Chapter 2

Assumptions and Results

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Chapter 2

Assumptions and Results

This chapter describes the methodology for calculating the potential demand for natural gas, the economical benefit, and CO_2 emissions; and provides the assumptions used for this study. Two of these common assumptions are:

- The incremental rise in natural gas demand will be met by imported LNG;
- The supply side infrastructure will be readily developed.

Here, the calculations will focus on the sectors on power generation, industry, residential and commercial, road transport, and marine transport. Non-energy use products and natural gas (i.e. LNG) exports are not considered because the feedstock of these sectors is expected to be met by indigenous production natural gas, which is beyond the scope of this study.

2.1 Power Generation Sector

Power generation is the sector with the largest demand for natural gas and substantial impact on the overall natural gas demand, depending on the assumption. In particular, the rehabilitation of existing but aged coal- or oil-fired power plants may substantially affect the natural gas demand depending on, say, whether the coal- or oil-fired power plants are renewed as–is, or replaced by natural gas-fired plants. In this study, the basic assumption is that existing thermal power plants would continue to operate or be renewed as–is.

Among EAS nations, the demand for electric power will significantly grow; therefore, a large number of new thermal power plants are expected to be constructed. This study prepared three scenarios for new thermal power plants when estimating the potential demand for natural gas.

2.1.1 Basic assumptions for the BAU scenario

The basic assumptions for the power sector are:

- The baseline is the BAU scenario as set forth in *ERIA Energy Outlook 2015*;
- Renewable energy will not be replaced by gas;
- Nuclear power generation will not be operated within the projection period, and will be replaced by thermal power generation;
- The calculation for natural gas-fired power generation in 2030 is as follows:

Power generation from GPP in 2030 [TWh]

= Power generation from additional TPPs in 2030 * share (three scenarios)

+ Power generation from existing GPPs that will still be in operation in 2030

+ Power generation from replaced GPPs by 2030

+ Power generation from replaced coal or oil thermal power plants by 2030

Whereas,

Additional thermal power generation in 2030 [TWh]

= Total thermal power generation in 2030 [TWh]

- Power generation from existing coal-, oil-, or natural gas-fired power plants that will still be in operation in 2030

- Power generation from replaced GPP by 2030

- Power generation from coal- or oil-fired power plants replaced by GPP by 2030

2.1.2 Three additional scenarios for thermal power generation

Three scenarios with different assumptions on the share of natural gas in additional thermal power generation are considered.

(A) Scenario 1: A 15% share of natural gas on the total sources of energy could be due to the following events:

- The LNG prices will increase as crude oil prices goes up;
- Momentum of actions against climate change (i.e. on CO_2 reduction) will be relatively weak;
- Domestic coal industry and CPP development will be promoted due to the domestic energy utilization policy and domestic industry protection policy.

(B) Scenario 2: 30% share of natural gas could be due to the following:

- The LNG prices will sustain its present level or moderately increase only;
- The current strength of climate change-related actions will be sustained;
- The present development ratio of CPP and GPP will be sustained;

(C) Scenario 3: The 60% share of natural gas could be due to the following developments:

- The LNG price will stay low due to an LNG glut following the on-schedule start of the new LNG project;
- Stronger action against climate change will take place to reduce CPP.

2.1.3 Existing thermal power plant

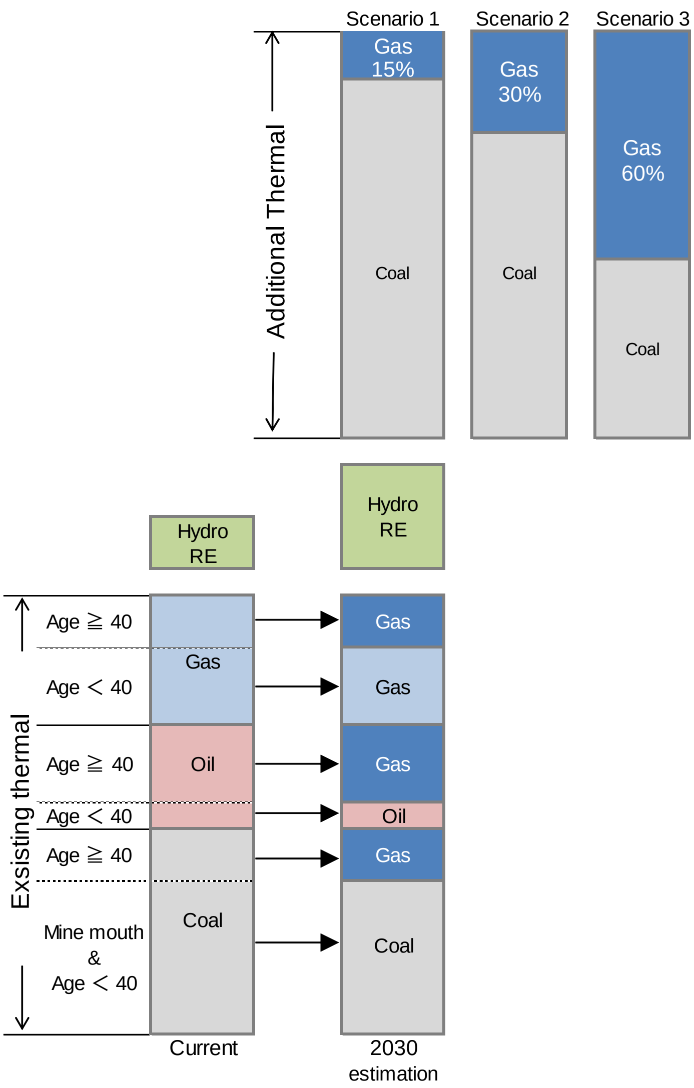
- Plants that have been operating for more than 40 years will be turned into GPPs;
- Mine mouth CPPs are exempted as their operation is combined with that of the coal mining business.

2.1.4 Summary of the power generation sector

Figure 2.1 shows the existing thermal power plants, the additional thermal power plants, and a comparison of the scenarios.

In estimating the existing thermal power plants, data from the UDI World Electric Power Plants Database of S&P Global Platts were used.

Figure 2.1. The Three Scenarios (Electricity Generation Mix)



Note: Scale is not accurate.

If a country's share of natural gas in the additional thermal power generation under a BAU scenario already exceeds 15% (Scenario 1), 30% (Scenario 2), or 45% (Scenario 3), the BAU scenario is applied. Table 2.1 shows the share of natural gas under a BAU scenario by country.

Table 2.1. Share of Natural Gas and Scenario Application

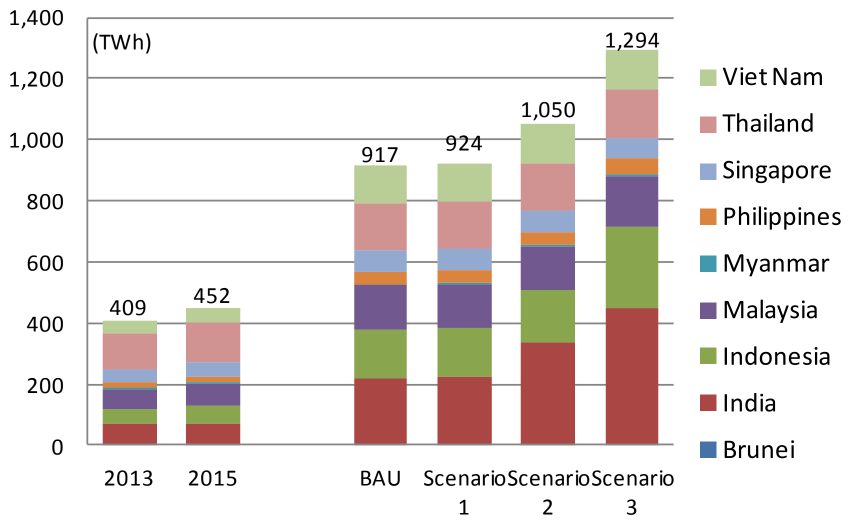
Country	Share of natural gas in additional TPP	Application of scenarios		
		Scenario 1 (15%)	Scenario 2 (30%)	Scenario 3 (60%)
Brunei	100%	BAU	BAU	BAU
Indonesia	26%	BAU	✓	✓
Malaysia	47%	BAU	BAU	✓
Myanmar	36%	BAU	BAU	✓
Philippines	37%	BAU	BAU	✓
Singapore	99%	BAU	BAU	BAU
Thailand	91%	BAU	BAU	BAU
Viet Nam	67%	BAU*	BAU*	BAU*
India	5%	Country-specific assumption		

'BAU' means BAU scenario is applied. '✓' means scenario 1, 2, or 3 is applied.
Note: * = excludes replacing nuclear power generation with TPP.

According to the sensitivity analysis, India's level of natural gas power generation under the BAU scenario is high. Therefore, in estimating the potential demand for natural gas in the power generation sector, this study created country-specific assumptions.

Figure 2.2 shows the power generation potential by country and by scenario. India presents the highest potential, followed by Indonesia.

Figure 2.2. Natural Gas-Fired Power Generation Potential by Country



BAU = business as usual.

2.2 Industry Sector

The industry sector has the second largest natural gas demand after the power generation sector. In the whole EAS region, the share of natural gas in the energy consumption of the industry sector is smaller than the Organisation for Economic Co-operation and Development's average. Natural gas mainly competes with oil, which is still subsidized in some EAS nations. Once subsidies for oil are abolished or reduced and natural gas pipeline networks are built in the future, the use of natural gas in the industry sector may substantially increase.

2.2.1 Scenario on the industry sector

The use of natural gas in the industrial sector can expand once the following predictive developments occur:

- Subsidies are eliminated, thus increasing oil prices for industrial use;
- The public begins to see the value of natural gas in light of climate protection;
- Energy efficiency standards are established and strengthened;
- Carbon emission amount will be limited;
- New LNG projects will start steadily, and sufficient LNG supply will be expected.

2.2.2 Assumption for the industry sector

Small increase in the demand for natural gas is assumed for countries where the natural gas utilization rate in 2030 under the BAU scenario is similar to or higher than the Organisation for Economic Co-operation and Development's average (33%).

In other countries, it is assumed that the natural gas utilization rate can increase by developing the supply infrastructure as well as by reinforcing the existing supply through such means as LNG imports.

It is also assumed that countries with lower natural gas demand outlook under the BAU scenario will have higher demand growth.

Table 2.2. Assumptions on Natural Gas Demand in the Industry Sector

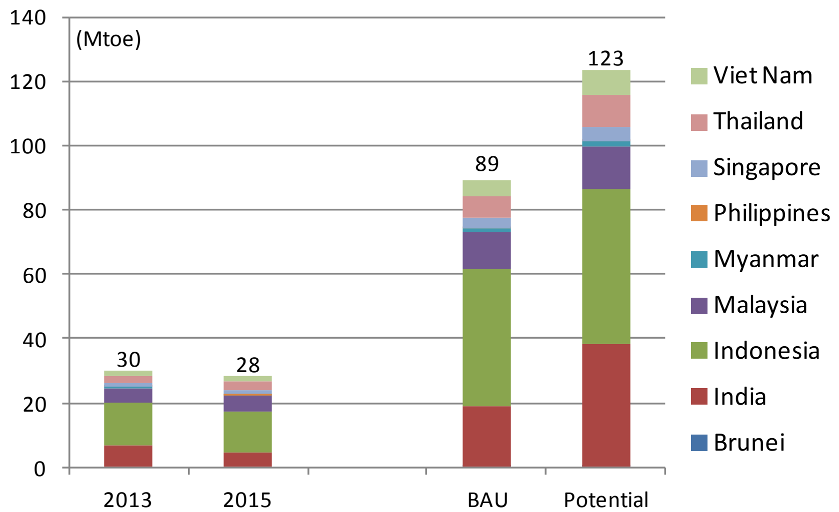
Share of natural gas in 2030 under BAU scenario	Increase of share	Applicable country
33% or more	+ 5% share compared to BAU	Indonesia, Malaysia
10% – 33%	1.5 times share compared to BAU (max. 33%)	Myanmar, Singapore, Thailand, Viet Nam
10% or less	2 times share compared to BAU	Brunei, India, Philippines

BAU = business as usual.

2.2.3 Summary for the industry sector

Figure 2.3 shows the potential demand for natural gas in the industry sector per country. Indonesia presents the highest potential, followed by India.

Figure 2.3. Potential Demand for Natural Gas in the Industry Sector



BAU = business as usual.

2.3 Residential and Commercial Sectors

In their residential and commercial sectors, the current natural gas utilization rate is 5% for Brunei and 6% for Singapore. However, the utilization is almost zero for this sector in other countries.

Natural gas in residential and commercial sectors has a demand growth potential as a replacement for oil (LPG, kerosene, etc.) as source of fuel. On the other hand, it is unlikely for the demand for conventional biomass to be directly outweighed by demand for natural gas due to price differentials and infrastructure bottleneck. Electricity demand will also be difficult to be replaced by oil because of the difference in the reason for use and infrastructure development.

2.3.1 Scenario for residential and commercial sectors

The scenario assumes that based on the following predictive developments, the use of natural gas in the residential and commercial sectors will expand:

- The current natural gas utilization rate is 5% for Brunei and 6% for Singapore, but almost zero for other countries;
- To improve the quality of life and reduce risks on health, substitution from traditional biomass to commercial energy, and from coal and oil to natural gas will be promoted;
- Subsidies for oil products will be eliminated, and the price of oil (including LPG) for residential and commercial use will increase;
- Tightening of electricity supply-demand balance will drive the use of natural gas (e.g. for cooking, water heating, and autonomous power and heat generation);
- New LNG projects will gain a steady momentum, and a sufficient LNG supply will be expected;
- The development of natural gas supply infrastructure (e.g. pipelines) for industrial use will promote higher gas demand in urban areas.

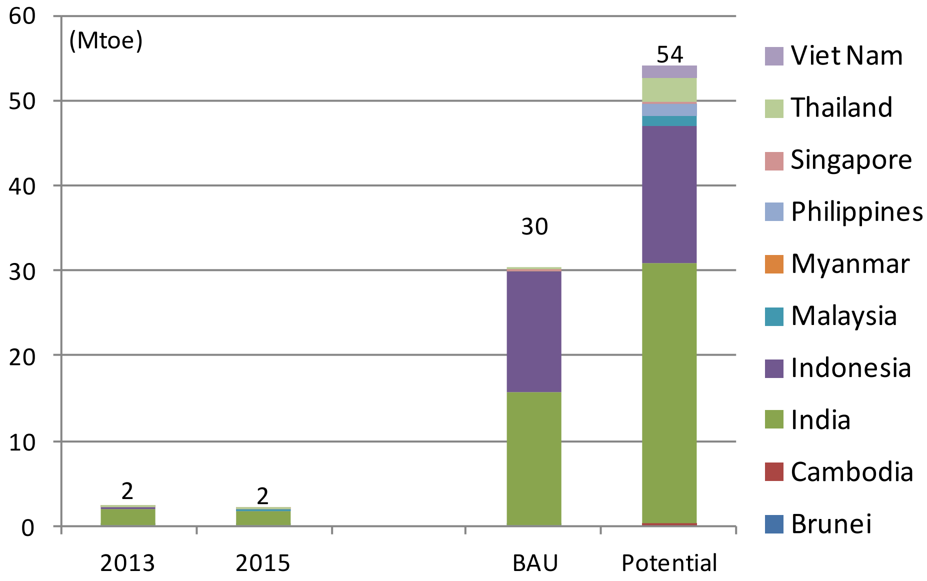
2.3.2 Assumption for residential and commercial sectors

It is assumed that 25% of the 2030 oil (mainly LPG) consumption under the BAU scenario will be replaced by city gas.

2.3.3 Summary on residential and commercial sectors

Figure 2.4 shows the potential demand for natural gas in the residential and commercial sectors per country. India shows the highest potential, followed by Indonesia.

Figure 2.4. Potential Demand for Natural Gas in Residential and Commercial Sectors



BAU = business as usual.

2.4 Road Transport Sector

Natural gas is used in the road transport sector in the form of compressed natural gas (CNG) and as fuel for LNG trucks. These gasoline-type engine trucks are larger and heavier than diesel engine trucks. However, most large LNG fuelled trucks are not suitable in the ASEAN region because of existing road conditions. In this study, LNG-fuelled trucks are assumed to not have been introduced in the ASEAN in 2030.

2.4.1 Scenario for the road transport sector

The following factors could help expand the use of natural gas vehicles:

- Subsidies for oil products will be eliminated; hence, prices of oil products for transport use will increase, and CNG prices will be competitive vis-a-vis oil prices;
- Air pollution in urban areas will deteriorate further and stronger measures will be required;
- Restriction on the use of obsolete vehicles;
- Tougher emission standards for new vehicles.

2.4.2 Assumptions for the road transport sector

The potential demand for CNG is calculated by doubling the annual average growth rate of CNG demand for vehicles under the BAU status (from 2013 to 2030). Results are shown in Table 2.3.

Note that for countries whose vehicles have zero natural gas demand by 2030 under the BAU scenario (i.e. Brunei, Viet Nam), it is assumed that 1% of oil demand for the transport sector will be replaced by natural gas.

Table 2.3. Projected Annual Average % Growth in Demand for Compressed Natural Gas for Vehicles

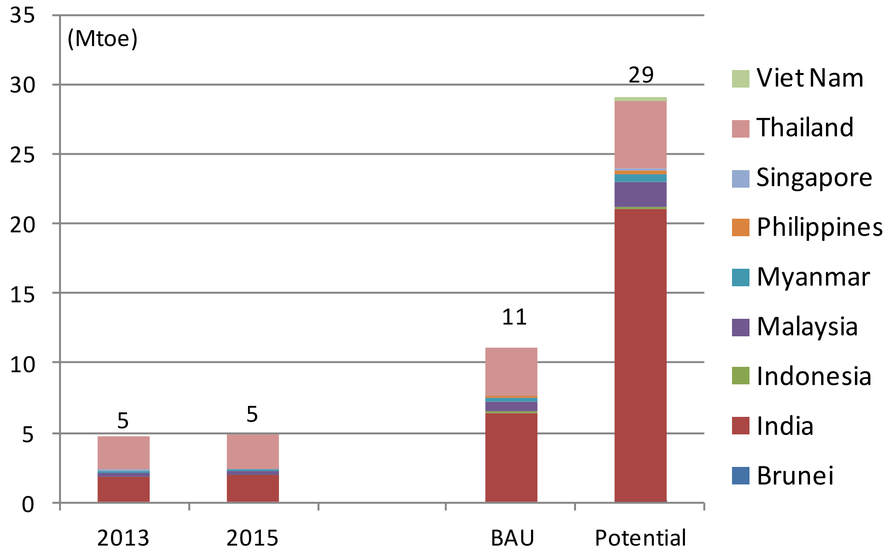
Country	Actual 2013/2000 (Annual growth rate)	BAU scenario 2030/2013 (Annual growth rate)	Potential 2030/2013 (Annual growth rate)
Brunei Darussalam	-	-	**1% of oil demand**
India	28%	8%	**16%**
Indonesia	2%	7%	**14%**
Malaysia	-	1%	**2%**
Myanmar	41%	3%	**6%**
Philippines	-	21%	**42%**
Singapore	-	2%	**4%**
Thailand	73%	2%	**4%**
Viet Nam	-	-	**1% of oil demand**

BAU = business as usual.

2.4.3 Summary of road transport sector

Figure 2.5 shows the potential demand for natural gas by country in the road transport sector. India represents the highest potential, followed by Thailand.

Figure 2.5. Potential Demand for Natural Gas in Road Transport Sector



BAU = business as usual.

2.5 Marine Transport Sector

According to statistics from the International Energy Agency (IEA) as of 2014, oil was the fuel of choice in the marine transport sector. In particular, high sulphur fuel oil was used in the international marine sector, while natural gas was not used. However, according to the International Maritime Organization,[1] after the implementation of stronger regulations on sulphur content for bunker fuels, LNG has gained some attention as a low sulphur bunker fuel.

2.5.1 International marine bunker

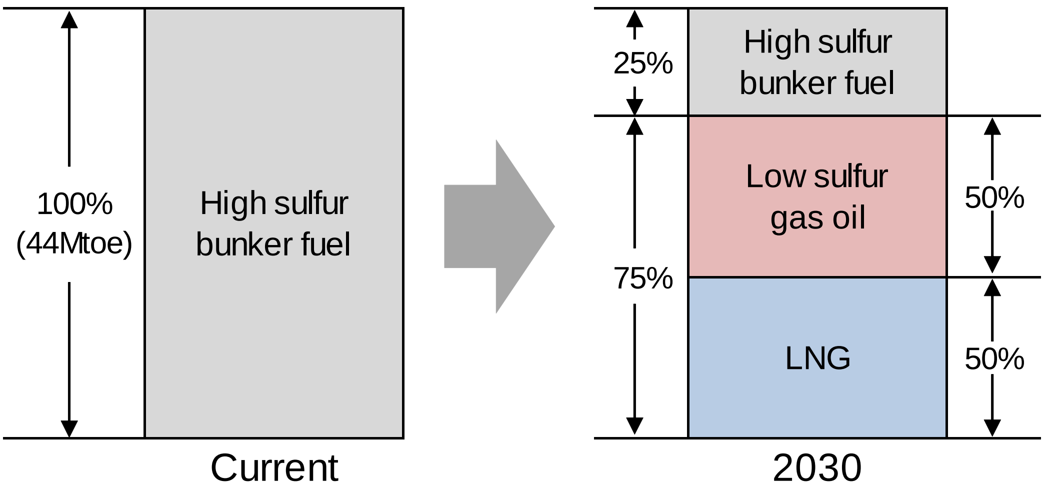
The following assumptions are expected to introduce and expand the practice of` LNG bunkering:

- The total bunker fuel demand in 2030 is assumed to be almost the same as the current demand;
- The demand to fuel ships with LNG is assumed to increase as International Maritime Organization regulations on sulphur oxide emissions from ocean vessels will be strengthened from 2020;

[1] The International Maritime Organization (IMO) is a specialized agency of the United Nations responsible for regulating shipping.

- Because of stronger regulations, there are three options for operators in the marine industry:
  - ✧ Continue to use high sulphur bunker fuel and install exhaust gas desulphurization equipment (25% of demand);
  - ✧ Replace with low sulphur diesel (32.5% of demand);
  - ✧ Replace with LNG (32.5% of demand).

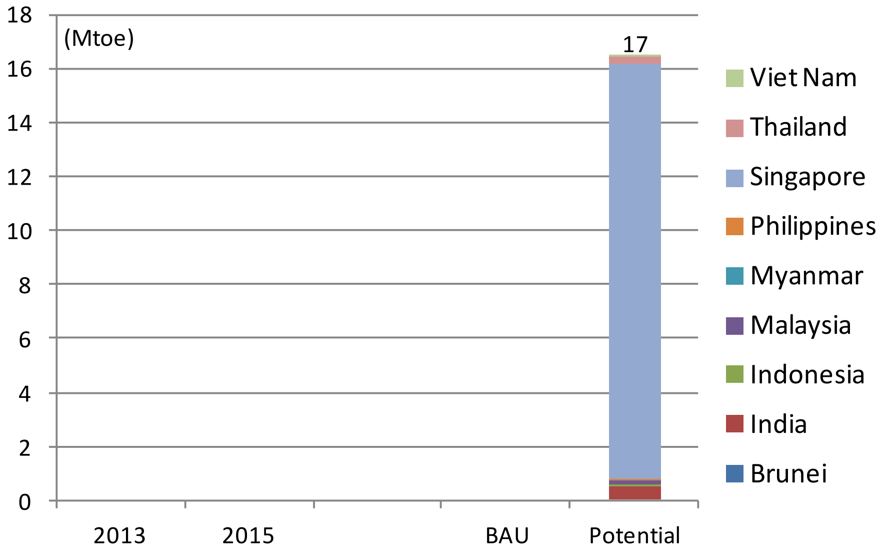
Figure 2.6. Bunker Fuel in the Future



LNG = liquefied natural gas; MToe = one million tonne of oil equivalent.

Figure 2.7 shows the potential demand for natural gas as bunker fuel in the international marine sector of each nation. This study assumes that Singapore will continue to account for a large proportion (in potential demand for natural gas) of the international marine bunker fuel market in 2030.

Figure 2.7. Potential Demand for Natural Gas in International Marine Sector



BAU = business as usual.

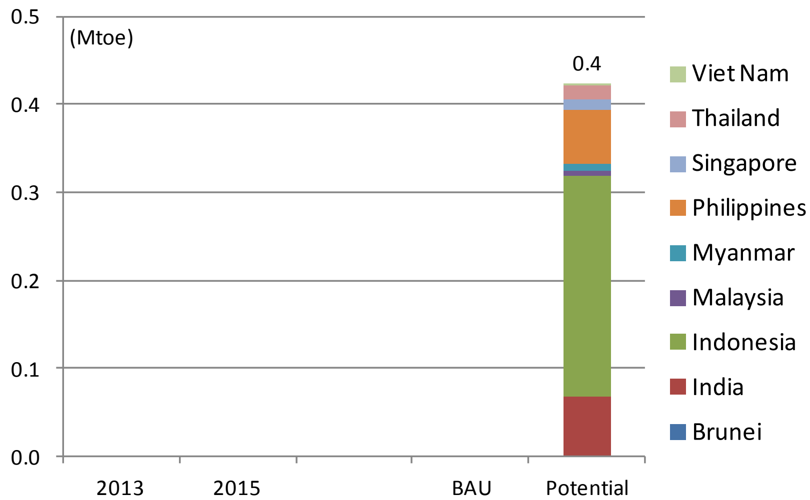
2.5.2 Domestic marine bunker fuel

The domestic marine bunker fuel is expected to see LNG used more at ports where LNG bunkering facilities for international marine are to be set up.

However, since there is only a limited number of ports with available LNG bunkering facilities, the shift to LNG as domestic marine bunker fuel is assumed to be 10% only.

Figure 2.8 reveals the potential demand for LNG as domestic marine bunker fuel by country. Note that the size of the local market is smaller than that of the international marine bunker fuel market.

Figure 2.8. Potential Demand for Natural Gas in Domestic Marine Bunker Fuel



BAU = business as usual.

2.6 Other natural gas demand

Other natural gas demand—for example, those for non-energy use (e.g. petrochemicals and fertilizers)—and LNG exports are not considered in this study, because the feedstock of these sectors is expected to be met by locally produced natural gas, which is beyond the focus of this research.

2.7 Cost and CO_2 emissions

When estimating the potential demand for natural gas, it is also necessary to estimate its impact on the economy and the environment. This section describes the assumptions for international fossil fuel prices, thermal power plant construction costs, and specific CO_2 emissions, which can have economic and environmental implications.

2.7.1 International fossil fuel price

The demand for fossil fuels in ASEAN + India is expected to substantially rise from 2013 to 2030. In this study, the increase in the demand is assumed to be covered by imports.

Table 2.4 presents the assumption for the fossil fuel import prices and the comparison of prices per tonne oil equivalent (toe). Oil and natural gas are represented by crude oil and LNG, respectively. For the import prices of coal, crude oil, and LNG (US$11.9/MMbtu), the assumptions adopted in IEA's New Policy Scenario in the *World Energy Outlook 2016* was used. Import prices of LNG are based on the following assumptions:

LNG US$6/MMbtu: Assume current LNG market conditions will remain.

LNG US$9/MMbtu: Median of IEA assumption and US$6/MMBtu.

Table 2.4. International Fossil Fuel Costs

Coal	Crude oil	LNG		
77 US$/ton **(125)** US$/toe	**111** US$/bbl **(820)** US$/toe	**11.9** US$/MMbtu **(472)** US$/toe	**9** US$/MMbtu **(357)** US$/toe	**6** US$/MMbtu **(238)** US$/toe

Note: LNG prices (US$9 and US$6/MMbtu): Assumptions
Source: International Energy Agency (2016a).

2.7.2 Thermal power generation plant construction cost

The economy is affected not only by fuel costs, but by the power plant's construction cost as well. In this study, only the plant construction cost is assessed; other costs such as the land acquisition cost and project finance cost are not considered. For the plant construction cost, data from the *Southeast* Asia *Energy Outlook 2015*[2] are used.

Table 2.5. Unit Power Plant Construction Cost

Fuel	Construction cost	Life time
Coal (SC)	US$1,600/kW	30 years
Natural gas (CCGT)	US$700/kW	25 years

SC = Supercritical, CCGT = Combined Cycle Gas Turbine.
Source: International Energy Agency (2015).

2.7.3 Specific CO_2 emissions

In this section, the impact of CO_2 emissions on the environment is assessed. Table 2.6 shows specific CO_2 emissions based on data from *CO_2 Emissions from Fuel Combustion 2016.*[3]

Table 2.6. Specific CO_2 Emissions

Power Generation		
Fuel		**g-CO_2/kWh**
Coal	Anthracite	925
	Coking coal	825
	Other bituminous coal	875
	Sub-bituminous coal	945
	Lignite	1,035
Oil	Fuel oil	675
Natural gas	Natural gas	400

Other consumption			
Fuel		**Carbon content, kg/GJ**	**kg-CO_2/toe**
Coal	Other bituminous coal	25.8	2.259
Oil	LPG	17.2	1.506
	Motor gasoline	18.9	1.655
	Kerosene	19.6	1.717
	Diesel/Gas oil	20.2	1.769
	Fuel oil	21.1	1.848
Natural gas	Natural gas	15.3	1.340

Source: International Energy Agency (2016).

2 In 'Chapter 2: Energy demand prospects' of the *Southeast* Asia *Energy Outlook 2015.*

3 From '2. Indicator Sources And Methods' of *CO2 Emissions from Fuel Combustion 2016*,