

APERC **Gas** Report 2018



PUBLISHED BY:

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Foreword

Demand for natural gas has been growing globally over the past decade. This growth has been at even faster rates in the APEC region. The fact that natural gas produces less pollutant emissions than other fossil fuels, amid growing concerns on climate change and de-carbonisation, has reflected positively on gas consumption. Moreover, the so-called shale revolution is impacting the gas sector well beyond the border of North America, and is expected to continue this trend.

The release of this first edition of the APERC Gas Market Report reflects both the ongoing importance of gas to the APEC region and the state of flux the sector currently finds itself in. This report is part of the first series of APERC Reports, along with the Coal Report 2017 and Oil Report 2018. Fossil fuels, and in particular gas, are still an important pillar of the power and industry sectors and will remain a sizable component of the energy mix in most APEC economies for many years to come.

I would like to express my sincere gratitude to the authors and contributors for their time and effort in writing and publishing this report. However, I would also like to note that the views expressed in this paper are those of the authors and not necessarily of APERC.

Takato OJIMI

President

Asia Pacific Energy Research Centre

April 2018

Acknowledgements

We are grateful for the full support and insightful advice from Expert Group on Clean Fossil Energy members. We also wish to thank the administrative staff of APERC and IEEJ, as this study could not have been completed without their assistance.

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Contents

Foreword.....	iii
Acknowledgements	iv
Abbreviation and Acronyms	vii
List of Figures	viii
List of Tables.....	ix
Summary and key trends.....	1
Section 1: Gas Demand.....	3
1-1. World and APEC Natural Gas Demand.....	3
<i>1-1-1 Overview.....</i>	<i>3</i>
<i>1-1-2 United States</i>	<i>4</i>
<i>1-1-3 Russia.....</i>	<i>4</i>
<i>1-1-4 China.....</i>	<i>4</i>
<i>1-1-5 Japan.....</i>	<i>6</i>
<i>1-1-6 Korea.....</i>	<i>6</i>
1-2 World LNG Demand.....	7
1-3 Gas Demand Outlook	9
Section 2. Gas Supply.....	12
2-1 World and APEC Natural Gas Supply.....	12
<i>2-1-1 Overview.....</i>	<i>12</i>
<i>2-1-2 United States</i>	<i>14</i>
<i>2-1-3 Russia.....</i>	<i>14</i>
<i>2-1-4 Canada.....</i>	<i>15</i>
<i>2-1-5 China.....</i>	<i>15</i>
<i>2-1-6 Australia.....</i>	<i>15</i>
2-2 World LNG Supply.....	16
2-3 Future Outlook.....	18
Section 3. Gas Trade	20
3-1 Gas Imports in the World and the APEC region.....	20

3-2 Gas Exports in the World and the APEC region	23
3-3 Gas Trade outlook in the World and the APEC region	25
Section 4. Gas Prices	27
4-1 Change in Major Natural Gas Prices of the World	27
4-2 Future Outlook.....	28
Section 5. Case study: US gas exports to Mexico and Mexico’s gas market reform	30
5.-1 Shale Revolution, gas from the US to the World.....	30
5.-2 Mexico’s rapid growing demand facing challenges.....	32
5.-3 Mexico’s energy reform and the birth of a gas market.....	35
References	39

Abbreviation and Acronyms

Abbreviation

Bcm	billion cubic metres
GW	gigawatts
kWh	kilo-Watt hour
Mtoe	million tonnes of oil equivalent
Mt	million tonnes
USD	US Dollar

Acronyms

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
EIA	Energy Information Administration, USA
ESTO	Energy Statistic and Training Office, APERC
EU	European Union
GDP	gross domestic production
IEA	International Energy Agency
IEEJ	Institute of Energy Economics Japan
NBS	National Bureau of Statistics, China
UN Comtrade	United Nations Commodity Trade Statistics Database
USA	United States of America
USGS	United States Geological Survey

List of Figures

<i>Figure 1-1 Natural gas consumption in APEC economies, 2006-2016</i>	5
<i>Figure 1-2 Changes in natural gas consumption of APEC member economies, 2006-2016</i>	6
<i>Figure 1-3 APEC member economies LNG imports, 2006-2013</i>	8
<i>Figure 1-4 Change in LNG imports of APEC member economies (2006-2016)</i>	9
<i>Figure 1-5 Outlook for natural gas consumption in APEC, 2015-2040</i>	11
<i>Figure 1-6 Outlook for change in natural gas consumption of APEC member economies, 2015-2040</i>	11
<i>Figure 2-1 Natural gas supply of APEC member economies, 2006-2016</i>	13
<i>Figure 2-2 Change in natural gas supply of APEC member economies, 2006-2016</i>	13
<i>Figure 2-3 APEC LNG supply, 2006-2016</i>	17
<i>Figure 3-1 Major natural gas trade flows, 2016</i>	20
<i>Figure 3-2 APEC members' natural gas imports, 2006-2016</i>	23
<i>Figure 3-3 Natural gas exports by APEC members, 2006-2016</i>	25
<i>Figure 3-4 Major natural gas trade flows (2030) Reference Scenario</i>	26
<i>Figure 4-1 Trends in major natural gas price indexes, 2015-2017</i>	27
<i>Figure 5-1, Total US gas exports (2000-2016, bcf)</i>	31
<i>Figure 5-2, Mexico's Power Generation Fuel Mix (2002-2016, Gwh)</i>	33
<i>Figure 5-3, Mexico's Gas Demand and Supply (2005-2015, bcm)</i>	34
<i>Figure 5-4, Mexico's gas transport network and its additions since 2012</i>	36

List of Tables

<i>Table 1-1 APEC member economies natural gas consumption, 2006-2016</i>	3
<i>Table 1-2 APEC member economies LNG imports, 2006-2016</i>	7
<i>Table 1-3 APEC member economies natural gas consumption, 2015-2040</i>	10
<i>Table 2-1 APEC member economies natural gas production, 2006-2016</i>	12
<i>Table 2-2 APEC LNG exports, 2006-2016</i>	17
<i>Table 2-3 APEC economies natural gas supply forecast, 2015-2030</i>	18
<i>Table 3-1 APEC members' natural gas imports, 2016</i>	21
<i>Table 3-2 APEC members' natural gas exports, 2016</i>	24

Summary and key trends

- World gas demand has grown by 2.2% on average in the past 10 years, while APEC gas consumption has grown faster, by 2.6% per year on average.
- Around 60% of global gas consumption takes place in APEC member economies. In 2006 it was 53%.
- The US remains the main gas consumer in the world.
- In the last decade, US gas consumption grew by 29% (148 Mtoe) while China's increased by 264% (124 Mtoe). They are the largest contributors to the APEC region demand growth.
- World LNG demand has grown by 5.4% on average in the past 10 years, while APEC LNG imports increased on average by 2.6% per year.
- Despite this, APEC LNG demand represented 71% of world imports. China was also the largest contributor to the APEC region LNG demand growth, followed by Japan.
- Worldwide natural gas consumption will increase by an average 1.8% per year, growing from 2,944 Mtoe in 2015 to 4,550 Mtoe 2040.
- APEC gas demand will grow by an average 2.2% per year from 1,663 to 2,854 Mtoe during the same period.
- The US and China will continue to lead gas consumption growth in the APEC region.
- The US surpassed Russia in 2012 as the world's largest producer (shale revolution).
- The US and China are the largest contributors to the APEC region production growth.
- Conversely, Mexico's production shrank by 28%, around 12 Mtoe.
- World LNG supply has grown by 5.6%, oversupplying the market.
- Despite increasing production, APEC LNG exports decreased from 45% of the world's exports to 39%.
- Australia and Russia contributed 31 Mtpa of exports, almost all of the APEC region's growth.
- World gas imports grew by 2.1% per year from 2006 to 2016.
- APEC members' share of global natural gas imports increased from 35% to 43% in the last decade.
- Only 3 out of 21 APEC members do not trade gas: New Zealand, Viet Nam and the Philippines.
- Japan remains the largest LNG and natural gas importer in the world.
- While US imports decreased, it still is the second biggest importer.
- Mexico's imports are growing fast and will probably surpass Korea in the coming years.

- Russia remains the world's largest gas exporter. In addition, it is building infrastructure to export to markets other than its traditional destination, Europe.
- Canada still exports massive volumes to the US, but they decreased by 18% during the last decade.
- The US more than tripled natural gas exports including pipeline deliveries and LNG exports.
- Australia nearly tripled its LNG exports during the same period.
- Possible upward trend in Asian LNG prices as long-term contracts are linked to crude oil prices, which are expected to gradually rise in the future.
- However, there is uncertainty over importing companies, which might want to renew contracts at lower prices, opting for short-term lower prices or spot contracts.
- Despite LNG demand growth, pushed mainly by China, LNG markets will continue to be oversupplied with new capacity additions.
- Because of this, the Asian LNG spot price is forecasted to stay at or below \$6/MMBtu, increasing the gap with long-term contract prices.
- Gas prices in Europe have a mixed future. In the short run, prices will have a downward tendency because of slow demand growth and intensified competition from exporters. In the mid-term, however, the North Sea's production decline and demand for power generation will pressure natural gas prices in Europe, and they will recover to the level of \$7/MMBtu at around 2020.
- Gas prices in the United States are expected to be lower in the near future. On the other hand, the recovery of the oil price might raise development and production costs. The start of LNG exports on the US Gulf Coast may also add upward pressure on the domestic price, but prices are expected to remain below \$4/MMBtu in the mid-term.

Section 1: Gas Demand

1-1. World and APEC Natural Gas Demand

1-1-1 Overview

World natural gas consumption has continued to grow by an average of 2.2% per year over the past 10 years since 2006, increasing from 2,421 Mtoe (2,535 Bcm) in 2006 to 3,001 Mtoe (3,142 Bcm) in 2016 (Table 1-1). APEC gas consumption saw larger growth, increasing by an average 2.6% per year from 1,297 Mtoe (1,358 Bcm) in 2006 to 1,676 Mtoe (1,755 Bcm) in 2016. APEC accounted for 55.9% of world natural gas consumption, growing by about 2% from 2006 when it accounted for 53.6% of consumption. The increase in natural gas consumption in APEC member economies is attributable mainly to the United States and China, with consumption in these economies alone increasing 273 Mtoe (286 Bcm) from 2006 to 2016. This represents about 47% of the global consumption increase over the same 10-year period.

Table 1-1 APEC member economies natural gas consumption, 2006-2016

Economy	Natural Gas Consumption (Mtoe)										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
APEC Total	1,297	1,369	1,390	1,372	1,469	1,537	1,582	1,630	1,666	1,663	1,676
Australia	23	26	29	29	28	30	29	30	32	32	33
Brunei	3	3	3	2	3	3	3	2	3	2	2
Canada	79	79	79	78	79	83	83	86	88	87	85
Chile	6	4	2	3	4	5	4	4	4	4	4
China	47	59	68	75	89	110	123	140	154	159	171
Hong Kong	2	2	3	3	3	2	2	2	2	3	3
Indonesia	29	28	30	34	39	36	35	37	37	38	40
Japan	77	83	84	81	86	100	105	106	107	100	101
Korea	29	31	32	32	39	42	45	48	43	39	41
Malaysia	34	35	38	32	31	32	32	38	38	38	39
Mexico	52	51	52	54	54	57	59	62	61	65	66
New Zealand	3	4	3	4	4	3	4	4	4	4	4
Papua New Guinea	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Peru	2	3	3	4	5	6	7	6	8	8	8
Philippines	3	3	3	3	3	3	3	3	3	3	3
Russia	359	366	366	350	383	396	387	386	385	364	354
Singapore	6	6	7	7	7	7	8	9	9	9	9
Taiwan	9	10	11	10	13	14	13	13	14	15	15
Thailand	27	28	31	29	33	31	35	38	38	38	38
United States	502	543	541	535	556	569	595	606	627	646	650
Vietnam	5	5	6	7	8	8	8	9	9	10	10
World Total	2,421	2,527	2,593	2,536	2,736	2,791	2,842	2,894	2,911	2,944	3,001
APEC Share	53.6%	54.2%	53.6%	54.1%	53.7%	55.1%	55.7%	56.3%	57.2%	56.5%	55.9%

Sources: International Energy Agency (IEA), World Energy Balances 2017; Asia Pacific Energy Research Centre, Energy Balance Table

1-1-2 United States

The United States was the largest primary energy consumer in the world as of 2006, but its overall energy consumption has declined in recent years, and was surpassed by the rapidly growing economy of China in 2009. In contrast, domestic natural gas production has increased rapidly since 2006 due to the shale revolution, which drove down gas prices and increased its competitiveness with coal in the electricity generation sector. Additionally, the Obama administration policies promoting natural gas as a cleaner energy and regulations on coal-fired power generation encouraged a coal-to-gas shift as a measure to combat climate change. As a result, the ratio of natural gas in primary energy consumption rose from 23%, in 2006, to 30% in 2016, with gas consumption increasing by 29%, or 650 Mtoe (681Bcm), compared to 2006. This is equivalent to 20% of global natural gas consumption.

1-1-3 Russia

Russia is the second largest natural gas consumer in the world after the United States. Russia's power generation capacity mainly comprises gas-fired power plants that use its abundant domestic resources. For this reason, reforming the overreliance on natural gas and the power supply and demand structure have been central issues in energy policy and power development in Russia. By implementing policies focused on nuclear and coal power generation, Russia reduced the proportion of natural gas in primary energy consumption from 54% in 2007 to 51% in 2015. Additionally, overall domestic primary energy consumption also continued to decline because of the economic downturn from 2012 onwards, which has affected natural gas demand. As a result, gas demand in 2016 was slightly below the demand level in 2006. Gas consumption has scarcely increased in the last decade. Russia has recently started new initiatives, such as introducing combined cycle gas turbines (CCGT).

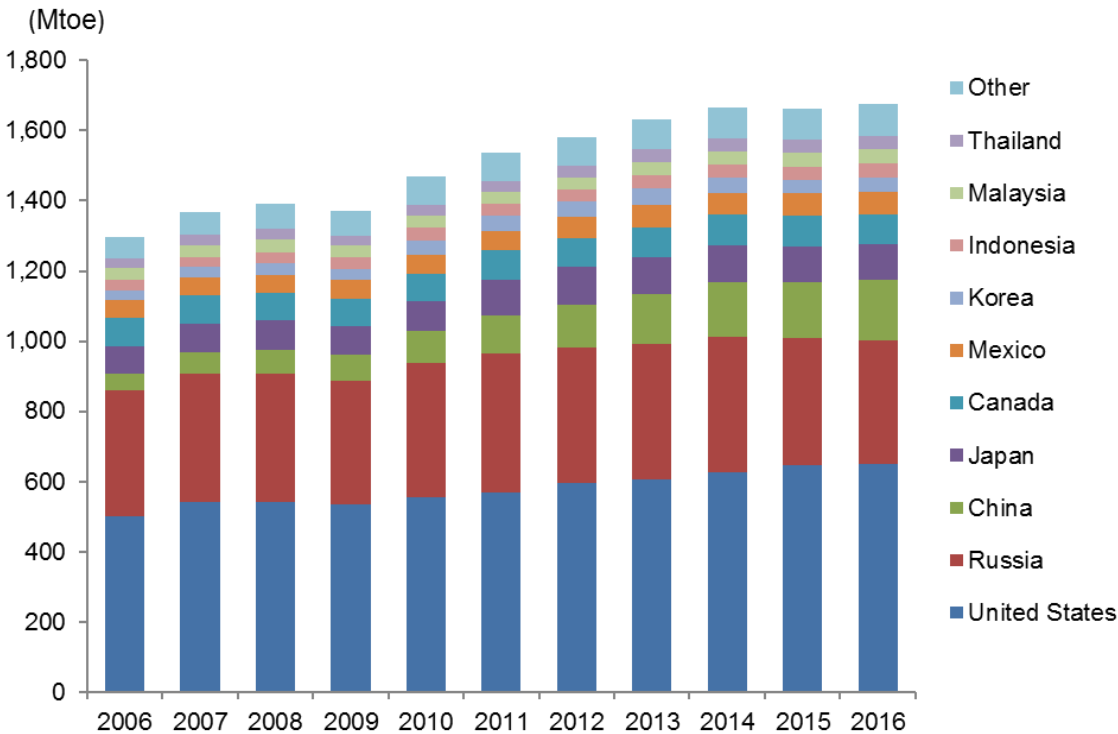
1-1-4 China

Energy consumption in China continues to grow rapidly because of economic development, making it the world's largest energy consumer since 2009. Although growth has slowed in recent years, China consumes approximately 1.4 times more primary energy than the United States, the second largest consumer. The massive quantity of domestically produced coal is its main source of primary energy, accounting for more than 60% of energy consumption. However, China's shift to natural gas enhances its energy security, combats environmental pollution and reduces CO₂ emissions. China has grown to become the third largest natural gas consumer in the world. Its primary energy consumption share of natural gas has grown from 2.5% in 2006 to 5.3% in 2015. The *Thirteenth Five-Year Plan*, announced in March 2016, sets forth specific numerical targets in its energy consumption, reducing the ratio of coal in its primary energy consumption to 58% or less and increasing the ratio of natural gas to 10%

or more in 2020, which is expected to further accelerate the shift to natural gas. The laying of pipelines is a crucial factor for boosting domestic gas demand. China has recently built, at least, these major pipelines:

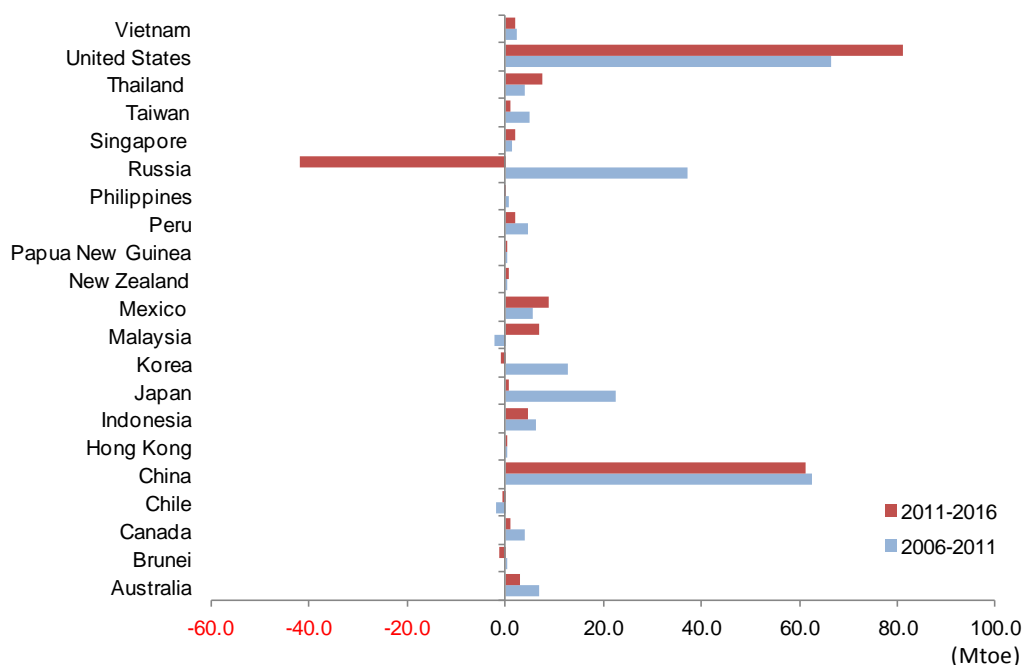
1. The 3,839-kilometer-long West–East Gas Pipeline carrying natural gas from Xinjiang in the west to Shanghai in the east, in 2005;
2. The 4,978-kilometer-long West–East Gas Pipeline II from Xinjiang to Guangzhou and Hong Kong, China in 2011; and
3. The 5,220-kilometer-long West–East Gas Pipeline III from Xinjiang to Fuzhou, in 2015.

Figure 1-1 Natural gas consumption in APEC economies, 2006-2016



Source: IEA, World Energy Balances 2017

Figure 1-2 Changes in natural gas consumption of APEC member economies, 2006-2016



Source: IEA, World Energy Balances 2017

1-1-5 Japan

Japan is the world’s largest LNG-importer and the fourth natural gas consumer, supplying approximately 97% of its natural gas demand with imported LNG. Since the 1970’s oil crises, it has been promoting the use of alternative energies in order to reduce its dependence on imported oil. As a result, the proportion of oil for power generation has significantly declined while increasing the ratio of coal, natural gas and nuclear power. This has pushed up the demand for natural gas.

As a consequence of the Great East Japan Earthquake in March 2011, all Japan’s nuclear power plants were shut down, dramatically increasing the demand for natural gas as a substitute fuel. This has resulted in a rapid expansion of the natural gas share of primary energy consumption from about 17% to more than 23%, two years after the earthquake. Consumption of natural gas decreased slightly after 2015, because of the restarting of the Sendai Nuclear Power Plant and the Ikata Nuclear Power Plant, as well as the decline in the overall primary energy consumption. Going forward, uncertainty arises in forecasting gas demand as Japan pushes to restart nuclear power plants and adopt renewable energies.

1-1-6 Korea

Korea almost totally covers its gas demand with imports. Natural gas consumption has continued to

grow, but since 2013, the demand for nuclear power, oil, and coal has risen, while gas consumption has slightly dropped. According to the *12th Long-Term Natural Gas Supply and Demand Plan* for 2015 to 2029, gas demand for the residential sector will increase by 2.06% annually, but overall demand is forecasted to decrease by 4.17% annually with the start of operations of new coal-fired and nuclear power plants.

However, with the election of President Moon Jae-in in May 2017, who has stated his opposition to nuclear and coal power, natural gas is expected to grow again as an alternative energy. The *3rd National Energy Basic Plan*, reflecting President Moon's energy pledge, is expected to be formulated in 2018.

1-2 World LNG Demand

World LNG imports increased by an average 5.4% per year from 131 million tons per annum (Mtpa), in 2006, to 222 Mtpa, in 2016. APEC LNG imports were below the world's growth rate, increasing by an average 4.8% per year from 99 Mtpa in 2006, to 158 Mtpa in 2016. In addition, APEC accounted for 71.3% of global LNG imports in 2016, with the majority of these volumes produced within the APEC region. However, APEC's LNG demand as a share of global demand has decreased by about 4% compared with 75.5% in 2006. This means that LNG demand outside APEC is increasing, for example in India, Pakistan and Bangladesh.

Table 1-2 APEC member economies LNG imports, 2006-2016

Economy	LNG Import (Mtpa)										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
APEC Total	99	110	107	107	126	143	145	158	156	150	158
Australia	0	0	0	0	0	0	0	0	0	0	0
Brunei	0	0	0	0	0	0	0	0	0	0	0
Canada	0	0	0	1	1	2	1	1	0	0	0
Chile	0	0	0	0	2	2	3	3	2	2	3
China	1	3	3	5	8	10	13	15	17	17	21
Hong Kong	0	0	0	0	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0	0	0	0	0
Japan	57	62	62	60	64	75	79	80	80	75	76
Korea	23	23	26	23	30	32	33	37	34	30	31
Malaysia	0	0	0	0	0	0	0	4	3	3	2
Mexico	1	2	2	2	4	2	3	5	5	7	8
New Zealand	0	0	0	0	0	0	0	0	0	0	0
Papua New Guinea	0	0	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	0	0	0	0	0
Philippines	0	0	0	0	0	0	0	0	0	0	0
Russia	0	0	0	0	0	0	0	0	0	0	0
Singapore	0	0	0	0	0	0	0	1	1	1	1
Taiwan	7	7	8	8	10	11	10	10	11	12	12
Thailand	0	0	0	0	0	1	1	1	1	1	2
United States	11	14	6	8	8	6	3	2	1	1	1
Vietnam	0	0	0	0	0	0	0	0	0	0	0
World Total	131	141	140	156	190	209	206	205	206	212	221
APEC Share	75.5%	78.2%	76.3%	68.8%	66.4%	68.1%	70.7%	77.0%	75.7%	70.8%	71.3%

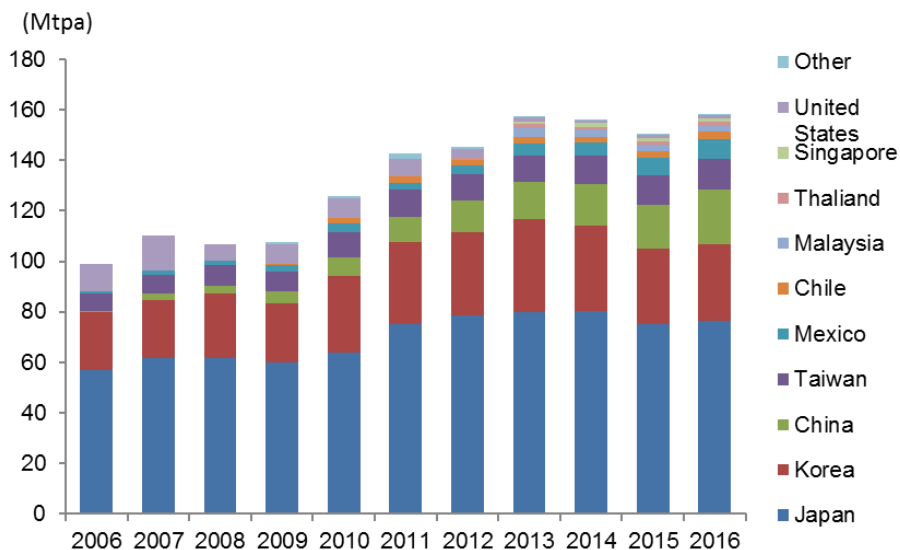
Source: IEA, World Energy Balances 2017; Cedigaz, Natural Gas in the World

In 2006, there were six APEC member economies importing LNG; this number increased to 11 in 2016. By volume, Japan, Korea and China account for most of the LNG imports among APEC member economies, with these three economies importing 128 Mtpa of LNG in 2016. This is equivalent to 58% of worldwide LNG imports and 81% of APEC LNG imports.

Demand for natural gas in China is growing rapidly. As domestic production is not enough to meet demand, China continues to import gas via pipeline and LNG. In 2016, 67.2% of natural gas demand was supplied with domestic production, 16.4% with LNG imports and 16.4% with pipeline imports. The first domestic LNG receiving terminal in China began operation in 2006, and 13 LNG receiving terminals have begun operations in the past decade. It is expected that natural gas demand will increase in the future, and more regasification terminals are planned.

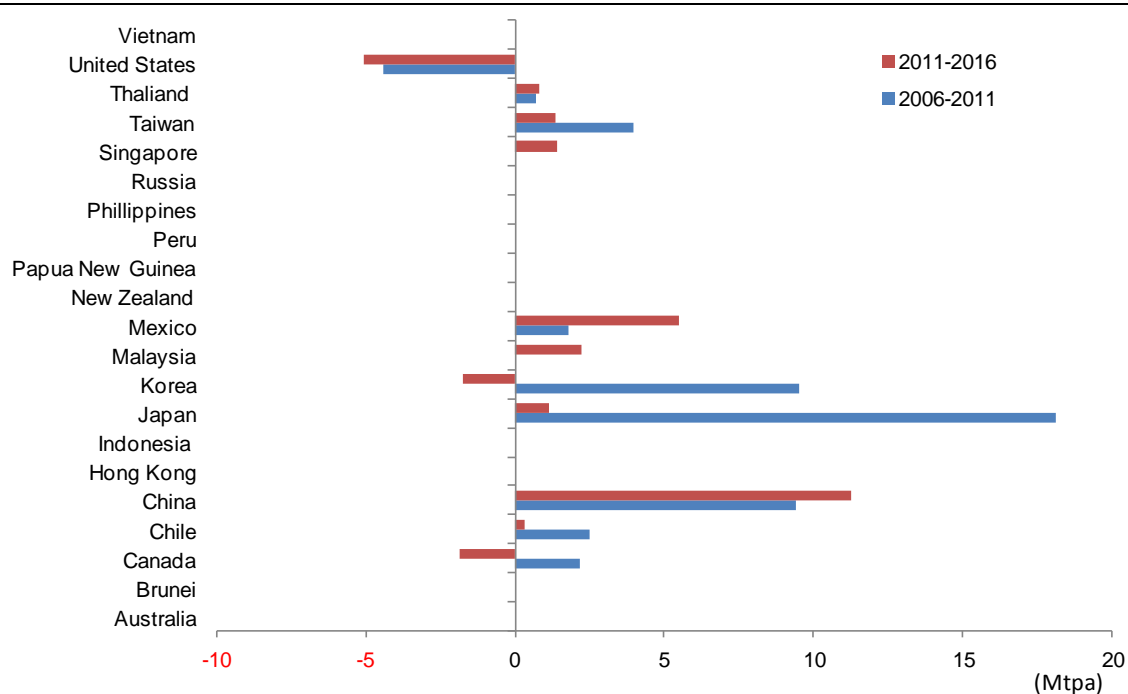
The United States, once a net LNG importer, has seen an annual decline in the amount of imported LNG because of the increase in domestic natural gas production. In 2016, exports from Sabine Pass LNG began and have been growing rapidly. Like the United States, Canadian production of unconventional gas has progressed, but while the Canaport LNG receiving terminal began operation in 2009, it only imported LNG from 2009 to 2013. There are several LNG export projects currently being considered on the Canadian west coast that have their eyes set on the Asian LNG market.

Figure 1-3 APEC member economies LNG imports, 2006-2013



Source: IEA, World Energy Balances 2017; Cedigaz, Natural Gas in the World

Figure 1-4 Change in LNG imports of APEC member economies (2006-2016)



Source: IEA, *World Energy Balances 2017*; Cedigaz, *Natural Gas in the World*

New Zealand, The Philippines and Viet Nam are the only APEC economies that do not trade natural gas. However, the two latter economies are planning the construction of LNG receiving terminals. The Philippines is expected to start imports around 2019 and Viet Nam after 2020. Australia became the world’s second largest LNG exporter in 2016. Three LNG export projects in eastern Australia have started operations. However, this has caused a shortage of natural gas and high prices for the domestic market in this Australian region. To counter the shortfall, AGL Energy, an Australian electricity and gas company, is considering the construction of a floating LNG receiving terminal near Melbourne, Victoria, aiming to start construction in 2019 and begin operations in 2020.

1-3 Gas Demand Outlook

According to the Asia Pacific Energy Research Centre’s (APERC) *APEC Energy Demand and Supply Outlook 6th Edition*, worldwide natural gas consumption will increase by an average 1.8% per year, growing from 2,944 Mtoe (3,082 Bcm) in 2015, to 4,550 Mtoe (4,763 Bcm) in 2040. APEC gas demand is expected to increase by an average 2.2% per year from 1,663 (1,741) to 2,854 Mtoe (2,988 Bcm) during the same period.

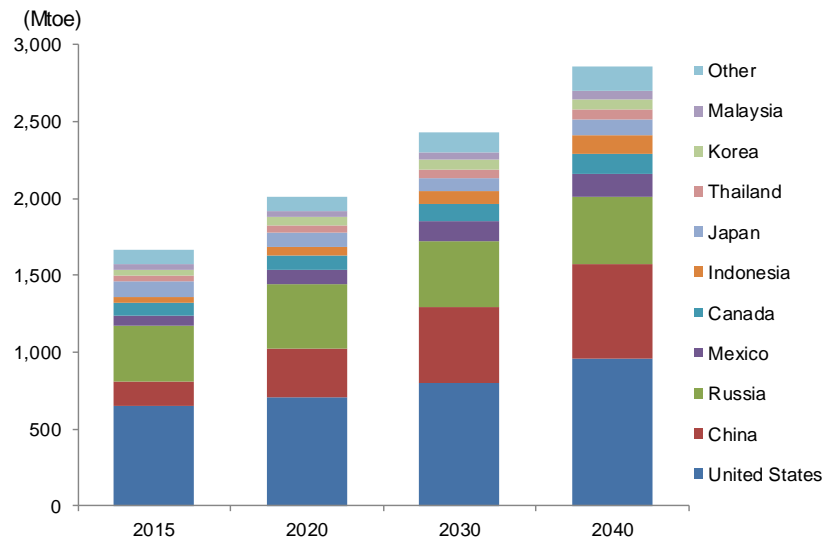
Table 1-3 APEC member economies natural gas consumption, 2015-2040

Economy	Natural Gas Consumption (Mtoe)				2015-2040	
	2015	2020	2030	2040	Change	Change %
APEC Total	1,663	2,014	2,429	2,854	1,191	71.6%
Australia	32	35	42	51	18	57.2%
Brunei	2	3	4	4	2	94.6%
Canada	87	95	114	128	41	46.9%
Chile	4	5	6	7	3	86.7%
China	159	320	489	610	452	285.0%
Hong Kong	3	3	5	7	4	157.0%
Indonesia	38	54	81	118	81	212.9%
Japan	100	95	90	102	2	1.6%
Korea	39	53	58	61	21	53.9%
Malaysia	38	40	49	58	20	53.4%
Mexico	65	92	123	150	85	131.4%
New Zealand	4	4	4	4	-0	-8.2%
Papua New Guinea	0.2	0.8	2.1	4.5	4.3	2232.7%
Peru	8	9	14	20	12	149.0%
Philippines	3	4	5	6	3	111.2%
Russia	364	419	434	443	78	21.5%
Singapore	9	10	12	12	3	34.0%
Taiwan	15	13	21	21	7	44.1%
Thailand	38	44	58	71	34	88.8%
United States	646	704	802	961	315	48.7%
Vietnam	10	10	16	16	7	71.9%
World Total	2,944	3,179	3,845	4,550	1,606	54.6%
APEC Share	56.5%	63.3%	63.2%	62.7%	-	-

Source: APERC, APEC Energy Demand and Supply Outlook 6th Edition

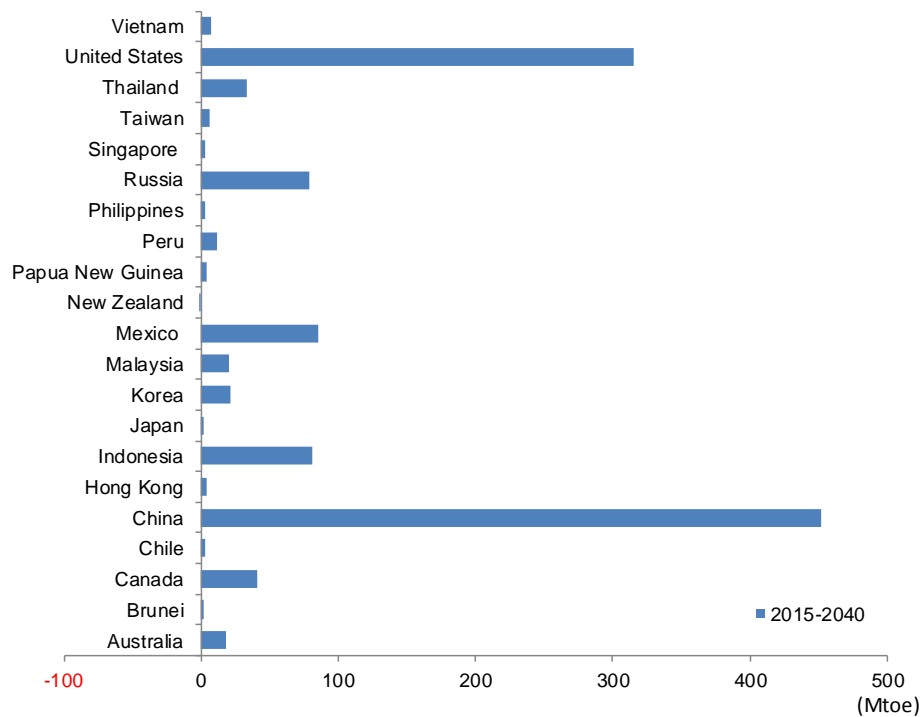
The APEC outlook expects demand for gas to increase significantly, mainly in the United States and China. In addition, OECD members in the APEC region will increase their demand on average 1.4% per year, and non-OECD economies will increase 4.4% per year. While demand for natural gas is growing globally, gas demand in Japan, the world's largest LNG importer, has hit a peak and is expected to maintain its current levels by 2040.

Figure 1-5 Outlook for natural gas consumption in APEC, 2015-2040



Source: APERC, APEC Energy Demand and Supply Outlook 6th Edition

Figure 1-6 Outlook for change in natural gas consumption of APEC member economies, 2015-2040



Source: APERC, APEC Energy Demand and Supply Outlook 6th Edition

Section 2. Gas Supply

2-1 World and APEC Natural Gas Supply

2-1-1 Overview

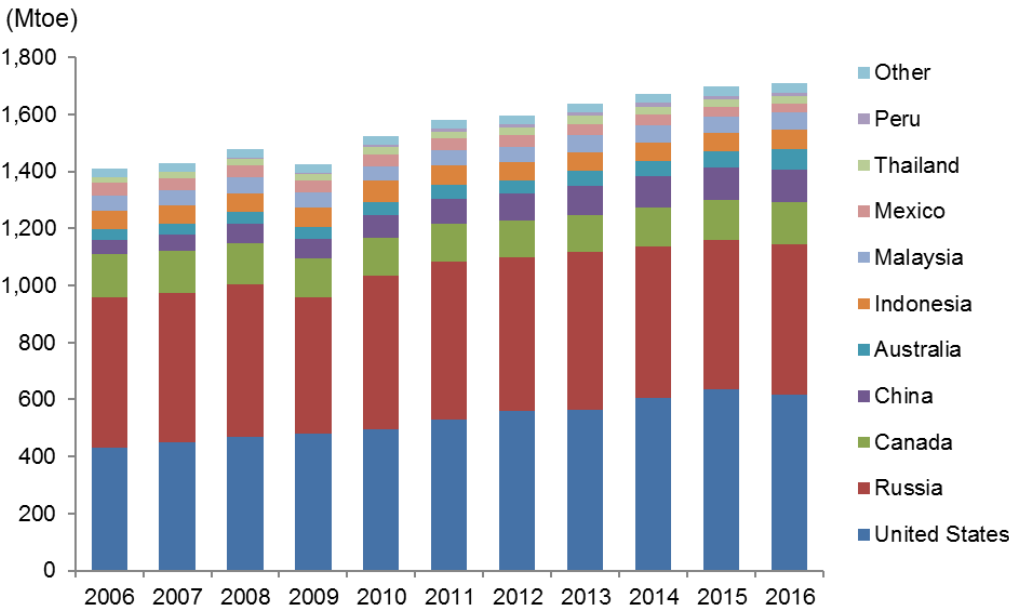
Table 2-1 APEC member economies natural gas production, 2006-2016

Economy	Natural Gas Production (Mtoe)										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
APEC Total	1,409	1,429	1,476	1,425	1,523	1,582	1,595	1,638	1,672	1,696	1,710
Australia	36	38	40	42	44	48	46	52	53	56	74
Brunei	11	11	11	10	10	11	11	10	10	9	9
Canada	155	150	145	135	132	132	130	130	138	139	146
Chile	2	1	1	2	2	1	1	1	1	1	1
China	49	58	67	71	80	88	93	101	109	113	115
Hong Kong	0	0	0	0	0	0	0	0	0	0	0
Indonesia	65	62	64	67	75	71	67	67	66	65	67
Japan	3	4	4	3	3	3	3	3	2	2	3
Korea	0	0	0	0	0	0	0	0	0	0	0
Malaysia	55	54	57	52	51	53	51	58	59	58	59
Mexico	43	43	42	44	43	42	41	40	37	34	31
New Zealand	3	4	3	4	4	3	4	4	4	4	4
Papua New Guinea	0	0	0	0	0	0	0	0	2	2	3
Peru	2	3	3	4	8	12	12	12	13	13	14
Philippines	3	3	3	3	3	3	3	3	3	3	3
Russia	526	522	535	479	540	553	541	554	531	524	529
Singapore	0	0	0	0	0	0	0	0	0	0	0
Taiwan	0	0	0	0	0	0	0	0	0	0	0
Thailand	19	20	23	21	25	22	26	28	29	26	25
United States	432	450	470	480	495	531	558	564	606	636	616
Vietnam	6	6	7	7	8	8	8	9	9	10	10
World Total	2,447	2,511	2,613	2,536	2,715	2,788	2,837	2,896	2,935	2,976	2,998
APEC Share	57.6%	56.9%	56.5%	56.2%	56.1%	56.7%	56.2%	56.6%	57.0%	57.0%	57.0%

Source: International Energy Agency (IEA), *World Energy Balances 2017*; Asia Pacific Energy Research Centre, *Energy Balance Table*

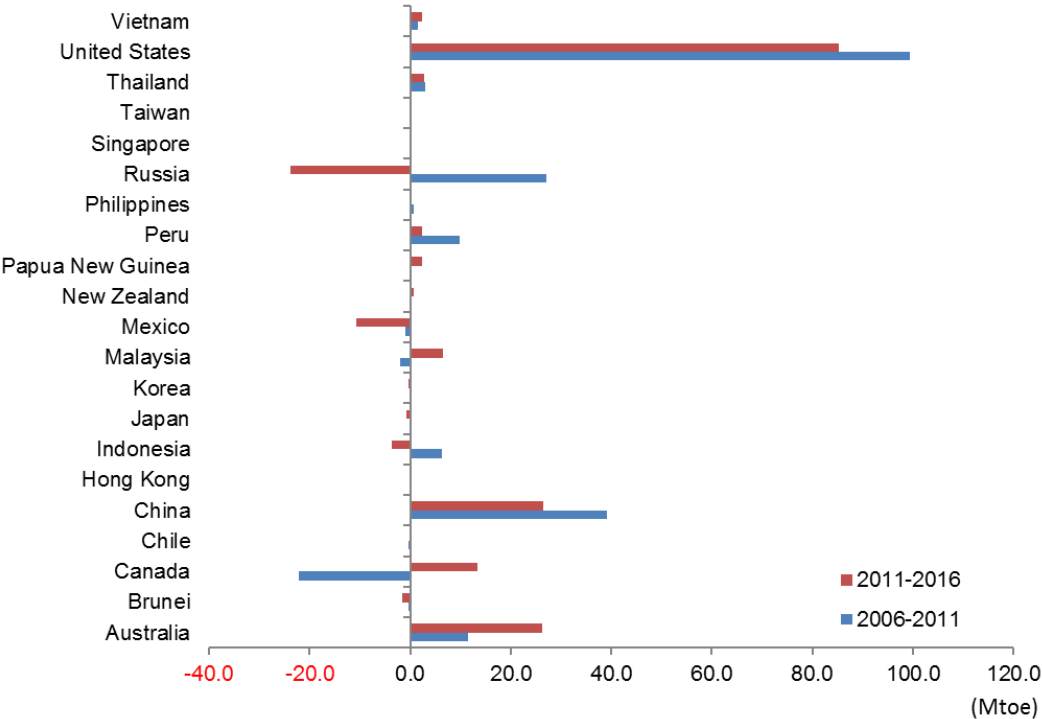
Over the past decade, the world's natural gas supply has continued to expand, following demand. Table 2-1 shows natural gas supply from 2006 to 2016 according to the IEA's *World Energy Balances 2017*. World supply increased by an average 2.1% per year from 2,447 Mtoe (2,562 Bcm) in 2006 to 2,998 Mtoe (3,139 Bcm) in 2016. APEC gas supply also increased by an average 2.0% per year from 1,409 Mtoe (1,475 Bcm) in 2006 to 1,710 Mtoe (1,790 Bcm) in 2016. APEC's share of world supply did not change significantly, marginally decreasing from 57.6% in 2006 to 57.0% in 2016. APEC member economies, supply growth was concentrated in the United States, China and Australia, accounting alone for an increase of 288 Mtoe (302 Bcm) from 2006 to 2016, about 30% of the world supply increase.

Figure 2-1 Natural gas supply of APEC member economies, 2006-2016



Source: International Energy Agency (IEA), World Energy Balances 2017; Asia Pacific Energy Research Centre, Energy Balance Table

Figure 2-2 Change in natural gas supply of APEC member economies, 2006-2016



Source: IEA, World Energy Balances 2017; Cedigaz, Natural Gas in the World

2-1-2 United States

Until the late 2000s, due to the increase in domestic demand and levelling off of domestic production, the US government estimated that it would need to import nearly 400 Mtpa of LNG by 2030. Consequently, some pipelines and LNG receiving terminals started construction for importing natural gas. However, the shale revolution changed circumstances, increasing dramatically the United States unconventional gas production, especially shale gas. In 2011, with the increase in production, the United States produced more gas than in any other time in its history, exceeding the 1973 record production levels. In 2012, the US surpassed Russia to become the world's largest supplier.

There are numerous LNG export projects planned to come online in the US in the future, and the supply of natural gas is expected to increase under the Trump administration's *An America First Energy Plan*, which expects to increase employment and lower trade deficits by ramping up the production of shale oil and gas. Although United States LNG exports are losing an expected price advantage because of the sharp drop in international crude oil prices and the subsequent decline of Asian LNG prices in recent years, US LNG exports have no restrictions on destination. US LNG exports may contribute to revitalizing LNG markets.

2-1-3 Russia

Russia remains as one of the world's leading natural gas suppliers, despite little increase in its production from 2006 to 2016. Currently, most of the gas produced in Russia is supplied to Europe via pipeline. In 2006, 2009, and 2015, Russia cut off its gas exports to Ukraine over disputes on gas pricing, triggering gas shortages in some parts of Europe, where Russian piped gas exports transit through Ukraine. These actions forced some European governments to take measures to mitigate their dependence on Russia by substituting their imports with LNG imports, especially by procuring LNG in the spot market. However, Europe still remains heavily reliant on Russian gas imports. This is due to several reasons. First, the North Sea gas fields, which have been the main source of gas in Europe up to now, continue to age and decrease their production. Second, the Dutch Groningen gas field, the largest in Europe, is also in decline. Finally, LNG projects in the United States, which are expected to increase supply in the future, only started exporting in 2016. Under these circumstances, Russia is working to build the Nord Stream II and the Turkish Stream pipelines to increase its European exports while developing new gas fields at home.

China is expected to be a key destination for Russian gas exports. As previously mentioned, China is securing a variety of gas supply options by importing piped gas, LNG, and developing domestic unconventional gas. This has put Russia in a difficult position. However, Russian piped gas exports to China will start when the Power of Siberia pipeline comes into stream. Similarly, Russia is also expected to export LNG to China from the recently finished Yamal LNG terminal and the Sakhalin 2 LNG terminal,

currently under expansion and expected to be concluded after 2020.

2-1-4 Canada

As of 2016, Canada was the world's fifth largest natural gas supplier, but its supply volume has decreased from 155 Mtoe (162 Bcm) in 2006 to 146 Mtoe (153 Bcm) in 2016. Canada, originally, did not consume much natural gas, exporting by pipeline to the United States more than 50% of production. However, due to the sharp increase in shale gas in the United States, Canadian gas exports have decreased. Canada has plans to export LNG to Asia and other markets. In 2014, 20 LNG projects were proposed in the province of British Columbia alone. Nevertheless, after oil prices went down, no projects have moved forward with a final investment decision as December 2017.

2-1-5 China

China's natural gas consumption is forecasted to continue increasing, and the government is proceeding to expand the production of natural gas along with it. The Chinese government has set a goal of increasing natural gas consumption so that it represents at least 10% of primary energy consumption by 2020, improving energy security and decreasing pollutant emissions.

China's natural gas supply sources can be roughly divided into domestic production, imports via pipeline and LNG imports. With respect to domestic natural gas production, in October 2013 China's National Energy Administration announced its shale gas industry policy, positioning shale gas development as a national strategically emerging industry, and implementing support measures such as subsidies, allowances for producers and tax exemptions for facilities that import gas from abroad as a result of exploration and development. Based on this policy, Chinese companies are proceeding to develop unconventional natural gas. In 2016, coalbed methane (CBM) and shale gas combined produced around 15 Bcm (14 Mtoe), with the Chinese government planning to raise this to about 40Bcm (38Mtoe) by 2020.¹ China imports gas via pipeline from Turkmenistan, Kazakhstan, Uzbekistan and Myanmar. Piped imports from Russia will begin when the Power of Siberia pipeline, currently under construction, is completed around 2019, with a maximum import capacity of 38 Bcm (36 Mtoe). China has been importing LNG since 2006, and imports have increased annually. LNG import volumes in 2016 were 37.4% higher than the previous year.

2-1-6 Australia

In Australia, natural gas production has dramatically increased in the past few years as many

¹ Presentation made by the National Energy Administration of China at the 5th Unconventional Natural Gas Forum held in Brisbane, Australia on 23 February 2017.

liquefaction projects have recently come online. These large-scale projects include the QCLNG project in 2014, the GLNG project in 2015, the Gorgon LNG project in 2016 and the Australia Pacific LNG project. More liquefaction projects are scheduled to start by 2020, and supply is expected to continue increasing in the upcoming years.

However, some changes in domestic regulations in Australia in recent years may affect gas supply. In August 2016, the government of the south-eastern state of Victoria announced a policy to indefinitely prohibit advanced shale gas drilling technology, such as hydraulic fracturing (fracking). The ban applies to onshore drilling but excludes offshore oilfields, with possibility of future restrictions on new developments. In July 2017, the Australian government announced it would implement the Australian Domestic Gas Security Mechanism (ADGSM), which can impose LNG export restrictions if there is an imminent domestic gas supply shortage. Only one project in eastern Australia has been affected by this mechanism, and the impact on the international gas market has been limited.

2-2 World LNG Supply

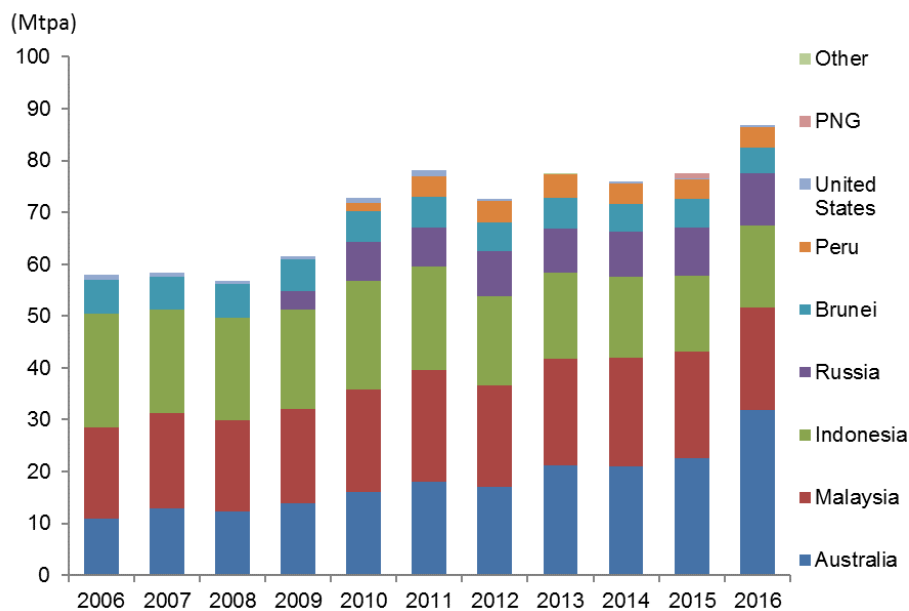
World LNG supply has increased by an average 5.6% per year over the past 10 years, increasing from 130 MTPA in 2006 to 224 MTPA in 2016. APEC's LNG supply is below the world's growth rate, increasing by an average 4.1% per year from 58 MTPA in 2006, to 87 MTPA in 2016. For both, the world and APEC, the LNG supply growth rate exceeds that of natural gas production, indicating that LNG transactions have become more active. APEC's LNG share of global LNG supply decreased from 44.6% in 2006, to 38.7% in 2016. However, APEC's share is expected to recover as Australia and the United States are expected to increase their LNG supply.

Australia and Russia are the fastest growing economies, as both alone increased supply by 31 MTPA from 2006 to 2016, accounting for the majority of APEC's growth in LNG supply. As mentioned, the fact that many liquefaction projects in Australia have come online has led to an increase in the supply of LNG.

LNG supply in Indonesia and Malaysia, traditional LNG suppliers, declined and remained flat, respectively. While LNG is an important export industry in both economies, domestic demand for natural gas has also increased in recent years. This has resulted in efforts to direct production to domestic markets. Moreover, some LNG import terminals have already started operation in both economies.

US LNG exports grew dramatically during 2016 from about less than one bcm up to around four bcm, driven mainly by shale gas production. These volumes are expected to continue increasing significantly and most probably going to the European and Asian markets.

Figure 2-3 APEC LNG supply, 2006-2016



Source: IEA, World Energy Balances 2017; Cedigaz, Natural Gas in the World

Table 2-2 APEC LNG exports, 2006-2016

Country	LNG Export (Mtpa)											
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
APEC Total	58	58	57	62	73	78	73	77	76	78	90	
Australia	11	13	12	14	16	18	17	21	21	23	32	
Brunei	7	6	7	6	6	6	6	6	5	6	5	
Canada	0	0	0	0	0	0	0	0	0	0	0	
Chile	0	0	0	0	0	0	0	0	0	0	0	
China	0	0	0	0	0	0	0	0	0	0	0	
Indonesia	22	20	20	19	21	20	17	17	15	15	16	
Japan	0	0	0	0	0	0	0	0	0	0	0	
Korea	0	0	0	0	0	0	0	0	0	0	0	
Malaysia	18	18	18	18	20	22	20	21	21	21	20	
Mexico	0	0	0	0	0	0	0	0	0	0	0	
New Zealand	0	0	0	0	0	0	0	0	0	0	0	
Papua New Guinea	0	0	0	0	0	0	0	0	0	1	0	
Peru	0	0	0	0	2	4	4	5	4	4	4	
Philippines	0	0	0	0	0	0	0	0	0	0	0	
Russia	0	0	0	4	8	8	9	9	9	9	10	
Singapore	0	0	0	0	0	0	0	0	0	0	0	
Taiwan	0	0	0	0	0	0	0	0	0	0	0	
Thailand	0	0	0	0	0	0	0	0	0	0	0	
United States	1	1	1	1	1	1	0	0	0	0	4	
Vietnam	0	0	0	0	0	0	0	0	0	0	0	
World Total	130	140	140	154	189	204	205	208	209	216	224	
APEC Share	44.6%	41.9%	40.6%	39.9%	38.5%	38.2%	35.4%	37.1%	36.2%	36.0%	40.3%	

Source: IEA, World Energy Balances 2017; Cedigaz, Natural Gas in the World

2-3 Future Outlook

The *APEC Energy Demand and Supply Outlook 6th Edition* forecasts global natural gas supply to grow from 2,976 Mtoe (3,116 Bcm) in 2015, to 4,550 Mtoe (4,764 Bcm) in 2040. APEC's gas supply will increase from 1,696 Mtoe (1,776 Bcm) to 2,620 Mtoe (2,743 Bcm) during the same period, an expansion of about 50%. Supply volumes are forecasted to grow in APEC member economies, especially in the United States, China, Australia and Russia by 746 Mtoe (781 Bcm) altogether from 2015 to 2040.

Table 2-3 APEC economies natural gas supply forecast, 2015-2030

Economy	National Gas Puroduction (Mtoe)				2015-2040	
	2015	2020	2030	2040	Change	Change %
APEC Total	1,696	2,015	2,392	2,620	923	54.4%
Australia	56	57	76	102	45	80.2%
Brunei	9	12	13	15	6	59.3%
Canada	139	155	170	171	32	23.1%
Chile	1	1	1	1	0	47.0%
China	113	216	330	347	234	208.0%
Hong Kong	0	0	0	0	0	-
Indonesia	65	69	63	63	-3	-4.4%
Japan	2	3	3	3	1	33.6%
Korea	0	0	0	0	0	48.1%
Malaysia	58	53	53	51	-7	-12.1%
Mexico	34	68	104	146	112	325.9%
New Zealand	4	4	4	4	-0	-7.2%
Papua New Guinea	2	7	7	7	5.4	277.7%
Peru	13	32	50	58	46	359.7%
Philippines	3	3	3	3	0	4.4%
Russia	524	556	599	629	105	20.1%
Singapore	0	0	0	0	0	-
Taiwan	0	0	0	0	-0	-1.7%
Thailand	26	17	12	12	-14	-54.5%
United States	636	749	886	998	362	56.8%
Vietnam	10	12	17	8	-1	-11.8%
World Total	2,976	3,181	3,847	4,550	1,574	52.9%
APEC Share	57.0%	63.3%	62.2%	57.6%	-	-

Source: APERC, *APEC Energy Demand and Supply Outlook 6th Edition*

In the United States, natural gas production is expected to grow, as numerous LNG projects are scheduled to start operations and the Trump administration favours reducing regulatory burden for the oil industry and shale gas production increases. In response to higher domestic consumption,

China is expected to increase its domestic natural gas production and both pipeline and LNG imports.

A key element for expanding Russia's gas supply is export pipelines construction. The Turk Stream pipeline construction, connecting Russia and Turkey, began in May 2017. Progress has been made on the Nord Stream II pipeline, expanding the capacity of the underwater connection between Russia and Germany, as a result of a financing agreement between Nord Stream 2 AG and five European energy companies (ENGIE, OMV, Shell, Uniper, and Wintershall) in April 2017. Furthermore, the 3,000 km-long Power of Siberia pipeline, linking Russia and China is also under construction and expected to be operational by 2019. The completion of these pipelines will significantly expand Russia's gas export capacity.

A non-APEC member economy to take particular notice of is Qatar, the world's largest LNG exporter. Since 2005, Qatar has had a moratorium, essentially a self-imposed restraint from any new development on its massive North Field. However, in April 2017 it lifted the moratorium and has increased production since then. State-owned oil company Qatar Petroleum announced that it would increase its LNG production from 77 MTPA to 100 MTPA by 2024. Qatar's aim appears to be to maintain its market share against Australia, the United States, Russia and other competitors.

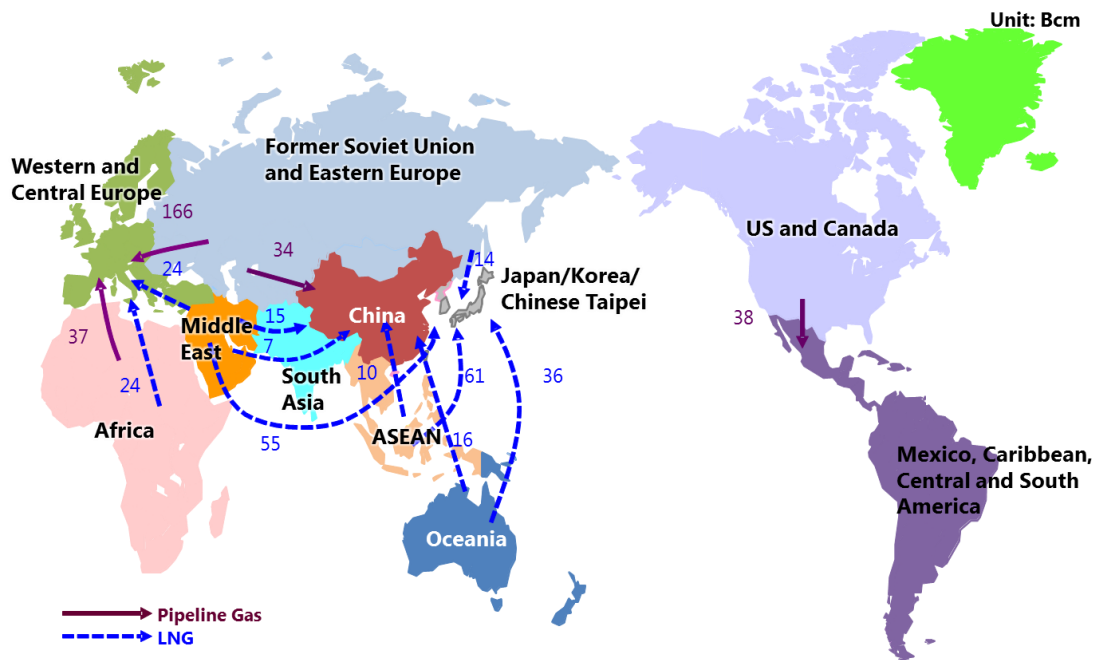
As mentioned, global natural gas supply is expected to increase in the short to medium term because of several LNG projects coming online and the construction of new pipelines. However, due to excess supply and the decline in Asian LNG prices in recent years, investment in the upstream sector has slowed down. There were virtually no final investment decisions (FID) made for new projects in 2016. In the medium term, global gas supply and demand will face a hard time with possible shortages and uncertainty if these trends continue.

Section 3. Gas Trade

According to the World Energy Balances 2017 by IEA, internationally traded gas volumes, as a whole, grew by 2.1% per year from 2006 to 2016, measured at the import end.² The share of LNG of total internationally traded gas increased during the same period from 23% in 2006 to 32% in 2016, because of a yearly 5.4% growth rate for LNG and a significantly slower growth of pipeline trade of 0.7% per year. This means that more gas is transported via LNG than it was 10 years ago, resulting in a stronger dependence between producers and consumers.

Among the 21 APEC members, 8 economies are net gas exporters, 10 are net importers and 3 do not trade gas. These economies are New Zealand, the Philippines, and Viet Nam; the latter two are expected to begin imports of LNG in the coming years.

Figure 3-1 Major natural gas trade flows, 2016



Source: IEEJ Outlook 2018

3-1 Gas Imports in the World and the APEC region

Natural gas imports in the world as a whole grew by 2.1% per year from 734 Mtoe (889 bcm), in 2006

² At the export end, the growth rate was 2.3% per year according to the same IEA statistics.

to 907 Mtoe (1,098 bcm) in 2016. During the same period, natural gas imports by APEC members increased by 4.1% per year, faster than the world average, from 259 Mtoe (313 bcm) to 386 Mtoe (467 bcm). As a result, APEC members' share of global natural gas imports increased from 35% 43% in the last decade.

During the same period, natural gas consumption grew by 2.6% per year in APEC member economies and by 2.2% per year in the world, respectively. The share on imports out of total gas consumption, which used to be lower for the APEC members at 20% than for the world as a whole at 30%. However, it crept up to 23% for the APEC members, while the share of the world as a whole stayed at the same level.

The APEC region, which includes some of the largest natural gas producers and used to be self-sufficient for their natural gas supply, has increased dependence on imports as they have increased natural gas consumption faster than the world average. However, total gas production in the region is still bigger than total consumption but some of these volumes are exported to other regions, mainly Europe. At the same time, some APEC members import LNG from non-APEC economies in the Middle East, Africa, South America, and Europe.

Table 3-1 APEC members' natural gas imports, 2016

	Bcm
Japan	95
United States	66
People's Republic of China	58
Korea	38
Mexico	34
Canada	16
Chinese Taipei	15
Thailand	12
Singapore	9
Russian Federation	7
Malaysia	6
Australia	6
Chile	4
Hong Kong (China)	3

*Unit: billion cubic meters. Calculated from the figures in Mtoe in the source.
Source: The World Energy Balances 2017, IEA*

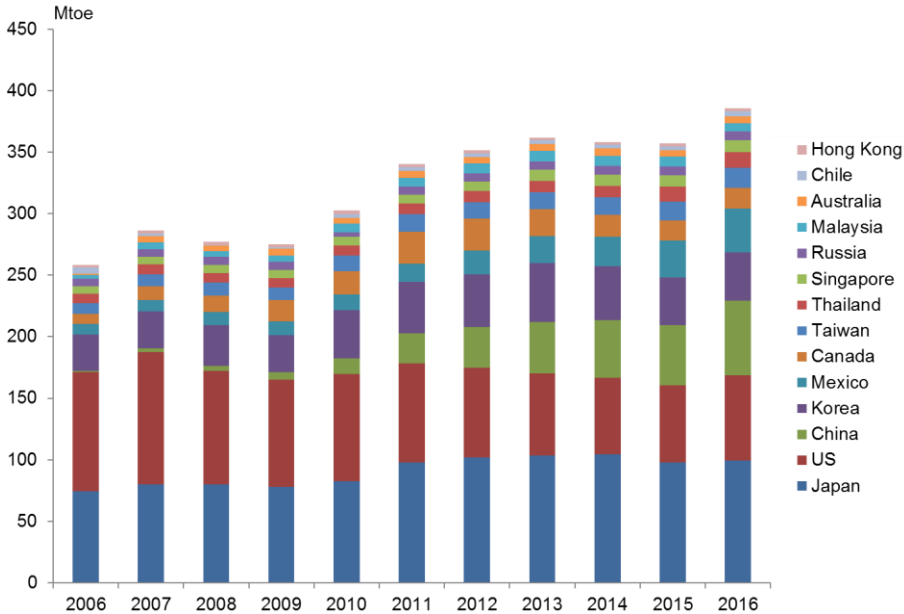
Japan is the largest LNG and natural gas importer in the world. Japanese LNG imports peaked in 2014 and decreased slightly in the last two years. From 2006 to 2016, Japan's natural gas imports increased by 34%, or 30 bcm, representing a 2.9% per year growth on average.

The United States, which is expected to be a major LNG exporter to the global market soon, is still a net gas importer. It is connected to its neighbours, Canada and Mexico, with extensive pipeline networks. Only in 2016, the US imported around 83 Bcm from Canada. However, US total gas imports (including LNG) shrunk by nearly 30%, or 34 Bcm, from 2006 to 2016.

China is rapidly emerging as one of the largest importers of natural gas in the world from its self-sufficient status in 2005. About 33% of natural gas consumed in China in 2016 came from imports. Canada is one of the largest producers of natural gas in the world, although still some volumes from the United States make their way into Canada, in exchange for even larger volumes coming from the north. Russia, the world's largest natural gas exporter, also imports small volumes of natural gas via pipeline. Malaysia, which exports significant volumes of LNG from the eastern state of Sarawak, offtakes gas from the joint development areas with Viet Nam and Thailand, as well as some LNG. Australia, which is expected to soon become the world's top LNG exporter, receives gas from the joint development area with Timor Leste, which in turn is converted into LNG for exports. In addition, there is a proposal to install an LNG receiving terminal in the state of Victoria. Hong-Kong, China receives natural gas from a China's offshore gas field via pipeline.

Among the 14 APEC members that import natural gas, only Japan, the United States, China, Korea, Mexico, and Chinese Taipei were LNG importers in 2006. By 2016, Canada, Thailand, Singapore, Malaysia, and Chile also developed LNG import terminals. While APEC LNG imports decreased during the period as a share of world LNG imports, LNG consumption in the APEC region grew from 13%, in 2006, to 17% in 2016.

Figure 3-2 APEC members' natural gas imports, 2006-2016



Sources: The World Energy Balances 2017, IEA

3-2 Gas Exports in the World and the APEC region

Exports of natural gas in the world grew by 2.3% per year from 730 Mtoe (884 bcm) in 2006, to 918 Mtoe (1,112 bcm) in 2016. During the same period, APEC members' gas exports increased slower than the world average by 1.9% per year, from 350 Mtoe (424 bcm) in 2006 to 421 Mtoe (509 bcm) in 2016. As a result, the share of APEC members in the global natural gas exports declined slightly from 48% in 2006, to 46% in 2016. During the same period, natural gas production grew by 2.0% per year in the APEC region and by 2.1% per year in the world, respectively. Gas exports as a share of total gas production did not change much in the APEC region, staying at 25%, while slightly increased globally from 30% to 31% from 2006 to 2016.

Table 3-2 APEC members' natural gas exports, 2016

	Bcm
Russian Federation	168
Canada	66
United States	51
Australia	39
Indonesia	28
Malaysia	26
Papua New Guinea	10
Brunei Darussalam	6
Peru	5
People's Republic of China	3
Chile	0.3
Mexico	0.02
Viet Nam	0

Note: Viet Nam ceased gas delivery from the joint development area with Malaysia in 2008.

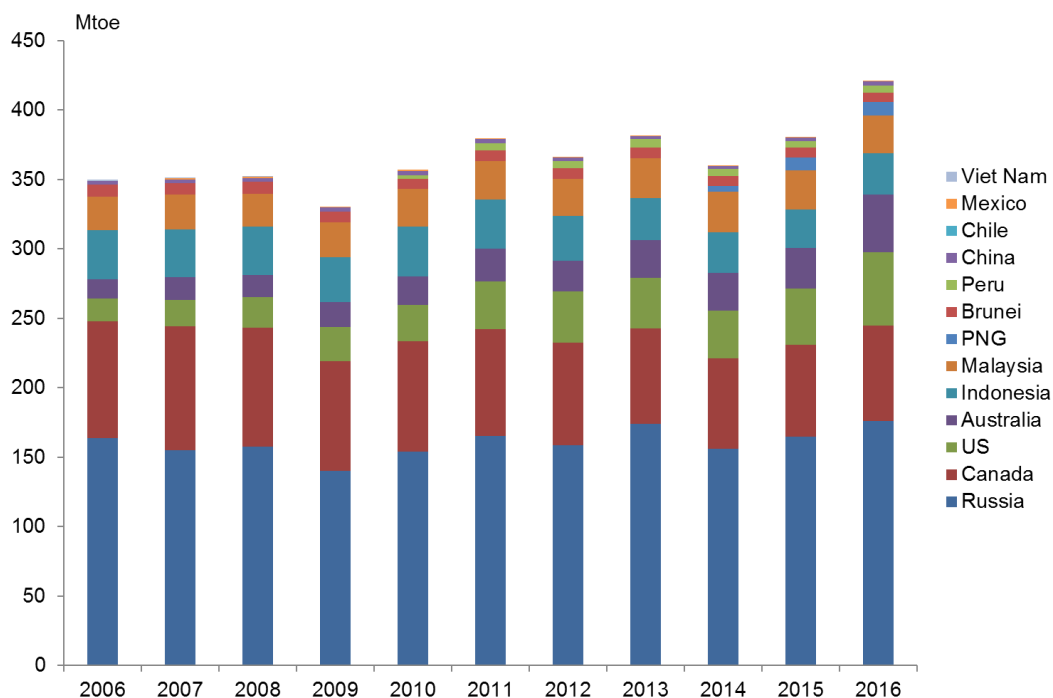
Unit: billion cubic meters. Calculated from the figures in Mtoe in the source.

Source: The World Energy Balances 2017, IEA

Russia has been the world's largest natural gas exporter for decades. In addition to major gas pipeline infrastructure connected to Europe and former Soviet Union countries, Russia added an LNG export terminal in the Pacific region in 2009. This APEC member also developed another LNG export plant in the Arctic region, Yamal LNG, which started operations in December 2017. Canada still exports massive volumes of natural gas to the United States via pipeline, but the exported volumes to its southern neighbour decreased by 18%, or 18 bcm, between 2006 and 2016. On the other hand, the United States more than tripled natural gas exports during the same period, including pipeline deliveries to Canada and Mexico, as well as LNG exports from the Gulf of Mexico.

Australia nearly tripled its LNG exports during the same period. Other traditional LNG exporters in the APEC region like Indonesia, Malaysia, and Brunei continued exporting similar gas volumes during the same period. During the last decade, Peru and Papua New Guinea emerged as new LNG exporters, mostly targeting to other APEC member markets. Chile re-exports to Argentina some of its regasified imported LNG. Mexico exports some gas volumes to the United States but imports are much larger than exports. Viet Nam ceased to deliver gas from the joint development area with Malaysia in 2009.

Figure 3-3 Natural gas exports by APEC members, 2006-2016



Source: The World Energy Balances 2017, IEA

3-3 Gas Trade outlook in the World and the APEC region

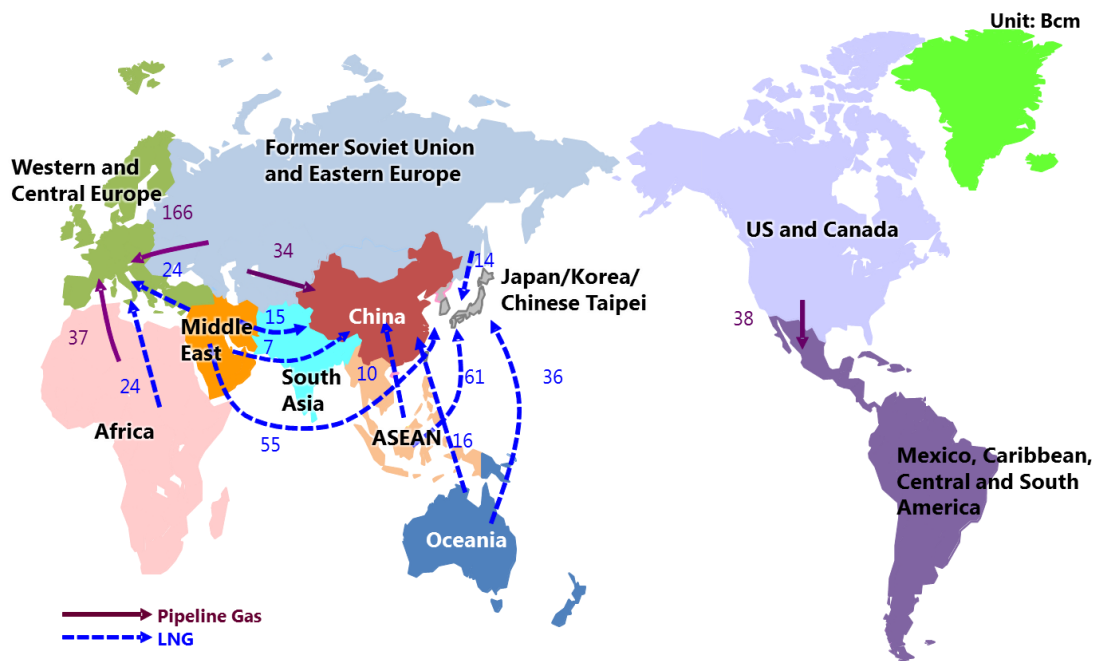
The United States, which used to be a significant LNG importer, has decreased LNG imports rapidly because of the rise in domestic gas production. Moreover, it is rapidly increasing its exports and is expected to become a net gas exporter. Canada also has increased its own gas production and has imported meaningful volumes of LNG since inaugurating its only LNG receiving terminal in 2009.

In 2016, Russia exported 17% of the world’s total gas exports via pipeline to Europe. While LNG trade used to be dominated by Southeast Asia exporters to Japan and Korea, the global LNG trade flows have been diversified in recent years along with increasing LNG production projects in places like Qatar and Australia. With the arrival of new LNG exporters like Peru, Papua New Guinea or Mozambique, trade patterns are also expected to be more diversified in the future.

Looking ahead toward 2030, the majority of natural gas exports are expected to come from Oceania and North America, where numerous LNG projects are planned to start operations between 2020 and 2025. As for absolute volumes of exports, Russia and the Former Soviet Union economies are expected to continue being the largest gas-exporting region. New pipeline projects to China and Europe and LNG export terminals, such as Yamal LNG, will further increase the region’s exports.

Beyond 2030, international natural gas trade growth is expected to slow down. Slower gas demand growth in OECD countries and increasing unconventional gas production in China and Latin America should reduce import requirements in those regions. North American LNG supply, considered one of the most important global LNG supply sources towards 2040, should represent a significant part of natural gas supply in the APEC region. As for pipeline gas trade, while Russian exports to Europe are expected to slow down along with stagnant demand in the region, global trade is expected to grow steadily. Besides, by 2040, some pipeline proposals, linking Central Asia to South Asia and the Middle East with South Asia, may eventually materialize.

Figure 3-4 Major natural gas trade flows (2030) Reference Scenario



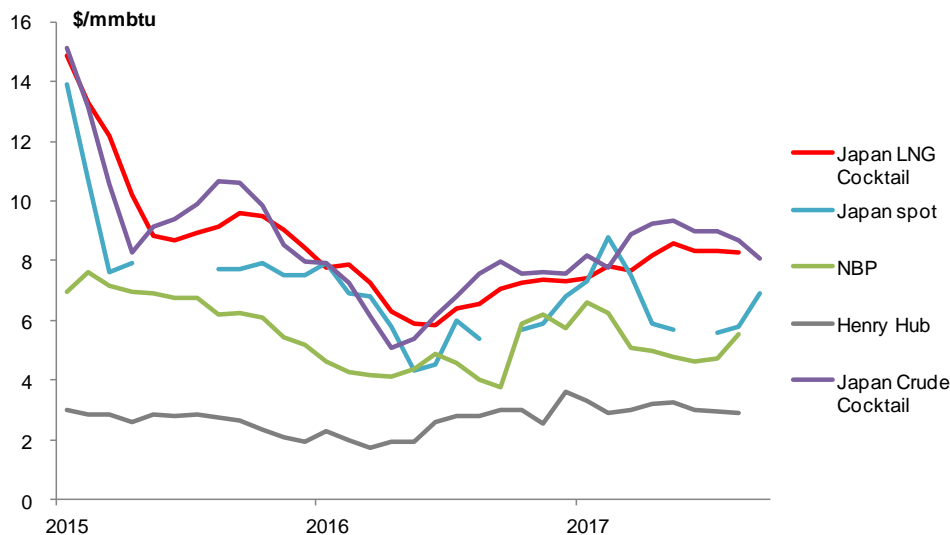
Source: IEEJ Outlook 2018

Section 4. Gas Prices

4-1 Change in Major Natural Gas Prices of the World

The world’s major natural gas price indexes in 2016 and 2017 can be said to be generally stable, although they have been showing an upward trend. The Japan LNG import price increased from around \$6/MMBtu to around \$8/MMBtu from 2016 to 2017. This reflected the moderate rise in international crude oil prices, which rose from \$30/bbl. to \$50/bbl. during the same period. Most of the LNG traded in the Asia-Pacific region is based on long-term contracts, and since the trading price of long-term contracts is still overwhelmingly linked to the price of crude oil, LNG prices in the Asia-Pacific region are strongly influenced by crude oil price trends.

Figure 4-1 Trends in major natural gas price indexes, 2015-2017



Sources: Ministry of Finance of Japan, Agency of Natural Resources of Energy of Japan, U.S. Energy Information Administration, Intercontinental Exchange

However, although traded volumes at spot prices are not necessarily large in the region, the Asian LNG spot price has lingered at a considerably low level compared with the average Japan LNG import price. This reflects the surplus in supply in the Asian LNG market in recent years. As a consequence, and the price difference between the average import price and the Japanese spot price has doubled from 2016 to 2017. As mentioned, LNG long-term contract prices in Asia mirror crude oil prices, and with its continued rise, LNG excess supply in the international market will persist, while spot prices are expected to remain comparatively low.

The Japanese spot price has been below the average import price since 2016 with the exception of the beginning of 2017. This was due to a supply disruption caused by a technical problem at a large LNG facility in Australia in the fourth quarter of 2016 and a decline in nuclear power generation in Korea. This increased demand for LNG, causing a temporarily soar to \$9/MMBtu in spot prices. Following that, the spot price fell back to \$5/MMBtu. As of December 2017, there are signs that the spot price will rise as winter sets in.

The NBP (National Balancing Point), the standard price in Europe, also showed a stable trend. From the fourth quarter of 2016 to the first quarter of 2017, the price exceeded \$6/MMBtu, but this was attributable to lower than normal winter temperatures. It was also affected by the shutdown of 18 nuclear power plants in France due to repairs. The European market, however, is receiving extensive exports from Russia that should cause the price to drop again and maintain a level around \$5/MMBtu, following the winter demand period.

The Henry Hub index, the standard price in the United States, has remained at around the \$3/MMBtu level for the past five years, influenced mainly by the shale revolution. During 2016, the Henry Hub maintained its equilibrium as production remained at almost 820 Bcm/year despite a lower number of rigs in operation. Although US LNG exports in the Gulf Coast began in 2016, there has been no evidence of LNG exports affecting domestic price levels. Despite the fact, that the United States was ravaged by a series of hurricanes in September 2017, prices were not impacted significantly.

4-2 Future Outlook

In the most possible scenario, major natural gas indexes will continue the current trends. Nevertheless, there will be an upward trend in LNG prices in Asia as long-term contracts for crude oil prices are expected to gradually rise in the future. However, given the current relaxed supply and demand, there is a possibility that LNG prices in Asia do not follow crude oil prices because importing companies will want to renew contracts at lower prices, and some companies will opt for short-term lower prices or spot contracts. Although LNG demand is growing in recent years, pushed by China and emerging economies in South Asia and Southeast Asia, it is certain that LNG markets will continue to be oversupplied in the near future, as new LNG projects will begin operations. Because of this, the Asian LNG spot price is forecasted to stay at or below \$6/MMBtu, and the price difference with the long-term contract price will further increase.

Natural gas prices in Europe have a mixed future. In the short run, prices will have a downward tendency because of slow demand growth and intensified competition from exporters for both piped gas and LNG, especially from Russia, the United States, Africa and the Middle East. In particular, LNG production capacity in the United States will significantly expand between 2018 and 2019, with most

of it likely flowing to Europe. On the other hand, with Russia long being aggressive in its sales strategy for the European market, competition between Russian and American exports will likely be fierce. In the mid-term, however, the North Sea's production decline and demand for power generation will pressure natural gas prices in Europe, and they will recover to the level of \$7/MMBtu at around 2020.

Finally, the natural gas price in the United States is expected to be somewhat lower in the near future. Since the Henry Hub is already at a very low level, around \$3/MMBtu, compared with other regions, the decline will be limited only to a very small scale. The number of rigs for gas development in the United States fell to less than 80 on summer of 2017 but began to increase later and reached a total of 180 as of October 2017. Since the number of rigs is an indicator of production volume, it is possible that natural gas production in the United States further increases in the future. On the other hand, the recovery of the oil price might raise development and production costs because it boosts upstream activities and has traditionally raised equipment and personnel costs. The start of LNG exports in the US Gulf Coast may also add upward pressure on the domestic price level. Based on these factors, the price in the United States will slightly increase from the current \$3/MMBtu level, but remaining below \$4/MMBtu in the mid-term.

Section 5. Case study: US gas exports to Mexico and Mexico's gas market reform

Almost a decade has passed since North American natural gas markets were drastically transformed by the so-called "US shale revolution". The increased shale gas production has boosted US exports, in spite of a domestic consumption increase over the last 10 years. The main destination of US gas exports is Mexico, which in 2013 started an ambitious energy reform plan to transition from vertically integrated monopolies run by state-owned companies (Pemex and CFE) to a free market.

Mexico's natural gas market is in its infancy but has a promising future with a growing demand driven by an oil-to-gas fuel switch in power generation. US exports to Mexico totalled 40 bcm in 2016 and they are expected to continue growing. While the nascent Mexican market faces challenges, the combination of the shale revolution and ambitious reforms have created a promising future for gas.

5.-1 Shale Revolution, gas from the US to the World.

The shale revolution was, in essence, a combination of technological advancements, land property arrangements, policies by local governments and other factors that lead to dramatic reductions in production costs, which made commercially profitable the production of unconventional gas in the United States. Natural gas production in the United States rose from around 520 billion cubic meters (bcm) in 2006 to 755 bcm in 2016, becoming the biggest natural gas producer, surpassing Russia in 2009.³ In 2016, shale and tight production accounted for 60% of total production⁴.

The Northamerican Henry Hub Index reached 14 USD per Million British Thermal Units (MMBTU) in 2005, more expensive than any other region. In contrast, prices averaged 4.62 USD/MMBTU from 2006 to 2016 and even went as low as 1.49 USD/MMBTU in 2016.⁵ Such a major transformation in the United States has surpassed borders and continents, influencing gas markets in Europe and Asia. The two most frequently cited markers for the European and Asian markets, the UK Net Balancing Point (NBP) and the Japanese Korea Marker (JKMTM), have been going down every year since 2014.⁶ However, the surge of US shale gas has been only one of the several factors in each market's complex dynamics.

³ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm>

⁴ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/tools/faqs/faq.php?id=907&t=8>

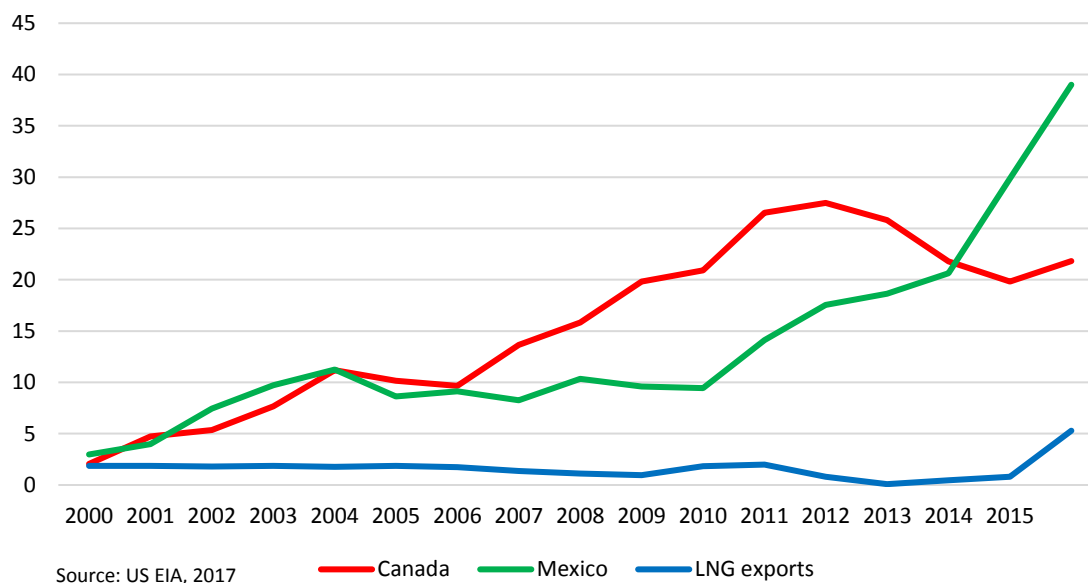
⁵ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/dnav/ng/hist/rngwhhdD.htm>

⁶ BP Global, Natural gas prices, Retrieved from: <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/natural-gas/natural-gas-prices.html>

The increased shale gas production has transformed gas trade in the US, in spite of a domestic consumption increase over the last 10 years. In 2006, the US imported around 120 bcm and exported only 20 bcm.⁷ In contrast, the US exported 66 bcm in 2016 and is expected to become a gas net exporter by the end of 2017.⁸ Moreover, since 2013, US Liquefied Natural Gas (LNG) exports have been growing almost exponentially. In fact, the US and Australia are leading the liquefaction capacity expansion globally, with 107 and 118 bcm to be operational by 2022, respectively. US liquefaction capacity will be larger than that of Qatar and only second to Australia.⁹ However, the main destination of US gas exports is not Asia, Europe or other LNG markets, but rather its southern neighbour, Mexico.

The US and Mexico share more than 3,100 kilometres of continental border, with bilateral trade accounting for around 1.4 billion USD every day.¹⁰ Mexico and the US have daily gas exchanges in both directions in some of the 17 pipelines that crossed the border at the end of 2016. Almost every unconventional gas play in the Permian and Eagle Ford basins are closer to major consumption centres located in Mexico than in any other US state outside of Texas. When taking some of these factors into consideration, it is unsurprising that American gas producers are eager to sell their low-cost shale gas to their southern neighbours, who demands it anxiously. US gas exports have been growing since 2006, but the fastest growing and largest destination is Mexico with around 40 bcm in 2016.

Figure 5-1, Total US gas exports (2000-2016, bcm)



⁷ U.S. Energy Information Administration, (2017, December 16). Retrieved from: https://www.eia.gov/dnav/ng/ng_move_expc_s1_m.htm

⁸ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/todayinenergy/detail.php?id=32412>

⁹ International Energy Agency, *Gas 2017: Analysis and Forecasts to 2022*, Market Report Series, 2017.

¹⁰ US Department of State, US Relations with Mexico, (2017, December 16). Retrieved from: <https://www.state.gov/r/pa/ei/bgn/35749.htm>

5.-2 Mexico's rapid growing demand facing challenges

If the global energy sector has changed substantially when compared with what it looked like 10 years ago, the energy sector in Mexico has been deeply transformed, especially after the 2013 Energy Reform. In 2000, Mexico's primary energy demand was around 150 million tons of oil equivalent (Mtoe), of which oil represented almost 60%, followed by gas with only 24%. In 2015, primary energy demand increased to 188 Mtoe, and the share of natural gas rose up to 34%.¹¹ The main driver of this oil-to-gas shift in energy consumption was power generation. This was the result of several factors including policies, geopolitical events and energy industry developments. However, three main events seem to have been the most influential: high international oil price above 100 US Dollars per barrel (USD/b) in the late 2000's, the shale revolution in the US and the 2011 policy on oil-to-gas shift,¹² and the 2013 Energy Reform.

By 2002, Mexico's power generation used predominantly fossil fuels, with oil as the main fuel accounting for 47% and gas for 25%.¹³ At this time, the West Texas Intermediate price averaged 26 USD/b while the Henry Hub was 3.38 USD/MBTU. Additionally, Mexico's whole power value chain from generation to commercialisation was an effective monopoly run by the state-owned utility *Comisión Federal de Electricidad* (CFE). When oil prices started to rise and become more volatile in 2002, the Mexican government decided to speed up fuel diversification for power generation. By the end of 2007, CFE had almost doubled its gas-fired power generation capacity versus 2002 levels and effective generation had switched with gas accounting for 45% and oil for 28%, as shown in figure 5-2¹⁴. While oil prices reached almost 100 USD/b and Henry Hub was at around 7 USD/MBTU in 2007, the US gas industry had its largest annual production since 1980.

This switch from oil to natural gas drastically changed the gas balance in Mexico. In 1999, Mexico's demand was around 36 bcm, while production was at similar levels and net imports were close to zero.¹⁵ Natural gas demand grew since 2000 by an annual average rate of 5%, reaching almost 80 bcm in 2016.

¹¹ Asia Pacific Economic Cooperation Energy Working Group, *APEC Energy Statistics 2015*, page 84.

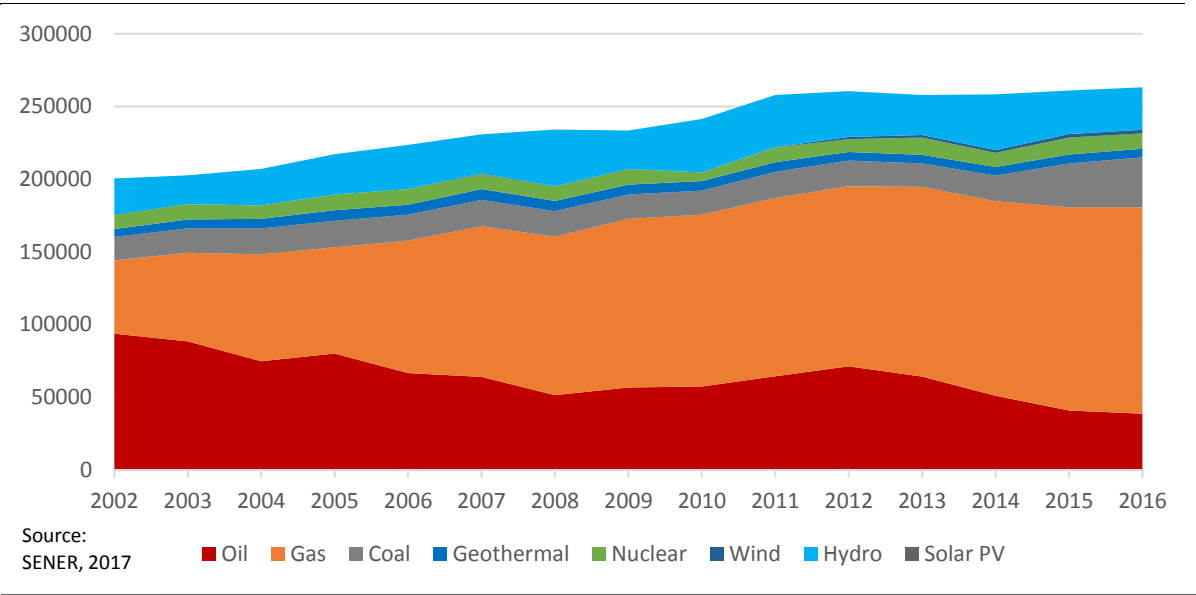
¹² Presidencia de la Republica, *Cambio Estructural en el Mercado de Gas Natural en México*, Blog de la Presidencia, November 2011, (2017, December 16). Retrieved from: <http://calderon.presidencia.gob.mx/el-blog/cambio-estructural-en-el-mercado-de-gas-natural-en-mexico/>

¹³ Secretaría de Energía, Sistema de Información Energética, (2017, December 16). Retrieved from: <http://sie.energia.gob.mx/bdiController.do?action=temas>

¹⁴ *Ibidem*.

¹⁵ *Ibidem*.

Figure 5-2, Mexico's Power Generation Fuel Mix (2002-2016, Gwh)



However, domestic gas production has been unable to keep up with growing demand. In fact, since 2010, production has been decreasing each year, plummeting from 52 bcm in that year to around 36 bcm in 2016.¹⁶ At least three factors help to explain the massive fall in Mexico's gas production: the pre-reform sector's monopolistic structure, the fact that around 70% of the production is associated gas, and the maturity of Mexico's largest fields.

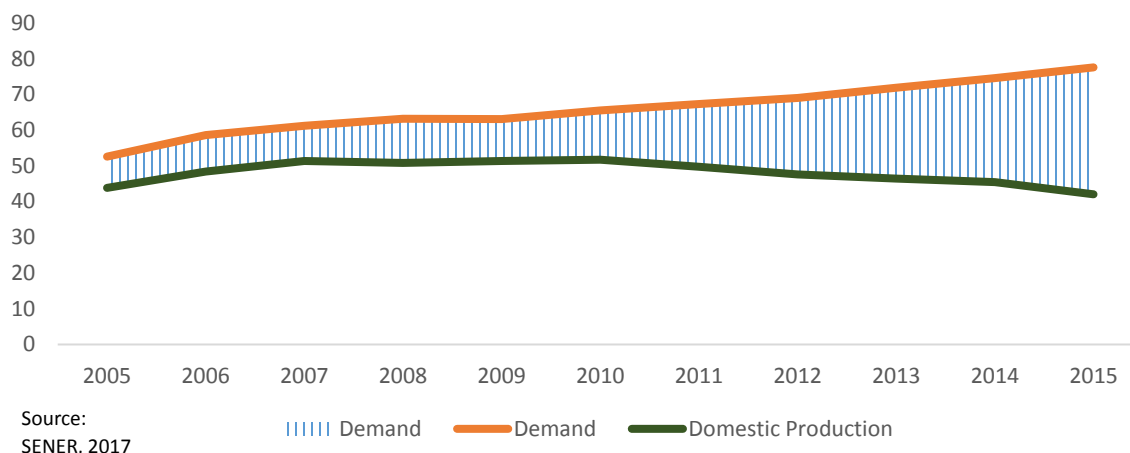
In a similar fashion to the power sector, before 2013, only state-owned *Petróleos Mexicanos* (Pemex) was allowed to participate in the whole oil and gas value chain. Considering that Mexico is a net crude oil exporter, the high international oil prices in the 2000's, the high efficiency of US producers and the financial burdens and limits on investment by Pemex, it was perhaps not surprising that Pemex decided to prioritise oil production over gas. At the time, whatever Pemex could not or did not want to produce, was simply not produced. Moreover, if gas production was not a priority when oil prices were high, Pemex budgets for gas exploration and production went to historical minimums when international oil prices collapsed in 2014.

With demand rising as production fell, Mexico was forced to cover this increasing gap with imports. The only available option in the early 2000's was piped imports from the US. From 1999 to 2004, US gas exports to Mexico grew from 1.7 to 11 bcm. US exports to Mexico remained stable until 2010, when Mexico's gas production peaked and started decreasing. With domestic production plummeting and with inexpensive and competitive shale gas flowing from the US, imports to Mexico started growing almost exponentially, from around 11 bcm, in that year, to 40 bcm in 2016; reaching a new

¹⁶ Secretaría de Energía, *Prospectiva de Gas Natural 2016-2030*, Mexico, 2016 (2017, December 16). Retrieved from: https://www.gob.mx/cms/uploads/attachment/file/177624/Prospectiva_de_Gas_Natural_2016-2030.pdf

historical record every year.¹⁷With increasing import needs and relying only on the US, Mexico built three regasification terminals: Altamira, on the Gulf Coast, and Ensenada and Manzanillo in the Pacific Coast. Liquefied Natural Gas (LNG) imports have averaged six bcm since 2012¹⁸, which a decreasing share of 12% of the total in 2016.

Figure 5-3, Mexico's Gas Demand and Supply (2005-2015, bcm)



Prior to 2013, the oil and gas industry was almost completely monopolised by Pemex. The state-owned company owned virtually all midstream infrastructure and controlled the totality of domestic gas production and the majority of gas imports. The government-controlled gas prices and there were no incentives for major private-sector infrastructure investments, with a handful of exceptions. Consequently, Mexico's gas pipeline network did not have a proportional infrastructure expansion to the massive increase in gas volumes being transported each day. As a result, the Mexican gas pipeline network faced severe saturation, getting to a critical level between 2012 and 2013. During these years, despite hitting record high imports from the US, gas shortages and increased prices for power generation and industrial users were frequent.

In 2011, the Ministry of Energy announced the construction of more than 4,400 km of gas pipeline; which represented a 40% increase of the gas pipeline network.¹⁹These pipelines had an innovative in which Pemex or CFE would assure gas demand, 'anchoring' the viability of these projects in partnership with private investors. The underlying idea was to further increase US imports to continue subsisting oil consumption with gas. These pipelines would also provide redundancy to the network and take gas to regions without previous access to it. This was the start of an aggressive gas midstream infrastructure expansion that is still underway. However, the 2012-2013 gas crisis proved that the government's response was late.

¹⁷ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/dnav/ng/hist/rngwhhdD.htm>

¹⁸ Secretaría de Energía, Sistema de Información Energética, (2017, December 16). Retrieved from: <http://sie.energia.gob.mx/bdiController.do?action=temas>

¹⁹ Presidencia de la Republica, *Op. cit.*

5.-3 Mexico's energy reform and the birth of a gas market

In late 2013, the Energy Reform triggered a massive transformation not only in the gas industry but also in the whole Mexican energy sector. The so-called *Reforma Energetica* was a constitutional amendment that ended the monopoly of both Pemex and CFE, and promoted competition by allowing the participation of private companies. The most evident consequence was that companies other than Pemex would be allowed to have contracts for hydrocarbon exploration and production. Nevertheless, it also meant private companies participating in the mid- and downstream sectors, competition in the power generation sector, and the creation of a power market, which included green certificates, among several other measures. At the very heart of the reform was the challenge to undertake a metamorphosis of both Pemex and CFE, from vertically integrated monopolies to unbundled companies facing competition from private companies and government regulation.

The Mexican government started tendering oil and gas contracts in 2015; 24 companies other than Pemex have been awarded contracts for exploration and production of gas.²⁰ Some of them have already started production. However, even in the most optimistic forecasts of the Mexican Ministry of Energy, gas production is expected to continue decaying and then have a steady growth, just to peak at 2016 levels by 2027. This includes the development of shale resources, of which Mexico has the six largest reserves in the world.²¹ Whichever the scenario, domestic supply will not be able to cover rising gas demand.

As part of the new regulations, Mexico's Energy Regulatory Commission (CRE) forbade gas companies to be marketers and transporters at the same time. Consequently, in 2015, Pemex transferred more than 10,000 kilometres of gas pipelines, which represented around 90% of Mexico's gas pipeline network.²² These assets were transferred to CENAGAS (*Centro Nacional de Control de Gas Natural*), a public independent operator established in 2014, responsible for managing the gas transport and storage network. In May 2017, CENAGAS undertook its first open season, in which 55% of gas volumes were assigned to marketers other than Pemex.²³

Since 2011, 25 new gas pipelines have been launched in Mexican territory and 6 in the US, accounting for an investment of around 12 billion USD and more than 8,500 kilometres. By July 2017, 19 new pipelines were already operational, while 12 are still under construction. This meant also the addition

²⁰ Comisión Reguladora de Energía (CRE), *Avances en la Apertura del Mercado de Gas Natural*, presentation by Commission's Chairman, (2017, December 16).

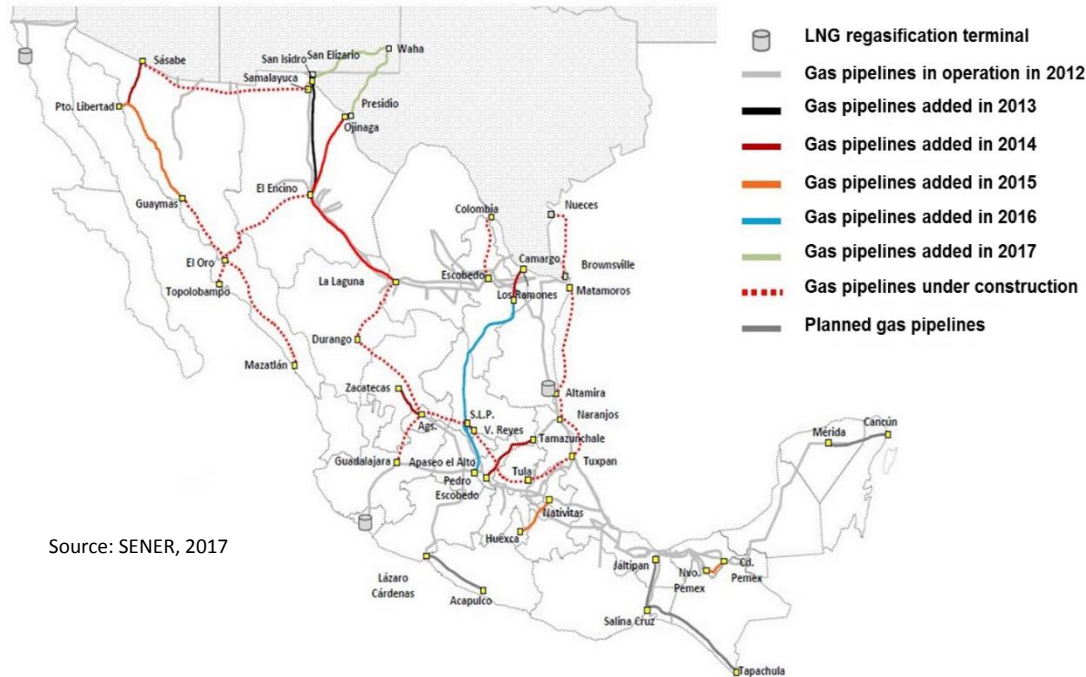
²¹ EIA (US Energy Information Administration) (2013), *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*,

²² Petróleos Mexicanos, *Informe Anual 2011, 2012*, (2017, December 16). Retrieved from: http://www.pemex.com/acerca/informes_publicaciones/Documents/informes_art70/Informe_anual_2011_art70.pdf

²³ Comisión Reguladora de Energía, *Op. cit.*

of seven interconnections with the US, increasing import capacity by 81 bcm per year (bcm/y).²⁴ Mexico’s total gas import capacity is expected to be around 114 bcm/y by 2019.²⁵

Figure 5-4, Mexico’s gas transport network and its additions since 2012



Source: SENER, 2017

For the downstream gas industry, the task is huge, the creation of a competitive gas market where Pemex reigned for almost 80 years. In February 2017, the CRE mandated Pemex to transfer 70% of the gas volume it used to market. Therefore, clients could choose to find another gas provider or stay with Pemex. As of September 2017, Pemex had transferred already 32% of these contracts. This was just one of a series of asymmetrical regulatory measures approved by the CRE to bolster competition in the sector.

Another measure undertaken by the CRE was the abolition of the “first-hand” fee (*Venta de Primera Mano* or VPM). VPM was a price control on the first sale of natural gas that Pemex made to a third party for delivery in Mexican territory. The elimination of VPM allows suppliers other than PEMEX to offer gas volumes on a free-market basis.²⁶ The goal of the CRE and CENAGAS is to create a natural gas market with competitive prices and to take natural gas to new regions. While power generators and industry represent the bulk of natural gas demand, consumption in the residential and transportation sectors has also grown in recent years.

²⁴ Data from Mexico’s CRE and the IEA, APERC analysis.
²⁵ Sener, *Estatus de gasoductos 2017*, 2017
²⁶ U.S. Energy Information Administration, (2017, December 16). Retrieved from: <https://www.eia.gov/naturalgas/weekly/?scr=email#tabs-prices-1>

Consequently, with demand expected to grow by 2.6% annually up to 92 BCM by 2023 and domestic production expected to peak around 40 BCM, Mexico's gas imports will continue growing and US shale piped exports are, by far, the most competitive option.²⁷ Mexico's Ministry of Energy expects gas imports to increase to 56 BCM by 2021, which is 50% more than 2015 levels.²⁸ Mexico's only other alternative to US imports is LNG, which is in most cases more expensive than piped imports. However, Mexico is also importing LNG from the US; in 2016, represented 10% of Mexico's total LNG imports.

In 2016, US gas exports totalled 66 bcm, 60% of them directed to Mexico. US gas exports to Mexico are expected to be between 40 and 56 BCM every year, at least, until 2030.²⁹ While 40 BCM corresponds to only 1% of global gas production, it represents 4% of global gas trade.³⁰ US gas exports to Mexico in 2016 were larger than all piped gas imported by China; they were also equivalent to Indonesia's total gas demand or Nigeria's whole gas production. When compared with LNG market volumes, US gas exports to Mexico are almost as big as 2016 Korean LNG imports or Algerian total LNG exports.³¹ The IEA expects the US to export around 80 BCM in the LNG markets by 2022.³² However, volatile oil prices, geopolitical instability and the expected oversupply in the LNG markets will be tough challenges for US producers and LNG exporters. It is not unreasonable to expect that if LNG market conditions are not favourable, some US gas producers might prefer exporting more piped gas to Mexico than venturing into LNG.

Mexico's nascent gas market has a promising future for US gas producers and exporters, power companies, industry, and consumers in general. Mexico's oil-to-gas power switch has driven a fast growth in gas demand, by around 70% in the last decade. With declining domestic production, US gas imports have more than quadrupled in less than 10 years. However, the transition from a state-owned monopolistic scheme to the creation of a competitive gas market is full of challenges. While the infant gas market takes its first steps in the right direction, the path seems to be steep and paved of obstacles.

Probably one of the most challenging issues is the delays in the construction of the new pipelines that are supposed to take imported gas to consumption centres in Mexico. At least six projects have delayed commercial operation for more than a year, because of rights-of-way disputes or social protests. One example is the 550-kilometre long El Encino-Topolobampo gas pipeline, built by TransCanada and planned to come to stream in July 2016. The project faced opposition from indigenous communities and subsequent suspensions from judicial injunctions. While three other

²⁷ Secretaría de Energía, *op. cit.* 2016

²⁸ *Ibidem.*

²⁹ U.S. Energy Information Administration, *US gas exports*, 2018.

³⁰ International Energy Agency, *Op. cit.*

³¹ *Ibidem.*

³² *Ibidem.*

connecting pipelines are already operational, unconventional gas from the Permian basin will not be able to flow to four power plants on the Pacific coast of Mexico until the key El Encino-Topolobampo pipeline is completed.

Other issues such as effective regulation, price indexation controversies, lack of storage capacity, an increased dependency from US gas market, competition from low-priced renewable power generation and, even, the Trump administration's characteristic unpredictability have raised concerns from several stakeholders in both, Mexico and the US. However, the extremely competitive US shale gas production and Mexico's gas market reform are promising signs for strengthening and increasing this bilateral market, one of the biggest in the world.

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