User Guidelines for Transportation Sector

Indonesia 2050 Pathway Calculator

List of Contents

List of Tables

List of Figures

1. General Overview of Transportation Sector

The use of energy in transportation sector in 2011 accounts for 37.68% of total energy consumption, the second largest after industry sector. Energy consumption in transportation sector in 2011 was 277,36 million BOE comprised 52% of gasoline, 21% of ADO, 8% of B5 biofuel, 0.01% of IDO, 0.06% of fuel oil, 0.07% of natural gas, 0.005% of aviation gasoline and 17% of jet fuel (PUSDATIN ESDM 2012a).

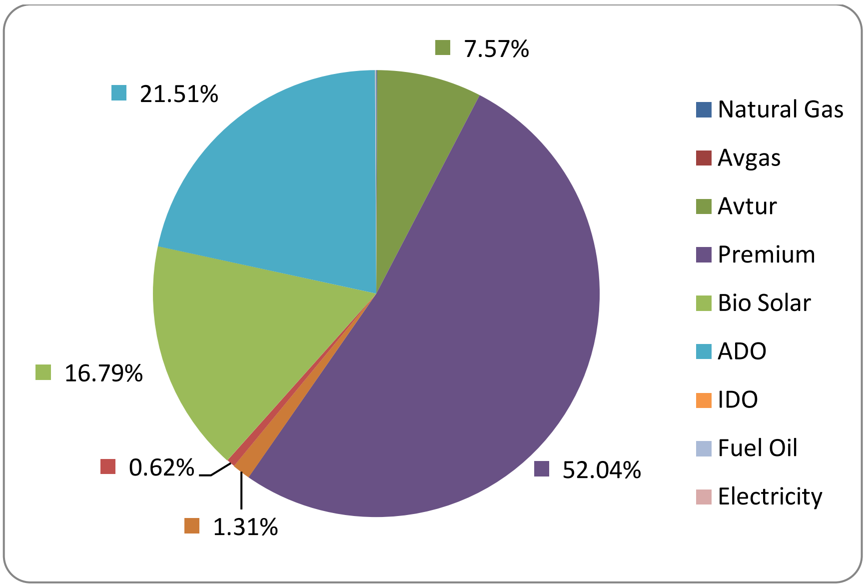

Figure 1 Fuel Mix of Transportation Sector in 2011 (PUSDATIN ESDM 2012a)

Government policy in transportation sector reveals the importance of transportation sector in supporting development and national integration as part of the efforts to improve people welfare as mandated by the Law No. 22 of 2009 on road traffic and transportation.

Transportation in I2050PC is divided into three sub-sectors, namely (1) passenger transportation sub-sector that covers road transportation, railway based transportation and water transportation; (2) freight transportation sector that also covers road transportation, railway based transportation and water transportation; and (3) aviation transportation sub-sector. Passenger transportation sub-sector is further divided into two, namely urban transportation and inter-city transportation. Classification of transportation sector is shown in Figure 2.

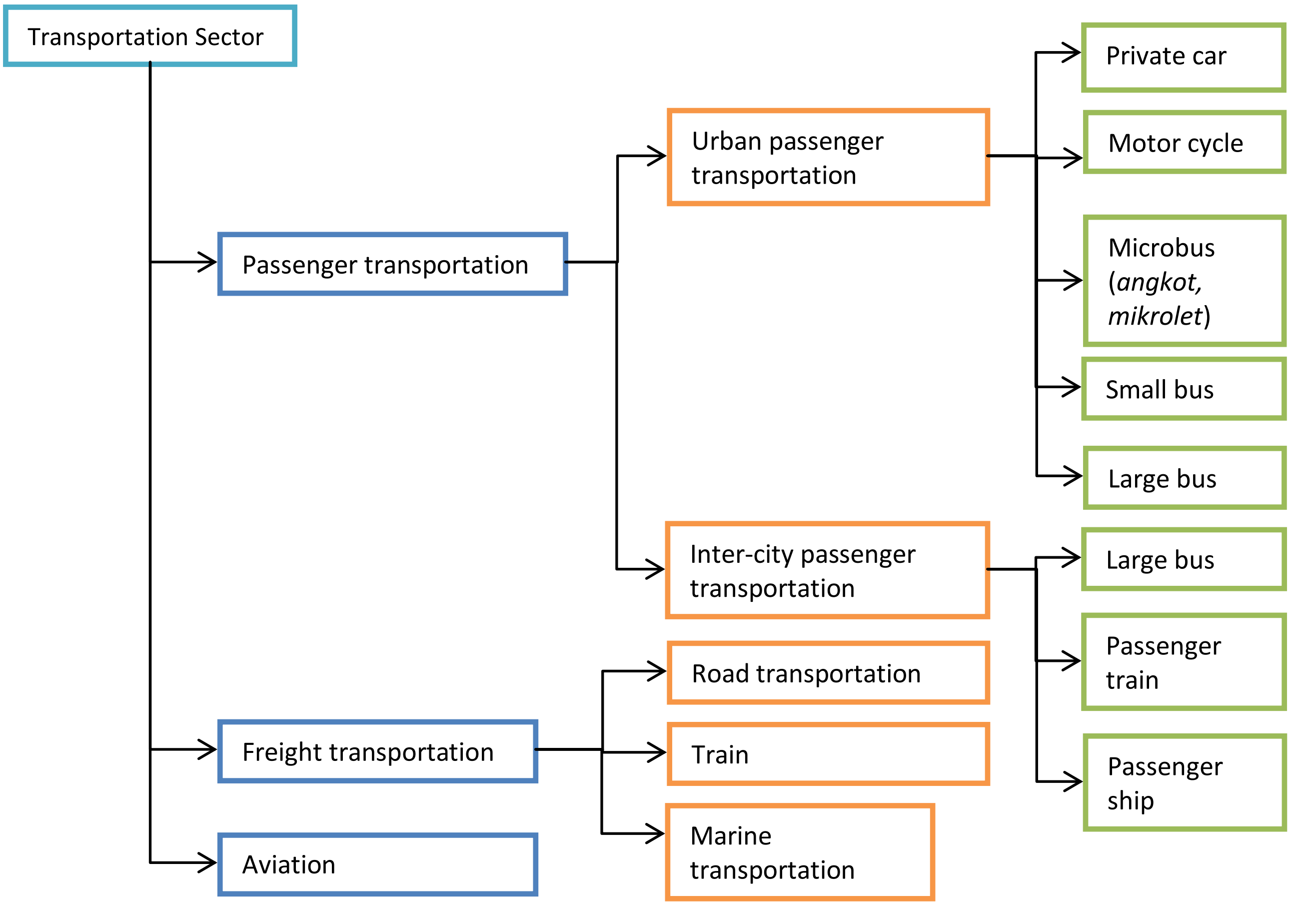

Figure 2. Classification of Transportation Sector in I2050PC

Factors contributing to the growth of passenger transportation sector are number of vehicles, growth of public transportation infrastructure, urban spatial situation, and quality of public transportation. Freight transportation sector will increase following the growth in industry sector. Aviation transportation sector is projected to increase as a suitable mode of transportation for an archipelagic country.

2. Methodology

Energy demand of transportation sector in this model is calculated using ASIF method that was developed by Lee Schiper (2000). This method has been widely used as a reference for emission calculation in transportation sector, for instance in the study conducted by the International Energy Agency (IEA), Asian Development Bank (ADB), and United Nations (UN). This approach accommodates various factors which affect greenhouse gases emission. The approach includes transportation activity (**A**ctivity), vehicle mix used for transportation activity (**S**tructure), level of energy use per movement unit (**I**ntensity) and fuel type used for the trip (**F**uel type).

$$G = A \times S \times I \times F \qquad (1)$$

G Greenhouse gases emission from transportation sector.

A Transportation activity both for passenger and freight, in km-passenger or km-ton unit. Activity can be calculated by using the number of vehicles, travel distance and occupancy factor or vehicle's average capacity.

S Structure is defined as vehicle mode that is used including non-motorized transportation such as walking and cycling.

I Energy intensity is obtained from the fuel content divided by distance unit, for example liter of fuel per km-passenger. Energy intensity of a fuel is influenced by type of fuel, vehicle technology, driving mode (for instance driving under traffic jam circumstance) and occupancy rate.

F Carbon content of fuel represents carbon emission that is released to the environment for each energy unit (kilogram CO_2/ Mega Joule). One of the references used globally or this parameter is emission coefficient that is issued by the Intergovernmental Panel on Climate Change (IPCC).

Development of I2050PC model refers to energy demand as the basis for emission calculation. Energy demand calculation in transportation sector uses ASIF method that has been simplified as follow:

Energy Demand = activity x energy intensity *(2)*

Activity variable under freight transportation sub-sector is calculated based on Gross Domestic Product (GDP) data and other supporting data due to the following reasons: First, limited availability of activity data for freight transportation. In addition, GDP data can be used to estimate the transportation data that is generally available as an aggregate figure that has not been broken down into each sub-sector. Second, GDP data provides overview of the trend in sub-sector growth based on historical data that is used as a reference for future projection. This approach has been used when the National Action Plan for Greenhouse Gases Emission Reduction (RAN-GRK) for transportation sector was developed, particularly for freight transportation and aviation. In passenger transportation sub-sector, the activity is calculated using vehicle's travel distance data and number of vehicles. Meanwhile in aviation sub-sector, activity variable is calculated by using data on number aircrafts. Model structure of transportation sector is presented in Table 1.

Table 1. Model structure of transportation sector

Structure	Activity	Energy Intensity Unit
Passenger transportation	• Travel distance • vehicle number by type of vehicle	BOE/travel distance/ Type of vehicle/ year
Freight transportation	GDP	BOE/rupiah/year
Aviation	Number of aircrafts	BOE/unit/year

Raw data of fuel consumption for the base year of transportation sector in I2050PC is obtained from BPPT Study in 2012 on fuel consumption by type of vehicle as well as number of vehicle as listed in Handbook of Energy & Economic Statistics of Indonesia 2012 (see Table 2).

Table 2. Fuel Consumption of Transportation Sector (Sugiyono 2012, PUSDATIN ESDM 2012a)

Transportation Mode	Vehicle Type	Fuel type	Fuel Consumption (Million BOE)
Road transportation	Passenger car	Gasoline	66,27
		ADO	2,02
		Biofuel B5	1,19
	Small bus	Gasoline	4,05
	Medium bus	ADO	1,60
		Biofuel B5	1,72
	Big bus	ADO	6,64
		CNG	0,18
	Small truck	Gasoline	5,84
	Medium Truck	ADO	34,32
		Biofuel B5	38,62
	Big truck	ADO	6,56
		Biofuel	5,06
	Motorcycle	Gasoline	73,52
Train	Passenger	ADO	1,20
	Electric train	Electricity	0,05
	Freight	ADO	0,14
Marine Transport		ADO	7,19
		IDO	0,03
		MFO	0,16
Aviation		Aviation Gasoline	0,01
		Jet Fuel	20,98
TOTAL		277,36	

Development and selection of assumptions and parameters in one pager that affect the energy demand projection up to 2050 was done through expert judgment and stakeholder consultation with business actors, government, associations and academicians.

3. Freight Transportation Sub-Sector

Freight transportation is still dominated by the road transportation that accounts of 93.5%, followed by marine transportation with 6%; train accounts for 0.23% and aviation accounts for 0.02% (See Table 3). Under the Presidential Regulation No. 26 of 2012 on National Logistic System, Indonesia has a policy direction towards the national freight transportation development. Prior to the issuance of this regulation, the policy related to freight transportation was partial and covered freight transportation business permit, standard and specification of vehicle for freight transportation, and other provisions of freight transportation which did not lead to the development of efficient and competitive freight transportation system. The absence of a well-structured freight transportation that is equipped with clear working mechanism and technical standards leads to the country's poor logistic performance, when compared to other ASEAN countries. Such poor performance also caused a high logistic expenditure (World Bank 2013).

Table 3. Share of Freight Transportation in Indonesia in 2006 (UNCRD 2006)

Transportation Mode	Road Transportation		Railway transportation		Crossing Transportation		Marine Transportation		Aviation		Total	Share
Island	Kton/ year	Share	Kton/ year	Share	Kton/ year	Share	Kton/ year	Share	Kton/ year	Share	kton/ Year	
Sumatera	807,972	90.7%	1,636	0.2%	-	0%	80,776	9.1%	160	0.0%	890,545	10%
Jawa	7,605,578	95.7%	19,023	0.2%	-	0%	321,861	4.0%	1,029	0.0%	7,947,491	87%
Bali,NTB,NTT	75,773	93.5%	15	0.0%	-	0%	5,147	6.4%	102	0.1%	81,037	1%
Kalimantan	4,146	11.0%	2	0.0%	109	0%	33,444	88.5%	73	0.2%	37,775	0%
Sulawesi	85,692	39.5%	227	0.1%	-	0%	130,091	60.0%	746	0.3%	216,756	2%
Maluku, Papua	11	0.4%	-	0.0%	-	0%	2,859	98.9%	22	0.8%	2,892	0%
Indonesia	8,579,173	93.5%	20,903	0.23%	109	0%	574,178	6.3%	2,133	0.02%	9,176,496	100%

Source: Survey of Origin Destination of National Transportation, MOT 2006

Freight transportation sub-sector covers 3 transportation modes namely road transportation that features truck, railway based transportation that features train that uses diesel machine, and marine transportation. One pager scenario of freight transportation sub-sector covers the change of transportation mode towards railway based and marine transportation; it also covers the fuel mix that affects the greenhouse gases emission up to 2050. This scenario is developed on the basis of government policy pathway that was dominated by road transportation and the high intake of fossil fuels. Energy demand calculation for freight transportation sub-sector is given below:

Energy demand = GDP x Energy Intensity *(3)*

Based on the above equation (3), projection of sub-sector GDP and energy intensity are required to calculate the energy demand of freight transportation sub-sector. Hence, the fixed assumptions in energy demand model for freight transportation are GDP of freight transportation subsector and energy intensity in 2011, as well as the growth of GDP and energy intensity.

a. Fixed assumption

1. GDP of freight transportation sub-sector in base year

In order to obtain the estimated GDP of freight transportation sub-sector, first it is essential to set the basic assumption to determine the share between freight and passenger transportation from the aggregate GDP that is compiled based on transportation mode (BPS, 2014). Basic assumption to set the share of freight and passenger transportation was determined based on the expert judgment of the model team as presented in Table 4, column 3 and 4. Some assumptions used are as follow: for railway-based transportation, the ratio of PT KAI revenue between freight and passenger was the basis for basic assumption in determining the share. Meanwhile, for the other transportation modes, GDP share of freight transportation directly contributes to the activity of such sector. Once the share between passenger and freight transportation is set, the share of freight transportation is later used to calculate the GDP value designated for freight transportation in 2011 (base year). The calculation result of freight transportation share in GDP for each transportation mode is shown in Table 5.

Table 4. GDP share assumption for freight and passenger transportation

Transportation Mode	GDP constant price 2011 (billion rupiahs)	Share of passenger transportatio n	Share of freight transportatio n	GDP of passenger transportation	GDP of freight transportatio n
1	**2**	**3**	**4**	**5**	**6**
1). Road transportation	38.339	50%	50%	19.169	19.169
2). Railway transportation	798	57,3%	42,7%	457	341
3). Marine transportation	9.157	20%	80%	1.831	7.325
4). River, lake and crossing transportation	3.083	60%	40%	1.850	1.233
			TOTAL	23.308	28.069

Table 5. GDP share of freight transportation by mode

Mode of road transportation	Share of GDP
Road transportation	68,29%
Railway transportation	1,22%
Marine transportation (including river, lake and crossing transportation)	30,49%
TOTAL	100%

Source: based on expert judgment

2. GDP growth projection of freight transportation sub-sector

GDP growth of freight transportation sub-sector is estimated high until 2035 along the economic growth particularly in industry sector (based on Stakeholder Consultation Meeting, September 2014). Growth projection of aircraft number is assumed 7% per year until 2025 which will later rise to 8% until 2035 and finally fall to 5% until 2050 (see Table 6). GDP growth assumption is based on the economic growth of 7% as set in KP3EI model.

Table 6. Projection of GDP Growth of Freight Transportation Sub-sector.

Year	2025	2035	2050
Annual GDP growth	7%	8%	5%

Source: based on expert judgment

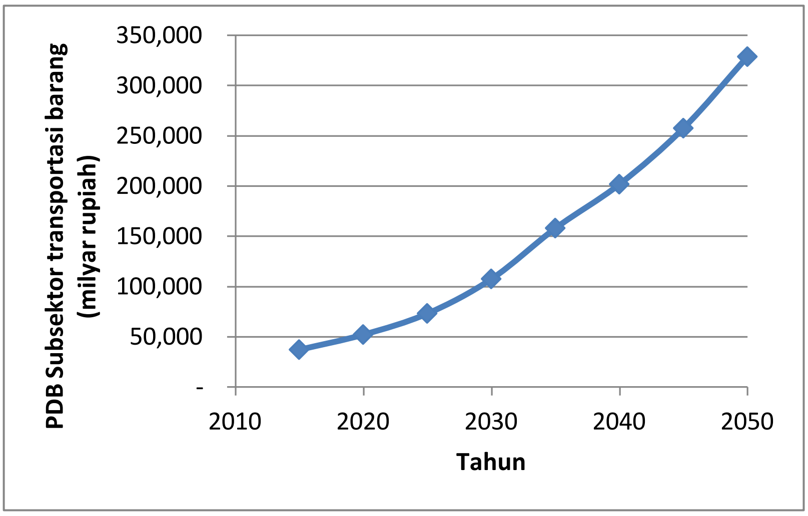

Figure 3. Projection of GDP growth of Freight Transportation Sub-sector

3. Total energy consumption of freight transportation sub-sector in base year

Estimated energy consumption of freight transportation sub-sector for truck and train in 2011 is obtained from BPPT Study (Sugiyono 2011) on energy consumption by transportation mode. Meanwhile, the energy consumption of freight transportation for marine transportation mode and river, lake and crossing transportation mode is assumed on the basis of GDP share (See Table 7). Henceforth, estimation of total energy consumption and fuel mix of freight transportation sub-sector is obtained (Table 8).

Table 7. Energy consumption of marine transportation and river, lake and crossing transportation in 2011

Fuel type	Fuel consumption (million BOE)	Assumption on Freight Transportation Share (BOE)	Energy Share of Passenger Transportation (BOE)	Freight Transportation Energy Consumption (BOE)	Share of freight transportation energy consumption

ADO	7,189	40%	60%	2.875.543	95,13%
IDO	0,026	80%	20%	20.800	0,69%
MFO	0,158	80%	20%	126.400	4,18%

Table 8. Energy consumption of freight transportation in 2011 (Sugiyono 2012)

Transportation Mode	Fuel Type	Freight transportation energy consumption (BOE)	Fuel Mix
Road transportation	Gasoline	5.842.554,32	6,46%
	ADO	82.373.563,07	91,12%
	Biofuel	2.183.871,82	2,41%
Subtotal		90.399.989,21	100%
Train	ADO	140.556,07	100%
	Biofuel	-	0%
	Electricity	-	0%
Subtotal		140.556,07	100%
Marine Transportation	ADO	2.875.543,30	95,13%
	IDO	20.800	0,69%
	MFO	126.400	4,18%
	Biofuel	0	0%
	Natural Gas	0	0%
Subtotal		3.022.743,30	100%

4. Projection of energy intensity growth of freight transportation

Growth of energy intensity of freight transportation sub-sector is assumed in Table 9 below. This assumption is based on the historical data of average energy intensity growth of road transportation, railway-based transportation and marine transportation from 2004 to 2011, which is 2%. Energy intensity growth of marine transportation is relatively higher than those of railway and road transportation. Such higher growth in marine transport is caused by the shift of freight transportation to marine transportation. Energy intensity of freight transportation does not proportionate directly with the improvement of transportation efficiency owing to technology innovation. Nonetheless, energy intensity of freight transportation is assumed to increase until 2050 due to the ongoing infrastructure growth that leads to an increase in sector activity.

Table 9. Projection of Energy Intensity Growth of Freight Transportation Sub-Sector

Freight transportation mode	Year		
	2025	2035	2050
Road transportation	0,5%	0,75%	1%
Train	0,5%	0,75%	1%

Marine transportation (including river, lake and crossing transportation)	0,5%	1%	1,5%

Source: based on expert judgment

b. Trajectory assumption

Trajectory assumption for freight transportation sub-sector includes the share of subsector's GDP for each transportation mode and fuel mix of freight transportation until 2050.

1. Projection of Freight Transportation's GDP Share by Transportation Mode

Projection of freight transportation's GDP share by transportation mode will experience a shift. Train and ship will replace truck that currently dominates the freight transportation. Share increase of train and ship is triggered by the government policy on infrastructure construction for railway and marine transportation. Ship share will increase following the marine terminal (*tol laut*) policy that will construct 24 big ports in Indonesia and rearrange the structure and system of marine transportation's supply chain. Meanwhile, share of freight transportation through train will also increase following the double track construction at the southern coast of Java, Trans Sumatera railway, Trans Sulawesi railway and Trans Kalimantan railway. The use of a more efficient railway and ship modes is expected to decrease the energy consumption share of freight transportation until 2050. The scenario's level 1 to 4 for GDP share of freight transportation by transportation mode is explained as follow:

Level 1

Level 1 assumes that in 2050, the freight transportation will still be dominated by truck compare to train and ship. Train capacity increases following the double track in Java Island and the construction of railway network system in 5 main islands that has been 20% completed. GDP share of freight transportation in 2050 is similar to that of base year, with 2,39% share of train and 30.13% share of marine transportation.

Level 2

Level 2 assumes that in 2050, capacity of railway system increases following the 40% completion of railway system construction on 5 main islands. Improvement of ports has been done in the Western part of Indonesia. It leads to an increase in GDP share of freight transportation, with 5% share of train and 35% share of marine transportation by 2050.

Level 3

Level 3 assumes that in 2050, capacity of railway system increases following the 60% completion of railway system construction on 5 main islands. Improvement of ports has been done in the Western and Central parts of Indonesia, thereby Marine Terminal program could be implemented effectively in Western and Central parts of Indonesia. It leads to an increase in GDP share of freight transportation, with 19% share of train and 38% share of marine transportation by 2050.

Level 4

Level 4 assumes that the Eastern part of Indonesia by 2050 has developed significantly, thus load factor of ship from this area increases and the Marine Terminal program could be implemented effectively. Share of road transportation becomes lower and the railway system construction has completed 100%. This situation leads to an increase in GDP share of freight transportation, with 15% share of train and 42.5% share of marine transportation by 2050.

Table 10. Assumption on GDP share of Freight Transportation

Mode	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Truck	68,29%	60%	53%	42,5%
Train	1,22%	5%	19%	15%
Ship	30,49%	35%	15%	42,5%

Source: Based on Expert Judgment

2. Fuel mix of freight transportation sub-sector

Currently, the freight transportation relies on vehicles that use fossil fuels (Sugiyono 2012). To improve the energy efficiency and reduce greenhouse gases emission of freight transportation sub-sector, the fuel mix of freight transportation sub-sector is guided towards the increase use of vegetable oil, namely biofuel for road transportation and natural gas for marine transportation. Nowadays, a test on the use of natural gas for ship has been carried out. Mixing them with biofuel can reduce the use of fossil fuels for road transportation. However, the mix ratio should not be more than 20% given the nature of machinery technology that exists nowadays. It is in concordance with government policy on the use of biofuel that is mandated under Minister of Energy and Mineral Resources Regulation No. 20 of 2014.

Level 1 scenario on the fuel mix of freight transportation sub-sector describes the current situation that is not affected by the regulation, thus the fuel mix in 2050 is similar to the one in base year. Level 2 assumes that the fuel mix has accommodated the existing policies. Level 4 describes a very optimistic condition on the use of biofuel, in which half of ADO demand has been replaced by pure biodiesel. Meanwhile, level 3 is the condition between level 2 and level 4 that is described by using some assumptions as a result of stakeholders and core team consultation. As for marine transportation, PT PELNI conducts a test on the use of natural gas for marine transportation. The testing is the basis of the negative trend projection of ADO consumption in 2050 for each level. Based on the consultation result with stakeholders, alteration in fuel mix of freight transportation is projected linear up to 2050.

Level 1

Level 1 assumes that in 2050, the share of pure biodiesel use in freight transportation is still similar to the base year, that is 2.42% for truck. Alternative fuel has not been tapped for freight train. Meanwhile, natural gas has been used for marine transportation with 2% share.

Level 2

Level 2 assumes that in 2050 the use of natural gas is marine transportation will reach 5% share following the construction of natural gas distribution infrastructure in the main ports. Share of biofuel increases to 30% for road transportation following the mandate in the Minister of Energy and Mineral Resources No.20 of 2014. Share of biofuel for train will get to 10% by 2050.

Level 3

Level 3 assumes that biofuel share reaches 40% for road transportation with the adoption of flexible fuel vehicle technology. Biofuel share for train will be 15% by 2050. And natural gas share for marine transportation will reach 10% due to the government policy on ship obligation to use natural gas.

Level 4

Level 4 assumes that marine transportation in 2050 would have used natural gas in the amount of 20% of total fuel mix due the expansion of natural gas distribution infrastructure. Biofuel accounts for 50% of total fuel mix for road transportation following the introduction of machine technology for vehicle that uses pure biodiesel. Biofuel for freight train will account for 30% share of fuel mix by 2050.

Table 11. Fuel mix of freight transportation sub-sector in 2050

Vehicle	Technology	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Truck	biofuel	2,42%	30%*	40%*	50%*
		*) of total ADO demand			
Train	biofuel	0%	10%	15%	30%
Marine Transportation	Natural gas	2%	5%	10%	20%

Source: based on expert judgment

4. Passenger Transportation Sub-sector

Currently, the motorized passenger transportation is still dominated by passenger car and motorcycle. Significant uncontrolled growth of motorized vehicle causes a major traffic jam issue in urban area. The use of public transportation including small bus (*mikrolet, KWK*), taxi, large bus and train is still limited due to a poor public transportation system at this moment (Ministry of Public Works, 2009). The focus of current government is to push the shift of transportation mode from private vehicle to public transportation in order to improve efficiency and reduce greenhouse gases emission. In urban area, Buss Raid Transit (BRT) and Mass Rapid System (MRT) are the long-term solution to reduce energy intensity in transportation sector. Modal shift from private vehicle to public transportation can be achieved if the public transportation is operated pursuant to the good service standards that is safe, comfortable and reliable (PUSDATIN ESDM 2012b). Minister of Energy and Mineral Resources Regulation No. 0031 of 2005 article 5 regulates the energy saving measures in transportation system by pushing the use of gasoline product named Pertamax for private vehicle and natural gas for public transportation. This regulation aims for reducing fossil fuel subsidy that is consumed mostly by the private vehicles. Thereby, the fuel mix in passenger transportation sub-sector is still dominated by fossil fuels. Unfortunately, fossil fuel reserve is predicted to continuously decrease in the future. (PUSDATIN ESDM 2012b).

In general, government policy related to urban public transportation is listed as follow:

1. Improvement of urban public transportation standard;
2. Limit the use of private vehicle through vehicle ownership requirements;
3. Endorse the use of BRT and railway based mass transportation;
4. Fuel diversification;
5. Encourage the development of urban traffic management system;
6. Encourage the development of technology that targets the limitation of private vehicle use, such as electronic road pricing (ERP);

7. Encourage walking as alternative transportation mode by providing facilities to pedestrian;
8. Encourage the use of off street parking (parking pocket and parking building) by limiting the on street parking on the urban main roads.

(Hubdat 2014)

Passenger transportation sub-sector covers three transportation modes, namely road transportation, electric railway based transportation and marine transportation. This sub-sector is divided into two parts, namely urban transportation and inter-city transportation. One pager scenario of passenger transportation sub-sector includes the shift of transportation mode to public transportation; and conventional vehicle technology to low emission technology that affects energy intensity of each type of vehicle and fuel mix. This scenario is based on the government policy to reduce the use of private vehicles and shift it to a more efficient public transportation, and accommodate the use of environmentally friendly vehicle technology.

Energy demand calculation for passenger transportation sub-sector is divided into urban and inter-city transportation. It is based on the trend of increasing urbanization. It is estimated that 70% of Indonesian population will live in urban area by 2020 (DG of Spatial of the Ministry of Public Work 2913). A large passenger movement also happens inter-city, apart from urban transportation. Demand calculation method is done by using the following formula:

Energy demand = number of vehicle x travel distance x energy intensity (4)

Based on equation (4), in order to calculate the energy demand, the projections of vehicle number, travel distance and energy intensity are required. Therefore, the fixed assumptions in energy demand model for passenger transportation sub-sector are vehicle number data, travel distance and energy intensity in 2011. Base year later was later projected towards 2050 using assumed growth rate derived from expert judgment.

Shift of transportation mode is calculated based on the number of private vehicle that is replaced by public transportation. Number of vehicle is the calculation basis for passenger who shifts to public transportation and the number of public bus required to accommodate the passenger shift. In equation (4) number of private vehicle has incorporated the vehicle reduction due to the shift to public transportation. It also applies to public transportation, the number of vehicle in equation 4 has also incorporated the additional vehicle required to accommodate modal shift. In order to calculate trip activity by passenger, the number of trip per year parameter for each type of vehicle is included in the following calculation formula:

$$Nu = Np \times Jp \times Kp / (Ju \times Ku) \qquad (5)$$

Where:

Nu = Number of public vehicle required
Np = Number of private vehicle that is replaced by public transportation
Jp = Number of trips using private vehicle per year
Kp = Number of average passenger of private vehicle
Ju = Number of private vehicle trip per year
Ku = Average capacity of public transportation

Based on the above equation (5), in order to project the additional public vehicle unit required for modal shift, calculations of average public transportation capacity and projection of average passenger of private vehicle until 2050 are required. This calculation is also the fixed assumption to obtain the energy demand model projection for passenger transportation sub-sector in urban area.

4.a. Passenger Transportation Sub-sector in Urban Area

a. Fixed assumption

1. Vehicle growth

Vehicle growth of passenger transportation sub-sector in urban area is calculated using some assumptions based on the number of vehicle in base year and BPS historical data from 2004 (BPS 2014). Vehicle growth is assumed similar to its historical growth (CAGR) that is calculated from 2004. Referring to literature on motorization phenomenon and vehicle ownership in some countries, it is assumed that the vehicle growth will slow down when per capita income has reached USD 10,000 (Dargay et al. 2007). Motorcycle growth is assumed stagnant when the ratio of motorcycle to population is 1 to 2, it is confirmed with Indonesia's situation based on average household size of Indonesia and the tendency to purchase car after owning 2 or 3 motorcycles (based on expert judgment). Growth of public transportation unit is assumed similar to the historical data. The number of commuter line units in Jabodetabek was obtained from PT.KCJ. Growth of commuter line unit is assumed to increase five folds in 2050, following the government target to build mass transportation in five big cities pursuant to the Mid-term Development Plan 2010 – 2014.

Table 12. Number of Vehicle in Base Year 2011

Vehicle Type	Number of Vehicle	Reference
Car	8.828.000	BPS
Motorcycle	61.133.000	BPS
Microbus (*angkot, mikrolet*)	1.684.000	BPPT
Small bus	178.000	BPPT
Big bus	468.848	BPPT
Commuter line, MRT, monorail	30 trains	PT. KCJ

2. Number of passenger per each vehicle

Average passenger number is assumed based on the study that has been conducted and load factor of public transportation is based on the expert judgment (See Table 13). Average capacity of public transportation is vehicle maximum capacity times load factor that is defined as empirical value, expressed in in percentage, of vehicle capacity that is filled with passenger. Load factor data of personal vehicle in base year refers to JABODETABEK Urban Transportation Policy Integration Project (JUTPI) study in 2011 and JABODETABEK Public Transportation Policy Implementation Strategy (JAPTraPIS) study by JICA in 2012. Load factors of public transportation and train are taken from Land Transportation in Figures 2013.

Table 13. Number of Average Passenger in base Year 2011

Type of vehicle	Average passenger number in 2011	Projection of average passenger number in 2050
Car	1,3 person	1,3 orang
Motorcycle	1,2 person	1 orang
Microbus (*angkot, mikrolet*)	14 people with the load factor of 30%	14 people with the load factor of 60%
Small bus	24 people with the load factor of 30%	24 people with the load factor of 60%
Big bus	80 people with the load factor of 30%	80 people with the load factor of 60%
Commuter line, MRT, monorail	2500 people with the load factor of 50%	2500 people with the load factor of 70%

Source: JUTPI 2011, Japtrapis 2012, Land Transportation in Figures 2013

3. Travel distance per each vehicle

Average travel distance of car and motorcycle per year is obtained through estimation from total energy consumption in 2011. Average travel distance of microbus and small bus per year is determined based on expert judgment. Meanwhile, average travel distance bus in urban area per year is obtained from Transjakarta study for natural gas use model (BPPT 2014). Projection figures in 2050 are set based on expert judgment and upon consultation with stakeholders. Travel distance of commuter line is based on Jakarta- Bogor route. Growth of vehicle's travel distance is projected linear up to 2050.

Table 14. Average travel distance in Base Year 2011

Type of vehicle	Average travel distance in 2011	Projection of average travel distance in 2050
Car	32 km/day (10 km/day with 3,2 trips/day)	20 km/day
Motorcycle	16 km/day(4 km/day with 4 trips /day)	15 km/day
Microbus (*angkot, mikrolet*)	90 km/day	150 km/day
Small bus	90 km/day	150 km/day
Big bus	278 km/day (34.75 km/ day with 8 trips/day)	250 km/day
Commuter line, MRT, monorail	45 km/day with 8 trips/day	45 km/day with 8 trips/day

4. Energy efficiency by type of vehicle and fuel

Vehicle's energy efficiency in this model is defined as energy consumption required to travel one kilometer distance while carries average passenger capacity per vehicle; and it is expressed in BOE/km unit. Energy efficiency could be calculated based on fuel energy content in one liter of fuel (BOE/liter) divided by fuel specific consumption per type of vehicle to travel certain distance (km/liter). Energy content data per type of fuel is obtained from various sources (see Table 15). Estimation of alternative fuel energy content such as VGas, CNG, bioethanol and biofuel is assumed based on energy content comparison with gasoline and ADO (EIA 2013). Fossil fuel specific consumption for car and motorcycle is obtained from survey conducted by Swisscontact Foundation in 2008 and is projected linear up to 2050 based on expert judgment (see table 16) (Suhadi 2008). For vehicle's energy efficiency approach with advanced and low emission technology such as electric vehicle and fuel cell, data can be obtained from vehicle's specification that have been commercialized in developed countries at the moment (Gekgo Worldwide 2014, US-DOE/US-EPA 2014b, US-DOE/US-EPA 2014c).

Table 15. Fuel energy content in base year 2011

Type of fuel	Energy Content (BOE/liter)	Source
Gasoline	0,0058275	BPPT
ADO	0,0064871	BPPT
CNG	37,5% of gasoline energy content	(EIA 2013)
Biofuel	0,006162745	(Kutz 2008)
Bioethanol	80% of gasoline energy content	(EIA 2013)

Table 16. Fuel consumption by vehicle (Suhadi 2008)

Type of vehicle	Fuel consumption in 2011(km/l)	Fuel consumption in 2050 (km/l)
Car	8,5	15
Motorcycle	28	28

Figure 4 describes the energy efficiency by type of fuel of private car from the base year 2011 to 2050. Basic assumptions for car are: saving technology will still develop and traffic jam issue in the big cities of Indonesia will lessen, thus fuel specific consumption increases. For hybrid car, it is assumed that fuel specific consumption increases from 35 km/l in base year 2011 to 50 km/l in 2050. Assumption on hybrid car's energy efficiency in 2050 is similar to the specification of hybrid car that is being used in developed countries at the moment (Autoguide.com 2011). Currently, car in Indonesia averagely uses machine with Euro 2 emission standard. However, motor machine technology is assumed to be stagnant, thus the energy efficiency will not change until 2050. Low emission and advance technology motorcycle and car are predicted to penetrate Indonesia's market in 2020. Their energy efficiency is considered similar up to 2050 with the same assumption of the car specification that has been commercialized in developed country at the moment. Due to limited budget availability, energy efficiency of public transportation is calculated from total energy consumption data by type of vehicle divided by travel distance per year and it is estimated constant until 2050 (See Table 17).

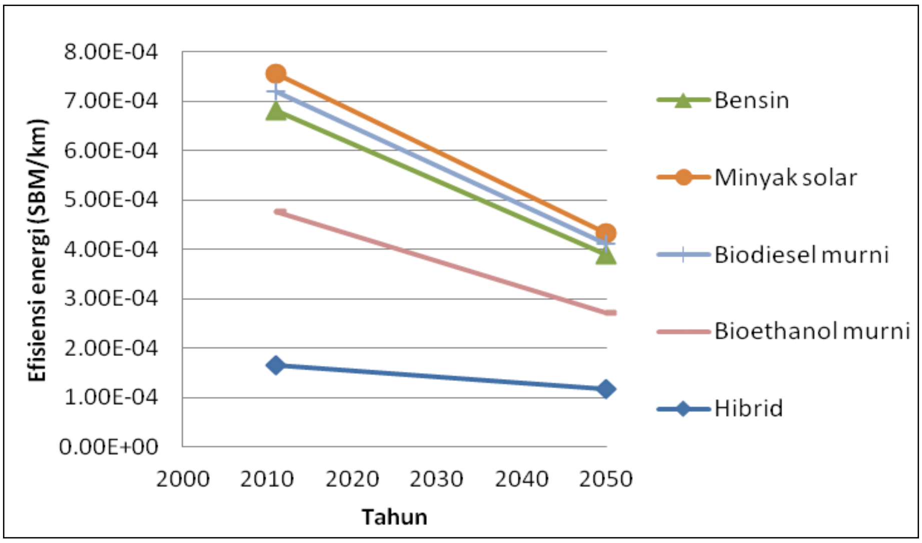

Figure 4. Energy efficiency of private car until 2050

Table 17. Energy Efficiency of private car

Type of vehicle	Type of fuel/technology	Energy efficiency in 2011 (BOE/km)	Energy Efficiency in 2050 (BOE/km)
Car	Gasoline	6.80E-04	3.89E-04
	ADO	7.57E-04	4.32E-04
	VGas	5.44E-06	3.11E-06
	CNG	2.55E-04	1.46E-04
	Pure biofuel	7.19E-04	4.11E-04
	Pure bioethanol	4.76E-04	2.72E-04
	Hybrid	1.67E-04	1.17E-04
	Electric	1.32E-04	1.32E-04
	Fuel cell	5.12E-05	5.12E-05
Motorcycle	Gasoline	2.08E-04	2.08E-04
	Pure bioethanol	1.34E-04	1.34E-04
	Electric	1.28E-04	1.28E-04
Microbus (*angkot, mikrolet*)	Gasoline	7.43E-05	1.49E-04
Small bus	ADO	5.77E-04	1.15E-03
	Pure biofuel	5.48E-04	1.10E-03
Big bus	ADO	1.51E-04	3.03E-04
	Pure biofuel	1.44E-04	2.87E-04
	CNG	4.94E-05	9.88E-05
Commuter line, MRT, monorail	Electric	1.52E-02	2.12E-02

Source: data processing from various literatures and surveys

b. Trajectory assumption

One pager of energy consumption projection of passenger transportation sub-sector in urban area is divided into three: (1) modal shift of passenger transportation, (2) vehicle technology, both conventional and (3) advanced and low emission technology for urban transportation.

1. Modal shift of passenger transportation

Traffic jam issue in Indonesia causes inefficient use of energy since the vehicle needs more fuel to travel a short distance. It is caused by road infrastructure capacity that could not cope with the increasing number of vehicle. One of the solutions to this problem is increasing the use of public and mass transportation because the fuel specific consumption for public transportation is much lower than private vehicle[1]. One of public transport models that start to be developed in the big cities is the bus rapid transport (BRT), like TransJakarta. BRT is defined as the road-based mass transportation that utilizes bus with specific and protected lane, thus enable the increase of carrying capacity (PUSDATIN ESDM 2012b). Other strategy to reduce energy consumption derived from motorized vehicle is to encourage the non-motorized transportation by providing facility for pedestrians and bike lane.

One pager of passenger transportation's modal shift is based on the current condition of urban passenger transportation that is still dominated by private car and motorcycle. Current focus of government policy is to encourage modal shift from private vehicle to public transportation in order to improve energy efficiency and reduce greenhouse gases emission. In urban area, Bus Rapid Transit (BRT) and Mass Rapid Transit (MRT) systems are considered as a long-term solution to reduce energy intensity in transportation sector. This one pager is not applied to the inter-city transportation. In one pager of passenger transportation's modal shift, level 1 describes the absence of modal shift from private vehicle to public transportation. BRT has been adopted in base year 2011 in some big cities in Indonesia and it is assumed that the systems will be adopted and developed until 2050. However, in level 1, the use of private car is assumed to increase and people still prefer to use private vehicle than massive transportation (BRT and MRT), thus the modal shift of private vehicle does not happen. The higher levels represent the lower private vehicle growth because half of private vehicle owners prefer to use public transportation, hence the growth of public transportation is higher. With the provision of supporting infrastructures and reliable and integrated urban public transportation in level 4, it is assumed that the efforts succeed to encourage the

[1] For instance, the fuel specific consumption of private vehicle in Jakarta is 10.04 km/liter-passenger. Meanwhile, the fuel specific consumption of large bus in Jakarta is 0.88 liter/km-passenger (PUSDATIN ESDM 2012b).

transportation user in shifting their transportation mode to non-motorized system such as walking and cycling.

Level 1

Level 1 assumes that in 2050, the urban transportation is still dominated by private vehicle. Development of public transportation infrastructure is still low. The use of private vehicle in urban area has not been significantly shifted to BRT and railway based transportation (commuter line, monorail, MRT [Mass Rapid Transit], and etc.).

Level 2

Level 2 assumes that in 2050, the modal shift in 2050 from private vehicle to railway based transportation increases 20% owing the provision of infrastructures for public transportation, particularly BRT and railway based transportation

Level 3

Level 3 assumes that in 2050, the modal shift from private vehicle to bus and railway-based transportation increases 25% following the infrastructure provision for public transportation.

Level 4

Level 4 assumes that the growth of integrated railway based passenger transportation that is integrated with the bus system is able to shift 30% private vehicle users to public transportation in 2050. The most optimistic scenario of modal shift to MRT is assumed in 20 cities of Indonesia that has a system like commuter line that currently exists in Jabodetabek. In addition, with the provision of a reliable MRT, 5% of private vehicle users shift to non-motorized transportation such as walking and cycling. Modal shift to NMT is assumed to be triggered by the urban planning that locates residential close to commercial area and also the work from home lifestyle as the impact of a more modern communication technology.

Table 18. Modal shift level of passenger transportation

Modal Shift from Private Vehicle to	2011	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Urban BRT & MRT	0%	0%	20%	25%	30%
Non-motorized system					5%

Source: based on expert judgment

2. Passenger transportation technology

One pager of alternative technology and fuel of passenger transportation is based on government policy related to the use of biofuel as stated in the Minister of Energy and Mineral Resources Regulation No. 20 of 2014 as well as the use of advance and environmentally friendly technology (Table 19).

Level 1

Level 1 assumes that in 2050 private vehicle technology is still based on ICT and dominated by the use of conventional fossil fuels. The use of pure biofuel has been adopted in land transportation sub-sector like the situation nowadays; therefore the share of biofuel in 2050 is still similar to that in 2011. Natural gas share for passenger transportation including public bus in 2050 is still similar to the condition of baseline year. In 2050, the share of vehicle with low emission technology is 0.1% out of total private vehicles.

Level 2

Level assumes that the share of pure biofuel increases to 30% out of total demand of ADO in 2020 and bioethanol share is 20% pursuant to the Minister of Energy and Mineral Resources Regulation No. 20 of 2014. Share of natural gas for urban bus reaches 12% in 2050. The growth of transportation sector is supported by the transportation infrastructure including fuel station and provision of natural gas and biofuel. Share of vehicle with low emission technology reaches 1% out of total private vehicles.

Level 3

Level 3 assumes that in 2050, the share of vehicle that uses biofuel has increased to 40% out of total diesel cars. Bioethanol share is 25%. This circumstance is achieved by flexible fuel vehicle technology, which refers to the machine that could use pure biofuel with higher mix level. Share of natural gas for bus reaches 25% in 2050 following the increasing number of fuel station and the policy to support the provision of biofuel. In 2050, share of vehicle with low emission technology will be12% and electric motorcycle will be 30%.

Level 4

Level 4 assumes that in 2050, the share of biofuel use for road transportation reaches 50% and bioethanol reaches 35% for private vehicle following incentive policy and domestic production of flexible fuel technology. Share of natural gas for bus will be 50%. In 2050, share of vehicle with low emission technology reaches 30% and electric motorcycle reaches 65%.

Table 19. Technology level of conventional urban passenger transportation

Vehicle	Technology	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Car	biofuel	0.1%	30%	40%	50%
Car / Motorcycle	bioethanol	0%	20%	25%	35%
		*) out of total gasoline			
Car	Hybrid&electric	0.1%	1%	12%	30%
Motorcycle		0.1%	1%	50%	80%
Bus	Biofuel	0%	30%	40%	50%
	Natural gas	8.2%	12%	25%	50%

Source: based on expert judgment

3. Passenger vehicle with low emission technology

Passenger vehicle with advance and low emission technology includes hybrid technology and electric car. Hybrid technology has been developed by some famous automotive industries such as Honda from Japan, BMW from Europe, as well as General Motor and Ford from Unites Stated. Hybrid technology has a system to regenerate wasted mechanical energy (due to deacceleration process) into stored energy in a form of electricity. Therefore, the fuel specific consumption decreases because the energy demand has been partially provided by the electric motor. The laboratory test shows the reduction in fuel specific consumption up to 31 km/liter (Pusdatin ESDM 2012 b)

Electric car technology is a car that is powered by electricity alone from the electric motor and a rechargeable battery package. Electric car has some benefits compare to the other cars with internal combustion machine, such as energy efficient and environmentally friendly. Electric car converts approximately 59 – 62% if electricity from grid into wheel movement. Meanwhile, conventional gasoline car converts only 17 – 21% of energy from gasoline into movement. Electric car does not produce emission directly, yet the emission might be emitted from the power plant that generates electricity. It is also expected that the power plant also produces less emission such as nuclear, hydro, wind and (US-DOE/US-EPA 2014a). The average share of electric car technology in developed country in 2013 is estimated 0.93% (Shahan 2014).

One pager of passenger vehicle with low emission technology accommodates the possibility of an increase in hybrid technology and electric vehicle use that is currently being commercialized in developed countries. It allows the emission reduction in transportation sector by reducing the use of conventional fossil fuels and vehicle technology with low emission feature. Current average share of electric vehicle in developed country is used as the reference for level 2 of electric vehicle share. In level 2, the share of electric vehicle in Indonesia in 2050 is assumed similar to the current condition in developed countries.

Option A

Option A assumes that in 2050, all passenger cars with low emission technology will be fully hybrid. And, motorcycle with low emission technology will be fully electric.

Option B

Option B assumed that in 2050, 70% of passenger car with low emission technology will be hybrid and 30% will be electric. Meanwhile, motorcycle with low emission technology will be fully electric.

Option C

Option C assumes that in 2050, 50% of passenger car with low emission technology will be hybrid and 50% will be electric. Meanwhile, motorcycle with low emission technology will be fully electric.

Option D

Option D assumes that in 2050, all passenger vehicles with low emission technology will be electric.

Table 20. Level of low emission technology passenger vehicle

Vehicle	Technology	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Car	Hybrid	100%	70%	50%	0%
Car	Electric	0%	30%	50%	100%
Motorcycle	Electric	100%	100%	100%	100%

Source: based on expert judgment

4. b. Inter-city passenger transportation sub-sector.

a. Fixed assumption

1. Vehicle growth

The number of inter-city bus unit and marine transportation is obtained from Transportation Statistic 2012 (Kemenhub 2013). Vehicle growth is projected based on historical data from 2008. Number of train unit is obtained from BPPT Study for energy consumption by type of vehicle 2011, and the growth uses historical data of diesel train in 2009 from PT KAI Annual Report 2009 (PT. KAI 2013). The unit growth is projected linear until 2050.

Table 21. Number of vehicle unit in base year 2011

Type of vehicle	Number of unit	Reference
Inter-city bus	21.152	Transportation Statistic 2012 (Kemenhub 2013)
Diesel train	194 locomotives	BPPT (Sugiyono 2012)
Ship	14.926	Transportation Statistic 2012 (Kemenhub 2013)

2. Travel distance by type of vehicle

For inter-city transportation, average bus travel distance is assumed similar to the daily distance of Jakarta – Semarang for 360 operational days per year. Average train travel distance per year is assumed similar to the distance of Jakarta – Surabaya per day with 360 operational days per year. Average marine transportation is assumed based on the distance of Merak – Bakauheni with the frequency of 4 times a day for 360 operational days per year distance (ANTARA Sumatera Barat 2012, Kompas 2011). Travel distance of inter-city transportation is assumed constant until 2050.

Table 22. Average travel distance in base year 2011

Type of vehicle	Average travel distance in 2011	Average travel distance projection in 2050
Inter-city bus	477 km/day	477 km/day
Diesel train	785 km/day	785 km/day
Ship	15 nautical miles/day with 4 trips/day	15 nautical miles/day with 4 trips/day

Source: based on expert judgment

3. Energy efficiency by type of vehicle and fuel

Energy efficiency of vehicle in this model is defined as the amount of energy required to travel one kilometer and carry passengers, equal to vehicle's average capacity, and expressed in BOE/km. Due to data constrain, the energy efficiency of passenger vehicle is calculated by dividing total energy consumption data by annual travel distance, and the figure is assumed constant until 2050 (See Table 23). Estimation of energy content of ADO and MFO for marine transportation is assumed based on energy content data comparison from UNFCCC report (2012).

Table 23. Energy efficiency of public transportation

Type of vehicle	Type of Fuel/Technology	Energy Efficiency (BOE/km)
Inter-city bus	ADO	0.0002163
	Pure biofuel	0.0002055
Diesel train	ADO	0.0219147
	Pure biofuel	0.0208189

Ship	ADO	0.0072908
	CNG	0.0024855
	IDO	0.0071595
	MFO	0.0066491
	Pure biofuel	0.0069263

b. Trajectory assumption

One pager of energy use projection in inter-city passenger transportation sub-sector accommodates the use of alternative fuel for inter-city vehicles.

Passenger transportation's technology

One pager of alternative technology and fuel of passenger transportation is based on the government policy related to the use of biofuel. Level 1 assumes that the government policy has not come into effect yet. Level 2 assumes that the Minister of Energy and Mineral Resources Regulation No. 20 of 2014 have been implemented. Level 3 and 4 assume that the flexible fuel vehicle technology that utilizes biofuel has been adopted for bus and train; natural gas is used for marine transportation (Table 24).

Level 1

Level 1 assumes that in 2050, inter-city transportation is still dominated by ICT-based technology and fossil fuels. The use of pure biofuel for inter-city transportation has not been in place yet until 2050. Meanwhile, the test on natural gas use for marine transportation is succeeded, thus the share is 2% in 2050.

Level 2

Level 2 assumes that the use of biofuel for inter-city transportation has been implemented pursuant to Minister of Energy and Mineral Resources No.20/2014. Share of biofuel in ADO is 30% for inter-city bus. Diesel train has used 10% pure natural gas in 2050. Growth of transportation sector is supported by the development of transportation infrastructure including the construction of fuel station that provides natural gas and biofuel. Meanwhile, share of natural gas for marine transportation has reached 5% in 2050.

Level 3

Level 3 assumes that in 2050, the share of public transportation that uses biofuel has reached 40% for inter-city bus and 15% for train. Share of natural gas for bus and marine transportation will be 10% by 2050 with a lot of fuel stations and other policies that support the provision of natural gas.

Level 4

Level 4 assumes that in 2050, the share of road transportation that uses biofuel will be 50% by 2050 following the incentive policy and the domestic production of flexible fuel vehicle. Share of natural gas for marine transportation will be 20%.

Table 24. Fuel mix level for inter-city passenger transportation

Vehicle	Technology	Level 1 2050	Level 2 2050	Level 3 2050	Level 4 2050
Bus	Biofuel	0%	30%	40%	50%
Train	Biofuel	0%	10%	15%	30%
Marine Transportation	Natural gas	2%	5%	10%	20%

Source: based on expert judgment

5. Aviation Sub-sector

In 2010, greenhouse gases derived from transportation sector was 105 million tCO2e, aviation contributed 9% out of total transportation sector's emission (PUSDATIN ESDM 2012b). GHG emission reduction covers the energy saving measures in aviation sub-sector. The measures are improve the effectiveness of air traffic controller, improvement of airport management, improvement of operational system and procedures, as well as fossil fuel efficiency by utilizing biofuel for aviation (bioavtur) (Kemenhub 2012). Referring to the above policy, one pager scenario for aviation sub-sector is divided into two: improvement of flight operational efficiency and increase the use of biofuel in aviation fuel mix until 2050.

In line with the international agreement, IATA (International Air Transport Association) announced the GHG emission target related to climate change mitigation phenomenon under Carbon Neutral Growth 2020 (CNG2020) and Carbon Zero Growth 2050 to reduce emissions in 2050 by half compare to the emissions in 2005. This initiative comprises four strategic pillars in the international aviation industry, namely improvement in technology, operation, infrastructure and carbon trading scheme (IATA 2013).

The use of bioavtur is a strategy to reduce carbon emission in aviation sector. It also aims to reduce the use of fossil fuel. Bioavtur is IATA strategy towards CNG 2020 target (IATA 2011). IATA focuses on biofuel second generation or new findings (algae, jatropa and cameline) and biomass. These fuels could be produced sustainably to minimize impacts on food and freshwater use. Tests in 2008 and

2009 show that biofuel from those sources could be used without modification of aviation's machine. Such type of biofuels could be mixed with fossil fuel for direct use. In 2011, Lufthansa was the first aviation company to test the use of bioavtur. Within 6 months, the aircraft A321 enrouted from Hamburg to Frankfurt use the fuel mix with 58% biokerosene content (Bisnis.com 2013). In September 2014, Lufthansa flew for the first time in Europe using 10% biokerosene farnesene for Frankfurt – Berlin route. Farnesene is a sugar-based biokerosene that has passed the test and could improve the fuel emission characteristic (Lufthansa 2014). Raw material for bioavtur and bioavtur production technology are required to produce bioavtur that has the same characteristic as avtur from fossil fuels. Bioavtur could be made from fatty oil such as coconut oil and jatropa oil through hydrogenation technology (Soerawidjaja 2010).

Energy demand for aviation sub-sector in I2050PC is calculated using the following formula:

Energy Demand = number of aircraft unit x energy intensity *(6)*

Based on equation (6) above, energy demand projection of aviation sub-sector requires the data on number of aircraft unit and energy intensity. Therefore, the fixed assumption in modeling the energy demand of aviation sub-sector is number of aircraft unit in 2011. Meanwhile, projection of energy intensity per aircraft and projection of energy mix until 2050 are parts of trajectory assumption

a. Fixed assumption

Projection of Aircraft Growth

Projection of aircraft growth is assumed 12.5% until 2025 based on GDP growth per year from 2004 to 2011 which is 11.3% (See Table 25). This projection is higher than historical data to accommodate the potential growth of freight transportation through aviation. The growth of aircraft number is assumed slower to 10% per year between 2025 to 2035 and 7.5% between 2035 to 2050. Such weakened growth until 2050 is assumed triggered by saturated growth of aviation sector.

Basic assumption of aircraft growth that is relatively high is caused by, first, government policy to develop a number of big airports in some areas according to Long-Term Planning of Ministry of Transportation 2005 – 2025, that states that the aviation sector will grow; second, high potential of e-commerce (goods shipment using aviation service) that is predicted to grow 30% by 2020 (based on Stakeholder Consultation Meeting, December 2014); third, possibility of open space adoption due to ASEAN Economic Community (AEC) which will commence in 2015. It allows the overseas aircraft to land on local airport without transit in the main airport in advance. Therefore, the government needs to build more international airports.

Table 25. GDP of Aviation Sector (BPS 2014)

Year	2004	2005	2006	2007	2008	2009	2010	2011
GDP (billion rupiah)	9384,30	10362,30	11466,20	12385,30	13044,40	14564,30	17330,40	19815,70

Table 26. Projection of aircraft growth

Year	2011	2015	2020	2025	2030	2035	2040	2045	2050
Number of Aircrafts	1067	1710	3082	5554	8945	14407	20684	29695	42632

Source: based on expert judgment

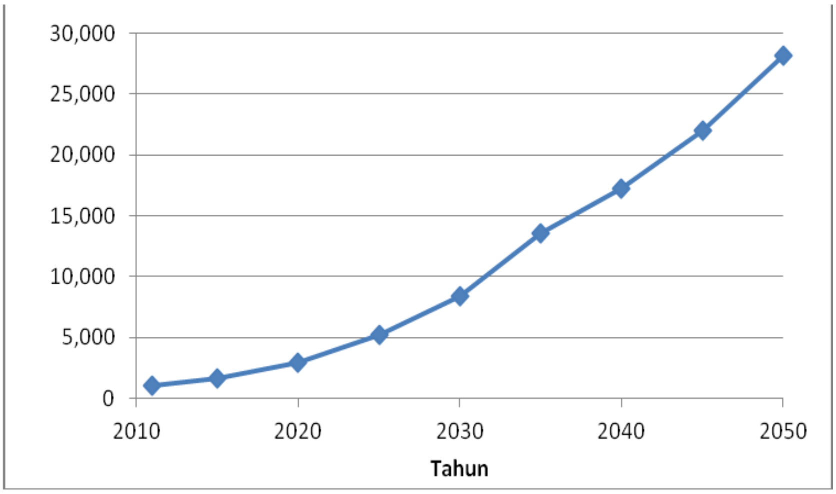

Figure 5. Projection of aircraft growth

b. Trajectory assumption

Trajectory assumption for aviation sub-sector comprises energy intensity and fuel mix until 2050.

1. Energy intensity of aviation sub-sector

Average energy intensity in base year for aviation sub-sector is the average energy consumption per aircraft unit, that is obtained by dividing the total energy consumption of aviation sub-sector by number of aircraft in 2011 (see Table 27). Decline in energy intensity is affected by two factors, which are aircraft fleet revitalization and efficiency in flight operation that covers improvement of airport operational management and air traffic control management.

Table 27. Energy intensity of Aviation Sub-sector in base year 2011

Parameter	Value	Unit	Source
Total energy consumption of aviation sub-sector in 2011	20.996.000	BOE	(PUSDATIN ESDM 2012a)
Number of aircraft in 2011	1067	Unit	(Kemenhub 2014)
Average energy intensity of aviation sub-sector in 2011	19.677,60	BOE/Unit	Calculation Result

Change in energy intensity of aviation sub-sector due to aircraft fleet revitalization is calculated based on the proportion of aircraft age in 2011 that was obtained from the Minister of Transportation (2014). The data reveals that there was 1067 aircrafts in 2011, in which 75 out of 531 passenger aircrafts are new and the aircraft is averagely used for 5 years. The data is used as a reference to assume the age proportion of aircraft. The estimation of aircraft's age proportion is listed in Table 28.

Table 28. Estimation of aircraft's age proportion in base year 2011

Aircraft Age	Number of Aircraft (unit)	Proportion of aircraft age (%)
Under 1 year	75	7,03%
Under 5 years	436	42,74%
More than 5 years	536	50,23%
Number of aircraft	1067	100%

Projection of aircraft's age proportion until 2050 is decided based on expert judgment (see Table 29). Proportion growth is projected linearly until 2050

Table 29. Projection of aircraft's age proportion

Level	Year	Aircraft age		
		Aircraft < 1 year	Aircraft 1-5 years	Aircraft > 5 years
Base year	2011	7,03%	42,74%	50,23%
Level 1	2050	10%	45%	45%
Level 2	2050	25%	37,5%	37,5%
Level 3	2050	40%	30%	30%
Level 4	2050	50%	25%	25%

Source: based on expert judgment

Considering that the use of a new aircraft could save energy up to 15% (based on Stakeholder Consultation, September 2014), it is assumed that the energy consumption in 2050 for the aircrafts that are operated under 1 year, will be 15% lower than the average energy consumption per aircraft in base year. The aircraft which has been operated between 1-5 years consumes energy with the same intensity as those of base year, meanwhile the aircraft that has been operated for more than 5 years consumes 15% more energy than the average energy consumption per aircraft in base year.

By calculating the projection of total energy consumption of aviation sub-sector divided by the projection of vehicle number in 2050, the average energy intensity of aviation sub-sector in 2050 is obtained. The figure was later compared to the 2011 figure (due to aircraft rejuvenation). Other factor that that affects the energy intensity of aviation sub-sector is the efficiency in flight operation comprising improvement of operational management and a more efficient air traffic control. This factor is assumed to reduce energy intensity by 5% in 2020 based on the consultation with stakeholders. Thus, the estimated energy intensity of aviation sub-sector in 2050 is obtained. The growth of energy intensity in aviation sub-sector is projected linear until 2050. Level 1 to level 4 scenarios for the change in intensity of aviation sub-sector owing to efficiency improvement of flight operational are described below.

Level 1

Level 1 assumes that the efficiency improvement program of flight operational is adopted slowly; thereby the energy intensity is 2% lower in 2050. Aircraft fleet revitalization has been implemented that 10% operated aircrafts are under 5 years. This measure increases the energy intensity of aviation sub-sector by 3.25% in 2050.

Level 2

Level 2 assumes that the efficiency improvement program of flight operational is adopted; thereby the energy intensity is 5% lower in 2050. Aircraft fleet revitalization has been implemented that 25% operated aircrafts are under 5 years. This measure reduces the energy intensity of aviation sub-sector by 3.1% in 2050.

Level 3

Level 3 assumes that the efficiency improvement program of flight operational is adopted; thereby the energy intensity is 5% lower in 2050. Aircraft fleet revitalization has been implemented that 40% operated aircrafts are under 5 years. This measure reduces the energy intensity of aviation sub-sector by 6.5% in 2050.

Level 4

Level 4 assumes that the efficiency improvement program of flight operational is adopted in all airports in Indonesia; thereby the energy intensity is 10% lower in 2050. Aircraft fleet revitalization has been implemented that 50% operated aircrafts are under 5 years. This measure reduces the energy intensity of aviation sub-sector by 13.75% in 2050.

Table 30. Projection of energy intensity in aviation sub-sector in 2050

Level	Year	Energy intensity due to aircraft rejuvenation	Change in energy intensity due to flight operational efficiency	Energy intensity of aviation sub-sector
Base year	2011	0%	0%	100%
Level 1	2050	105,25%	-2%	103,25%
Level 2	2050	101,88%	-5%	96,88%
Level 3	2050	98,5%	-5%	93,5%
Level 4	2050	96,25%	-10%	86,25%

2. The use of bioavtur

Fuel mix projection of aviation sub-sector is determined by the projection of jet fuel (avtur) and aviation gas (avgas) consumption in aviation sub-sector. Growth of jet fuel consumption is assumed 10%, thus the figure in 2050 will be close to the historical data of GDP growth in aviation sub-sector which is 11.3%. Meanwhile, the growth of aviation gas consumption is assumed 6% - 7.5% until 2050 based on the projection of national GDP growth stated in RUEN and KP3EI. The estimation of total fuel consumption in aviation sub-sector in 2050 is used as a reference to estimate the fuel mix of aviation sub-sector in 2050 including the use of bioavtur (see Table 31) and later projected linearly down to base year. Level 1 of one pager for the use of bioavtur in aviation sub-sector is assumed to have adopted the Minister of Transportation's target, which is 3% share of bioavtur in 2018. Level 2 to level 4 assumes an increasing share of bioavtur use.

Level 1

Level 1 assumes that the use of biofuel for aviation in 2018 reaches 3% share pursuant to the RAN GRK target of the Ministry of Transportation.

Level 2

Level 1 assumes that the use of biofuel for aviation in 2025 reaches 25% share pursuant to the Minister of Energy and Mineral Resources Regulation No. 20 of 2014.

Level 3

Level 3 assumes that the government has a strong policy support towards biofuel supply; the share of pure biofuel in transportation sub-sector (bioavtur) in 2050 will be 30%.

Level 4

Level 4 assumes that the machine technology of an aircraft has been able to use pure biofuel, thus pure biofuel share in aviation sub-sector in 2050 reaches 50%.

Table 31. Level of fuel mix in aviation sub-sector in 2050

Level	Year	Fuel Type		
		Jet Fuel	Bioavtur	Aviation gas
Base year	2011	99,94%	0%	0,06%
Level 1	2050	89,99%	10,00%	0,01%
Level 2	2050	79,99%	20,00%	0,01%
Level 3	2050	70%	29,99%	0,01%
Level 4	2050	50%	49,99%	0,01%

Source: expert judgment

6. Calculation Result

By using the above methodology and assumption, the energy demand of transportation sector is calculated below. The energy demand of freight transportation is shown in Figure 6. Level 4 of one pager scenario for "Modal shift of freight transportation' affect the decline of energy demand in 2050 that is 33.3% lower than the demand in level 1. One pagers for "alternative fuel for freight transportation sub-sector" for road transportation, train and marine transportation are presented in figure 7, 8 and 9 respectively.

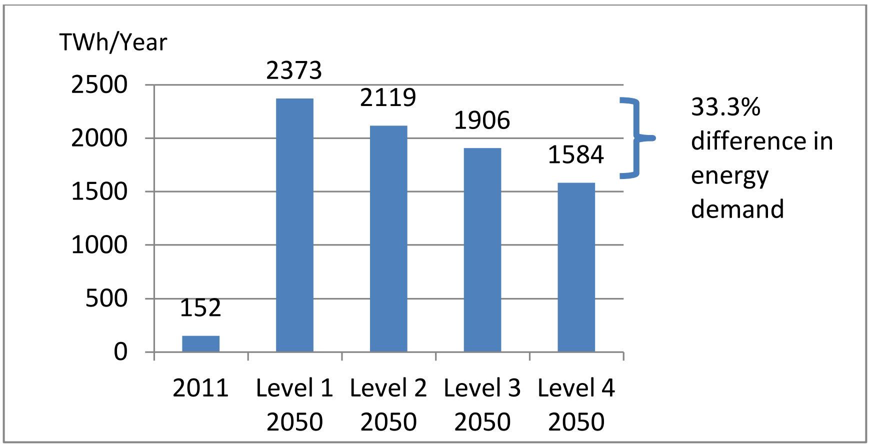

Figure 6. Energy demand of freight transportation sub-sector

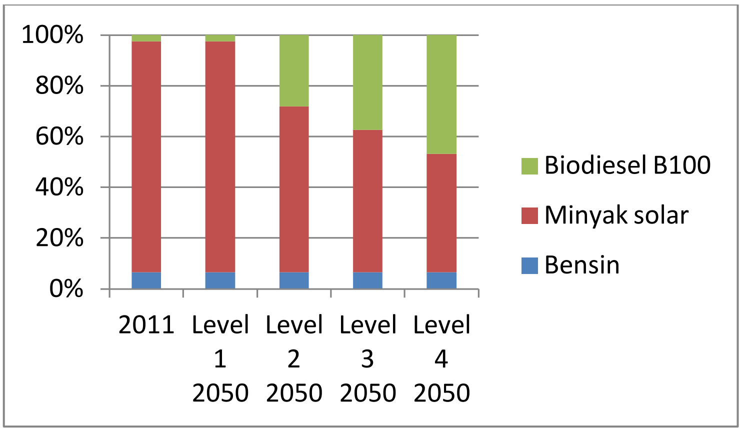

Figure 7. Fuel mix of freight transportation using road transportation

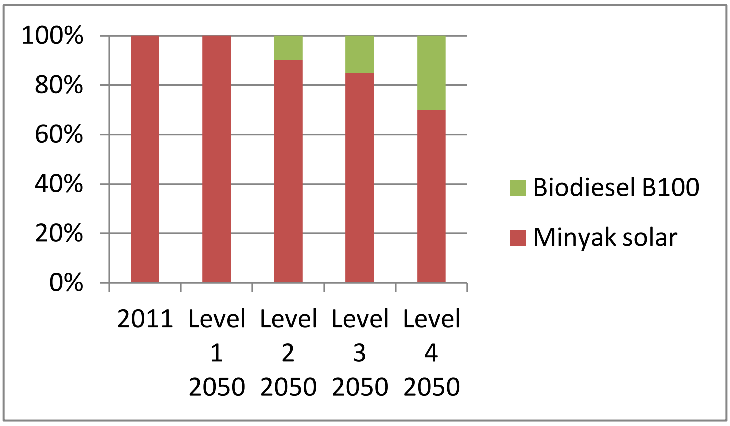

Figure 8. Fuel mix of freight transportation using train

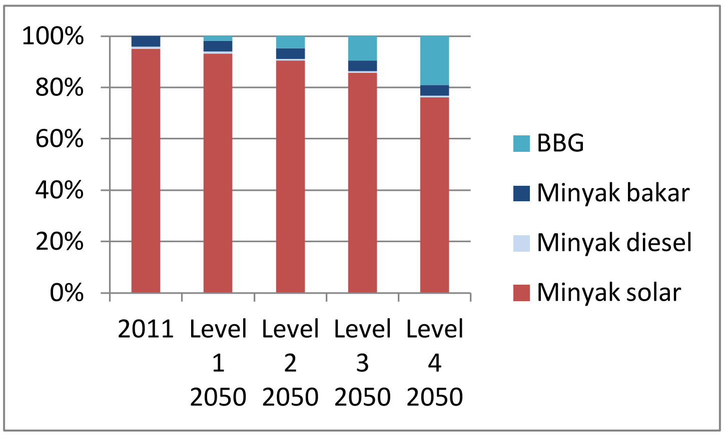

Figure 9. Fuel mix freight transportation using marine transportation

Energy demand of passenger transportation sub-sector is presented in Figure 10. Level 4 of one pager scenario for “Modal shift of urban transportation” causes a decline of energy demand in 2050 that is 9.3% lower than the demand in level 1. Energy mix of urban passenger transportation is presented in figure 11, 12 and 13 respectively. Low emission technology mix for urban passenger transportation based on one pager for "low emission passenger transportation" is presented in Figure 14. Energy mix for inter-city passenger transportation is presented in Figure 15.

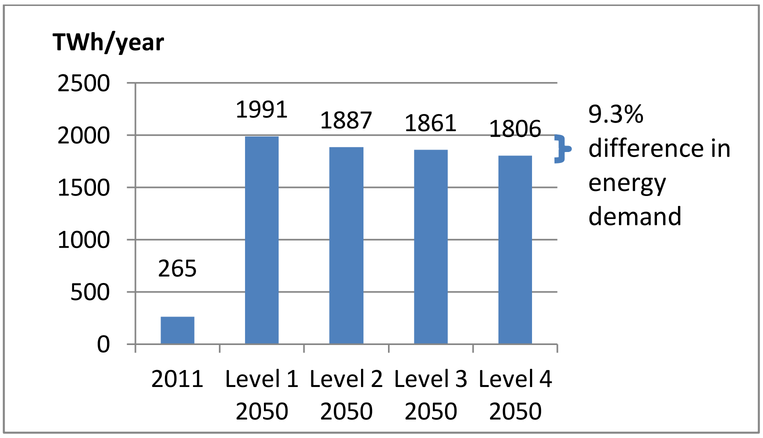

Figure 10. Energy demand of passenger transportation sub-sector

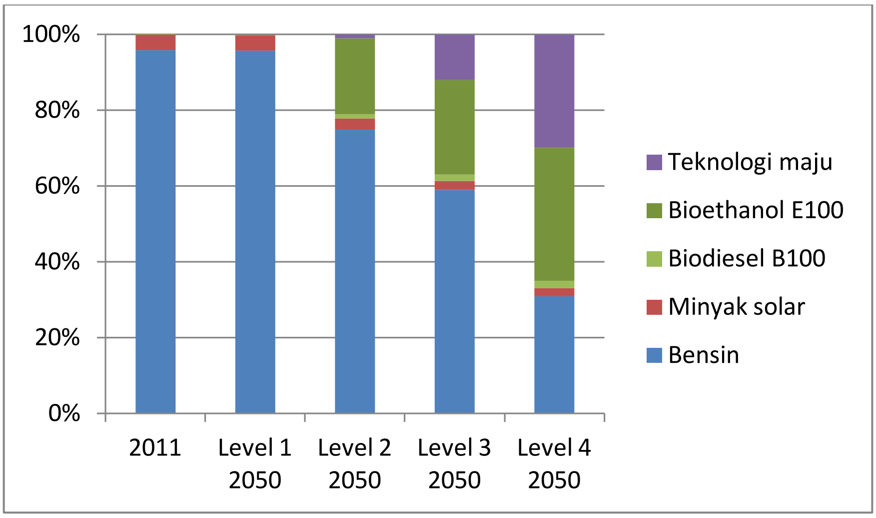

Figure 11. Fuel mix of urban passenger transportation – passenger car

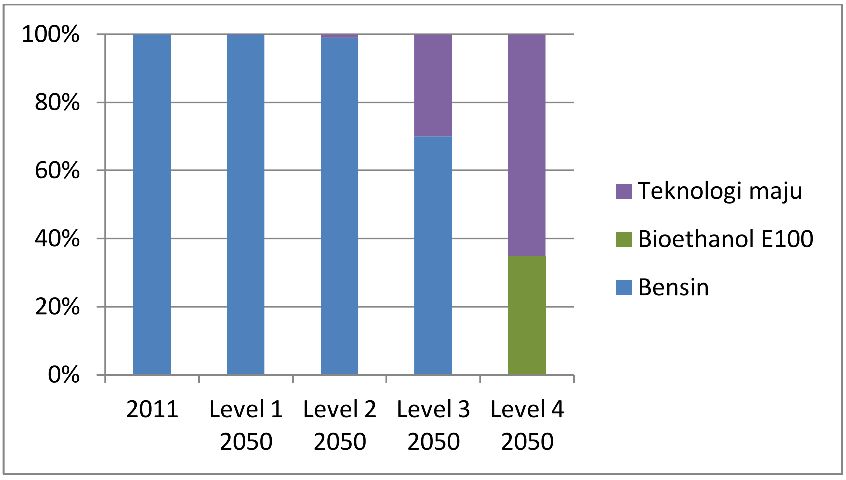

Figure 12. Fuel mix of urban passenger transportation – motorcycle

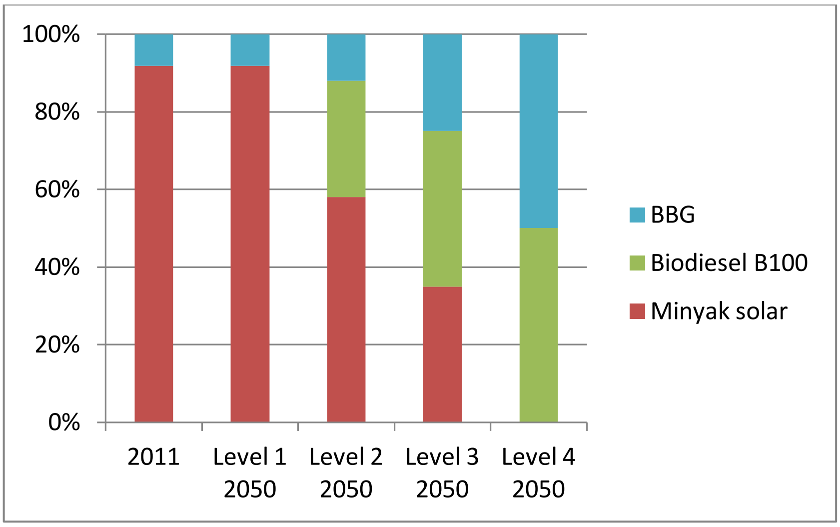

Figure 13. Fuel mix of urban passenger transportation – large bus

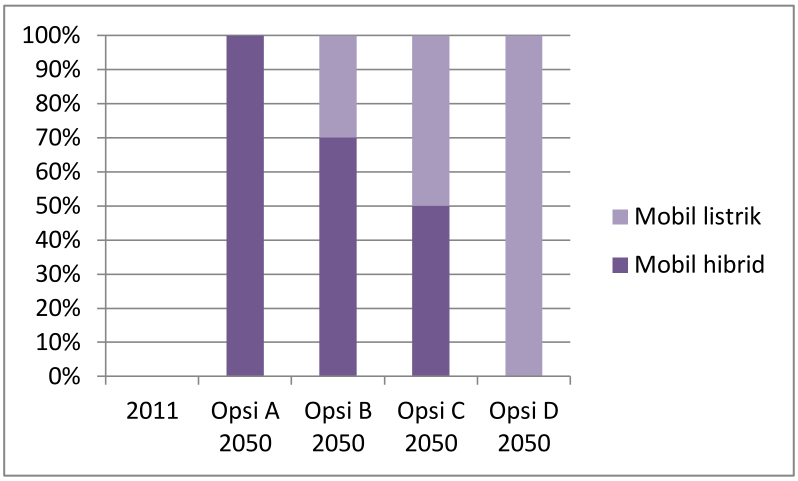

Figure 14. Low emission technology mix of urban passenger transportation sub-sector

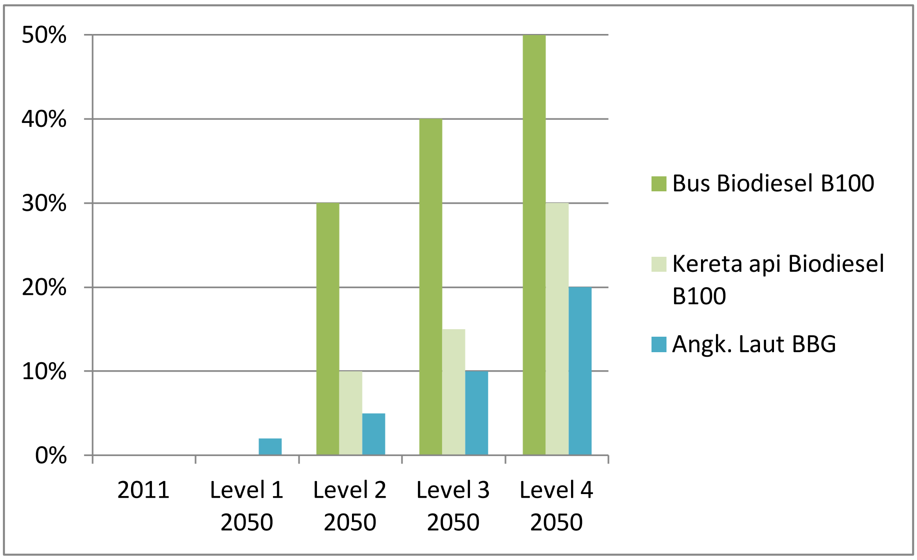

Figure 15. Fuel mix of inter-city passenger transportation

Energy demand of aviation sub-sector is presented in Figure 16. One pager for fuel mix of aviation under "the use of bioavtur" is presented in Figure 17.

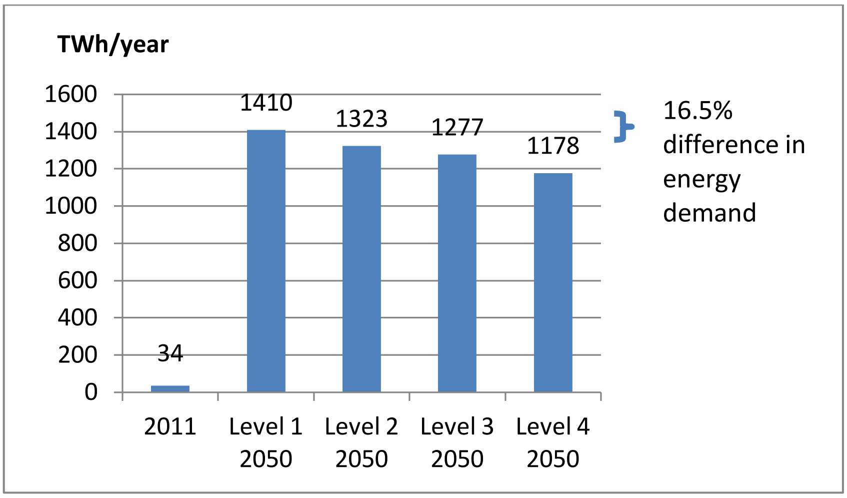

Figure 16. Energy demand of aviation sub-sector

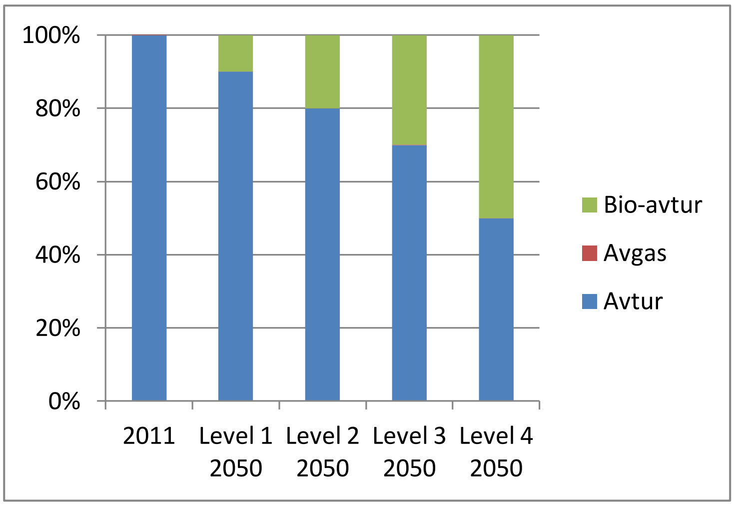

Figure 17. Fuel mix of aviation sub-sector

Based on various levels of one pagers of transportation sector, transportation could potentially reduce its energy demand up to 26%. If the scenarios of all one pagers of transportation sector are set to level 1, the energy demand in 2050 will be 496.5 Mtoe. If all scenarios are set to level 4, the energy demand will be 367.7 Mtoe in 2050. Energy demand reduction potential is presented in Figure 18.

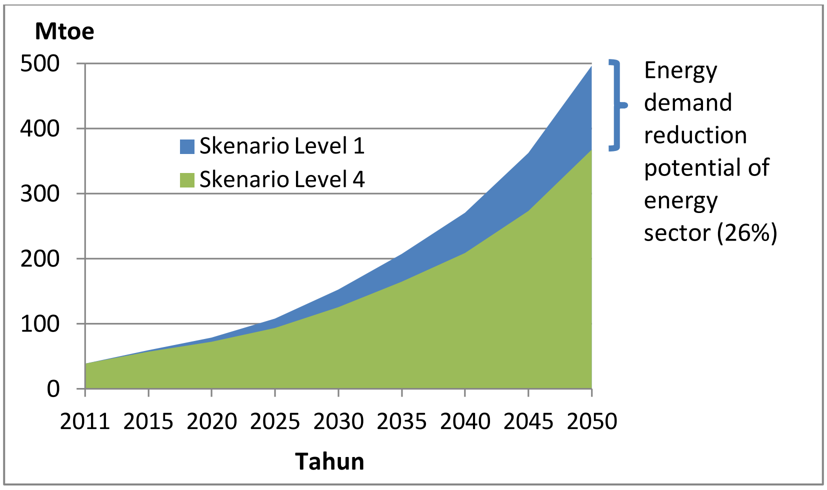

Figure 18. Comparison of total energy demand in transportation sector between level 1 and level 4

7. References

ANTARA Sumatera Barat. 2012. ASDP Bakauheni: Tidak Ada Peningkatan Pengiriman Barang. http://www.antarasumbar.com/berita/nusantara/d/22/208791/asdp-bakauheni-tidak-ada-peningkatan-pengiriman-barang.html. Diakses pada: 26 November 2014.

Autoguide.com. 2011. *Toyota Prius Plug-in Hybrid Gets 112-MPG Rating: 2011 Frankfurt Auto Show 2011.*http://www.autoguide.com/auto-news/2011/09/toyota-prius-plug-in-hybrid-gets-112-mpg-rating-2011-frankfurt-auto-show.html Diakses pada: 31 Desember 2014.

Bisnis.com. 2013. Efisiensi Avtur, Antara Keseimbangan Bisnis & Green Aviation. http://m.bisnis.com/bisnis-indonesia/read/20130930/250/166174/efisiensi-avtur-antara-keseimbangan-bisnis-green-aviation. Diakses pada: 2 Desember 2014.

Bongardt, Daniel. 2013. *Low-carbon Land Transport: Policy Handbook.* Routledge. http://books.google.co.id/books?id=jUwVmXiUEe0C. Diakses pada: 27 November 2014.

BPPT. 2014. Outlook Energi Indonesia 2014: Pengembangan Energi untuk Mendukung Program Substitusi BBM. Editor: Agus Sugiyono, et al. Jakarta: Pusat Teknologi Pengembangan Sumberdaya Energi BPPT.

BPS. 2014. Produk Domestik Bruto Atas Dasar Harga Konstan 2000 Menurut Lapangan Usaha (Miliar Rupiah), 2000-2013. http://www.bps.go.id/tab_sub/view.php?kat=2&tabel=1&daftar=1&id_subyek=11&notab=3. Diakses pada: 26 November 2014.

Dargay, J., D. Gately and M. Sommer. 2007. *Vehicle Ownership and Income Growth, Worldwide: 1960-2030.* http://www.econ.nyu.edu/dept/courses/gately/DGS_Vehicle%20Ownership_2007.pdf. Diakses pada: 31 Desember 2014.

EIA. 2013. *Few transportation fuels surprass the energy densities of gasoline and diesel.* http://www.eia.gov/todayinenergy/detail.cfm?id=9991. Diakses pada: 26 November 2014.

Gekgo Worldwide. 2014. *Verucci Gas Scooters.* http://www.gekgo.com/verucci-gas-scooters.html. Diakses pada: 26 November 2014.

Hubdat. 2014. Kebijakan Transportasi Perkotaan. http://hubdat.web.id/kebijakan/30-kebijakan-transportasi-perkotaan. Diakses pada: 12 Desember 2014.

IATA. 2011. *A global approach to reducing aviation emissions: First stop: carbon-neutral growth from 2020.* http://www.uns.ethz.ch/edu/teach/bachelor/autumn/energmob/IATA_Global_Approach_Reducing_Emissions_251109web.pdf. Diakses pada: 2 Desember 2014.

IATA. 2013. *Historic Agreement on Carbon Neutral Growth.* http://www.iata.org/pressroom/pr/Pages/2013-06-03-05.aspx. Diakses pada: 16 Desember 2014.

Kemen PU. 2009. "Pembatasan Kendaraan untuk Mengurangi Kemacetan Jakarta" dalam Online buletin Tata Ruang. http://penataanruang.pu.go.id/bulletin/index.asp?mod=_fullart&idart=165. Kementerian Pekerjaan Umum. Diakses pada: 2 Desember 2014.

Kemenhub 2012. Kemenhub Susun Roadmap Turunkan Emisi Gas Rumah Kaca Di Sektor Udara. http://hubud.dephub.go.id/?id/news/detail/1614. Kementerian Perhubungan. Diakses pada: 2 Desember 2014.

Kemenhub. 2013. Statistik Perhubungan Buku I Tahun 2012. http://kemhubri.dephub.go.id/pusdatin/files/statistik/STATISTIK_PERHUBUNGAN_2012_BUKU_1.pdf. Kementerian Perhubungan. Diakses pada: 26 November 2014.

Kemenhub 2014. Status Registrasi Pesawat Udara. Dipresentasikan pada Pertemuan *Stakeholder Consulation* I2050PC. Jakarta, 1 September 2014.

Kompas. 2011. Pengalaman Pahit Pemberi Madu Pelayaran. http://health.kompas.com/read/2011/02/22/02364851/Pengalaman.Pahit.Pemberi.Madu.Pelayaran. Diakses pada: 26 November 2014.

Kutz, Myer. 2008. *Environmentally conscious transportation*. Hoboken, N.J.: John Wiley & Sons. http://books.google.co.id. Diakses pada: 26 November 2014.

Lufthansa. 2014. *Lufthansa conducts first European schedules flight using sugar-based biofuels.* http://www.lufthansagroup.com/en/press/news-releases/singleview/archive/2014/september/15/article/3215.html. Diakses pada: 2 Desember 2014.

PT. KAI (Persero). 2014. Laporan Tahunan 2013. https://www.kereta-api.co.id/media/document/annual_report_2013.pdf. Diakses pada: 26 November 2014.

PUSDATIN ESDM. 2012a. *Handbook of Energy and Economic Statistics of Indonesia 2012.* http://prokum.esdm.go.id/Publikasi/Handbook%20of%20Energy%20&%20Economic%20Statistics%20of%20Indonesia%20/Handbook%20of%20Energy%20&%20Economic%20Statistics%20ind%202012.pdf. Diakses pada: 26 November 2014.

PUSDATIN KESDM. 2012b. Kajian Emisi Gas Rumah Kaca Sektor Transportasi. http://prokum.esdm.go.id/Publikasi/Hasil%20Kajian/ESDM%20GRK.pdf. Diakses pada: 27 November 2014.

Schipper, L., C. Marie and R. Gorham. (2000) *Flexing the Link: An Urban Transport CO2 Strategy for the World Bank*. Washington: World Bank and Paris: International Energy Agency.

Shahan, Zachary. 2014. Electric vehicle market share in 19 countries. http://www.abb-conversations.com/2014/03/electric-vehicle-market-share-in-19-countries/ Diakses pada: 26 November 2014.

Soerawidjaja, Tatang H. 2010. Peran Bioenergi dan Arah-arah Utama LitBangRap-nya di Indonesia. Dipresentasikan pada Lokakarya Gasifikasi Biomassa. Bandung, 16-17 Desember 2010. http://www.lppm.itb.ac.id/wp-content/uploads/2011/01/THS-PeranBioenergiDanArahUtamaLitbangrap.pdf. Diakses pada: 2 Desember 2014.

Sugiyono, Agus. 2012. BPPT-*Model Transport Energy Demand*. Jakarta: BPPT.

Suhadi, Dollaris Riauaty. (2008) Penyusunan Petunjuk Teknis Perkiraan Beban Pencemar Udara dari Kendaraan Bermotor di Indonesia. Laporan Akhir. Naskah Akademis. Disampaikan kepada Asisten Deputi 5/II Urusan Pengendalian Pencemaran Emisi Sumber Bergerak, Kementerian Negara Lingkungan Hidup Republik Indonesia. Volume 2: Uji Coba Perhitungan. Yayasan Swisscontact Indonesia. December 2008. 109pp manuscript. Indonesian language.

UNCRD. 2006. Survey of Origin Destination of National Transportation, MOT. http://www.uncrd.or.jp/content/documents/7EST-P3-3.pdf. Diakses pada: 31 Desember 2014.

UNFCCC. 2012. *Monitoring report form (Version 03.1) Ranteballa Small-Scale Hydroelectric Power Project*. http://cdm.unfccc.int/filestorage/r/t/7MGLCXPRB6OQ5F2NJIZEU49KV30T81.pdf/MR_3474_15%20apr.pdf?t=Q0J8bmZtcXl2fDAOE_tZct18bCLLWoG0uYjf. Diakses pada: 26 November 2014.

US-DOE/US-EPA. 2014a. *All-Electric Vehicles (EVs).* http://www.fueleconomy.gov/feg/evtech.shtml. Diakses pada: 31 Desember 2014.

— 2014b. *Compare Side by side 2013 Tesla Model S (60 kW-hr battery pack) & 2013 Tesla Model S (85 kW-hr battery pack).* http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=33367&id=33368. Diakses pada: 26 November 2014.

— 2014c. *Recently Tested Vehicles: 2015 Hyundai Tucson Fuel Cell.* http://www.fueleconomy.gov/feg/fcv_sbs.shtml. Diakses pada: 26 November 2014.

World Bank. 2013. Studi Bank Dunia akan mendukung Pelindo memperkuat konektivitas di Indonesia. http://www.worldbank.org/in/news/press-release/2013/11/12/world-bank-study-to-support-connectivity-agenda-in-indonesia. Diakses pada: 31 Desember 2014.