ERIA Research Project Report 2016, No. 07a

Formulating Policy Options for Promoting Natural Gas Utilization in the East Asia Summit Region

Volume I: Demand Side Analysis

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Unless otherwise specified, the sources of figures and tables in this report are from the results of the study.

Foreword

There has been an increasing interest in understanding the demand potential demand of natural gas and its implication in the East Asia Summit region. In 2016, this Economic Research Institute for ASEAN and East Asia (ERIA) study on the future natural gas demand was proposed by Japan during the 10th East Asia Summit Energy Ministers Meeting (EAS EMM). Focusing on ASEAN and India, the study estimates the size of the natural gas market on the demand side, and correspondingly derives the necessary investment in infrastructure on the supply side. Then, the challenges and policy options are drawn for both demand and supply sides.

An expanded demand in natural gas is expected to lead to increases in the fuel costs in the power generation sector, as it mostly substitutes cheap coal. However, this could be partly offset by a reduction in construction costs since natural gas-fired power plants have lower capital costs. Other sectors will see significant benefits in fuel costs as natural gas could be cheaper than oil products. A reduction in carbon emission is also expected in all sectors. To maximize the demand potential, various policies are, however, required. These include clear and coherent policies on the promotion of natural gas use, economic competitiveness of natural gas, support for developing the supply infrastructure, and institutional and capacity building. Volume I of this report is dedicated to the demand side analysis.

Meanwhile, by focusing on the supply side analysis, Volume II tries to identify the most suitable and feasible supply chain solutions based on the size of demand, main users of natural gas, technical constraints, geographical constraints, as well as available existing transport infrastructure such as roads, rails, and ports. Despite the number of existing and planned primary liquefied natural gas (LNG) terminals, more primary LNG terminals are needed by 2030. The study also shows that primary LNG terminals in ASEAN can encompass other countries' areas. Investment in the additional LNG supply chain by 2030 is estimated to hit US$81 billion. Thus, the study recommends that the cost of natural gas infrastructure be shared.

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Research Study Leader

Acknowledgement

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Contents

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List of Figures

List of Tables

List of Abbreviations/Acronyms

ASEAN	Association of South-East Asian Nations
BAU	Business As Usual
CO_2	carbon dioxide
CNG	compressed natural gas
CPP	coal-fired power plant
EAS	East Asia Summit
ERIA	Economic Research Institute for ASEAN and East Asia
GPP	gas-fired power plant
IEA	International Energy Agency
LNG	liquefied natural gas
LPG	liquefied petroleum gas
Mtoe	one million tonne of oil equivalent
NPP	nuclear power plant
TPP	thermal power plant

Executive Summary

1. Assumptions

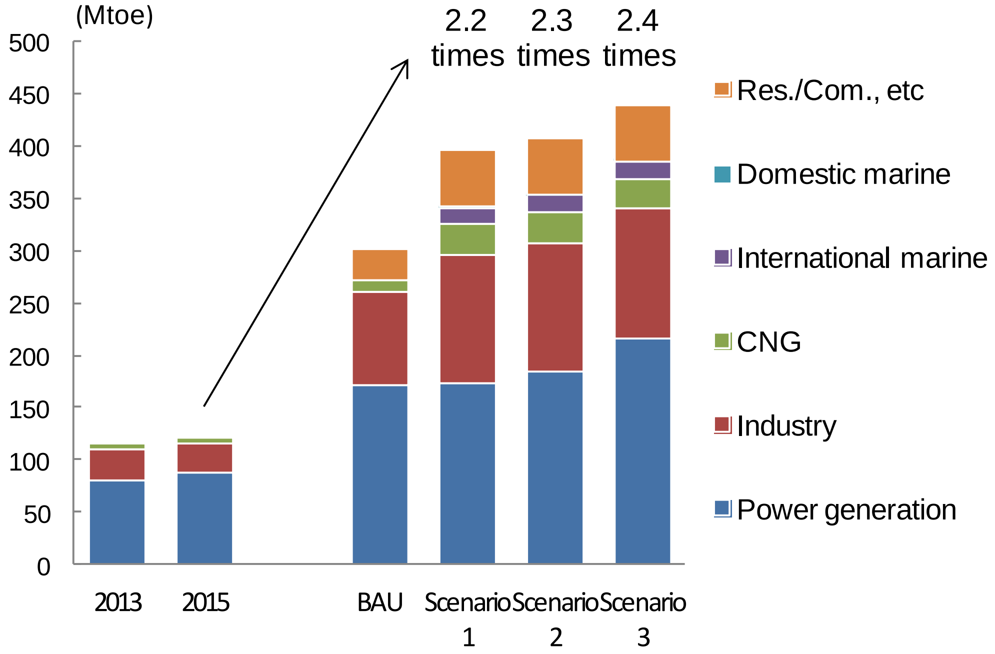
The table below shows the assumptions used in estimating the potential demand for natural gas by sector. For the baseline, the business as usual (BAU) scenario for 2030 in the *ERIA Energy Outlook 2015* was used. For the power generation sector, three scenarios were prepared.

Sector	Assumptions
Baseline of estimation	Based on the ERIA Energy Outlook 2015 Up until 2030 (BAU scenario)
Power generation	Renewable energy (RE) power generation will not be replaced by gas. Existing coal–or oil-fired plants will be replaced by gas after 40 years life. **New/additional thermal power plants – Share of gas: 15%, 30%, and 60% under the three scenarios, respectively**
Industry	Assumes an increase in the share of gas depending on baseline estimates: Share of gas in 2030: more than 33% in BAU >> 5% higher share Share of gas in 2030: between 10% to 33% in BAU >> 1.5 times share Share of gas in 2030: less than 10% in BAU >> 2 times share
Residential & Commercial	Assumes 25% of the consumption of oil by 2030 under BAU scenario will be replaced by gas.
Road transport	Assumes two times higher annual growth rate in gas demand than BAU.
Marine transport	Assumes 32.5% of high sulphur bunker fuel demand in BAU will be replaced by liquefied natural gas.

2. Potential Demand for Natural Gas (Preliminary)

Figure 1 shows the potential demand for natural gas by sectors in ASEAN + India. The potential demand for natural gas is expected to increase by up to 2.4 times from 2015, or by 322 Mtoe/year. The power generation sector shows the highest potential, followed by the industry sector.

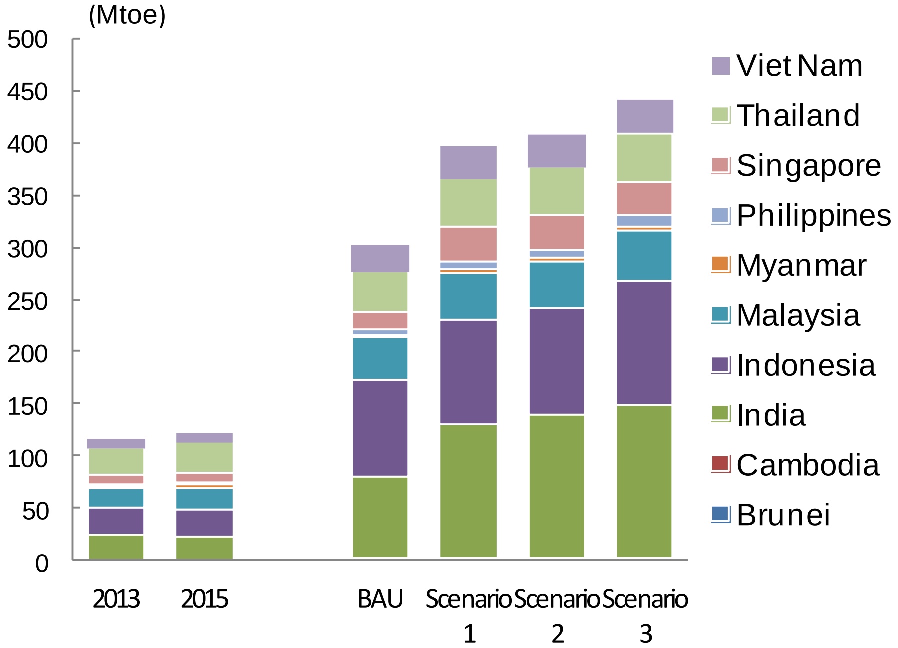
Figure 1. Potential Demand for Natural Gas by Sector, ASEAN + India



BAU = business as usual; CNG = compressed natural gas.

Figure 2, meanwhile, shows the potential demand for natural gas by nation. The highest demand is expected to be from India, followed by Indonesia.

Figure 2. Potential Demand for Natural Gas by Country, ASEAN + India



BAU = business as usual.

3. Expected Economic and Environmental Benefit

The impact of the change in potential demand for natural gas on both the economy and the environment was also estimated and compared with the baseline— i.e. the BAU state. Assumptions on fuel cost and power plant construction cost are shown in Tables 1 and 2.

Table 1. Assumptions on 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: Assumption: LNG prices (US$9 and 6/MMbtu)
Source: International Energy Agency (2016a).
.

Table 2. Assumptions on 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

Notes: SC = Supercritical, CCGT = Combined Cycle Gas Turbine
Source: International Energy Agency (2015), *Southeast Asia Energy Outlook 2015*. Paris.

Table 3 shows fuel costs, construction costs, and CO_2 emissions in the power generation sector under a BAU scenario and three other scenarios. Part of the increase in fuel cost is expected to be tempered by a reduction in construction cost. There are scenarios where a reduction in CO_2 emissions can be expected.

Table 3. Cost and CO_2 Emission (Power Generation), ASEAN + India

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.7	+0.5	+0.4	* +0.1	* +6.4 (+0%)
2	+7.5	+4.9	+2.2	-0.5	-55.8 (-2%)
3	+20.7	+13.3	+5.6	-1.7	-176.5 (-6%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.
Note: * Based on the assumption that Viet Nam's BAU scenario for nuclear power generation after 2028 will be substituted by coal–and natural gas-fired power.
Source: Assumption on specific CO_2 emission data is from the International Energy Agency.

In Scenario 1, the fuel import cost is expected to increase by as much as US$700 million. The construction cost is expected to increase by US$100 million even if the cost of the gas-fired power plant is lower than that of the coal-fired facility. The increase in construction cost is based on the assumption on nuclear power generation in Viet Nam. That is, although the BAU's original plan for Viet Nam is to commence the operation of a nuclear plant in 2028, this plan will be shelved and instead replaced by a thermal plant. In terms of the NPP power generation equivalent, neither the coal-fired power plant (CPP) nor gas-fired power plant (GPP) are an alternative, but both will be constructed on a net basis.

Estimating the NPP construction cost is difficult; thus, only the thermal power plant's (TPP) construction cost is considered in this study. The climb in the CO_2 emission (+6.4 million tons) is due to the same reason for the rise in construction costs.

In Scenario 2, the fuel import cost is expected to increase by as much as US$7.9 billion due to a higher gas power generation compared to Scenario 1. Construction cost is expected to decrease by US$500 million. The CO_2 emission is expected to drop by 55.8 million tons. The increase in gas power generation compared to Scenario 1 reduces the effect of having to replace NPP with TPP, on the construction cost and CO_2 emission.

In Scenario 3, the fuel import cost is expected to climb by as much as US$20.7 billion because of the expected higher gas power generation compared to Scenario 1. Construction cost will drop by US$1.7 billion, while CO_2 emission is expected to decline by 176.5 million tons. The rise in gas power generation when compared to Scenario 2 further lessens the impact of the shift from NPP with TPP on the construction cost and CO_2 emission.

The following table shows fuel costs, construction costs, and CO_2 emissions in sectors (total) other than the power generation sector. In these other sectors, both fuel cost and CO_2 emissions can be reduced by substituting oil products with natural gas.

Table 4. Cost and CO_2 Emission (Other Sectors Combined), ASEAN + India

Fuel import cost			**CO_2 emission** (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-23.9	-34.6	-45.6	-0.048 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide; MMbtu = one million British thermal units

The fuel import cost in the power generation sector is expected to increase by as much as US$20.7 billion (Table 3), while the combined fuel import cost in other sectors is expected to decrease by at least US$23.9 billion (Table 4). If all the potential demand for natural gas is met, there will be a benefit in the total fuel cost of the power generation sector and other sectors even if the LNG price is at US$11.9/MMbtu (Tables 3 and 4).

4. Policy recommendations

The following policy recommendations aim to help attain the potential demand for natural gas in the region.

Set clear policies that promote natural gas use.

- Have an energy/electricity mix target.
- Set climate and environmental regulations to promote lower carbon energy.

Enhance economic competitiveness of natural gas.

- Eliminate energy subsidies.
- Put in place mechanisms that will maximize the environmental value of natural gas (e.g. through carbon pricing).

Develop the supply infrastructure (liquefied natural gas receiving terminal, pipeline, etc.).

- Help meet residential and commercial demand.
- Dialogue with stakeholders to gain acceptance for natural gas.
- Present a clear regulatory framework.
- Find financial support for projects (e.g. low interest rate loan, tax benefits).

Support human capacity building on how to:

- Develop laws and regulations on gas infrastructure construction and operation.
- Develop safety (technical) standards.
- Control and monitor markets (e.g. change in prices).
- Monitor business operations (commercial and technical operations).
- Review and consider new gas utilization technologies.

Chapter 1
Introduction

1.1 Background

On 22 September 2016, delegates to the East Asia Summit (EAS) Energy Ministers Meeting agreed to support the research on natural gas. Part of their Joint Ministerial Statement states:

> To advance the EAS collaboration on natural gas, the Ministers welcomed Japan's proposal to facilitate collaboration and discussion among EAS countries with the support of the ASEAN Council on Petroleum, the ASEAN Centre for Energy, and the Economic Research Institute for ASEAN and East Asia (ERIA), on ways in which governments can spur the development of natural gas markets that are open, transparent, competitive and resilient, and promote new technologies for the storage and efficient use of this clean energy resource. The Ministers noted that Japan would endeavour to formulate pro-market policy options to ensure that gas markets operate efficiently for possible consideration of the next EAS Energy Cooperation Task Force meeting.

Thus, Japan and ERIA commenced the research project, whose results were to be presented to the EAS Energy Cooperation Task Force meeting in July 2017.

1.2 Objective

This study investigates the future natural gas demand in ASEAN countries and India as well as the necessary investment needed to meet the demand. It shall provide a picture on the market size of natural gas in EAS countries, identify the challenges faced in expanding the natural gas market and propose policy options to address identified issues.

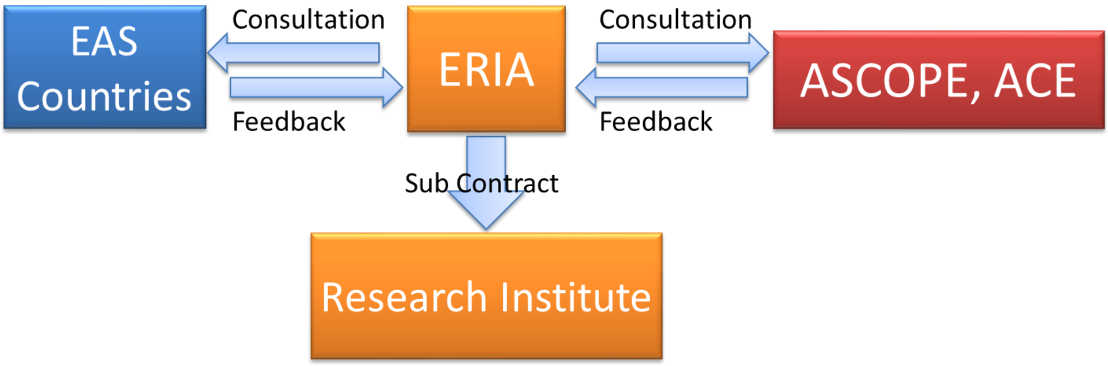
1.3 Methodologies

(A) Identify sub-sectors that can shift to natural gas as source of energy (such as transport sector and select industry subsectors, residential users).
(B) Gather data on the natural gas demand potential in countries.
(C) Clarify challenges and issues in natural gas utilization.
(D) Propose policies on the adoption of natural gas as source of energy and on investments in related infrastructure in the region.

1.4 Research Scheme

The following chart shows the scheme for this research. Following its consultation with EAS countries, the ASEAN Council on Petroleum, and the ASEAN Centre for Energy, the ERIA drew up the research outline and commissioned the help of research institutions in carrying out the study.

Figure 1.1. Research Scheme of the Study



ASCOPE = ASEAN Council on Petroleum; ACE = ASEAN Centre for Energy; ERIA = Economic Research Institute for ASEAN and East Asia; EAS = East Asian Summit.

1.5 Multiple Advantage of Natural Gas

Natural gas has various advantages from the environmental, energy security, and economic viewpoints:

(A) **Power Generation Sector**

(a) Environmental benefits

Gas-fired power plants (GPP) will be the more attractive option, given the increasingly stricter environmental regulations.

On air pollution issues:

- Natural gas is the least emitter of air pollutants (sulphur oxides, nitrogen oxides, particulate matter) among fossil fuels, thus helping improve residents' quality of life.
- Gas-fired power plants have better public acceptance than do coal–and oil-fired plants.

On global warming issues:

- Natural gas is the least CO_2 emitter among fossil fuels.

- If carbon pricing is introduced in the future, the economic advantage of GPP will increase.

(b) Operational benefit

A gas-fired power plant is capable of quick start-up and power adjustment; hence, it is optimal as a backup to variable renewable energy supply, which is expected to increasingly flow into power grids in the future.

(c) Supply security benefit

Many new natural gas liquefaction projects are planned in countries such as Australia and Mozambique. In addition, thanks to the growing number of unconventional natural gas suppliers from the United States, one can expect sufficient natural gas supply.

(B) **Other Sectors**

(a) Security benefit

The region deals daily with energy security risks such as decreasing crude oil self-sufficiency and continued dependence on the Middle East. Its industrial and transport sectors are highly dependent on oil, and substituting to natural gas is one way to reduce such energy security risks.

On the supply side, ASEAN countries Brunei Darussalam, Indonesia, and Malaysia are gas producing and liquefied natural gas (LNG) exporting countries. In addition, it is possible to import from those countries with less energy security risks, such as Australia and the United States.

(b) Economic benefit

Given the trend towards tighter environmental regulations, natural gas is expected to be more advantageous than oil and coal in terms of environmental costs.

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

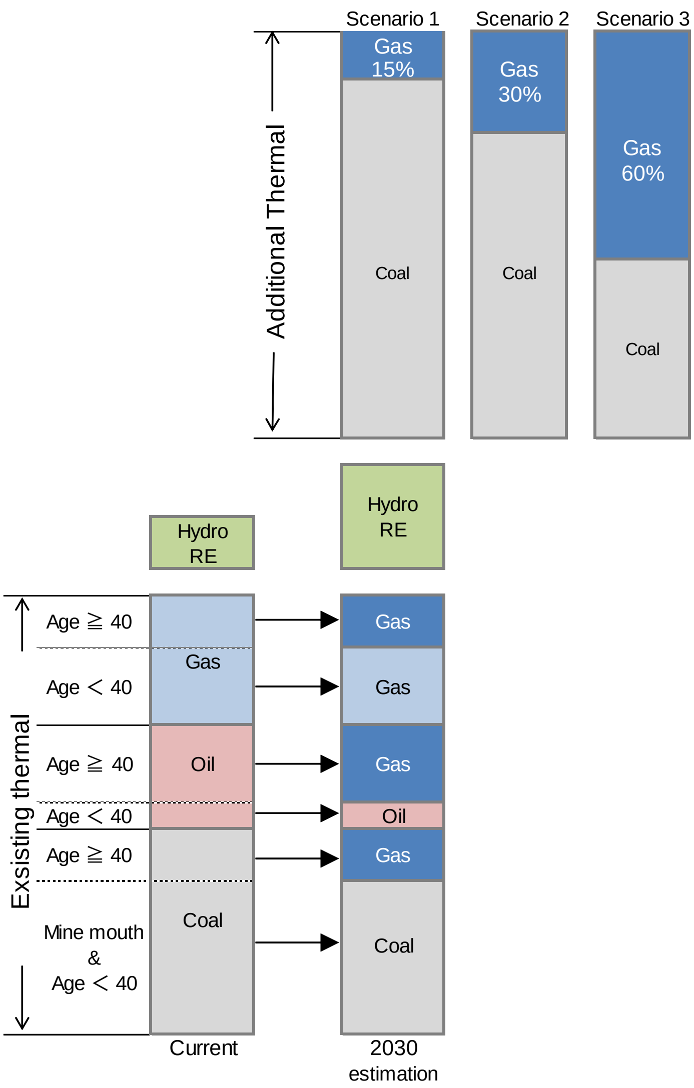
- Plants that have been operating for more than 40 years will be turned into GPPs;
- Mine mouth CPPs are exempted as their operation is combined with that of the coal mining business.

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

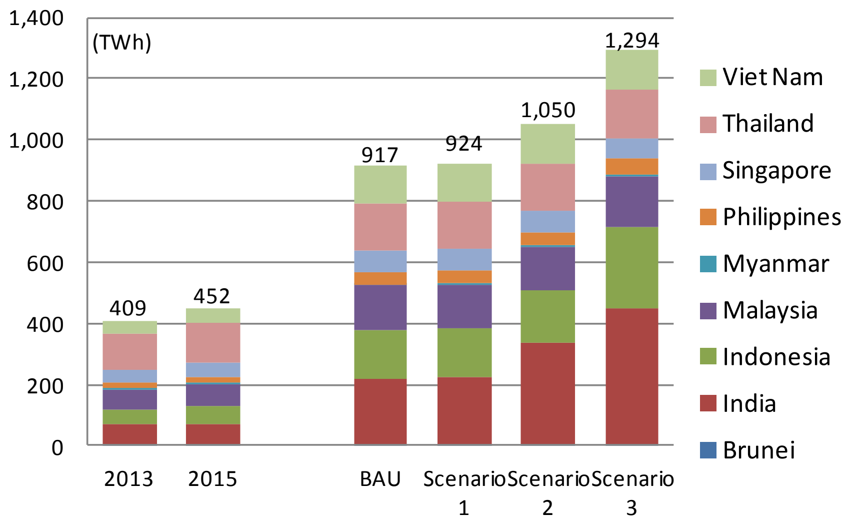
Country	Share of natural gas in additional TPP	Application of scenarios		
		Scenario 1 (15%)	Scenario 2 (30%)	Scenario 3 (60%)
Brunei	100%	BAU	BAU	BAU
Indonesia	26%	BAU	✓	✓
Malaysia	47%	BAU	BAU	✓
Myanmar	36%	BAU	BAU	✓
Philippines	37%	BAU	BAU	✓
Singapore	99%	BAU	BAU	BAU
Thailand	91%	BAU	BAU	BAU
Viet Nam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

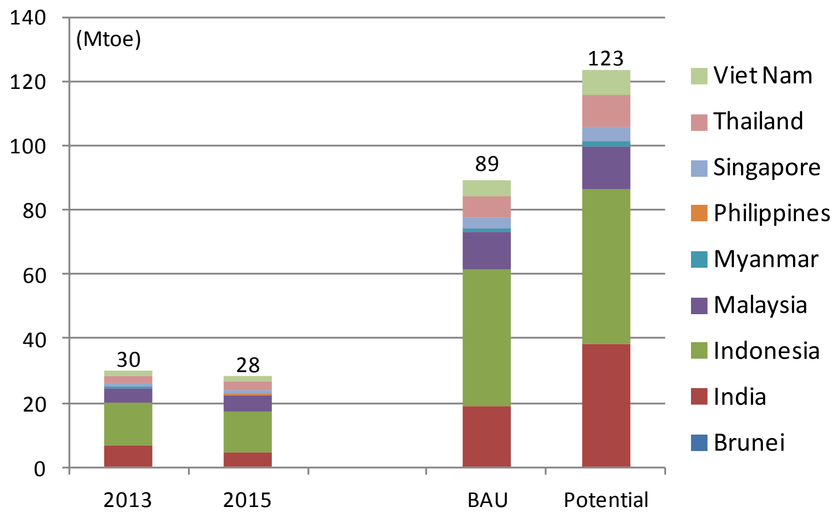
Share of natural gas in 2030 under BAU scenario	Increase of share	Applicable country
33% or more	+ 5% share compared to BAU	Indonesia, Malaysia
10% – 33%	1.5 times share compared to BAU (max. 33%)	Myanmar, Singapore, Thailand, Viet Nam
10% or less	2 times share compared to BAU	Brunei, India, Philippines

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.

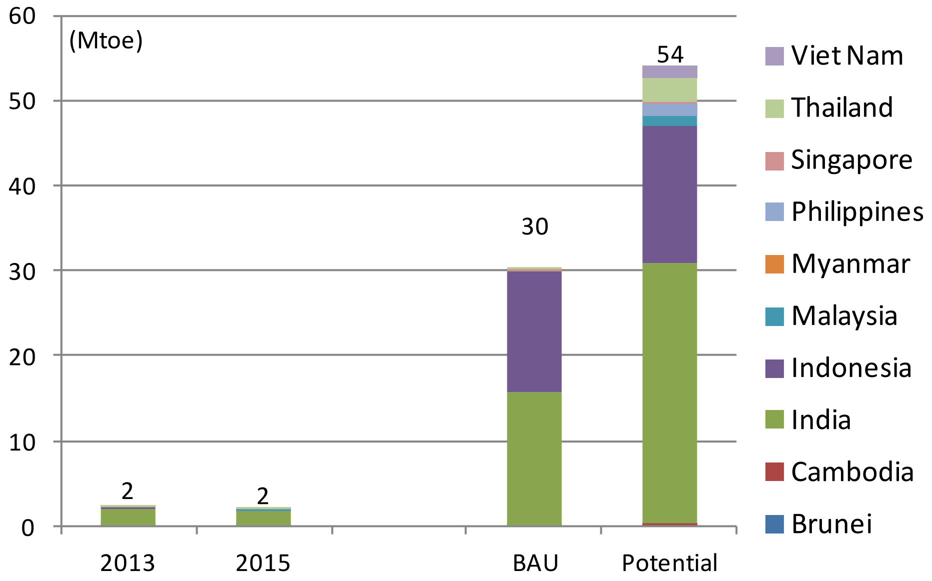
2.3.2 Assumption for residential and commercial sectors

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

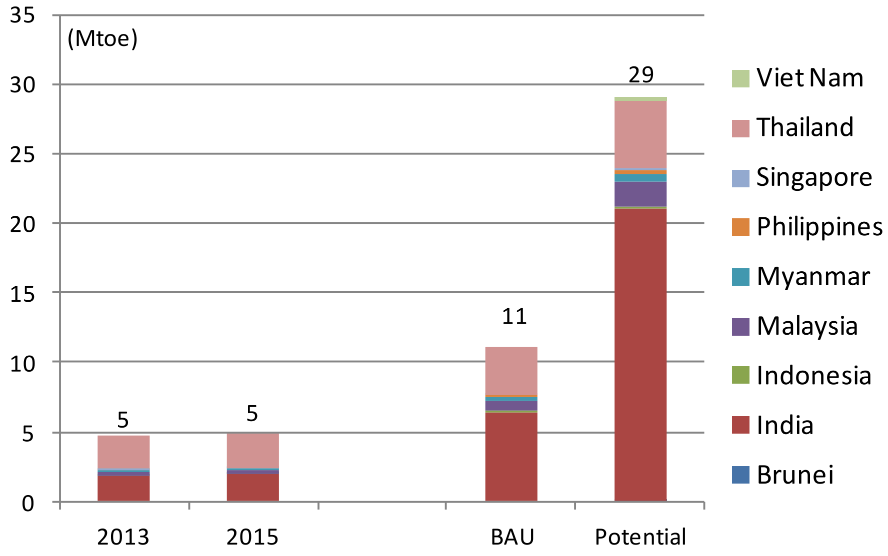
Country	**Actual 2013/2000 (Annual growth rate)**	**BAU scenario 2030/2013 (Annual growth rate)**	**Potential 2030/2013 (Annual growth rate)**
Brunei Darussalam	-	-	**1% of oil demand**
India	28%	8%	**16%**
Indonesia	2%	7%	**14%**
Malaysia	-	1%	**2%**
Myanmar	41%	3%	**6%**
Philippines	-	21%	**42%**
Singapore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

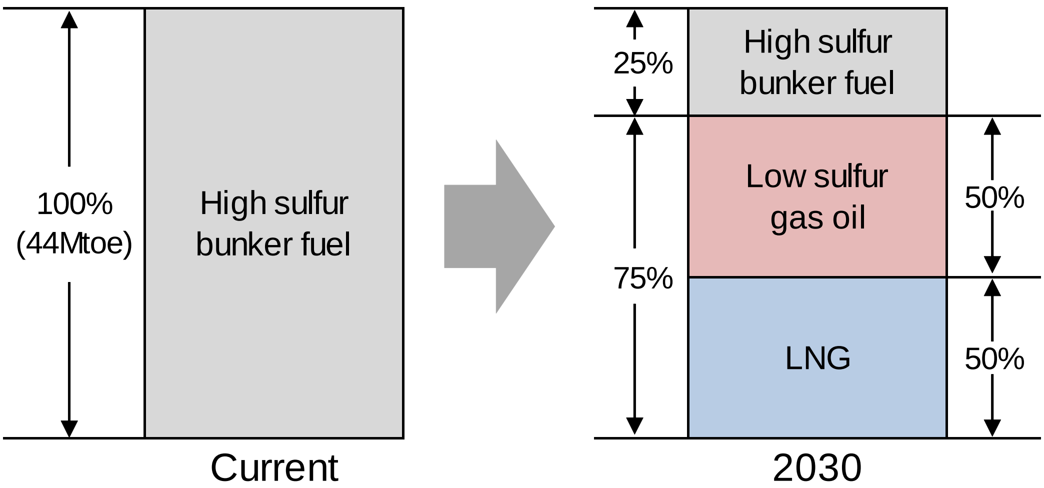
The following assumptions are expected to introduce and expand the practice of` LNG bunkering:

- 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).

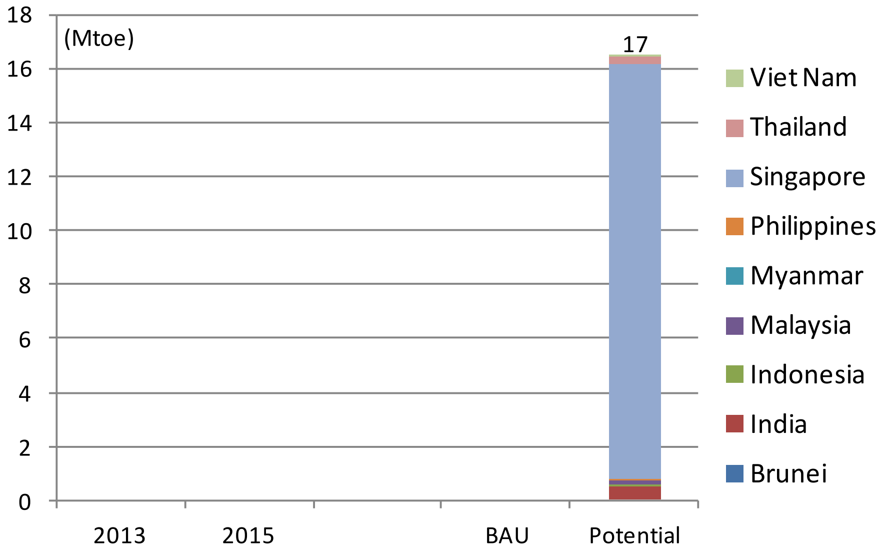
Figure 2.6. Bunker Fuel in the Future



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.

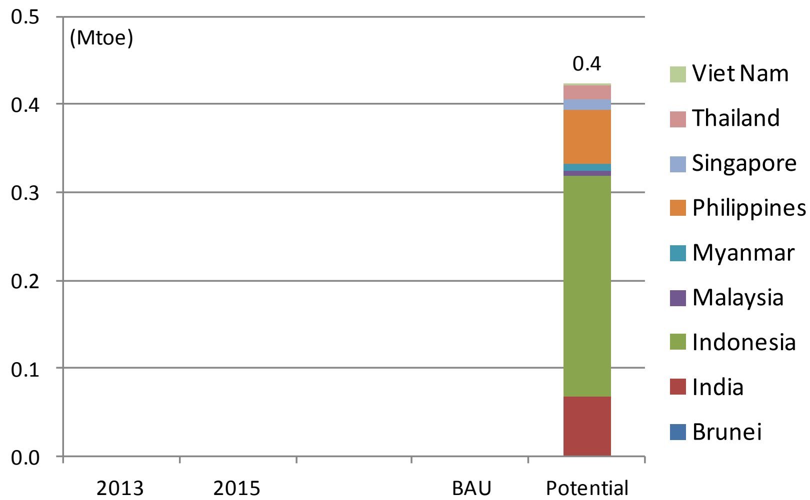
2.5.2 Domestic marine bunker fuel

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*,

Chapter 3

Potential Demand for Natural Gas By Country

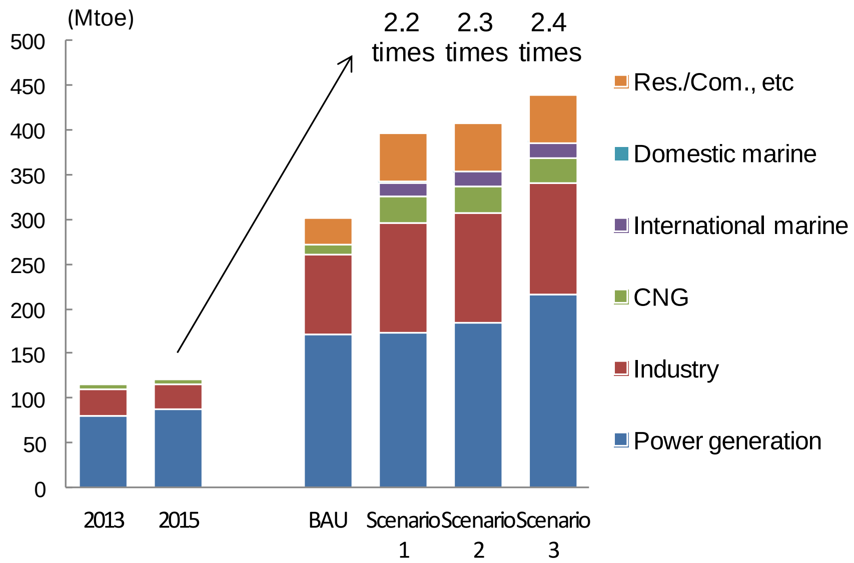
This chapter describes the potential demand for natural gas by country based on the assumptions enumerated in Chapter 2. It also explains the impact of the potential demand for natural gas on the economy in comparison to the BAU scenario. It should be noted, however, that this report's preliminary study found it difficult to establish the potential demand for natural gas in the Lao PDR[4].

3.1 ASEAN + India

3.1.1 Potential demand for natural gas by sector

Figure 3.1 shows potential demand for natural gas by sector in ASEAN + India. The potential demand for natural gas by the year of 2030 is estimated to increase by up to 322 Mtoe compared to the 2015 level. The power generation sector has the largest potential demand for natural gas, followed by the industry sector.

Figure 3.1. Potential Demand for Natural Gas by Sector, ASEAN + India



Notes: BAU = business as usual; CNG = compressed natural gas

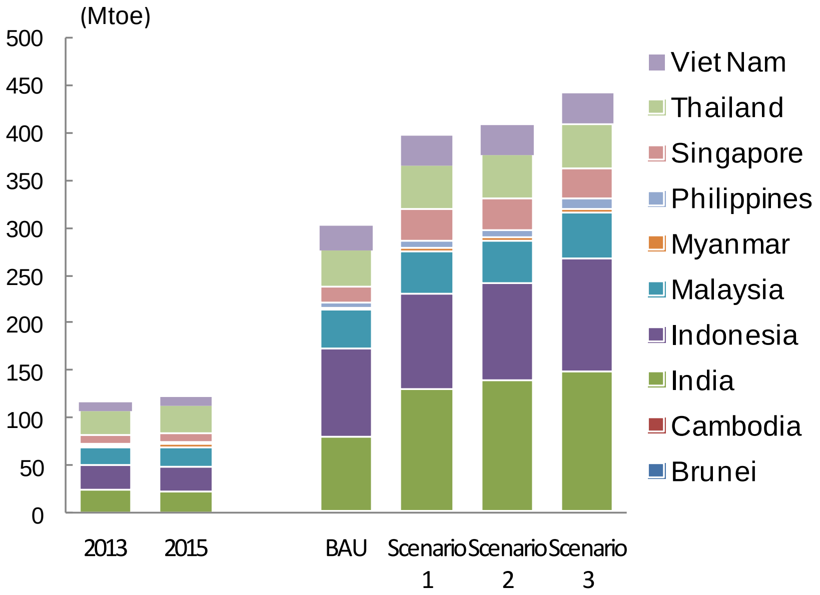
[4] That is, there is no room to introduce GPP because the Lao PDR has abundant hydro power to export.

Furthermore, the demand in its Other Sectors is too small, and the source of the demand is too far from coastlines where natural gas is found. Thus, meeting the demand with gas-fired power stations will entail considerable infrastructure investment.

3.1.2 Natural gas demand by country

On the other hand, Figure 3.2 demonstrates the potential demand for natural gas by country. India holds the largest potential demand for natural gas, followed by Indonesia.

Figure 3.2. Potential Demand for Natural Gas by Country, ASEAN + India

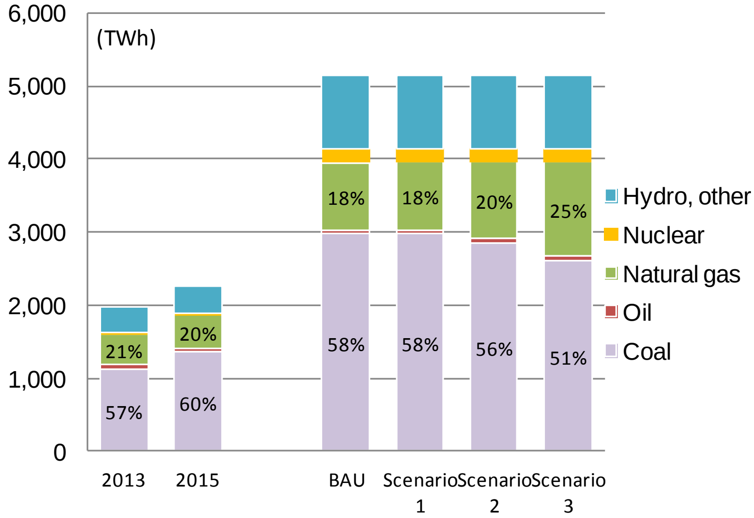


BAU = business as usual.

3.1.3 Power generation structure

Figure 3.3 shows the estimated power generation mix for ASEAN + India. While the share of natural gas-fired power generation was 20% in 2015, a decrease to 18% is expected in 2030 under the BAU scenario. In contrast, Scenario 3 estimates show that the share of natural gas-fired power generation in 2030 will exceed the share in 2015.

Figure 3.3. Power Generation Mix, ASEAN + India



BAU = business as usual.

3.1.4 Cost and CO_2 emission comparisons

The economic impact on costs and CO_2 emissions are then analysed based on the following assumptions:

- Input fuel (coal, oil, and natural gas) is priced at international levels;
- Estimates on the economic impact of oil and natural gas are based on that of crude oil and LNG, respectively;
- Power generation sector
  - ❖ Heat efficiency: Coal = 40%, Natural gas = 50%; and

    Power generation (TWh) /heat efficiency = required input energy
  - ❖ Capacity utilization rate: 60%; and

    Power generation (TWh)/365 (days)/24 (hours)/60%

    = required power generation capacity

Results of the impact are then compared with that of the BAU scenario.

Table 3.1 presents costs by scenarios and by LNG prices in the power generation sector, and a comparison of CO_2 emissions. The positive values represent emission increases, while the negative values represent emission decreases. In the power generation sector, CPP and GPP are compared.

Table 3.1. Cost, CO_2 Emission (Power Generation), ASEAN + India

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.7	+0.5	+0.4	+0.1	+6.4 (+0%)
2	+7.5	+4.9	+2.2	-0.5	-55.8 (-2%)
3	+20.7	+13.3	+5.6	-1.7	-176.5 (-6%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

The heat efficiency of GPP is higher than CPP, and the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is very low compared to the LNG price, which is US$6/MMbtu (US$238/toe) at its lowest. Therefore, the fuel cost increases under all the scenarios, as shown in Table 3.1.

Since the power plant construction cost for GPP is lower than CPP, there will be a benefit under all the scenarios. The increase in the construction cost in Scenario 1 is based on the assumption for nuclear power generation in Viet Nam. In other words, the BAU scenario for Viet Nam assumes that an NPP will commence operation in 2028. However, in this study, no NPP is assumed to commence operation even in 2030. This is because the NPP power generation equivalent under the BAU scenario is assumed to be replaced with thermal power generation. Neither CPP nor GPP are an alternative to NPP as power generation equivalents, although both will increase on a net basis. Obtaining the estimates on the NPP construction cost is quite difficult; thus, only TPP construction cost increases are considered in this study.

Since the specific CO_2 emission of GPP is lower than that of CPP, the CO_2 emission should decrease in general in all scenarios. The increase in CO_2 emission in Scenario 1 is due to the assumption that TPPs will replace NPPs in Viet Nam.

Under Scenarios 2 and 3, the impact of replacing NPPs with TPPs in Viet Nam is offset by an increase in GPPs as compared to that in Scenario 1.

In sectors other than in power generation, oil will be replaced by natural gas. Even if the LNG price is US$11.9/MMbtu (US$472/toe), it is lower than the crude oil price (US$820/toe); therefore, there will be a net saving on the fuel cost. In addition, the specific CO_2 emission from natural gas is lesser than that from oil.

Table 3.2. Cost and CO_2 Emission (Other Sector Total), ASEAN + India

Fuel import cost			
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	**CO_2 emission** (Million tons-CO_2)
-23.9	-34.6	-45.6	-0.048 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If all the potential demand for natural gas is met, there will be a net saving as well in the total calculated fuel cost for all sectors even if the LNG price is US$11.9/MMbtu.

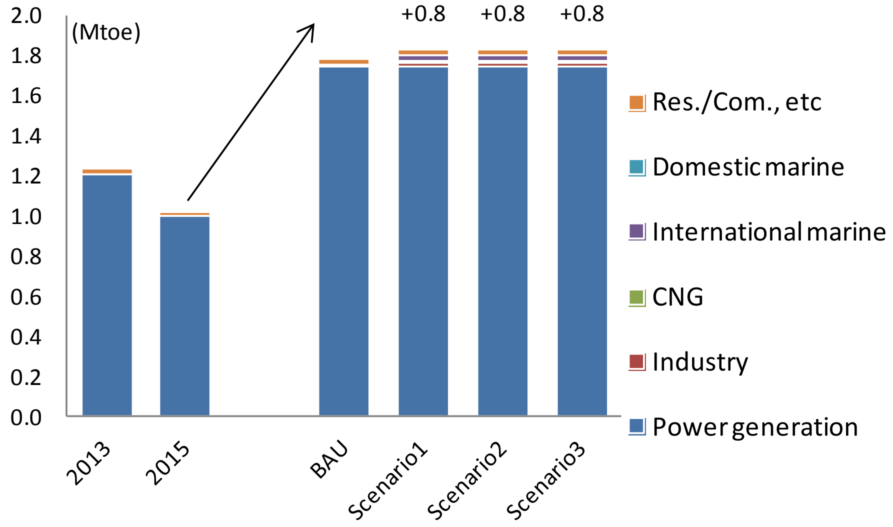
The next subsections present the results by country.

3.2 Brunei Darussalam

3.2.1 Potential demand for natural gas by sector

Figure 3.4 shows that the power generation sector has the highest potential domestic demand for natural gas.

Figure 3.4. Potential Demand for Natural Gas by Sector (Brunei Darussalam)

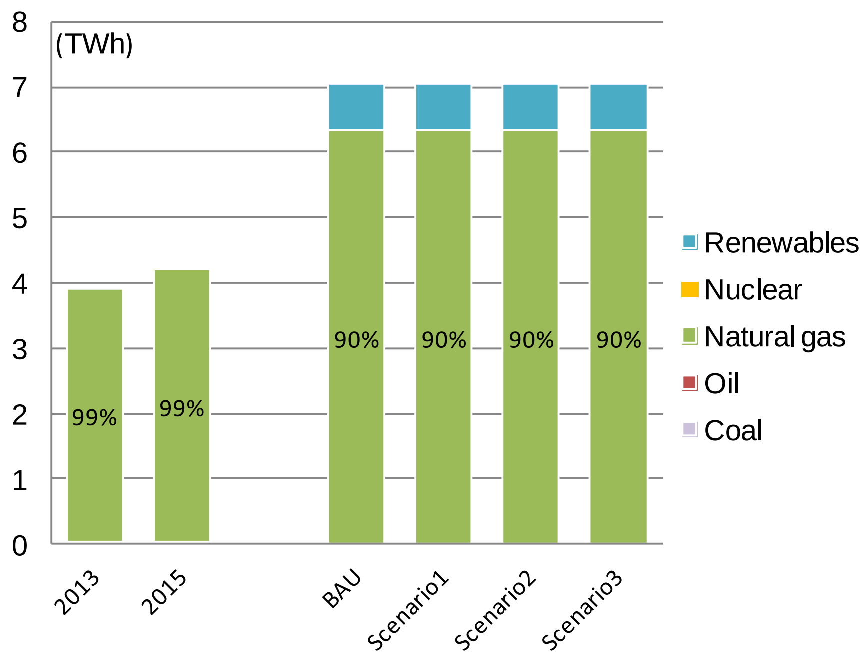


Notes: BAU = business as usual; CNG = compressed natural gas.

3.2.2 Power generation structure

Figure 3.5 reveals the estimated power generation mix for Brunei. The nation has a high natural gas share, and all of the three scenarios have similar results as that of the BAU scenario.

Figure 3.5. Power Generation Mix, Brunei Darussalam



BAU = business as usual.

3.2.3 Cost and CO_2 emission comparisons

The impact of the potential demand for natural gas on the cost and CO_2 emissions are estimated as an increment or decrement of carbon emissions from coal, oil, and natural gas in comparison to the BAU scenario.

As mentioned earlier, Brunei has a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors other than the power generation sector are compared in this study.

In sectors other than the power generation sector, oil will be replaced by natural gas. Even if the LNG price is US$11.9/MMbtu (US$472/toe), such is still lower than the crude oil price (US$820/toe) and, therefore, presents a large saving in the fuel cost. In addition, natural gas has lesser CO_2 emission than oil.

Table 3.3. Cost and CO_2 Mission (Other Sectors), Brunei Darussalam

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.002	-0.002	-0.003	-0.00002 (-1%)

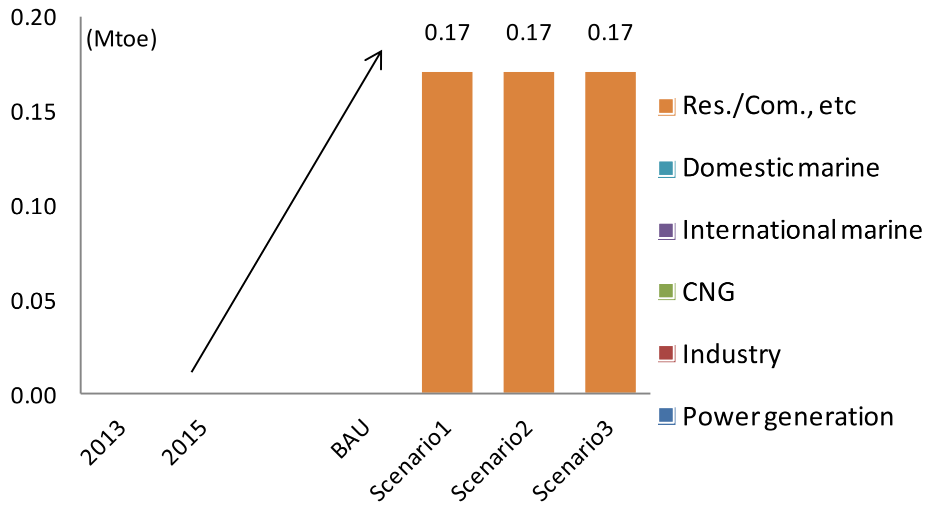
LNG = liquefied natural gas; CO_2 = carbon dioxide.

3.3 Cambodia

3.3.1 Potential demand for natural gas by sector

Under the BAU scenario for Cambodia, there is no natural gas demand. In this study, the assumption is that potential demand for natural gas exists in the residential and commercial sectors.

Figure 3.6. Potential Demand for Natural Gas by Sector, Cambodia



Notes: BAU = business as usual; CNG = compressed natural gas.

3.2.2 Cost and CO_2 emission comparisons

In the case of Cambodia, sectors other than the power generation sector are compared in this study. Here, oil will be replaced by natural gas. At US$11.9/MMbtu (US$472/toe), the LNG price is lower than the crude oil price (US$820/toe), and therefore, presents a large advantage in fuel costs. Also, the CO_2 emitted by natural gas is lesser than that by oil.

Table 3.4. Cost and CO_2 Emission (Other Sectors), Cambodia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.06	-0.08	-0.10	-0.00005 (-0%)

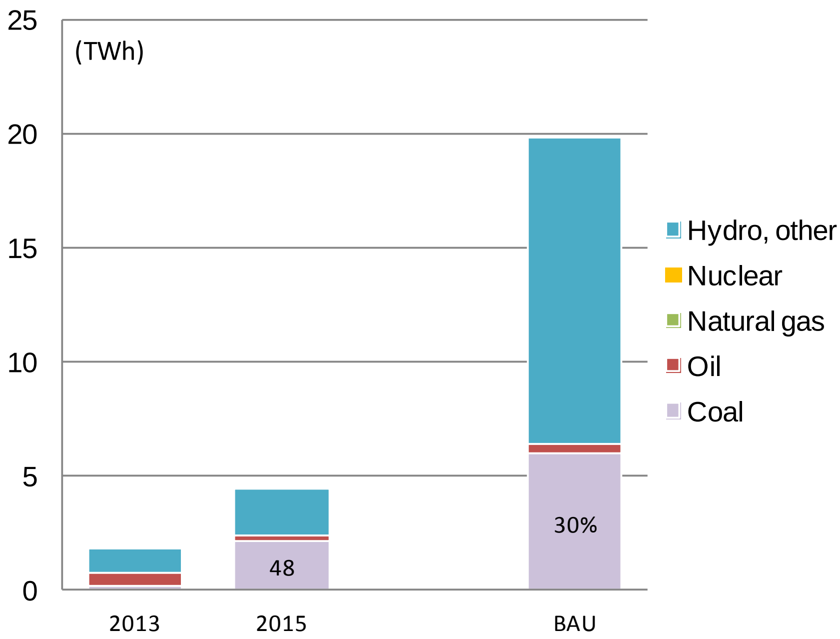
LNG = liquefied natural gas; CO_2 = carbon dioxide.

Power generation structure (Reference)

Figure 3.7 estimates the power generation mix for Cambodia under the BAU scenario as a reference.

Under the BAU scenario, 30% of Cambodia's power generation is assumed to be attributed to CPPs. The CPP power generation under the BAU scenario can be covered by the nation's existing CPP capacity. New hydro power represents much of the country's additional power generation aside from CPP.

Figure 3.7. (Reference) Power Generation Mix, Cambodia



BAU = business as usual.

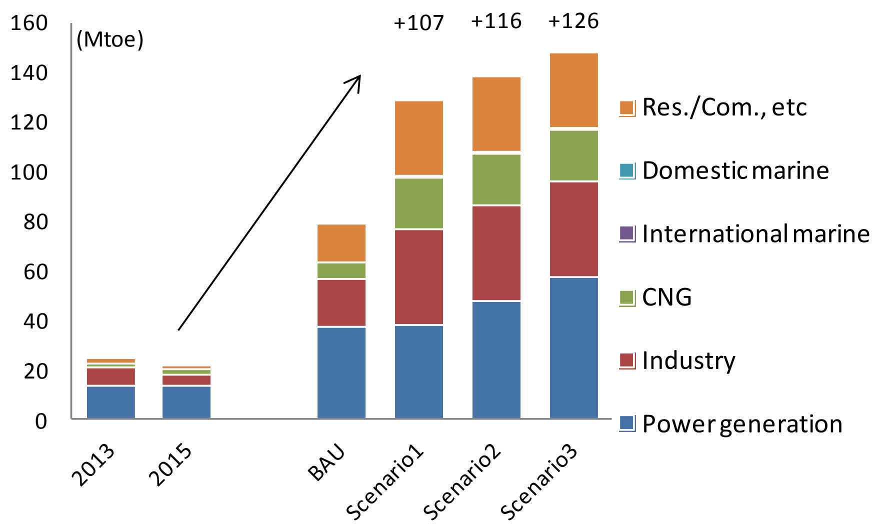
3.4 India

3.4.1 Potential demand for natural gas by sector

India's potential demand for natural gas is estimated to be up to 126 Mtoe/year more than its 2015 figures.

The highest potential demand for natural gas in India is represented by these sectors: power generation, industry, residential and commercial, and road transport (arranged in descending order).

Figure 3.8. Potential Demand for Natural Gas by Sector, India



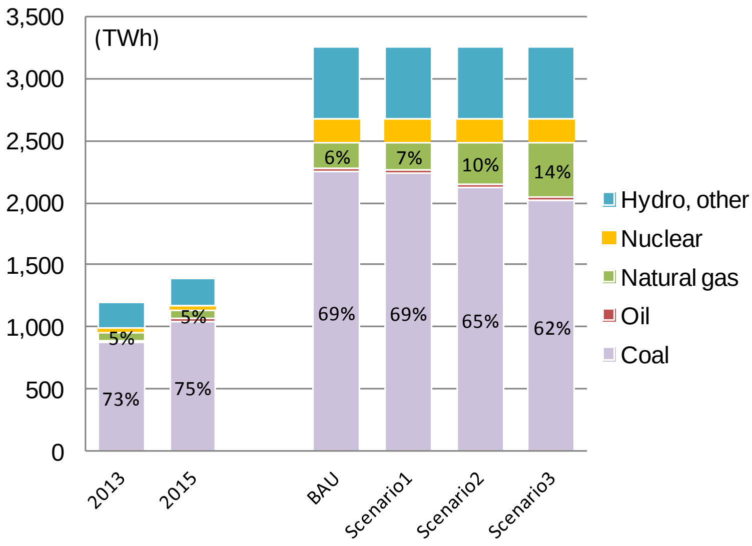
BAU = business as usual; CNG = compressed natural gas.

3.4.2 Power generation structure

In contrast to the power generation structure for the entire ASEAN region, the size of power generation in India is larger, but its share in natural gas power generation is smaller. The sensitivity analysis also shows that India's level of natural gas power generation under the BAU scenario is high. Therefore, to estimate the potential demand for natural gas in the power generation sector, the study made specific assumptions – i.e. assumptions different from those for the ASEAN nations.

Figure 3.9 shows the estimated power generation mix for India. Under Scenario 3, the calculated share of natural gas power generation reaches a maximum of 14%.

Figure 3.9. Power Generation Mix, India



BAU = business as usual.

3.4.3 Cost and CO_2 emission comparisons

Results show that India's fuel cost increases in all scenarios.

Since the power plant construction cost for GPP is lower than that for CPP, India will be better off under the three scenarios as compared to its BAU scenario.

Likewise, specific CO_2 emission will decrease under the three scenarios since the resulting emission numbers for GPPs are lower than those for CPPs.

Table 3.5. Cost and CO_2 Emission (Power Generation), India

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.3	+0.2	+0.1	-0.0	-2.5 (+0%)
2	+6.4	+4.1	+1.7	-0.6	-58.6 (-3%)
3	+12.6	+8.0	+3.3	-1.1	-114.7 (-5%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Meanwhile, in sectors outside the power generation sector, oil will be replaced by natural gas. Even at US$11.9/MMbtu (US$472/toe), the LNG price is still lower than the crude oil price (US$820 /toe), which therefore brings benefits to consumers. In addition, there will be less CO_2 emission from natural gas than from oil.

Table 3.6. Cost and CO_2 Emission (Other Sectors), India

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-10.4	-16.1	-22.0	-0.026 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

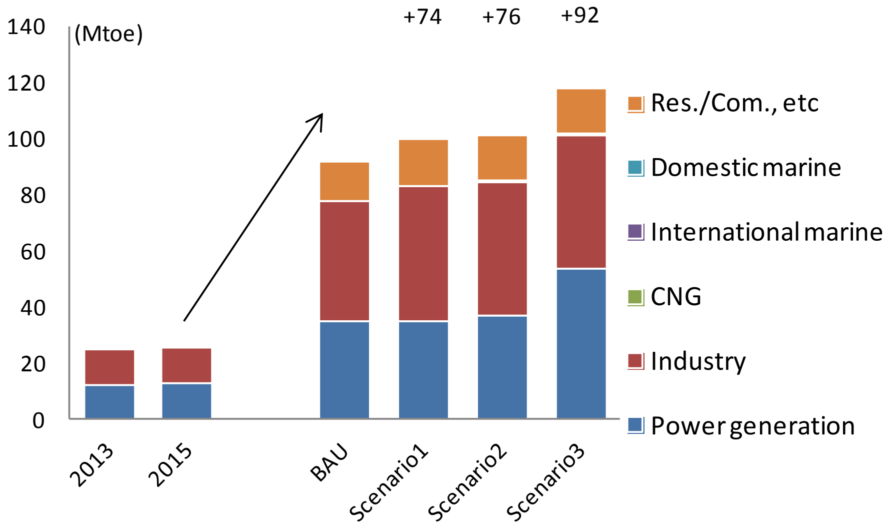
Assuming that the supply infrastructure has been put in place to meet the potential demand for natural gas, results under Scenario 3 show no benefit in terms of the total fuel cost when the LNG price is at its highest at US$11.9/MMbtu for the power generation sector and other sectors combined.

3.5 Indonesia

3.5.1 Potential demand for natural gas by sector

Indonesia's potential demand for natural gas is estimated to be larger by 92 Mtoe/year at best when compared with its figure in 2015. Its industry sector has the highest potential demand for natural gas, followed by the power generation sector.

Figure 3.10. Potential Demand for Natural Gas by Sector, Indonesia

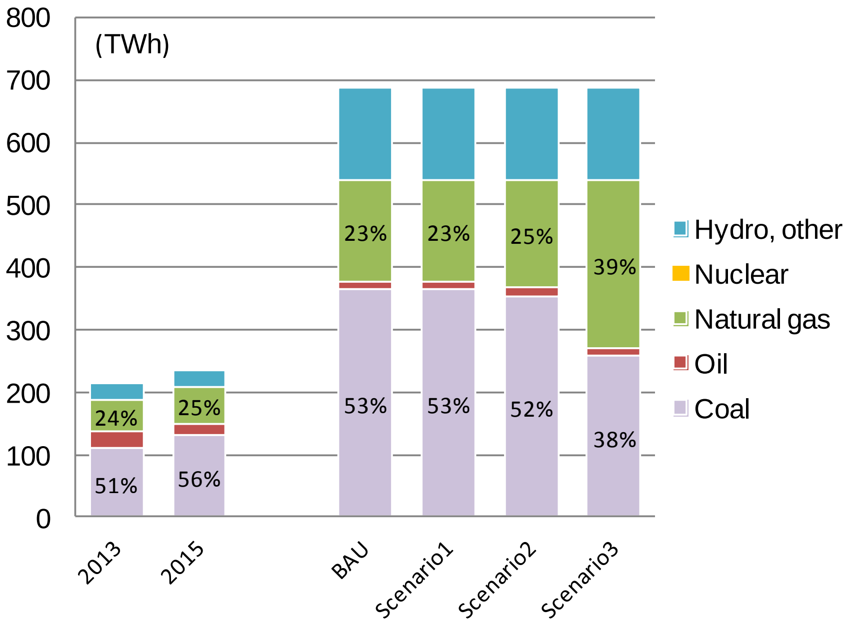


BAU = business as usual; CNG = compressed natural gas

3.5.2 Power generation structure

In Figure 3.11, the share of natural gas already reached 23% under the BAU scenario, and the assumption in Scenario 1 was the same as the BAU scenario. Under Scenario 3, results show that the share of natural gas power generation will reach 39%.

Figure 3.11. Power Generation Mix, Indonesia



BAU = business as usual.

3.5.3 Cost and CO_2 emission comparison

In the power generation sector, CPP and GPP are compared. Results show that Scenario 1 is the same as that of Indonesia's BAU scenario.

The heat efficiency of GPP is higher than of the CPP, while the required input energy of GPP is smaller than that of CPP. However, the coal price (US$125/toe) is very low even when compared with the lowest LNG price of US$6/MMbtu (US$238/toe). Therefore, fuel cost increases are expected under Scenarios 2 and 3.

Since the unit power plant construction cost with GPP is lower than with CPP, there will be a benefit under Scenarios 2 and 3.

Also, since the specific CO_2 emission with GPP is lower than CPP, CO_2 emissions are expected to lessen under Scenarios 2 and 3.

Table 3.7. Cost and CO_2 Emission (Power Generation Sector), Indonesia

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	+0.6	+0.4	+0.2	-0.1	-5.3 (-1%)
3	+5.8	+3.7	+1.5	-0.5	-53.1 (-13%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Results show that in sectors other than the power generation sector, oil will be replaced by natural gas. Likewise, LNG prices are low. Even if the LNG price is at US$11.9/MMbtu (US$472/toe), it remains lower than the crude oil price (US$820/toe), allowing for a large advantage in terms of fuel costs. In addition, since the specific CO_2 emission of natural gas is less than oil, there will be less CO_2 emission.

Table 3.8. Cost and CO_2 Emission (Other Sectors), Indonesia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-2.7	-3.6	-4.5	-0.004 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

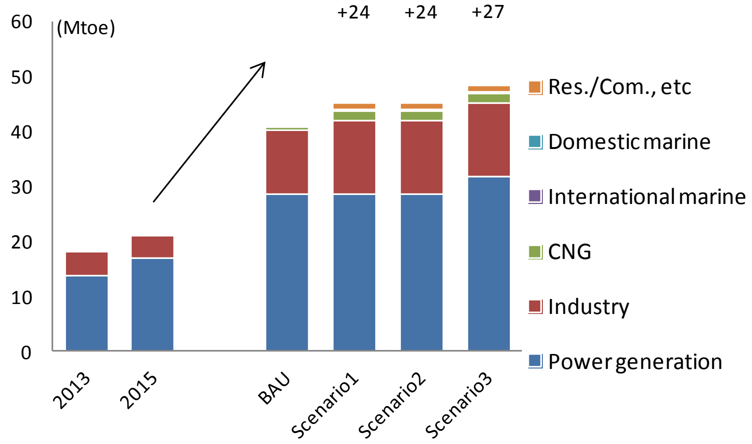
Even if all the potential demand for natural gas are met under Scenario 3, there will be no advantage in terms of the total fuel cost in cases where the LNG price is at its highest at US$11.9/MMbtu. This finding is based on calculations on the power generation sector and other sectors combined.

3.6 Malaysia

3.6.1 Potential demand for natural gas by sector

Estimates for Malaysia show that the potential demand for natural gas—excluding those for non-energy use and export—will be higher by up to 27 Mtoe/year compared to 2015 figures. The power generation sector has the highest potential demand for natural gas, followed by the industry sector.

Figure 3.12. Potential Demand for Natural Gas by Sector, Malaysia

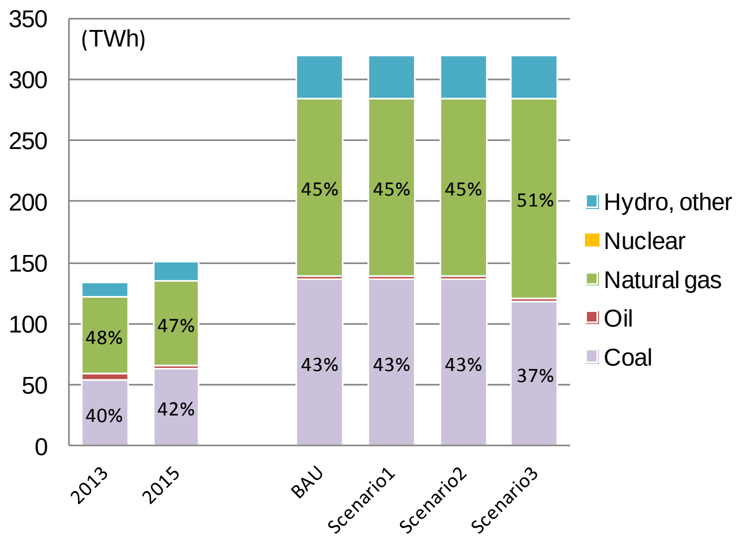


Notes: BAU = business as usual; CNG = compressed natural gas

3.6.2 Power generation structure

Malaysia is a natural gas-producing country, with its share of natural gas almost reaching 50% in 2015. While the share of natural gas decreased in the BAU scenario, Scenario 3 reveals a figure that will exceed the 2015 level. Scenarios 1 and 2 bear the same assumption as that under the BAU scenario.

Figure 3.13. Power Generation Mix, Malaysia



BAU = business as usual.

3.6.3 Cost and CO_2 emission comparisons

In the power generation sector, CPP and GPP are compared. Note that since Scenarios 1 and 2 are the same as the BAU scenario, the comparison showed no differences with regard the impact on either costs or CO_2 emissions.

The heat efficiency of GPP is higher than that of CPP, while the required input energy of GPP is smaller than CPP's. However, the coal price (US$125/toe) is very low even when compared to the lowest LNG price of US$6/MMbtu (US$238/toe) for this study. The fuel cost under Scenario 3 therefore increases.

Scenario 3 also shows some benefits on the construction cost and CO_2 emission since the construction cost of a GPP is lower than that of a CPP. The CO_2 emissions will likewise be lesser when GPP is opted over CPP.

Table 3.9. Cost and CO_2 Emission (Power Generation), Malaysia

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+1.0	+0.6	+0.3	-0.1	-9.2 (-5%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

In sectors other than power generation, natural gas will replace oil. Even if the LNG price is US$11.9/MMbtu (US$472/toe), it is still lower than the crude oil price (US$820/toe). The specific CO_2 emission from natural gas will also be lesser compared to that from oil.

Table 3.10. Cost and CO_2 Emission (Other Sectors), Malaysia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.4	-1.9	-2.4	-0.002 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

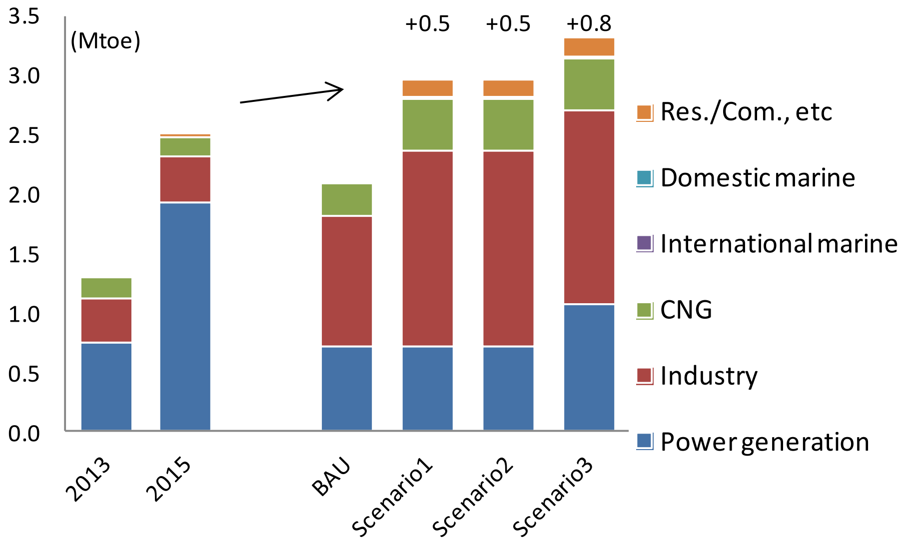
If the supply infrastructure is put in place to meet the potential demand for natural gas, some benefits may be expected in the total fuel cost even in cases where the LNG price is at its highest at US$11.9/MMbtu (Under Scenario 3, all sectors).

3.7 Myanmar

3.7.1 Potential demand for natural gas by sector

For Myanmar, estimates show that the potential demand for natural gas will be larger by up to 0.8 Mtoe/year in Scenario 3 compared to 2015 figures. Its industry sector presents the highest potential demand for natural gas, followed by the domestic power generation sector.

Figure 3.14. Potential Demand for Natural Gas by Sector (Myanmar)



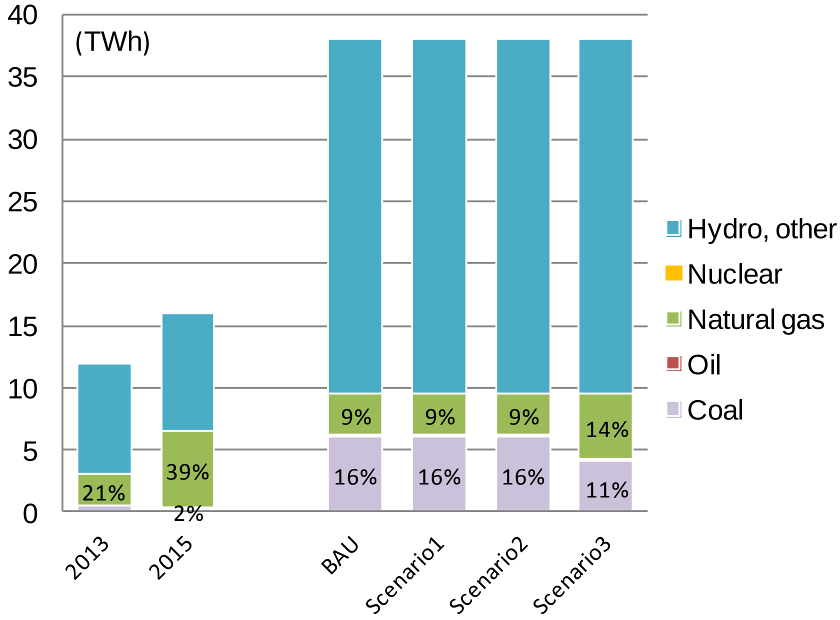
BAU = business as usual; CNG = compressed natural gas.

3.7.2 Power generation structure

Myanmar's share of natural gas in 2015 was 39%. However, under its BAU scenario, its share of natural gas is expected to decrease. Even Scenario 3 assumes that the share will be below the 2015 level. Meanwhile, Scenarios 1 and 2 have the same assumption as the BAU scenario.

Myanmar gets its main energy source from hydro power.

Figure 3.15. Power Generation Mix (Myanmar)



BAU = business as usual.

3.7.3 Cost and CO_2 emission comparisons

The CPP and GPP in Myanmar's power generation sector are compared, although note that since Scenarios 1 and 2 are the same as the BAU scenario, there should be no differences in the outcomes.

The heat efficiency of GPP is higher than CPP, and the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is already very low even when compared with LNG's lowest price of US$6/MMbtu (US$238/toe). Therefore, the fuel cost under Scenario 3 increases.

Since each GPP's construction cost is lower than that of the CPP, and CO_2 emission from GPP is lower than that from CPPs, Scenario 3 brings some benefit.

Table 3.11. Cost and CO_2 Emission (Power Generation), Myanmar

Scenario	**Fuel import cost**			**Construction cost** (US$ billion)	**CO_2 emission** (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+0.1	+0.1	+0.03	-0.01	-1.0 (-15%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Similar to the study's results on other countries, oil will be replaced by natural gas in Myanmar's sectors outside of power generation. Its LNG price, even at US$11.9/MMbtu (US$472/toe), is lower than that of the crude oil price (US$820 /toe). The specific CO_2 emission from natural gas is lesser than that from oil.

Table 3.12. Cost and CO_2 Emission (Other Sector, Total), Myanmar

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.3	-0.4	-0.5	-0.0004 (-3%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

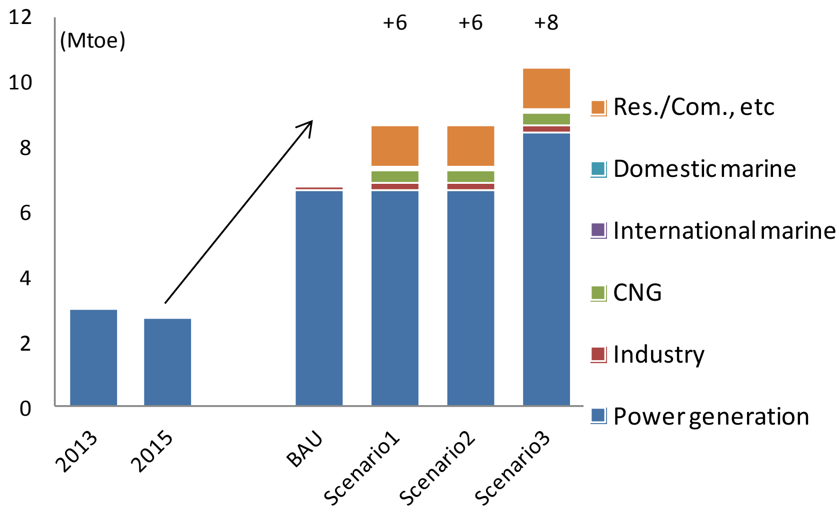
Assuming that Myanmar sets in place the supply infrastructure to meet all the potential demands for natural gas, the country can see some benefit from the total fuel cost (even if the LNG price is at US$11.9/MMbtu) in the power generation sector as well as other sectors under Scenario 3.

3.8 Philippines

3.8.1 Potential demand for natural gas by sector

The study estimates the Philippines' potential demand for natural gas to expand by up to 8 Mtoe/year as compared to its 2015 figures. The highest potential demand for natural gas comes from the power generation sector, followed by the residential and commercial sector.

Figure 3.16. Potential Demand for Natural Gas by Sector (Philippines)

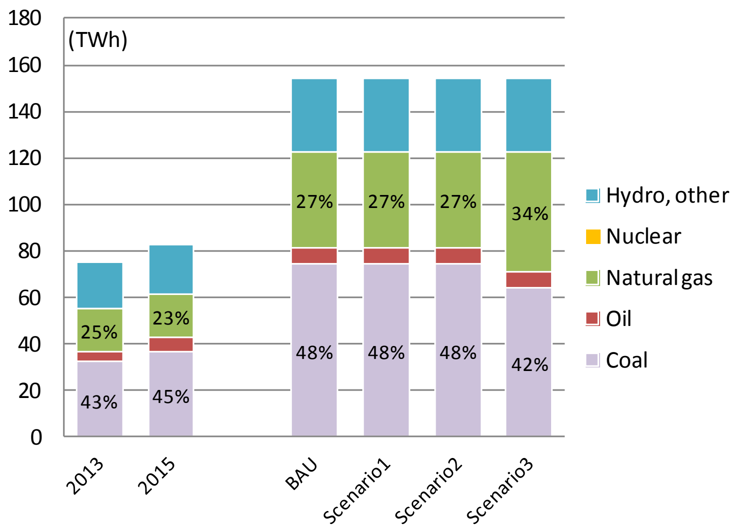


Notes: BAU = business as usual; CNG = compressed natural gas

3.8.2 Power generation structure

Results further show that the share of natural gas in the Philippines' power generation mix in 2015 was 23%. However, under the BAU scenario, the share of natural gas will increase to 27%. Furthermore, Scenario 3 assumes that the share will reach 34%. Scenario 1 and 2 have the same assumption as the BAU scenario.

Figure 3.17. Power Generation Mix, Philippines



BAU = business as usual.

3.8.3 Cost and CO_2 emission comparisons

In the power generation sector, the heat efficiency of GPP is higher than that of CPP, while the required input energy of GPP is smaller than that of the CPP. However, the coal price (US$125/toe) is significantly lower than the LNG's price (even at US$6/MMbtu (US$238/toe). Therefore, Scenario 3 shows an increase in fuel cost.

However, Scenario 3 sees lower construction costs as well as lesser CO_2 emission from GPP than from CPP.

Table 3.13. Cost and CO_2 Emission (Power Generation), Philippines

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+0.6	+0.4	+0.1	-0.05	-5.1 (-15%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

In the country's other sectors, natural gas is seen to replace oil. Likewise, a large benefit is anticipated in terms of fuel costs since the LNG price of US$11.9/MMbtu (US$472/toe) is lower than that of crude oil (US$820 /toe). There will also be lesser CO_2 emission coming from natural gas than from oil.

Table 3.14. Cost and CO_2 Emission (Other Sectors), Philippines

Fuel import cost			**CO_2 emission** (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.6	-0.8	-1.0	-0.001 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If the country meets the potential demand for natural gas, there will be a benefit in total fuel costs in all sectors (including the energy generation sector) if the LNG price is US$9/MMbtu or US$6/MMbtu. Where the LNG price is US$11.9/MMbtu, the increase in fuel cost in the power generation sector will be offset by the fuel cost reduction in other sectors.

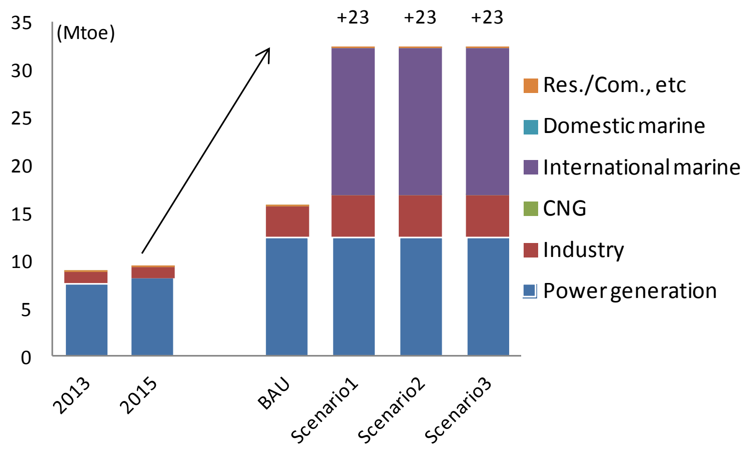
3.9 Singapore

3.9.1 Potential demand for natural gas by sector

Singapore's potential demand for natural gas is estimated to be larger by up to 23 Mtoe/year compared to the figures in 2015.

The international marine bunker sector has the highest potential demand for natural gas. Currently, Singapore has a large international bunker fuel market. The study assumes thus that the market in LNG bunkering will also exhibit significant growth in the future. In addition, the natural gas demand is expected to become stronger than the BAU scenario in the industry sector.

Figure 3.18. Potential Demand for Natural Gas by Sector, Singapore

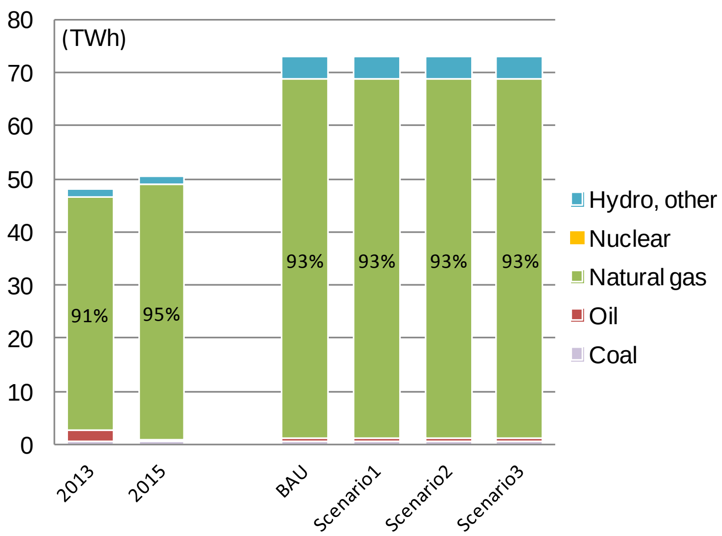


Notes: BAU = business as usual; CNG = compressed natural gas

3.9.2 Power generation structure

Results show that the share of natural gas in Singapore exceeds 90%, and Scenarios 1 to 3 are the same as the BAU scenario.

Figure 3.19. Power Generation Mix, Singapore



BAU = business as usual.

3.9.3 Cost and CO_2 emission comparisons

Singapore has a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors other than the power generation sector are compared.

In sectors other than the power generation sector, natural gas will replace oil. A large benefit in fuel cost is anticipated as estimates show that LNG that is priced even at US$11.9/MMbtu (US$472/toe) is lower than the crude oil price (US$820/toe).The specific CO_2 emission coming from natural gas is also lesser compared to that from oil.

Table 3.15. Cost and CO_2 Emission (Other Sectors), Singapore

Fuel import cost			**CO_2 emission** (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-5.8	-7.7	-9.7	-0.008 (-6%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

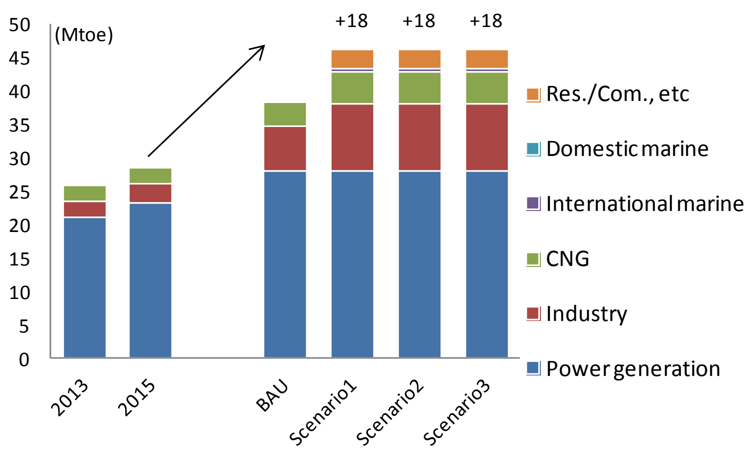
3.10 Thailand

3.10.1 Potential demand for natural gas by sector

Thailand's potential demand for natural gas is estimated to be larger by up to 30 Mtoe/year compared to 2015 figures.

Sector-wise, its power generation sector presents the highest potential demand for natural gas. However, since the share of natural gas in the total power generation is high, the potential demand for natural gas in Thailand's power generation sector remains the same as that under the BAU scenario. Higher potential demand for natural gas under the BAU scenario is assumed in the industry sector, road transport sector, and residential and commercial sector.

Figure 3.20. Potential Demand for Natural Gas by Sector, Thailand

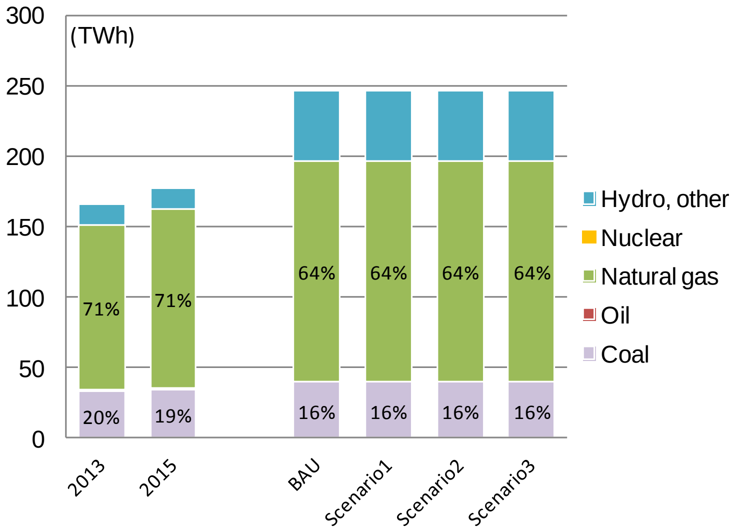


Notes: BAU = business as usual; CNG = compressed natural gas

3.10.2 Power generation structure

Figure 3.21 shows that the share of natural gas in 2013 was as high as 71%, and will be 64% in the BAU scenario for 2030. The potential demand for natural gas in the power generation sector in scenarios 1 to 3 is the same as the BAU scenario.

Figure 3.21. Power Generation Mix, Thailand



BAU = business as usual.

3.10.3 Cost and CO_2 emission comparisons

Thailand shows a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors outside of the power generation sector are compared.

In other sectors (i.e. excluding the power generation sector), natural gas will replace oil. A large benefit in the cost of fuel is expected since the LNG price of US$11.9/MMbtu (US$472/toe) is lower than the crude oil price (US$820/toe). The CO_2 emission from natural gas is also lesser.

Table 3.16. Cost and CO_2 Emission (Other Sectors), Thailand

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.1	-2.0	-2.9	-0.005 (-2%)

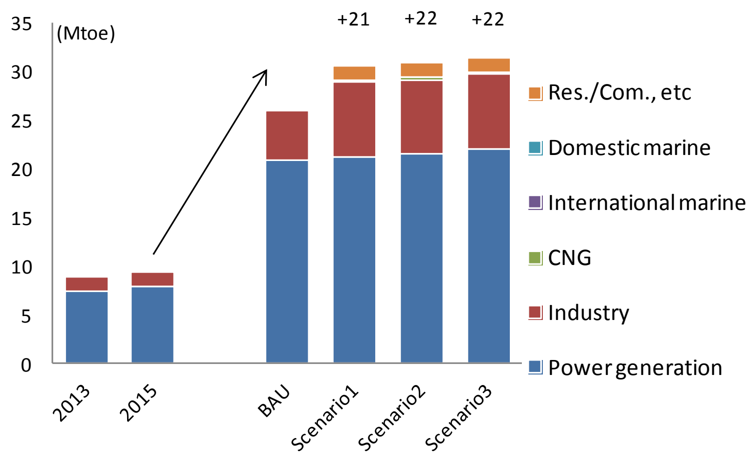
LNG = liquefied natural gas; CO_2 = carbon dioxide.

3.11 Viet Nam

3.11.1 Potential demand for natural gas by sector

Viet Nam's potential demand for natural gas is estimated to be larger by up to 22 Mtoe/year than its 2015 levels. The highest potential demand for natural gas comes from the power generation sector and the industry sector.

Figure 3.22. Potential Demand for Natural Gas by Sector, Viet Nam

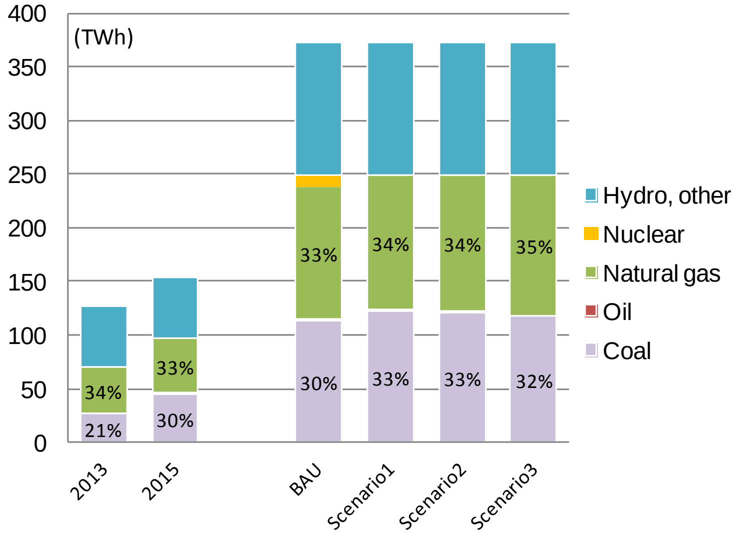


Notes: BAU = business as usual; CNG = compressed natural gas

3.11.3 Power generation structure

Viet Nam's BAU scenario assumes that an NPP will commence operation in 2028. However, in this study, the assumption used is that no NPP would commence operation even in 2030. Assuming further that the NPP power generation equivalent in the BAU scenario would be replaced by thermal power generation, the study's three scenarios allocate different mixes of coal and natural gas.

Figure 3.23. Power Generation Mix, Viet Nam



BAU = business as usual.

3.11.3 Cost and CO_2 emission comparisons

In the power generation sector, the heat efficiency of GPP is higher than CPP, while the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is significantly low when compared to even the lowest LNG price of US$6/MMbtu (US$238/toe). Therefore, the fuel cost increases under all this study's scenarios.

Since the cost of constructing a GPP is lower than that of the CPP, there are some gains under all scenarios.

As mentioned earlier, the increase in the construction cost under the BAU scenario is based on the assumption that Viet Nam's NPP will commence operation in 2028. However, under the three scenarios, the assumption is that no NPP will commence operation even in 2030. This is because the NPP power generation under the BAU scenario is anticipated to be replaced with thermal power generation. While neither CPP nor GPP are the equivalent of the NPP power generation, both are expected to increase on a net basis.

Note that since estimates on the NPP construction cost are difficult to draw, only the TPP construction cost is considered in this study.

The CO_2 emission decreases in all three scenarios when GPP is preferred more over CPPs. However, CO_2 emission as well as the construction cost climb once nuclear power generation becomes the option in Viet Nam.

Table 3.17. Cost and CO_2 Emission (Power Generation), Viet Nam

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.4	+0.3	+0.3	+0.1	+8.9 (+6%)
2	+0.5	+0.4	+0.3	+0.1	+8.1 (+5%)
3	+0.6	+0.5	+0.4	+0.1	+6.5 (+4%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Meanwhile, in all other sectors, natural gas will replace oil. Even if the LNG is priced at US$11.9/MMbtu (US$472/toe), it remains lower than the crude oil price (US$820/toe). Aside from the lower fuel cost, the CO_2 emission from natural gas is also lesser than that from oil.

Table 3.18. Cost and CO_2 Emission (Other Sectors), Viet Nam

Fuel import cost			CO_2 emission (Million tons CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.5	-2.0	-2.5	-0.002 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If all the potential demand for natural gas is met, an improved fuel cost is expected to benefit both the power generation sector and other sectors as a whole even at the LNG price of US$11.9/MMbtu.

Chapter 4

Policy Recommendations

Compared to coal and oil, natural gas has various advantages, including an environmental benefit. However, natural gas is weak in some aspects such as in infrastructure availability and competitiveness in fuel price. Therefore, to realize the potential demand for natural gas, it is necessary to have a powerful political support.

The policy recommendations here are meant to help realize the potential demand for natural gas. Also, specific tasks by sectors are summarized at the end of this chapter.

1) Have clear policies on the promotion of natural gas use.

- **Set energy/electricity mix target.** It is necessary for the government to first clearly position natural gas in the medium- to long-term primary energy supply or power generation mix. Without these guidelines on how to expand the uses of natural gas in the medium to long term, companies will hesitate to make any investment, as this involves risks.
- **Formulate climate and environmental regulations** (i.e. promotion of lower carbon energy). To make use of the advantages of natural gas over other fossil fuels, environmental regulations ought to be strengthened. For instance, regulations that encourage the growth of low-carbon energy sources can promote the use of natural gas.

2) Enhance economical competitiveness of natural gas.

- **Eliminate energy subsidies.** Price is an important factor in the selection of an energy source, particularly in the industry sector. In many final consumption categories, natural gas competes with oil products. If subsidies were adopted for oil products, the price-competitiveness of natural gas would be eroded. Subsidies would also distort market mechanisms. Therefore, all subsidies for energy prices must be removed by phases. Eliminating these subsidies will help achieve the potential demand for natural gas as well as reduce the government's financial deficits.
- **Set mechanisms to institutionalize the environmental value of natural gas.** Although natural gas is superior to other fossil energy sources from the environmental viewpoint, many countries have not appropriately reflected this in prices. Adopting a mechanism that reflects the difference in environmental performance in prices will raise the competitiveness of and demand for natural gas.

3) Support the development of supply infrastructure (LNG receiving terminal, pipeline, etc.).

- **Help elicit residential and commercial demand.** The natural gas supply infrastructure requires an enormous investment. Therefore, it is difficult for investors to decide on an investment unless a certain level of demand for natural gas is secured. In this sense, one of the ideas is to implement the conversion to natural gas in the residential and commercial sector under the leadership of the current administration.

- **Dialogue with stakeholders to gain acceptance.** Any construction of an LNG receiving terminal or a pipeline may face opposition from residents around the terminal or along the pipeline because of safety concerns. To cope with such a movement, it is necessary to engage in dialogues with the affected people.

- **Present a clear regulatory framework.** Before building a natural gas supply chain such as an LNG receiving terminal and a pipeline, it is necessary to clarify the regulations on their construction and operation beforehand. Those planning to set up city gas businesses or sell natural gas to households would also need to be aware of and abide by existing regulations.

- **Consider financial support** (e.g. low interest rate loan, tax benefit). Building a natural gas supply infrastructure and setting up a city gas business will require enormous investments. Therefore, realizing the potential demand for natural gas poses huge financial challenges. This may require operators to solicit financial support such as in terms of low-interest loans from a domestic or overseas public financial institution or a preferential tax benefit for the construction of an LNG receiving terminal or a pipeline.

4) Build human capacity.

- **Bring in competent regulators.** In the supply of natural gas, governments must create ordinances that can regulate and manage businesses, set technical standards for safety, and monitor the market, including prices. Therefore, it is essential to have competent experts and market regulators whose scope includes:

  - ❖ Development of laws and regulations.
  - ❖ Development of safety (technical) standards.
  - ❖ Control and monitoring of market (i.e. enforcement of regulations, change of price)
  - ❖ Gas business operation (commercial and technical operations)
  - ❖ Gas utilization technology.

Table 4.1. Factors Affecting the Increase in Natural Gas Demand

Sector	Political factor	Economical factor	Social factor	Technological factor
Cross sectoral	• Insufficient policy to promote natural gas use (e.g. energy mix policy, air/GHG emission regulation) • Insufficient regulatory framework for commercial and technical operation of gas business • Insufficient human capability to develop necessary policies and	• Competition with other forms of energy • Existing energy price subsidies – Hidden true cost of energy – Uneven competition • No mechanism to internalize • Large upfront cost of supply infrastructure	• Insufficient knowledge for natural gas • Local acceptance for natural gas-related infrastructure (including land acquisition, landscape, problems of fournd	• Lack of technologies, know-how, engineers • No technical/safety standard for natural gas use
Power generation	• Contradiction with policy to protect domestic coal industry • Contradiction with policies for other power sources	• Price competitiveness against coal • Price competitiveness against cost-reducing renewable energy	-	• Lack of technology and industry for O&M of GPP
Industry	• Less incentive for replacing old equipment due to lax EE&C policy	• Secure critical minimum demand to make gas business feasible • Too far from primary supply location to be economically feasible • Less capability of small & medium size eneterprises and people for investment • Competition with electricity	• Low awarness of benefits of natural gas use	• Lack of technologies, know-how, engineers for city gas business • Lack of supply of natural gas utilization equipment
Residential & commercial	• Insufficient regulatory framework for city gas business		• Low awarness of benefits of natural gas use • Concern for gas safety	
Road transportation	• Absence of promotion policy • Absence of regulation	• Small number of natural gas fueling station • Competition with EV, biofuel	• Low awarness of benefits of natural gas use among freight operators	• Insufficient supply of natural gas/LNG driven fleet • Absence of technical standards
Marine transportation		• Small number of bunkering port • Competition with low sulfur oil		

References

International Energy Agency (2015), *Southeast Asia Energy Outlook 2015*. Paris: International Energy Agency.

International Energy Agency (2016), *CO_2 Emissions from Fuel Combustion 2016*. Paris: International Energy Agency.

International Energy Agency (2016a), *World Energy Outlook 2016*. Paris: International Energy Agency.

UDI World Electric Power Plants Database (2017), Published by S&P Global Platts. Updated 10 January 2017.