2. Simulation of Transportation Energy by Energy Mix Model

2.1. Objective and Scope

The objective of this study is to investigate the potential of a diversified transportation energy mix and its effective use up to 2030. It covers five countries (Thailand, Indonesia, Malaysia, the Philippines, and Viet Nam) in the Association of Southeast Asian Nations (ASEAN) by considering their respective economy, energy status, and automotive market scale (Table 2.2.1-1).

Table 2.2.1-1. Economic, Energy, and Automotive Market Information of the ASEAN Member States

	Data	Year	Units	Country									
				Brunei	Cambodia	Indonesia	Lao PDR	Malaysia	Mynmar	Philippines	Singapore	Thailand	Vietnam
Economics	Area	2014	Sq.km.	5,765	181,035	1,904,567	236,797	329,847	676,578	300,000	683	513,113	331,689
	Population	2013	Million	0.4	15	250	6.7	30	53	98	5	67	90
	GDP	2013	Billion USD	16	15	868	11	313	56	272	298	387	171
	GDP per capita	2013	USD	38,563	1,007	3,475	1,661	10,538	1,103	2,765	55,182	5,779	1,910
	GDP Growth	2013	%	-1.8%	7.4%	5.8%	8.5%	4.7%	8.3%	7.2%	3.9%	1.8%	5.4%
Energies	Crude Oil Proved Reserve	2011	Billion Barrels	1.1	-	3.7	-	4	0.1	0.1	-	0.5	4.4
	Natural Gas Proved Reserve	2011	Trillion Cubic Feet	14	-	103	-	83	10	3.5	-	8.4	25
	Total Petroleum Production	2012	'000 Barrels/day	9	-	946	-	561	16	172	1,099	1,197	150
	Domestic Use	2012	'000 Barrels/day	18	29	1,698	3	670	25	310	192	1,152	453
	Import												
	Refined Product	2012	'000 Barrels/day	8	29	699	3	303	9	152	1,914	67	298
	Crude Oil	2012	'000 Barrels/day	-	-	374	-	200	-	136	1,078	803	-
	Export												
	Refined Product	2012	'000 Barrels/day	-	-	79	-	236	-	12	1,685	234	35
	Crude Oil	2012	'000 Barrels/day	142	-	401	-	245	1	26	0	45	314
	Natural Gas Production	2013	Billion Cubic Feet	440	-	2,486	-	2,260	463	103	-	1,476	311
	Natural Gas Consumption	2013	Billion Cubic Feet	105	-	1,381	-	1,125	162	103	340	1,846	311
	Electricity Generation	2012	Billion Kilowatthour	4	1	185	12	127	10	70	45	156	118
	Electricity Consumption	2012	Billion Kilowatthour	4	3	167	3	119	8	61	44	156	108
	Primary Energy Production	2012	Quadrillion BTU	0.8	0.0	16.3	0.1	3.8	0.6	0.5	0.0	2.6	2.6
	Primary Energy Consumption	2012	Quadrillion BTU	0.2	0.1	6.4	0.1	3.1	0.3	1.3	3.1	5.1	2.3
	Number of refinery	2014	Units	1	-	8	-	6	3	2	3	8	1
	Crude Distillation Capacity	2012	'000 Barrels/day	9	-	1,012	-	539	57	273	1,357	584	140
		2014	'000 Barrels/day	na	-	1,095	-	591	na	290	1,514	1,242	140
Auto Market	Vehicle Ownership Rate		Units/'000 people	510	21	69	20	361	7	30	149	206	23
	Vehicle Stock number		Units										
	Vehicle Sales in 2014	2014	Units	18,114	-	1,208,019	-	666,465	-	234,747	47,443	881,832	133,588
	Motocycle Sales in 2014	2014	Units	-	-	7,908,941	-	442,749	-	790,425	8,145	1,701,535	-
	Vehicle Production in 2014	2014	Units	-	-	1,298,523	-	596,418	-	88,845	-	1,880,007	121,084

ASEAN = Association of Southeast Asian Nations.
Sources: World Bank, International Monetary Fund, Energy Information Administration, ASEAN Centre for Energy, ASEAN Automotive Federation.

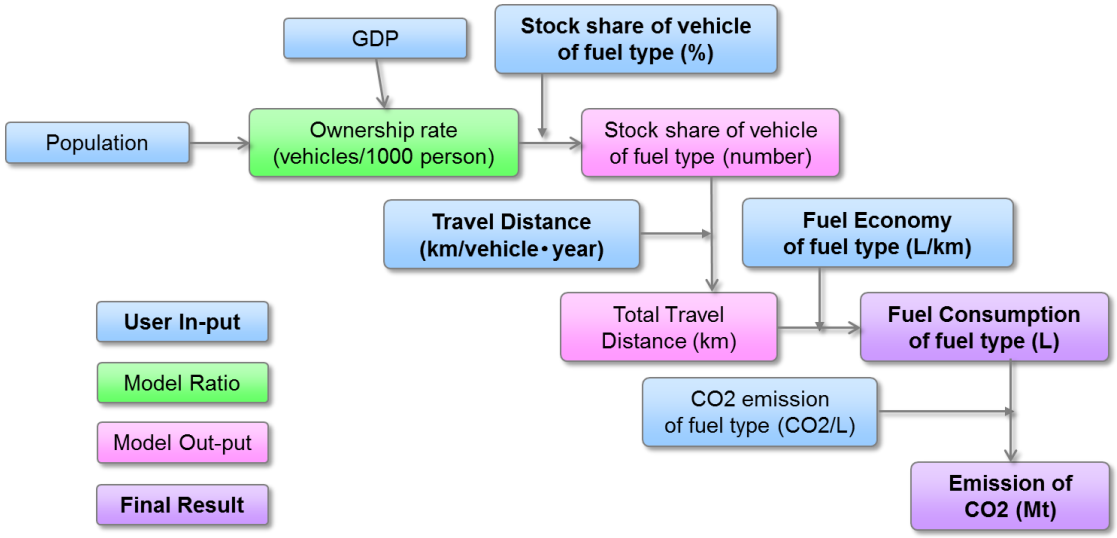
The study looked at existing energy policies, fuel supply and demand status related to road transportation, petroleum products (gasoline and diesel fuel) and alternative fuels such as natural gas and biofuels (ethanol and biodiesel), as well as oil refining/biofuel production capacity, amongst others. To correct for gaps between oil reduction targets and business-as-usual (BAU) consumption as well as required amounts of biofuel to achieve introduction targets and possible supply, measures to minimise these gaps or to achieve policy targets were investigated and proposed.

2.2. Methodology

Using the Energy Mix Model, we simulated the energy consumption trend of road transportation up to 2030. The simulation model of each country was developed by Toyota Motor Corporation (in corporation with Mizuho Information & Research Institute, Inc.) based on the IEA/SMP Model.

The calculation flow of energy consumption is shown in Figure 2.2.2-1, which enables estimation of CO_2 emissions of road transportation by using the CO_2 emission factor of each type of fuel. The IEA/SMP Model deals with data for transportation energy globally, but we modified and established a fit-for-road transportation country base Energy Mix Model.

Figure 2.2.2-1. Calculation Flow of Energy Consumption by Energy Mix Model



CO2 = carbon dioxide, GDP = gross domestic product, km = kilometre, L = litre, Mt = megaton.
Source: Authors.

For the simulation, ASEAN Member States provided specific data based on statistical data and literature for each country, including vehicle registration numbers, actual fuel economy varies depending on the usage condition of a vehicle, and mileage travelled annually by vehicle/fuel type. In addition, we collected and studied information on energy policies, supply ability of domestic resources, and oil refining/biofuel production capacity.

The following are the steps of our investigation:

1) Estimate BAU energy consumption trend up to 2030
2) Estimate energy consumption trend after energy policies (energy conservation, alternative energy introduction, etc.) are implemented
3) Examine possibility of achieving energy policy target at the same time based on supply ability of petroleum products, biofuels, etc.
4) Once gaps between BAU and policy targets become clear, investigate measures to minimise them by considering supply ability of domestic resources (oil, natural gas, raw materials for biofuels), together with oil refining/biofuel production capacity for mitigating energy issues in each country

2.3. Results and Discussion

1) Thailand

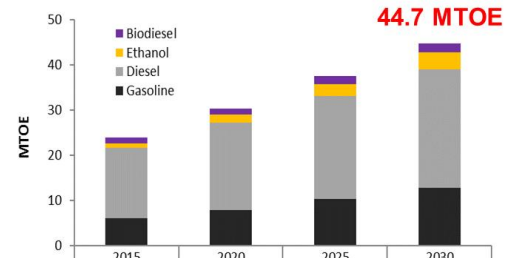
Policies of Thailand related to transportation energy are the Alternative Energy Development Plan (AEDP 2015–2036) and the Energy Efficiency Plan (EEP 2015-2036). The AEDP promotes use of biofuels by aiming to reach 11.3 million litres per day of ethanol (up to E20/E85) and 14 million litres per day of biodiesel (up to B10/B20) by 2036. The EEP encourages energy conservation, and the Ministry of Energy projects that a 46.2% reduction of energy consumption compared to BAU is required in the transportation sector by 2036. We evaluate the appropriateness of target setting for road transportation and difficulty in achieving policy targets.

1-1) Oil Consumption and Biofuel Introduction Potential

The Energy Mix Model of Thailand estimates total energy consumption of road transportation in terms million tonnes of oil equivalent (MTOE) up to 2030. The results of the simulation for both the BAU and biofuels cases are shown in Figure 2.2.3-1. Total energy consumption for the biofuels case increased because of lower calorific value of biofuels compared to gasoline/diesel fuel after a large amount of biofuels is introduced by 2030.

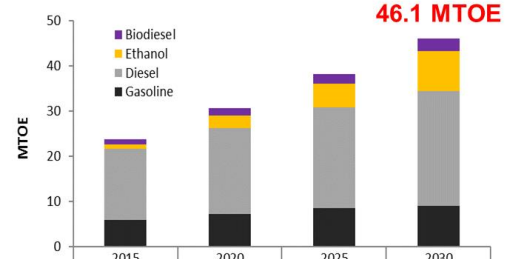
Figure 2.2.3-1. Total Energy Consumption of Road Transportation in Thailand

a) Business as usual



	2015	2020	2025	2030
Biodiesel	1.17	1.45	1.71	1.98
Ethanol	1.05	1.82	2.67	3.73
Diesel	15.58	19.21	22.70	26.24
Gasoline	6.04	7.91	10.39	12.75

b) Biofuels case



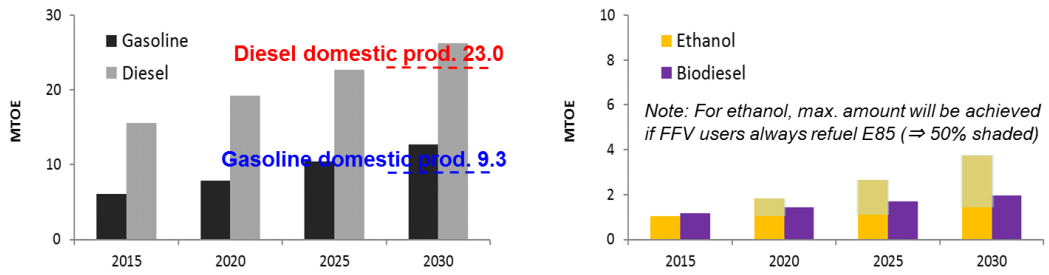
	2015	2020	2025	2030
Biodiesel	1.17	1.63	2.16	2.82
Ethanol	1.09	2.76	5.22	8.75
Diesel	15.58	19.03	22.25	25.39
Gasoline	6.00	7.23	8.55	9.09

MTOE = million tonnes of oil equivalent.
Source: Authors.

Figures 2.2.3-2 and 2.2.3-3 show gasoline/diesel fuel and biofuel consumption of the BAU case and biofuels case, respectively. The supply ability of each type of fuel is shown in the corresponding graph.

Figure 2.2.3-2. Fuel Consumption of Business-as-Usual Case in Thailand

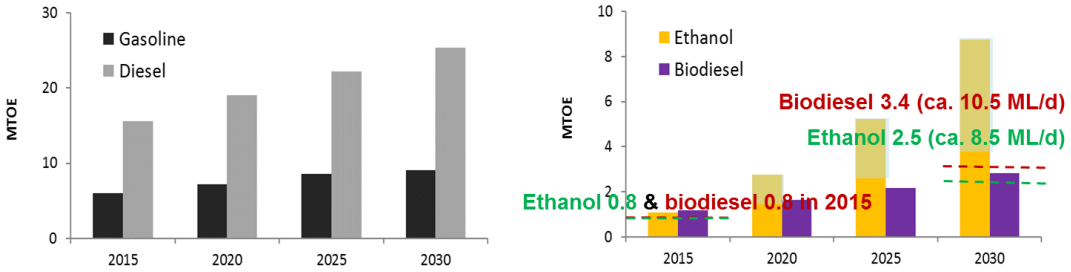
a) Gasoline/diesel fuel **b) Biofuels**



FFV = flexible fuel vehicle, MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-3. Fuel Consumption of Biofuels Case in Thailand

a) Gasoline/diesel fuel **b) Biofuels**



ML/d = megalitre per day, MTOE = million tonnes of oil equivalent.
Source: Authors.

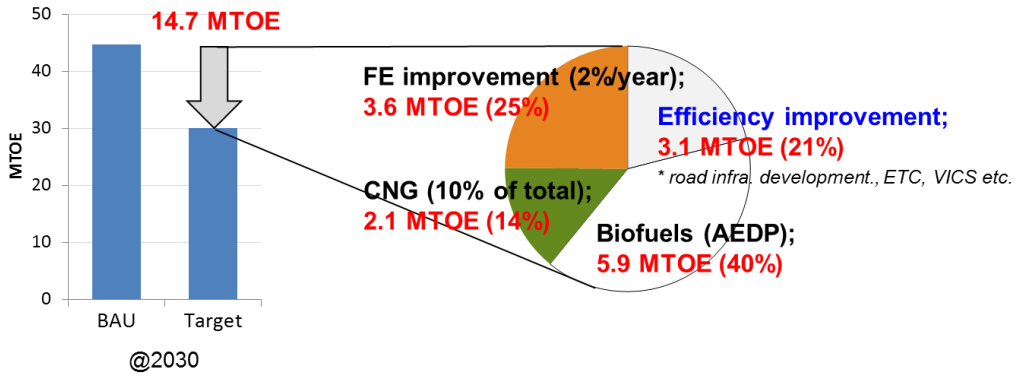
The transportation sector in Thailand consumes more diesel fuel than gasoline. This imbalance in gasoline and diesel fuel consumption is one of the energy issues; if the difference in gasoline and diesel fuel consumption becomes too big, it will affect the healthy operations of oil refineries.

As shown in Figures 2.2.3-2 and 2.2.3-3, the introduction volume of ethanol for the gasoline blend is larger than that of biodiesel for the diesel fuel blend, especially once the AEDP target is fully implemented (biofuels case), and the imbalance between gasoline and diesel fuel consumption will worsen compared to the level today (the blending mandate is E10/E20 and B7). We believe that the biofuel introduction target setting of the AEDP is inadequate, and full implementation of the AEDP target is not recommended. On the other hand, according to the current ethanol production ability projection, it may be difficult to secure sufficient ethanol to fulfil the AEDP target, but the government is making an ongoing effort to increase raw material production for ethanol. The biodiesel production ability projection shows sufficient capability, if the raw material supply is secured.

1-2) Oil Reduction (Energy Conservation) Potential

The required energy reduction – or oil reduction in the case of road transportation – by the EEP in the transportation sector by 2030 is 14.7 MTOE. Figure 2.2.3-4 shows the estimates of the allocation of oil reduction measures based on the AEDP target, compressed natural gas (CNG) use, possible oil reduction by fuel economy (FE) improvement of new vehicles, and remaining portion.

Figure 2.2.3-4. Evaluation of Oil Reduction Potential Based on the Energy Efficiency Plan Requirement in Thailand



AEDP = Alternative Energy Development Plan, BAU = business as usual, CNG = compressed natural gas, ETC = electronic toll collection, FE = fuel economy, MTOE = million tonnes of oil equivalent, VICS = vehicle information and communication system.
Note: Target is an assumption based on EEP 2015-36.
Source: Authors.

The biofuel introduction target of the AEDP will reduce oil consumption by 5.9 MTOE, CNG (set to be the same as the current CNG utilisation ratio, that is approximately 10% of current total energy consumption) can replace 2.1 MTOE of oil, and FE improvement of new vehicles (at a reasonable level of 2% improvement per year) will reduce consumption by 3.6 MTOE. In order to fulfil the requirement, a further 3.1 MTOE of oil reduction has to be achieved through efficiency improvement of the traffic system, such as road infrastructure development and traffic flow management (electronic toll collection, vehicle information and communication system, etc.) to increase the average traffic speed. A so-called integrated approach of oil reduction measures is required, which includes not only direct replacement of oil by alternative fuels and reduction of oil consumption by FE improvement of new vehicles, but also conservation of oil through efficiency improvement of the traffic system.

Achieving the energy conservation target of the EEP by 2030 will mean an estimated CO_2 emissions reduction of road transportation of 37.1 kilotonnes of CO_2 (kt-CO_2), equivalent to the reduction of oil use of 43.3 kt-CO_2 and 6.2 kt-CO_2 through CNG use.

1-3) Summary

Energy issues, today and in future (up to 2030)

1) Increasing import dependency of oil and gas
2) For fossil fuels, the imbalance between gasoline and diesel fuel consumption (diesel fuel consumption is much larger compared to gasoline consumption) is an issue; reducing diesel fuel consumption should be prioritised.
3) For biofuels, supply ability of ethanol is optimistic compared to that of biodiesel in the future. However, prioritising the reduction of diesel fuel requires securing sufficient biodiesel production.
4) To introduce higher blending of biodiesel, implementation of hydrotreated vegetable oil (HVO) in addition to fatty acid methyl esters (FAME) is necessary to realise higher blending without any vehicle warranty issues.

Possible measures

1) Achieving the oil reduction target requires an integrated approach of oil reduction measures through efficiency improvement of the traffic system, such as infrastructure development and traffic flow management.
2) An effective measure for reducing diesel fuel consumption is to discourage excessive use of pickups (equipped with diesel engine).
3) Furthermore, securing feedstock for biodiesel (for diesel fuel blend) is important, and promoting HVO use is appropriate.
4) A new funding system to support increased biofuel utilisation is required, because the current status of relying on the Oil Fund system is no longer sustainable.

2) Indonesia

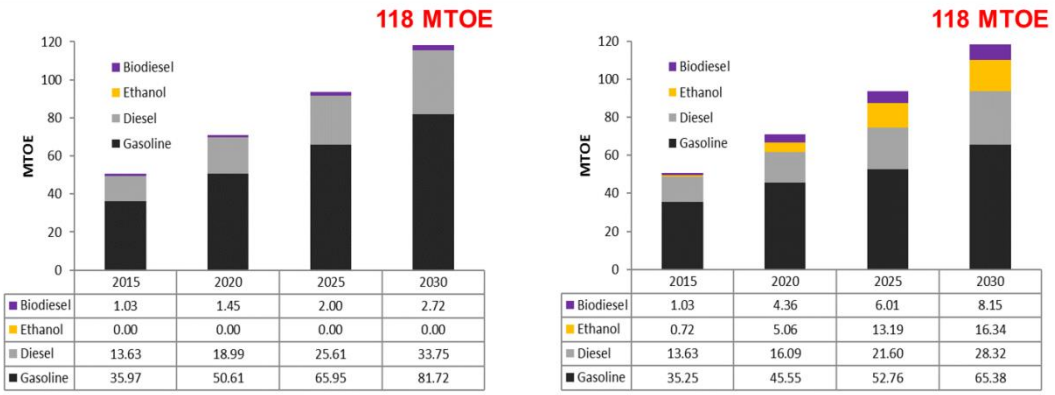
The National Energy Policy (or KEN) defines the national energy mix of primary energy consumption. Based on the statistics of the demand and supply of petroleum products in Indonesia, 68% of total oil consumption is estimated to be consumed by road transportation. The General Planning for National Energy (or RUEN) specifies the direction and measures for achieving the KEN target in each sector, together with the introduction target of alternative fuels. According to the Ministry of Energy and Mineral Resources, examples of planned targets related to the transportation sector include mandatory blending of E20 and B30 aiming for total biofuel usage of 5.73 million kilolitres (kL) in 2025, introduction of 2 million units of CNG vehicles aiming for natural gas utilisation of 289 million standard cubic feet per day (mmscfd) until 2025.

2-1) Oil Consumption and Biofuel Introduction Potential

The Energy Mix Model of Indonesia estimates the total energy consumption of road transportation up to 2030. The results of the simulation for both the BAU case and biofuels case are shown in Figure 2.2.3-5.

Figure 2.2.3-5. Total Energy Consumption of Road Transportation in Indonesia

a) Business as usual **b) Biofuels case**



	2015	2020	2025	2030
Biodiesel	1.03	1.45	2.00	2.72
Ethanol	0.00	0.00	0.00	0.00
Diesel	13.63	18.99	25.61	33.75
Gasoline	35.97	50.61	65.95	81.72

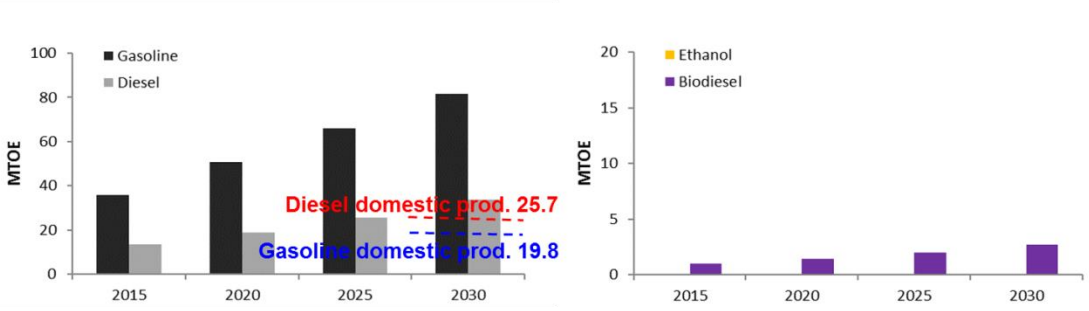
	2015	2020	2025	2030
Biodiesel	1.03	4.36	6.01	8.15
Ethanol	0.72	5.06	13.19	16.34
Diesel	13.63	16.09	21.60	28.32
Gasoline	35.25	45.55	52.76	65.38

MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-6 shows gasoline/diesel fuel and biofuel consumption of the BAU case, and Figure 2.2.3-7 shows those of the biofuels case. The supply ability of each type of fuel is shown in the corresponding graphs.

Figure 2.2.3-6. Fuel Consumption of Business-as-Usual Case in Indonesia

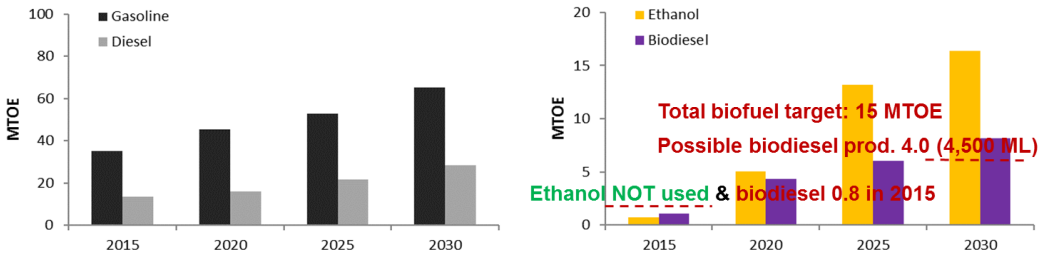
a) Gasoline/diesel fuel **b) Biofuels**



MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-7. Fuel Consumption of Biofuels Case in Indonesia

a) Gasoline/diesel fuel **b) Biofuels**



ML = megalitre, MTOE = million tonnes of oil equivalent.
Source: Authors.

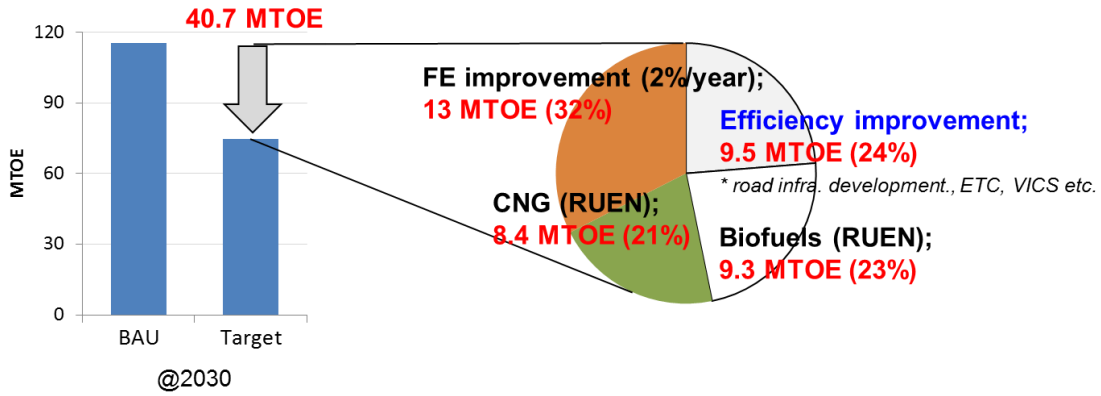
In Indonesia, gasoline consumption is higher than that of diesel fuel in the transportation sector. It is said that approximately 60% of gasoline is consumed by the large number of motorcycles in the country. One energy issue is the imbalance between gasoline and diesel fuel consumption. If the difference in gasoline and diesel fuel consumption becomes too big, it will affect the healthy operations of oil refineries. Domestic refining capacity is below demand, and Indonesia relies on petroleum products import currently, but once the domestic refining capacity fulfils demand in the future (through new refinery projects), this imbalance between gasoline and diesel fuel consumption will be a problem.

Ethanol is currently not used and therefore not considered in the BAU case (Figure 2.2.3-6). According to the biofuel blending mandate of the Ministry of Energy and Mineral Resources Regulation No. 20 of 2014, both ethanol and biodiesel are planned to be used. However, only biodiesel is promoted to increase the blending ratio in practice (already B20) and the imbalance between gasoline and diesel fuel consumption in future will become worse. As shown in Figure 2.2.3-7 (biofuels case), the required volume of ethanol for the gasoline blend is larger than that of biodiesel for the diesel fuel blend once the biofuel blending mandate is fully implemented. We believe that introduction of both ethanol and biodiesel is necessary to mitigate the energy issue of road transportation, but securing sufficient ethanol to fulfil the blending mandate domestically is difficult and the government needs to come up with concrete planned countermeasures. Nevertheless, the biodiesel production projection may meet the blending mandate.

2-2) Oil Reduction (Energy Conservation) Potential

The required oil reduction by the KEN for road transportation (68% of total oil consumption) by 2030 is 40.7 MTOE. Figure 2.2.3-8 shows the estimates of the allocation of oil reduction measures of alternative fuels based on the RUEN introduction target, possible oil reduction by FE improvement of new vehicles, and the remaining portion.

Figure 2.2.3-8. Evaluation of Oil Reduction Potential Based on the KEN Requirement in Indonesia



BAU = business as usual, CNG = compressed natural gas, ETC = electronic toll collection, FE = fuel economy, MTOE = million tonnes of oil equivalent, RUEN = General Planning for National Energy, VICS = vehicle information and communication system.
Note: reduction by each measure are assumptions based on RUEN transport sector.
Source: Authors.

The targeted biofuel and CNG introduction of the RUEN can replace 9.3 MTOE and 8.4 MTOE of oil, respectively, and the FE improvement of new vehicles will reduce 13 MTOE. In order to fulfil the oil reduction requirement, a further 9.5 MTOE oil reduction has to be achieved through efficiency improvement of the traffic system, such as road infrastructure development and implementation of traffic flow management (electronic toll collection, vehicle information and communication system, etc.). An integrated approach of oil reduction measures including efficiency improvement of the traffic system is required for the sake of energy conservation in the transportation sector.

The CO_2 emissions reduction of road transportation is estimated to be 101.4 kt-CO_2 (sum of –128.2 kt-CO_2 through reduction of oil use and +26.8 kt-CO_2 through CNG use) under the condition of achieving the primary energy consumption mix by the KEN by 2030.

2-3) Summary

Energy issues, today and in future (up to 2030)

1) Increasing import dependency of oil and lack of domestic refining capacity compared to demand
2) For fossil fuels, the imbalance between gasoline and diesel fuel consumption (gasoline consumption is much larger compared to diesel fuel consumption) is an issue; reducing gasoline consumption should be prioritised.

3) For biofuels, supply ability of biodiesel is sufficient, but that of ethanol is more difficult. Prioritising the reduction of gasoline introduction of ethanol requires securing its production/supply.

4) To introduce higher blending of biodiesel, implementation of HVO in addition to FAME is necessary to realise higher blending of biodiesel without any vehicle warranty issues.

Possible measures

1) Achieving the oil reduction target requires an integrated approach of oil reduction measures through efficiency improvement of the traffic system, such as infrastructure development and traffic flow management.

2) Utilising domestic gas for public transportation including taxis, as well as fixed route logistic trucks.

3) As motorcycles consume the majority of gasoline, an effective measure to reduce gasoline consumption is promoting electric motorcycles.

4) A funding system to support ethanol (for the gasoline blend) is necessary by encouraging cellulosic ethanol and promotion of HVO.

3) Philippines

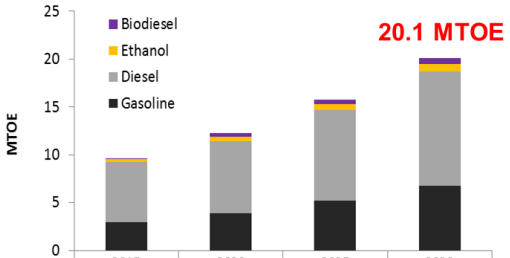
The low-carbon scenario (LCS) of the current Philippine Energy Plan (PEP 2012-2030) lays out the target of the reduced energy consumption and sustainable energy mix. According to the LCS for the transportation sector, road transportation accounts for approximately 75%–80% of total transportation energy consumption in 2030, and use of alternative fuels including biofuels, CNG/LPG, and electricity for electric vehicles are promoted. The Department of Energy's National Biofuels Program 2013–2030 is also planning to introduce ethanol and biodiesel up to E20 and B20 respectively until 2025.

3-1) Oil Consumption and Biofuel Introduction Potential

The Energy Mix Model of the Philippines estimated the total energy consumption of road transportation up to 2030. The results of the simulation for both the BAU case and biofuels case are shown in Figure 2.2.3-9. By following the LCS for the transportation sector, it takes into account not only the increased use of biofuels but also energy conservation in the biofuels case.

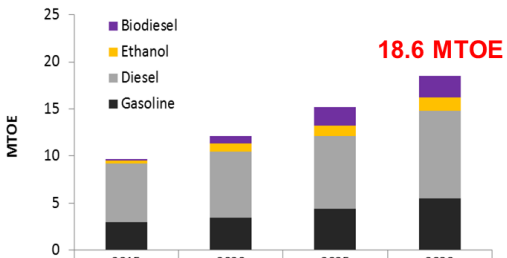
Figure 2.2.3-9. Total Energy Consumption of Road Transportation in the Philippines

a) Business as usual



	2015	2020	2025	2030
Biodiesel	0.13	0.40	0.50	0.63
Ethanol	0.33	0.44	0.58	0.75
Diesel	6.21	7.51	9.50	11.93
Gasoline	2.98	3.92	5.19	6.75

b) Biofuels case



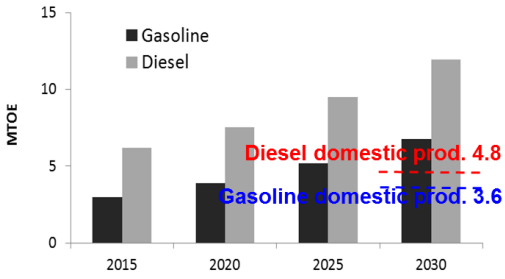
	2015	2020	2025	2030
Biodiesel	0.13	0.78	1.93	2.33
Ethanol	0.33	0.86	1.10	1.38
Diesel	6.21	7.05	7.72	9.32
Gasoline	2.98	3.44	4.42	5.51

MTOE = million tonnes of oil equivalent.
Source: Authors.

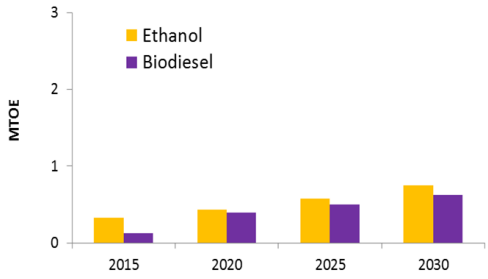
Figure 2.2.3-10 shows the gasoline/diesel fuel and biofuel consumption of the BAU case, and Figure 2.2.3-11 shows those of the biofuels case. The supply ability of each type of fuel is shown in the corresponding graphs.

Figure 2.2.3-10. Fuel Consumption of Business-as-Usual Case in the Philippines

a) Gasoline/diesel fuel



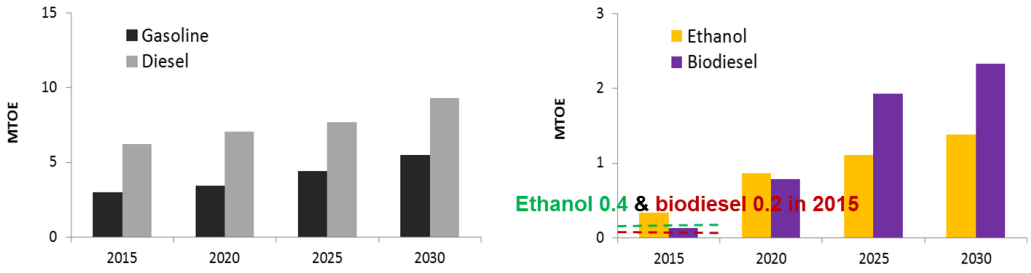
b) Biofuels



MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-11. Fuel Consumption of Biofuels Case in the Philippines

a) Gasoline/diesel fuel **b) Biofuels**



MTOE = million tonnes of oil equivalent.
Source: Authors.

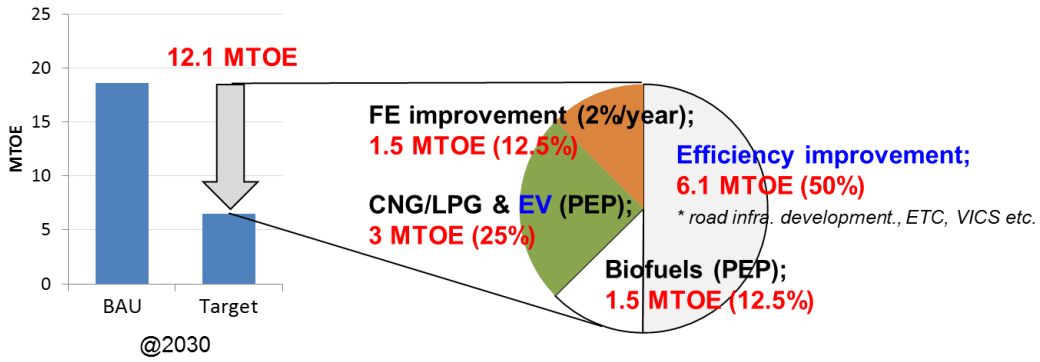
In the Philippines, diesel fuel consumption is higher than that of gasoline in the transportation sector. However, the gap between gasoline and diesel fuel consumption is within the acceptable level. The domestic refining capacity is below demand and the Philippines like Indonesia relies on petroleum products import.

The ethanol-blended gasoline E10 is being introduced nationwide by using imported ethanol, partially as domestic production capacity is not sufficient. Securing biodiesel production is more difficult, and we estimate a slow implementation of the National Biofuels Program (B5) in the BAU case (Figure 2.2.3-10). The required biodiesel amount will be larger than that of ethanol in the future once the National Biofuels Program is fully implemented as shown in Figure 2.2.3-11 (biofuels case). We expect achieving the biofuel introduction target to be very difficult as raw material production in the Philippines is limited, especially for biodiesel. The government needs to make concrete plans for biofuel introduction with countermeasures to increase domestic biofuel production and import biofuels (raw materials or products) at the same time.

3-2) Oil Reduction (Energy Conservation) Potential

The LCS for the transportation sector of the PEP requires an oil reduction of 12.1 MTOE by the transportation sector by 2030. Estimates of the allocation of oil reduction measures of alternative fuels based on the LCS for the transportation sector, possible oil reduction by FE improvement of new vehicles, and the remaining portion are shown in Figure 2.2.3-12.

Figure 2.2.3-12. Evaluation of Oil Reduction Potential Based on the PEP Requirement in the Philippines



Note: Target is an assumption based on PEP 2012-30

BAU = business as usual, CNG = compressed natural gas, ETC = electronic toll collection, EV = electric vehicle, FE = fuel economy, MTOE = million tonnes of oil equivalent, PEP = Philippine Energy Plan, VICS = vehicle information and communication system.
Note: Target is an assumption based on PEP 2012-30.
Source: Authors.

The PEP biofuel and CNG/LPG introduction targets could replace 1.5 MTOE and 3 MTOE of oil, respectively, and the FE improvement of new vehicles will reduce oil consumption by 1.5 MTOE. We do not take electricity for EVs into consideration, as its realisation is not foreseen and its contribution is negligible. To fulfil the oil reduction requirement, the remaining 6.1 MTOE of oil reduction has to be achieved through efficiency improvement of the traffic system, such as road infrastructure development and implementation of traffic flow management (electronic toll collection, vehicle information and communication system, etc.). As the required oil reduction compared to the total oil consumption scale is relatively large in the current PEP, an integrated approach of oil reduction measures, especially efficiency improvement of the traffic system, plays an important role for energy conservation in the transportation sector.

The CO_2 emissions reduction of road transportation is estimated to be 35.4 kt-CO_2 (sum of –38.6 kt-CO_2 through reduction of oil use and +3.2 kt-CO_2 through CNG use) under the condition of achieving the reduced energy consumption by the PEP by 2030.

3-3) Summary

Energy issues, today and in future (up to 2030)

1) Increasing import dependency of oil and lack of domestic refining capacity compared to demand

2) For fossil fuels, increasing diesel fuel consumption compared to that of gasoline is an issue; reducing diesel fuel must be considered.

3) For biofuels, ethanol production at a competitive cost is insufficient as the domestic supply of molasses is limited; the same can be said for biodiesel and securing biodiesel production is more difficult.

4) To cope with diesel fuel reduction and introduce higher blending of biodiesel, implementing HVO in addition to FAME is necessary to realise higher blending of biodiesel without any vehicle warranty issues.

Possible measures

1) To achieve the oil reduction target, an integrated approach of oil reduction measures is required through efficiency improvement of the traffic system, such as infrastructure development, traffic flow management, etc.

2) Use of gas might be limited to public transportation with minimum investment for CNG infrastructure.

3) To produce more biodiesel (for the diesel fuel blend), a wide variety of feedstock other than coconuts is necessary.

4) A system to support further biofuel implementation including trading (import raw materials or products) is required.

4) Malaysia

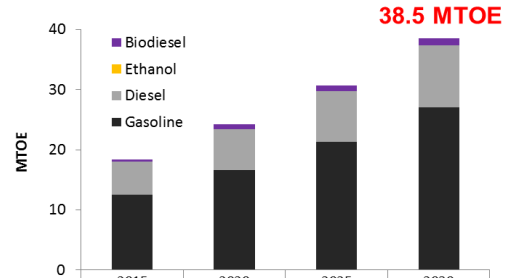
In Malaysia, under the National Automotive Policy (NAP 2014), the Energy Efficient Vehicle (EEV) Policy is being implemented by aiming to become an energy-efficient and advanced technology vehicle production hub in the Association of Southeast Asian Nations (ASEAN). The EEV Policy promotes EEV production by automotive manufactures that meet the investment and technology (e.g. fuel efficiency) criteria and provide incentives. According to the Ministry of International Trade and Industry, the 11th Malaysia Plan (2016–2020) encourages energy (oil) reduction by introducing EEVs, promoting use of biodiesel (B15) and CNG in the transportation sector. However, the government has not specified a clear reduction target of oil, and we tentatively set an oil reduction target of 35% compared to BAU for road transportation, which is equal to the government's CO_2 reduction commitment of the Paris Agreement in this study.

4-1) Oil Consumption and Biofuel Introduction Potential

The Energy Mix Model of Malaysia estimates the total energy consumption of road transportation up to 2030. The results of the simulation for both the BAU case and biofuels case are shown in Figure 2.2.3-13.

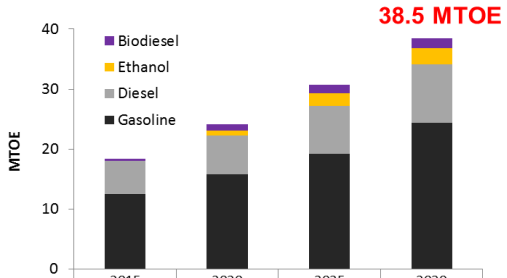
Figure 2.2.3-13. Total Energy Consumption of Road Transportation in Malaysia

a) Business as usual



	2015	2020	2025	2030
Biodiesel	0.41	0.75	0.93	1.15
Ethanol	0.00	0.00	0.00	0.00
Diesel	5.48	6.77	8.40	10.35
Gasoline	12.48	16.64	21.32	26.99

b) Biofuels case



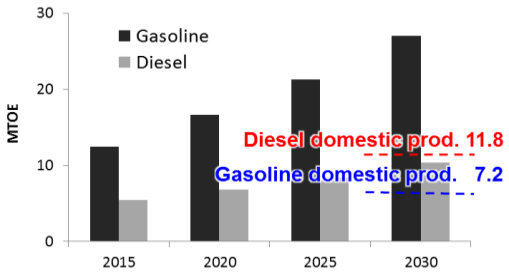
	2015	2020	2025	2030
Biodiesel	0.41	1.13	1.40	1.73
Ethanol	0.00	0.82	2.11	2.67
Diesel	5.48	6.40	7.93	9.78
Gasoline	12.48	15.82	19.21	24.32

MTOE = million tonnes of oil equivalent.
Source: Authors.

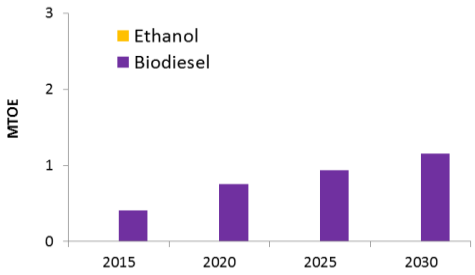
Figure 2.2.3-14 shows the gasoline/diesel fuel and biofuels consumption of the BAU case, and Figure 2.2.3-15 shows those of the biofuels case. The supply ability of each type of fuel is shown in the corresponding graphs.

Figure 2.2.3-14. Fuel Consumption of Business-as-Usual Case in Malaysia

a) Gasoline/diesel fuel



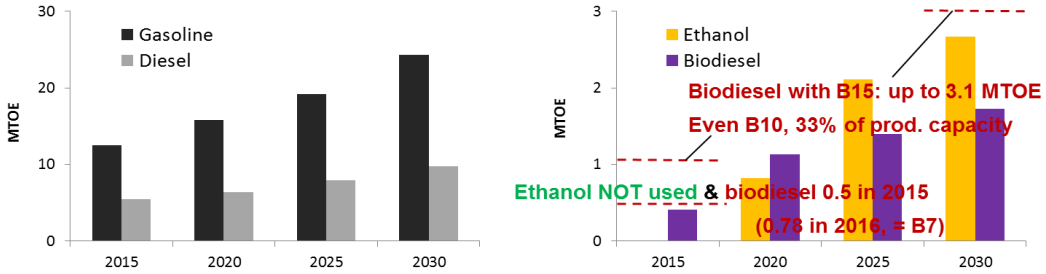
b) Biofuels



MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-15. Fuel Consumption of Biofuels Case in Malaysia

a) Gasoline/diesel fuel **b) Biofuels**



MTOE = million tonnes of oil equivalent.

Source: Authors.

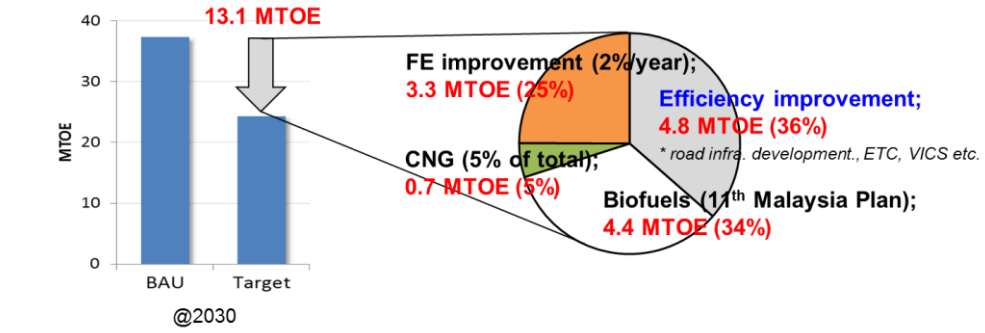
In Malaysia, as in Indonesia, gasoline consumption is higher than that of diesel fuel in the transportation sector. The imbalance between gasoline and diesel fuel consumption is one of the energy issues. If the difference in gasoline and diesel fuel consumption becomes too big, it will affect the healthy operations of oil refineries. The domestic refining capacity is about to meet the demand except for gasoline, and Malaysia relies on gasoline import (from Singapore) to some extent.

Ethanol is not currently used and therefore not considered in the BAU case (Figure 2.2.3-14). According to the government's biofuel plan, only biodiesel is promoted (B10) and utilisation of ethanol is not considered. However, if only biodiesel and increasing the blending ratio are promoted, the imbalance between gasoline and diesel fuel consumption will become worse. As shown in Figure 2.2.3-15, we consider both ethanol and biodiesel use in the biofuels case. The required volume of ethanol for the gasoline blend is larger than that of biodiesel for the diesel fuel blend. We believe that introducing both ethanol and biodiesel is necessary to mitigate the energy issues of road transportation, but securing sufficient ethanol domestically is quite difficult and the government needs to have a concrete plan of countermeasures. On the other hand, the biodiesel production ability projection shows that it is sufficient to meet the amount in the government's biofuel plan.

4-2) Oil Reduction (Energy Conservation) Potential

Based on our tentative target setting of 35% oil reduction for the transportation sector, the required oil reduction for road transportation by 2030 is 13.1 MTOE. Estimates of the allocation of oil reduction measures of alternative fuels, based on the 11th Malaysia Plan for biodiesel and oil replacement of 5% with CNG for the transportation sector, possible oil reduction by FE improvement of new vehicles, and the remaining portion are shown in Figure 2.2.3-16.

Figure 2.2.3-16. Evaluation of Oil Reduction Potential Based on Our Tentative Target Setting of 35% Reduction



BAU = business as usual, CNG = compressed natural gas, ETC = electronic toll collection, FE = fuel economy, MTOE = million tonnes of oil equivalent, VICS = vehicle information and communication system.
Note: Target is our own assumption and tentatively set to 35% reduction.
Source: Authors.

The introduction of biofuel and CNG can replace 4.4 MTOE and 0.7 MTOE of oil, respectively, and FE improvement of new vehicles will reduce 3.3 MTOE. In order to fulfil the oil reduction requirement, a further 4.8 MTOE oil reduction has to be achieved through efficiency improvement of the traffic system, such as road infrastructure development and implementation of traffic flow management (electronic toll collection, vehicle information and communication system, etc.). An integrated approach of oil reduction measures including efficiency improvement of the traffic system is required for the sake of energy conservation in the transportation sector.

The CO_2 emissions reduction of road transportation is estimated to be 39.9 kt-CO_2 (sum of –42.1 kt-CO_2 reduction through of oil use and +2.2 kt-CO_2 by CNG use) under the condition of 35% reduced energy consumption at 2030.

4-3) Summary

Energy issues, today and in future (up to 2030)

1) Increasing import dependency of oil
2) For fossil fuels, the imbalance between gasoline and diesel fuel consumption (gasoline consumption is much larger compared to that of diesel fuel) is an issue; reducing gasoline consumption should be prioritised.
3) For biofuels, the supply ability of biodiesel has potential, but securing ethanol (for gasoline blend) to realise a reduction of gasoline consumption is not foreseeable (no appropriate feedstock).
4) To introduce higher blending of biodiesel, implementation of HVO in addition to FAME is necessary to realise higher blending of biodiesel without any vehicle warranty issues.

Possible measures

1) To reduce oil consumption in the future, an integrated approach of oil reduction measures is required through efficiency improvement of the traffic system, such as infrastructure development and traffic flow management.
2) Increased use of domestic gas for public transportation including taxis
3) To reduce gasoline consumption, securing feedstock for ethanol is definitely required, and development of cellulosic ethanol will be an option.
4) Funding system to promote ethanol utilisation

5) Viet Nam

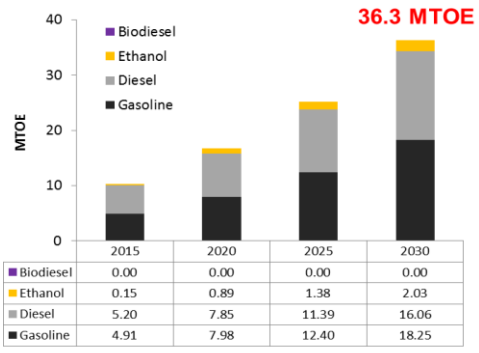
The Government of Viet Nam is promoting better fuel economy vehicles by introducing the Energy Efficiency Labelling scheme since 2014 based on the Laws on Saving and Efficient Energy Use, 50/2010/QH12. For biofuel utilisation, the Biofuel Roadmap plans to implement both ethanol (E5 as of 2015 and up to E10 as of 2017) and biodiesel (B5 as of 2015), according to the Ministry of Industry and Trade and Ministry of Transportation. However, the government has not specified a clear reduction target of oil, and we tentatively set an oil reduction target of 20% compared to BAU for road transportation that is equal to the government's CO_2 reduction commitment of the Paris Agreement in this study.

5-1) Oil Consumption and Biofuel Introduction Potential

The Energy Mix Model of Viet Nam estimated the total energy consumption of road transportation up to 2030. The results of the simulation for both the BAU case and biofuels case are shown in Figure 2.2.3-17.

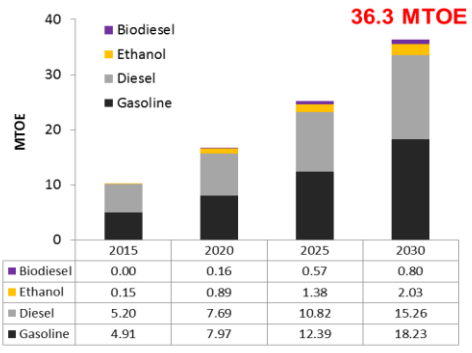
Figure 2.2.3-17. Total Energy Consumption of Road Transportation in Viet Nam

a) Business as usual



	2015	2020	2025	2030
Biodiesel	0.00	0.00	0.00	0.00
Ethanol	0.15	0.89	1.38	2.03
Diesel	5.20	7.85	11.39	16.06
Gasoline	4.91	7.98	12.40	18.25

b) Biofuels case



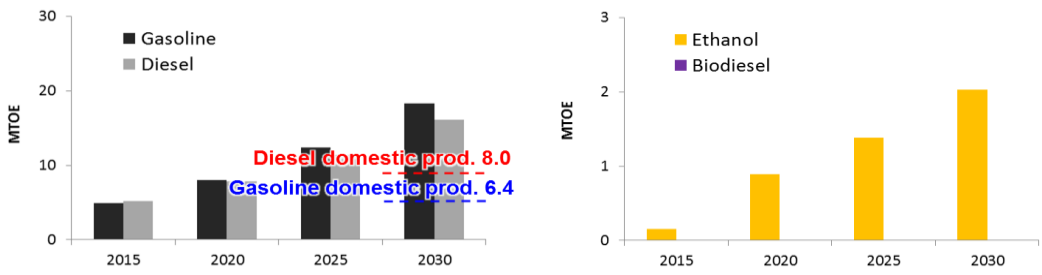
	2015	2020	2025	2030
Biodiesel	0.00	0.16	0.57	0.80
Ethanol	0.15	0.89	1.38	2.03
Diesel	5.20	7.69	10.82	15.26
Gasoline	4.91	7.97	12.39	18.23

MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-18 shows the gasoline/diesel fuel and biofuel consumption of the BAU case, and Figure 2.2.3-19 shows those of the biofuels case. The supply ability of each type of fuel is shown in the corresponding graphs.

Figure 2.2.3-18. Fuel Consumption of Business-as-Usual Case in Viet Nam

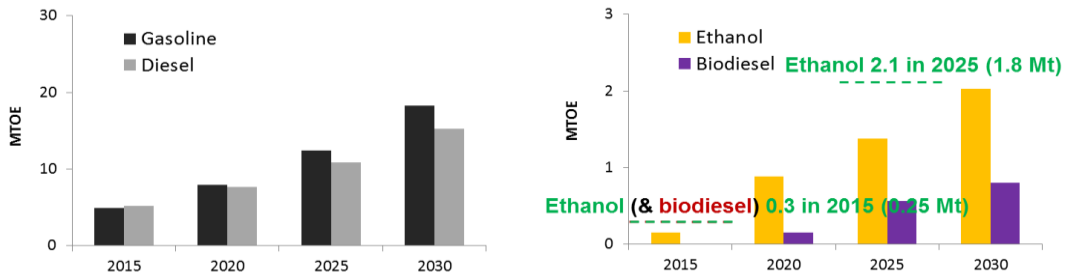
a) Gasoline/diesel fuel **b) Biofuels**



MTOE = million tonnes of oil equivalent.
Source: Authors.

Figure 2.2.3-19. Fuel Consumption of Biofuels Case in Viet Nam

a) Gasoline/diesel fuel **b) Biofuels**



MTOE = million tonnes of oil equivalent.
Source: Authors.

In Viet Nam, the current gasoline and diesel fuel consumption in the transportation sector are fairly balanced, but gasoline consumption is expected to be dominant in future as an increasing number of motorcycles will consume more gasoline. Domestic refining capacity is below demand as there is only one refinery and the country relies on petroleum products import.

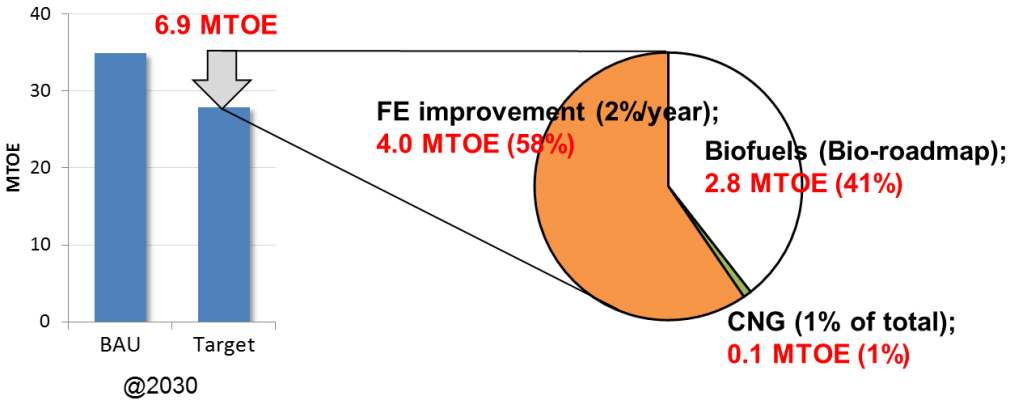
Currently, ethanol-blended gasoline E5 is being introduced in some cities. Implementation is slightly behind the timeline set out in the Biofuel Roadmap because domestic ethanol production capacity is insufficient. Securing biodiesel production is difficult as the lack of raw

material is a serious problem. Since it is not being implemented, it is not considered in the BAU case (Figure 2.2.3-18). However, we consider both ethanol and biodiesel use in the biofuels case, with slow implementation compared to the Biofuel Roadmap, as shown in Figure 2.2.3-19. Difficulty in achieving the biofuel introduction target is expected, as raw material production is limited, especially for biodiesel. The government needs to make a concrete plan to introduce biofuel with countermeasures to increase domestic biofuel production as much as possible, as well as import.

5-2) Oil Reduction (Energy Conservation) Potential

Based on our tentative target setting of 20% of oil reduction for the transportation sector, the required oil reduction for road transportation by 2030 is 6.9 MTOE. Estimates of the allocation of oil reduction measures of alternative fuels, based on the Biofuel Roadmap for biofuels and oil replacement of 1% with CNG for the transportation sector, and possible oil reduction by FE improvement of new vehicles are shown in Figure 2.2.3-20.

Figure 2.2.3-20. Evaluation of Oil Reduction Potential Based on Our Tentative Target Setting of 20% Reduction



Note: Target is our own assumption & tentatively set to 20% reduction

BAU = business as usual, CNG = compressed natural gas, FE = fuel economy, MTOE = million tonnes of oil equivalent.
Note: Target is our own assumption and tentatively set to 20% reduction.
Source: Authors.

Introduction of biofuel and CNG can replace 2.8 MTOE and 0.1 MTOE of oil, respectively, and FE improvement of new vehicles will reduce 4.0 MTOE. As the required oil reduction compared to BAU oil consumption is relatively small in this study (as our tentative target for Viet Nam), no integrated approach of oil reduction measures including efficiency improvement of the traffic system is required, but alternative fuel introduction and FE improvement of new vehicles are sufficient for energy conservation in the transportation sector.

The CO_2 emissions reduction of road transportation is estimated to be 21.7 kt-CO_2 (sum of –22.0 kt-CO_2 through reduction of oil use and +0.3 kt-CO_2 through CNG use) under the condition of 20% reduced energy consumption by 2030.

5-3) Summary

Energy issues, today and in future (up to 2030)

1) Increasing import dependency of oil and lack of domestic refining capacity compared to demand
2) For fossil fuels, gasoline and diesel fuel consumption is balanced, but gasoline consumption may further increase because of the large number of motorcycles in the future.
3) For biofuels, insufficient biofuels feedstock supply ability and production capacity, especially for biodiesel.
4) Production of ethanol (from cassava) could possibly increase, but securing a sufficient amount of biodiesel domestically is difficult (no appropriate feedstock).

Possible measures

1) To reduce oil consumption in the future, an integrated approach of oil reduction measures is required through efficiency improvement of the traffic system, such as infrastructure development and traffic flow management.
2) Utilisation of domestic gas for public transportation including taxis
3) To reduce petroleum products consumption, introduction of both ethanol and biodiesel is required; securing feedstock or products, especially for biodiesel, is a key to achieving the Biofuel Roadmap.
4) For a system to support increased biofuel implementation, not only fiscal support but also trading (import raw materials or products) is required.

3. Policy Recommendation

3.1. Evaluation of the Current Energy Policies and Needs for Multinational Cooperation within ASEAN

The investigation of existing energy policies and possible measures to achieve policy targets by estimating energy consumption of road transportation up to 2030 has revealed the following concerns and limitations to solve energy issues within each country.