UP. SPLL Department of Transportation DKI Jakarta: Crossing Traffic using ATCS Data, 2018 ▪ PT Transjakarta: BRT and Feeder Data, 2010-2018 ▪ PT MRT Jakarta: Operation Data of MRT and LRT, 2018 ▪ PT Indonesia Commuter Train: Operation Data of KRL, 2010-2018
Energy	▪ Pusdatin, Ministry of Energy and Mineral Resources, Indonesia: ▪ PT Green Building and Council Indonesia: Green Building Consumption Energy Data, 2018 ▪ BPH Migas and PT Pertamina: Biofuel Statistics Data, 2010-2018 ▪ PT PGN: DKI Jakarta gas consumption data, 2010-2018
Regulation	▪ Governor Regulation No. 131/2012: The Provincial Action Plan (RAD GRK) ▪ Presidential Regulation No. 61/2011 and No. 71/2011 on national action plans for GHG reduction ▪ Ministry of Environment Regulation No. P.73/2017: Guidelines for National Greenhouse Gas Emissions ▪ Intended Nationally Determined Contribution (INDC) Republic of Indonesia, 2015

Acronyms:

AFOLU	Agriculture Forestry and Other Land Use	LED	Light Emitting Diode
BAT	Best Available Technology	LRT	Light Rail Transit
BaU	Business as usual	LTS	Long Term Strategy
BBG	Bahan Bakar Gas	MFO	Marine Fuel Oil
BPH Migas	Badan Pengatur Hilir Minyak dan Gas	MRT	Mass Rapid Transit
BPS	Badan Pusat Statistik	Mtoe	Million tons of oil equivalent
BRT	Bus Rapid Transit	NDC	Nationally Determined Contribution
CM	Counter measure	NIES	National Institute for Environmental Studies, Japan
EV	Electric Vehicle	NPS	Non-Party Stakeholder
ExSS	Extended Snapshot	PA	Paris Agreement
GAMS	General Algebraic Modeling System	pass-km	Passenger-km
GBK	Gelora Bung Karno	PGN	Perusahaan Gas Negara
GDP	Gross Domestic Product	PLN	Perusahaan Listrik Negara
GHG	Greenhouse Gasses	PS	Party Stakeholder
HSD	High Speed Diesel	PV	Photovoltaics
IDO	Diesel Oil	RAD-GRK	Rencana Aksi Daerah Gas Rumah Kaca
IGES	Institute for Global Environmental Strategies	Rp	Rupiah
INDC	Intended Nationally Determined Contribution	RDF	Refuse Derived Fuel
JAMALI	Jawa Madura Bali	SHS	Solar Home Systems
Jargas	Jaringan Gas	tCO_{2e}	Tons of Carbon Dioxide Equivalent
LC	Low Carbon	WWTP	Waste Water Treatment Plant
LCS	Low Carbon Society	3R	Reduce, Reuse, and Recycle
LCDS	Low Carbon Development Strategy		

Long-Term Strategy to Achieve DKI Jakarta's Low Carbon Society 2050

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Study Team:

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