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Natural Gas Master Plan for Myanmar

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Foreword

Myanmar is endowed with rich natural resources in quantities that, if fully developed, would be sufficient to meet most of the country's daily energy needs. Myanmar's energy policy is generally aimed at ensuring energy independence by increasing national production of available primary energy resources through intensive exploration and development activities. Myanmar also acknowledges electricity as the main power source driving economic development and it addresses the need to generate and distribute more power in terms of greater volumes, density, and reliability. Myanmar's natural gas will play a very important role in Myanmar's future. Although Myanmar has been a major producer of natural gas in Asia, the country has not fully utilised natural gas for its own uses. As energy demand is expected to increase significantly in the future, Myanmar will need to have a clear policy direction towards its resource uses, including the natural gas development for both import and export. However, natural gas is expected to have a larger share of the primary energy mix, just after oil, by 2040.

Thus, Myanmar's natural gas will play a greater role in providing energy security as the country will be exposed to increasing energy demand in all sectors particularly gas consumption in the power sector and industries. Myanmar's oil and gas sector faces several challenges that will have to be overcome to ensure its sustainability. Domestic gas will need to be managed effectively to secure a stable supply to businesses and end-use consumers.

The Natural Gas Master Plan is designed to be the country's long-term plan as it should ensure sustainable energy sector development and conserving the environment sustainably. It also necessitates adopting national strategies for a sustainable and reliable energy supply, ultimately complementing the United Nation's Sustainable Development Goals of 2015. Natural gas has become the preferred fuel in Myanmar in terms of available reserves, environmentally friendly electricity generation, as well as the development of industry. Thus, the natural gas demand cannot be realised without infrastructure development. That is why the Natural Gas Master Plan places such high importance on energy infrastructure development such as investment in and development of the upstream sector, the pipeline sector, the LNG sector, and city gas as well.

The Natural Gas Master Plan provides us with a clearer view of the most likely future energy landscape including key trends that are likely to shape Myanmar's energy mix over the next 20 years. Natural gas will serve as a backbone for fueling economic growth as we look to the decades ahead.

The Ministry of Electricity and Energy of Union of Myanmar (MOEE) and the Economic Research Institute for ASEAN and East Asia (ERIA) have carried out this valuable study, which will serve Myanmar's energy security interests by utilising natural gas development for sustainable economic growth.

The MOEE and ERIA look forward to further fruitful cooperation on energy policy support for Myanmar, so the country can use its resources to steer economic growth in a sustainable way.



U Win Khaing
Union Minister
Ministry of Electricity and Energy
December, 2018



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The Natural Gas Master Plan of Myanmar was prepared by the Economic Research Institute for ASEAN and East Asia (ERIA) at the request of the Oil and Gas Planning Department (OGPD), Ministry of Electricity of the Union of Myanmar. My compliments, on behalf of the Ministry of Electricity and Energy, to ERIA and the Institute of Energy and Economics, Japan (IEEJ) for their efforts in preparing this Natural Gas Master Plan. I am also very grateful for all support provided by the staff of OGPD, for their full support of the experts in providing government policy documents related to energy policy development in Myanmar as well as their assistance in field data collection.

I also congratulate ERIA on producing sound estimates of natural gas supply, demand, and trade balances up to 2040. I am very impressed with the results of this master plan for what infrastructure to develop to ensure that the supply of Natural Gas or Liquefied Natural Gas (LNG) meets future demand. I firmly believe that this plan provides a stable, sustainable, and reliable energy supply to ensure long-term economic stability.

Myanmar's pipeline network is becoming a pressing issue for the government. We are aware that the role of natural gas is vital for the economic development of the country and we need to adopt the comprehensive and integrated Master Plan. We hope that it will become the foundation for the long-term sustainable development of the energy sector.

I would like to express our appreciation to all the energy ministries concerned, the Steering and Working Committee members of the Natural Gas Master Plan, ERIA, and IEEJ, for their efforts and cooperation during the planning process and the Gas Master Plan Study.

After this planning process, we have to embark on the implementation phase of the Natural Gas Master Plan. The Ministry will count on ERIA's participation to help guide this plan's implementation and we are hoping to receive ERIA's continuous support and cooperation in our upcoming energy development activities.



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List of Abbreviations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
bbbl	barrel
bcm	billion cubic metres
CNG	compressed natural gas
CNPC	China National Petroleum Corporation
ERIA	Economic Research Institute for ASEAN and East Asia
FID	final investment decision
FSRU	floating storage regasification unit
FY	fiscal year
GDP	gross domestic product
IEEJ	Institute of Energy Economics, Japan
IMF	International Monetary Fund
km	kilometre
LNG	liquefied natural gas
LPG	liquefied petroleum gas
m	metre
MDB	multilateral development bank
MEMP	Myanmar Energy Master Plan
MIPC	Myotha Industrial Park City
MIZ	Mandalay Industrial Zone
MMBtu	million British thermal units
MOEE	Ministry of Electricity and Energy
MOGE	Myanma Oil and Gas Enterprise
mtpa	million tonnes per annum
MW	megawatt
NEP	National Electrification Plan
PTTEP	PTT Exploration and Production
SEZ	Special Economic Zone
US	United States
YBS	Yangon Bus Services

Executive Summary

Natural gas will play very important role in Myanmar in the future. Although Myanmar has been a major producer of natural gas in Asia, the country has not fully utilised natural gas for its own uses. Thanks to the sustained economic growth that has followed the 2011 economic reform, the demand for energy and natural gas has grown significantly. Demand for natural gas in Myanmar has increased 1.4 times since 2011, the second largest demand growth after oil. The primary driver of this growth has been demand for natural gas to generate power, which accounted for 72% of total natural gas consumption in 2017. Natural gas (compressed natural gas) is also used by the transportation sector as fuel, but demand from the industrial sector is limited, and there is no residential demand as of 2017.

Natural gas demand is forecasted to grow from 457 million cubic feet per day (mmcf) in 2017 to 1,142 mmcf in 2040. Although demand from the power sector will continue to lead demand growth in the country, demand from the industrial sector and (after 2030) the residential sector is also expected to grow significantly.

Industrial demand for natural gas will be mainly observed in the Yangon and Mandalay regions. Thilawah Special Economic Zone (SEZ), in particular, is a prospective user of natural gas for manufacturing. Once the supply infrastructure is developed, city gas will become a more cost-competitive energy source than liquefied petroleum gas such as butane. Natural gas will be increasingly demanded by power plants that supply electricity to manufacturing factories in the SEZ. Because the SEZ is located close to the existing pipeline network, the cost of developing the necessary infrastructure will be limited. The investment cost of developing industrial demand in the Yangon region is estimated at \$3.5 million.

Natural gas demand from the industrial sector in the Mandalay region will be developed in several locations. To develop industrial demand in Mandalay Industrial Zone, near downtown Mandalay, a pipeline network more than 40 km long needs to be constructed. Due to the high cost of such infrastructure development, some form of public support will be required to realise the pipeline development. Another potential demand area is Myotha Industrial Park City. Located near the existing natural gas export pipeline to China, it has good access to a natural gas supply and, given the size of the area, has significant potential to develop demand in the future. The required total investment to develop industrial demand in the Mandalay region is estimated at \$24.5 million.

Residential demand will take longer to realise than industrial demand. This is because infrastructure development is more difficult in economic terms due to the small size of each demand lot. In a country like Myanmar, residential demand for natural gas is usually used for cooking, and there is no large demand for hot water unlike in northeast Asia or Europe. Residential demand for natural gas will be realised in New Yangon City (currently under consideration), Yangon, and downtown Mandalay city. Demand in both Yangon and Mandalay will be realised after 2030. Overall strong government commitment and policy implementation are necessary to create residential demand in Asia. The required investment amount for residential demand development is estimated at \$0.7 million in Yangon and \$2.5 million in Mandalay.

Demand from the transportation and fertiliser feedstock sectors will remain mostly flat. Existing fertiliser plants will continue operating and a new plant may be onstreamed once a natural gas feedstock becomes available. CNG will also be utilised as a primary fuel for public transportation in Yangon city, and demand will slowly grow in the future as the number of bus passengers increases.

On the other hand, domestic natural gas production is forecasted to decline. Two offshore fields and several onshore fields are in development, and production from these new supply sources will increase; however, such growth, even if fully realised as scheduled, will only partially offset the decline in production from existing fields. As of 2017, 75% of domestic production is exported to Thailand and China. As domestic production declines, the export volume will also need to be reduced. To make up the gap between declining supply and increasing demand, three LNG-receiving projects are being discussed. All three projects are in the south of the country and are associated with gas-fired power generation.

As the country's dependence on natural gas grows, its domestic infrastructure will need to be upgraded. Without a well-functioning pipeline network, the natural gas supply to final consumers will be unstable, leading to economic and supply security problems. The pipeline connecting Shwedaung and Magway in particular needs to be renovated urgently as it is currently out of service due to corrosion and leakage. Renovating the pipeline will restore the north-south pipeline linkage, making it possible to allocate natural gas more efficiently and improve supply security. The amount required for the renovation is estimated at \$77.4 million.

Gaps are expected to appear in Myanmar's natural gas balance around 2023. This suggests that the country will need to import LNG, reduce exports to Thailand and China, or otherwise restrain domestic demand further. Importing LNG will likely be the most realistic

option, and deploying floating storage and regasification units will make it relatively easy to import LNG to Myanmar. Myanmar may also be able to reduce natural gas exports and allocate more gas to domestic demand if Thailand and/or China agree. However, reallocating natural gas will only postpone the need to import LNG for a few years. In any case, Myanmar will need to import LNG by the early 2030s at the latest.

The Government of Myanmar should continue to play a pivotal role in developing the natural gas market. Since a market mechanism cannot fully reflect the benefits offered by natural gas, including its nature as a clean and low-carbon source of energy, the supply security advantages that it offers, and the convenience of its use, the government should provide policy support to promote the use of natural gas. Such policy actions include the following:

- (i) Create demand. Natural gas demand is created; it does not emerge automatically. The government should create initiatives to develop infrastructure and implement relevant policy arrangements such as setting an energy mix target.
- (ii) Encourage and accelerate domestic upstream development. Since domestic natural gas production is the most reliable supply source available, all projects at the development stage should be developed in a timely manner and exploration efforts should continue.
- (iii) Enhance the resilience of the pipeline network. Myanmar's pipeline network is in a vulnerable condition and may experience more interruptions due to leakages. A comprehensive review of the domestic pipeline network and renovation of critical parts of the existing network should be undertaken.
- (iv) Reform the energy pricing system. The current pricing system needs to be reformed to ensure sufficient returns from infrastructure development. Gradual but steady reform will be required.
- (v) Manage quality issues with natural gas. The allocation of high and low heat-value gas needs to be optimised after LNG is imported.
- (vi) Grow human capital to utilise LNG. Although Myanmar has extensive human resources to deal with natural gas, importing and utilising LNG requires another type of expertise. Training the country's natural gas experts will facilitate LNG imports and use in the future.

Natural gas is a very promising energy source, and there is no reason that Myanmar should forego this valuable option in developing its future energy mix. Firm commitment and proactive policy planning and implementation will lead to a 'gasified Myanmar' in the near future.

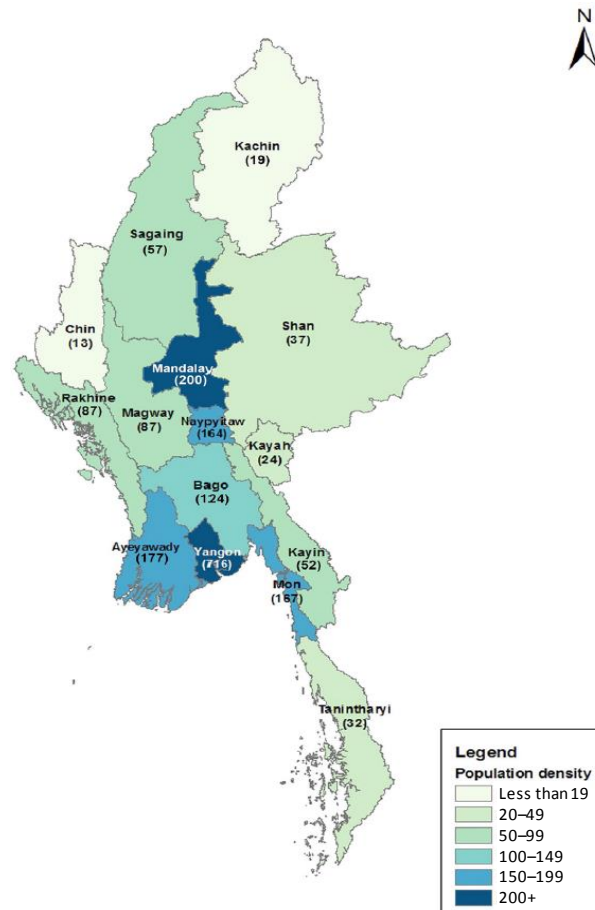
Chapter 1

Introduction

1. Background and Study Objectives

Myanmar is the largest country in mainland Southeast Asia, with 14 states and regions, and a land area of 676,577 square kilometres (Figure 1.1). Bordered by China, Thailand, and India, Myanmar occupies a strategically important position in Southeast Asia. Central states such as Yangon and Mandalay, which contain large cities, have a higher population density, while the northeastern states of Kachin and Shan are more demographically dispersed.

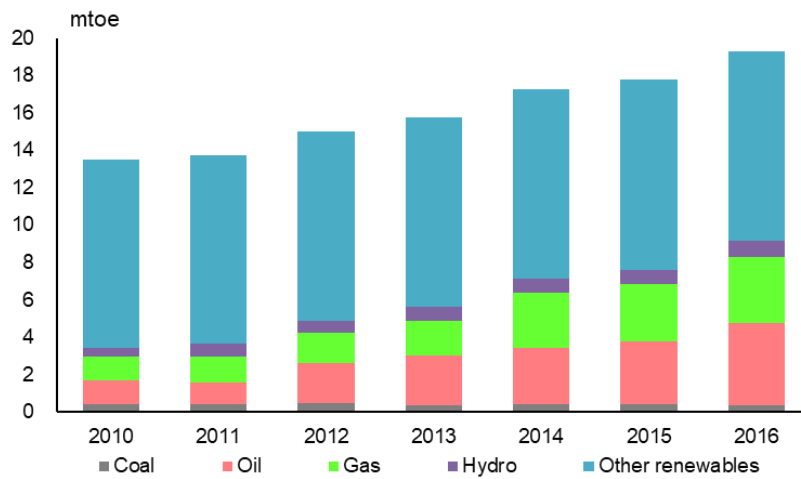
Figure 1.1: Administrative Regions and Population of Myanmar



Source: Myanmar Department of Population (2017b).

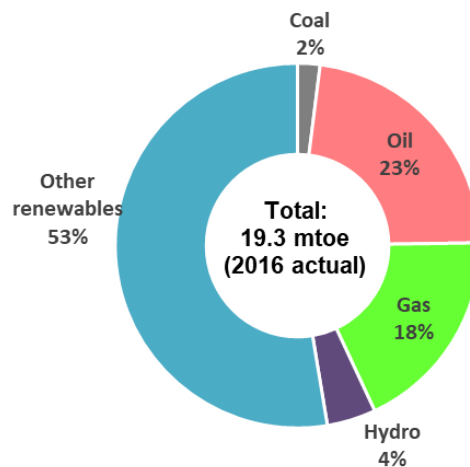
Since the 2011 economic reform, Myanmar’s economy has achieved remarkable growth. During 2011–2016, the average annual gross domestic product (GDP) growth rate was 7.0%, much higher than both the global average (3.6%) and the average of the Association of Southeast Asian Nations (ASEAN)-5 countries (Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam) (5.1%) (IMF, 2018). Backed by sustained economic growth, energy demand in Myanmar also increased remarkably. From 2011 to 2016, the country’s GDP expanded 1.52 times and energy demand increased 1.43 times. With the current high economic growth likely to continue, Myanmar is in the process of expanding its economic activities significantly and becoming an economic power in Asia.

Figure 1.2: Total Primary Energy Supply of Myanmar (2010–2016)



Hydro = hydropower, mtoe = metric tonnes of oil equivalent.
Source: International Energy Agency (2018).

Figure 1.3: Total Primary Energy Supply of Myanmar (as of 2016)



Hydro = hydropower, mtoe = metric tonnes of oil equivalent.
Source: International Energy Agency (2018).

Whether Myanmar can sustain the level of growth that it has experienced since the 2011 reform largely depends on whether it can ensure a stable energy supply. Myanmar's energy consumption is currently one of the lowest in the world (134th of 143 countries), with a per capita consumption rate of 0.365 tonnes of oil equivalent in 2016 (International Energy Agency, 2018). This suggests that the country will need an immense volume of energy to continue its economic growth.

The importance of natural gas, which currently accounts for only 18% of the country's energy mix, is expected to increase sharply. Demand for gas will rise, particularly from the power generation sector, as building additional hydropower plants becomes more difficult for environmental reasons. Sound economic and social development in Myanmar will be unachievable without a stable energy supply, and the country's socioeconomic future largely hinges on this factor.

Given this energy demand scenario, the major objectives of the Myanmar Natural Gas Master Plan are as follows:

- (i) To forecast Myanmar's natural gas demand, supply, and trade balances through 2040;
- (ii) To explore the possibility of using gas in large cities in Myanmar;
- (iii) To understand what infrastructure must be developed to ensure that the supply of natural gas or liquefied natural gas (LNG) meets future demand; and
- (iv) To consider policy options to 'gasify' the country's energy mix.

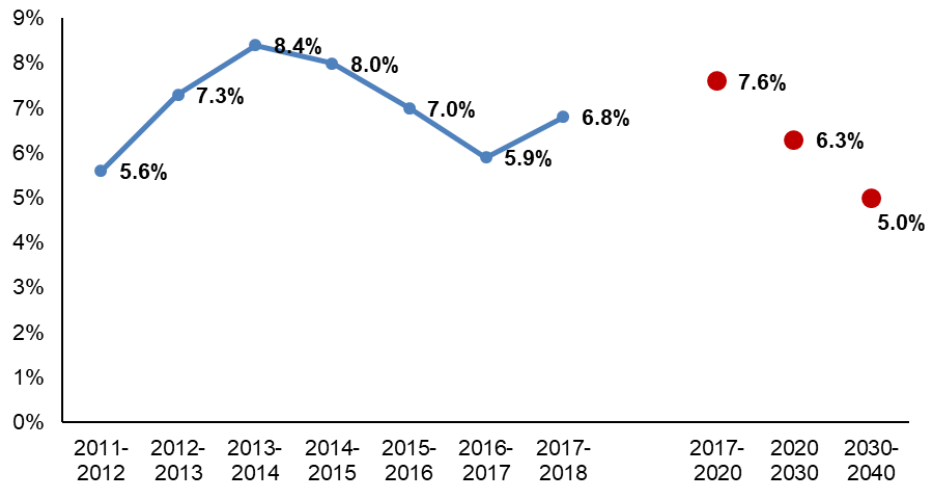
2. Key Assumptions

To prepare a future energy supply and demand outlook, it is critically important to provide appropriate assumptions for several key benchmarks.

2.1. Gross Domestic Product and Macroeconomics

Myanmar has achieved significant economic growth since the 2011-2012 economic reform, with rates as high as 8.4 percent in fiscal year 2013-2014 (Figure 1.4)

Figure 1.4: Gross Domestic Product Growth Rate and its Outlook

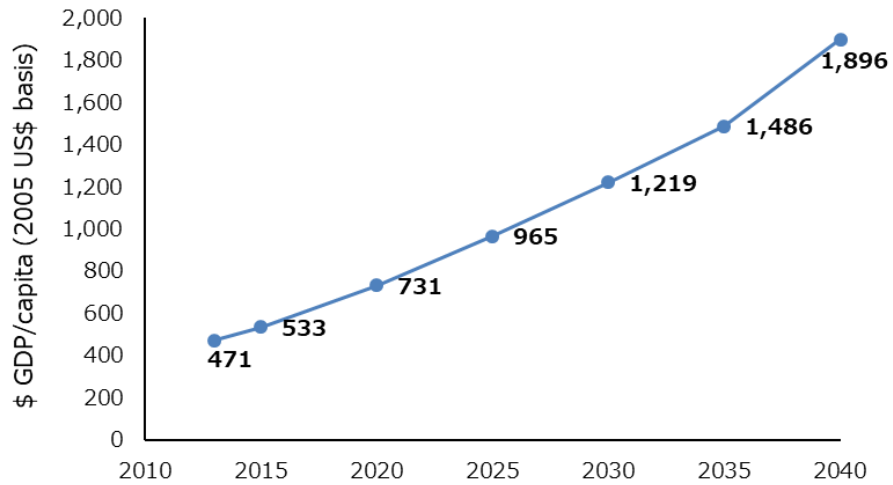


Sources: Data provided by the Government of Myanmar; figures beyond 2017–2018 are based on the Economic Research Institute for ASEAN and East Asia (2016).

In terms of GDP growth, the country is highly likely to sustain its current strong economic performance until 2020 and beyond. Many major institutions project that the country’s economy will continue to perform well in the coming years. The Asian Development Bank’s Energy Master Plan estimated the GDP growth rate at 7.1% through 2030 (ADB, 2015: 7), and the International Monetary Fund (IMF) estimates that this rate will remain above 7% at least through the mid-2020s (IMF, 2018). In line with the previous energy outlook prepared by the Economic Research Institute for ASEAN and East Asia, this study places the average GDP growth rate during the study period at 6.8%. More specifically, it is estimated that growth will reach 7.6% in 2015–2020, 6.3% in 2020–2030, and 5.0% in 2030–2040 (Figure 1.4) (ERIA, 2016). The growth rate is expected to moderate as the country’s economy expands, as seen in many other developing countries.

GDP per capita, which affects the level of energy demand, has also increased significantly since 2010, and is forecasted to reach \$731 in 2020, \$1,219 in 2030, and \$1,896 in 2040. However, although this figure is growing steadily, it is not high enough assuming that city gas will be used extensively in the residential and commercial sectors. City gas use in these sectors will be limited to large cities with higher incomes through 2040.

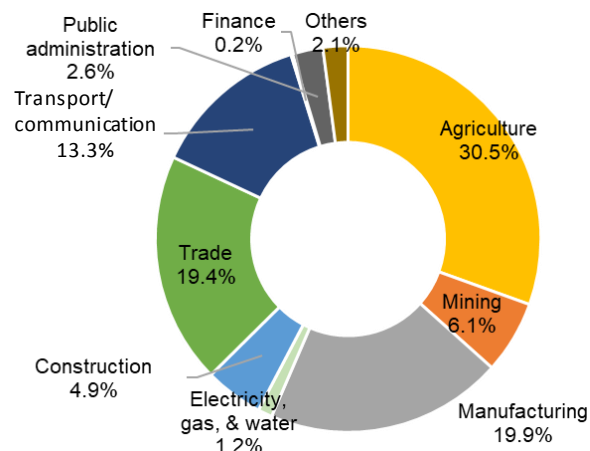
Figure 1.5: Gross Domestic Product per Capita and its Outlook



GDP = gross domestic product.

Sources: Data provided by the Government of Myanmar; figures beyond 2017 are based on the Economic Research Institute of ASEAN and East Asia (2016).

Figure 1.6: Gross Domestic Product Component of Myanmar as of 2012



Source: Asian Development Bank (2015).

The largest economic sector in Myanmar is agriculture, which accounts for more 30% of the country's GDP. Myanmar is known for its fertile soil and delta areas along the Ayeyarwady River. The country has been a major exporter of rice to other Asian countries for many years, and beans and rice are two of the country's primary export products. While

other economic sectors such as manufacturing will grow, agriculture will remain a cornerstone of Myanmar's economy through 2040.

Another important economic sector in Myanmar is that of natural resources. Myanmar for many years has been known for its mining resources, particularly natural gas, which is by far the country's largest export commodity. Myanmar began exporting natural gas to Thailand in 2000, and to China in 2014. Thanks to the discovery of new natural gas fields off the country's northwestern coast and rising international commodity prices since 2011, exports of natural gas to Thailand have increased significantly, bringing Myanmar a sizeable amount of export revenues. Domestic demand for natural gas is growing and industrial users in Myanmar are facing supply shortages (see Chapter 5). However, as natural gas exports are a valuable source of earned foreign currency for the country, and the exports to Thailand and China are based on long-term contracts, it will not be easy to reallocate exported natural gas to domestic needs.

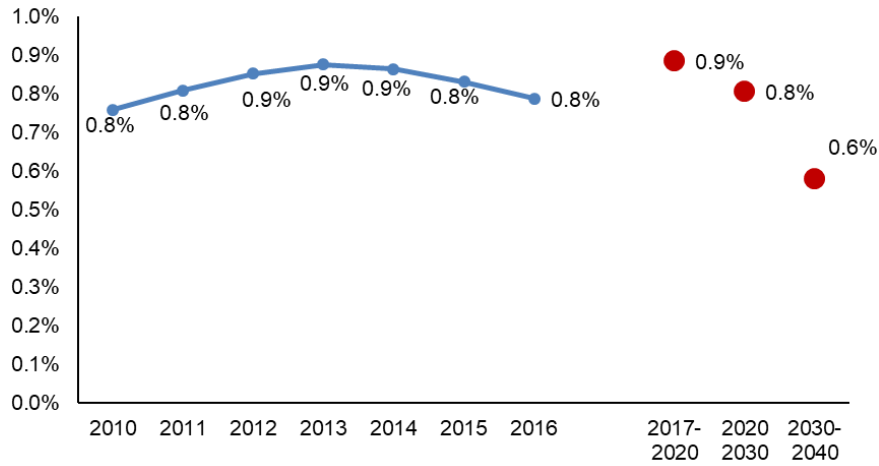
Recent economic growth has been also driven by the expansion of manufacturing activities. Economic reform policies implemented by the Government of Myanmar have played a critical role by allowing more foreign direct investment and the operation of private businesses, including foreign companies. Although there are several manufacturing bases and factories in Yangon and Mandalay, much of the manufacturing in the country is considered 'light industry' in terms of energy consumption such as food processing, the assembly of automobile parts, and textile sewing. The potential natural gas demand from the industrial sector is not currently expected to be very large; however, if large economic zone projects currently planned in Yangon or Mandalay succeed in inviting a number of investors, industrial demand for natural gas could grow significantly.

In the future, manufacturing will likely account for a higher share of Myanmar's GDP, although that of agriculture and mining will also remain high. As the country's economy becomes increasingly weighted towards manufacturing in the coming decades, its energy intensity is expected to rise, and demand growth may also accelerate.

2.2 Population

Since 2010, Myanmar's population has grown at a moderate annual rate (0.8%–0.9%). However, this represents an acceleration from the rate in the mid-2000s (0.6%), and will affect future energy demand levels.

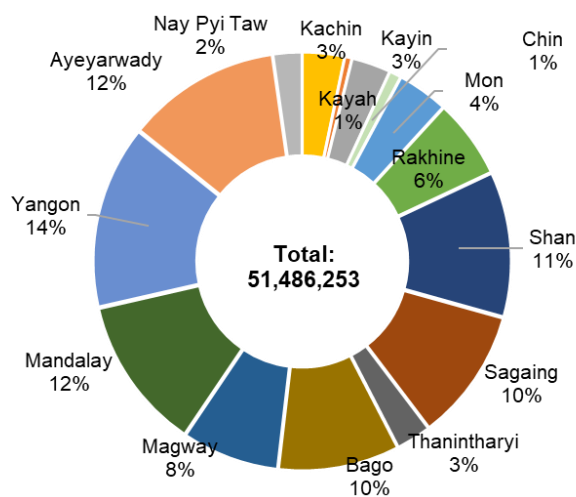
Figure 1.7: Population Growth Rates



Sources: International Monetary Fund (2018); Economic Research Institute of ASEAN and East Asia (2016).

The population census conducted by the Ministry of Planning in 2014 provided a more accurate picture of Myanmar’s population dynamics. The country’s total population was previously believed to be more than 60 million, but the census revealed that the actual figure was approximately 51 million. The census also revealed that the population is geographically diversified. Yangon, the most heavily populated region, is home to only 14% of the total population, and the number of its inhabitants does not far exceed that of Ayeyarwady, the second most populous region, nor that of Mandalay, the third (Figure 1.8).

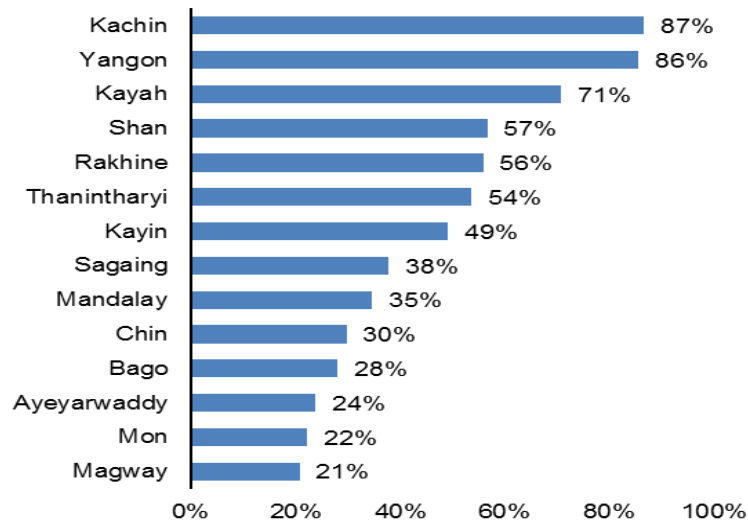
Figure 1.8: Population in Each District as of 2014



Source: Myanmar Department of Population (2017a).

The census also revealed that the northern districts of Kachin, Kayah, and Shan have higher historic rates of growth (1983–2014), while the central and southern districts (other than Yangon) have lower rates.

Figure 1.9: Population Growth Rate by Each District (1983–2014)



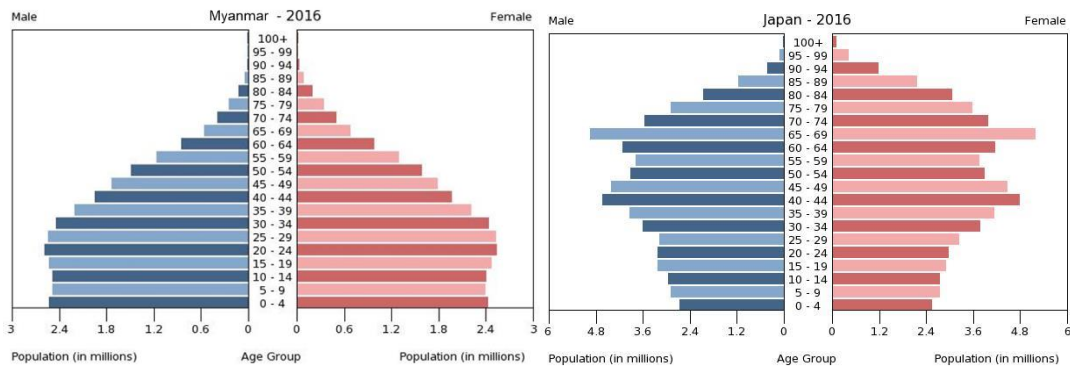
Source: Myanmar Department of Population (2017a).

The census also showed the ratio of urban to rural population in Myanmar, and revealed that 71% of the country’s total population still lives in rural areas. Access to commercial energy sources such as natural gas or oil products tends to be limited in rural areas due to logistical difficulties and higher supply costs. Inhabitants of such areas usually use conventional biomass energy including charcoal and firewood as their primary energy sources in daily life. As the country’s economy expands, more people will move to urban areas to access employment opportunities, accelerating the process of urbanisation. As the population of urban areas increases and living standards improve, this will generate a greater demand for commercial energy. As observed previously, the country’s average per capita GDP will remain moderate, but inhabitants of urban areas such as Yangon or Mandalay may be able to afford to pay for a city gas supply in the future.

Demographically, Myanmar is a relatively young country. In 2017 the median age was estimated at 28.2, the 133rd lowest of 229 surveyed countries (US CIA website). This suggests that the energy demand will increase significantly in the future. This is supported by the population pyramid in Figure 1.10, which indicates that 26.85% of the total population is younger than 14 years old. This percentage appears remarkably high compared

to an ageing country like Japan. This demographic profile means that the number of people of working age in Myanmar is increasing, allowing the country to enjoy the benefits of a ‘population bonus’, which will contribute to the economy and boost energy demand.

Figure 1.10: Population Pyramid of Myanmar in Comparison with Japan



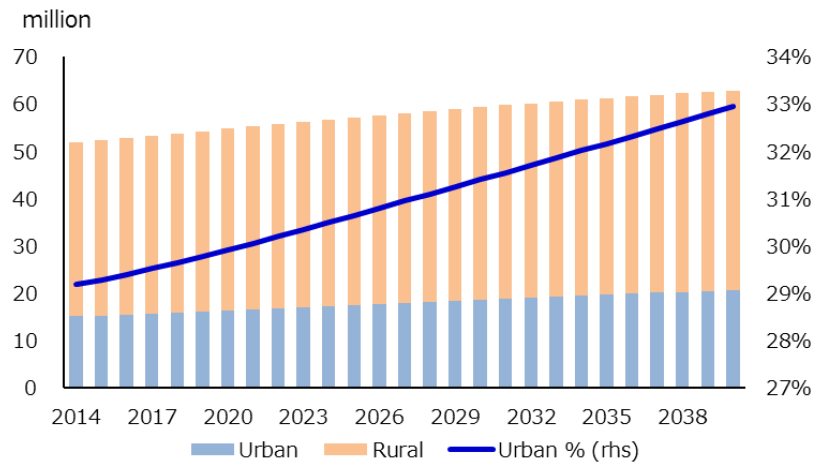
Source: United States Central Intelligence Agency website. Modified by the Institute of Energy Economics, Japan.

The country’s population is forecasted to grow from 52.5 million in 2015 to 62.9 million in 2040.¹ Early in the outlook period the population growth rate is expected to be high because a large share of the younger population will have children, and an improved health care system thanks to economic growth will extend life expectancies. Growth is expected to decline in the longer term as the effect of the above factors weakens, and average fertility rates fall as the country’s economy and per capita income improves (as observed in many other countries around the world).

Urbanisation, which will influence the demand for commercial energy, will also increase steadily, from 29% in 2015 to 33% in 2040. Although a large percentage of the population still resides in rural areas, urbanisation will positively affect the demand for natural gas in urban areas.

¹ Data provided by the Ministry of Electricity and Energy.

Figure 1.11: Population in Urban and Rural Areas



rhs = right-hand scale.

Source: Data provided by the Ministry of Electricity and Energy.

2.3 Energy Prices

Another important factor affecting the volume of both energy supply and demand is the energy price. This also influences Myanmar’s macroeconomic performance as a resource-exporting country. Since the government regulates energy prices, international energy prices do not directly influence the energy demand in Myanmar; however, international prices, particularly the price of LNG, will affect the country’s future import demand and energy balance. The price of international crude oil and LNG, as well as supply and demand during the period under study, is examined in Chapter 2.

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Chapter 2

Trends in the Global Gas Market

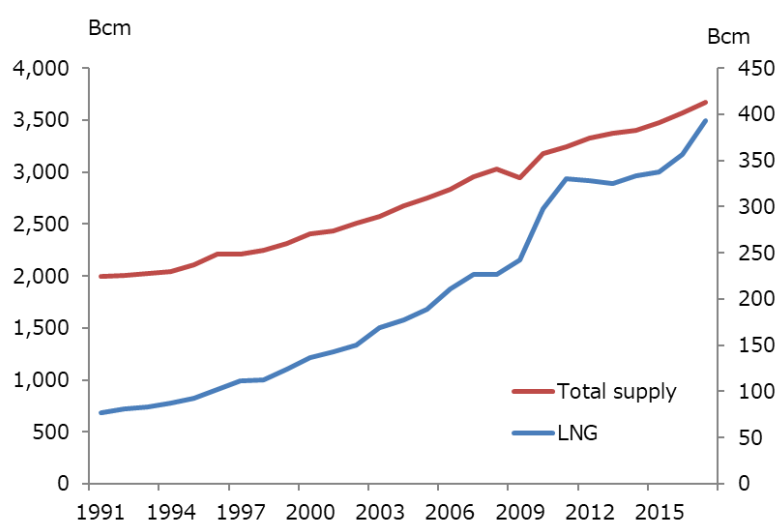
As discussed in Chapter 1, energy prices in Myanmar are regulated and international price levels do not directly affect the country's energy demand. However, the current energy pricing policy may be reviewed and possibly reformed during the period under study (through 2040). Moreover, international price levels, particularly that of liquefied natural gas (LNG), will likely affect LNG imports in the future. Based on these considerations, this chapter explores the supply–demand balance of the international LNG market and its price outlook.

1. Long-Term Outlook of Liquefied Natural Gas Supply and Demand

1.1 Overview

LNG demand in the world has increased remarkably in recent years, from just over 110 million tonnes in 1997 to almost 300 million tonnes in 2017. The LNG industry is relatively young (the first cargo of LNG was shipped from Algeria 54 years ago, in October 1964), and it is expected that the industry will continue to change and evolve.

Figure 2.1: Natural Gas and Liquefied Natural Gas Supply in the World



Bcm = billion cubic metres, LNG = liquefied natural gas.

Source: BP (2018).

The LNG industry's latest expansion phase was characterised by unprecedented transformation. The supply capacity increased dramatically between 2009 and 2011. Then, when the Fukushima Daiichi nuclear plant accident in March 2011 prompted the shutdown of all nuclear power plants in Japan, power companies rushed to secure LNG cargo to compensate for the energy loss. The traditional LNG transaction formula, which assumed a long-term contract, could not fully accommodate the new situation with significantly expanded supply and demand and wide discrepancies in location. Instead, new trading patterns such as spot trading, short-term contracts, arbitrage, equity lifting, and portfolio trading are spreading widely in the global LNG trade.

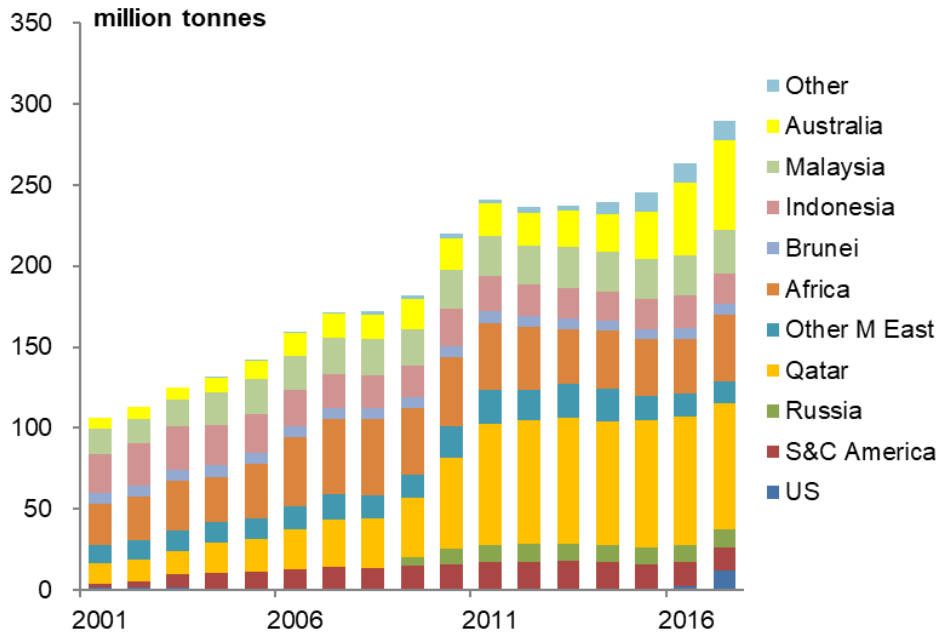
As of 2018, trading patterns are evolving further with the global LNG supply capacity increasing significantly and other LNG importers emerging, such as China. In the ongoing expansion phase, Australia and the United States (US) are increasing their presence as production centres. The wave of big project startups is almost over as the Ichthys and Prelude projects are scheduled to begin in 2018. LNG from the US will bring another layer of flexibility and liquidity to the market, as its supply is free from destination restriction.

On the other hand, emerging LNG importers are more price-elastic than traditional importers such as Japan and the Republic of Korea (henceforth, Korea) and prefer spot or short-term contracts with volume flexibility. This is because the emerging importers have more energy supply options such as domestic production, pipeline imports, coal, or even renewable energy; and LNG is regarded as a 'balancing' energy source rather than 'baseload'. Such demand characteristics are urging LNG producers to be more flexible in their supply to secure buyers.

1.2. Major Producers and Consumers

On the supply side, Qatar is by far the largest supplier of LNG, followed by Australia and Malaysia. By region, the share of traditional Southeast Asian suppliers has waned while the presence of the Middle East and Australia has consistently grown (Figure 2.2). With regard to demand, Japan has been the largest consumer of LNG for more than three decades; however, demand has been expanding rapidly in China, which surpassed Korea as the second largest LNG consumer in 2017 (Figure 2.3).

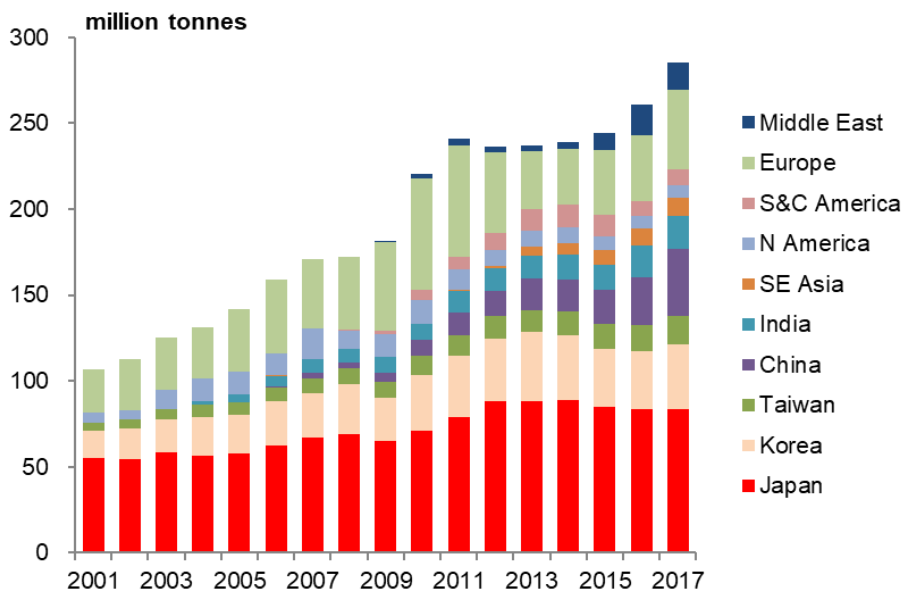
Figure 2.2: World Liquefied Natural Gas Suppliers



Other M East = other Middle East, S&C America = South and Central America, US = United States.

Source: International Group of Liquefied Natural Gas Importers (n.d.).

Figure 2.3: World Liquefied Natural Gas Consumers



N America = North America, S&C America = South and Central America, SE Asia = Southeast Asia.

Source: International Group of Liquefied Natural Gas Importers (n.d.).

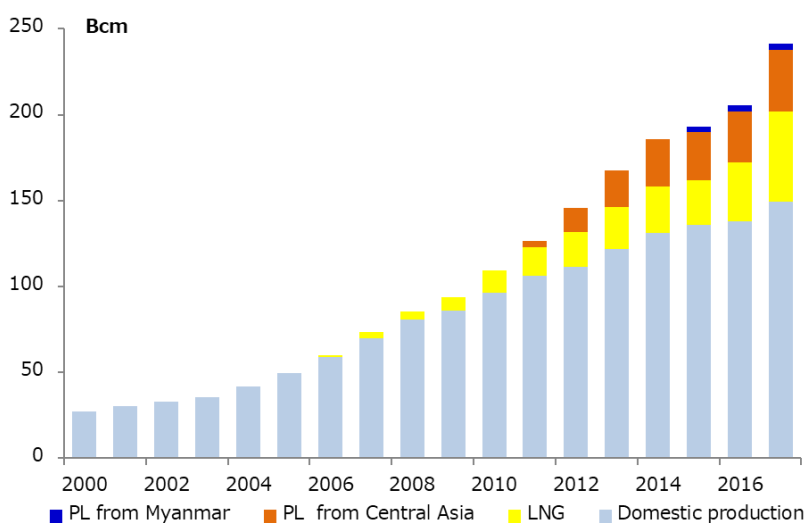
1.3 Key Players and Factors in the International Liquefied Natural Gas Market

China

China is undoubtedly one of the most important players shaping the future conditions of the global LNG market. As one of the largest LNG importers in the world (second only to Japan in 2017), the country already has a significant presence in the international LNG market. However, natural gas only accounted for 7% of the country's total primary energy supply as of 2017, and LNG only supplies 22% of the country's total natural gas demand. Thus, notwithstanding the country's increasing presence and influence in the international LNG market, LNG accounts for only 1.5% of the country's total energy supply. As this share is currently very small, there is significant potential for LNG demand in China to grow.

Of the various factors affecting China's future LNG demand, the most significant is the country's macro economy. In China, natural gas is mainly used by the power and industrial sectors, both of which are more influenced by economic activities than the residential or commercial sectors. Thus, macroeconomic conditions affect the country's natural gas demand more directly. Energy policy is also an important factor. The surge in China's LNG imports in 2016–2017 was largely due to the government's policy to restrict coal consumption to mitigate air pollution in the northeast of the country. The development of its natural gas resources also affects the natural gas balance of the country and thus the volume of its LNG imports. As China is driven to develop more difficult gas resources, including unconventional resources, the speed and extent of the future development of its gas resources will become increasingly uncertain.

Figure 2.4: Natural Gas and Liquefied Natural Gas in China



Bcm = billion cubic metres, LNG = liquefied natural gas, PL = pipeline.
Source: BP (2018), *Statistical Review of the World*. London.

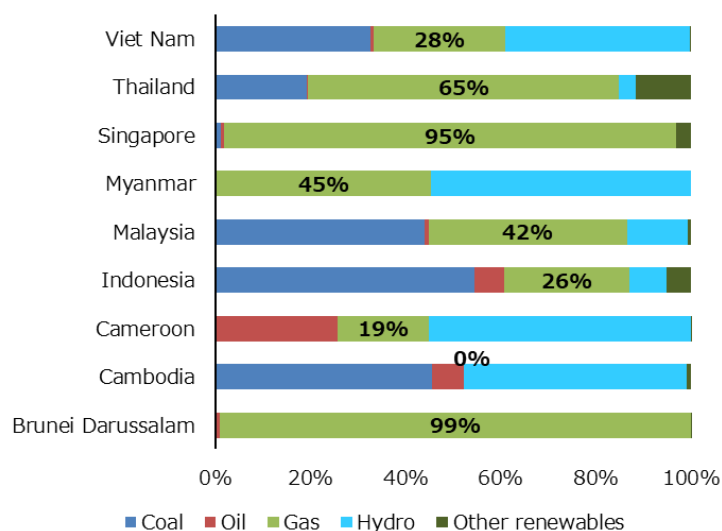
There is also notable uncertainty about when and what volume of natural gas will be imported from Russia by pipeline. In 2014, China agreed to begin importing natural gas from Russia in 2019 (through an international pipeline named the Power of Siberia) at a volume of 38 billion cubic metres per year (equivalent to 28 million tonnes of LNG). However, it is not certain whether the supply will actually start as scheduled, nor what the supplied volume will be, as it is not likely to reach peak volume in the short term due to the variable availability of natural gas. If the project is significantly delayed, China will need to enter the LNG market to make up the volume shortfall.

ASEAN markets

The Association of Southeast Asian Nations (ASEAN) used to be a major LNG-exporting region; however, due to declining domestic natural gas production and increasing domestic energy demand, three ASEAN countries (Indonesia, Malaysia, and Singapore), have begun to import LNG. While ASEAN as a region is predicted to remain a net natural gas exporter until 2030, the region’s LNG imports are expected to grow.

The primary LNG demand sectors in ASEAN are the power and industrial sectors. Natural gas is already a major fuel for power generation in many ASEAN countries (Figure 2.5). Due to the sustained growth of electricity demand, public preference for cleaner fuel, and declining domestic production, natural gas will remain a preferred choice for new power generation requirements.

Figure 2.5: Power Generation Mix of Major Association of Southeast Asian Nations Countries (2016)



Hydro = hydropower.

Note: Energy balance data of the Lao People’s Democratic Republic are not included in the International Energy Agency Energy Balances database.

Source: Compiled by the Institute of Energy Economics, Japan based on data from the International Energy Agency (2018).

In 2012, Indonesia, the largest LNG supplier in the world until the mid-2000s, became the first ASEAN country to import LNG. This was made necessary by the geographical distance between its demand centre and its natural gas resources. Although most of its natural gas exists in the country's western regions such as Sumatra or Java, efforts to develop its natural gas resources are increasing in the east. At the end of 2017, Indonesia had four receiving terminals in operation (three floating and one onshore) with a total receiving capacity of 9.1 million tonnes per year. In 2017 the country imported 2.64 million tonnes of natural gas.

In Singapore, fossil fuel imports have been the dominant energy supply source as the country is not endowed with energy resources. Singapore began to import natural gas by pipeline from Malaysia in 1992 and from Indonesia in 2001. However, in the first half of the 2000s, Singapore experienced several disruptions to its supply from Indonesia. Indonesia and Malaysia were both facing growing domestic natural gas demand, and were thus expected to have less natural gas available for export. With natural gas playing an increasing role in power generation, in 2006 the Government of Singapore decided to import LNG to diversify its gas supplies further and enhance gas security. The plan was suspended after the 2008 Lehman Crisis, but was restarted under the strong initiative of the Government of Singapore, and the country began to import LNG in 2013. Singapore aims to be a 'hub' of the Asian LNG market and has been quite active in expanding its receiving terminal facilities to allow LNG bunkering or to launch an LNG futures trading market.

In Malaysia, as in Indonesia, a geographical gap between natural gas resources and gas demand has forced the country to begin importing LNG. Although Malaysia is still the world's third largest LNG producer (after Qatar and Australia), the country has imported LNG since 2013. This is because the country's major centres such as Kuala Lumpur are located in the Malay Peninsula on the west side of the country, while its major natural gas resources are in Sarawak in the east. The demand in the Malay Peninsula used to be supplied from offshore production, but as this began to decline and demand to increase, Malaysia had to find another supply source to meet the demand in the peninsula. Building a pipeline connection from Sarawak to the Malay Peninsula was difficult because of the great distance between the two (over 1,000 kilometres). Therefore, Malaysia decided to import LNG. At the end of 2017, a single LNG terminal was operating in Port Dickson.

In 2011, Thailand began importing LNG at the Map Ta Phut receiving terminal, to fill the gap between the growing demand for natural gas and declining domestic offshore natural gas production. PTT initially procured LNG on a spot-contract basis, but began to

import LNG on long-term contract with Qatar in 2015. Demand reached almost 4 million tonnes per year in 2018, and most of the imported LNG is used by the power generation sector. Domestic production is likely to continue to decline, and LNG demand is also forecasted to increase in the future. Since the existing terminal can accommodate 10 million tonnes of imported LNG per year, the country's LNG import can increase if additional demand for natural gas is developed.

In the Philippines, decreasing production of natural gas is driving the country to find an alternative source. The service contract of the Malampaya gas field will expire in 2024, and the field is expected to cease production after this date. The field supplies gas to three power plants in Batangas, and these supply 30% of the total power demand in Luzon (the country's most populous island). The only realistic alternative to the field's gas production is LNG, and the country is planning to initiate LNG imports as early as 2023.

ASEAN is expected to be a key market for small-scale LNG projects. In archipelagic countries such as Indonesia and Philippines, many islands have been using oil products for power generation for a long time, and replacing old and inefficient oil-fired power generation with more efficient natural gas systems is seen as economically justifiable. The largest barrier to extending small-scale LNG to smaller islands is cost. Therefore, to extend the small-scale LNG supply network in ASEAN it is critical to consider how sufficient demand is aggregated and generated, and logistic operation can be optimised.

South Asia

South Asia is another driver of future LNG demand growth. In India, the largest LNG users are oil refineries, followed by the fertiliser industry and industrial users. All of these users are very sensitive to prices as they have alternative options for sourcing energy other than importing LNG. Although LNG is also used for power generation, due to subsidised electricity prices imported LNG is not a preferred fuel, despite a decrease in import prices since 2016.

Unlike China, India does not import gas via pipelines. International pipeline connections are planned from Turkmenistan and from Iran, but these projects have not progressed due to security and geopolitical concerns, and they are not expected to materialise soon.

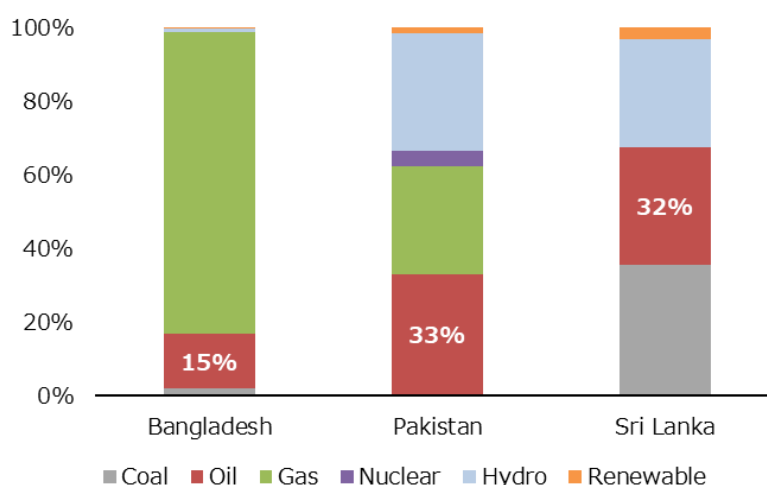
Since India's LNG demand is highly price-elastic, the market balance and price level of international LNG markets will greatly influence the country's import volume. Regulated energy prices discourage Indian buyers from procuring LNG if the market price is high.

Infrastructure for LNG-receiving facilities is another challenge. Currently LNG is mainly used in coastal areas near receiving facilities due to a lack of infrastructure. If pipeline infrastructure to the country’s interior is developed, it will cultivate new demand.

Elsewhere in South Asia, LNG demand in Pakistan, Bangladesh, and Sri Lanka has attracted considerable attention over the past few years due to the regions’ significant demand potential. Pakistan imported almost 3 million tonnes of LNG since 2016, and its demand growth is expected to continue. Bangladesh began importing LNG in 2018 to address its severe energy supply shortage problem, partly a result of stagnant domestic natural gas production.

Besides the ever-increasing domestic energy demand, South Asian countries share a high dependence on oil in the power sector (Figure 2.6). Most of this is fuel oil or diesel oil whose price is linked to international crude oil prices. If the LNG price stays below oil product prices, which is mostly the case, replacing oil with LNG will make economic sense.

Figure 2.6: Power Generation Mix in Pakistan and Bangladesh (as of 2016)



Hydro = hydropower.

Source: International Energy Agency (2018).

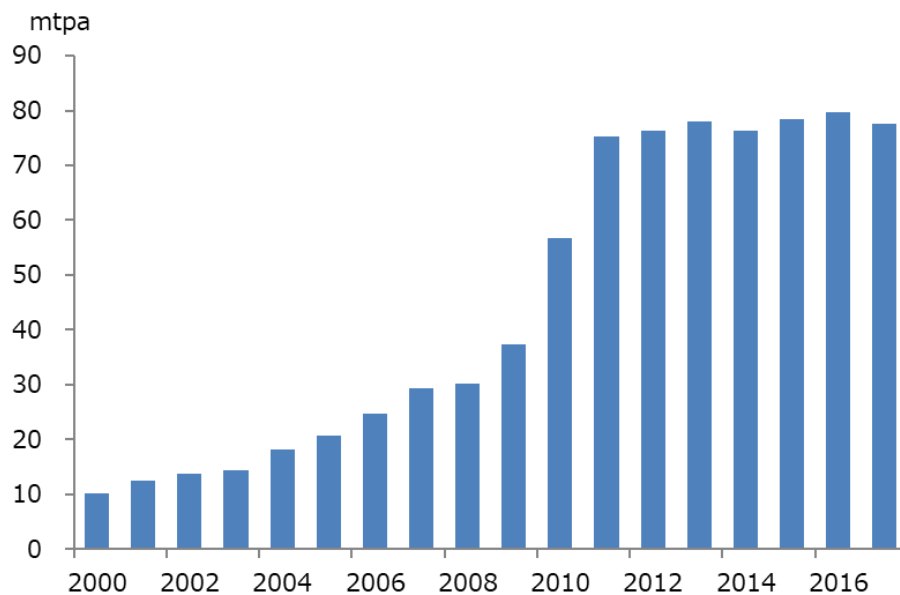
Pakistan and Bangladesh are also both natural gas-producing countries; however, their future in this regard is not bright. In Pakistan, natural gas production peaked in 2012 and has been slowly declining. In Bangladesh, although domestic production is still growing, this growth is too short by far to meet the rapidly growing domestic demand, and it is uncertain how long production will continue to grow. Thus, it is inevitable that these two countries will need to find an additional source of natural gas. One positive factor for these two countries is that they already have the necessary infrastructure for the use of natural gas,

which will greatly facilitate the introduction of imported LNG.

Qatari expansion

Qatar is a major supply-side player that affects the future balance of the world LNG market. In April 2017, the country announced that it was lifting the moratorium on new liquefaction capacity development that it adopted in 2005, and announced plans to expand its annual liquefaction capacity from 77 million tonnes to 100 million tonnes by 2024. Saad Sherida Al Kaabi, the chief executive officer of QP (Qatar's national oil company), suggested that this could even be raised to 110 million tonnes (Shoeb, 2018). Due to its vast natural gas reserves, the historical record of supply stability and reliability, and the cost competitiveness of its LNG, Qatar has played a key role in ensuring the sound development of the global LNG market. This capacity expansion will strengthen Qatar's presence and influence on the world LNG market in the future. The expansion project is expected to include the debottlenecking of existing liquefaction trains and construction of new trains. Japan's Chiyoda Corporation has been awarded a front-end engineering design study of the debottlenecking projects.

Figure 2.7: Qatar's Liquefied Natural Gas Export Volume



mtpa = million tonnes per annum.

Source: International Group of Liquefied Natural Gas Importers (n.d.)

Qatar's expansion plan, however, may cause adverse side-effects for the future LNG market because other new and relatively high-cost liquefaction projects may grow concerned about competing against Qatar to secure LNG buyers and thus defer final investment decisions. Of course, the Qatari expansion alone will be unable to meet the growing global demand for LNG, and timely investments in other projects is necessary. Any

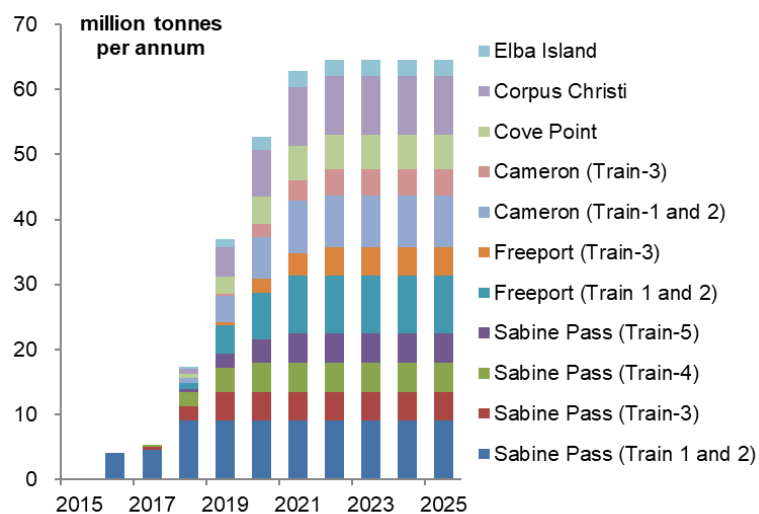
unexpected delays in the Qatari expansion may result in unexpected supply crunches during the 2020s if investment in other projects is insufficient. Therefore, the size and timing of the Qatar expansion will be a critical supply factor to shape the future LNG market balance.

Surge of the United States’ liquefied natural gas supply

The US is one of the oldest LNG suppliers in the world. LNG exports from Alaska contributed greatly to the early development of the Asian LNG market. Backed by the significant expansion of its natural gas resource base and production, the US began to export LNG from the lower 48 states in February 2016, and it may reach an annual supply capacity of around 60 million tonnes by 2020.

The American LNG supply has the potential to bring significant change to both the physical supply–demand balance and trading pattern of the global LNG market. The rapid expansion of the country’s supply capacity (around 18 million tonnes per year at the end of 2017) has already provided a new global supply source and accelerated the supply surplus since 2014. The scheduled supply capacity expansion will help maintain the current surplus balance well into the 2020s. The peculiar aspect of American LNG is its flexibility. Unlike traditional LNG suppliers, the US does not impose any destination restrictions on its LNG, and exports can be resold to other parties depending on market conditions. This flexibility will activate the spot trading of LNG cargoes, and may change current pricing practices based on the crude oil price by creating a more transparent benchmark. Such pricing practice changes can take time, but it can certainly change the structure of the LNG market.

Figure 2.8: United States Liquefied Natural Gas Export Capacity Outlook



LNG = liquefied natural gas.

Source: Institute of Energy Economics, Japan based on publicly available information.

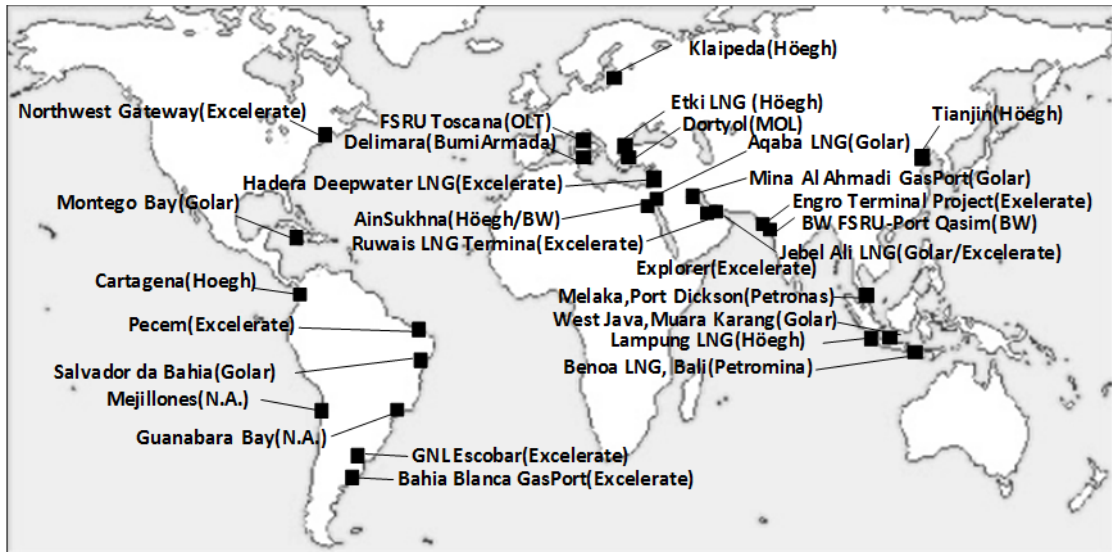
Adoption of floating technologies

The application of floating liquefaction and regasification technology is expanding in the international LNG market. Floating liquefaction refers to a liquefaction facility on a floating object. The only floating liquefaction facility in operation at the end of 2017 was the Petronas Floating LNG project in Malaysia; two more projects, Prelude Floating LNG in Australia and Cameroon LNG in Cameroon, are under construction as of the end of September 2018. The biggest benefit of this technology is that land is not needed for the construction of a liquefaction facility. Minimising construction work at the site saves time securing land and minimises the labour cost of constructing the facility. Drawbacks of floating liquefaction include high initial capital expenditures per unit, limits on future capacity expansion, and operational vulnerability to sea and weather conditions. These drawbacks may be solved by modifying and utilising existing LNG tankers as floating liquefaction facilities, adopting lease arrangements once the technology becomes universally acceptable, and using learning-by-doing processes in operation.

Floating technology has been adopted and utilised more widely for regasification. At the end of 2017, 29 floating storage and regasification units (FSRUs) were in operation. Like floating liquefaction, FSRUs do not require an onshore site, thus offering a number of benefits to the receiving country.

There are several drawbacks to an FSRU. Its operating expenses are higher than those of conventional onshore receiving terminals, and its receiving capacity usually cannot be expanded. In an LNG-importing country whose LNG demand is expected to grow steadily, an onshore receiving terminal is a more reasonable option in the long term. However, FSRUs are often preferred in emerging countries because the initial capital expenditure is significantly lower (roughly half that of an onshore facility of the same capacity), and it can be introduced more quickly, usually within a year or so. The lower initial payment in particular will be a very appealing aspect of FSRUs, as emerging LNG importers often have limited financial resources for infrastructure development. In fact, FSRUs have played a significant role in lowering the hurdle of LNG introduction and enabled several countries to access LNG. In February 2018, 53 FSRU projects are planned to begin operating, and the application of this technology is likely to grow quickly in the future.

Figure 2.9: Floating Storage and Regasification Units Projects in the World



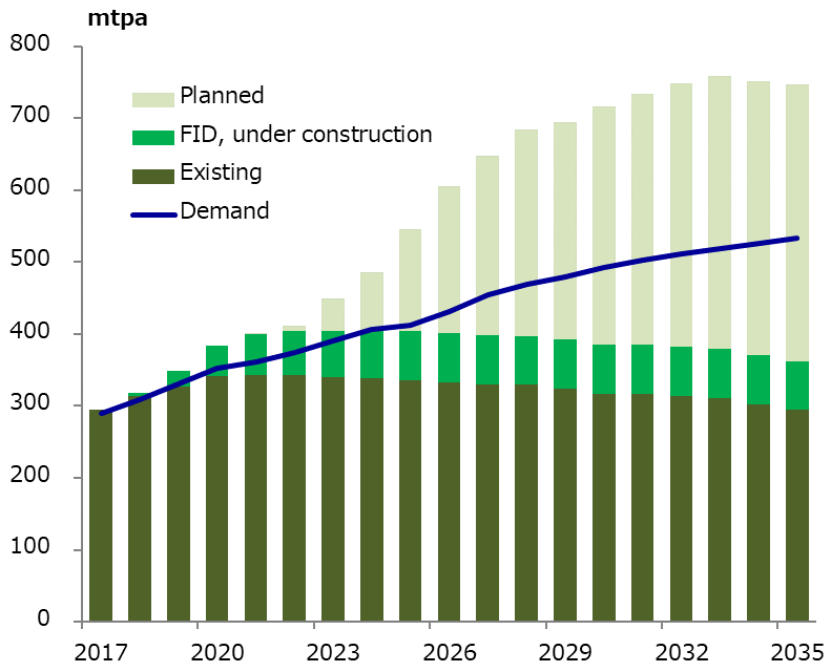
FSRU = floating storage and reunification units, N.A. = not available.

Source: Compiled by the Institute of Energy Economics, Japan based on publicly available information.

1.4 Long-Term Liquefied Natural Gas Demand and Supply Balance

Based on the above observations and the world energy outlook provided by the Institute of Energy Economics, Japan (IEEJ) (IEEJ, 2017), Figure 2.10 shows the long-term LNG demand and supply outlook. The IEEJ estimated LNG demand by assessing natural gas demand, natural gas production, and pipeline trade in existing and future LNG-importing countries. The world LNG demand is expected to rise to around 350 million tonnes in 2020 and 500 million tonnes in 2030. On the supply side, three categories of capacity are calculated: existing capacity, capacity under construction, and planned capacity awaiting final investment decisions. The sum of existing capacity and capacity under construction is considered to be firm. This capacity will rise to around 400 million tonnes in 2020, but will gradually decline towards 2035 as existing capacity depletes.

Figure 2.10: Long-Term Liquefied Natural Gas Demand and Supply Balance until 2030



FID = final investment decision, mtpa = million tonnes per annum.
 Source: Institute of Energy Economics, Japan analysis.

The firm capacity will exceed demand until the mid-2020s, suggesting that the surplus supply balance will continue in the short and medium term. After the mid-2020s, however, demand will overtake the firm capacity, and the market may become tight if the planned capacity is not realised. In 2016–2017, only one or two final investment decisions (FIDs) were realised due to lower international oil and gas prices. In 2018, only two FIDs were made (as of September). The risk of a supply crunch has increased gradually but steadily. To avoid supply shortages, timely FIDs and swift realisation of planned liquefaction projects are strongly needed.

3. Long-Term Price Scenarios

The most decisive factor in economic evaluations is the estimation of international oil and gas prices. In this sense, price scenario setting is an important factor that determines the success or failure of a project.

3.1. Natural Gas Price

In the summer of 2014 triggered by the shale revolution in the US, crude oil and natural gas prices plunged from historic highs. The world crude oil price began to recover in 2017, largely due to sustained global demand growth and collective production cuts by the Organization of the Petroleum Exporting Countries and other countries. Due to the recovery of the crude oil price and its remaining link to the LNG price, the LNG price in Asia began to rise again although the Henry Hub, a benchmark price in the US, remains low.

In the US, the first LNG exports from the lower 48 states were shipped from Sabine Pass, Texas in February 2016. When these exports began, the difference between the Henry Hub and Asian LNG prices was small, and American LNG exports did not make economic sense. However, thanks to rising crude prices since 2017, the differential has widened, activating exports to Asia.

In the global gas market, Asia is expected to remain the main source of demand growth. The European market will maintain its advantageous market conditions whereby it can secure import supplies from a wide range of sources (including Russia, Africa, the Middle East, and the US). Meanwhile, the price gap between the European and the Asian markets will gradually diminish due to a number of new LNG projects being launched around the world, especially the Pacific rim region.

Based on the above analysis, the following price forecast is provided:

- (i) Although they will not reach previous levels, by 2020 natural gas prices will rebound from the present level to the following:
 - (a) US Henry Hub = \$3.0/million British thermal units (MMBtu)–\$5.2/MMBtu
 - (b) British National Balancing Point = \$5.8/MMBtu–\$8.9/MMBtu
 - (c) Asian LNG cost + insurance + freight = \$8.1/MMBtu–\$10.4/MMBtu
- (ii) Gas prices will continue to increase after 2020 but much more slowly as an ample gas supply will come into the market at higher prices.
- (iii) Price differences among markets will continue, but will be much smaller than the Asian premiums seen in the early 2010s, being regulated by a much easier market arbitrage balance after the Panama Canal expansion in 2016.

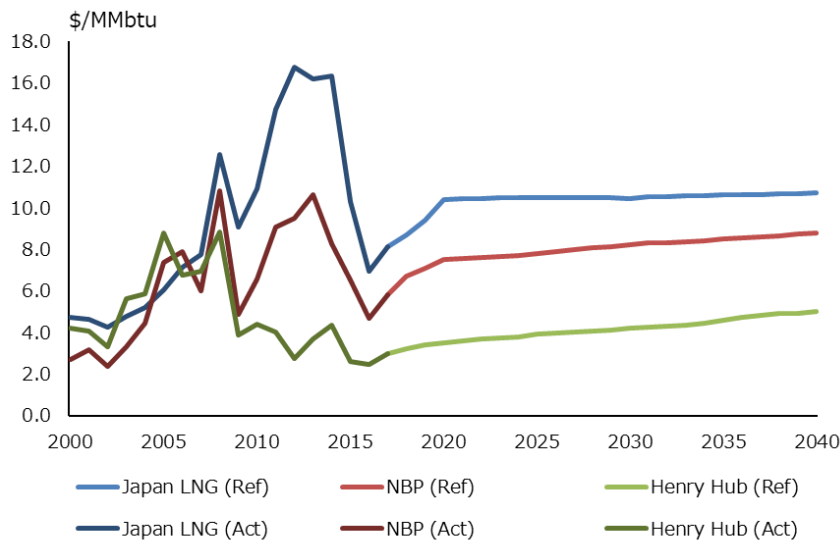
Table 2.1: Natural Gas Price Outlook

	Asia LNG CIF \$/Mmbtu	Europe NBP \$/Mmbtu	US Henry Hub \$/Mmbtu
2017	8.1	5.8	3.0
2020	10.4	7.5	3.5
2030	10.5	8.2	4.2
2040	10.7	8.8	5.0

CIF = cost + insurance + freight, LNG = liquefied natural gas, MMBtu = million British thermal units, NBP = national balancing point, US = United States.

Source: Institute of Energy Economics, Japan analysis.

Figure 2.11: World Natural Gas Price Outlook



Act = actual, LNG = liquefied natural gas, MMBtu = million British thermal units, NBP = national balancing point, Ref = reference.

Source: Institute of Energy Economics, Japan analysis.

3.2. Crude Oil Price Outlook

The 2014 shale revolution substantially affected crude oil prices in the US. After collapsing to \$35 per barrel (bbl) in December 2014, oil prices have gradually bounced back, reaching \$75/bbl in September 2018. Despite supply pressure from US, tight oil has thus far been less evident than in the mid-2010s. If the crude oil price exceeds a certain threshold price, tight oil production may increase once again. In addition, advanced hydrofracking technologies are being applied to conventional oil fields, which may lead to increased recovery.

On the demand side, oil consumption will maintain solid growth backed by the global economic growth. Most of this will be seen in countries not in the Organisation for Economic Co-operation and Development. Although electric vehicles have attracted a lot of attention, this fleet remains too small to reduce demand noticeably. This study projects that the global oil demand will continue to grow until at least 2030; prior to this date, the global oil demand is not likely to peak nor will the price of oil fall significantly due to lower demand.

Based on this evaluation, it is estimated that the international price of crude oil will rise gradually to \$95/bbl in 2030 and \$115/bbl in 2040.

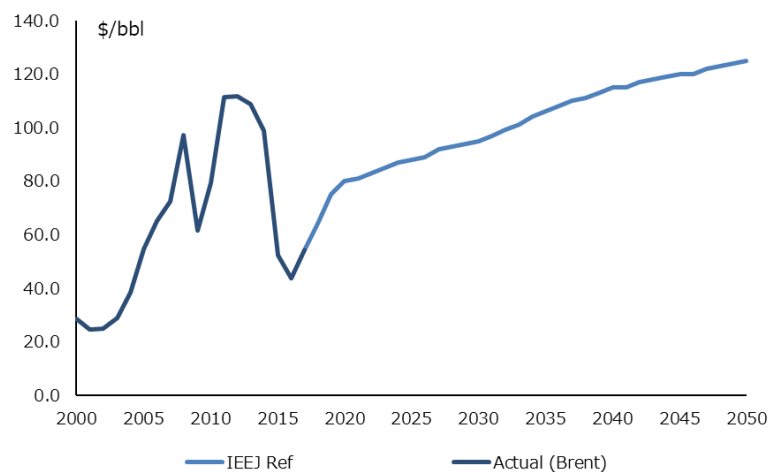
Table 2.2: Oil Price Outlook

Year	Brent \$/bbl
2017	54
2020	80
2030	95
2040	115

bbl = barrel.

Source: Institute of Energy Economics, Japan analysis.

Figure 2.12: Oil Price Outlook



bbl = barrels; IEEJ = Institute of Energy Economics, Japan; Ref = reference.
Source: IEEJ analysis.

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Chapter 3

Policies and Strategies Related to Energy Development Planning in Myanmar

1. Introduction

Myanmar is endowed with rich natural resources in quantities that, if fully developed, would be sufficient to meet most of the country's daily energy needs. Myanmar's energy policy is generally aimed at ensuring energy independence by increasing national production of available primary energy resources through intensive exploration and development activities. It also acknowledges electricity as the main power source driving economic development, and addresses the need to generate and distribute more power in terms of greater volume, density, and reliability. The Myanmar Energy Master Plan (MEMP) 2015, so far the only strategic policy document being used to guide future energy-related policies, also advocates the utilisation of water resources as a source of renewable energy for generating electricity, thus saving non-renewable sources such as fossil fuels for alternative and future use. The MEMP is a mixed guiding strategy rather than a policy itself because Myanmar is in the process of formulating separate policies for both the upstream and downstream energy sectors. At present, Myanmar's general strategy encourages energy self-sufficiency and independence. The MEMP highlights the current energy situation, predicts future energy consumption, and draws several policy implications.

This chapter reviews key strategies and policies related to energy development in Myanmar, especially in the gas sector. It also looks at associated policies, such as electricity access and energy efficiency and conservation, which aim to (i) save energy through effective energy management, (ii) reduce energy consumption, and (iii) minimise harmful environmental impacts through the utilisation of new and renewable energy sources (especially solar and wind, which are abundant in Myanmar).

Myanmar faces many obstacles as it works to develop comprehensive energy policies that will guide the sustainable use of natural resources, and will stimulate infrastructure investment quickly enough to secure an adequate energy supply to meet the rapidly growing demand. It is critically important to develop a strategy for the utilisation of Myanmar's domestic resources (including natural gas, oil, coal, and renewables) to enable the country to plan energy infrastructure investment. It is also necessary to prepare a policy that will ensure the best energy mix possible, such as the amount of coal and gas used for generating power, and the amount of gas used for transportation, residential, and commercial purposes (such as cooking and heating). Sooner or later, Myanmar's natural gas, coal, crude oil, and renewable energy resources will play a significant role in the country's energy mix, and will help ensure Myanmar's energy independence and security.

2. National Energy Policy

The objectives of Myanmar's overall national energy policy are as follows:

- (i) To invite local and foreign investment in the extraction and utilisation of natural resources to meet the nation's energy needs while minimising environmental impacts; following the Health, Safety, and Environment Policy; and practicing corporate social responsibility activities;
- (ii) To adopt plans that prioritise energy efficiency and conservation;
- (iii) To define energy pricing by observing the energy pricing policy of the Association of Southeast Asian Nations (ASEAN) and international market to ensure affordable and reliable energy prices for end users and customers;
- (iv) To formulate nationally appropriate energy standards and specifications that comply with ASEAN and international practices;
- (v) To promote private sector participation or privatisation in keeping with the state's economic policy;
- (vi) To formulate both short- and long-term plans to increase the power-generation capacity of hydropower, renewable energy sources, and thermal power plants, as well as other feasible alternative energy sources;
- (vii) To encourage regional cooperation for energy by expanding the power grid and pipeline network to neighbouring countries;
- (viii) To implement full energy independence through short- and long-term plans to stabilise power generation;
- (ix) To establish an energy database system, and to draw and execute energy supply plans after surveying the nation's annual energy demand;
- (x) To stockpile energy to boost energy security; and
- (xi) To formulate short- and long-term plans to fulfill the country's requirements for petrochemical products by constructing innovative refineries and plants.

The objectives of Myanmar's petroleum sector policy are:

- (i) To fulfill domestic energy requirements as a priority;
- (ii) To implement sustainable energy development;
- (iii) To promote wider use of new and renewable energy sources;
- (iv) To promote energy efficiency and conservation;
- (v) To promote the household use of alternative fuels;
- (vi) To use discovered crude oil and natural gas resources effectively in the interests of the entire nation, including the regions where the resources are discovered; and
- (vii) To promote more private participation in the energy sector.

The objectives of Myanmar's electric power sector policy are:

- (i) To expand the national power grid to utilise effectively power generated from available energy resources such as hydropower, wind, solar, thermal, and other alternative sources;
- (ii) To generate and distribute electricity using advanced technologies, and to boost and enhance private participation in regional distribution activities;
- (iii) To conduct environmental and social impact assessments for power generation and transmission in order to minimise these impacts;
- (iv) To restructure the power sector with cooperation from boards, private companies, and regional organisations to encourage more participation from local and foreign investors and the formation of competitive power utilities; and
- (v) To formulate electricity acts and regulations with the assistance of local and international experts to align more closely with the current open economic policy.

The objectives of Myanmar's coal sector policy are:

- (i) To study the coal policies of ASEAN member countries;
- (ii) To conduct a comparative study of coal resources, development programs, and supply and demand in Myanmar and other ASEAN member countries;
- (iii) To collaborate with ASEAN member countries in coal sector development projects;
- (iv) To implement advanced technology for the use of coal instead of firewood to prevent deforestation;
- (v) To collaborate with ASEAN member countries in constructing coal-fired power plants equipped with clean coal technology to supplement energy requirements;
- (vi) To collaborate with ASEAN member countries in developing coal-based industry;
- (vii) To collaborate with ASEAN member countries in developing quality specification laboratory techniques and coal marketing techniques to promote the trading of coal amongst countries;
- (viii) To coordinate with other relevant ministries in Myanmar and other ASEAN member countries in carrying out environmental impact assessment studies for coal projects;
- (ix) To be responsible for and lead the collaboration program with relevant countries;
- (x) To allow coal exports with the approval of the Government of Myanmar;
- (xi) To exploit coal resources safely using the open pit and underground methods;
- (xii) To reuse old mines after the coal has been extracted.

The objectives of Myanmar's renewable energy sector policy are:

- (i) To formulate a national renewable energy policy, strategy, and roadmap based on international practices and in cooperation with the concerned ministries;
- (ii) To enhance research projects;
- (iii) To train local practitioners and transfer technology to small and medium-sized enterprises;
- (iv) To develop renewable energy standards and provide testing services to the renewable energy market; and
- (v) To strengthen international cooperation and collaboration in the renewable energy sector.

Myanmar's initial energy efficiency target was a 5% reduction in total energy consumption from 2005 to 2015, and an 8% reduction by 2020 to align with the targets set by ASEAN. The energy policy framework aims to:

- (i) Maintain Myanmar's energy-independent status,
- (ii) Promote the wider use of new and renewable sources of energy,
- (iii) Promote energy efficiency and cooperation, and
- (iv) Promote the use of alternate fuels for households.

3. Institutions Overseeing the Oil and Gas Sector

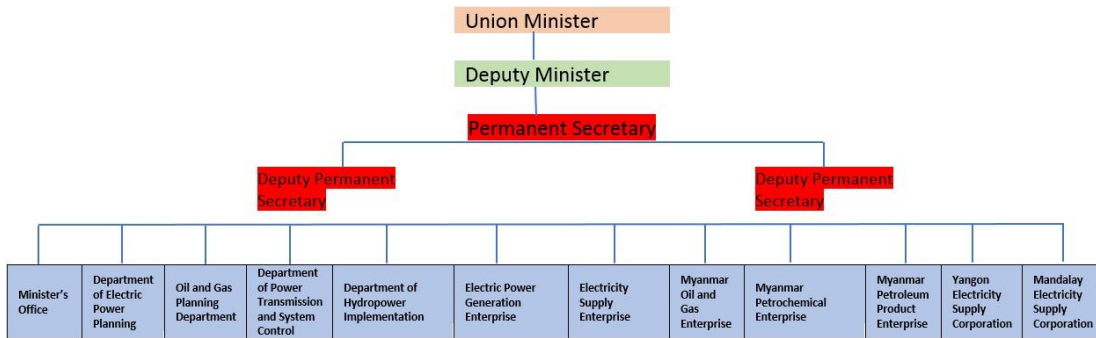
The Ministry of Electricity and Energy is responsible for the oil and gas sector, and for generating electricity and power. In terms of oil and gas, the Ministry of Electricity and Energy oversees three state-owned enterprises: Myanma Oil and Gas Enterprise (MOGE), Myanmar Petrochemical Enterprise, and Myanmar Petroleum Products Enterprise. It also oversees the Oil and Gas Planning Department. The natural gas sector is the responsibility of MOGE, which is entirely state-owned. MOGE is also responsible for the upstream petroleum subsector, and has four basic responsibilities: (i) to explore and produce oil and gas using its own resources, (ii) to supply domestic natural gas by constructing its own pipelines, (iii) to supply compressed natural gas as a substitute fuel for vehicles, and (iv) to participate in and oversee production-sharing agreements in cooperation with foreign oil companies.

4. Policy Related to the Oil and Gas Sector

The laws and regulations that govern Myanmar's oil and gas sector mostly date back to British legal codes in pre-independence Indian statutes. A few of these laws and regulations remain important and applicable, including the Oilfield Act (1918); Oilfield Rules (1936); Petroleum Rules (1987); Essential Supplies and Services Law No. 13/2012; Oilfields (Labor and Welfare) Act (1951); Petroleum Resources (Development Regulation) Act (1957); Law Amending the Petroleum Resources (Development Regulation) Act (1969); Myanmar

Petroleum Concession Rules (1962); Petroleum and Petroleum Products Law (2017); Hand Dug Well Law (2017); and Notification No. 100/2013, relating to the import, storage, transportation, and distribution of petroleum and products.

Figure 3.1: Organisational Structure of the Ministry of Electricity and Energy



Source: Government of Myanmar, Ministry of Electricity and Energy (2015).

MOGE plays an important role in Myanmar’s economy. According to the State-Owned Economic Enterprises Law, the government has the sole right to carry out exploration for, extract, and sell petroleum and natural gas, and produce products of the same. However, the government may, in the interest of the state, permit such activities to be carried out jointly between the government and a private or foreign investor, through MOGE, or solely through any other organisation. MOGE has recently tried to promote private participation in Myanmar’s oil and gas sector. Foreign investment has been attracted by production-sharing contracts and improved petroleum recovery contracts. Under the current tax policy, companies in the oil and gas sector are subject to a 25% tax on profits under the Income Tax Law, and a 12.5% royalty on all available petroleum is payable by the contractor.

According to the State-Owned Economic Enterprises Law, MOGE is responsible for the exploration and production sector under production-sharing contracts with private companies. Several rules and regulations were issued in 2017 to guide investments; these include the MIC Notification No. 35/2017, or the Foreign Investment Rule (passed on 30 March); MIC Notification No. 10/2017, or the Designation of Development Zones (passed on 22 February); MIC Notification No. 13/2017, or the Classification of Promoted Sectors (passed on 1 April); and MIC Notification No. 15/2017 regarding types of restricted activities (passed on 10 April).

5. Liquid and Gaseous Fuel

In 2015, natural gas accounted for 45% of all primary energy production. Natural gas has mainly been used for domestic electricity production and industrial purposes, whereas most

gas produced in Myanmar was exported (MEMP, 2015). Currently, most gas produced off-shore is exported to Thailand and China. However, locally produced gas could also be allocated to pharmaceutical and chemical industry processes, fertiliser production, the production of refined petroleum products, power production, fuel for passenger vehicles, and fuel for cooking. In recent years, the government has considered establishing a terminal to receive imported liquefied natural gas (LNG) to supplement domestic natural gas supplies. It has also considered developing and upgrading existing gas pipelines and distribution networks in keeping with the gas master plan, which outlines the need for gas infrastructure in Myanmar.

In addition, biodiesel and bioethanol production in Myanmar is currently limited to a few production facilities; several other existing bioethanol facilities have stopped production due to a lack of subsidies, and no information indicating the construction of new facilities has been found. So far, only pilot-scale biodiesel facilities have been built in Myanmar, which are producing small amounts of biodiesel for use by agricultural machinery.

6. Refined Oil Products

There are three small refineries currently operating in Myanmar, but they are old, their operating efficiency is low, and their production is insufficient to meet the increasing demand. Hence, the only feasible strategy for liquid fuels must involve the construction of new capacity and/or imports. However, if Myanmar chooses to construct new refineries, the country has the right to use the Sino-Burma pipeline (with a transfer capacity of 50,000 barrels per day), which could be used as a feedstock for a potential new refinery. An inland refinery adjacent to the pipeline could create a competitive advantage by locating production close to consumption, which would reduce transportation costs.

7. Natural Gas

The gas supply–demand projection shows that the outlook is tight (see Chapter 4). However, if natural gas supplies do not develop as anticipated, fuel imports can be used to supplement the supply for the transportation and agriculture sectors, in order to release the capacity required by the industry and power sectors.

Based on the MEMP 2015, three different scenarios involving different energy mixes are being considered (Table). Under Scenario 3 (power resource balance), the total installed capacity will reach 23,594 megawatts by 2030 (the lowest of the three scenarios), with hydropower accounting for 38% of generation, coal 34%, gas 20%, and renewables (solar, wind, etc.) 8%.

Table 3.1: Installed Capacity and Power Supply Scenarios for 2030

No.	Scenario 1	Scenario 2		Scenario 3			
	(Domestic energy consumption)	(Least cost)		(Power resources balance)			
	Energy resources	Installed capacity		Installed capacity			
		MW	%	MW	%	MW	%
1	Hydropower (large)	12,147	42	12,147	43	1,412	6
2	Hydropower (small and medium)	6,891	24	6,891	24	7,484	32
3	Gas	4,986	17	2,484	9	4,758	20
4	Coal	2,760	10	5,030	18	7,940	34
5	Renewables	2,000	7	2,000	7	2,000	8
Total		28,784		28,552		23,594	

MW = megawatt.

Source: Government of Myanmar, National Energy Management Plan (2015).

If Myanmar chooses to pursue Scenario 3, large investments will be necessary to secure a gas supply from domestic sources in addition to importing LNG, and it will be necessary to develop LNG-receiving terminals and other gas pipelines and distribution networks. As domestic gas prices are fully regulated, and any future LNG terminal would deliver gas at international prices, the government would incur significant costs if it continues to subsidise gas prices partially for the power sector. Instead, gas policy could be based on international LNG market prices to increase the viability of an LNG terminal if one is developed. In this case, the general strategy would be to reserve gas for industry and the power sector, and to meet other demands by alternative means. The decision to pursue alternatives, such as an LNG terminal, can be decided as a matter of government policy to secure the natural gas supply-demand balance in the medium and long term (through 2040). Using biofuels (biodiesel and bioethanol) for transportation could notably reduce the use of diesel and gasoline.

8. Electrification and Related Policies

Myanmar is the largest country in mainland Southeast Asia, but it has one of the lowest population densities in the region. This creates a diseconomy of scale for the development and expansion of a conventional centralised electricity grid. Electrification varies widely between urban and rural areas. Although about 27% of the country's 64,346 villages are electrified, only about 7% are covered by the national power grid (Ngwe, 2014). Considering its abundant and broadly distributed renewable energy resources (including biomass, hydropower, solar, and wind), Myanmar can accelerate on- and off-grid electrification to deliver universal electricity much more quickly than would be possible through conventional centralised generation and grid expansion.

The Government's National Electrification Plan 2015, which was developed with technical assistance from the World Bank, aims to electrify 7.2 million households and achieve universal access to electricity by 2030. The plan calls for \$5.8 billion in investments over the next 15 years to extend the distribution grid and electrify off-grid areas. The government has also developed the Myanmar Energy Master Plan with technical assistance

from the Asian Development Bank, and a Power Sector Master Plan (for the generation and transmission subsectors) with assistance from the Japan International Cooperation Agency. After decades of operating in a closed economy, the energy sector's institutional and regulatory framework is fragmented, particularly in the sphere of rural electrification. Having realised these challenges, Myanmar has been undertaking reform in all sectors, including the energy sector, since the 2015 national election. Major energy-related master plans in Myanmar as seen in the most recent developments include the following:

- (i) The MEMP 2015 is a comprehensive energy strategy document covering all energy-related sectors. The MEMP 2015 was formulated by utilising the inputs of studies and research carried out by multiple institutions and supported by various players, including the National Electrification Plan (NEP) by the World Bank, and the Power Sector Master Plan by the Japan International Cooperation Agency.

- (ii) The NEP 2015 targets universal electricity access or 7.2 million new connections by 2030. The plan involves a two-pronged approach: the rapid extension of the national grid, and the use of off-grid electricity (including modern solar home systems and mini-grids). The first phase of the plan calls for 1.7 million households to be connected to electricity by 2020 and an investment of approximately \$700 million. The plan started with an initial fund of \$400 million from the World Bank's International Development Association, of which \$80 million was earmarked for off-grid electrification. Total grid investment could be as much as \$6 billion.

- (iii) The Power Sector Master Plan 2013–2030 highlighted strategies to ensure a sustainable, affordable, and secure energy supply for Myanmar over the longer term. The plan also aims to develop a mix of energy sources to provide a stable and reliable energy supply through 2030, in which coal-fired power generation as a share of the total energy mix will increase from 2% in 2015 to 20% in 2030. The plan targets the following primary energy mix by 2030: 33% biomass, 22% oil, 20% coal, 13% gas, 11% hydropower, and 1% renewable energy. The plan estimates that Myanmar's energy sector will need \$30 billion–\$40 billion over the next 15–20 years.

- (iv) The National Energy Efficiency and Conservation Policy, Strategy and Roadmap for Myanmar 2015 was supported by the Asian Development Bank and Japan Fund for Poverty Reduction. Based on the calculated potential energy savings, the National Energy Efficiency Policy targets the following objectives by 2020, using 2012 as a baseline: (i) to reduce the national electricity demand by 12%, (ii) reduce biomass consumption by 2.3%, and (iii) reduce national carbon dioxide emissions by 78,690 tonnes. To reach the overall energy efficiency objective, it is necessary to develop a strategy to save energy for all important energy-intensive sectors such as industry, transport, commercial, and residential sectors.

If Myanmar follows the National Electrification Plan, it will electrify almost 100% of households by 2030. This implies a huge installed generation capacity from different fuel-based generators. These will not be limited to coal, gas, and hydropower; instead, small distributed energy systems such as renewable energy will play a significant role in providing electricity access. Off-grid renewable energy and distributed energy system generators are expected to account for 7%–10% of the generation mix.

Currently, about 7.2 million households are not yet connected to modern electricity sources. The NEP 2015 primarily addresses this issue with the ultimate aim of achieving 100% electrification in Myanmar. The NEP also recognises that distributed energy systems require off-grid electricity. It is estimated that about half a million new connections will be needed every year to meet the full electricity demand. This is an enormous task and will require huge levels of investment and coordination. The plan should be realistic and mention distributed energy systems for both off-grid and on-grid distributed energy systems in Myanmar.

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Chapter 4

Natural Gas Supply Outlook

1. Current Natural Gas Production

1.1 Brief History of Upstream Development in Myanmar¹

Myanmar has a long history of upstream oil and gas development. The first modern well was drilled in the Yenangyaung field in the Magway region, a central inland area of the country, in 1855. As the country was under British colonial rule until 1948, early upstream operations were mainly carried out by British oil companies, particularly Burma Oil, a private British oil company that initially enjoyed what was almost a monopoly on the country's upstream sector. In 1901, other foreign companies began to enter Myanmar and commence operations, starting with Standard Oil, a private American company. Most foreign companies targeted the Yenangyaung field, with more than 4,000 wells drilled in the field as of 1915.

When the Japanese army invaded Myanmar looking for resources to fuel its military operations during World War II, British companies operating in the country destroyed their oil production facilities and evacuated the country. After the war, Burma Oil resumed its upstream operations, once more under almost monopolistic conditions. In 1961, Unocal (now merged with Chevron) entered the country, and operating companies became more diversified. In 1963, however, the country's oil industry was nationalised by the U Ne Win administration. All upstream assets were transferred to a newly established state-owned entity, Myanma Oil and Gas Enterprise (MOGE), which then engaged the country's upstream operation exclusively.

In 1988, Myanmar decided to invite foreign companies to its upstream sector again, and the first bid round was conducted in 1989. Total, a French oil company, entered the country by acquiring an undeveloped gas field in Yadana, and partnered with Unocal to begin production. Since then several large gas fields have been discovered by foreign companies: Texaco (United States), Premier Oil (United Kingdom), and Nippon Oil (Japan) discovered the Yetagun field in 1992; and Daewoo (Republic of Korea, henceforth Korea) discovered Shwe in 2000.

¹ The descriptions in this section are drawn from Thornton, S.E. (2015).

Thanks to this series of discoveries, Myanmar began exporting natural gas to Thailand and China, and natural gas accounted for 26.7% of the country's total export revenues in 2017 (JETRO, 2017). As mentioned in Section 4.2, MOGE plans to develop two new offshore blocks, and the country's upstream sector is continuing active operations.

Table 4.1: Status of Major Offshore Natural Gas Field Developments

Gas field	Initial recoverable reserves (tcf)	Block	Production capacity (mcf/d)	Start of operation
Yadana	6.354	M-5, M-6	850	1998
Yetagun	2.276	M-12, M-13, M-14	200	2000
Shwe	3.315	A-1, A-3	550	2013
Zawtika	1.690	M-9	300	2014

mcf/d = million cubic feet per day, tcf = trillion cubic feet.

Source: Asian Development Bank (2016).

1.2. Current Production

Myanmar has four large offshore natural gas fields (Table 4.1), the largest of which is the Yadana field. In 1992, Total and MOGE set up a joint-venture company to develop the proven and probable large natural reserves at Yadana. After exploration began, the Thai state-owned company PTT Exploration and Production (PTTEP), and an independent American oil company Unocal (now merged with Chevron) joined the development consortium. The equity structure of the project is as follows: Total (31.24%), Chevron (28.26%), PTTEP (25.50%), and MOGE (15.00%). Production at the field began in 1998 after the pipeline network was developed; and it currently supplies approximately 54% of the natural gas exported from Myanmar and almost half of the domestic gas supply.

Myanmar's second largest gas field, Yetagun, was discovered in 1992, and production commenced in 2000. All of the produced gas is exported to Thailand without supplying the domestic market. The field also produces condensate, which is stored in a floating storage and offloading system and sold on the international market or supplied to domestic refineries. The operator of the field is the Malaysian national oil company Petronas, which holds 40.91% of the total equity. Its partners are MOGE (which holds 20.45%), PTTEP (19.32%), and JX Nippon Oil and Gas Exploration Corporation (19.32%).

The other offshore gas field in the southern basin is the Zawtika field. The newest offshore gas field, it began production in 2014. Two-thirds of the produced gas is exported

to Thailand by pipeline, and the remaining one-third is supplied to the domestic market. Of the gas field's equity, PTTEP owns 80% and MOGE owns 20%.

The only producing mid-northern offshore field is the Shwe field, which commenced operations in 2013. Of the produced gas, 80% is exported to China via pipeline and 20% is supplied to the domestic market. Daewoo, a private Korean company, operates the project and owns 51% of the block. Other partners include two Indian state-owned companies, the Oil and Natural Gas Company (which holds 17.0%) and the Gas Authority of India (8.5%); a Korean state-owned gas company, Kogas (8.5%); and MOGE (15.0%).

Two-thirds of Myanmar's offshore natural gas production is exported (Table 4.2).

Table 4.2: Export and Domestic Supply of Gas Fields in Myanmar

Gas field	Allocation to export (mmcf/d)	Direction of export	Allocated to domestic market (mmcf/d)	Partners (%)
Yadana	560	Thailand	200	Total (31.24%) Chevron (28.26%) PTTEP (25.50%) MOGE (15.00%)
Yetagun	150	Thailand	0	Petronas (40.91%) Nippon (19.32%) PTT (19.32%) MOGE (20.45%)
Shwe	340	China	100	Daewoo (51%) ONGC (17%) GAIL (8.5%) Kogas (8.5%) MOGE (15%)
Zawtika	200	Thailand	100	PTTEP (80%) MOGE (20%)
Onshore fields	0	Domestic	50	MOGE
Total	1,500		450	

mmcf/d = million cubic feet per day, MOGE = Myanma Oil and Gas Enterprise, ONGC = Oil and Natural Gas Company, PTTEP = PTT Exploration and Production.

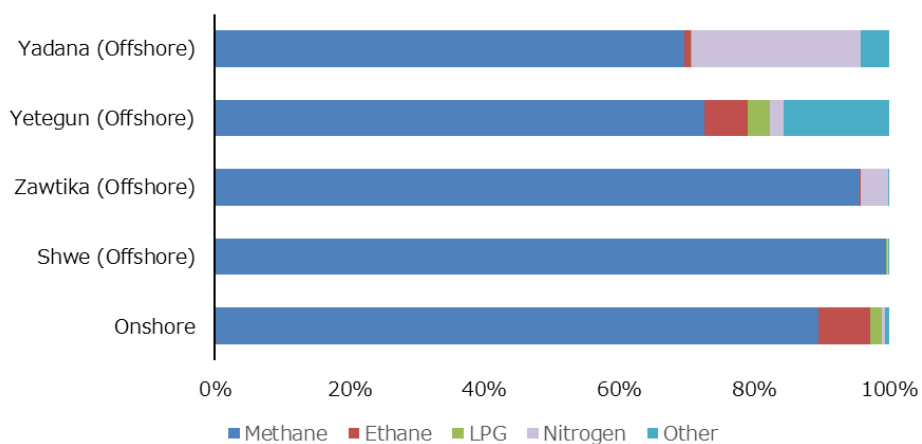
Source: Presentation material of the Ministry of Electricity and Energy (July 2017).

The quality of the natural gas produced in Myanmar varies from field to field. The natural gas from the northern Shwe field is very 'lean' (having a high methane content) while that from Yetagun in the south has a higher share of ethane or propane, indicating a high calorific content. Natural gas produced from Yadana contains a high volume of nitrogen lowering its heat value significantly (even lower than that from Shwe).

Because the natural gas supply is operated separately in the north and south due to

the cutoff of the north–south pipeline network, these differences in quality have not yet been considered a significant issue. Yet, as the country’s natural gas demand grows, and it becomes increasingly necessary to interchange natural gas across regions, the heat value of natural gas may need to be adjusted in the future. Generally speaking, the power generation and residential sectors can accommodate a wider range of calorific values of natural gas as fuels; however, the industry sector sometimes requires a stable calorific value because changing calorific values cause fluctuations in heat content and might adversely affect the quality of manufactured products (such as ceramics).

Figure 4.1: Quality of Offshore Natural Gas in Myanmar



LPG = liquefied petroleum gas.

Note: The quality of ‘onshore’ shows the quality of the Maubin field.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Myanmar also produces a small volume of natural gas onshore, 53 million cubic feet per day (mmcf) in 2018 (3% of total production). The largest onshore field, Maubin in the Ayeyarwady region, produces 25 mmcf, almost half the total onshore production. Most of the country’s onshore fields exist in the central and southern regions. Natural gas from onshore fields is used in various demand sectors such as power generation, compressed natural gas for automobiles, industry fuel, and fertiliser feedstock. Onshore exploration and development works are being actively pursued, and onshore production is expected to grow significantly through 2030.

2. Natural Gas Production Outlook

While production from existing fields will decline in the future, this will be partially offset by production from several newly discovered fields, both offshore and onshore.

Table 4.3: Major Discoveries in Myanmar

Block	Basin	Expected production (mmcf/d)	Start of operation
M-3	Moattama offshore	n/a	2023
A-6	Rakhine offshore	60	2025

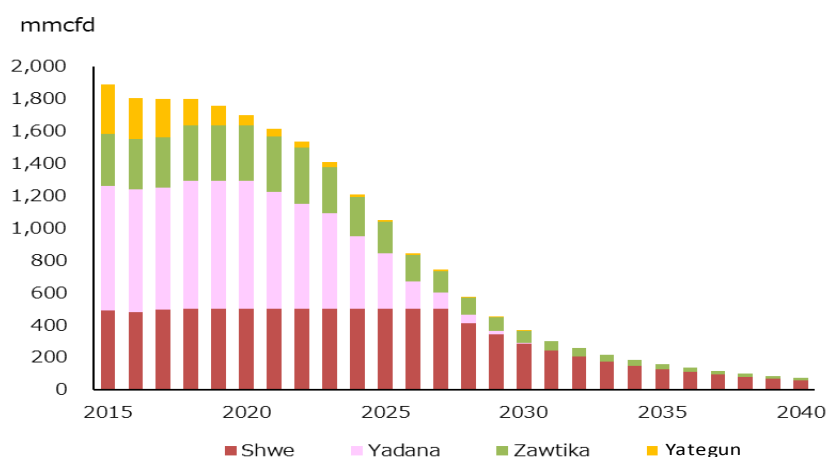
mmcf/d = million cubic feet per day; n/a = not available

Source: Institute of Energy Economics, Japan, based on interviews with Myanmar Oil and Gas Enterprise in May 2018.

Natural gas from existing offshore fields, which account for more than 90% of the country's total production, will decline from about 1,900 mmcf/d in 2015 to less than 100 mmcf/d in 2040. Production from the relatively new Shwe field will plateau at 500 mmcf/d until the mid-2020s, after which point it will decrease.

The development of two new fields, the M-3 and A-6 blocks, will be pursued. Production from M-3 will be onstreamed in 2023 and production from A-6 will be onstreamed in 2025. Supplies from these new sources will partially offset the decline in production from existing offshore fields, but to make up the production losses fully, Myanmar will need to secure additional supply sources such as onshore production or LNG imports.

Figure 4.2: Production Outlook of Existing Offshore Fields



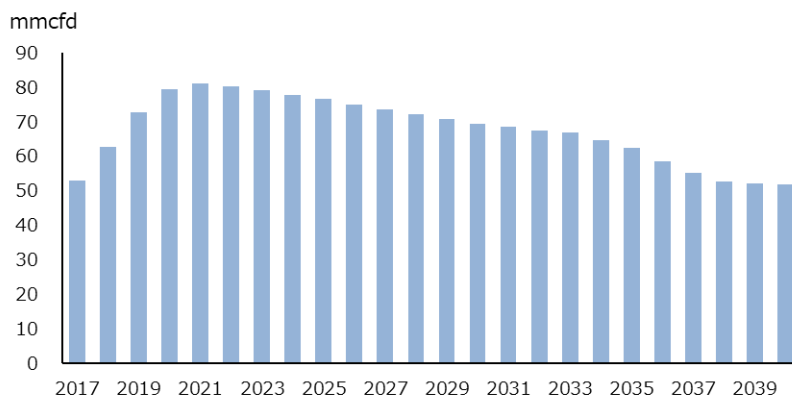
mmcf/d = million cubic feet per day.

Note: Production from newly developed fields is NOT included.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Onshore production on the other hand is expected to grow in coming years. As of 2018, more than 70% of Myanmar’s onshore production comes from its southern fields such as Maubin, Nyaundon, and Apyauk. Production from the mid-northern onshore field in Magway is expected to grow and make up for declining production through 2040. However, most of these additional onshore fields are still in the planning stages and the actual supply is not guaranteed. A more detailed and precise analysis of potential production from onshore sources must be conducted to ensure a more correct supply picture in the future.

Figure 4.3: Outlook of Existing Onshore Fields



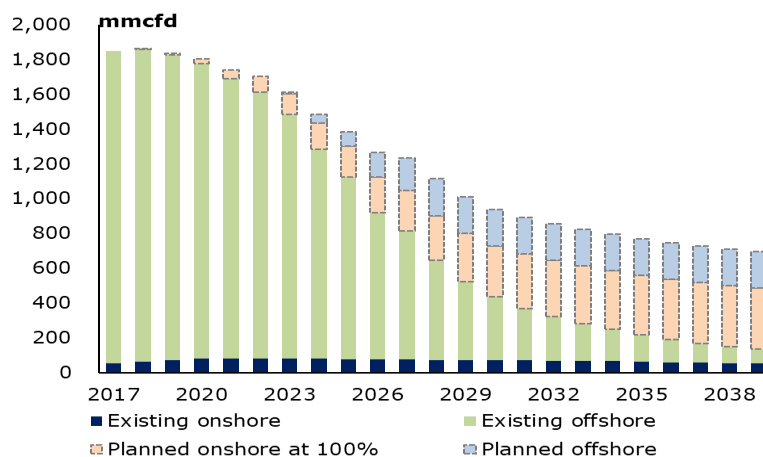
mmcf = million cubic feet per day.

Note: Production from newly developed fields is NOT included.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Total domestic natural gas production will remain close to current levels through the mid-2020s, but will gradually decline afterward. The most prominent reason for this decline is the depletion of existing offshore fields. Although this will be temporarily offset by increased production from onshore fields, from the mid-2020s the total domestic production will begin to decline. Production is expected to fall to 1,350 mmcf by 2030 and 810 mmcf by 2040. The supply source of domestic gas is also expected to change over time. The share of the domestic supply sourced from offshore fields is projected to slide from more than 97% as of 2018 to almost 50% by 2040 (Figure 4.4).

Figure 4.4: Domestic Production Outlook in Myanmar



mmcf = million cubic feet per day.

Note: Assuming that planned onshore field developments produce 100% of the targeted volume.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

If the planned onshore production is not realised, Myanmar will need to import LNG as another natural gas supply option. Since Myanmar lacks a natural gas import pipeline, it will need to import natural gas in the form of LNG. Myanmar is considering three LNG import projects (Table 4.4), all of which are planned in the southern coastal areas where demand is expected to be large. Declining domestic production from southern offshore fields may also drive the country to secure an alternative natural gas supply in the region.

Table 4.4: Planned Liquefied Natural Gas Receiving Terminals

Project	Import capacity (mtpa)	Installed generation capacity
Alone	0.4	356
LNG to Power project		
MeeLongGyaing	1.6	1,390
LNG to Power project		
Kaunbaur	1.0	1,230
LNG to Power project		

LNG = liquefied natural gas, mtpa = million tonnes per annum, MW = megawatt.

Source: Information provided by the Ministry of Electricity and Energy.

LNG will be another natural gas supply source for Myanmar. Three LNG receiving projects are being planned. These planned LNG receiving capacities are smaller than the

standard receiving capacity (3 million–5 million tonnes per year). This is mainly because the demand is not large.

All planned LNG projects in Myanmar are so-called gas-to-power projects, or the combined LNG receiving facility and gas-fired power generation construction. Most of the imported LNG will be consumed by power plants, and some surplus LNG will be supplied to the domestic pipeline network for city gas use. The shallow draft in the southern coastal areas also prohibits standard-size LNG tankers from berthing. To meet the demand for imported LNG, Myanmar will need to adopt floating storage and regasification unit technology, an effective means of fast-tracking LNG imports currently used by a number of new LNG importing countries (see Chapter 2).

A potential impediment to introducing LNG to Myanmar is the difference between the international LNG price and domestic natural gas price. As the Government of Myanmar sets the domestic natural gas price at a lower level than the international price, it may need to subsidise this gap. Such additional fiscal expenses will become a heavy burden on the government. In fact, all LNG import projects are expected to supply electricity at \$0.09 cents per kilowatt-hour as the power tariff is also regulated and set at a lower level by the government. Therefore, designing an economically viable LNG import scheme is a very challenging task for potential project developers and investors.

3. Natural Gas Exports

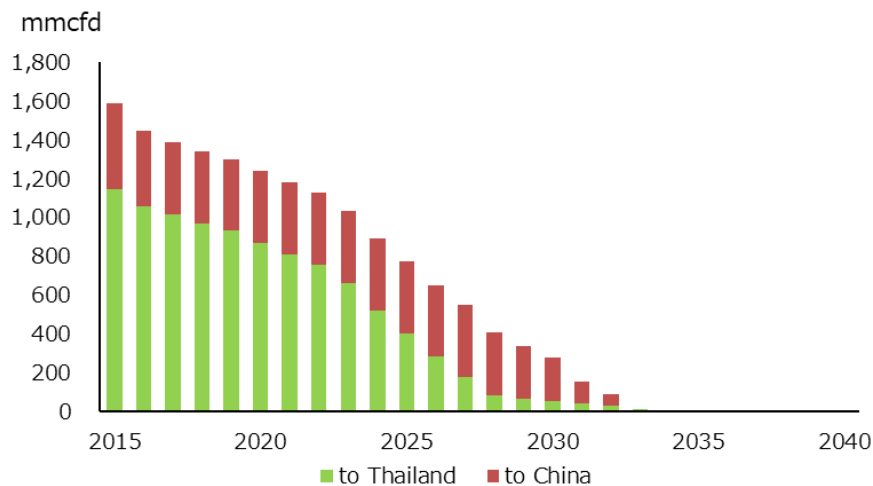
In 2017, approximately two-thirds of Myanmar's natural gas production was exported to Thailand (10.4 billion cubic metres [bcm] or 1,016 mmcfd) and China (3.8 bcm [371 mmcfd]). The exported volume to these countries has remained stable. Exports to Thailand are provided under a 30-year contract that expires in 2028, and the volume has remained stable at around 8 bcm–10 bcm since 2000. These exports are sourced from the southern offshore gas fields including Yadana, Zawtika, and Yetagun. Myanmar began exporting natural gas to China in 2014, after the completion of the export pipeline from the northern offshore Shwe gas field to the Chinese border. In 2017, 3.8 bcm, approximately 80% of the Shwe gas field production, was exported to China.

Due to a growing demand for natural gas in Thailand and China and both countries' increasing dependence on imports, the export market for Myanmar's gas is promising. In Thailand, declining domestic natural gas production and surging domestic power demand

are driving the country to secure more natural gas. Meanwhile, the Government of China’s ‘Blue Sky’ policy to improve air quality has created a large demand for natural gas by switching from coal as a fuel. The question is whether Myanmar has enough gas to sustain the level of exports needed by these two countries.

This study assumes that exports to Thailand and China will decrease and eventually stop during the study period. Data provided by the Ministry of Electricity and Energy suggest that all exported natural gas comes from offshore natural gas fields as of 2018, and that the existing fields will be depleted around 2030. The Yadana, Yetagun, and Zawtika fields supply gas for export to Thailand; and Shwe supplies gas for export to China. This study assumes that exports to Thailand will stop in 2035, and exports from Shwe will stop in 2033. This is mainly because production from these fields will decline and the additional potential supply from onshore fields will be prioritised to supply the domestic market. As the southern offshore fields will start to deplete earlier than Shwe, exports to Thailand will stop earlier.

Figure 4.5: Export Volume Assumption of this Study



mscfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

In both cases, it is still possible that the export pipeline will continue to be used to transport imported and regasified gas from LNG receiving terminals in Myanmar. If a receiving facility is built in Kyaukpyu (the feeding point of the existing export pipeline to China), LNG may be imported and regasified at the Kyaukpyu terminal, then shipped through Myanmar to the Chinese border. The same arrangement will be possible if an LNG receiving

facility is developed along Myanmar's southern coast (e.g., in Dawei). This is more likely for a pipeline to China because China has been keen to diversify its natural gas supply routes. The country has developed a pipeline network from Central Asia and Myanmar, and is currently developing another pipeline from Russia. The existing Myanmar–China pipeline has become an important supply route in light of China's aim to diversify. Even if production from the Shwe gas field declines, China may want to import natural gas through the pipeline by building an LNG terminal in Kyaukpyu and sending regasified gas through the pipeline.

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Chapter 5

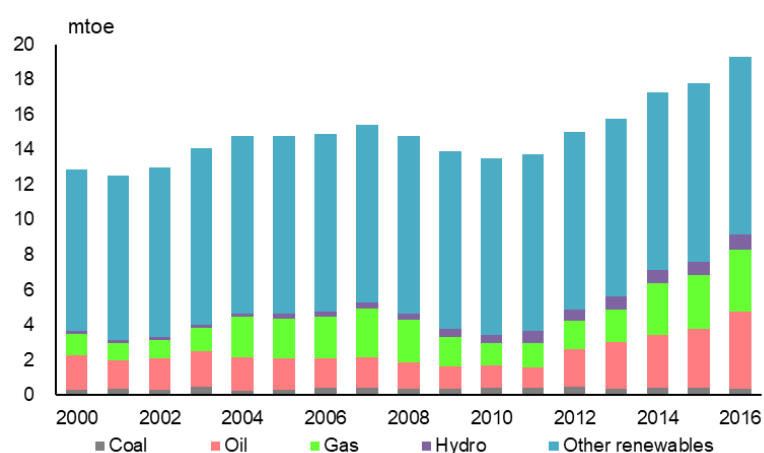
Natural Gas Demand Outlook

1. Historical Natural Gas Demand

1.1. Overview

Myanmar is known for its vast resources of natural gas. However, the country's natural gas demand is small relative to the size of its resource base. In 2016, natural gas accounted for just 18% of the total primary energy supply, making it the country's fourth largest energy source after other renewables (conventional biomass such as firewood and charcoal), oil, and hydropower.

Figure 5.1: Total Primary Energy Supply in Myanmar since 2000

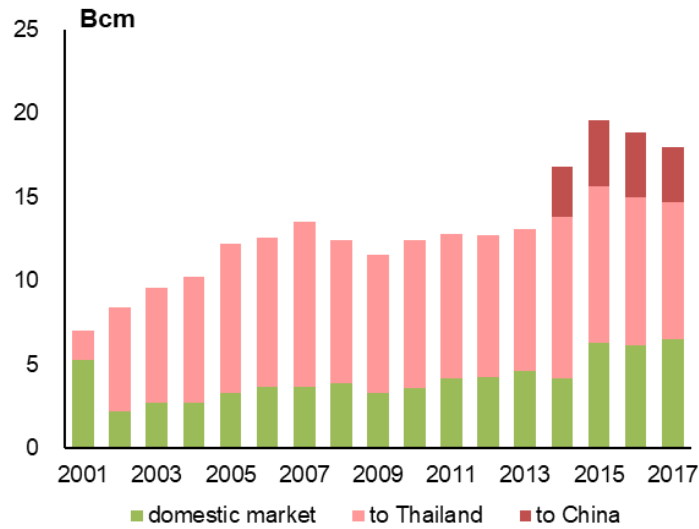


Hydro = hydropower, mtoe = million tonnes of oil equivalent.

Source: International Energy Agency (2018).

This moderate use of natural gas is due to the fact that natural gas has been regarded as an export product to earn foreign currency, rather than an energy source for domestic use. Two-thirds of the natural gas produced in Myanmar in 2017 was exported to Thailand and China (Figure 5.2). However, domestic demand for natural gas has also increased steadily since 2010, mainly driven by demand from the power sector. As the country's energy demand grows in line with its economic growth, it is highly likely that natural gas will play a far more important role in Myanmar's future energy mix.

Figure 5.2: Direction of Natural Gas Production in Myanmar



Bcm = billion cubic metres.

Note: Due to differences in the referenced statistics, the total amount of energy differs from that in the other tables and figures in this chapter.

Source: BP (2018).

1.2. Natural Gas Demand by Region

Myanmar consumed 457 million cubic feet per day (mmcf/d) of natural gas in fiscal year (FY) 2017 according to data provided by the Ministry of Electricity and Energy (MOEE).¹ The Yangon region is the largest regional gas market in Myanmar, accounting for almost half of the country’s total consumption. Approximately 90% of the gas consumed in Yangon is used by the power sector, and the remainder is used by the transportation sector (in the form of compressed natural gas [CNG]) and industry sector. All public buses and many taxis in Yangon city use CNG, and natural gas is an indispensable fuel for public transportation. Although Yangon is Myanmar’s largest city, its residential and commercial sectors do not consume natural gas.

¹ ‘FY’ before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 ended on 31 March 2017. The fiscal year (FY) of the Government of Myanmar previously ended on 31 March. However, due to recent changes in government policy, FY2019 began on 1 October 2018 and will end on 30 September 2019.

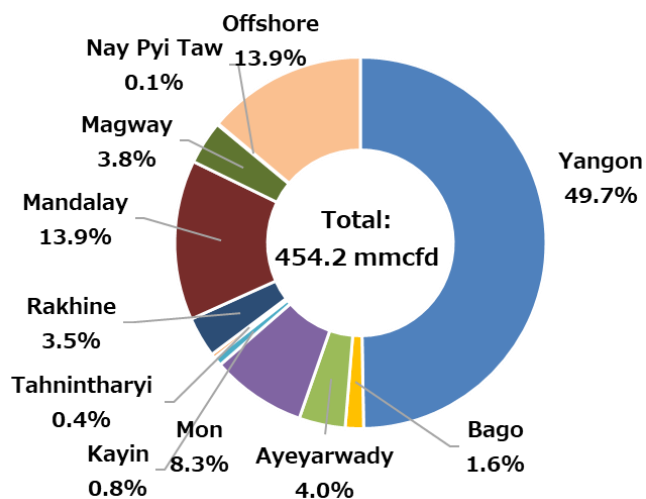
Table 5.1: Natural Gas Consumption by Region and Sector in Fiscal Year 2017

Unit: mmcfd	Power	Industry	CNG	Fertiliser	Energy industry	Total
Yangon	203.0	4.7	17.7		0.5	225.8
Bago	6.6	0.7				7.3
Ayeyarwady	3.1	1.2		13.1	0.8	18.3
Mon	37.5	0.1				37.5
Kayin		3.6				3.6
Tahnintharyi		1.6				1.6
Rakhine	15.9					15.9
Mandalay	56.7		6.6			63.3
Magway	5.6	2.9	6.1	2.6	0.1	17.2
Nay Pyi Taw		0.5				0.5
Offshore					63.1	63.1
Total	328.5	15.2	30.3	15.7	64.5	454.2
Share	72.3%	3.3%	6.7%	3.5%	14.2%	100.00%

CNG = compressed natural gas, mmcfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Figure 5.3: Gas Consumption by Region in Fiscal Year 2017



mmcfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Mandalay is the second largest gas-consuming region in Myanmar. The demand components in the Mandalay region are similar to those in Yangon: power generation accounts for 80% of the region's gas consumption, and the remaining gas is consumed by

the transportation and industry sectors. Although Mandalay city is the country's second largest city, it does not consume natural gas because it is located far from the existing pipeline network, and it has not yet been connected to it.

Myanmar's offshore demand for natural gas is one of the country's largest areas of demand. All natural gas consumed offshore is used at natural gas development sites such as the Yadana or Yetagun gas fields. Such offshore upstream operations account for approximately 14% of the country's total natural gas consumption.

Mon state is also a big user of natural gas. Located between Yangon and Thanintharyi, Mon state has very good access to a natural gas supply, and it takes advantage of its location by using natural gas mainly to generate power.

Other gas-consuming regions are located in the south (Ayeyarwady, Kayin, and Thanintharyi) and mid-north (Rakhine, Magway, Bago, and Nay Pyi Taw) of the country. Myanmar has a long history of domestic oil and gas production, and its natural gas pipeline network is well developed. Natural gas consumption therefore extends to many different regions of the country. Natural gas use in these regions is concentrated in the power and industry sectors, except in Magway where most natural gas (in the form of CNG) is used for transportation.

1.3 Natural Gas Demand by Sector

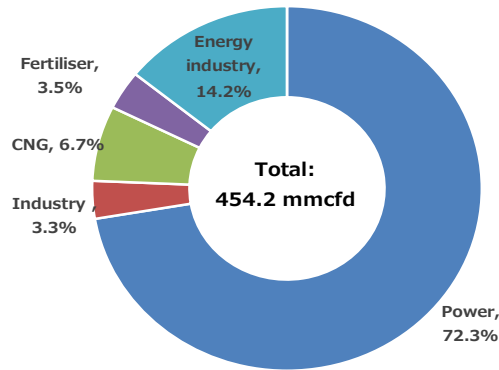
Power sector

Since 2010, natural gas demand has grown rapidly, largely driven by the power generation sector. Almost three-quarters of natural gas demand comes from Myanmar's power sector (Figure 5.4). Thanks to strong economic growth after the country's economic reform, demand for energy and electricity has grown rapidly.

Hydropower generation has traditionally been Myanmar's primary source of energy for power generation, but its capacity development and generation have not caught up with the pace of power demand growth. This is because there are few remaining sites suitable for hydropower generation, and opposition from local communities has intensified against the construction of new hydropower generation plants. It is becoming increasingly difficult to expand hydropower generation, and natural gas is being used more often as an alternate baseload power generation source. According to the International Energy Agency, natural gas demand from the power sector more than quintupled from 493 kilotonnes of oil equivalent in 2011 to 2,653 kilotonnes of oil equivalent in 2016, and its share of total

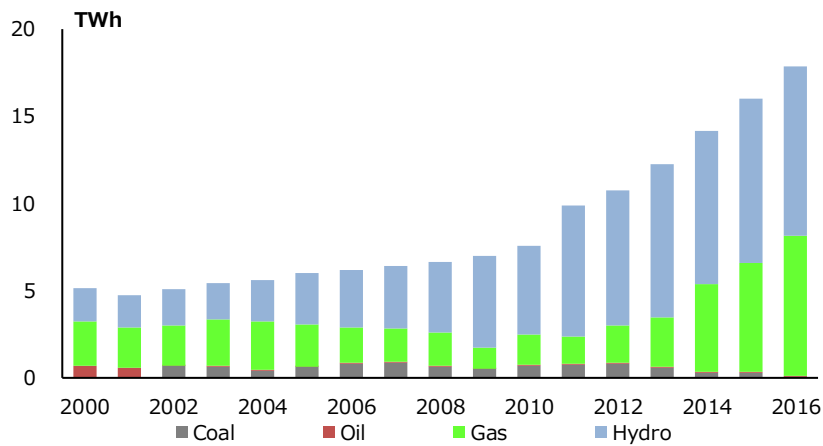
electricity generated rose from 23% in 2010 to 45% in 2016.

Figure 5.4: Natural Gas Consumption by Sector in Myanmar



CNG = compressed natural gas, mmcfd = million cubic feet per day.
 Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Figure 5.5: Historical Power Generation in Myanmar by Fuel



Hydro = hydropower, TWh = terawatt-hour.
 Source: International Energy Agency (2018), *Energy Balances of the World*, Paris.

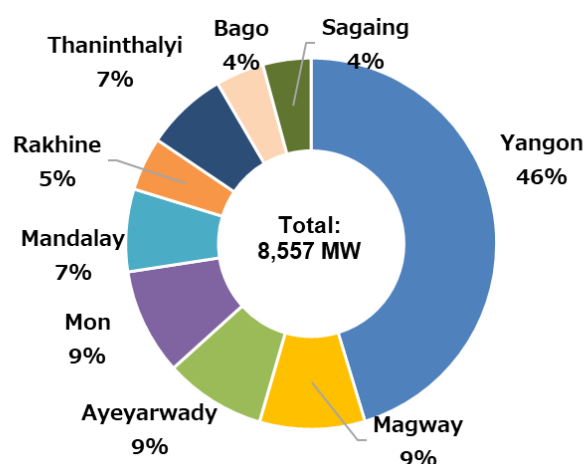
As of mid-2016, Myanmar's total installed power generation capacity was 4,764 megawatts (MW), 38% of which (1,824 MW) comes from natural gas-fired power plants according to statistics provided by the Asian Development Bank (ADB) (ADB, 2016).² Most

² Hydropower has the largest capacity (2,820 MW), while coal has a capacity of 120 MW.

of this capacity comes from gas turbines, but some smaller power plants use gas engines. Natural gas-fired power has been traditionally used as a mid- or peak-load generation source, since hydropower has been the primary baseload generation source. However, since the 2010s natural gas is increasingly being used as a baseload generation source, as the demand for power grows and the addition of new hydropower generation slows.

Demand for power generation is concentrated in the Yangon region, which is the centre of the country’s economic activities. The Yangon region accounts for more than 40% of the country’s gas power generation capacity and 60% of its gas consumption for power generation. Other gas-fired generation plants are located along the country’s long-distance pipeline network, in places such as Magway, Ayeyarwady, and Mon.

Figure 5.6: Natural Gas Demand for Power Generation by Region



MW = megawatt.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Myanmar’s electrification rate is very low. Although it improved significantly from 16% in 2006 to 34% in 2015, it has a long way to go before reaching the global average (86%) (IEA, 2017). This rate varies across regions: it is relatively high in urban areas (78% in Yangon, 46% in Kayar, 40% in Mandalay, and 39% in Nay Pyi Taw), but only 20% in rural areas (ADB, 2016).

The most realistic and sustainable option to raise the electrification rate in rural areas is to construct gas-fired power generation plants along the coast and send the electricity through the grid. As production from domestic natural gas fields matures, using imported liquefied natural gas (LNG) gas to generate power (gas-to-power operation) will become an increasingly important option.

Transportation sector

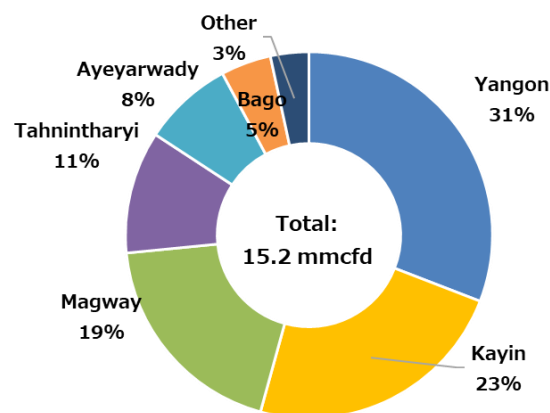
Transportation is the second largest area of gas demand in Myanmar, consuming 49 mmcf of CNG in FY2017. In the mid-1980s, Myanmar began to develop a CNG supply network for transportation use to reduce dependence on imported oil products. However, initial efforts were relatively limited, with only five CNG stations built and about 580 CNG vehicles deployed during 1986–2004. The development program was reactivated in 2004 when the international crude oil price began to rise, and the development of CNG infrastructure has since accelerated.

In 2016, 46 CNG stations were operating in Myanmar. Of these, 41 are in Yangon, and the remaining 5 are in Magway and other regions near the onshore natural gas fields in the north of the country. In Yangon, public buses and many taxis run on CNG. The price of CNG for public transportation is regulated at a low level to enable people to use inexpensive means of transportation.

Industrial sector

The industrial sector is the third largest area of natural gas demand in Myanmar, accounting for just under 5% of total gas consumption in FY2017. Many of Myanmar's businesses are classed as 'light industry' such as food and plastic processing, which does not consume much energy. In Yangon, several industrial zones have been developed, some of which have access to natural gas. However, as explained below, many industrial customers lack an adequate natural gas supply and therefore cannot use natural gas as a power source. In this sense, the industrial sector contains a large unfulfilled demand, and its potential demand could be huge if a larger supply should become available.

Figure 5.7: Natural Gas Demand for Industry by Region



mmcf = million cubic feet per day.

Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

Fertiliser feedstock

Natural gas is also used as feedstock for fertiliser production in Myanmar, with 15.7 mmcf of natural gas consumed for this purpose in FY2017. Since agriculture is the country's largest economic segment, the supply of fertiliser is critically important. In 2016, fertiliser plants existed in Yangon, Magway, and Patheingyi in the Ayeyarwady region, although actual gas consumption for fertiliser feedstock was confirmed only in Ayeyarwady and Magway according to the MOEE. Since domestic production cannot meet the full demand for fertiliser, Myanmar imports fertiliser to fill the gap.

There is a plan to build a new fertiliser plant in Pyaw, in the Bago region. Since the Shwedaung–Magway pipeline is not operating, the planned plant does not have a sufficient supply of natural gas feedstock. Once the pipeline is renovated or replaced and the natural gas supply is restored, construction of the plant will be realisable and the plant will be able to consume natural gas.

Residential sector

No residential use of natural gas was observed in FY2017. In Myanmar, traditional biomass such as charcoal and firewood accounts for around 80% of the total residential energy demand. Due to the country's warm climate, residential demand is mainly used for cooking, and demand for heating is limited. While traditional biomass is dominant in residential energy, in urban areas, electricity and liquefied petroleum gas (LPG) are increasingly being used due to their convenience. As the urban population grows, demand for such commercial energy sources will surely grow as well.

LPG will likely be used more widely in Myanmar in keeping with the common trend that sees LPG demand grow as a country's economy expands and the average income of the population increases. New LPG-import facilities are being developed, and LPG-utilisation facilities are being installed as a common feature in new buildings in large cities such as Yangon.

On the other hand, the prospect of natural gas demand from the residential sector is not very promising. No Southeast Asian country (except for Singapore) currently uses LNG as a source of residential energy. This is because the demand size of each household is small, and the development of a pipeline network cannot be economically justified. Regulated energy prices also prohibit investors from recovering their investments. As discussed in Chapter 6, the government will need a well-crafted urban development plan to realise residential use of natural gas in Myanmar.

Figure 5.8: Liquefied Petroleum Gas Supply Station in Yangon City

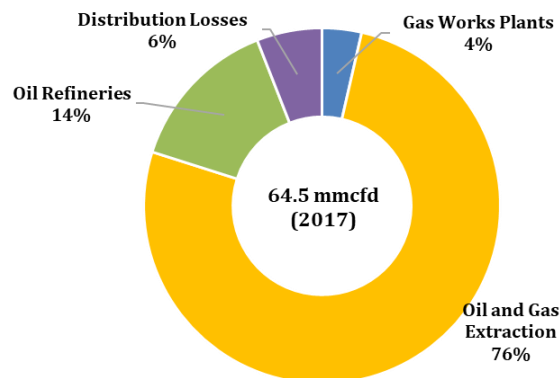


Source: Photograph taken by the study team.

Energy industry

Finally, Myanmar's energy industry, or the oil and gas industry more specifically, is also a large user of natural gas. It consumed 64.5 mmcf of natural gas in FY2017, 14% of all gas consumed. Oil and gas production consumes by far the most energy in this demand segment, followed by oil refineries. In terms of consumption by location, offshore operations consume the most natural gas. Since energy consumption by oil and gas changes in accordance with the level of oil and gas production, demand in this segment is likely to decrease in the coming years.

Figure 5.9: Component of Natural Gas Consumption in the Oil and Gas Industry in Fiscal Year 2017



Source: Institute of Energy Economics, Japan based on data provided by the Ministry of Electricity and Energy.

2. Natural Gas Demand Outlook

2.1. Overview

This section provides the natural gas demand outlook for Myanmar through 2040. This outlook is calculated based on the energy demand outlook published by the Economic Research Institute for ASEAN and East Asia (ERIA) in 2016 (ERIA, 2016). Some basic assumptions such as gross domestic product growth or population growth refer to assumptions in the 2016 ERIA outlook.

Several updates have been made to the original ERIA outlook. For example, the outlook for city gas demand (i.e., from the industry, transportation, fertiliser, and residential and commercial sectors) has been updated based on findings made by the study team during their field trips (see the Appendix for a summary of the trip findings). The demand outlook also reflects communications with government officials in both Nay Pyi Taw and local administrative centres.

The second update is a technical change to the base year for the demand forecast. While the original ERIA outlook adopted the demand figure from 2013 as the base year, this study adopts the demand figure from 2016 as the base year because updated demand data are now available for this year. Since actual demand in 2016 was much larger than the demand forecasted in the original 2016 outlook, the overall demand level in this study exceeds the original outlook figures.

One caveat to analysing natural gas demand in Myanmar is that the historical demand discussed in this section is the observed consumption of natural gas. However, there is a large volume of unfulfilled demand, that is, demand that was not realised due to the lack of a physical supply of natural gas or necessary infrastructure. In Myanmar, there is a sizable gap between the realised historical demand and unfulfilled demand. In a market in which there is a sufficient supply and adequate infrastructure, the gap between the two demands is small. However, in a country like Myanmar where the natural gas supply is limited and domestic production and infrastructure are underdeveloped, many power generation and industrial users cannot secure the natural gas that they need, and the gap tends to be wider. The historical demand discussed in this section deals only with the realised demand, not unfulfilled demand. Section 5.2, which discusses demand outlook, also assumes the to-be-realised demand based on the assumption that a natural gas supply and relevant infrastructure will be available. In a growing natural gas market, demand can be created by supply. A greater supply capacity or more extensive infrastructure creates upside potential for forecasted demand.

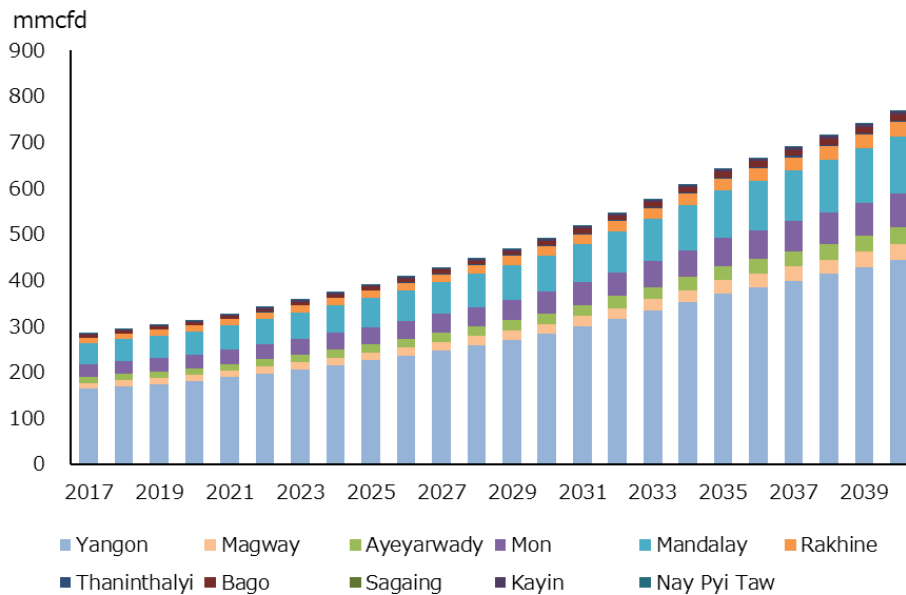
2.2 Demand Outlook by Sector

Power generation sector

The power sector will remain the largest demand sector for natural gas in Myanmar. As electricity demand grows, the role of and expectations for natural gas will also continue to increase, given the limited availability of alternative power supply sources in Myanmar. It is becoming more difficult to develop additional hydropower generation plants due to environmental concerns over the development of new plants and a lack of ideal locations for hydropower generation. Similarly, it is difficult to construct new coal-fired power plants due to public opposition from local communities. Myanmar has tried to install renewable power generation, but a back-up source is still necessary to ensure a stable power supply. Natural gas-fired power generation is the last resort for establishing a power supply for Myanmar, and the demand for gas-fired power generation will inevitably increase during the study period.

Most of the demand increase will emerge in Yangon and other regions in the south where several new gas-fired power generation development projects are expected.

Figure 5.10: Forecast of Natural Gas Demand for Power Generation in Myanmar



mmcf/d = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

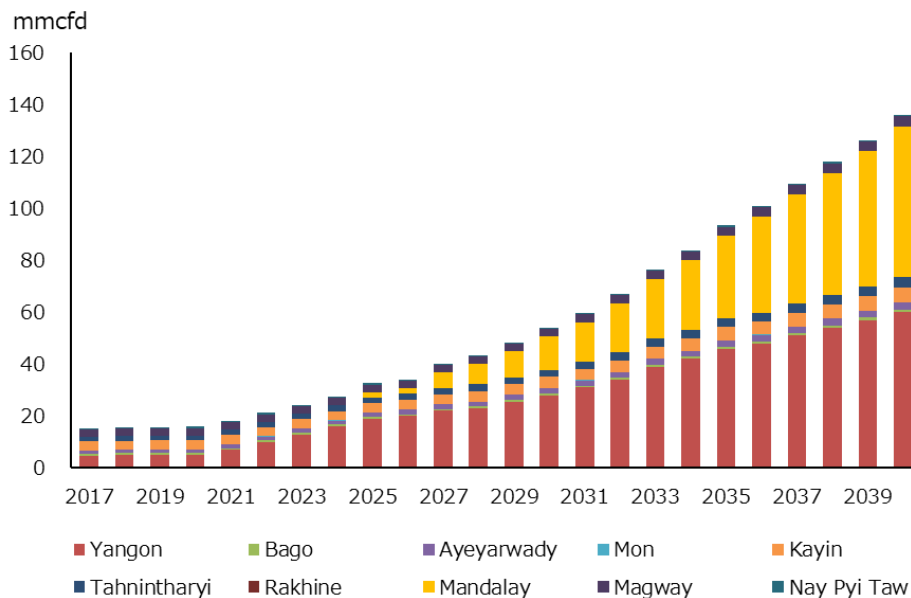
Industrial sector

A large part of incremental natural gas demand in Myanmar will be in the industrial sector. Since many industries being developed in Myanmar are labour-intensive, demand from individual users will be rather small. The government is promoting the development of industrial zones for manufacturing industries, and new industrial gas users will be found in these zones as the development of supply infrastructure becomes economically justifiable to meet the demand that accumulates in these areas.

One such industrial zone is the Thilawah Special Economic Zone (SEZ). According to the regional government of Yangon, the SEZ is planning to build a 50-MW gas-fired power plant that may consume 21 mmcf of fuel. In addition to the demand for power generation in Thilawah SEZ, several factories will use city gas for their manufacturing activities. The expected city gas demand at this stage is estimated at 6.2 mmcf–7.0 mmcf, which will grow further as the development of the SEZ proceeds towards 2040.

The study assumes that such industrial demand will grow steadily, mainly in the Yangon and Mandalay areas. The estimated demand outlook for industrial gas consumption is shown in Figure 5.11.

Figure 5.11: Forecast of Natural Gas Demand for Industry in Myanmar



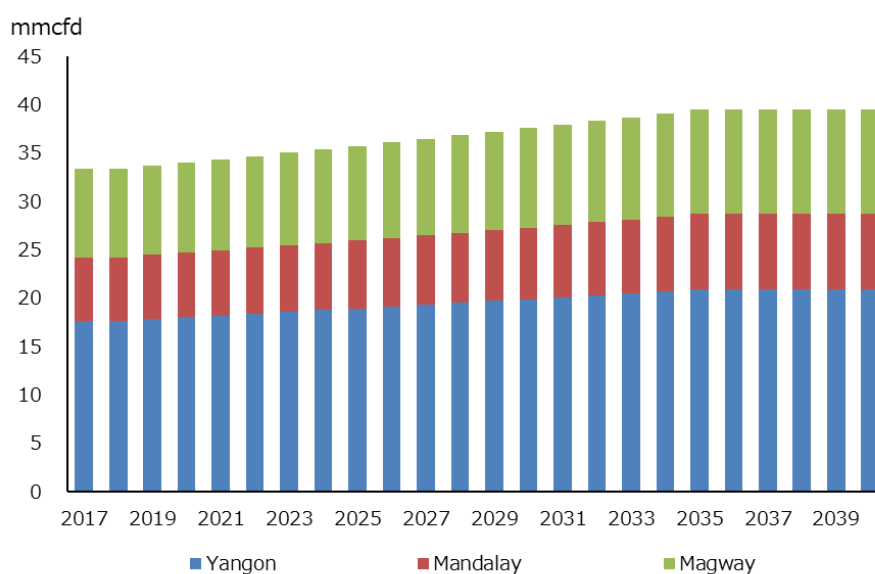
mmcf = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

Transportation sector

Myanmar has been using natural gas as a transportation fuel since the mid-2000s. More than 500 CNG vehicles are in use and there are 46 CNG-fuelling stations in the country. Although it is expected that the existing infrastructure for CNG will be used during the study period, expansion of the supply capacity is unlikely due to anticipated shortages in the supply of natural gas in the future. This study assumes that the CNG demand will increase slightly during the study period.

Figure 5.12: Forecast of Natural Gas Demand for Transportation in Myanmar



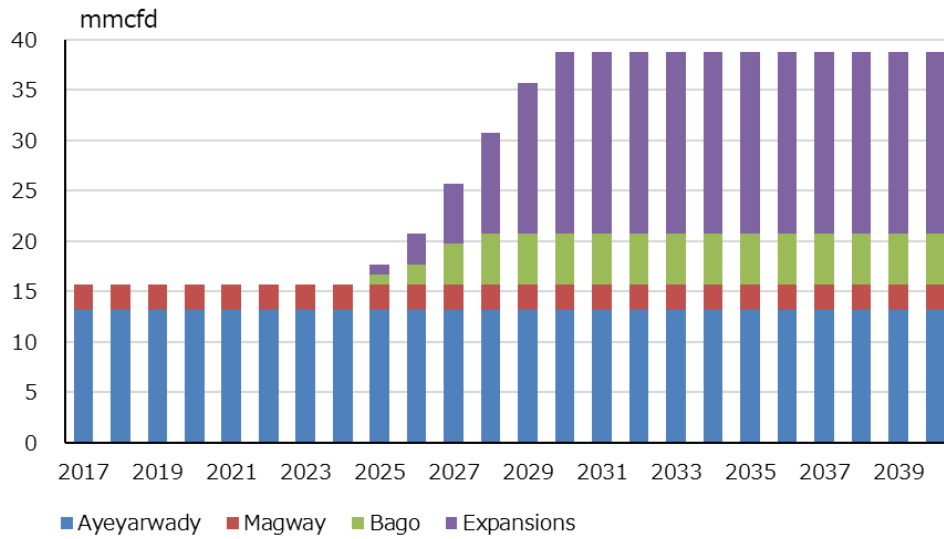
mmcf = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

Chemical feedstock

Natural gas consumption as chemical feedstock for fertiliser will increase moderately during the study period. According to the MOEE, three fertiliser plants were consuming 16 mmcf of natural gas for feedstock as of FY2017. Since fertiliser is a critical material for the country's agricultural sector and demand is very likely to continue to grow, the existing capacity will be fully utilised during the study period. There is a plan to build another fertiliser plant in Pyay, and it will begin operating after the pipeline network from Magway is renovated. This study assumes that the pipeline renovation will be completed in 2025, that capacity expansions will be implemented in existing plants, and that demand for fertiliser feedstock will also grow moderately from the mid-2020s to 2030.

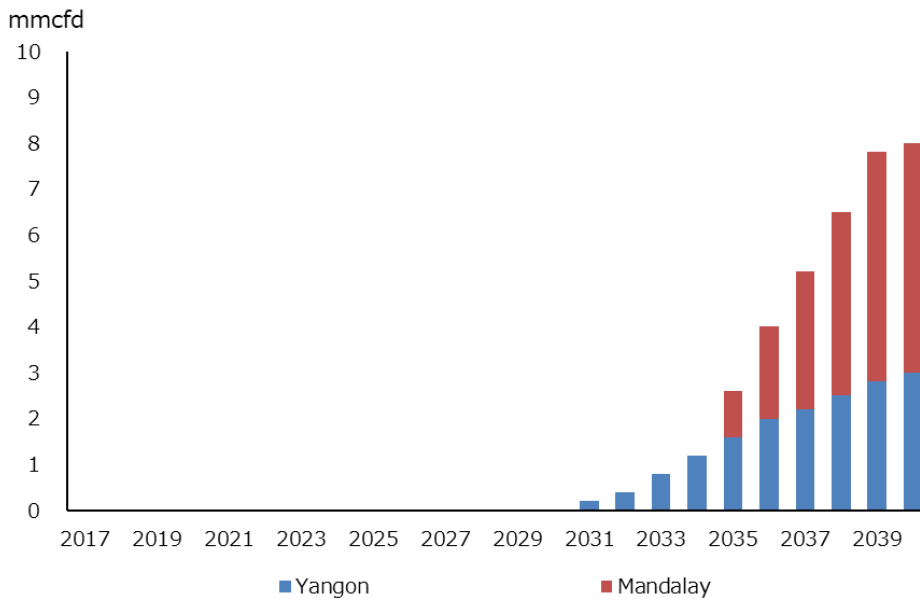
Figure 5.13: Forecast of Natural Gas Demand for Chemical Feedstock in Myanmar



mmcfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

Figure 5.14: Forecast of Natural Gas Demand for the Residential and Commercial Sectors in Myanmar



mmcfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

Residential and commercial sectors

Natural gas demand in the residential and commercial sectors will be developed only in Myanmar's two largest cities, Yangon and Mandalay. However, the volume will be small compared to demand from other sectors. Due to price competitiveness, electricity will remain the primary source of energy for households. LPG demand may increase as it is relatively easy to handle; however, residential and commercial use of natural gas will be limited due to the high cost of developing a pipeline network and limited availability of a low-cost natural gas supply.

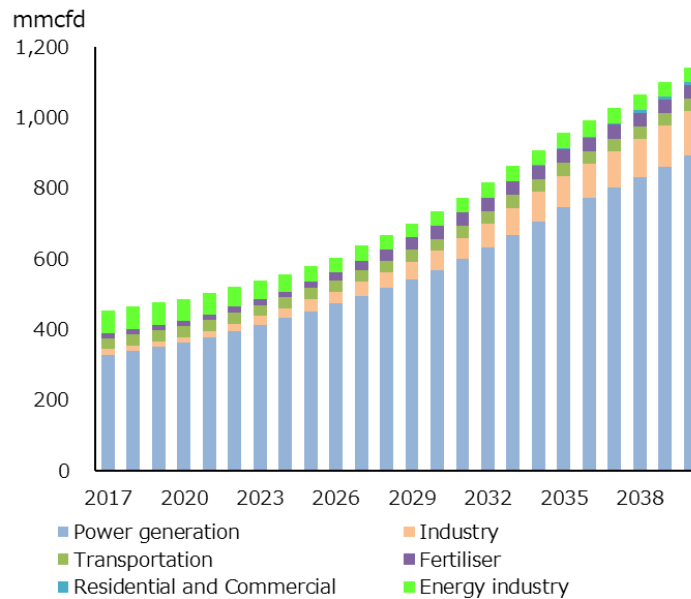
Energy Industry

Oil and gas industry consumes a large volume of natural gas as well. The sector consumes about 14% of the total natural gas consumption in fiscal year 2017. As mentioned above, most of the current demand is found in the upstream sector, and thus the upstream is expected to decline in the future. But in the downstream sector, a new refinery will be built in Myanmar and thus the downstream demand is expected to grow. Because the demand decline in the upstream sector is larger than the demand growth in the downstream sector, the total demand for energy industry will decrease during the forecasted period.

Total demand

Natural gas demand in Myanmar will continue to rise, from 457 mmcf in 2017 to 486 mmcf in 2020, 734 mmcf in 2030, and 1,142 mmcf in 2040 (Figure 5.15). Power generation will remain the dominant demand sector, with its share of total gas consumption increasing from 72% in 2017 to 79% in 2040. Demand growth will exceed the rate of growth in the city gas sector (non-power final natural gas users).

Figure 5.15: Forecast of Total Natural Gas Demand in Myanmar



mscfd = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

As of 2017, demand from the transportation sector (for CNG vehicles) is the largest segment of city gas demand. Industrial demand is expected to rise in the future as manufacturing businesses become more active, particularly in the Yangon and Mandalay regions. In the late 2020s, industrial demand will exceed transportation demand and become the second largest demand segment after the power generation sector. On the other hand, consumption in the energy industry will decline, reflecting diminishing domestic oil and gas production.

3. City Gas Network Development

This section explores city gas demand (excluding demand for power generation) in Yangon and Mandalay, the two largest cities in the country. The demand figures forecasted in this section reflect the demand outlook in the previous section.

3.1 Yangon

City overview

Yangon is Myanmar’s largest city and the most promising place for city gas demand development in the country. As a region, Yangon comprises 45 townships, 33 of which are

in Yangon city. Yangon city had approximately 5.2 million inhabitants as of 2014. Located in the Ayeyarwady River delta, the city has enjoyed prosperity as the economic centre of Myanmar ever since it was designated the country's capital under British colonial rule. Even after the capital was moved to Nay Pyi Taw in 2006, the city has maintained its position as the country's economic and financial epicentre. There are 14 SEZs in the city, most of which contain a number of light industries such as the food processing and garment industries. Thilawah SEZ, located in the south of the city, is the largest economic zone in the city, and accommodates a number of manufacturing companies such as food factories, steel mills, and motorcycle assembly plants. Yangon's gross domestic product is growing faster than that in other parts of the country, and there is high potential for city gas demand development.

Current city gas demand

Yangon is the largest consumer of city gas in Myanmar. The total non-power generation demand in Yangon in 2018 is estimated at 22 mmcf/d. Most of this demand comes from the transportation sector (18 mmcf/d), but demand from the industrial sector is expected to grow as the country's manufacturing sector expands. As of FY2017, gas demand from the industrial sector was not very large (5 mmcf/d).

Figure 5.16: Location of Yangon City

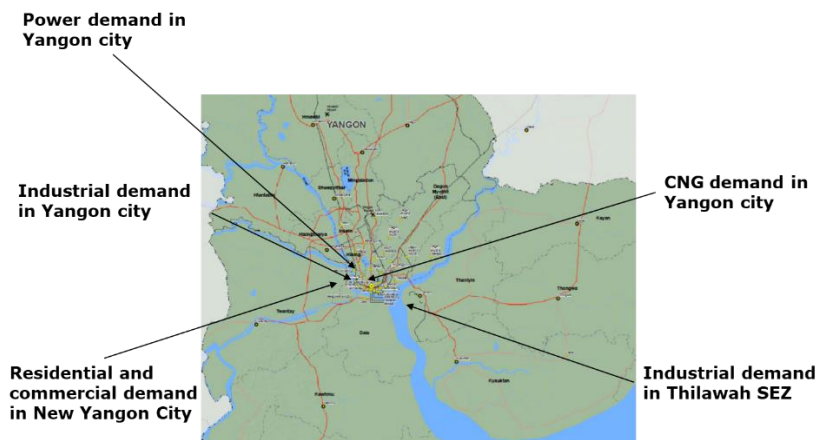


Source: United States Central Intelligence Agency.

City gas demand potential in Yangon

Several different areas of natural gas demand are expected to emerge in the future, and industrial demand is the most promising. Of the various industrial zones around Yangon city, Thilawah SEZ and the industrial zone in the northwest of the city in particular have a large demand potential. CNG demand will remain the major demand segment, and residential and commercial demand may be expected in the newly developed area in the southwest of the city.

Figure 5.17: Potential City Gas Demand Areas in Yangon City



CNG = compressed natural gas, SEZ = Special Economic Zone.
Source: Institute of Energy Economics, Japan.

Industry

The largest city gas demand potential exists in the industrial sector. As Myanmar's economic epicentre, Yangon has unrivaled demand potential for city gas use in the industrial sector. Industrial gas demand in the Yangon region is roughly split between (i) the existing industrial zones and (ii) Thilawah SEZ.

The largest segment of industrial gas demand in Yangon is in the newly developing industrial zone of Thilawah SEZ. Most of the operating factories are light industry, such as beverage and food manufacturers. A new gas-fired power plant (comprising two 25-MW gas-fired turbines) is planned to meet the growing demand for power in the SEZ. The gas demand from the power plant is expected to be 21 mmcf/d. This new plant will supply electricity only to Thilawah SEZ. As the development of the SEZ is expected to continue, the capacity of the new power plant will likely be expanded through 2040.

Figure 5.18: Thilawah Special Economic Zone



ha = hectares, Int'l = International, MJTD = Myanmar Japan Thilawa Development Limited, SEZ = Special Economic Zone.

Source: retrieved from Myanmar Japan Thilawa Development Limited (MJTD) website.

Figure 5.19: Planned Location of the Gas-Fired Power Generation Plant in Thilawah



Source: Photograph from the study team site visit.

Demand for gas as an industrial fuel will also grow. As of August 2018, companies such as food and motorcycle manufacturers are planning to use gas in Thilawah SEZ. The combined volume of the planned gas demand is 6 mmcf–7 mmcf. Since factories in the SEZ will use LPG as an industrial fuel, once the pipeline network to the SEZ is developed, LPG demand can be converted to city gas demand as natural gas is usually cheaper than LPG.

The study assumes that the combined industrial gas demand in Thilawah SEZ will reach 50 mmcf by 2040. As mentioned above, a demand of 27 mmcf–28 mmcf is already expected as a firm figure. Expanding gas-fired power plants beyond the planned 50 MW and adding natural gas demand from new factories in the SEZ will push up the gas demand level. Relative price competitiveness against that of electricity will remain a cause for concern, but many of the investors in the SEZ are foreign companies that use city gas in their home countries, and they will prefer to use natural gas for operational purposes if a supply is available.

The second largest demand potential for industrial gas use exists in the Ywama area, in the northwest of Yangon city. Several large factories in this area, including a steel mill, a tire factory, and a beverage factory, consume large volume of energy. As this area is located close to the existing gas supply infrastructure (the Ywama natural gas supply distribution centre), many of these factories already have a pipeline connection to the gas grid and are

consuming gas. As economic activities commence in the area, energy demand will surely increase in the coming decades. Natural gas is well-placed to capture this additional demand, at least in terms of supply infrastructure.

Figure 5.20: Gas Use Measurement System at a Consumer Product Factory in Ywama



Source: Photograph from the study team site visit.

The key issue as to whether natural gas can find a larger incremental demand in the area is one of supply availability rather than price level. A ceiling of allowed gas consumption is imposed on most factories operating in the area, and factories must slow their operation if their gas consumption will exceed the predetermined limit.³ The level of this limit is negotiated annually between the factory and the Myanmar Oil and Gas Enterprise (MOGE), and each factory has to report their actual consumption of natural gas to MOGE regularly. If a sufficient volume of natural gas becomes available, economic activities in the area will be boosted further.

³ Based on an interview conducted by the author in August 2018.

Price levels may not be a serious issue for city gas demand development, at least with regard to the demand from private industrial players. As of August 2018, one privately operating company in the area pays MOGE \$8 per million British thermal units (MMBtu)–\$9/MMBtu, and wants still more gas to sustain its manufacturing activities at the current level. The price level for private companies is not very low, as the international LNG spot price trades at around \$10/MMBtu. The contract gas price for private factories is also negotiated and agreed once a year like the ceiling volume with MOGE. This suggests that private companies at least are ready to pay higher prices to have a secured gas supply.

The study estimates the gas demand from existing industrial zones at 10 mmcf. The new gas demand will be centred in the northwest of Yangon, where the Ywama natural gas supply station is located. Supplying gas to neighbouring factories will be easier, and some nearby factories already have pipeline access. If supply constraints can be resolved through either additional domestic production or LNG imports, industrial demand has high growth potential.

Transportation

Besides power generation, transportation is currently the largest city gas demand segment in Yangon. Yangon is known for its extensive bus transportation network operated by Yangon Bus Services (YBS) and all YBS buses are fueled by CNG. The fee for bus transportation is set very low as buses are a vital means of transportation for Yangon's citizens, and the price of CNG is also set very low, at 270 kyats (\$0.22) per liter. As the economy of Yangon city grows, the urban population and, therefore, demand for public transportation will increase. In anticipation of such demand growth, YBS plans to order another 500–1,000 CNG buses, in addition to the existing 4,000 buses. CNG demand is currently flat as the number of CNG buses and taxis remains the same, but it will gradually increase as new CNG vehicles are deployed.

Figure 5.21: Compressed Natural Gas Station for Taxis in Yangon City

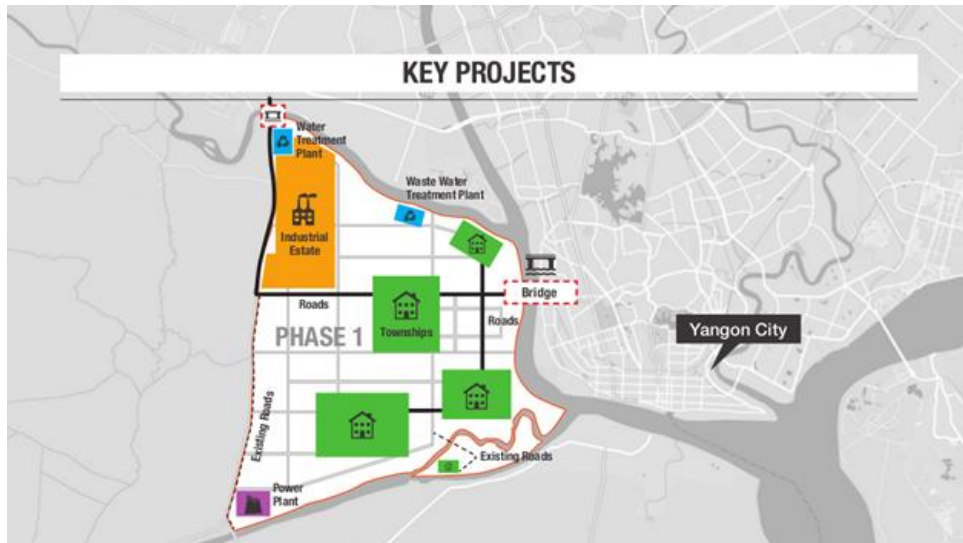


Source: Photograph from the study team site visit.

Residential and commercial

Residential and commercial demand appears limited in the short to medium term. The residential and commercial sectors are usually the last segments to develop demand for city gas because individual lots are small and investment in a pipeline network often cannot be justified. Downtown Yangon is not a planned city, and town lots are very complicated, making it extremely difficult to develop new pipeline infrastructure in this area. Yet, a newly developed residential and commercial zone would have demand potential. The New Yangon City project proposed by the New Yangon Development Corporation involves developing the west bank of the Hlai River into a new urban area with residential, commercial, and industrial zones. This will take a long time to realise and will require strong government support, in addition to well-planned and coordinated development. However, if such a development were to succeed, city gas demand from the residential and commercial sectors may emerge in Yangon city.

Figure 5.22: Location of New Yangon City



Source: New Yangon Development Company Ltd. web-site.

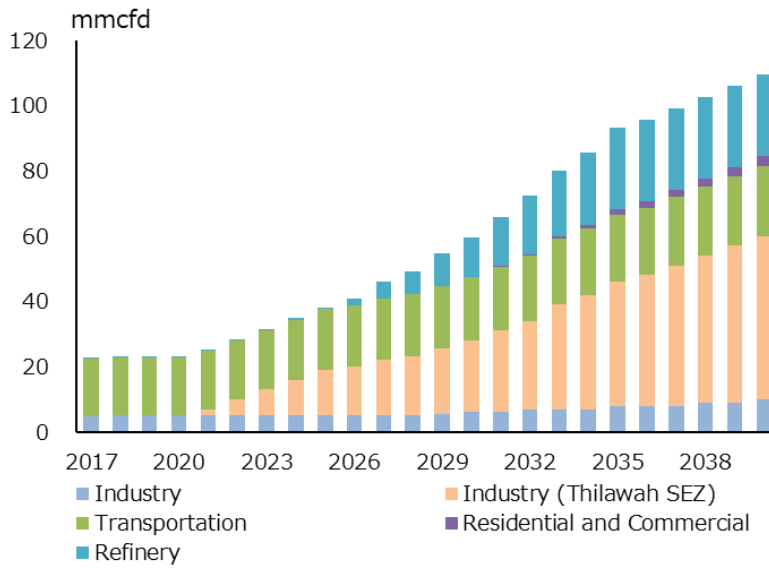
The study assumes that demand from New Yangon City will reach 2 mmcf by 2040. Electricity will remain the most reasonable energy for many of Yangon's residential and commercial users, and LPG use will also expand in the future as it is more convenient and easier to adopt than city gas. Creating residential and commercial gas demand in Yangon will require strong support and policy commitments by the government as extensive infrastructure development and an attractive pricing scheme for energy users are crucial.

Energy industry

As the economic activities expand, oil product demand is also expected to grow in the future. There are three refineries in Myanmar, but a new refinery will be needed and constructed in Myanmar in the future. Such a new refinery is expected to be built in Yangon region as it is the largest economic center and the largest oil consuming region. This study assumes that a new 200,000 barrels per day refinery will be built until 2030, and the natural gas will be used for the refinery as its fuel.

Combined city gas demand (excluding demand for power generation) will exceed 70 mmcf by 2040. Industrial demand, particularly in Thilawah SEZ, will drive demand growth.

Figure 5.23: City Gas Demand in Yangon



SEZ = Special Economic Zone.
Source: Study team estimate.

Required investments for city gas development in Yangon

As discussed above, an additional pipeline network must be developed to realise city gas demand in Yangon. The total estimated investment cost is \$4.2 million (Table 5.2).

Table 5.2: Estimated Cost of Developing a City Gas Network in Yangon

	Demand (mmcf)	Distance from gas source (m)	psi	Pipeline size (inches)	Underground construction (\$/m)	Above ground construction cost (\$/m)	Pipeline cost (\$/m)	Total cost (\$ million)
[Industry]								
Thilawah SEZ Northwestern Yangon city	50	4,000	75	12	595	297	99	2.0
Yangon city	10	4,000	75	8	488	244	62	1.6
[Residential and commercial]								
New Yangon City	3	2,000	75	4	457	228	25	0.7
Total								4.2

m = metre, mmcf = million cubic feet per day, SEZ = Special Economic Zone, psi = pounds per square inch.

Source: Study team estimate.

Given the size of the potential demand in Thilawah SEZ, it is estimated that it will be necessary to add approximately 4 kilometres (km) of 12-inch pipeline to the existing pipeline network. The unit cost of constructing the pipeline is estimated at approximately \$600 per metre (m) for underground works and \$300/m for aboveground works. It is assumed that one-third of the total pipeline will be built underground and two-thirds aboveground. The cost of coated pipeline is about \$100/m. Based on these assumptions, the cost of constructing a pipeline network to develop industrial demand in Thilawah is calculated at \$2.0 million.

To develop industrial demand in northwest Yangon, it will be necessary to construct an additional 4 km of 8-inch pipeline. The cost of construction is estimated at \$488/m for underground works and \$244/m for aboveground works. Like in Thilawah, one-third of the pipeline will be built underground. The total investment amount is estimated at \$1.6 million.

As for the residential sector, the assumed demand size is just 3 mmcfd, and the pipeline will be 4 inches in diameter. Similarly, the length of the required additional pipeline is rather small (2 km) as the planned location for the works is close to the existing pipeline network. The total investment cost of the residential demand network is estimated at \$0.7 million. We assumed that the natural gas supply to a new oil refinery will not need additional pipeline as the new refinery will be built in the same location as the existing refinery (Thanlyin).

3.2 Mandalay

City overview

Mandalay, Myanmar's second largest city, is another prospective market for city gas development in the country. Located on the east bank of the Ayeyarwady River, Mandalay is the economic centre of the mid-northern part of Myanmar. The last royal capital of Myanmar, Mandalay is regarded as the country's cultural centre and attracts a number of foreign tourists. The population of the Mandalay region is 6.2 million, but the population of Mandalay city is rather small, at around 930,000.

Located on the trading route between Myanmar and China, Mandalay has been a logistical focal point of trade with China for many years. Backed by the Belt and Road Initiative, investments from China have grown significantly in the last few years, and the regional economy is highly likely to keep expanding as trade with China grows. The opening of the international airport in Mandalay will expand the flow of goods and people to the

country and solidify the city's strategic role in Myanmar's economy. Energy demand in the city is therefore expected to expand in the coming decades.

Figure 5.24: Location of Mandalay City



Source: United States Central Intelligence Agency.

Current city gas demand

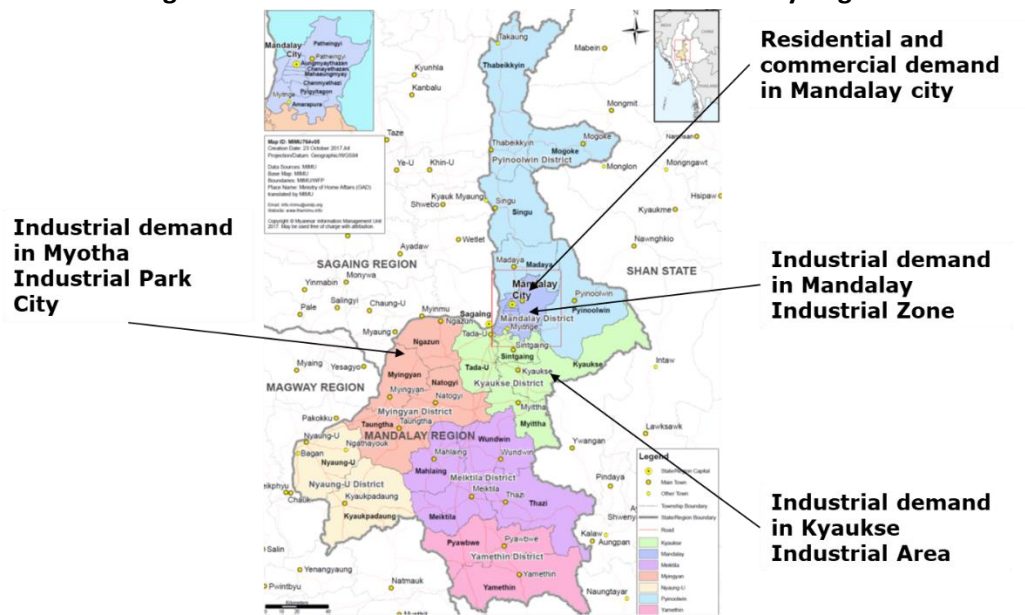
Natural gas demand in the Mandalay region is insignificant relative to the size of its economy. Downtown Mandalay city does not use natural gas because a pipeline network to the downtown area has not been developed. Mandalay as a region consumes a very small amount of gas for non-power purposes. Although the export natural gas pipeline to China passes through the region, its gas consumption is rather small. According to the MOEE, most non-power gas uses are in the transportation sector and, to a much smaller extent, in the industrial sector. Five factories in the Mandalay region use natural gas as an industrial fuel. Electricity, oil products, and coal are the major industrial fuels used in the region.

Potential city gas demand in Mandalay

The most likely potential growth area for non-power generation gas demand in

Mandalay is industry. Mandalay has several industrial zones, the largest of which (in terms of the number of operating factories) is Mandalay Industrial Zone (MIZ). Located about 10 km from the city centre, MIZ is the centre of the region's industrial activities. Major industries in this zone include food processing and garment textile manufacturing, based on the region's abundant resources. Residential and commercial demand in downtown Mandalay can be expected in the long term.

Figure 5.25: Potential Demand Areas in the Mandalay Region



Source: Institute of Energy Economics, Japan.

Industry

As of 2018, there is no demand for natural gas as an industrial fuel in MIZ due to a lack of pipeline access. Since most of the factories in this area are light industry, which is labour-intensive and does not consume a high volume of energy, the area's energy demand is not very large. Most energy sources for industrial activities in MIZ are electricity and oil products (diesel oil). Electricity is by far the largest energy source in MIZ. The tariff for electricity supplied to the factories in MIZ is regulated by the government at a low level (100 kyats or approximately \$0.08 per kilowatt-hour).

Factories in MIZ currently do not have a plan to use natural gas. The biggest reason for this is the cost of a pipeline connection. MIZ is located 40 km away from the Kyaukpyu–China pipeline, and any factory wanting to use natural gas must bear the cost of connecting to the pipeline at the offtake point of the existing pipeline network. No factory in MIZ at this

stage has the will or financial means to pay for this connection. The currently very competitive electricity tariff also prevents other energy sources from replacing the existing electricity demand.

However, natural gas demand in MIZ has potential to grow if the government or public sector take on the burden of developing the pipeline network to MIZ and revise the existing energy price mechanism. Subsidising the electricity supply may not be sustainable for a longer period and, if natural gas can become more price-competitive relative to electricity or oil products, it will have a chance to create demand in MIZ. Also, if an industry such as glass or ceramics is developed in MIZ, the manufacturers will choose natural gas as an industrial fuel because it is more easily used and adjusted, and thus more suitable to produce those products.

This study assumes that the industrial natural gas demand in MIZ will grow to 3 mmcf by 2040. Due to easier access to downtown Mandalay, industrial activities in MIZ will surely grow but, since several light industries will continue to operate and the industrial zone's ability to accommodate additional factories is limited, natural gas demand will not grow significantly, and demand will remain moderate.

Another potential demand area is the Kyaukse Industrial Area. Since it is located along the existing pipeline network system, two factories in this area (cement and glass works) used natural gas in the past. However, they no longer use natural gas due to its limited availability and factory renovations. The Kyaukse area is endowed with limestone resources and is known for its cement production. Six cement factories are in operation as of July 2018, and most of the fuel used in the factories is coal, both domestic and imported. The imported coal, most of which is from Australia, is first unloaded in Thilawah in the Yangon region, and then shipped by barge along the Ayeyarwady River to the Mandalay region. The cement industry usually prefers to use coal because it costs less than natural gas, and all of the interviewed factories plan to continue to use coal as their industrial fuel.

Natural gas demand in the Kyaukse region is not likely to be large in the short term, but it has significant potential in the long term. Using coal may become more difficult in the future as efforts to improve air quality and reduce carbon emissions proceed. Some cement factories may change to using natural gas, which is cleaner than coal. As of 2018, only one glass factory is in operation, but if another glass factory or other type of industry that prefers to use natural gas for processing reasons should emerge, demand for natural gas will grow. Easy access to a natural gas pipeline in Kyaukse will help develop natural gas demand in the area.

This study assumes that natural gas demand in Kyaukse will reach 10 mmcf by 2040. Although it will be very difficult to replace the existing demand for coal in the cement industry, if an industry that uses a large amount of heat such as steel, glass, or paper manufacturing expands in the region, demand for natural gas will also grow. Demand size is variable; for example, it can change depending on the size of a glass factory. This study assumes that five mid-sized glass factories will be developed in the area.

Mandalay Myotha Industrial Park City (MIPC) is a newly developed industrial 'city' that will include residential and commercial facilities (including golf courses) in addition to industrial zones. The industrial park city just began operating in 2016, and seven factories (including food, animal feed, and furniture manufacturers) are in operation as of July 2018. The operating factories mainly use electricity as an energy source, and consume a small amount of oil products. Although MIPC does not have access to a natural gas supply, like Kyaukse it is located along the existing natural gas pipeline network, and is conveniently located to develop access to the existing network.

As of July 2018, there is no plan to use natural gas in MIPC, and most industries that will operate in MIPC will likely be light industries such as animal feed or wood processing, which are not usually big energy users. Therefore, potential natural gas demand in MIPC is not very large at this stage.

However, if China's Belt and Road Initiative develops a logistics network in the region, MIPC may become a prosperous industrial base in Mandalay. China has already developed and used crude oil and natural gas pipelines from Kyaukpyu to China. The country also plans to build a highway and railroad network along the pipeline route. Once such a logistics network is completed, the Mandalay region will flourish further from activated trade with China. Thanks to its advantageous location, MIPC can accommodate a wide variety of industries, and will need more energy to support such industrial activities.

This study assumes that industrial natural gas demand in MIPC will grow to 50 mmcf by 2040. Because MIPC is located inland, it will be difficult to develop heavy industries such as steel or chemical manufacturing, and most factories operating in MIPC will remain light industry. However, there is a good chance that demand in MIPC will increase significantly because MIPC is very large (45 square km) and can host a large number of factories. If a new 25-MW natural gas-fired power generation plant is built to supply electricity to operating factories within MIPC, it will create an additional 10 mmcf of demand.

Residential and commercial

There is significant potential for residential and commercial demand growth in Mandalay city. As Myanmar's second largest city, Mandalay cannot be excluded as a candidate for the development of a residential and commercial city gas network. Its urban population (approximately 5.2 million as of 2014) is highly likely to grow in coming decades, and the number of potential customers will be sufficient to justify the extensive development of a city gas network to the downtown area.

However, it may take a long time to turn this potential demand into real demand in Mandalay. Most households currently use electricity for daily life purposes, and only a limited number use LPG. As the electricity tariff is low, households do not have a strong incentive to switch from electricity to natural gas, and few residential and commercial customers would like to bear the cost of a pipeline connection in particular. The city's moderate climate also limits the demand for natural gas, since the demand for hot water is limited. Commercial users such as shopping malls, restaurants, and hotels are more likely than residential customers to use natural gas.

While the regional government of Mandalay has a plan to switch household energy from electricity to city gas, the progress of the plan largely depends on the government's commitment and willingness. Because of the limited financial means of each residential household, developing a city gas network system will require a strong will and commitment by the regional government. To develop a city gas network system, either the federal or local government will need to prepare an elaborate pipeline network development plan, secure sufficient funds for pipeline development, and manage and monitor the appropriate use of natural gas in the city. As the size of economic activities in the area grows, it is becoming more difficult to develop extensive infrastructure. If the government implements a policy to begin developing a city gas network, actions to develop infrastructure should be initiated immediately.

The study assumes that commercial natural gas demand in Mandalay city will be about 5 mmcf/d as of 2040. This demand figure was derived from the assumption that there will be 10 large hotels, 3 large shopping malls, 3 hospitals, and 20 office buildings.

Table 5.3: Estimated Commercial Gas Demand in Mandalay as of 2040

User	Unit consumption (mmcm/y)	Number	Consumption (mmcf/d)
Large hospital	2,177	3	0.6
Luxury hotel	2,419	10	2.3
Office building	768	20	1.5
Shopping mall	1,362	3	0.4
Total			4.9

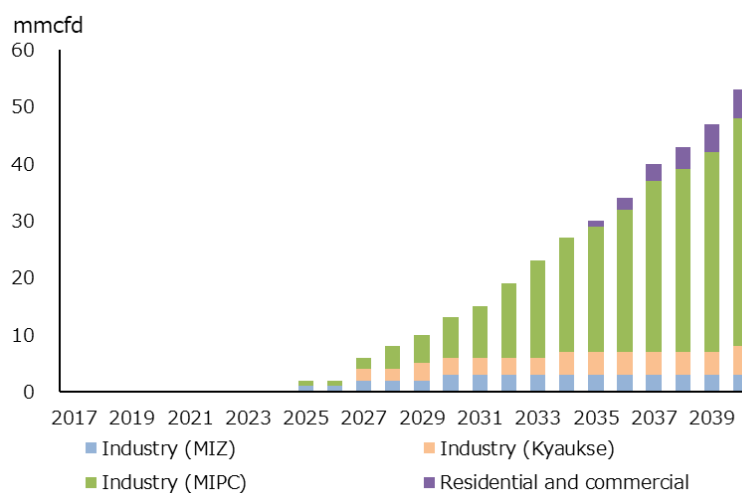
mmcm/y = million cubic metres per year, mmcf/d = million cubic feet per day.

Source: Study team estimate.

Total demand

The combined city gas demand (excluding demand for power generation) in Mandalay will reach around 30 mmcf/d by 2040. No demand is expected until 2025, when industrial demand will begin to emerge slowly as the region’s economy expands and industrial users that prefer to use natural gas start operating (expected in the latter half of the 2020s).

Figure 5.26: City Gas Demand in the Mandalay Region



MIPC = Myohta Industrial Park City, MIZ = Mandalay Industrial Zone, mmcf/d = million cubic feet per day.

Source: Study team estimate.

Required investments in city gas demand development

The total amount of investment required to develop the city gas network in Mandalay is estimated at \$27.0 million. This is much larger than that estimated for Yangon because

the construction of a long-distance pipeline (40 km) from the existing pipeline to downtown Mandalay is required.

As for industrial demand development in MIZ, the required investment is calculated at \$19.8 million. The pipeline will need to be 12 inches in diameter as it will also need to meet residential and commercial demand in downtown Mandalay. Like in Yangon, it is assumed that one-third of the pipeline will be underground and two-thirds will be aboveground.

The amount required to develop industrial demand in Kyaukse Industrial Area is estimated at \$1.7 million. As the expected demand is rather small and the distance from the existing pipeline is short, the required size of the pipeline is only 6 inches, lowering the estimated cost.

The cost of developing a pipeline network to supply city gas to MIPC is larger (\$3.0 million) because the expected demand is very large (50 mmcf/d) and the required pipeline size is also large.

As for residential demand development, the estimated amount is relatively low (\$2.5 million) because the cost of the long-distance pipeline (40 km) is counted in the cost of industrial demand development in MIZ.

Table 5.4: Estimated Cost of Developing a City Gas Network in the Mandalay Region

	Demand (mmcf/d)	Distance from gas source (m)	psi	Pipeline size (inches)	Underground construction (\$/m)	Above ground construction cost (\$/m)	Pipeline cost (\$/m)	Total cost (\$ million)
[Industry]								
Mandalay			40					
Industrial Zone	3	40,000	0	12	595	297	99	19.8
Kyaukse			40					
Industrial Area	5	5,000	0	6	467	234	37	1.7
Myotha								
Industrial Park			40					
City	40	5,000	0	16	680	340	142	3.0
[Residential and commercial]								
Downtown			40					
Mandalay	5	5,000	0	12	595	297	99	2.5
Total								27.0

m = metre, mmcf/d = million cubic feet per day, psi = pounds per square inch.

Source: Study team estimate.

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Chapter 6

Natural Gas Infrastructure

1. Existing Natural Gas Infrastructure

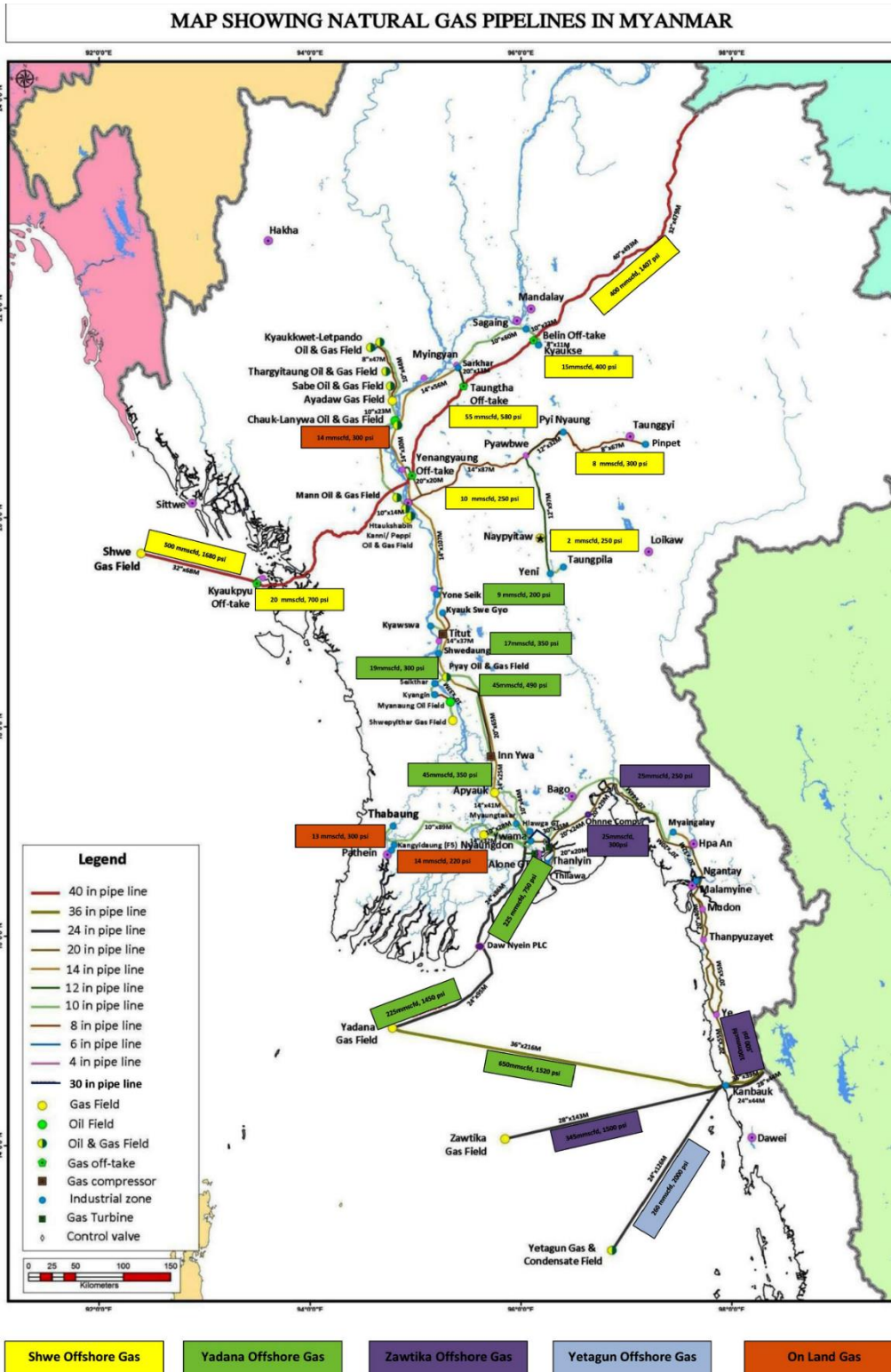
As one of the oldest oil and gas producers in Southeast Asia, Myanmar has a nationwide natural gas pipeline network covering all major demand centres in the country (Figure 6.1). The total length of the network is 4,100 kilometres (km). The state-owned Myanma Oil and Gas Enterprise (MOGE) owns and exclusively operates and maintains the pipeline network.

Myanmar has both a domestic pipeline network and export pipelines. The largest domestic natural gas pipeline is the Yangon–Magway pipeline network. This pipeline runs south–north through the centre of Myanmar and supplies offshore gas from the south to the interior of the country. As of September 2018, the pipeline is not fully operational; it is in use between Yangon and Shwedaung, but the pipeline between Shwedaung and Magway is out of operation due to a technical problem (gas leakage caused by pipeline corrosion).

Leakage problems are not unique to the Shwedaung–Magway pipeline. An assessment conducted by the Asian Development Bank (ADB) in 2016 found more than 100 leakages in the country's natural gas pipeline network, as a result of which 15% of the natural gas transported in the network is being lost (ADB, 2016). Restoring the Shwedaung–Magway pipeline segment is the most pressing issue in the country's natural gas logistics, and the Korean Export–Import Bank is conducting a study with the aim of replacing the existing pipeline.

Myanmar also has two export pipelines: one to Thailand and another to China. The Thailand pipeline began exporting natural gas in 2000, and had an export volume of 1,106 million cubic feet per day (mmcf) in 2017. Natural gas is Myanmar's largest export product, and the Thailand pipeline is a critically important piece of infrastructure for the country. Feed gas for export to Thailand is produced from three offshore gas fields in the south, namely, Yadana, Yetagun, and Zawtika.

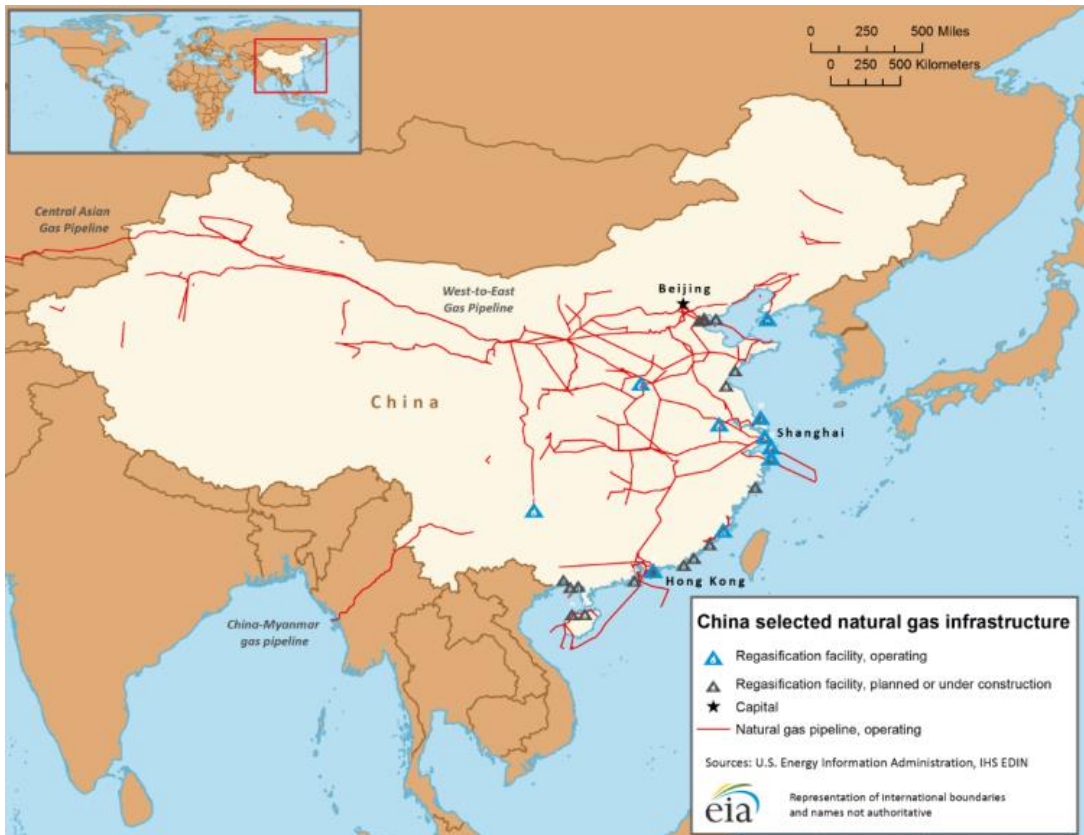
Figure 6.1: Existing Pipeline Network in Myanmar



" = inch, m = metre, mmscfd = million standard cubic feet per day, PLC = public limited company, psi = pounds per square inch.

Source: Data provided by the Myanma Oil and Gas Enterprise.

Figure 6.2: China's Natural Gas Import Infrastructure



EDIN = Energy Development in Island Nations; EIA = Energy Information Administration; IHS = Information Handling Services; U.S. = United States.

Source: Energy Information Administration website (2014).

The export pipeline to China is relatively new, having commenced operations in 2014. Its exported volume was 372 mmmcf as of fiscal year 2017. The pipeline runs west–east across northern Myanmar to the border with China. The exported gas is then transported to Yunnan Province and eventually to Chongqing City in China. To cope with rapidly increasing domestic natural gas demand, China has tried to secure natural gas from every available source as well as diversifying its natural gas supply sources in the interest of energy security. China therefore regards the import pipeline from Myanmar as a key piece of natural gas import infrastructure.

The export pipeline to China was constructed by the Chinese state-owned company, the China National Petroleum Corporation (CNPC), and is jointly owned by the CNPC and MOGE. The CNPC constructed a crude oil pipeline along the same route from Kyaukpyu to the Chinese border. The pipeline is 32 inches in diameter and its transportation capacity is approximately 12 billion cubic metres. However, utilisation of the pipeline is relatively low

(around 25%). The source of the gas exported to China is the Shwe gas field. There are four ‘offtake points’ of natural gas along the pipeline (Kyaukpyu, Yenangyaung, Taungtha, and Belin), and the allocated gas is consumed as fuel for gas-fired power generation plants, industrial fuel, and feedstock for fertiliser, among other uses.

2. Required Pipeline Development

2.1 North–South Pipeline Connection

While Myanmar has an extensive pipeline network, there are a number of operational issues and problems with its utilisation. One of the country’s highest priorities is to restore the pipeline connection between Shwedaung and Magway. Since this segment has been cut off due to corrosion, pipeline networks are currently being operated separately in the northern states (including Rakhain, Magway, and Mandalay) and in the southern states (including Yangon, Ayeyarwady, and Thanintharyi). Renovating the Shwedaung–Magway pipeline connection and restoring the network connection between the northern and southern pipeline systems are critical issues with regard to both supply security and operational concerns.

One of the reasons why it is urgent to restore this connection is to ensure supply security. As the country’s natural gas demand grows, its economic activities and social functions increasingly depend on a stable natural gas supply. If an offshore natural gas field in the south were forced to shut down, the natural gas supply to the domestic market would be severely impacted. Power plants would be unable to secure a natural gas supply to sustain generation, and public bus transportation in Yangon could also be affected as it depends mostly on the supply of compressed natural gas. Economic activities in newly developed industrial bases such as the Thilawah Special Economic Zone will also be damaged. Without the connection between the north and south networks, the natural gas supply cannot be adjusted flexibly to minimise impacts on the country’s economy and society.

Another mid- to long-term imperative is to build supply capability to fill the supply–demand gap in the north and south. As of 2018, states in both the north and south are self-sufficient in terms of their natural gas supply, and do not require a supply of natural gas from the other half of the country. There is also no significant demand along the interrupted pipeline section. Thus, other than the need to ensure supply security to prepare for unexpected supply disruptions, there is no imminent economic or operational need to

connect the northern and southern natural gas markets.

However, this connection will become more important as Myanmar's natural gas market evolves. First, the operational need to transport natural gas from the south to the north may increase in the future. The original purpose of the Shwedaung–Magway pipeline was to ship natural gas from southern offshore fields such as Yadana to meet demand along the pipeline to Magway. If there is an increase in the natural gas supply in the south, production from new offshore natural gas fields, or liquefied natural gas (LNG) imports, and a delay in the planned expansion of onshore natural gas production in the Magway region, the restored pipeline could provide an increased gas supply to the northern states.

On the other hand, a reverse flow from north to south could also be necessary. Demand growth will be larger in the southern states and, if southern offshore production growth stalls and LNG imports are delayed, the country will need to allocate onshore gas produced from the newly developed northern fields to demand in the south. Furthermore, if natural gas exported to China can be diverted to the domestic market with China's consent, the north–south pipeline will be the only route that can deliver the diverted gas to meet the demand in the southern market.

Connecting the pipelines may also help develop demand in the long run. Although there is no significant demand potential along the pipeline as of 2018, if the pipeline connection is restored and abundant natural gas is transported, new demand can be developed. Several industries, including cement factories and sugar and steel mills, are already connected to the existing pipeline and used to consume natural gas to operate in the past. If the pipeline is restored and the supply increases, these former users may revert to using natural gas for their operations.

2.2 Demand and Status of the Shwedaung–Magway Pipeline

Demand potential near the pipeline

In assessing the feasibility of renovating the Shwedaung–Magway pipeline, the study team found that natural gas demand potential along the pipeline is limited at this stage. In Shwedaung, only one gas-turbine power plant (the only power plant in the area) and one textile factory are using natural gas. The plant was built in 1982, and its generation capacity is 55.35 megawatts (from three 18.45-megawatt turbines). The plant is operated by the state-owned Electric Power Generation Enterprise. Each gas turbine consumes 9 mmcf/d of natural gas at full load, meaning that the plant consumes 27 mmcf/d if all three units are fully

operating. However, the plant is used as a mid- to peak-load power generation source, and its utilisation is not high. Its generational operation is largely affected by the hydropower plants that serve as baseload generation sources in Myanmar. The plant's gas consumption was only 6.6 mmcf/d in 2017. Since the plant is 36 years old and has a low heat efficiency (20%), an overhaul renovation funded by the Korean Export–Import Bank is being considered. Yet, as of 2018 no capacity addition plan is being implemented, and it currently has no natural gas demand growth potential.¹

Figure 6.3: Shwedaung Gas-Turbine Power Plant



Source: Photograph from the study team site visit.

City gas demand potential in Pyay and Shwedaung is also slim. The major industry in Shwedaung is agriculture, and manufacturing does not have a large presence. There is also no solid industrial policy or economic development program in the city. The only industrial gas user in Shwedaung is a single textile company. Along the pipeline route beyond Shwedaung several factories (cement, sugar, steel, and brick) are connected to the pipeline network; these used to consume natural gas, but they have all switched to alternate forms of energy. Some factories have shut down due to the limited profitability of their business, but others are not operating due to an insufficient supply of natural gas. Therefore, securing a natural gas supply, as well as renovating the pipeline, is crucial to develop demand along

¹ Study team interview at the Shwedaung power plant on 18 September 2018.

the pipeline route.

Pipeline status

The Shwedaung–Magway pipeline is operational up to the Aung Lan bar station, approximately 80 km north of Shwedaung (Figure 6.4). Beyond Aung Lan the pipeline is out of service due to corrosion and leakage problems.

Figure 6.4: Yangon–Magway (North–South) Pipeline



Source: United States Central Intelligence Agency.

The Shwedaung–Magway pipeline is not well-placed nor properly maintained. Most of the pipeline was laid in a bare condition without a protective coating and with no cathodic treatment. This is the main reason why corrosion forced the pipeline to cease operating. The relatively acidic soil between Aung Lan and Magway is another cause of pipeline

corrosion.²

Furthermore, although most of the pipeline is placed 3.0 feet–3.5 feet underground, in some places it runs aboveground without any protection. Signposts showing the location of the underground pipeline have been lost although they were placed immediately after the pipeline was constructed. This suggests that the underground pipeline may have been damaged by construction work or other infrastructure development such as highway and water works.

Figure 6.5: Aung Lan Bar Station



Source: Photograph from the study team site visit.

Another complicating feature of the Shwedaung–Magway pipeline is that it was placed some distance away from the main road, making it difficult to conduct regular monitoring and maintenance. While MOGE conducts regular safety inspections to safeguard pipeline operation, checking the status of the pipeline takes time as staff members have to walk through the bushes to reach the pipeline. The difficulty of conducting regular safety inspections makes it hard to note any irregularities in the pipeline.

² Study team interview at the MOGE pipeline operation office on 18 September 2018.

Figure 6.6: Unprotected Pipeline Appearing Aboveground at Aung Lan Bar Station



Source: Photograph from the study team site visit.

2.3 Estimated Investments for the North–South Connection

The cost of reconnecting the interrupted pipeline network between Shwedaung and Magway will be approximately \$77 million.

Table 6.1: Estimated Cost of the Magway–Aung Lan Pipeline Connection

	Distance from gas source (m)	psi	Pipeline size (inches)	Underground construction (\$/m)	Above ground construction cost (\$/m)	Pipeline cost (\$/m)	Total cost (\$ million)
Aung Lan - Magway	130,000	400	16	680	340	142	77.4

m = metre, psi = pounds per square inch.

Source: Study team estimate.

The cost was calculated based on the assumption that a new pipeline will be built between Magway and Aung Lan, the northernmost end of the pipeline network currently in operation. Building a new pipeline is recommended because (i) the existing pipeline was laid in a bare condition and has not been properly maintained; (ii) significant corrosion is expected in the existing pipeline as a result, and renovating the existing pipeline may be more costly than building a new pipeline; and (iii) the new pipeline should be built along a new route to make it easier to carry out regular inspection and maintenance. The existing pipeline is 14 inches in diameter; however, given the growing natural gas demand and

expanding size of the country's natural gas market, this should be upgraded to 16 inches to accommodate a greater flow of natural gas.

Construction of the new pipeline will start from the Aung Lan bar station, the northernmost end of the operational pipeline network, to Magway (a distance of about 13 km). The unit cost of the pipeline construction is assumed to be \$680 per metre for the underground section and \$340 per metre for the aboveground section. The cost of coated pipe is \$142 per metre. These costs have been estimated based on representative costs in Japan, and adjusted to reflect construction, labour, and engineer costs in Myanmar.

The cost estimate assumes that the new pipe will be coated for cathodic protection. In addition to this coating, additional protection methods such as the installation of galvanic anodes or the application of impressed current can be adopted.³ However, the estimate does not include the cost of such additional arrangements.

3. Required Liquefied Natural Gas Receiving Terminals

3.1 Natural Gas Demand and Supply Balance

As domestic natural gas demand grows while domestic production declines, Myanmar will need to secure additional supply sources. There are several options to consider, including increasing domestic production, importing LNG, and reducing exports. The first option has already been explored and is being implemented by the government; the second and third options still need to be considered and implemented, either separately or in combination.

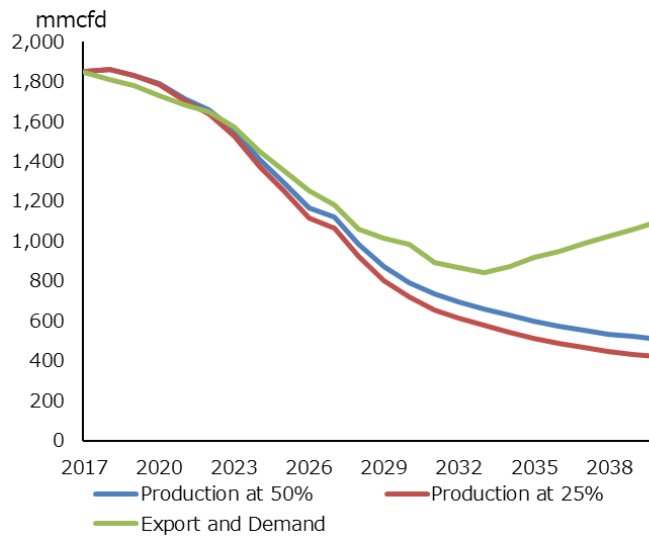
Myanmar's natural gas balance will depend various factors. If demand grows faster than expected, particularly in the power sector, the natural gas shortage will be more severe than expected in the near future. If, on the other hand, domestic natural gas production grows thanks to the discovery of new fields or enhanced recovery from existing fields, the supply–demand balance will ease.

This study estimates that Myanmar will need to begin importing natural gas from 2022 or 2023. Figure 6.7 shows the balance of domestic production, domestic demand, and export requirements for natural gas. Because the level of onshore production remains uncertain, the figure shows two domestic production scenarios, that is, 25% and 50% of

³ For further details, see the American Society of Mechanical Engineers (2016), *B31.3-2016 Process Piping*. New York, p.96.

MOGE’s targeted production volume. The figure suggests that Myanmar will have to begin importing natural gas from 2022 if onshore production reaches only 25% of the targeted volume, and from 2023 if production reaches 50% of the targeted volume.

Figure 6.7: Natural Gas Balance of Myanmar



mcf = million cubic feet per day.

Source: Institute of Energy Economics, Japan estimate.

There is a caveat to this balance outlook. While the figure suggests that the gross natural gas demand (domestic demand plus export requirements) will exceed domestic production, the actual gross demand will be equal to domestic production because there is no inventory adjustment. If production is insufficient to meet the gross demand, either the domestic demand or export volume will need to be reduced to achieve the necessary balance. The demand shown in the figure is an implied demand calculated from the specific assumptions of this study.

3.2 Liquefied Natural Gas Import Requirements

As there is no international natural gas import pipeline project for Myanmar, LNG is the only import option. Myanmar is planning three LNG import terminals using gas-fired power generation in the south of the country (Table 6.2). The project near Yangon is small because the draft in that area is shallow and the size of the receiving facility is limited.

The LNG demand volume is forecasted to reach 1.4 million tonnes per annum (mtpa)–2.1 mtpa by 2030 and 4.2 mtpa–5.2 mtpa by 2040. As shown in Figure 5.3, Yangon will be the largest demand centre for Myanmar; thus, the development of the Yangon and Kanbauk terminal projects should be prioritised. The Mee Long Gyaing terminal project may be developed later because it requires the development of additional pipeline from the receiving terminal to the existing pipeline network. Since all three projects are small and insufficient to meet the forecasted import demand, it will be necessary to either expand these terminals or build an additional LNG import terminal. As shown in Figure 6.8, demand in the northern regions of the country such as Mandalay and Magway is expected to grow. Thus, additional LNG receiving terminals should be planned in the long term.

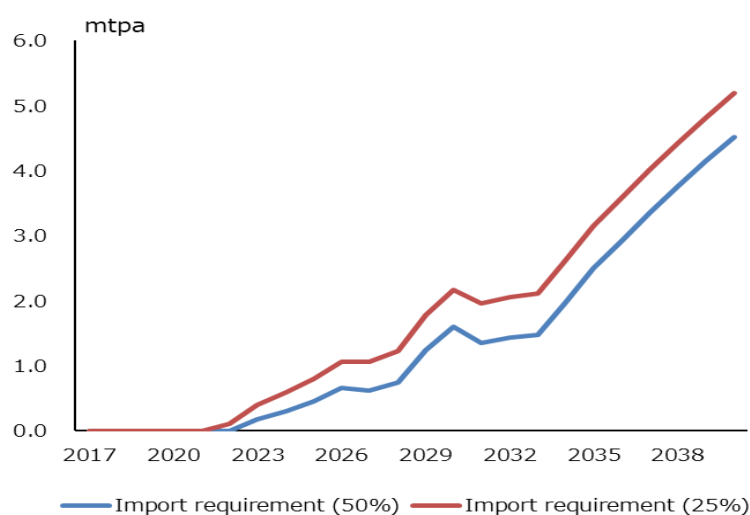
Table 6.2: Liquefied Natural Gas Import Projects in Myanmar

Project	Import capacity (mtpa)	Installed generation capacity	Region
Alone	0.4	356	Yangon
LNG to Power project			
Mee Long Gyaing	1.6	1,390	Ayeyarwady
LNG to Power project			
Kaunbauk	1.0	1,230	Tanyintharyi

LNG = liquefied natural gas, mtpa = million tonnes per annum, MW = megawatt.

Source: Data provided by the Ministry of Electricity and Energy.

Figure 6.8: Liquefied Natural Gas Import Requirements for Myanmar



mtpa = million tonnes per annum.

Source: Institute of Energy Economics, Japan.

It is estimated that these LNG receiving terminals (excluding power generation) will require \$1.35 billion in investment through 2040. All three terminals are assumed to be floating storage and regasification units (FSRUs) because these are easier to install in a short period of time than conventional onshore terminals. The estimated investment necessary to build three standard-size FSRUs (2 mtpa each) in the southern part of the country is \$1.35 billion (\$450 million each). This estimate assumes that all three FSRUs will be new-build vessels. If secondhand tankers are utilised, the capital expenditure will be saved. To develop an additional section of pipeline 10 inches in diameter from Mee Long Gyang to Pathein (about 20 km) will cost approximately \$8.8 million.

The study also recommends the installation of one FSRU in Kyaukpyu to meet the growing demand in the north. As Kyaukpyu already has a pipeline network, it will be easy to connect the new FSRU to the existing network. An LNG receiving terminal in Kyaukpyu will significantly improve supply capacity to the northern regions. If the Shwedaung–Magway pipeline connection is restored, the surplus can be sent to Yangon. Since the Kyaukpyu–China pipeline has a large surplus capacity, Myanmar can jointly procure LNG with China, and China can import the regasified gas via the pipeline. Myanmar may even be able to procure LNG at a competitive price by taking advantage of China’s bargaining power through the joint procurement.

Figure 6.9: Location of Planned Liquefied Natural Gas Receiving Facilities in Myanmar



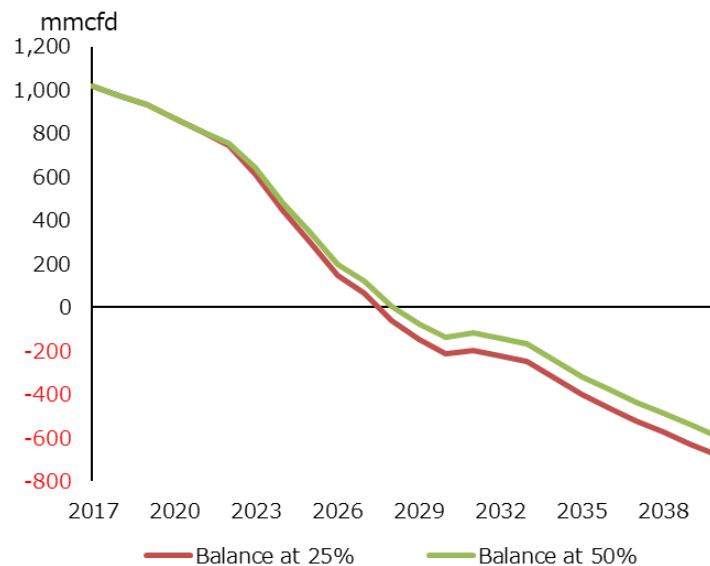
Source: United States Central Intelligence Agency.

3.3 Reducing Exports

Importing LNG is the most realistic and effective option to meet the growing power and natural gas demand in Myanmar. However, importing LNG is not easy, and requires many difficult decisions and arrangements on the receiving side. For example, the government must determine who will lead the project, who will be partners, who will take what risks during the project development and implementation phases, from which country the LNG will be procured, to whom the regasified gas will be provided, and at what price. It can take a long time for the government, state-owned entities such as MOGE or the Electric Power Generation Enterprise, and the foreign companies proposing an LNG receiving project to agree on the project structure and proceed with actual planning, development, and operation.

If Myanmar is unable to import LNG before the mid-2020s, it may need to reduce its exports to Thailand and/or China after obtaining their consent. Reducing exports to Thailand will be more effective because this export volume is larger and this border is closer to Yangon. If Myanmar can divert exports to Thailand to domestic needs, it can defer importing LNG for another 5 years to 2028 (Figure 6.10).

Figure 6.10: Natural Gas Balance if Exports to Thailand are Diverted to Meet Domestic Demand



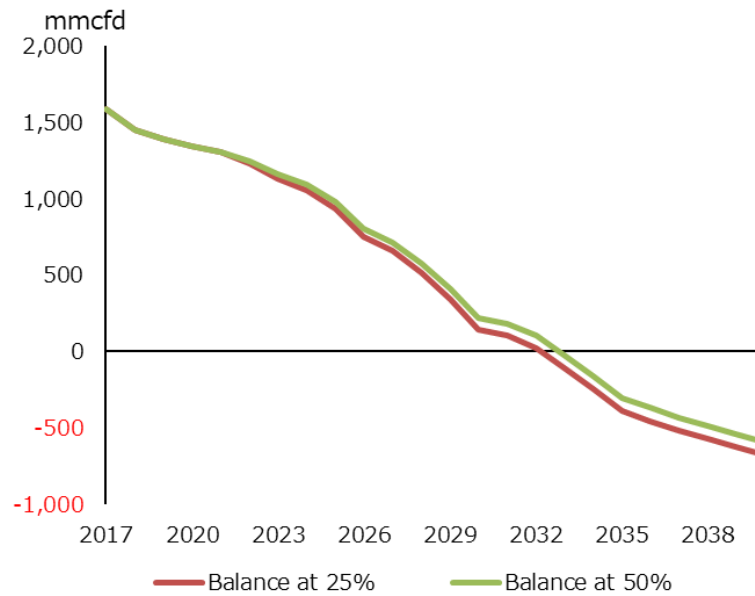
mmcf/d = million cubic feet per day.

Notes: The 'balance at 50%' case shows the balance of natural gas when 50% of the targeted onshore production is achieved and exports to Thailand are diverted to the domestic market. The 'balance at 25%' case shows the balance of natural gas when 25% of the targeted onshore production is achieved and exports to Thailand are diverted to the domestic market.

Source: Institute of Energy Economics, Japan.

If all exports including exports to China can be diverted to the domestic market, the LNG import deadline can be deferred further. Figure 6.11 shows that the natural gas balance in both cases will become negative from 2033, suggesting that Myanmar can be self-sufficient for another 10 years compared to the base cases.

Figure 6.11: Natural Gas Balance if All Exports are Diverted to Meet Domestic Demand



mmcf/d = million cubic feet per day.

Notes: The 'balance at 50%' case shows the balance of natural gas when 50% of the targeted onshore production is achieved and all exports can be diverted to the domestic market. The 'balance at 25%' case shows the balance of natural gas when 25% of the targeted onshore production is achieved and all exports can be diverted to the domestic market

Source: Institute of Energy Economics, Japan.

As always, this assumption comes with several caveats. First, the supply–demand balance can change subject to various factors, including macroeconomic conditions, domestic production, infrastructure development, and domestic demand status. Thus, the 'deadline' years specified above should be treated as benchmarks at which point Myanmar will have to begin importing LNG.

Second, Myanmar must obtain consent from Thailand and China before diverting these natural gas exports to the domestic market. China and Thailand are both net natural gas importers and regard natural gas imports from Myanmar as a vital gas supply source. Thus, they are very likely to insist that imports from Myanmar continue. Exports to these countries are made under long-term contracts, and Myanmar is subject to supply obligations as provided in these contracts. Myanmar may even have to pay a penalty or compensation to

cancel the contracts and divert the supply. Such potential economic costs must be taken into account if the option to divert exports is chosen.

Third, the infrastructure needs to be modified. Currently, the infrastructure (particularly pipelines from production sites) is designed for export, not domestic supply. Thus, the pipeline capacity to the domestic market would have to be expanded to accommodate the increased supply to the domestic market. In this regard, it may be worth considering constructing a new subsea pipeline from Kanbauk, where export gas is accumulated, to Yangon. If exports to China are diverted, the Magway–Shwedaung pipeline connection will need to be reactivated because some of the diverted gas will need to be supplied to the Yangon region. Thus, comprehensive pipeline renovation will need to be implemented to realise the diversion plans.

Finally, reducing pipeline gas exports means reducing foreign currency revenues. Natural gas exports have long been a major source of foreign currency for the country, and other sources of foreign currency revenues will need to be secured. If the diverted natural gas is supplied to the domestic market at a regulated price, this will create opportunity losses as the exported gas is sold at the international market price. Thus, the government must compare such economic costs with the benefits of diversion, and decide what option to take.

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Chapter 7

Roadmap for Infrastructure Development

1. Upstream Sector

The most critical issue in Myanmar's upstream sector is ensuring that production from the offshore M-3 and A-6 blocks begins as scheduled. The prompt development of these sizable blocks will greatly help to ease the natural gas supply shortage in Myanmar. Thus, the Government of Myanmar and Myanma Oil and Gas Enterprise should work to realise production from the blocks as soon as possible.

It is also important to accelerate the development of Myanmar's onshore fields, despite the relatively small increase in production that would result. Since the pipeline linkage from the south to the north is out of service, increasing onshore production in the Magway region will play a central role in supplying gas to Myanmar's northern states. This study assumes a base case of 50% of the production target; however, the production volume should be raised as close as possible to the targeted level.

In addition to planned offshore and onshore development projects, exploration should also continue. Improving the conditions of the production sharing agreement will be seriously considered, and auctions of new acreage should continue as in the past.

2. Pipeline Sector

With regard to pipeline development, the government should first initiate a nationwide pipeline renovation and development plan. As natural gas demand grows, bottlenecks in the domestic pipeline may emerge at various locations. It is crucial to begin identifying these bottlenecks immediately, and to provide solutions to solve them by 2020. As most of the domestic pipeline was constructed in a bare condition (without a protective coating), there is a high risk of corrosion and leakage in many parts of the country's pipeline network. Reviewing the current condition of the pipeline network and identifying vulnerable parts of the network will form a central part of the pipeline renovation plan.

Although a linkage between the northern and southern pipeline networks is not immediately needed for operational purposes, it is urgently required to ensure supply security. Ongoing negotiations with an overseas export credit agency should be settled soon

and the feasibility study of the pipeline linkage should begin by 2020. The north–south pipeline will be completed by 2025.

Pipeline development in southern states such as Ayeyarwady and Mon will also be pursued after 2020 since demand from the power sector will accelerate in the 2020s.

3. Liquefied Natural Gas Sector

It is inevitable that Myanmar will rely on imported liquefied natural gas (LNG) at some point in the future. Even if the country halts exports and allocates all of its production to domestic needs, it will have to start importing LNG by 2030. Therefore, the government urgently needs to prepare to import LNG.

As of 2018, three gas-to-power projects have been proposed, with a combined receiving capacity of 3 million tonnes per annum. Although this may be sufficient to address the expected natural gas balance shortage by 2030, if there are any delays in the startup of new offshore and onshore production, Myanmar will have to import more natural gas to maintain the supply–demand balance. Depending on how the demand for domestic natural gas develops, it may be worth considering installing another floating storage and regasification unit in Kyaukpyu. Regasified gas from Kyaukpyu would be utilised in northern states such as Magway or Mandalay, and any surplus could be exported to China via the existing export pipeline.

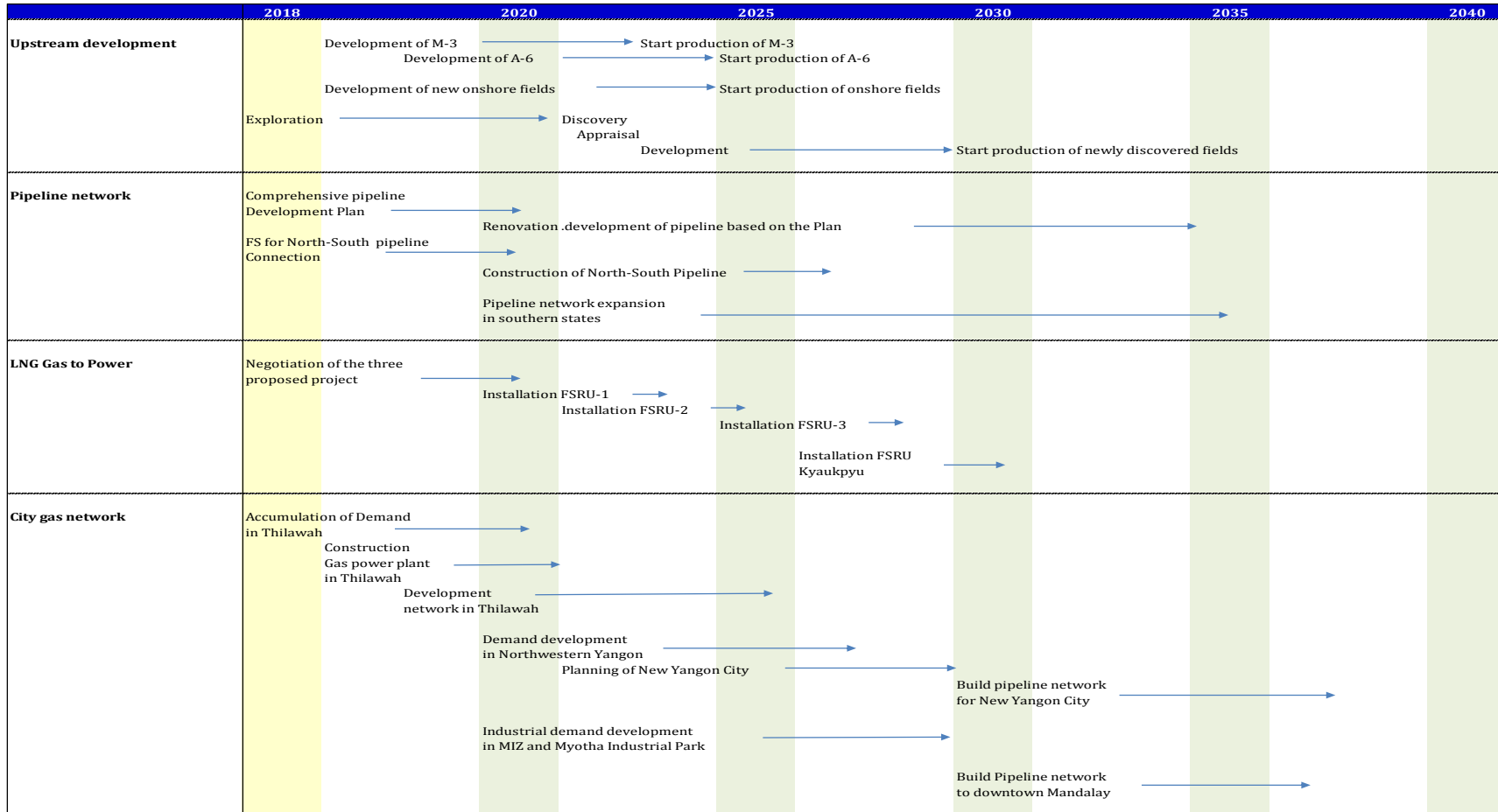
4. City Gas Sector

Regarding the industrial use of city gas in Yangon, the government should first promote and solidify the demand for natural gas in the Thilawah Special Economic Zone (SEZ). Swiftly establishing a gas power plant for the SEZ will help ease the power supply–demand balance in Yangon. This should be completed by the early 2020s when LNG imports will start, thus ensuring a sufficient supply of natural gas. Work on the pipeline should begin in 2025 to ensure a city gas supply to the SEZ.

It will also be necessary to extend the pipeline network to downtown Mandalay city. A feasibility study should kick off in 2020, and the actual pipeline construction should begin by 2025. At this stage, industrial and residential demand for natural gas is relatively low, and creating residential and commercial demand for natural gas in Myanmar will take time. As

it is currently difficult to construct a pipeline network in downtown Yangon, installing pipelines in newly developed areas such as New Yangon City will be a primary focus of demand development in the region. In Mandalay, demand from the residential and commercial sectors will be developed along with industrial demand. This will require well-coordinated infrastructure planning and demand development. Necessary actions and their specific timeframes (based on the observations made in chapters 1–6) are summarised in Table 7.1.

Table 7.1: Roadmap for the Development of Myanmar’s Natural Gas Market



FS= Feasibility Study; FRSU= Floating Storage and Regasification Unit; LNG= Liquefied Natural Gas; MIZ= Mandalay Industrial Zone
 Source: Authors.

Chapter 8

Conclusions

To realise the development of Myanmar's natural gas market as discussed in chapters 1–7, the Government of Myanmar must undertake a number of tasks. This chapter summarises the required policy actions in conclusion to this study.

1. Imperatives of Government Involvement

1.1 Benefits that Cannot be Realised through a Market Mechanism

Government involvement is essential to develop a natural gas market. This is because many of the benefits of a natural gas market cannot be fully realised through a market mechanism, and it is difficult to develop natural gas demand simply by letting the market function work.

Several benefits of natural gas cannot be fully realised in a market environment. The first such benefit is the nature of natural gas as a source of clean and low-carbon energy. As natural gas produces only 60% of the carbon emissions produced by coal, it can play a pivotal role in reducing greenhouse gas emissions in many countries in the future. However, the value of clean and low-carbon energy cannot be fully reflected in the current energy market. Carbon pricing or another type of adjustment is needed to ensure that the value of clean energy is properly priced in the market. This suggests that the market mechanism alone is not enough to develop natural gas demand. As the market mechanism is limited, the government should intervene in the market and ensure that market participants realise the real value of natural gas.

The second benefit is energy security. The shale revolution in the United States (US) significantly expanded the size of these resources, and there are no longer concerns that limited resources will be unable to meet the growing global demand for natural gas. Traditional natural gas resources are concentrated in the Middle East and Russia. The emergence of shale gas resources in the US not only increased the size of the world's natural gas resources but also diversified the supply sources of natural gas. This abundance and diversity of resources is one of the primary benefits of natural gas. In the US, a liquefaction

capacity of more than 100 million tonnes per annum is planned, and its supply capacity of liquefied natural gas (LNG) will be able to absorb the rapidly increasing global demand.

The third benefit of natural gas is convenience. Natural gas appliances do not require cumbersome fuelling operations and are very easy to turn on and off. Furthermore, since the supply is connected from the source to the final consumption appliances via pipelines, inventory management is also unnecessary, unlike with liquefied petroleum gas or oil products. However, it is difficult to recognise such user 'convenience' properly in the market.

Although these benefits are real, they are not easily recognised through an ordinary market mechanism. Government involvement is therefore justified to ensure that the value of natural gas is properly appreciated. The government has played an important role in developing the natural gas market in many countries. In Europe, state-owned companies have developed pipeline infrastructure under the regulated tariff system. The current extensive use of natural gas in Europe is possible because government-backed companies built pipeline infrastructure under a regulated monopoly system. Although many gas and power companies in Europe are privatised, this liberalisation occurred after the nationwide pipeline network was developed. Without government involvement, private companies would be unable to provide the infrastructure necessary for the wide use of natural gas. In the US, contrary to widely shared perceptions, gas and power businesses in many states are publicly owned. In Japan, although most city gas companies are privately owned, the industry has been rigidly regulated since the 2010s, and the regulated tariff system allows city gas companies to develop extensive pipeline networks by themselves. The history of the global natural gas market demonstrates that government involvement, either direct or indirect, is necessary to build a successful natural gas market.

1.2. Need for Demand Creation

In a growing energy market like Myanmar, demand for natural gas is something that needs to be created. This is because natural gas demand cannot be realised without infrastructure, and such infrastructure is usually underdeveloped in a growing energy market. Once the infrastructure is built, it tends to be utilised fully to recover the large upfront investment expenditures, and natural gas demand is generated, to some extent, artificially. Since natural gas is expensive and difficult to use, demand for natural gas usually does not emerge autonomously. Instead, it must be created either directly or indirectly by several conditions such as policy targets or regulations on the use of natural gas.

Infrastructure development is mandatory to expand natural gas demand in a growing energy market. In established natural gas markets like Europe, the US, or Japan, the government or government-regulated entities have played critical roles in developing the necessary infrastructure. Similarly, the Government of Myanmar is expected to initiate and promote infrastructure development.

Policy and regulatory arrangements will greatly contribute to demand creation. The most notable recent example of this is China, where an unexpected increase in LNG demand since 2016 has been largely driven by a government policy to reduce coal consumption. Because the current Xi administration places a high importance on improving air quality, it has set a numerical target to reduce particulate matter in each province. This caused a rapid fuel switch from coal to natural gas in the winters of 2016–2017 and 2017–2018, despite the increased international price of LNG. Although this policy was not intended to create natural gas demand per se, demand growth in China suggests that policy can make a difference. This example indicates that setting numerical targets for carbon emissions, particulate matter emissions, or a specific energy mix can help create demand. Clear policy direction for the utilisation of natural gas and firm commitment thereto by the Government of Myanmar will mobilise various resources both at home and abroad, and will speed up the country's gasification.

2. Policy Actions

2.1 Encourage and Accelerate Domestic Upstream Development

One of Myanmar's highest priorities in terms of policy actions is to expand the natural gas market by continuing to encourage and accelerate the development of domestic natural gas. Despite a globalised natural gas market and a more liquid global LNG market, it is clear that domestic production is Myanmar's most reliable supply source. Therefore, the government should continue to explore both onshore and offshore fields, and minimise the depletion of existing fields.

Offshore operations are currently scheduled to begin at the M-3 block in 2023 and at the A-6 block in 2025. Given the fields' expected size (150 million cubic feet per day [mmcfd] from M-3 and 60 mmcfd from A-6), the Myanmar Oil and Gas Enterprise (MOGE) should prioritise development works at these two blocks. MOGE is also planning to boost onshore production from the current 54 mmcfd to more than 400 mmcfd by 2035. Onstreaming onshore production will greatly help to meet the country's growing demand.

Despite the development of a series of new fields, the planned production growth will still fall short of the expected demand growth. Thus, the government needs to encourage and accelerate the exploration and development of additional natural gas resources. In addition to swift decision-making by the government and MOGE, it may be necessary to revise the contractual conditions for the production sharing agreement to activate upstream development in Myanmar further. The agenda of such efforts may include revising the domestic natural gas price mechanism.

2.2. Enhancing the Resilience of the Pipeline Network

Another urgently required government action is the enhancement of the resilience of its natural gas pipeline network. Most of Myanmar's pipelines are in a bare condition without any anti-corrosion coating such as polyethylene. In the course of its field trip, the study team found that some parts of the country's pipeline network are poorly protected and vulnerable to external shocks. As dependence on natural gas increases in the country's energy mix, the reliability of pipeline transportation must be enhanced. Thus, reinforcing the resilience of the pipeline network is becoming a pressing issue for the government. Without appropriate arrangements, pipeline problems such as leakages will hinder the expansion of natural gas use in Myanmar.

As several actions are required to enhance the resilience of the pipeline network, the government should initiate a comprehensive review of the network to identify vulnerabilities to corrosion or external damage. The government should then prioritise the actions required to address these vulnerabilities based on their criticality to the country's natural gas supply. The stable operation of the pipeline network and ensuring an uninterrupted flow of natural gas is the most fundamental condition for expanding the use of natural gas in Myanmar.

2.3. Reform of Energy Prices

The next policy action is energy price reform, which will be a relatively long-term effort. Natural gas and electricity prices are regulated in Myanmar and set below the international standard. This pricing forms a part of Myanmar's social policy, and will not be easy to reform in the short term. Energy prices are closely related to the daily life of Myanmar's citizens, and drastic reform would cause confusion and disturbances in Myanmar's economy and society.

Although Myanmar's infrastructure should be developed with government initiative and support, investors should recover sound economic returns even if the entity is owned by the state. If foreign companies are invited to invest in the country's infrastructure, the price of electricity or city gas sold will be the most critical factor in their decision-making. Higher energy prices will also provide energy users with incentives to use energy more efficiently to optimise infrastructure development.

These energy pricing issues have caught the attention of energy policy circles in Myanmar. Myanmar's Energy Policy clearly stipulates that the country must address these energy price issues. The outright removal of energy subsidies will significantly impact Myanmar's citizens and may cause economic problems. Because energy prices broadly affect daily life, revising these prices is often regarded as a political issue. Reforming energy prices is never an easy task, and the government will have to approach this subject cautiously while working consistently to reduce the burden of subsidies.

2.4 Managing Quality Differences in Natural Gas

Another practical issue in natural gas use not discussed in detail in this study is a quality issue, that is, the heat value of natural gas. It is inevitable that Myanmar will start to import LNG sometime in the future; however, the heat values of LNG and of domestic gas differ significantly. The heat value of natural gas from the Yadana field, the primary source of natural gas in the Yangon region (27 megajoules per cubic meter), is low compared to the typical value of internationally traded LNG (around 40 megajoules per cubic meter).

Using LNG for a new power generation plant will not cause any significant issues if all of the imported LNG is used at the plant. However, using surplus LNG to supplement the city gas supply may cause problems as this could cause heat values to swing significantly. This could lead to critical issues for some industries that are sensitive to the level of heat values (such as the ceramics industry).

To manage differences in heat values, separate pipelines could be built for high-heat imported gas and low-heat domestic gas, the various types of gas could be blended to minimise differences in heat values, or a heat-value adjustment facility could be used. Well-planned policy and coordination amongst the government, gas suppliers, and gas users will be necessary to address this issue.

2.5. Growing Human Capital for Importing Liquefied Natural Gas

Myanmar has had much experience with natural gas and has a vast amount of human resources and expertise in handling and utilising this energy source. However, LNG differs from natural gas and requires different kinds of knowledge and technologies. The government should collaborate with other countries that have extensive experience using LNG, with the aim of training Myanmar's natural gas experts. This training should cover capacity development such as LNG receiving and regasification technologies, intelligence to analyse the international LNG market, contractual arrangement and commercial practices of the LNG trade, and financing LNG receiving and utilisation infrastructure.

Relevant agencies in Japan, the US, or the Republic of Korea will help Myanmar develop a regulatory system for receiving and utilising natural gas. Environmental regulation is a key area in this regard. A clear and consistent environmental regulatory system would clarify the role and task of project investors and facilitate investment through lowered regulatory risk. Similarly, implementing training programs on safety issues would help Myanmar develop a well-organised system of safety regulation to monitor operational safety and avoid unexpected accidents.

Appendix 1



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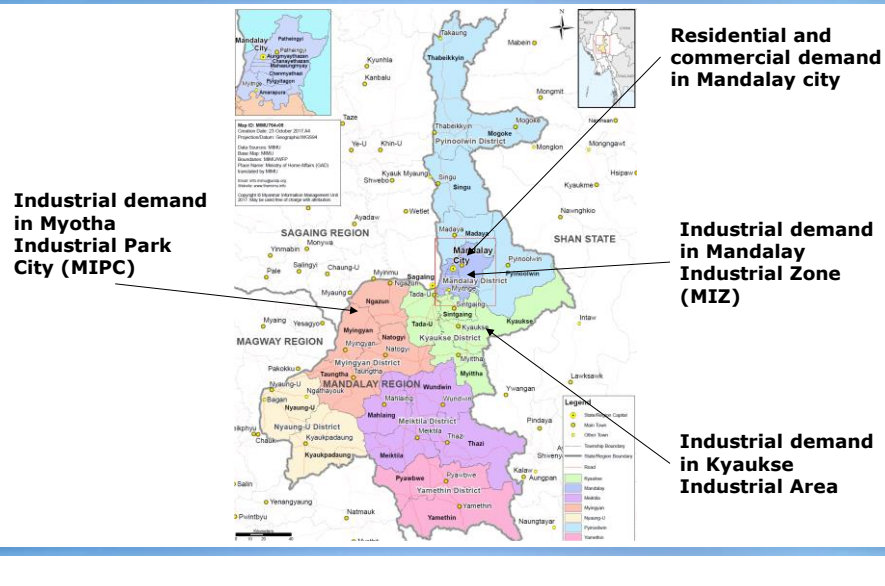
Trip schedule



- 30 July 2018 (Mandalay)
 - Government of Mandalay region (Energy Department and Industry Department)
 - Industries in Kyaukse (three cement factories)
- 31 July 2018 (Mandalay)
 - Mandalay Myotha Industrial Park City
- 1 August 2018 (Yangon)
 - Government of Yangon region
 - Thilawah Gas Power Plant
 - Compressed natural gas (CNG)-fuelling station for taxis
- 2 August 2018 (Yangon)
 - Liquefied petroleum gas (LPG)-distribution station
 - Ywama natural gas-distribution station
 - Ywama gas-fired power plant
 - Compressed Natural Gas (CNG) cylinder-testing centre
 - CNG Industry (a private city gas user)
- 3 August 2018 (Nay Pyi Taw)
 - Trip report to the Oil and Gas Production Department

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Potential gas demand in Mandalay



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Mandalay Industrial Zone

- There is no current plan to use natural gas in MIZ.
 - The high cost of constructing pipeline, concerns about supply reliability, and high energy prices are the primary reasons for this.
 - Most of the factories in MIZ are 'light industry' whose energy consumption is relatively small.
- Demand potential still exists.
 - MIZ is Myanmar's second largest economic centre.
 - It is close to the existing pipeline network.
 - Sustainability issues will drive the use of lower carbon energy in the long run.
 - More value-added industries will prefer to use gas.
- Access, cost, and reliability of the supply are key issues.
 - The government or the public sector may need to support pipeline development to create demand.
 - The price must be relatively competitive.
 - A stable supply must be ensured.



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Kyaukse Industrial Area

- Several industrial facilities have used natural gas in Kyaukse.
 - One cement factory and one glass factory have used natural gas in the past, but both no longer use natural gas due to supply unavailability and factory renovation.
- There are limited possibilities to use gas at this stage.
 - Most large energy users are cement factories that usually prefer to use cheaper coal.
 - There is severe competition among cement factories and high sensitivity to the input energy price.
- Future potential for natural gas use exists.
 - There is a potential supply from the existing Kyaukpyu–China pipeline network.
 - Intensive coal consumption will have environmental impacts in the long run.
 - The need to reduce carbon emissions is growing.
 - Another industry that prefers gas to coal may emerge.



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Myotha Industrial Park City

- MIPC is a newly developed industrial park.
 - It is part of a comprehensive regional development plan being implemented by the government.
 - Conveniently located on the Ayeyarwady River.
 - Seven factories are currently operating.
- It has large demand potential.
 - Easy access to the Kyaukpyu–China pipeline (approximately 5 kilometres away)
 - The Belt and Road Initiative may develop a highway or railroad between the Kyaukpyu deep sea port and the Chinese border.
 - + A liquefied natural gas-receiving facility in Kyaukpyu will boost gas supply capability along the pipeline route.
- Will the park be able to invite industry that uses natural gas intensively?
 - Thus far, the park only contains less energy-intensive industries such as food processing, furniture, and animal feed factories.
 - Industries such as glass, ceramics, and paper will be major users of natural gas.



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Residential and commercial demand in Mandalay city

- Energy demand from the residential and commercial sectors will grow.
 - This will be driven by population growth, enhanced incomes, economic expansion, and improved living standards.
- There is limited incentive to switch from electricity to gas at this stage, due to:
 - The high cost of a pipeline connection,
 - A relatively cheap electricity tariff, and
 - Limited demand for heating purposes.
- Residential and commercial demand is usually the last to develop in emerging countries.
- Commercial demand may emerge.
 - This would be driven by hotels, restaurants, and shopping malls in the city centre.
 - Targeted development of a pipeline network to the station area may be considered.
 - The government and/or the public sector will need to develop a pipeline network to realise the extensive use of natural gas in the residential and commercial sectors.



Potential gas demand in Yangon

Power demand in Yangon city

Industrial demand in Yangon city

Residential and commercial demand in 'New Yangon City'



CNG demand in Yangon city

Industrial demand in Thilawah Special Economic Zone (SEZ)

Gas demand for power in Yangon

9

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- The power sector will remain the dominant demand segment for the foreseeable future.
- Gas seems to be the only realistic option for power generation in Myanmar.
 - There is public opposition to a new coal or hydropower plant.
 - Other factors include high cost and limited available land for renewables.
- Older power plants need to be upgraded and replaced.
 - Older facilities (30–40 years old) have low efficiency.
 - Significant gains are expected from replacing these plants with advanced generation facilities.
- Power development is urgently needed.
 - A gas-to-power project is expected.
 - The utilisation of an independent power producers scheme is possible.
 - Electricity tariff reform should be on the future policy agenda.



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Industrial gas demand in Yangon

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- Demand for industrial energy is already high.
 - Large industries such as steel mills, tire factories, and beverage manufacturers exist near the Ywama natural gas-distribution station; it will be easier to extend the pipeline network to those factories.
- The key issue is the availability of the gas supply, rather than the price level.
 - Some factories will have to slow their operations to avoid breaching the upper limit of natural gas consumption.
 - Private industry can accommodate a higher gas price (\$8-\$9 per million British thermal units).
- Is it possible to provide re-gasified LNG to private industrial players?



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Gas demand in Thilawah Special Economic Zone

- Thilawah SEZ has a very large and firm demand potential.
- Power-generation demand
 - A new 50-megawatt power plant is planned, with an expected gas consumption of 21 million cubic feet per day (mmcf).
 - As the SEZ grows in size, further expansion is possible.
- Industrial demand
 - Some existing factories seem to be using liquefied petroleum gas.
 - + City gas can be competitive.
 - Suggested natural gas demand for industrial purposes at this stage is 6 mmcf-7 mmcf.
 - Demand can grow significantly depending on the development of the SEZ.



Compressed natural gas demand in Yangon

- Government initiative to promote the use of CNG
 - The adverse effects of a sudden increase in the price of crude oil in the 2000s had to be managed.
 - CNG played a significant role in reducing dependence on imported oil.
- CNG-based bus services (the Yangon Bus Service) is a vital means of transportation for Yangon's citizens.
 - There are currently 4,000 buses in operation.
 - Due to demand growth, another 500-1,000 buses are planned to be ordered.
- Demand is likely to remain flat.
 - Demand fundamentals are very strong.
 - Yet, due to the low availability of gas, it may be difficult to expand supply capacity.
 - Concerns exist as to the sustainability of subsidies, availability of cheap domestic natural gas, among other issues.



Residential and commercial demand

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- The residential and commercial sectors are the last city gas demand segment.
- It may be difficult to develop a city gas pipeline network in downtown Yangon at this stage.
 - As an increasing number of households are using LPG for cooking purposes, promoting the use of LPG for residential purposes is a more realistic option.
- Targeted 'gasification' might be possible in newly developed areas.
 - There is a plan to develop a 'New Yangon City' in the southwest part of Yangon city.
 - A well-developed plan and coordinated policy arrangements are needed.
 - Action must be taken immediately.
 - The availability and price of the gas supply will remain an issue.



Source: NYDC

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Domestic production and export

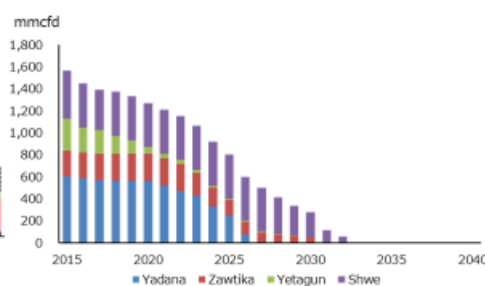
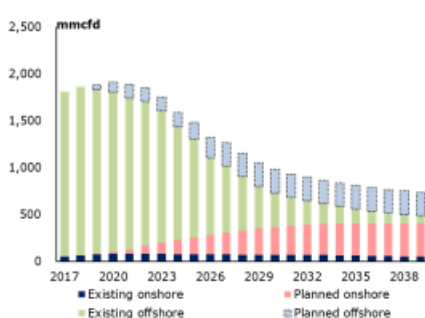
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- Received data suggest that onshore production will grow significantly.
 - Should all of the expected growth be counted?
- What is the expected peak production volume for the A-6 and M-3 blocks?
- Exports will stop in the 2030s.
 - Will production from the new gas fields be exported to Thailand and/or China?

Domestic production outlook

Natural gas exports by field



Sources: Ministry of Electricity and Energy, IEEJ.

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Next field trip

- Date
 - 17-20 September 2018
- Purpose
 - Research for a pipeline connection between Yangon and Magway
- Proposed schedule
 - 16 September (Sunday): Arrival from Japan to Yangon
 - 17 September (Monday): Trip from Yangon to Shwedaung
 - 18 September (Tuesday): Meetings with local government representatives and natural gas users in the Shwedaung area
 - 19 September (Wednesday): Pipeline status from Shwedaung to Magway, trip to Nay Pyi Taw
 - 20 September (Thursday): Meeting at the Oil and Gas Production Department, departure from Nay Pyi Taw to Japan
- Research items
 - Current status of the pipeline
 - Rough cost estimate for the pipeline renovation
 - Demand potential along the pipeline route

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Thank you for your attention.



The IEEJ was ranked **second** in the field of energy research in the 2017 **Global Think Tank Ranking** conducted by the University of Pennsylvania.

(ranked third in 2016 and first in 2015)

2017 Global Go To Think Tank Index Report
(p.305)
http://repository.upenn.edu/think_tanks/

Please visit our website at
<http://eneken.ieej.or.jp/>



Appendix 2



1

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ERIA Study for a Natural Gas Master Plan in Myanmar September Field Trip

20 September 2018
Yoshikazu Kobayashi

The Institute of Energy Economics, Japan (IEEJ)

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Trip schedule

2

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- 17 September 2018
 - Road trip from Yangon to Pyay
- 18 September 2018
 - Local township officer in Pyay
 - Shwedaung gas-turbine power station
 - Myanma Petroleum Product Enterprise
 - Myanma Oil and Gas Enterprise pipeline gas compression office in Titut
- 19 September 2018
 - Kyauk Swe Kyoe pressure control station
 - Yone Sade bar station
 - Aung Lan bar station
- 20 September 2018 (Nay Pyi Taw)
 - Trip report to the Oil and Gas Production Department



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Overview of Pyay

3

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- Overview of Pyay city
 - Mid-sized city along the Ayeyarwady River
 - Population: 251,643; downtown population: approximately 140,000
 - The primary industry is agriculture, and the main crop is rice.
 - Warm climate throughout the year (29.8–38.9 degrees Celsius)
- Its primary commercial energy is electricity.
 - Oil products for transportation and industry
 - Natural gas for generating power and textile manufacturing
- Natural gas supply to Pyay
 - Most natural gas is supplied from the offshore Yadana gas field via a 14-inch pipeline.
 - Limited production from the Pyay oil and gas field
- Status of the pipeline beyond Pyay
 - Pipeline connected, but not currently operating beyond Aung Lan bar station due to gas leakage caused by pipeline corrosion.



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City gas demand in Pyay

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- Current natural gas users
 - There is one gas-turbine plant and one textile company.
- Potential for industrial natural gas demand
 - The primary industry in the township is agriculture, and manufacturing has a limited presence.
 - There is no solid plan for economic or industrial development.
 - Given the city's good pipeline access, an increased natural gas supply at a competitive price may develop industrial demand.
- Residential and commercial demand
 - Limited demand for heat due to the warm climate.
 - The primary demand component is cooking.
 - The local government prioritises expanding LPG as a residential energy for its convenience and cleanliness.
 - + The use of charcoal is banned in Shwedaung.
- There is limited potential demand for natural gas in Pyay city and its suburbs at this stage.



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Demand for power generation in Pyay

- Potential demand for natural gas to generate power also appears limited at this stage.
- Shwedaung gas-turbine power plant
 - Built in 1982
 - Three 18.45-megawatt turbines (55.35 megawatts in total)
 - Heat efficiency rate of 20 percent
 - Gas consumption is 9 million cubic feet per day (mmcf) per turbine unit (a maximum of 27 mmcf)
- Utilisation is largely affected by hydropower generation.
 - Utilised as a peak-shaving generation source
 - Gas consumption has not grown in the last 2 years, although the region's power demand has grown. Imports from other regions supplement the increased demand.
- No expansion or renovation plan
 - Modifying the older unit will improve heat efficiency and save gas use.



Pipeline status

- Pipeline conditions
 - Bare pipeline without any coating
 - Signposts showing the pipeline location have been lost.
 - Although the pipeline mostly runs underground, in some locations it is placed aboveground without sufficient protection.
 - Comprehensive renovation is urgently required.
- Location of the existing pipeline
 - The pipeline is located away from major roads.
 - It is difficult to conduct regular safety inspections and identify irregularities in the pipeline operation.
 - The cost of maintenance tends to be high if access to the pipeline is difficult.
- Pressure monitoring
 - Monitoring is conducted at each bar station.
 - There is scope for the installation of a remote pressure monitoring system (such as Supervisory Control and Data Acquisition) in the future.



Toward pipeline renovation

- Anti-corrosion treatment is urgently needed for the entire pipeline network to avoid more problems with pipeline leakages.
 - Treatment while using the pipeline is possible.
- Route selection for the new pipeline (if built)
 - Building a new pipeline (instead of replacing the existing pipeline) appears to be a more realistic option.
 - The new pipeline can use the same route as the existing pipeline or a completely new pipeline can be built in a new route.
- Demand development along the pipeline
 - There are no natural gas users along the pipeline beyond Shwedaung.
 - Natural gas users once existed along the pipeline (including cement and brick factories, and steel and sugar mills), but they no longer use gas for various reasons.
 - Securing a natural gas supply as well as renovating the pipeline is necessary.

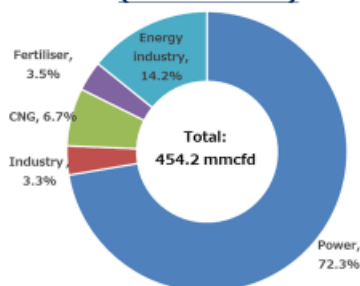


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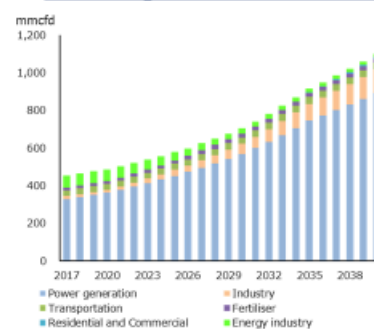
Demand outlook (interim)

- Most gas demand will be used in the power sector.
 - Given the current growth speed, the rate of demand growth may rise even higher.
- Industry will be the second largest demand segment.
- Residential demand may be created in Yangon and Mandalay.
 - This will require a well-prepared infrastructure plan and policy arrangement.
- Note: The level of natural gas demand is determined also by supply factors.

**Natural gas demand
(as of FY2017)**



Natural gas demand outlook



mcf = thousand cubic feet per day.

Sources: Ministry of Electricity and Energy (MOEE), IEEJ.

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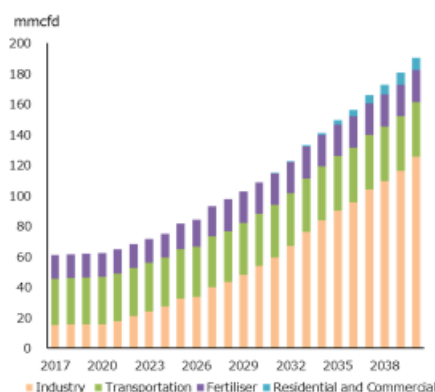
City gas demand outlook (interim)

9



- City gas demand (demand for non-power generation) is estimated to grow 2.3 times by 2040.
- Industrial demand will grow mainly in Yangon and Mandalay.
 - Many factories in Thilawah Special Economic Zone use liquefied petroleum gas; and city gas can be price-competitive.
 - Industrial demand in Mandalay is subject to the pipeline connection and availability of natural gas.
- The transportation sector is expected to grow but at a more moderate rate.
- It is assumed that residential demand will be created after 2030.
 - Demand creation is largely subject to infrastructure development and residents' ability to afford the supply.

City gas demand outlook



Source: IEEJ.

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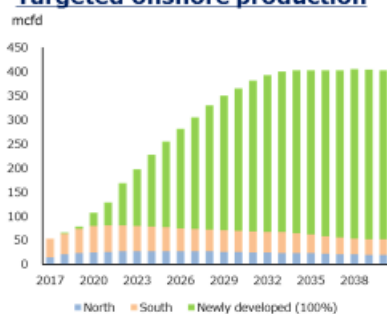
Natural gas balance (interim)

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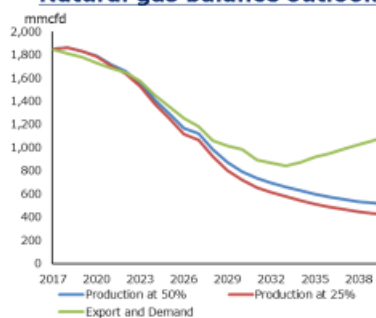


- It is forecasted that Myanmar will need to begin importing liquefied natural gas in the mid-2020s.
 - Domestic onshore production is targeted to increase by 350 mmcf by 2040.
 - Estimates assume 50 percent and 25 percent achievement of targeted production.
 - Pipeline exports to Thailand and China are expected to stop in the 2030s.
- As natural gas demand is constrained by supply, additional supply (domestic production or imported liquefied natural gas) will help secure demand.

Targeted onshore production



Natural gas balance outlook



mcf = thousand cubic feet per day.
Sources: MOEE, IEEJ.

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Proposal for final report seminar

- Date and time
 - **11 December 2018 09:30~12:00**
 - Followed by networking lunch
- Venue
 - Ballroom, **Thingaha Hotel**, Nay Pyi Taw
- Proposed agenda
 - 09:00–09:30 Registration
 - 09:30–09:50 Opening remarks
 - 09:50–10:00 Photo session
 - 10:00–10:20 Current natural gas policy in Myanmar (by the Oil and Gas Production Department, and MOEE)
 - 10:20–10:30 Introduction of the Economic Research Institute of ASEAN and East Asia (ERIA) project 'Natural Gas Master Plan in Myanmar' (by ERIA)
 - 10:30–11:50 Brief of the final ERIA report supporting the study project 'Natural Gas Master Plan in Myanmar' (by Yoshikazu Kobayashi [IEEJ])
 - 11:50–12:00 Summary (by ERIA)
 - 12:00 Closing and networking lunch



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