Chapter 5

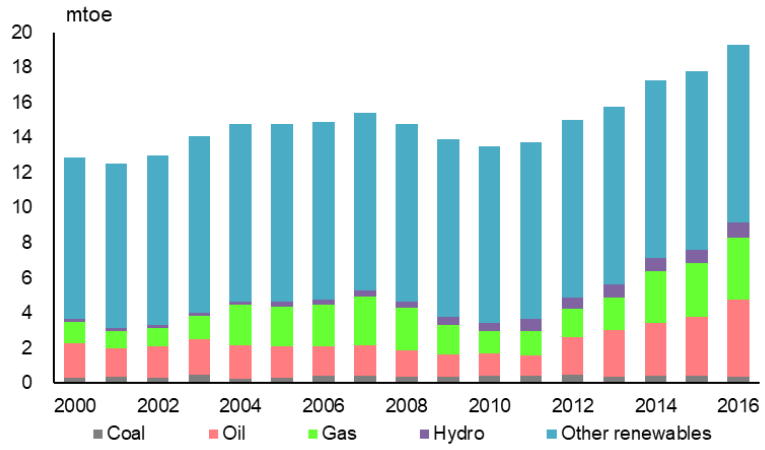
Natural Gas Demand Outlook

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.

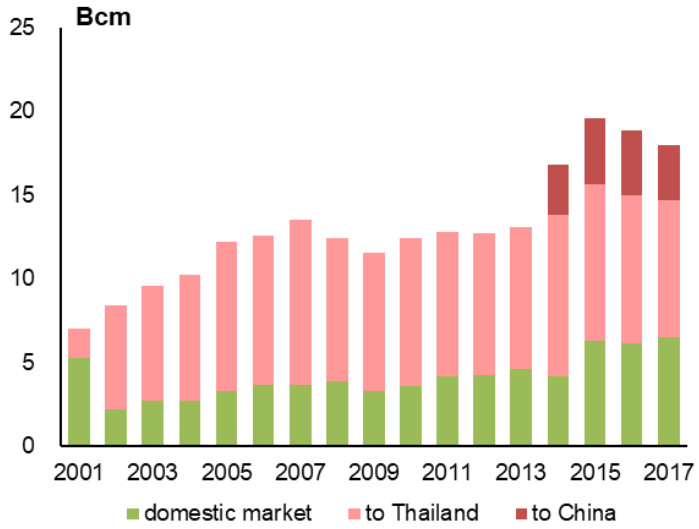
Figure 5.1: Total Primary Energy Supply in Myanmar since 2000



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 (mmcfd) 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.

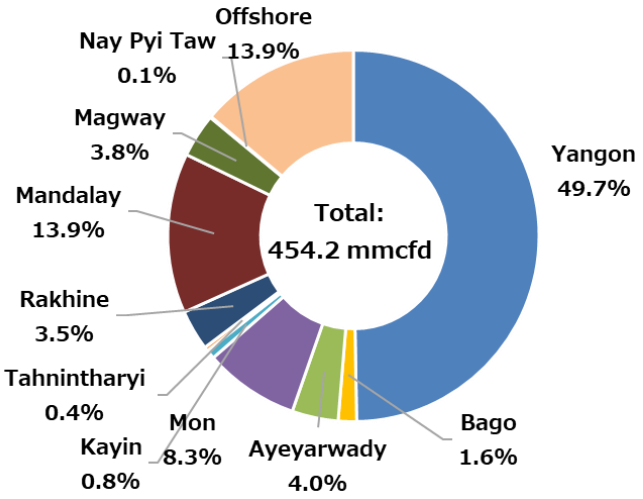
[1] 'FY' before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 ended on 31 March 2017. The fiscal year (FY) of the Government of Myanmar previously ended on 31 March. However, due to recent changes in government policy, FY2019 began on 1 October 2018 and will end on 30 September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

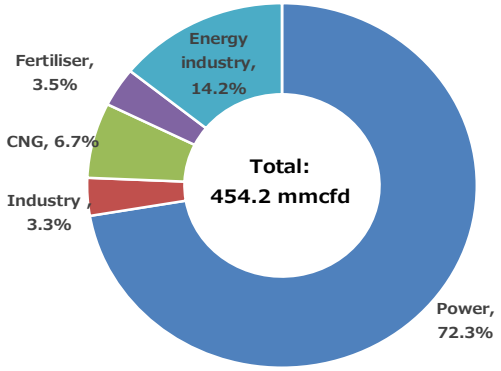
Power sector

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

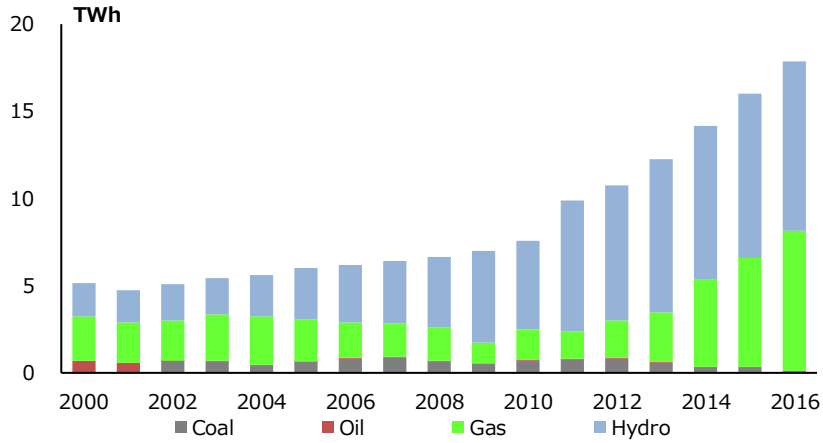
electricity generated rose from 23% in 2010 to 45% in 2016.

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.

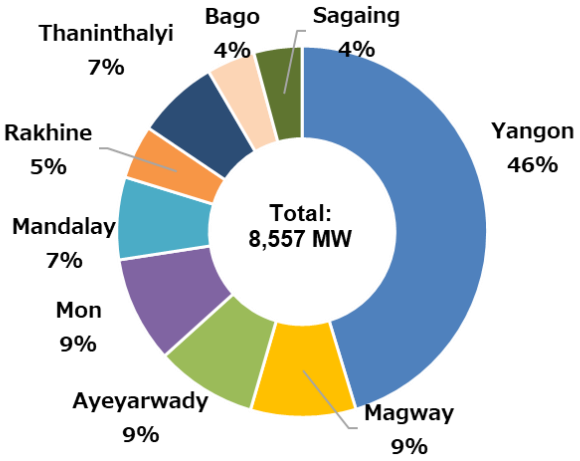
As of mid-2016, Myanmar's total installed power generation capacity was 4,764 megawatts (MW), 38% of which (1,824 MW) comes from natural gas-fired power plants according to statistics provided by the Asian Development Bank (ADB) (ADB, 2016).[2] Most

[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' 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

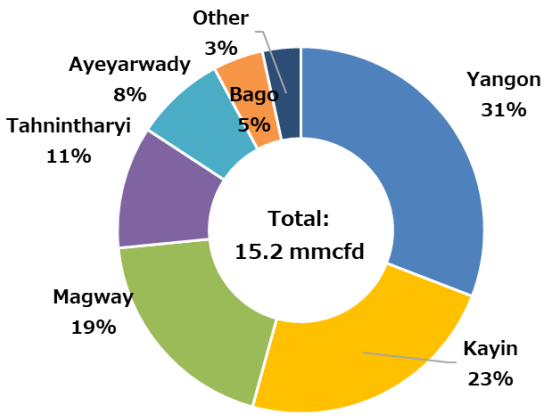
Transportation is the second largest area of gas demand in Myanmar, consuming 49 mmcfd of CNG in FY2017. In the mid-1980s, Myanmar began to develop a CNG supply network for transportation use to reduce dependence on imported oil products. However, initial efforts were relatively limited, with only five 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



mmcfd = 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 mmcfd 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 Pathein 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 Pyay, 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.

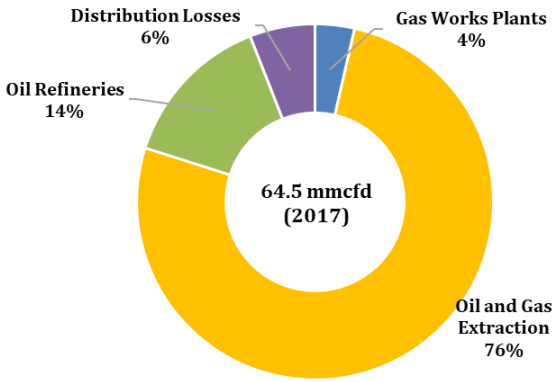
Figure 5.8: Liquefied Petroleum Gas Supply Station in Yangon City

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 mmcfd 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 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.

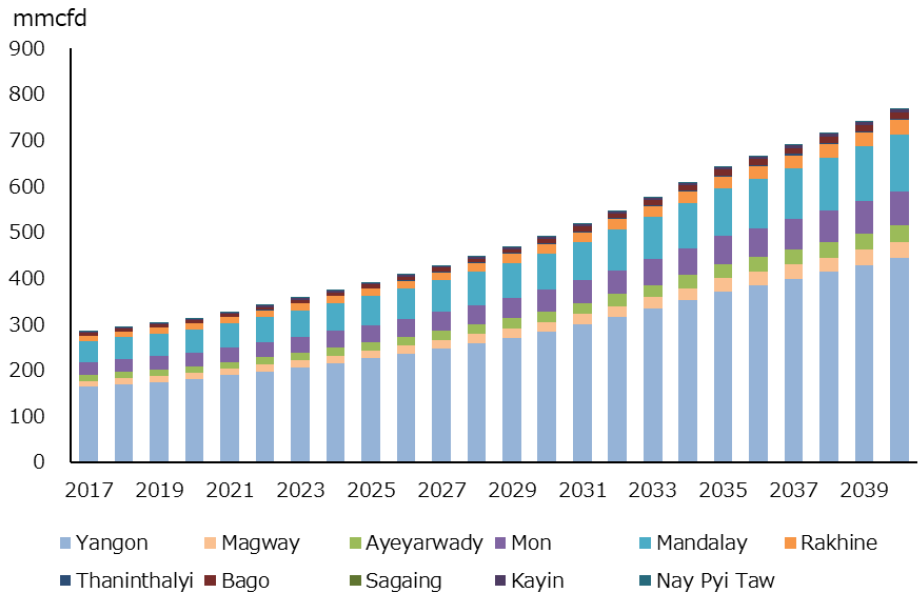
2.2 Demand Outlook by Sector

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



mmcfd = million cubic feet per day.
Source: Institute of Energy Economics, Japan estimate.

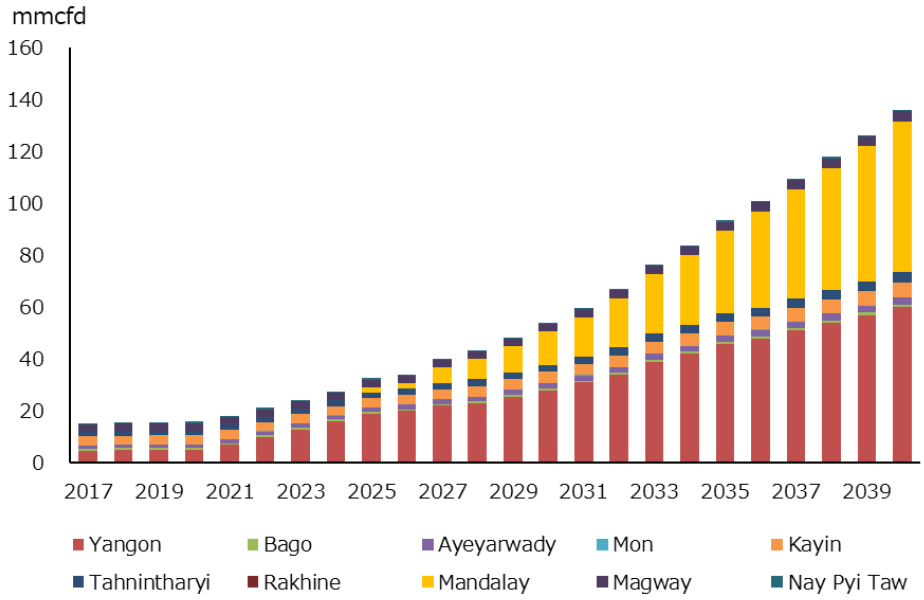
Industrial sector

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 mmcfd 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 mmcfd–7.0 mmcfd, 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

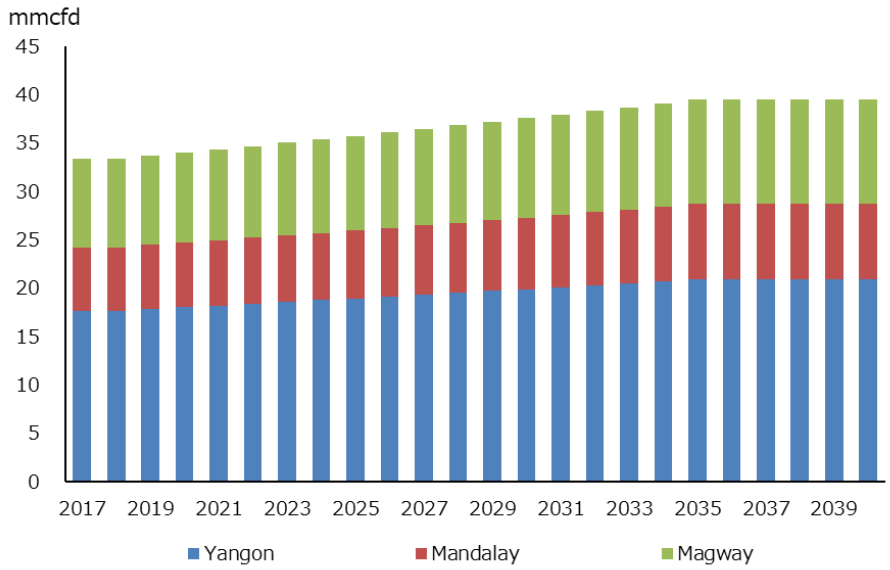


mmcfd = million cubic feet per day.
Source: Institute of Energy Economics, Japan estimate.

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

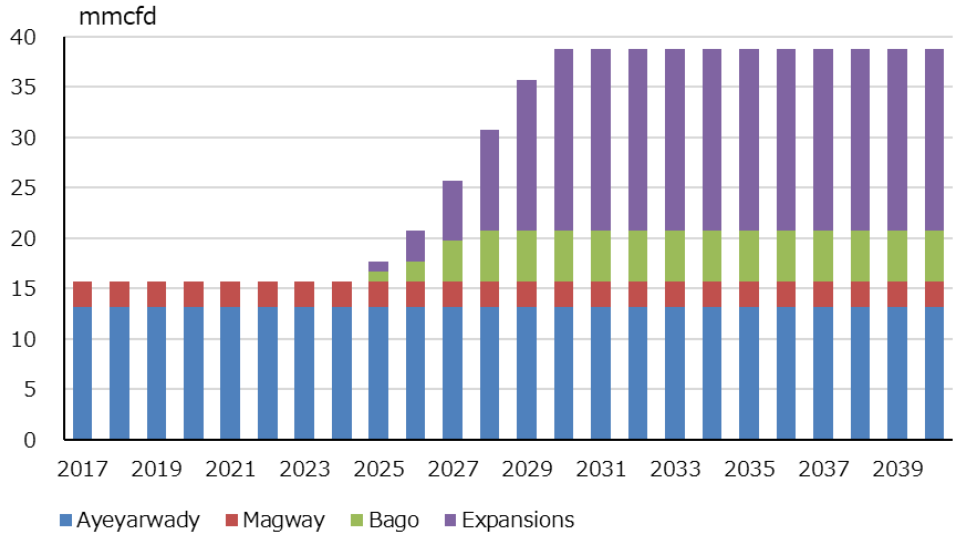


mmcfd = million cubic feet per day.
Source: Institute of Energy Economics, Japan estimate.

Chemical feedstock

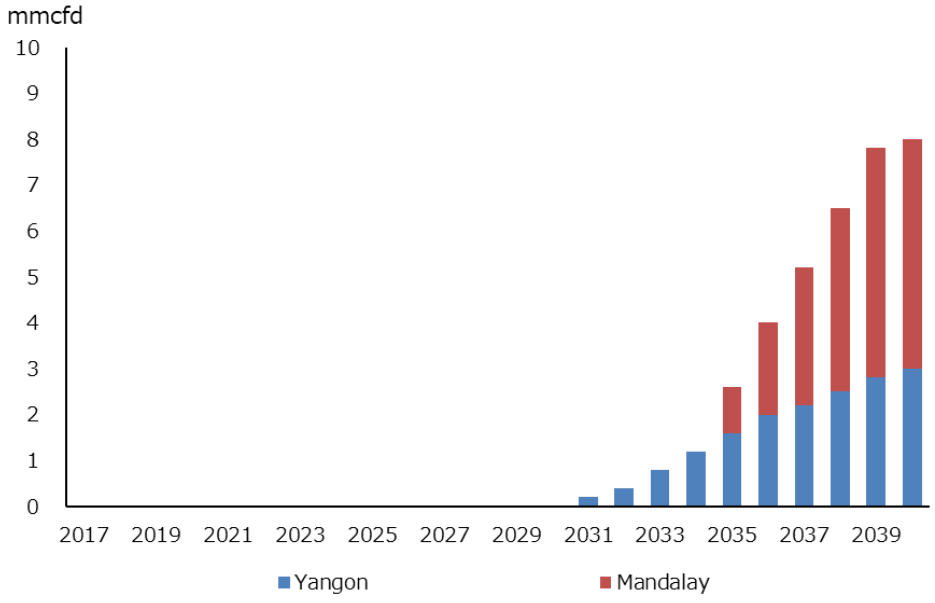
Natural gas consumption as chemical feedstock for fertiliser will increase moderately during the study period. According to the MOEE, three fertiliser plants were consuming 16 mmcfd of natural gas for feedstock as of FY2017. Since fertiliser is a critical material for the country's agricultural sector 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.

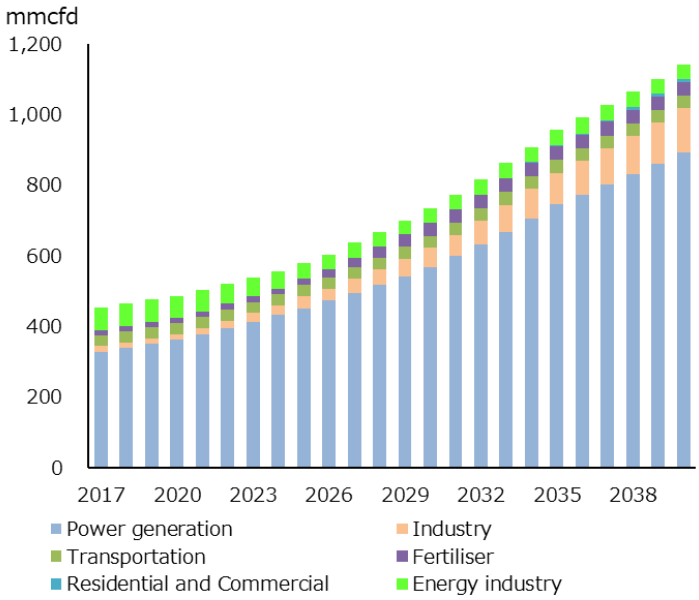
Energy Industry

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 mmcfd in 2017 to 486 mmcfd in 2020, 734 mmcfd in 2030, and 1,142 mmcfd 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



mmcfd = 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 mmcfd. Most of this demand comes from the transportation sector (18 mmcfd), 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 mmcfd).

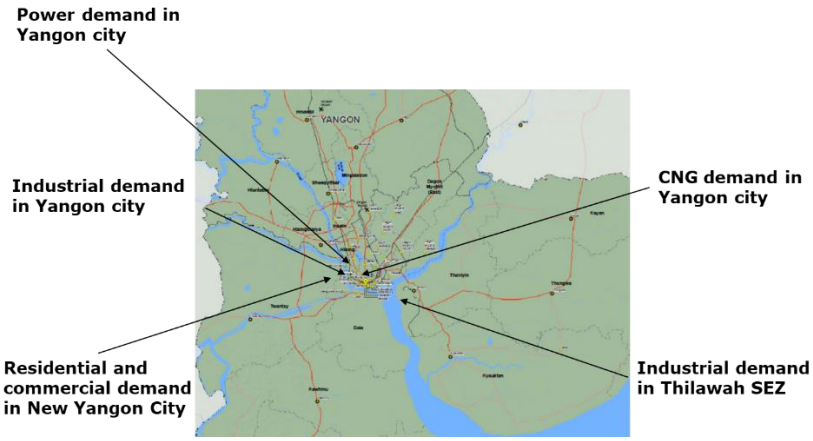
Figure 5.16: Location of Yangon City

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 mmcfd. 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 mmcfd–7 mmcfd. 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 mmcfd by 2040. As mentioned above, a demand of 27 mmcfd–28 mmcfd 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 Myanma 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 mmcfd. 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.

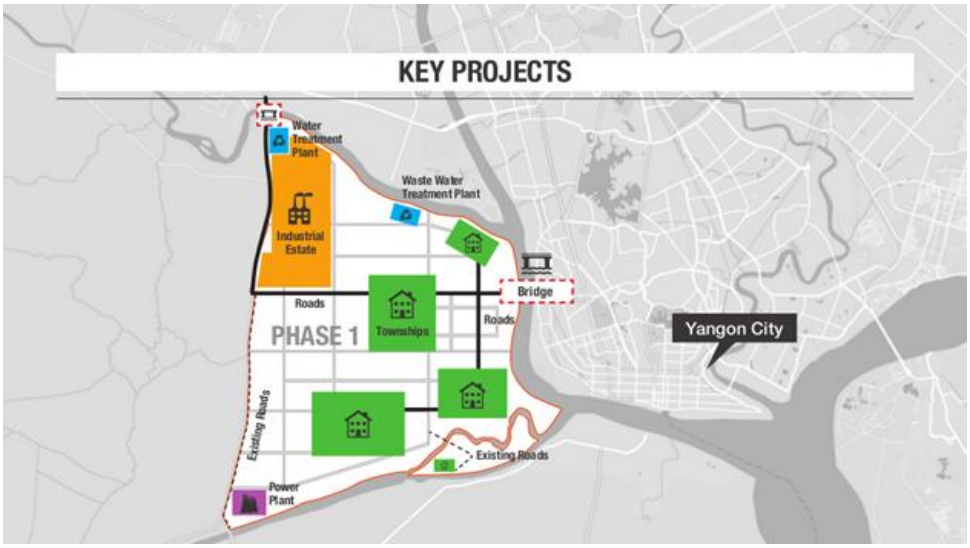
Figure 5.21: Compressed Natural Gas Station for Taxis in Yangon City

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.

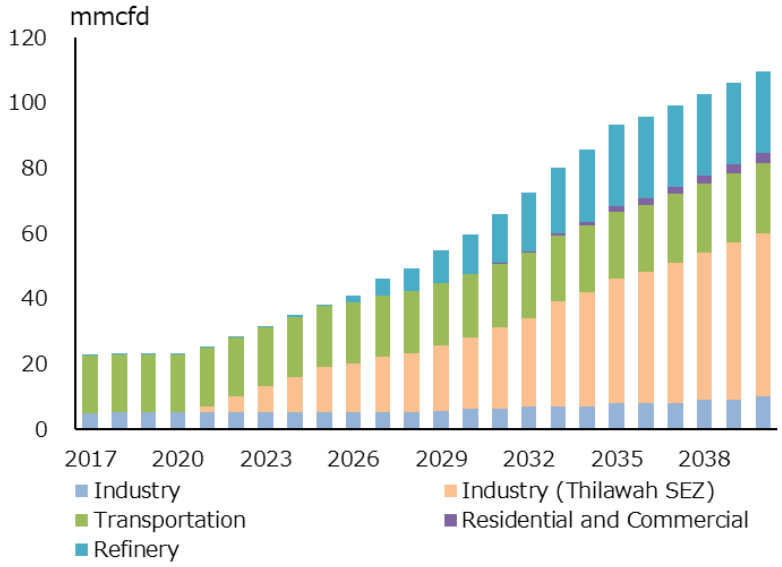
The study assumes that demand from New Yangon City will reach 2 mmcfd by 2040. Electricity will remain the most reasonable energy for many of Yangon's residential and commercial users, and LPG use will also expand in the future as it is more convenient and easier to adopt than city gas. Creating residential 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 mmcfd 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 (mmcfd)	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	50	4,000	750	12	595	297	99	2.0
Northwestern Yangon city	10	4,000	750	8	488	244	62	1.6
[Residential and commercial]								
New Yangon City	3	2,000	750	4	457	228	25	0.7
Total								**4.2**

m = metre, mmcfd = 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

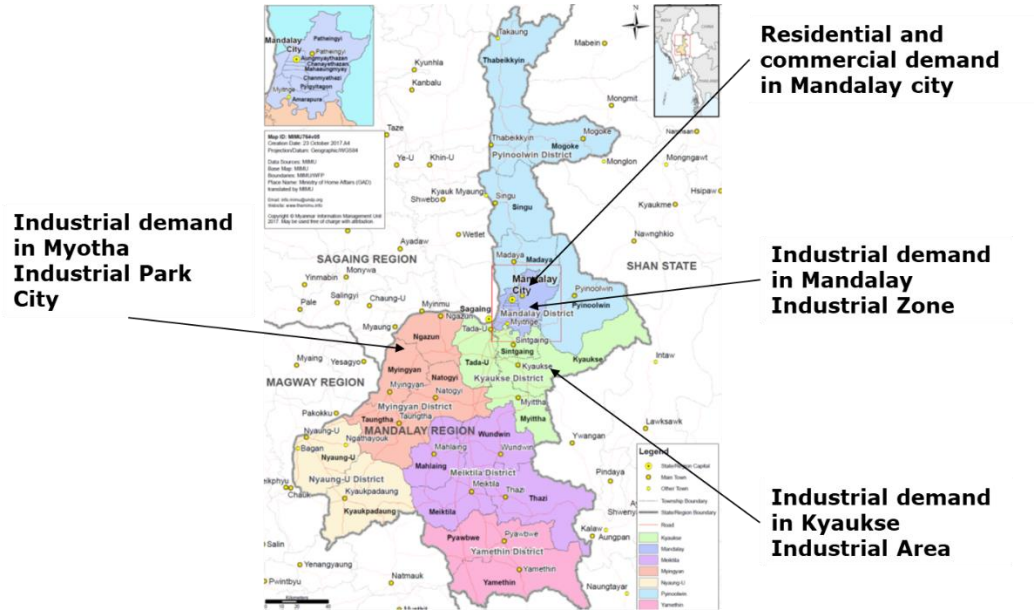
Natural gas demand in the Mandalay region is insignificant relative to the size of its economy. Downtown Mandalay city does not use natural gas because a pipeline network to the downtown area has not been developed. Mandalay as a region consumes a very small amount of gas for non-power purposes. Although 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 mmcfd 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 mmcfd 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 mmcfd as of 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 mmcfd 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 mmcfd 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

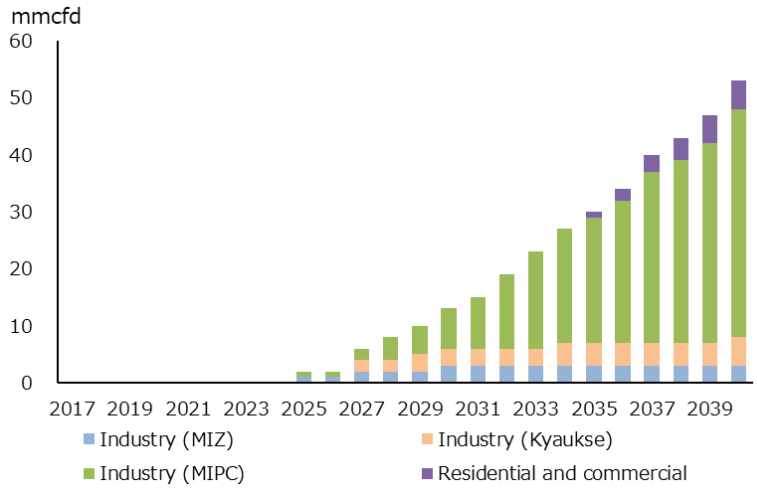
User	Unit consumption (mmcm/y)	Number	Consumption (mmcfd)
Large hospital	2,177	3	0.6
Luxury hotel	2,419	10	2.3
Office building	768	20	1.5
Shopping mall	1,362	3	0.4
Total			4.9

mmcm/y = million cubic metres per year, mmcfd = 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 mmcfd 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 = Myotha Industrial Park City, MIZ = Mandalay Industrial Zone, mmcfd = 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 mmcfd) 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 (mmcfd)	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 Industrial Zone	3	40,000	400	12	595	297	99	19.8
Kyaukse Industrial Area	5	5,000	400	6	467	234	37	1.7
Myotha Industrial Park City	40	5,000	400	16	680	340	142	3.0
[Residential and commercial]								
Downtown Mandalay	5	5,000	400	12	595	297	99	2.5
Total								**27.0**

m = metre, mmcfd = million cubic feet per day, psi = pounds per square inch.
Source: Study team estimate.

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