Gas Market Report 2019

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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 backed by increasing consumption by emerging economies such as China. The fact that natural gas produces less pollutant emissions than other fossil fuels, amid growing concerns about climate change and de-carbonisation, has reflected positively on gas consumption. Controlling air pollution in fact provides additional momentum for natural gas demand in APEC. As LNG exports from the United States grow, the shale revolution is affecting the gas sector well beyond the border of North America, and this trend is projected to continue.

The release of this second 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 a series of APERC Market Reports, along with the Coal Market Report 2019 and Oil Market Report 2019. 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.

Kazutomo IRIE

President

Asia Pacific Energy Research Centre (APERC)

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Abbreviation and acronyms

Abbreviation

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

Acronyms

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
EIA	Energy Information Administration, USA
EU	European Union
IEA	International Energy Agency
IEEJ	Institute of Energy Economics Japan
NBS	National Bureau of Statistics, China
UN Comtrade	United Nations Commodity Trade Statistics Database

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Executive summary

World natural gas demand has grown annually by 2.0% on average in the past 10 years, while gas demand in the APEC region increased faster, by 2.5% annually. In 2017, about 57% of global gas consumption took place in the APEC region, more than 10 years ago when this share reached 54% in 2007. Moreover, gas accounted for at least 10% of TPES in all APEC economies, except in three (Chile, China and Philippines).

In 2017, the US was the main gas consumer in the world, followed by Russia, which has had an overall sluggish demand growth over the past decade. In the last decade, US gas consumption grew by 29% (148 Mtoe or 172 bcm) while China increased by 264% (124 Mtoe or 144 bcm). They are the largest contributors to the APEC region demand growth. While Australia, Russia and Canada also increased domestic demand from 2012 to 2017, Korea and Japan had an overall decrease in their gas demand in the same period. Overall, electricity remains the main growth driver in the APEC region, but industry also increased rapidly. This contrasts with global gas demand growth, where industrial demand accounted for the largest growth sector.

APEC gas production increased 26% in the last decade, while its share remained stable at around 57% of world's production. The US surpassed Russia in 2012 as the world's largest producer. Moreover, APEC members not only account for most of global gas demand but also three of the world's four largest gas producers are APEC members (US, Russia and Canada). During the last decade, the US, Russia, China and Australia were the largest contributors to APEC production growth. Conversely, Mexico's production shrank by 40% (20 bcm) in the same period, the largest production decline of the 21 APEC member economies.

In terms of natural gas trade, APEC remains a net exporter region, mostly driven by Russian piped exports to Europe. However, only 25% of gas production in APEC economies is exported outside the APEC region. Most APEC members have active gas trade with the exception of Viet Nam, Philippines and New Zealand. Additionally, Russia remains the world's largest gas exporter. Nevertheless, the US more than tripled its natural gas exports including pipeline deliveries and LNG exports from 2007 and 2017. At the same time, Canada exported 88 bcm to the US in 2017, 20% lower than in 2007. APEC gas imports represented 42% of world imports. Japan was the largest natural gas and LNG importer in the world in 2017. However, China was the fastest growing importer in the world, with LNG accounting for 57% of its gas imports. While US imports decreased, it still was the third largest gas importer in APEC in 2017, mainly from Canadian piped gas.

While, globally most natural gas is still traded via pipeline, LNG trade has grown quite fast, and the APEC region is at the very core of this trend. From 2007-17, APEC LNG exports grew annually by 6.7% while world LNG exports grew by 6.0%. Australian LNG exports more than tripled in 10 years, leading growth both in the APEC region and globally. In addition, US LNG exports more than quadrupled

compared with 2016, as most of the first wave of liquefaction projects on the Gulf Coast were operational in 2017. On the other hand, traditional LNG exporters like Malaysia were stagnant while Indonesian exports have been decreasing. At the same time, LNG imports to APEC represented 72% of global imports, with 14 members importing LNG. Japan remains the largest LNG importer, despite falling demand since 2014. China became the second world's largest importer in 2017 with an impressive 47 bcm growth from 2007-17. Unsurprisingly, US LNG imports shrank by 18 bcm since 2007, following increased domestic production. Finally, Korean LNG imports grew for the first time since 2013, but uncertainty remains about its nuclear and coal-fired power generation policy and its impact on LNG imports.

According to the results of the APEC Energy Demand and Supply Outlook 7th Edition, APEC gas demand increases by an average 1.8% to 2 200 bcm by 2021. This growth is driven by increasing demand in all APEC economies, with only the exception of New Zealand and Japan. On the other hand, demand growth continues to be driven mainly by the US and China. On the supply side, APEC gas production increases to around 2 300 bcm by 2021. Combined production in United States, Russia, China and Australia increases by more than 267 bcm by 2021. Conversely, gas production in Mexico, Indonesia and Thailand decreases steadily by 2021. In terms of trade, both piped and LNG imports to China almost double by 2021, while North-east Asia and South-east Asia see growth in their gas imports, predominantly via LNG. US natural gas exports more than double from 2017 to 2021, with most growth in exported via LNG but also steady growth in piped exports to Mexico. Russian gas exports also increase robustly with volumes to Europe similar to the ones seen in the past five years and incremental exports going towards China, once the Power of Siberia pipeline is commissioned.

In conclusion, with 57% of global gas consumption and production, APEC members are at the centre of global natural gas dynamics. China and the US are driving gas demand growth. While the shale revolution has substantially changed gas demand in the US, the impact of US LNG exports is still relatively limited compared with its potential. China gas demand will keep growing to become the world's largest gas importer and later the biggest LNG importer in the next five years. After sluggish developments of new LNG projects in recent years, linked to low LNG prices in Asia, the supply and demand balance could become tight in the early 2020s as demand in China and Southeast Asia continues to grow. As a result, three dynamics demand special attention in the next years: Russian piped and LNG exports to China; China's actions on increasing domestic pipeline infrastructure, further regasification and storage capacity as well as pricing mechanisms; and US LNG exports and their competitiveness in global markets, particularly in Northeast Asia and China versus Europe.

Section 1. Natural gas updates in APEC economies

Economy	Topic
Australia	• Start-ups of new liquefaction capacities in Ichthys (November 2018) and Prelude (December 2018) increased the liquefaction capacity of Australia by 86.6 Mtpa.
Brunei Darussalam	• Construction of demonstration plant to produce hydrogen natural gas will be built at Sungai Liang Industrial Park (SPARK), Brunei. The plant will start operation from the end of 2019. The project is promoted by a consortium of Japanese companies
Canada	• Supply growth in new areas, insufficient infrastructure and declining demand from the US, have put Canadian natural gas prices at a heavy discount to Henry Hub prices. • In response to these developments, Canada has strived to attract investment in liquefaction facilities to export LNG to other markets. • LNG Canada and Woodfibre LNG have announced positive final investment decisions to build new-build LNG export facilities on Canada's west coast.
Chile	• Chile resumed natural gas piped imports from Argentina after more than 10 years, as a result of increasing Argentinean production from the Vaca Muerta field.
China	• As an effort to manage seasonal demand fluctuation, CNPC plans to increase its total working capacity of natural gas storage to 15 bcm by 2025, meeting 10% of the peak seasonal demand. CNPC plans to add seven new storage sites, as well as to drill more wells and add compression stations at the existing sites.
Indonesia	• Pertamina cancelled a planned LNG receiving terminal for 4 Mtpa in Bojonegara, near Jakarta in July 2018 because of the relative economics of LNG against coal.
Japan	• Natural gas consumption decreased slightly after 2015, because of the restarting of some nuclear power plants, as well as the decline in overall primary energy consumption. Uncertainty arises in forecasting gas demand as the government pushes to restart more nuclear power plants and adopt renewable energies.
Korea	• Korea expects its natural gas demand will rise to 40 million tonnes of LNG per annum in 2031, as Korea shifts away from coal and nuclear. It had previously forecast natural gas demand falling to 34.65 million tonnes.
Malaysia	• Malaysia's Petronas filed an application before the Federal Court seeking a declaration that the Petroleum Development Act 1974 is the law applicable for the petroleum industry in Malaysia, and that Petronas is the exclusive owner of the petroleum resources as well as regulator for the upstream industry throughout Malaysia including Sarawak.
Mexico	• Gas piped imports from the US have more than quadrupled since 2005, reaching almost 40 bcm in 2017. This trend seems likely to continue as the

	gap between decreasing domestic production and growing demand has widened in the past decade, mainly driven by power generation.
New Zealand	• The New Zealand government announced in April 2018, that it will not allow any new drilling for oil and gas development as a part of climate change actions. The existing permissions are for a maximum 40-year operation.
Papua New Guinea	• PNG LNG interrupted its operational in March because of an earthquake but restarted the operation in April 2018.
Peru	• Peru LNG also interrupted its operations in March 2018 because of a land slide that affected a pipeline.
Philippines	• The Asian Development Bank (ADB) signed an agreement with the Philippine National Oil Company (PNOC) to act as transaction advisor for the Philippines' first LNG regasification project in Batangas. Seven foreign companies have submitted unsolicited proposals to PNOC for a joint venture partnership to build an LNG terminal.
Russia	• Novatek announced that it started to export cargoes from the second train of Yamal LNG, some 11 Mtpa of capacity is in operation and another 6.4 Mtpa will be added at Yamal LNG.
Singapore	• Singapore initiated its efforts to be an LNG bunkering hub. The Maritime and Port Authority of Singapore awarded SGD 6 million to FuelLNG and Pavilion Gas for the building of two LNG bunker vessels. Total and Pavilion Gas signed an agreement to jointly develop an LNG bunker supply chain in the port of Singapore.
Chinese Taipei	• The plan for Chinese Taipei's third LNG receiving terminal was rejected early July by a government environmental committee, which cited a likely "grave impact" on the ecology of rare algae and coral species.
Thailand	• PTT started to study the feasibility of an LNG bunkering facility in Map Tha Phut port with Marubeni Corporation in January 2018.
United States	• U.S. liquefaction capacity expansion is on track. Cove Point LNG started their operations in April and other projects will follow. As part of another wave of liquefaction capacity expansion, Cheniere announced its FID on Train-3 of its Corpus Christi Project in May targeting the start of operation in 2021.
Viet Nam	• Given the depletion of domestic production and growing domestic demand, state-owned PV Gas plans to import natural gas. The company plans to spend US$4 billion into gas transport, processing, distribution and import infrastructure until 2020.

Section 2. Gas demand

2-1. World and APEC natural gas demand

2-1-1 Overview

More than half of global natural gas demand takes place in the APEC region. While world natural gas demand has grown by an average of 2.0% per year since 2007, APEC gas demand has grown at a slightly faster rate and accounts for 1 760 million tons of oil equivalent (Mtoe) or 2 047 billion cubic meters (bcm) in 2017 (Table 2-1). As a result, the APEC share of global demand increased from 54% in 2007 to 57% in 2017. This growth in gas demand in APEC member economies is attributable mainly to the United States and China, with consumption in these economies alone increasing 223 Mtoe (259 bcm) from 2007 to 2017. This represents about 39% of global demand growth over the same 10-year period (Figure 2-1).

Table 2-1 APEC member economies natural gas consumption, 2007-2017

	Natural Gas Consumption (Mtoe)										
Economy	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
APEC Total	1,368	1,391	1,372	1,472	1,537	1,582	1,639	1,676	1,679	1,722	1,760
Australia	27	29	29	28	30	29	30	32	32	35	35
Brunei Darussalam	3	3	2	3	3	3	2	3	2	2	3
Canada	79	79	78	79	83	83	87	88	87	95	103
Chile	4	2	3	4	5	4	4	4	4	4	4
China	66	76	84	101	124	133	152	166	171	187	197
Hong Kong, China	2	3	3	3	2	2	2	2	3	3	3
Indonesia	28	30	34	39	36	35	37	37	38	39	40
Japan	74	77	72	77	86	95	103	104	102	103	101
Korea	31	32	32	39	42	45	48	43	39	41	43
Malaysia	35	38	32	31	32	32	38	38	38	36	37
Mexico	51	52	54	54	57	59	62	61	65	66	67
New Zealand	4	3	4	4	3	4	4	4	4	4	4
Papua New Guinea	0	0	0	0	0	0	0	0	1	1	1
Peru	3	3	4	5	6	7	6	8	8	8	7
Philippines	3	3	3	3	3	3	3	3	3	3	3
Russia	366	366	350	384	396	387	386	385	364	371	405
Singapore	6	7	7	7	7	8	9	9	9	9	9
Chainese Taipei	10	11	10	13	14	13	13	14	15	15	17
Thailand	28	31	29	33	31	35	38	38	38	37	37
United States	543	541	536	556	569	595	607	628	647	653	635
Viet Nam	5	6	7	8	8	8	9	9	10	9	9
World Total	2,529	2,594	2,537	2,735	2,791	2,844	2,896	2,915	2,944	3,035	3,094
APEC Share	54.1%	53.6%	54.1%	53.8%	55.1%	55.6%	56.6%	57.5%	57.0%	56.7%	56.9%

Sources: International Energy Agency (IEA), World Energy Balances 2018; APEC Expert Group on Energy Data and Analysis, Energy Balance Table

2-1-2 United States

While primary energy demand in the United States has decreased in absolute terms by around 8.5% since 2007, its gas demand has increased by almost 17%. This has been mainly driven by the abundance of inexpensive shale gas production in the Appalachian basin and associated production in the Permian basin. The Henry-hub benchmark has averaged under 2.83 USD dollars per million British thermal units ($/MMBtu) from 2015 to 2018, 22% below its 3.62 $/MMBTU average in the 2012-2015 period (EIA, 2019).

These low prices enabled natural gas to displace coal as the main fuel for power generation fuel in 2016. While power generation has led demand growth in the US, demand has also grown in the industrial and residential sectors. As a result, the share of natural gas in primary energy demand rose from 23% in 2007 to 30% in 2017. The US is the largest gas consumer in the world, accounting for 635 Mtoe (738 Bcm), which is equivalent to 20% of global demand.

2-1-3 Russia

Russia is the second largest gas consumer and producer in the world and is also the top natural gas exporter. Power generation is the largest demand sector in Russia, with around 54% of the total, and gas remains the main fuel for power generation with around 41% of the total. However, other power generation technologies like nuclear and renewables have increased their share. Consequently, despite a modest growth in absolute terms, the gas demand share of primary energy demand has actually dropped from 54% in 2007 to 51% in 2017.

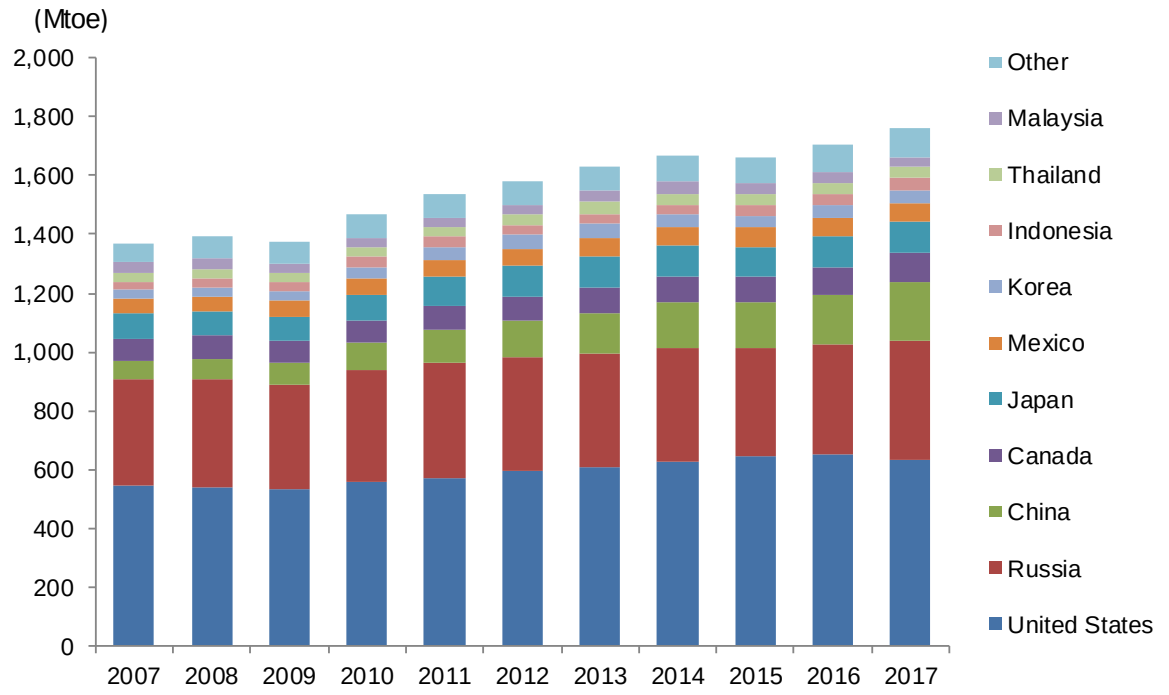
2-1-4 China

Energy consumption in China continues to grow rapidly because of economic development, making it the world's largest energy consumer since 2009. The massive quantity of domestically produced coal is its main source of primary energy, accounting for more than 60% of energy consumption. However, China gas demand has grown very fast since 2010, almost doubling in 2017 and becoming the third-largest natural gas consumer in the world in that same year. Nevertheless, the share of natural gas in China's primary energy consumption remains small, at around 6% of the total.

The Chinese government launched The Action Plan on Prevention and Control of Air Pollution in 2018 to combat the negative impacts associated with increasingly poor air quality and environmental pollution levels (Hao, 2018). This plan allocates financial support to assist central and local governments in replacing coal-fired heating boilers with gas-fired and electrical alternatives. However, this has increased the demand for natural gas during winter, especially in northern areas, widening the winter-to-summer demand ratio for natural gas. As there is insufficient major gas storage infrastructure to service demand peaks, gas imports increased dramatically, both via pipeline and in form of LNG, driving LNG spot prices in the Asia market upwards. This was particularly acute in the winter of 2017, but milder temperatures moderated this seasonal effect in 2018.

China's natural gas imports increased more than five-fold from to 2010 to 2017. However, LNG imports have been growing even faster, almost doubling from 2015 to 2017, surpassing Korea as the world's second-largest LNG importer (IEA, 2018). It is expected that China's LNG imports will keep growing as will piped imports following the commissioning of the Sino-Russian Power of Siberia pipeline by 2020.

Figure 2-1 Natural gas consumption in APEC economies, 2007-2017



Sources: International Energy Agency (IEA), World Energy Balances 2018; APEC Expert Group on Energy Data and Analysis, Energy Balance Table

2-1-5 Japan

Japan was still the world's largest LNG importer in 2017. As Japan has no international pipeline interconnections and domestic production is limited, LNG imports account for approximately 97% of total supply. LNG imports are particularly important for power generation, as around 40% of electricity generation came from gas-fired power plants in 2016.

The shutdown of all of Japan's nuclear power plants following the Great East Japan Earthquake in March 2011 dramatically increased the demand for substitute fuels such as coal and, in particular, natural gas. This resulted in a rapid expansion of the natural gas share of primary energy consumption from about 17% to at least 23% and a 27% increase on LNG imports from 2010 to 2013. Natural gas consumption decreased slightly after 2015, because of the restarting of some nuclear power plants, as well as the decline in the overall primary energy consumption. However, uncertainty arises in

forecasting gas demand as the Japanese government pushes to restart more nuclear power plants and adopt renewable energies.[1]

2-1-6 Mexico

Natural gas production peaked in 2009 at 44 Mtoe (51 bcm) but fell to 30 Mtoe (35 bcm) in 2016, a 30% decrease. Moreover, Mexican natural gas production competes with low-cost US natural gas imports, which have been covering rising demand and compensating for declining production. Lack of investment in exploration and infrastructure modernisation has been even more significant in the natural gas sector, since Pemex historically prioritised oil production.

Mexico is currently a net importer of natural gas, as the gap between decreasing domestic production and growing demand has widened in the past decade, mainly driven by power generation. Natural gas imports increased from 7.7 Mtoe in 2005 (8.7 bcm) to 36 Mtoe (41 bcm) in 2016, registering a record high every year from 2008. The vast majority (88%) of these imports are piped from the United States and the remainder is imported as LNG, mainly from Peru and the United States, to one of Mexico's three regasification terminals. However, further increase of both inexpensive gas imports from the US and domestic gas production is hampered by insufficient infrastructure. Since 2011, 25 new natural gas pipeline projects have been launched in Mexico and 6 in the United States, including the addition of 8 interconnections with the United States, increasing total natural gas import capacity to 114 bcm per year (103 Mtoe) by 2019. However, construction on at least six pipelines has been delayed for more than two years because of opposition from local communities, environmental groups, or indigenous groups resulting from concerns of surrounding the Free Prior Informed Consent processes. This may result in stagnant gas imports from inexpensive US Permian shale gas.

2-2 World LNG demand

World LNG imports increased by an average of 5.6% per year from 157 million tons per annum (Mtpa), (214 bcm) in 2007, to 273 Mtpa (371 bcm), in 2017. APEC LNG imports were below the world's growth rate, increasing by an average 4.8% per year from to 196 Mtpa (267bcm) in 2017 (Table 2-2). In addition, APEC accounted for 72% of global LNG imports in 2017, 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 6.5 percentage points from 78% in 2007. This is the result of increasing LNG demand outside the APEC region, for example, in India, Pakistan and Bangladesh.

[1] As of October 2018, nine nuclear power plants (Takahama, Ohi, Genkai, Sendai, and Ikata) have been restarted and restarting of other nuclear plants is scheduled.

Table 2-2 APEC member economies LNG imports, 2007-2017

	LNG Import (Mtpa)										
Economy	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
APEC Total	122	119	119	140	158	161	176	176	168	177	196
Australia	0	0	0	0	0	0	0	0	0	0	0
Brunei Darussalam	0	0	0	0	0	0	0	0	0	0	0
Canada	0	0	1	1	2	1	1	0	0	0	0
Chile	0	0	0	2	3	3	3	2	3	3	3
China	3	3	5	8	11	14	18	20	20	27	39
Hong Kong, China	0	0	0	0	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0	0	0	0	0
Japan	68	68	66	71	83	87	88	89	84	85	84
Korea	26	29	26	34	36	37	41	38	33	34	37
Malaysia	0	0	0	0	0	0	5	3	4	4	5
Mexico	2	2	3	4	3	3	5	6	5	4	5
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
Phillippines	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	1	2	2	2	2
Chainese Taipei	8	9	9	11	12	12	12	12	13	14	15
Thaliand	0	0	0	0	1	1	1	1	3	3	4
United States	15	7	9	9	7	3	2	1	2	2	1
Viet Nam	0	0	0	0	0	0	0	0	0	0	0
World Total	157	155	174	211	234	229	228	230	235	248	273
APEC Share	78.2%	76.3%	68.7%	66.2%	67.7%	70.4%	77.2%	76.5%	71.4%	71.4%	71.7%

Source: IEA, World Energy Balances 2018; Cedigaz, Natural Gas in the World

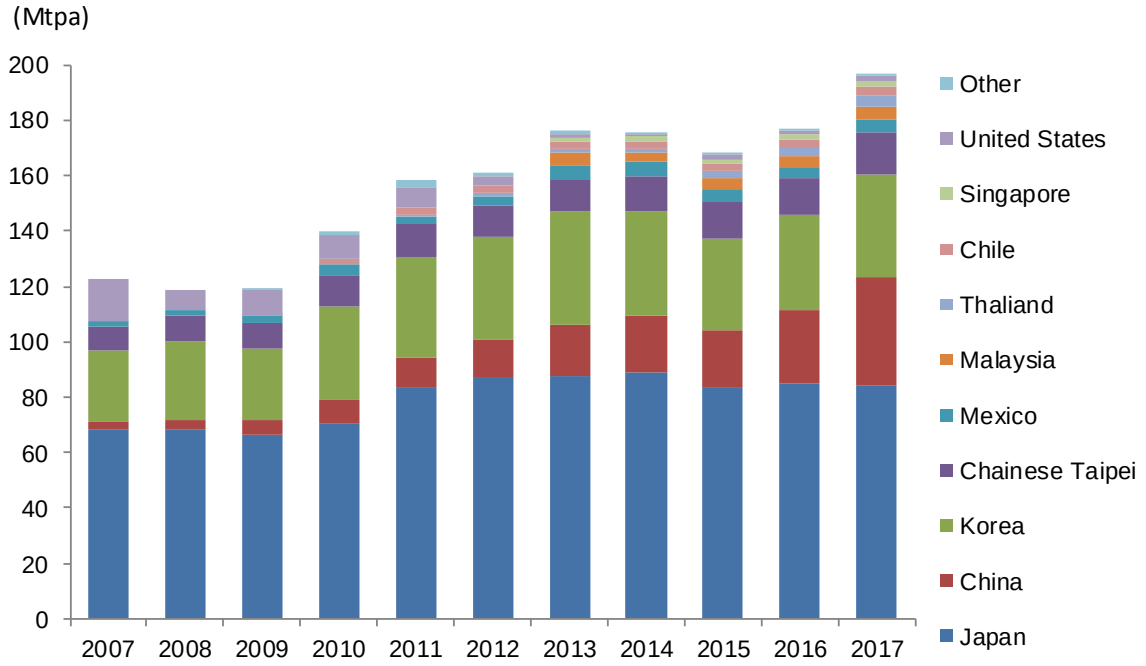
In 2007, there were six APEC member economies importing LNG; this number increased to 11 in 2017. By volume, Japan, China and Korea account for most of the LNG imports among APEC member economies, with these three economies importing 160 Mtpa of LNG in 2017. This is equivalent to 59% of worldwide LNG imports and 82% of APEC LNG imports.

Demand for natural gas in China is growing rapidly. As domestic production is not enough to meet demand, China has continued to import gas via pipeline and LNG. In 2017, 62% of natural gas demand was supplied with domestic production, 23% with LNG imports and 15% with pipeline imports. The first domestic LNG receiving terminal in China began operation in 2006 and 20 LNG receiving terminals were operating as of October 2018. In response to the rapid increase in natural gas demand, LNG import volume has been increasing in recent years, and in 2017, China became the second largest LNG importer in the world after Korea (Figure 2-2).

The United States, once a net LNG importer, has seen imports decline because of the increase in domestic natural gas production. Exports from Sabine Pass LNG, its first large-scale LNG export facility, started in 2016 and have since been growing rapidly.

Advances in hydraulic fracturing and horizontal drilling technologies have keep Canada's eastern markets supplied with low-cost gas from the US and reduced the need for imports at Canaport LNG, Canada's only LNG import facility. Imports have fallen by 88% from 2011 to 2017, remaining below one Mtpa of LNG per year in 2017 (NEB, 2018).

Figure 2-2 APEC member economies LNG imports, 2007-2017



Source: IEA, World Energy Balances 2018; 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 operation. However, this has caused a shortage of natural gas and high prices for the domestic market in this Australian region. To counter the shortfall, five LNG import terminal projects have been proposed and are aiming to begin operations in the early 2020s.

2-3 Gas demand outlook

According to the Asia Pacific Energy Research Centre's (APERC) APEC Energy Demand and Supply Outlook 7th Edition, APEC total gas demand grows by 13% up to 2021, reaching 1 925 Mtoe by 2021. The share of natural gas in the APEC fuel mix also grows from 21% in 2016 to 23% in 2021, as coal demand declines and oil demand shows slow growth. Power generation by natural gas remains the main driver of natural gas supply growth in this scenario and represents about 41% (793 Mtoe) of total primary gas supply in 2021. Additionally, every demand sector contributes to this growth, with industry demand increasing by 21% to reach 339 Mtoe by 2021.

Table 2-3 APEC member economies natural gas consumption, 2015-2021

	Natural gas demand by economy (Mtoe)						2016-21	
Economy	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Change**	**%**
Australia	34	37	39	39	39	41	6	19%
Brunei Darussalam	2.5	2.8	2.8	2.6	2.6	2.6	0.1	2%
Canada	95	97	99	99	99	98	3	3%
Chile	4.3	4.0	4.0	4.1	4.1	4.2	-0.2	-4%
China	169	187	206	224	241	253	84	50%
Hong-Kong, China	2.9	2.9	2.9	3.1	3.4	3.7	0.8	26%
Indonesia	39	34	36	39	41	42	3	8%
Japan	105	115	115	111	107	101	-5	-4%
Korea	41	38	41	42	41	41	-1	-2%
Malaysia	33	32	32	32	33	34	1	4%
Mexico	67	65	68	70	72	73	6	9%
New Zealand	4.2	4.3	4.2	4.0	3.8	3.9	-0.3	-7%
Papua New Guinea	1.4	1.5	1.5	1.5	1.5	1.6	0.2	11%
Peru	9.1	10	10	10	10	10	1	12%
Phillipines	3.3	2.2	2.1	0.8	0.8	1.2	-2.1	-65%
Russia	366	373	379	382	383	385	19	5%
Singapore	8.7	8.8	8.9	9.0	9.1	9.2	0.4	5%
Chinese Taipei	16	17	17	16	15	16	1	4%
Thailand	37	36	37	37	37	38	1	3%
USA	652	676	699	716	735	757	106	16%
Viet Nam	10	10	10	10	10	11	1	7%
APEC total	**1700**	**1754**	**1812**	**1850**	**1889**	**1925**	**225**	**13%**

Source: APERC, APEC Energy Demand and Supply Outlook 7th Edition (2018).

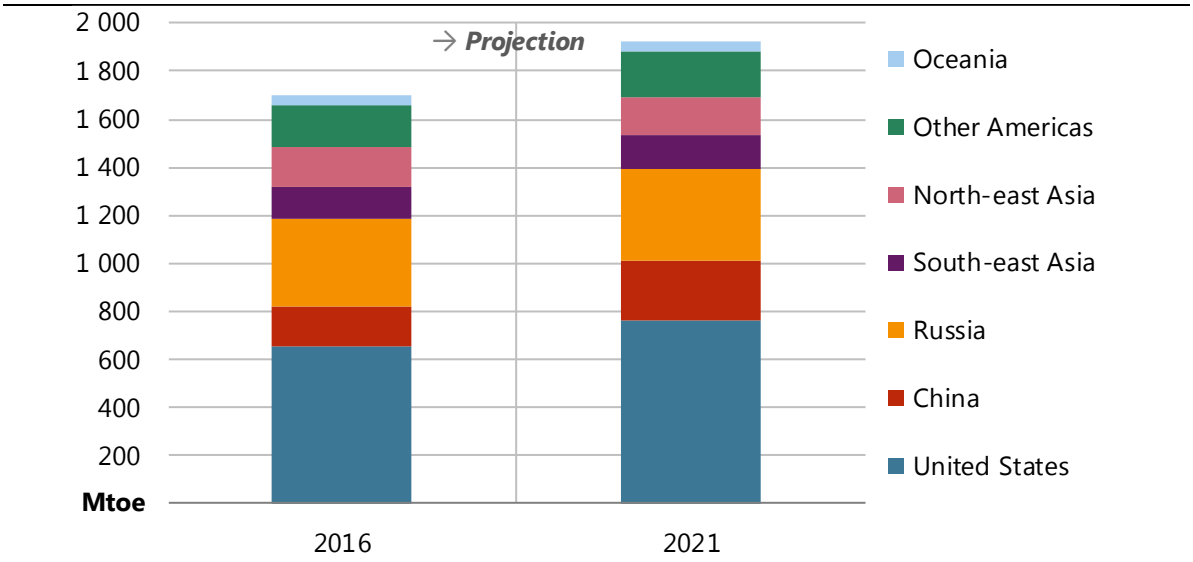
On a regional basis, the United States and China have historically driven APEC natural gas growth. In the United States, total primary gas demand grew by 28% from 507 Mtoe in 2005 to 652 Mtoe in 2016. China showed remarkable demand growth of 346% over the same period, from 38 Mtoe to 169 Mtoe, and now have the third-largest gas demand in APEC, behind the United States and Russia.

According to the APEC Energy Demand and Supply Outlook, natural gas represents at least 10% of TPES in every APEC economy by 2021, with the exception of Chile, China and the Philippines. While the United States and China dominate growth, 16 of the 21 APEC economies[2] show total gas demand growth from 2016 to 2021. Total primary gas demand in China, mainly driven by increasing demand from power generation and, to a lesser extent, industry, grows by 50% by 2021, leading gas supply growth in the APEC region. Natural gas demand in the United States increases by 16% to reach

[2] The exceptions are Chile, Korea, Japan, Phillipines and New Zealand.

757 Mtoe in 2050 and is mainly driven by increases in gas-fired power generation. Russia total supply grows 5%, reaching 385 Mtoe by 2050. South-east Asia gas demand remains at similar levels in the short term, as a result from modest growth from Indonesia and Thailand and decreasing consumption in Philippines. Gas demand in North-east Asia stagnate resulting from decreases in demand in Japan and Korea and timid growth in Chinese Taipei. Elsewhere, gas demand grows by 6% in the Other Americas, leaded by Mexico and Canada. Finally, gas demand in Oceania grows by 16% from to 2016 to 2021, mainly leaded by power generation in Australia.

Figure 2-3 Outlook for natural gas consumption in APEC, 2016-2021



Source: APERC, APEC Energy Demand and Supply Outlook 7th Edition

Section 3. Gas production

3-1 World and APEC natural gas production

3-1-1 Overview

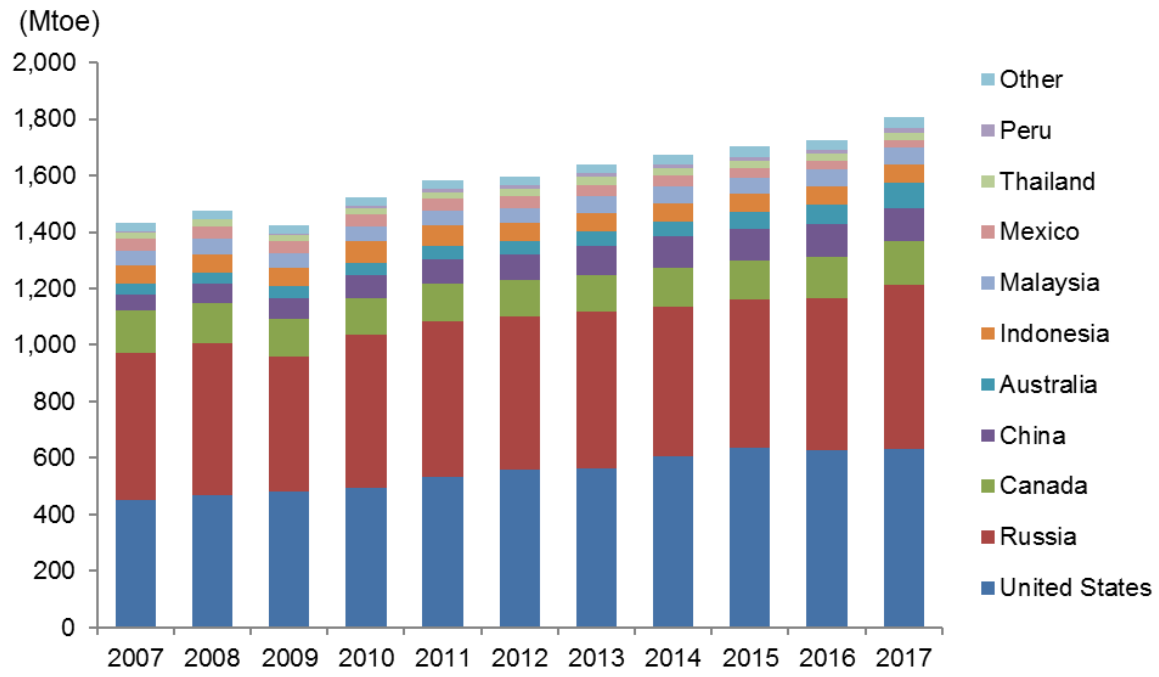
Table 3-1 APEC member economies natural gas production, 2007-2017

	Natural Gas Production (Mtoe)										
Economy	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
APEC Total	1,434	1,480	1,432	1,527	1,590	1,600	1,639	1,676	1,710	1,734	1,806
Australia	38	40	42	44	48	46	52	53	56	73	88
Brunei Darussalam	12	12	11	12	12	12	12	11	12	11	10
Canada	150	145	135	132	132	130	130	138	139	146	155
Chile	1	1	2	2	1	1	1	1	1	1	1
China	64	75	79	89	98	98	108	116	120	123	119
Hong Kong, China	0	0	0	0	0	0	0	0	0	0	0
Indonesia	61	63	66	73	69	66	66	65	64	63	65
Japan	3	3	3	3	3	3	3	3	2	4	3
Korea	0	0	0	0	0	0	0	0	0	0	0
Malaysia	52	55	52	47	52	51	53	53	56	52	63
Mexico	43	42	44	43	42	41	40	37	34	30	26
New Zealand	4	3	4	4	3	4	4	4	4	4	4
Papua New Guinea	0	0	0	0	0	0	0	2	8	7	8
Peru	2	3	4	7	10	11	11	12	11	13	16
Philippines	3	3	3	3	3	3	3	3	3	3	3
Russia	522	535	479	540	553	541	554	531	524	538	580
Singapore	0	0	0	0	0	0	0	0	0	0	0
Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0
Thailand	20	23	21	25	22	26	28	32	28	28	25
United States	450	470	480	495	531	558	564	606	637	627	632
Viet Nam	6	7	7	8	8	8	9	9	8	8	9
World Total	2,511	2,615	2,536	2,715	2,791	2,838	2,899	2,942	2,989	3,032	3,142
APEC Share	57.1%	56.6%	56.5%	56.3%	57.0%	56.4%	56.5%	57.0%	57.2%	57.2%	57.5%

Source: International Energy Agency (IEA), World Energy Balances 2018; APEC Expert Group on Energy Data and Analysis, Energy Balance Table

Over the past decade, the world's natural gas production has continued to expand following demand. Table 3-1 shows natural gas production from 2007 to 2017. World gas production increased by an average 2.3% per year from 2 511 Mtoe (2 920 bcm) in 2007 to 3 142 Mtoe (3 653 Bcm) in 2017. The production from APEC also increased by an average 2.3% per year from 1 434 Mtoe (1 667 bcm) in 2007 to 1 806 Mtoe (2 100 bcm) in 2017. APEC's share of world production increased marginally from 57.1% in 2007 to 57.5% in 2017. APEC member economies, where production growth was concentrated in the United States, China and Australia, accounted for an increase of 254 Mtoe (295 bcm) from 2007 to 2017, which stands for 45% of the world production increase.

Figure 3-1 Natural gas production of APEC member economies, 2007-2017



Source: International Energy Agency (IEA), World Energy Balances 2018; APEC Expert Group on Energy Data and Analysis, Energy Balance Table

3-1-2 United States

Enabled by advancements in horizontal drilling techniques that allowed the production of shale gas at very competitive prices, gas production in the US has grown 50% in the past 10 years. In 2012, the US surpassed Russia to become the world's largest supplier. Moreover, the production growth led not only to decrease gas imports, but also to increase exports via pipeline to both Mexico and Canada and, in the form of LNG, to international markets (EIA, 2019). This culminated with the US becoming a net gas exporter in 2017.

US LNG exports have grown steadily since 2015, reaching 17 bcm (15 Mtoe) in 2017, and growth should continue as liquefaction capacity is projected to grows up to 90 bcm per year by 2020 (EIA, 2019). The abundant reserves of the Permian and Appalachian basins, low production costs and the lack of restrictions on destination have raised expectations for the medium term, particularly in the Asian and European LNG markets. However, the escalating trade disputes between the US and China may hinder US LNG exports to the fastest growing gas importer in the world.

3-1-3 Russia

Russia is the second world's largest gas producer and the largest exporter. Traditionally, Russia exported most of its gas (around 220 bcm) via pipeline to European importers. Around 30% of Russia's gas production is exported to European consumers via pipeline. Recently, its LNG exports have grown

to 15 bcm in 2017 following the commissioning of Yamal LNG.

However, piped gas trade between Russia and Europe has been subject to geopolitical differences and tensions, particularly with gas volumes transiting through Ukraine. Russia and Ukraine held disputes on gas prices and transit fees, which resulted in Russia cutting off its European export through Ukraine in 2006, 2009, and 2015; this resulted in gas cuts and shortages in about 15 countries in Europe (OIES, 2019). The European Union is still dependent for about 40% of its total supply on Russian piped imports (BP, 2019).

Considerable uncertainty surrounds the complex Russian-EU gas trade. The EU aims to diminish dependence on Russian gas by building the South Stream pipeline project that will bring gas from Azerbaijan, and by increasing LNG imports. However, Russian piped imports have increased by 11% since 2012, when the Nordsteam pipeline, that bypasses Ukraine, became operational. Some of this increase is due to stagnant production in Norway and decreasing production in the Netherlands, both of which were traditional gas suppliers for the EU. Additionally, while there are big expectations for US LNG exports to Europe, its delivered cost is still more expensive than that of pipeline gas from Russia. Furthermore, the Nord Stream II and the Turkish Stream pipelines will increase Russian export capacity to Europe once they become operational.

At the same time, the Russian company Gazprom is also building the Power of Siberia pipeline, which will link China with 38 bcm per year of Russian natural gas capacity (Gazpom, 2019). This pipeline is expected to be operational by 2020. Finally, Russia aims to increase its LNG liquefaction capacity by almost 10-fold, with Novatek alone looking to increase its liquefaction capacity up to 95 bcm (Boersma and Mitrova, 2018).

3-1-4 Canada

As of 2017, Canada was the world's fifth-largest natural gas supplier; its production volume has increased from 150 Mtoe (174 bcm) in 2007 to 155 Mtoe (180 bcm) in 2017. Canada has historically exported its surplus production by pipeline to the United States. As Canada lost part of its traditional North American market to the rising production of low-cost shale gas in the United States, net exports to the United States have stabilised around 69 Mtoe (80 bcm) in recent years.

The technological advancements in hydraulic fracturing that led to the shale revolution in the United States have renewed the growth potential of Canada's Western Canadian Sedimentary Basin (WCSB), particularly in the tight resources known as the Montney formation and Alberta Deep Basin. These advancements have dropped production costs and have allowed Canada to reverse several years of production declines. However, this production growth is occurring in new areas of the WCSB, and this is creating bottlenecks, as infrastructure development has been unable to keep pace with resource development. This, combined with the declining demand from the US, has put Canadian natural gas prices at a heavy discount to Henry Hub prices (NEB, 2018e). Several producers are curtailing spending plans and production guidance in response to sustained low prices, which will limit the short-term

growth prospects for Canadian natural gas production. The prospects of long-term production growth depend on the successful reconfiguration of WCSB upstream infrastructure and the diversification of Canada's export markets.

In response to these developments, Canada has strived to attract investment in liquefaction facilities to export LNG to Asia and other markets. LNG Canada and Woodfibre LNG have announced positive final investment decisions to build new LNG export facilities on Canada's west coast, and the existing small-scale Tilbury LNG has entered into an agreement to supply China with LNG via ISO shipping containers (FortisBC, 2019). There is also interested from several other west coast projects and a couple projects on the east coast.

3-1-5 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 will represent 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. With respect to the 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 strategic industry, and providing supports 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 2017, coalbed methane (CBM) and shale gas combined produced around 15 bcm (13 Mtoe), with the Chinese government planning to raise this to about 40 bcm (34 Mtoe) by 2020.[3] Pipeline imports come from Turkmenistan, Kazakhstan, Uzbekistan and Myanmar. Piped imports from Russia will begin when the Power of Siberia pipeline, currently under construction, is completed by the end of 2020, with a maximum import capacity of 38 bcm per year. China has been importing LNG since 2006, and its LNG imports in 2017 have increased significantly by 53.3% compared with the previous year.

3-1-6 Australia

In Australia, natural gas production has dramatically increased in the past few years as many liquefaction projects have recently come online. These large-scale projects include the Gorgon LNG project and the Australia Pacific LNG project in 2016 and the Wheatstone LNG in 2017. More recently, the Ichthys LNG led by Inpex has shipped the first LNG in October 2018. Shell's floating LNG facility, Prelude is close to delivering the first LNG once fully operational. Australia's LNG supply is expected

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

to continue to increase in the coming years.

There have been some changes in domestic regulations in Australia in recent years. 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 could be affected by this mechanism, and the impact on the international gas market would be limited.

3-2 World LNG supply

World LNG supply has increased by an average 6.0% per year over the past 10 years from 155 Mtpa (211 bcm) in 2007 to 277 Mtpa (377 bcm) in 2017. APEC's LNG supply, exceeding the world's growth rate, has increased by an average 6.7% per year from 65 Mtpa (88 bcm) in 2007, to 124 Mtpa (169 bcm) in 2017. 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 increased from 42% in 2007, to 45% in 2017. APEC's share is expected to grow as Australia and the United States are expected to increase their LNG supply.

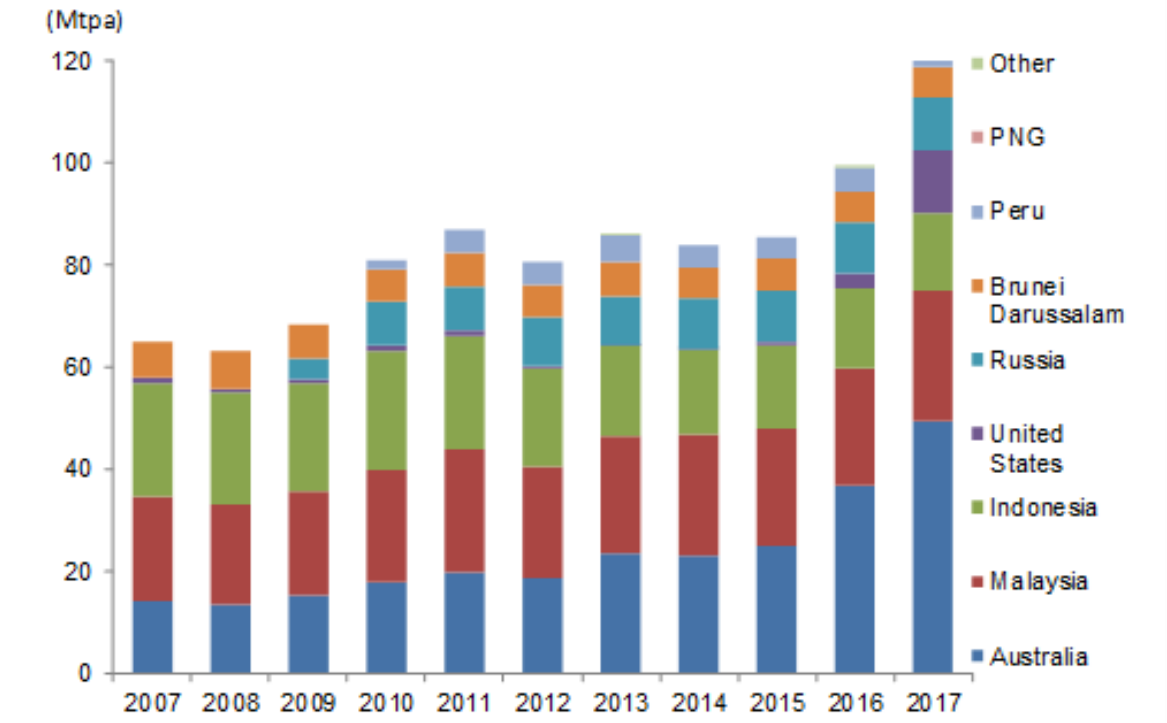
Table 3-2 APEC LNG exports, 2007-2017

	LNG Export (Mtpa)										
Economy	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
APEC Total	65	63	68	81	87	81	86	84	85	99	124
Australia	14	14	15	18	20	19	24	23	25	37	50
Brunei Darussalam	7	7	7	6	6	6	7	6	6	6	6
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	22	21	23	22	19	18	17	16	16	15
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	20	19	20	22	24	22	23	23	23	23	25
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	0	0
Peru	0	0	0	2	5	4	5	4	4	5	5
Philippines	0	0	0	0	0	0	0	0	0	0	0
Russia	0	0	4	8	9	10	9	10	10	10	10
Singapore	0	0	0	0	0	0	0	0	0	0	0
Chinese Taipei	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	0	0	0	1	3	12
Viet Nam	0	0	0	0	0	0	0	0	0	0	0
World Total	155	155	171	210	228	228	233	234	243	252	277
APEC Share	41.9%	40.7%	39.9%	38.5%	38.1%	35.4%	36.8%	35.8%	35.1%	39.4%	44.7%

Source: IEA, World Energy Balances 2018; Cedigaz, Natural Gas in the World

Australia and the United States are the biggest contributors to LNG supply in the APEC region, as they combined increased its LNG supply by 47 Mtpa (64 bcm) from 2007 to 2017, accounting for the most of APEC's growth in LNG supply. As mentioned, Australian liquefaction projects coming online have led to an increase in the supply of LNG. In the United States, Cheniere's Sabine Pass LNG project came online in 2016, and Dominion's Cove Point LNG project started its operation in January 2018, leading to a boost in US LNG exports. On the other hand, 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 thus diverting production to their domestic markets. In fact, some LNG import terminals have already started their operations in both economies. Russia's LNG supply has been almost flat around 10 Mtpa (14 bcm) in recent years. However, since the Yamal LNG project launched its operation in December 2017, adding 16.5 Mtpa of capacity, Russia's LNG supply is likely to grow faster.

Figure 3-3 APEC LNG supply, 2007-2017



Source: IEA, World Energy Balances 2018; Cedigaz, Natural Gas in the World

3-3 Gas production outlook

Natural gas production in APEC has grown robustly over the past 10 years, led by growth in the United States, China and Australia. US natural gas production rose from 422 Mtoe (491 bcm) in 2005 to 627 Mtoe (729 bcm) in 2016, a 49% increase, becoming the largest natural gas producer in the world (IEA, 2018a). Over the same period, China's gas production almost tripled (178%) and Australia's more than doubled (131%).

According to the APEC Energy Demand and Supply Outlook 7th Edition, gas production in APEC increases from 1 729 Mtoe (2 010 bcm) in 2016 to 1 971 Mtoe (2 292 bcm) in 2021, a 14% growth in only five years. Natural gas is the fastest-growing fossil fuel in the APEC region and according to this Outlook, natural gas production surpasses that of oil on an energy equivalent basis by 2021,

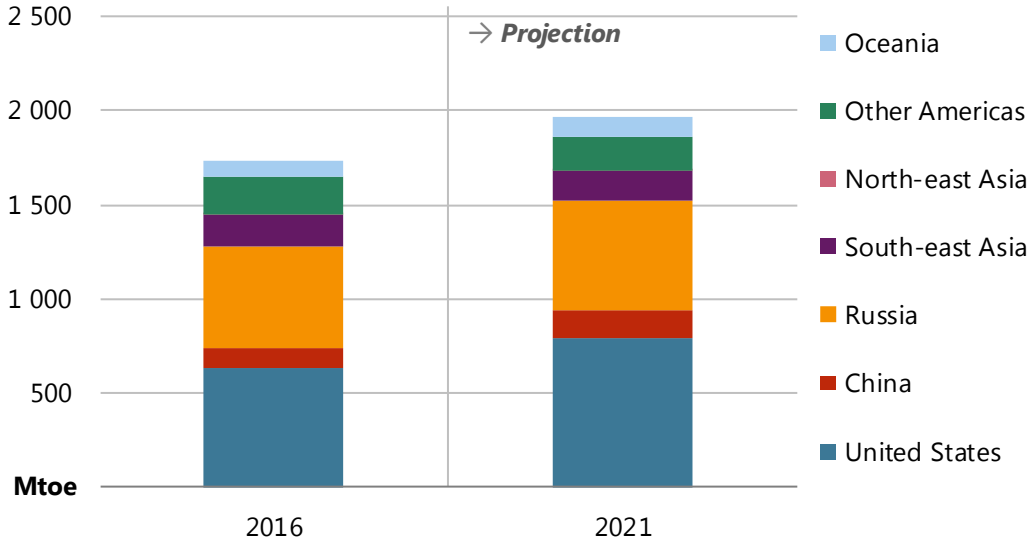
Table 3-3 APEC economies natural gas production outlook, 2016-2021

	Natural gas production by economy (Mtoe)						2016-21	
Economy	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Change**	**%**
Australia	73	87	96	97	99	101	29	39%
Brunei Darussalam	9.1	9.0	8.9	8.9	8.8	8.7	-0.4	-4%
Canada	146	145	147	143	140	137	-9	-6%
Chile	1.0	0.9	0.8	0.8	0.8	0.8	-0.2	-19%
China	115	120	127	135	144	153	39	34%
Hong-Kong, China	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Indonesia	65	63	63	62	62	61	-4	-5%
Japan	2.4	2.2	2.0	1.8	1.6	1.4	-1	-44%
Korea	0.1	0.1	0.1	0.1	0.1	0.0	0	-71%
Malaysia	57	57	57	57	57	57	0	0%
Mexico	30	30	30	29	29	28	-3	-8%
New Zealand	4.2	4.3	4.2	4.0	3.8	3.9	-0.3	-7%
Papua New Guinea	8.4	8.4	8.4	8.5	8.5	8.5	0.0	1%
Peru	14	14	14	14	14	14	0	-3%
Phillipines	3.3	2.2	2.1	0.8	0.8	0.8	-2.5	-77%
Russia	538	536	550	559	564	576	38	7%
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Chinese Taipei	0.2	0.2	0.2	0.2	0.2	0.2	-0.1	-23%
Thailand	25	24	23	22	21	20	-6	-23%
USA	627	685	716	745	779	789	162	26%
Viet Nam	9.5	10	9.4	10	10	11	1	13%
APEC total	**1729**	**1799**	**1859**	**1899**	**1942**	**1971**	**242**	**14%**

Source: APERC, APEC Energy Demand and Supply Outlook 7th Edition

Natural gas production in the United States continues to grow through 2021, rising 26% from 2016 to 2021 to reach 789 Mtoe (917 bcm). Increased production is not only expected to cover domestic demand growth but also to increase exports both piped and via LNG. Russia shows an increase of 7%, reaching 576 Mtoe (670 bcm), similarly covering growing domestic demand as well as increasing exports.

Figure 3-3 APEC LNG supply, 2007-2017



Source: APERC, APEC Energy Demand and Supply Outlook 7th Edition

China natural gas production grows by 34%, surpassing Canada by 2020 to become the third-largest natural gas producer in APEC. However, this increase in production is not enough to bridge faster growing demand, increasing also pipeline and LNG imports. In the other Americas region, natural gas production actually decreases by 6.3% down to 180 Mtoe (209 bcm) by 2021, mostly due to lesser production in Canada and Mexico. In contrast, gas production in Oceania (predominantly Australia) grows by 33% up to 113 Mtoe (131 bcm) by 2021. South-east Asia shows an overall decline of 6%, linked to assumed resource depletion in Malaysia and Indonesia in the absence of increased investment in exploration activities.

Section 4. Gas trade

Although most (71%) of the natural gas produced in the world is consumed domestically, some 933 Mtoe were exported in 2016 (IEA, 2018). In fact, traded gas volumes grew by 73% from 2000 to 2016 (IEA, 2018). In 2016, LNG represented about 30% of total traded natural gas volumes, while 70% was exchanged via pipeline and a negligible share by truck (IEA, 2018).

The APEC region has some of the most active gas trade dynamics in the world, including three of the top five world exporters (Russia, the United States and Canada) and three of the top five world importers (Japan, China and the United States) (IEA, 2018a). APEC as a whole is a natural gas net exporter; 70% of gas exports were piped while the remainder was LNG. On the natural gas imports side, by contrast, 47% was piped and 53% was LNG in 2016.

Among the 21 APEC members, 9 economies are currently net natural gas exporters, 9 are net importers and 3 do not trade gas (New Zealand, the Philippines and Viet Nam).4 The Philippines and Viet Nam are projected to begin imports of LNG in the coming years as increased demand for power generation pushes up domestic natural gas demand; in the Philippines, the rise in domestic demand occurs in tandem with declining production.

According to the IEA World Energy Balances 2018, internationally traded gas volumes in the world as a whole grew by 2.8% per year from 2007 to 2017, measured at the point of import. This growth rate is somewhat similar to the growth in natural gas consumption in the world of 2.0% per year (see Section 2). Having said that, the share of LNG in internationally traded gas increased significantly during the same period from 23% in 2007 to 33% in 2017, because of higher growth for the super-chilled fuel of 5.7% per year (see Section 2) with significantly slower growth of pipeline trades of 0.1%% per year. That means that larges gas volumes are transported for longer distances as well deeper interdependence between exporting and importing economies.

In the same period APEC's natural gas exports grew by 30%, and while LNG exports grew by 80%, the majority of gas exports are still done via pipeline. Japan was the largest natural gas and LNG importer in the world in 2016, accounting alone for 49% of LNG imports in APEC and 31% globally (IEA, 2018a).

4-1 Gas Imports in the world and the APEC region

Imports of natural gas in the world as a whole grew by 2.8% per year from 757 Mtoe (880 bcm) in 2007 to 998 Mtoe (1 160 bcm) in 2017. During the same period imports of natural gas by APEC members increased faster than the world average by 3.8% per year from 285 Mtoe (331 bcm) in 2007 to 414 Mtoe (481 bcm) in 2017. As a result, the share of APEC receipts in global natural gas imports

[4] The 9 APEC economies that are gas net exporter economies are: Australia, Brunei Darussalam, Canada, Indonesia, Malaysia, Papua New Guinea, Peru, Russia and the United States. The 9 net importers are: Chile, China, Hong Kong, Japan, Korea, Mexico, Singapore, Chinese Taipei and Thailand.

increased from 38% in 2007 to 41% in 2017.

During the same period, natural gas consumption grew by 2.5% per year in APEC member economies and by 2.0% per year in the world, respectively. The dependence on imports within total gas consumption, which used to be lower for the APEC members at 21% than for the world as a whole at 30%, crept up to 24% for APEC members and to 32% globally.

The APEC region however, remained overall as a net gas exporter in 2017, despite growing demand and import. Most gas imports in APEC where done via LNG, mostly from non-APEC economies (eg: Qatar, United Arab Emirates, Trinidad and Tobago, etc.) to Northeast Asia (Japan, Korea and Chinese Taipei) and China.

Table 4-1 APEC members' natural gas imports, 2017

	bcm
Japan	119
People's Republic of China	91
United States	85
Korea	53
Mexico	50
Canada	25
Chinese Taipei	22
Thailand	16
Singapore	11
Malaysia	9
Russian Federation	9
Australia	6
Chile	5
Hong Kong (China)	3

Unit: billion cubic meters. Calculated from the figures in Mtoe in the source.
Source: The World Energy Balances 2018, IEA

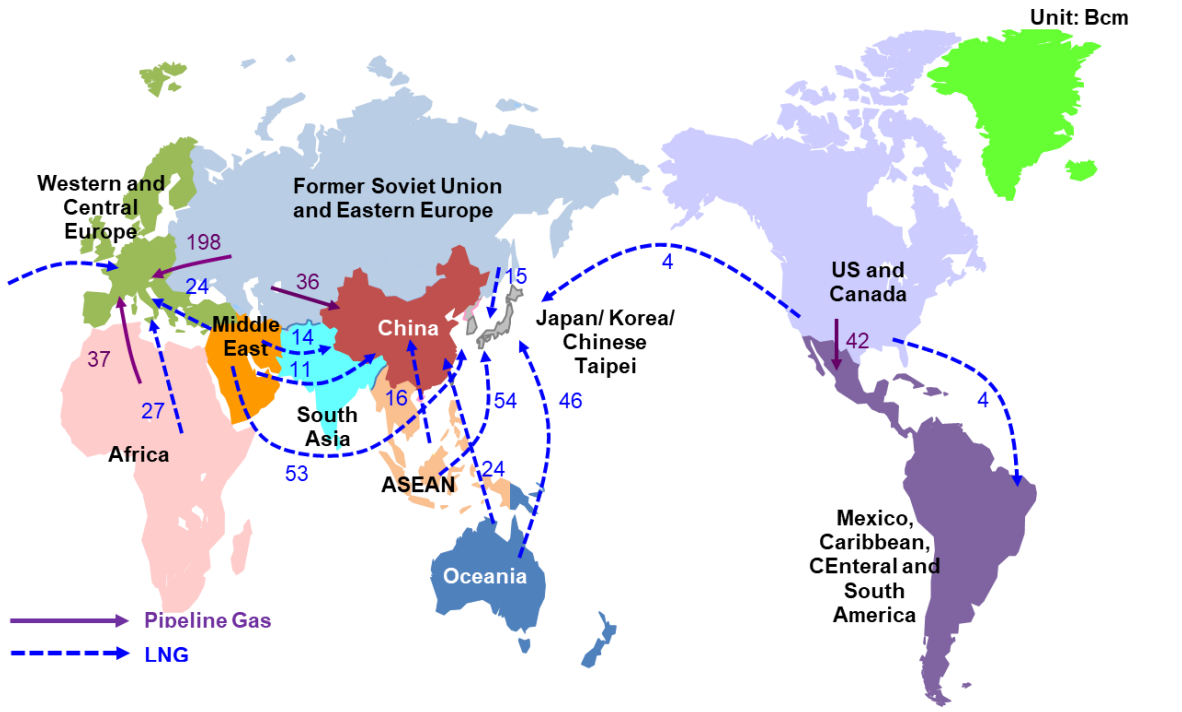
Japan was still the largest importer of LNG and natural gas as in the world in 2017. Japan's LNG imports hit the peak in 2014 and decreased slightly from the peak in the last three years. During the period from 2007 to 2017, Japan's gas imports (all of them via LNG) increased by 23%, or 18 bcm, representing a 2.1% per year growth on average.

China's imports have increase dramatically fast since 2005 and is poised to become the world's largest natural gas importer in the next years (see Section 6). Some 38% of China's natural gas consumption in 2017 came from imports.

The United States remains as one of the largest natural gas importers in the world, as rapid growing production is not enough to meet increasing demand and export needs. The US has extensive pipeline interconnections with its neighbours Mexico and Canada. It imports over 60 bcm of piped gas from Canada. However, US gas imports (including LNG) decreased by nearly 34%, or 37 bcm, from 2007 to 2017. Mexico is the main destination of US gas exports, owing to the availability of unexpansive gas in the Permian basin and the increasing interconnection between these two economies. Canada, one of the world's largest gas producers has traditionally imported over 20 bcm from the US,

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 be the top exporter of LNG in the world, receives gas from the joint development area with Timor Leste, which in turn is converted into LNG for exports. In addition, there are plans to install LNG receiving terminals on the East Coast. Hong Kong, China receives natural gas from China's offshore gas field via pipeline.

Figure 4-1 Major natural gas trade flows, 2017



Source: IEEJ Outlook 2019

Among the 14 APEC members listed in table 4-1, only Japan, the United States, China, Korea, Mexico, and Chinese Taipei were LNG importers in 2007. In 2017, Canada, Thailand, Singapore, Malaysia, Indonesia and Chile have supplemented their import capability with LNG receiving terminals. Although the 4.9 % annual growth rate of APEC LNG imports was lower than that global LNG imports (5.7%) during the same period, it was still higher that the annual growth rate of total natural gas

imports by the APEC members (3.8%). Additionally, the share of LNG in APEC members' total gas demand grew from 10% in 2007 to 13% in 2017.

4-2 Gas exports in the world and the APEC region

Global natural gas exports grew by 3.0% per year from 749 Mtoe (871 bcm) in 2007 to 1 010 Mtoe (1 174 bcm) in 2017. Natural gas exports in APEC have also grown since 2000, reaching 469 Mtoe (545 bcm) in 2017, of which roughly 70% was piped and the remaining 30% was via LNG. The share of APEC members in the global natural gas exports declined slightly from 47% in 2007 to 46% in 2017.

Accounting for 42% (230 bcm) of these volumes in 2016, Russia was the world's top natural gas exporter (IEA, 2018b). The Yamal LNG terminal in the Arctic region started operations in December 2017, adding export capacity to the extensive natural gas pipeline infrastructure that connects Europe and Russia. Canada, which sends virtually all of its natural gas exports to the United States via pipeline, shows a decline to 69 Mtoe exported in 2016 compared with 87 Mtoe in 2005. In parallel, the United States more than doubled its natural gas exports from 2010 to 2016, mainly via pipeline to Mexico, coupled with fast-growing LNG exports.

Table 4-2 APEC members' natural gas exports, 2017

	Bcm
Russian Federation	224
Canada	88
United States	86
Australia	70
Indonesia	37
Malaysia	30
Papua New Guinea	13
Brunei Darussalam	8
Peru	7
People's Republic of China	3
Chile	0.3
Mexico	0.02

Unit: billion cubic meters. Calculated from the figures in Mtoe in the source.
Source: The World Energy Balances 2018, IEA

Australia more than doubled its gas exports (all of them via LNG) since 2010, reaching 43 Mtoe in 2016. South-east Asia, which includes other traditional LNG exporters in APEC (e.g. Indonesia, Malaysia and Brunei Darussalam), decreased its natural gas exports by 14% from 2005 to 2016. Chile started re-exporting some of regasified imported LNG to Argentina in 2016, to cope with seasonal demand peaks. Mexico exports some gas volumes to the United States but this share remains

marginal compared to the imported volumes coming in the opposite direction. Finally, during the last decade, Peru and Papua New Guinea emerged as new LNG exporters, delivering mostly to other APEC economies.

4-3 Gas trade outlook in the world and the APEC region

According to the APEC Energy Demand and Supply Outlook 7th Edition, natural gas trade in APEC continues to grow, with exports rising by 19% and imports by 20% from 2016 to 2021. LNG imports are projected to play a major role within APEC, accounting for 51% of total imports and with growing trend. According to the APEC Outlook, this rapid growth continues beyond the scope of this report, with LNG imports almost tripling by 2050.

The United States, which used to be a significant LNG importer, has steadily decreased LNG imports in recent years thanks to rapidly growing domestic production. Moreover, the US started exporting LNG on the Gulf coast in 2016 and exports have grown robustly since then. With several liquefaction facilities scheduled to start operations in the next five years and given that US LNG do not have destination restrictions or oil-linked price schemes, US LNG exports are poised to be one of the most competitive sources of LNG both in the APEC region and beyond it (particularly in Europe).

Canada also has increased its domestic gas production and despite several project proposals to develop exporting LNG exports facilities in its Pacific coast, only a handful of them seem to be moving forward. At the time of writing this report, only LNG Canada and Woodfibre LNG have announced positive final investment decisions, while and the existing small-scale Tilbury LNG has entered into an agreement to supply China with LNG via ISO shipping containers (FortisBC, 2019).

Among the international gas exports in 2017, 18% was exported from Russia to Europe via pipeline. One of the key elements of expanding Russia's gas supply is export pipeline 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. Furthermore, the Power of Siberia pipeline, linking Russia and China is also under construction. The completion of these pipelines will significantly expand Russia's gas export capacity. Elsewhere in the APEC region, piped gas trade not only is poised to remain relevant but to grow through 2021, particularly in North America (US-Canada and US-Mexico).

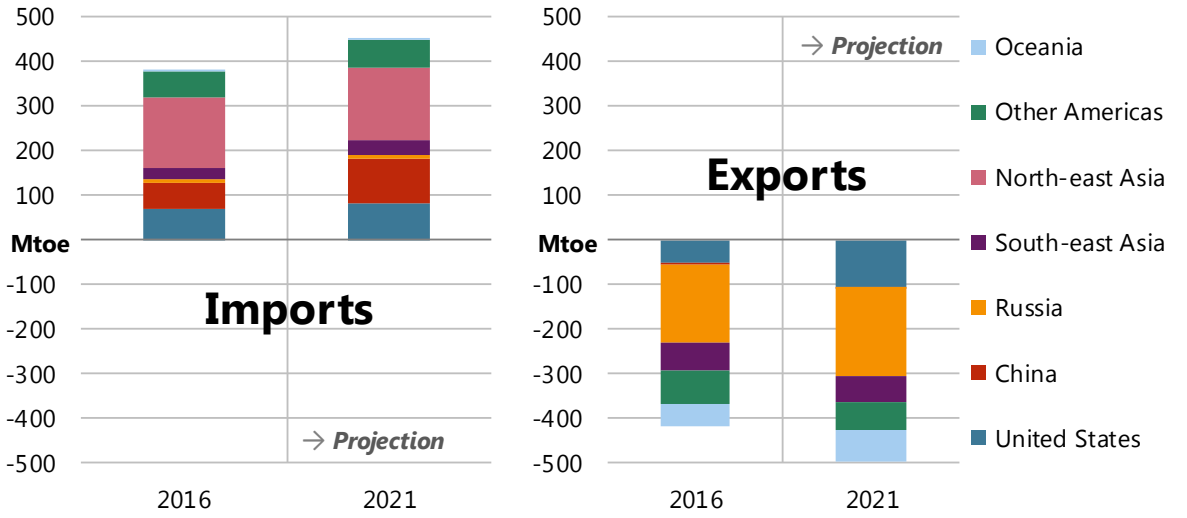
While LNG trades used to be dominated by volumes transported from Southeast Asia (mostly Malaysia, Indonesia and Brunei Darussalam) to Northeast Asia, including Japan and Korea. The global LNG trade flows have been diversified in recent years along with the increasing LNG production projects in places like the US, Qatar and Australia. Moreover, more economies have started recently (Papua New Guinea and Cameroon) and others expected are expected to start LNG imports soon, including Argentina and Mozambique. With a larger number of LNG exporters and importers, LNG trade patterns are expected to continue diversifying through 2021.

Nevertheless, up to 2017, consistent with sluggish development of new LNG projects under glut of supply and decline of Asian LNG prices, the investment in the upstream sector slowed down over the past few years. However, as mentioned, natural gas supply is expected to increase in the short-medium term because of the recent recovery of oil prices and start of several new LNG projects and pipelines. Although supply development is moving forward, motivated by a strong appetite especially in Asia, by some analysis, the supply and demand balance could become tight in the first half of 2020s.

Additionally, Russia is expanding its gas exports beyond their traditional piped exports through the expansion of its LNG export capacity. Russian LNG exports grew to 15 bcm in 2017 following the commissioning of Yamal LNG. New projects have been announced in Russia such as Arctic LNG-2, Cryogas-Vysotsk and Baltic LNG, currently under review.

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 on any new development in 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 110 Mtpa by 2024. In 2018, Qatar Petroleum decided to increase the capacity of Qatar's expansion project by adding four liquefaction trains. Qatar's aim appears to be to maintain its market share against Australia, the United States, Russia and other competitors.

Figure 4-2 Imports and exports of gas, by region, 2016 and 2021



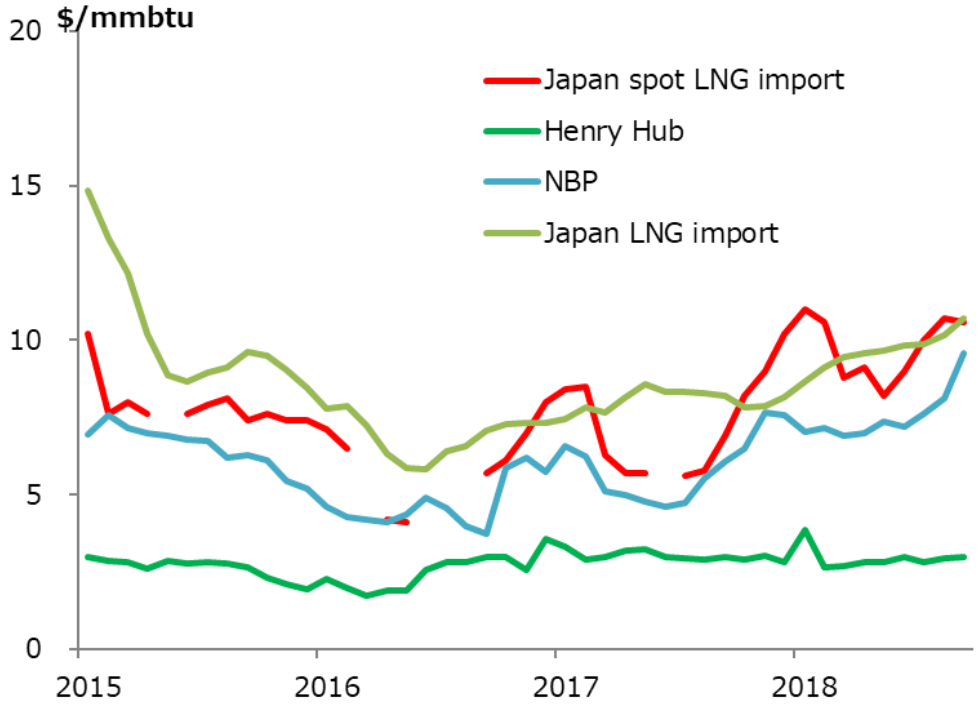
Source: APEC Energy Demand and Supply Outlook 7th Edition, 2019

Section 5. Gas prices

5-1 Change in major natural gas prices of the world

The world's major natural gas price indexes from 2017 to 2018 began to rise after several years of stability. The Japan LNG import price, a standard natural gas price in the Asia Pacific, increased from around $8/MMBtu to above $10/MMBtu from 2017 to the mid-2018. This reflected the moderate rise in international crude oil prices, which rose from $60/bbl to $80/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 5-1 Trends in major natural gas price indexes, 2015-2018



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

Although traded volumes at spot prices are not necessarily large, the LNG spot price also showed strength. Reflecting a demand surge from China in wintertime, the price hit $11/MMBtu in January 2018. The price then fell to around $8/MMBtu in spring, but it shows another sign of increase toward winter month from 2018 to 2019.

The NBP (National Balancing Point), the standard price in Europe, also showed a recovery trend. This

is because of the demand growth in the power sector and the rise of crude oil and oil product prices. The production decline from the Dutch Groningen gas field also tightened the market balance and supported the price level.

The Henry Hub index, the standard price in the United States, has remained at around the $3/MMBtu level for the past six years, influenced mainly by the shale revolution. Although US LNG exports in the Gulf Coast began in 2016, there has been no evidence of LNG exports affecting domestic price levels. The oil price recovery since 2017 boosted oil production in the U.S. and the production of associated natural gas provides additional supply to the market and keeps the price at a low level.

5-2 Future outlook

In the most likely scenario, major natural gas indexes are expected to remain around current levels. As for the LNG price in Asia, most of the LNG will continue to be linked to crude oil prices in 2019. Because the balance of the international crude oil market is expected to be soft toward 2019, the price of LNG price will also be capped by the crude oil price. As seasonal demand from rapid-growing LNG importers (predominately, China) is growing, the spot price will continue to be volatile in 2019, too.

In the long run, the world LNG market is expected to have ample capacity additions until the mid-2020s. The recent demand surge in China implies that future demand growth will be much more than initially expected, and the "rebalancing" moment of the market may come earlier. The Asian LNG spot price is forecasted to gradually rise to around $9-10/MMBtu by 2021.

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 toward 2020, 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 price is already at a very low level, around $3/MMBtu, compared with other regions, the decline will be limited. 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. US LNG exports may also add some upward pressure on the price level. Based on these factors, the Henry Hub price may slightly increase from the current $3/MMBtu level, but remaining below $4/MMBtu in the mid-term.

Section 6. Case study: China's growing natural gas consumption and impacts on the Asia Pacific markets

In 2018, China surpassed Japan to become the world's largest importer of natural gas. Nevertheless, natural gas still made up only 3% of China's total energy consumption as of 2016, far less than the 30% average in developed economies. Concerns over severe air pollution caused by the burning of coal have led to increased government support for natural gas as a cleaner alternative for residential heating, industrial boilers, transportation and to some extent power generation. In 2017, China recorded an astonishing 15% annual growth of its gas market. In 20 years, China is expected to be the largest consumer of natural gas in the APEC region, albeit growing at a considerably slower pace[5]. By 2040, China is projected to account for 17% share of the total APEC demand (currently 9.5%).

The demand for natural gas in China spiked towards the end of 2017 on the back of policy for coal-to-gas switching in industrial and residential boilers to reduce air pollution. The sudden demand surge, coupled with lagging mid-stream and upstream supply capacity, resulted in gas shortage in certain provinces and a surge in domestic spot prices. The experience highlighted the need for new measures to improve supply reliability, as the scope for gas use is broadened to include more sectors and consumers. In fact, supply security and price competitiveness with alternative fuels, notably coal, are the key factors affecting the degree of China's gas market growth.

Because of limited domestic production, pipeline supply interruptions and a lack of storage capacity, LNG imports were the biggest contributor to meeting the growing demand. China's LNG import spike in 2017 raised and maintained international LNG spot prices at a four year high throughout the following year. In the spring and summer 2018, the northeast Asian spot LNG price averaged USD 9/MMBtu to over USD 11/MMBtu, roughly USD 2-5/MMBtu higher than the year before. As China continues to rely on the international markets for clean winter heating and power generation, its import seasonality is likely to be reflected more strongly in regional pricing. As such, China's domestic market evolution presents significant implications for global LNG markets.

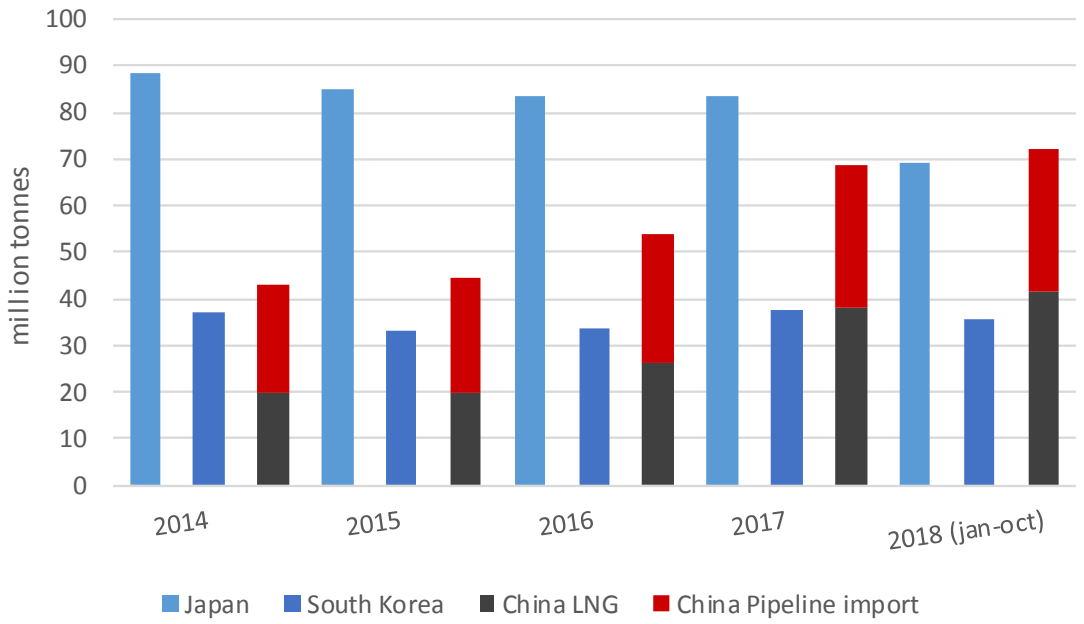
6-1 Growing demand and import dependence

6-1-1 Overview

In 2017, China surpassed Korea as the world's second largest importer of LNG. Then in the first 10 months of 2018, combined LNG and pipeline imports placed China ahead of Japan as the world's largest importer of natural gas.

[5] APERC Outlook 7th edition. China's natural gas consumption grew by 11% in 2017-2018, placing China seventh in the APEC region by the rate of growth. Its growth rate for the period 2030-2040 is expected to be 1.8%, the highest in the APEC region for this period.

Figure 6-1 Japan, Korea and China pipeline and LNG imports 2018 (Jan – Oct)



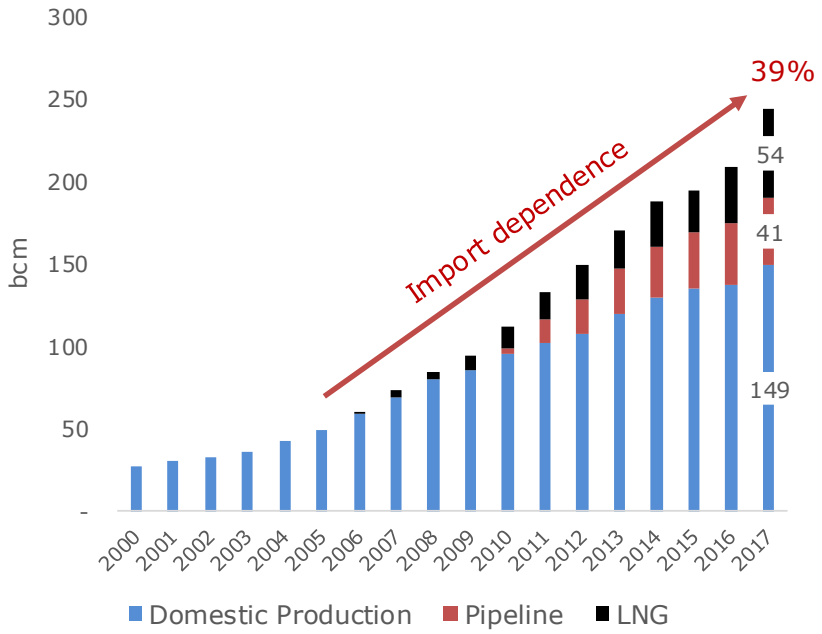
Source: Customs agencies Japan, Korea and China

China ranks among the top 10 economies with proven natural gas reserves and it has the largest shale gas reserves in the world. Despite this, the official domestic production targets have been consistently revised down because of technical and geological issues. Production increased by 10 bcm to 149 bcm (up 9% year on year basis [y-o-y]) in 2017. In September 2018, the State Council ordered local governments and companies to increase natural gas output to 200 bcm by 2020[6]. To meet the demand which has outpaced production since 2009, imports of natural gas have continued grow and in 2017 reached 39% share of the total gas supply.

The utilization rate of existing pipeline capacity (67 bcm) was at a low 61% in 2017 (import volume 41 bcm), which can be attributed to supply issues from Turkmenistan and Uzbekistan. Turkmenistan suffered a number of malfunctions and compressor failures since November 2017. Turkmen gas sales, which account for over 80% of China's piped imports, were stopped three times in January 2018. Supply issues also occurred with Uzbekistan, which faced gas shortages domestically. For 2018, officials have mandated the utilization rate of the Central Asian Gas Pipeline (CAGP) to be 93%.

[6] State Council, "Opinions of the State Council on promoting a coordinated and stable development of natural gas", September 2018, http://www.gov.cn/zhengce/content/2018-09/05/content_5319419.htm

Figure 6-2 China natural gas supply, 2000-17



Source: CNPC Economics & Technology Research Institute

The highly anticipated 3,000 km Power of Siberia pipeline developed by Gazprom and CNPC is expected to bring on-stream 38 bcm/year from 2020. CAGP's fourth Line D has been in the works since 2013 but has been subject to several delays. Construction of Line D resumed again in January 2018, with some reports suggesting first operations in 2020, while others report the starting date to be no sooner than the end of 2022. As for the West Line/Power of Siberia 2 gas pipeline from Russia to China's north-western border, negotiations between both economies appear to have been suspended after a series of disagreements.

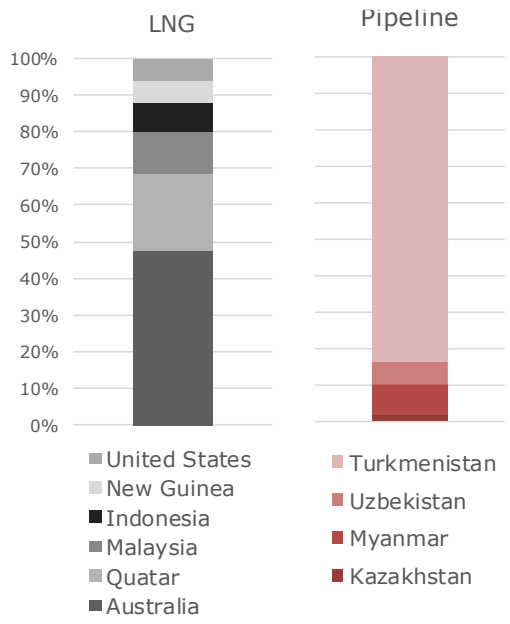
Table 6-1 China import pipelines (in operation and under development)

Source	Project	Capacity (bcm/year)	Status
Russia	Power of Siberia	38	Expected start Dec. 2019
	West Line/Power of Siberia 2	30	MOU signed/negotiation suspended
Central Asia (Turkmenistan 80%, Uzbekistan, Kazakhstan)	Line A	15	In operation
	Line B	15	In operation
	Line C	25	In operation
	Line D	30	Under construction
Myanmar	China-Myanmar oil and gas pipeline	12	In operation

Source: adapted from CNPC and company websites

Amidst the limitation on pipeline imports and moderate domestic production, LNG filled the supply shortfalls becoming the fastest growing source of gas supply for China in 2017. China imported 54 bcm of LNG in 2017, up 46% y-o-y, overtaking Korea as the world's second largest LNG buyer. As of October 2018, there are 20 operational import terminals with combined import capacity of 87 Bcm/year. Recent efforts on supply diversification and expansion of import capacity are further explored in section 6-3.

Figure 6-3 China natural gas supply, 2000-17



Source: China Customs agency

6-1-2 Sectoral demand outlook

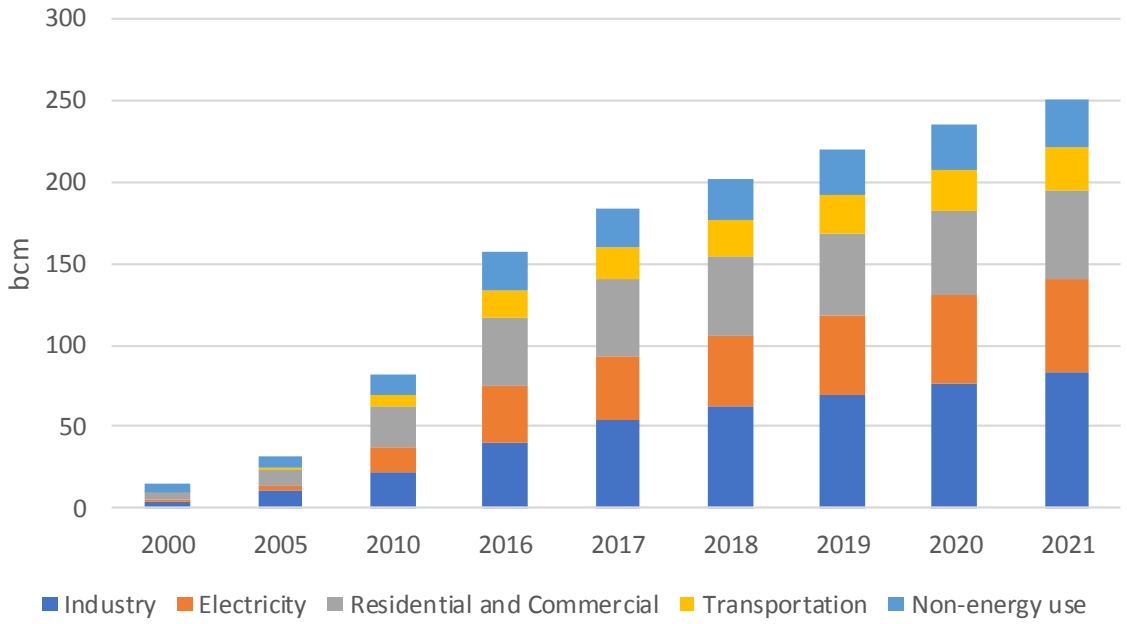
China's natural gas consumption totalled 231 bcm in 2017, up 15% y-o-y. The main demand sectors are industry, buildings, power generation and domestic transport. The industrial sector is projected to emerge as the main natural gas consumer in China thanks to fuel switching policies and economic restructuring. Natural gas will be increasingly used as fuel in industrial boilers and as non-energy feedstock for petrochemicals and fertilisers. Coal-to-gas switching policies have been actively implemented in industrial boilers since winter 2017. As such, the share of natural gas in industrial fuel is expected to increase from 4% to 9% between 2016 and 2020, partially replacing coal whose share drops from 55% to 47%. The shift in industrial fuel composition is supported by the decline from the construction sector and national plans that limit the output of iron, steel and cement by 2020. These heavy industries overwhelmingly rely on coal (over 75%) and only 2-3% on gas. The shift is part of a government push to develop less polluting, higher added value industries such as tech manufacturing and chemicals, which incidentally also show a higher share of natural gas.

Residential and commercial buildings currently account for the second largest demand for natural gas and their share is projected to increase annually by 5% on the backs of policies and measures promoting energy efficiency and clean heating fuel. It is assumed that green building standards for energy efficiency will continue to be promoted, prioritising government and public buildings, while energy-saving retrofits are also be expanded in residential buildings. Distributed renewable energy systems like solar water heaters will be installed on residential and large-scale commercial buildings. Lastly the outlook takes into account the 2+26 Clean Winter Heating Plan promoting coal to gas and electricity switching in key cities within the Beijing, Tianjin and Hebei regions.

Power generation has been the main driver of natural gas uptake in developed economies. By contrast, the growth in gas-fired generation in China will be more moderate due to competition with other sources. The government intends to limit the total capacity of coal power to no more than 1100 GW as of 2020. At the same time, developments in coal-fired technology and the domestic abundance of coal, are strengthening its dominant role in the baseload mix, especially in the coal-rich northern regions. It is assumed that renewable investments will be accelerated further, as indicated for instance by the overshoot of the 2020 solar targets in 2017. Variable renewables create additional need for peak-load and middle load capacity, which is to be filled with gas-fired power according to the government. The 13th FYP mandates that gas-fired power capacity equals over 110 GW as of 2020 (in 2016 there was 70GW). Combined with the government limit on new gas-fired CHPs, the APERC outlook expects the capacity factor and thereby gas consumption to be quite low, increasing from a 3% share of electricity output in 2016 to 5% in 2021.

Although the natural gas uptake in the transport sector will face some pressure from the "New-energy vehicles" policy, which supports EVs, PHEVs and FCEVs, the share of new natural gas vehicle sales will increase as follows: light vehicles (5.1% in 2016 to 6.4% in 2025), light trucks (6.3% to 10.1%), buses (4.9% to 6.5%) and heavy trucks (4.8% to 5.0%). As a result, the new natural gas fleet will grow 10% per year. In addition to new vehicle sales, there will be a significant proportion of converted vehicles, e.g. gasoline vehicles converted to 90-95% natural gas and 5-10% gasoline dual fuel vehicles, and diesel vehicles converted to 50-70% natural gas and 30-50% diesel dual fuel vehicles, through the installation of pressurized tanks and gas injection systems. Buses and taxis in particular will drive the demand in response to urban air quality requirements.

Figure 6-4 China natural gas demand for key sectors, 2000-2021



Source: APEC Energy Demand and Supply Outlook 7th Edition, BAU scenario.

Most recent drivers of demand growth have been the pollution reduction policies that mandate coal to gas switching in residential and industrial sectors. The policy-led surge in demand was so strong in the winter 2017/2018 that it outpaced the increase in natural gas supply, resulting in widespread fuel shortage in several northern regions. The incident offered an instructive lesson to China, prompting new measures to strengthen supply security, the expansion of market reforms and prioritization of sectors for natural gas application.

6-2 Gas supply shortage in winter 2017/2018

Coal is largely responsible for China's notorious air pollution in the northern regions where it is used for heating during the winter. In 2016, more than 80% of northern China's heating demand was met by coal, of which about 77% is *sanmei*, a highly polluting, low-quality coal used in rural boilers.

In September 2013, the State Council issued the Air Pollution Action Plan detailing pollution reduction targets for three key industrial areas surrounding Beijing, Tianjin and Hebei areas (Jing-Jin-Ji), as well as the Yangtze River Delta and the Pearl River Delta to be achieved in five years before the end of 2017.[7,8] The Action Plan's objectives included the elimination of coal-fired boilers with a capacity of

[7] State Council, "Notice: Air Pollution Prevention Action Plan," September 10, 2013, http://www.gov.cn/zwgk/2013-09/12/content_2486773.htm

[8] Barbara Finamore, NRDC [online research platform], "China Pledges to Tackle Air Pollution with New Plan", September 13, 2013, https://www.nrdc.org/experts/barbara-finamore/china-pledges-tackle-air-pollution-new-plan; "China to Tackle Air Pollution with a New Action Plan" 2013 http://cleanairasia.org/node12066/

up to 10 tonnes per hour (10 t/h) in urban areas and newly built rural areas. Nationwide, small coal-fired boilers fitting this description accounted for 16% of China's coal demand in 2014 – or 460,000 units with the average capacity of 4t/h (combined capacity 177 million t/h).[9]

However, the mid-term progress review of the 2013 Action Plan revealed that cities were lagging behind on their end-of 2017 targets. In February 2017 the governments of Beijing, Tianjin and 26 other cities jointly released the "2+26 Work Program" aimed at accelerating the elimination of coal in residential and industrial sectors.[10] New directives mandated that the residential sector replace coal stoves in 50,000 to 100,000 homes with gas boilers or electric heaters by the end of October. By June, every thermal coal power operator had to obtain a permit from the local authority. As for the industrial sector, steel and aluminium producers were required to cut output by more than 30% during the peak pollution season from November to February. Small enterprises without work permits had to be closed.

Local governments were incentivized to implement coal switching with subsidies based on the switching numbers that were achieved. Meeting coal replacement targets was part of the officials' key performance indicators. The Ministry of Ecology and Environment issued disciplinary action against 18,000 companies and 12,000 officials between May and September 2017. While the directives on removing coal boilers were actively implemented, in numerous instances there was a lack of coordination with the construction of upstream infrastructure. In many villages coal boilers were dismantled before new gas boilers were installed or connected to pipelines, while people were strongly warned against burning any coal even as they waited in sub-zero temperatures.[11]

Retiring small coal boilers resulted in an additional 23 bcm demand of natural gas. The incremental demand in the residential sector was 2 bcm of natural gas and 1 TWh of electricity. Some industrial users (many of whom just switched from coal to gas) faced supply cuts, as gas intended for the industrial sector was redirected towards residential heating on orders from the NDRC. Meanwhile, businesses relying on inland LNG had to suspend their operations when the domestic spot prices for LNG tripled[12]. Unlike pipeline gas, the inland LNG market is deregulated and populated by a number of diverse players that buy gas from pipelines, liquefy and sell it as LNG via trucks at the spot rate. Although the supply disruptions and price volatility were temporary, these incidents have understandably reduced confidence especially among industries that are currently considering switching to gas. Continuing forward, a host of new measures must be introduced by the government and the state utilities to secure supply, stabilize and reduce overall gas prices, and institute retrofitting subsidies in order to ensure a successful and equitable transition towards cleaner fuels.

[9] IEA, "Global Gas Security Review 2018". P. 14
[10] Ministry of Environment, "The 2017 Work Plan for the Prevention and Control of Air Pollution", February 2017, http://dqhj.mee.gov.cn/zcfg/201709/t20170915_421697.shtml
[11] Viola Zhou, "Pollution fight cold comfort for families without heating in northern China", November 22, 2017, https://www.scmp.com/news/china/policies-politics/article/2120958/pollution-fight-cold-comfort-families-without-heating
[12] IHS Markit, Jenny Yang, "The Power of Policy", Presentation: February 2, 2018, Tokyo. For instance between July and October 2017, spot prices tripled from the national average 3,000 RMB/t to 9,000 RMB/t (from 433.5 USD/t to 1,300.6 USD/t)

The outcome was a preliminary success in terms of achieving the pollution reduction objectives. In the 11 months of the 2+26 Policy implementation, the particulate matter (PM) 2.5 emissions fell by 54% year-on-year (y-o-y), to 58 μg/m3, exceeding the initial 60 μg/m3 target. Targets were similarly achieved in Tianjin, Hebei and other cities. Nevertheless, China's carbon emissions have climbed to their highest in four years and the air quality index remains considerably above what is recommended by the World Health Organization. Further reduction of the usage of coal across a wider range of sectors is needed to address both of air quality and carbon emission issues.

6-3 Supply security measures

While the demand for gas surged on the back of policy and strong enforcement, domestic gas production was unable to catch up. Moreover, LNG regasification terminals worked over capacity in northern China, while pipeline flows from Turkmenistan and Uzbekistan were disrupted because of issues of their own. The natural gas shortage of winter 2017/18 offers valuable lessons for supply side solutions, including measures to increase LNG import capacity, expand underground gas storage, and improve pipeline interconnectivity. The winter shortfalls in gas availability have not derailed the fuel's role in the China's energy plan but supply security will be decisive to its future adoption.

6-3-1 Gas storage

The government recognized the lack of natural gas storage in China as the main obstacle to gas market development and the reason of the shortage in the winter 2017/18. Natural gas storage must meet the surges in demand and to serve as insurance against any unforeseen events, natural disasters, or occurrences that may affect the production of delivery of natural gas. Currently the combined storage capacity of the underground and LNG terminal storage meets only 3.3% of China's gas consumption, far below the world average of 11.7%.

The 13th Five Year Plan on Natural Gas Development targets the development of 14.8 bcm of underground gas storage (UGS) capacity by 2020. The NDRC also mandated that by 2020 the following storage measures: 10% of annual contracted volume for wholesale suppliers, 5% of annual contracts for city gas distributors, and three days-worth of demand for each administrative region.[13] If achieved, this would equal to 16% of the national gas demand. Recently, PetroChina announced plans to develop 15 bcm of storage by 2025, the equivalent to 10% of China's peak seasonal demand.[14]

An obstacle faced by China is the lack of depleted salt caverns and gas fields that can be converted into UGS facilities. Moreover, this technically challenging and costly endeavour struggles to attract private commercial interest in the absence of price incentives. In the liberalized markets in Europe and United States, developers can take advantage of seasonal arbitrage by stockpiling gas when prices

[13] State Council "Opinions on Coordinated and Stable Development of Natural Gas", September 5, 2018 http://www.gov.cn/zhengce/content/2018-09/05/content_5319419.htm

[14] "China Petroleum's long-term effort to accelerate the construction of gas storage capacity" March 15, 2018, http://www.cnpc.com.cn/cnpc/jtxw/201803/b703da6ee93a486081ae0cad04237fb1.shtml

are cheap for resale in the winter when prices are high. Storage allows for price arbitrage between high demand and low demand seasons.

The NDRC document encourages various investment entities to participate in the development and operation of storage facilities, including pipeline operators, gas suppliers and independent third parties. Operators of storage facilities are also encouraged to receive sufficient remuneration for their operation and to promote seasonal arbitration.

6-3-2 Transmission and distribution measures

Poor pipeline interconnections resulted in transmission bottlenecks, exacerbating the supply disruption of December 2017. LNG imported in the south could not be piped north in sufficient quantities because of network limitations. This led to the underutilization of the southern regasification terminals, where utilization rates averaged only 46%. By contrast, northern LNG regasification terminals operated at full capacity, in some cases exceeding their nameplate capacity at a 151% utilization rate.

Domestic suppliers came up with a number of measures to address the constraints in the short term. In a first effort for China, CNOOC injected gas into CNPC's trunk pipeline (inter-provincial pipeline) to optimize supply to the northern part of Guangdong province. CNOOC's natural gas from its Zhuhai LNG terminal (south) and gas produced from the South China Sea was injected into the CNPC West-East pipeline III that supplies the north; 7.25 million bcm/day were allocated through this method to 1.5 million households. Before the end of 2019 PetroChina will invest more than 25.8 billion RMB (3.7 billion USD) to develop 33 interconnector projects for improving pipeline transmission. The company has also been working with CNOOC and Sinopec to connect the Guangxi LNG terminal to the China-Myanmar pipeline and to link the Guangdong LNG terminal to the West-East pipeline.

In the absence of pipelines capacity in December 2017, state-owned companies chartered LNG trucks to deliver LNG from their import terminals in the south to the north. CNOOC sent 100 LNG trucks in December 2017 and Sinopec sent one LNG truck in January 2018. It takes two days to cover the average 2,400 km route in one direction. Reuters calculated that for a 20 tonne truck with cargo value 180,000 RMB (26,000 USD), the transport costs came to roughly 50,400 RMB (7,240 USD), nearly a third of the price of cargo[15].

6-3-3 LNG regasification capacity

The construction of three new onshore LNG terminals (Tianjin Nangang, Shenzhen Defu, and Zhoushan) and the expansion of the Qidong terminal are scheduled for completion in 2018. Together, they add 14.3 bcm to China's LNG import capacity, bringing it to 87 bcm. The 4.1 bcm Tianjin Nangang

[15] Reuters, "As China gas crunch grows, CNOOC hires 100-truck convoy to ship LNG to icy north", December 15, 2017, https://www.reuters.com/article/china-pollution-gas-cnooc/as-china-gas-crunch-grows-cnooc-hires-100-truck-convoy-to-ship-lng-to-icy-north-idUSL4N1OF1HX

terminal increases northern import capacity to 20.2 bcm. Moreover, in June 2018, CNOOC and Norwegian Hoegh signed a three-year charter agreement with an option for one-year extension of a FSRU at the Tianjin Nangang. The chartered FSRU Esperanza has a regasification capacity of 750 million ton/day and storage capacity of 170,000 cubic meters. All in all, there are currently 20 construction and expansion projects under development and planning, which could bring the total terminal count to 31 with regasification capacity of 190.6 bcm.

6-4 Key policies

More than a dozen policies have been issued in the past two years to promote and clarify the central role natural gas is to have in the national energy strategy.

6-4-1 13th Five-Year Plan

In December 2016, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) released the 13th Five-Year Energy Development Plan announcing that the share of gas in primary energy consumption had to be increased from 5.9% in 2015 to 10% by 2020.[16]

Then in June 2017, the NDRC together with 13 ministries announced in its "Opinions on Accelerating the Application of Natural Gas" that gas is to "gradually become one of the main energy sources of China's modern clean energy system." [17] By 2020, underground gas storage is to have a working capacity of 14.8 bcm. By 2030, the plan aims to increase the share of natural gas in primary energy consumption to 15% and to raise the underground storage to more than 35 bcm. The notice further encourages the development of natural gas peak shaving to balance the output from photovoltaic and wind power stations.

6-4-2 Winter clean heating in northern China

The NDRC, NEA and 10 government agencies published a 5-year plan (2017-21) for clean winter heating in northern China in December 2017[18]. Although Clean Heating in the plan refers to a mix of energy solutions including electricity and coal, incremental natural gas demand is expected to be 23 bcm by 2021. The figure is made up of 9 bcm/year of additional gas use from switching coal-fired to gas-fired boilers in 12 million households, 7.5 bcm/year of new and renovated gas-fired co-generation plants, and 5.6 bcm/year from new and renovated gas-fired boilers, and 0.9 bcm/year from gas-fired

[16] NDRC and NEA, "13th Five-Year Energy Development Plan" December 2016, http://www.gov.cn/xinwen/2017-01/17/5160588/files/595b9ac5f61d46c4828b99404578eba5.pdf
[17] NDRC, "Opinions on Accelerating the Application of Natural Gas", June 2017, http://www.ndrc.gov.cn/zcfb/zcfbtz/201707/W020170704620817903063.pdf
[18] NDRC, "Winter clean heating plan in the northern regions (2017-2021)", December 2017, http://www.gov.cn/xinwen/2017-12/20/5248855/files/7ed7d7cda8984ae39a4e9620a4660c7f.pdf

distributed heating.[19]

6-4-3 The battle for Blue Sky Policy

In June 2018, the State Council issued a three-year action plan to win the "Blue Sky" battle. It aims to reduce emissions in the Beijing, Tianjin, and Shanghai areas, as well as certain cities in Hebei, Henan, Shanxi, Shanxi, Shandong, Jiangsu, Zhejiang and Anhui provinces. By 2020, NO_x and SO_x concentrations are to be reduced by 15%, while PM 2.5 concentrations are to be reduced by 18% from a 2015 baseline (the same targets for PM 2.5 reductions were set in the 13th Five-Year-Plan in 2016, but many cities under-performed; new cities were also included in this current policy).

There are mixed implications of the Blue Sky plan for natural gas. On one hand, the plan recognizes of the need for more storage capacity after the supply shortage of December 2017. Natural gas is to be prioritized in urban heating. At the same time the plan calls for an "orderly development of new gas-fired power peaking stations." There would also be "no new gas co-generation plants and natural gas chemical projects." At the same time, the share of centralized "clean coal" CHP is to be increased in power generation from 43% in 2015 to more than 55% in 2020.[20]

6-4-3 Transport

With more than 6 million natural gas vehicles (NGVs) China is the largest market for NGVs, accounting for one-fifth of NGVs.[21] The 13th FYP aims to increase the fleet of NGVs to 10.5 million by 2020, mandating an increase by 12.2% of annual vehicle production until then. Other supportive measures for the gas uptake in the transport sector include subsidies for LNG fuelled trucks, zero VAT on transport gas, favourable diesel and gas price differentials, and the government backed expansion of natural gas refuelling stations. China has nearly 200,000 heavy-duty trucks that use LNG as fuel.[22] China has been increasing the production of gas-fuelled trucks in recent years: nearly 96,000 units were produced in 2017, up by 389% from the year before.[23] As of this writing, the transport and environment ministries are reportedly drafting a plan to replace a million heavy duty diesel trucks, almost 20 percent of the national trucking fleet, with trucks that run on higher-grade diesel called National Five, and electric or LNG based trucks.[24]

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[19] IEA, "Global Gas Security Review 2018", p. 25

[20] State Council, "Notice on the Three-year action plan to win the blue sky war", June 2018, http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm

[21] Natural Gas Vehicle Knowledge Base, Current Natural Gas Vehicle Statistics, 6 July 2018, http://www.iangv.org/current-ngv-stats/

[22] International Gas Union (IGU), "Small Scale LNG", 2012-2015 Triennium Work Report", June 2015, http://www.igu.org/sites/default/files/node-page-field_file/SmallScaleLNG.pdf

[23] Xie Guangyao, *cvworld.cn* transportation industry portal, 30 May 2018, http://www.cvworld.cn/news/sycnews/guangyao/180530/145380.html

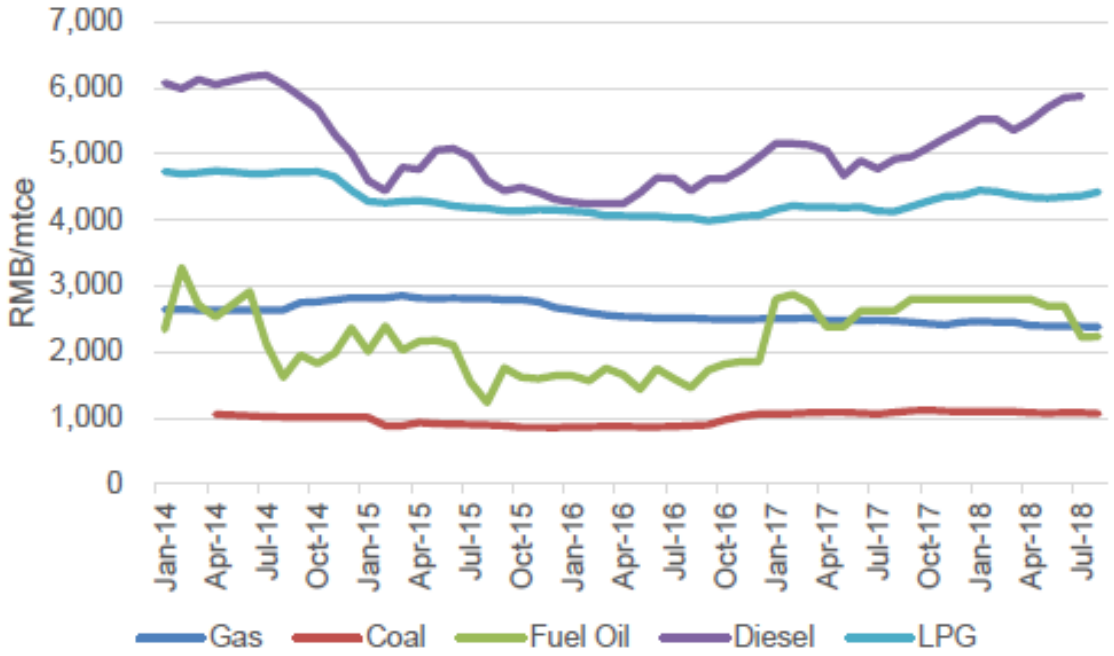
[24] Meng and Josephine Mason, "In war on smog, China considers how to take polluting diesel trucks off the road", Reuters, 13 September 2018, https://www.reuters.com/article/us-china-pollution-diesel/in-war-on-smog-china-considers-how-to-take-polluting-diesel-trucks-off-the-road-idUSKCN1LT0NQ

6-5 Fuel competition

6-5-1 Price competitiveness and expansion of "clean coal"

While the prices of coal and oil rose in 2017 (up 52% and 30% y-o-y respectively), international spot LNG prices were down 40% y-o-y.[25] The gradual improvement of the price competitiveness of gas was a contributing factor to its marginal demand growth. Still despite the narrowing price gap, coal remains the most affordable fuel for industries and power utilities.

Figure 6-5 Domestic energy costs for China's industrial sector, 2014-2018



Source: O'Sullivan, Oxford Institute for Energy Studies November 2018

To incentivize gas use in heating, the finance ministry indicated that it would pilot gas switching subsidies in certain cities. The budget of RMB 0.5 to 1 billion (about USD 73 – 146 million) was to be distributed to 12 pilot cities. Critics of this policy look at the experience of Beijing, where subsidies have run out but the pollution is continuing, demonstrating that if China's richest city was unable to elicit a long-term behavioural change with subsidies then poorer cities would have a harder time. In other words, unless natural gas prices can be consistently levelled with alternative fuels, the relative and absolute increase in natural gas consumption will continue to face challenges.

[25] Shan Weiguo, CNPC Economics & Technology Research Institute, "Golden Era is back to China?" Nov. 1 2017, at the IGU.

6-5-2 Coal use policies

Coal-to-gas switching is competing with an emerging government push for *sanmei*-to-"clean coal" switching both in heating and power generation sectors. *Sanmei* is a highly polluting, low-quality coal used in dispersed, rural heating. This is to be replaced by large, centralized coal-fired CHP and coal boilers with ultra-low emissions, referred to as "clean coal" technology.

Coal-fired power generation technology underwent many upgrades in recent years with certain models reaching the same level of emissions as gas-fired power.[26] As such, the 2018-20 "Blue Sky" pollution reduction plan mandates that more than 55% of coal use in China is to be concentrated in power generation, up from 43% in 2015.[27] The implication is that cross-sectoral use of distributed coal is reduced and consolidated in large power generation centres where pollution reduction is more manageable. In China where renewable sources are the centrepiece of the electricity mix, large baseload thermal power will be preferred to "clean coal", while gas is to be used in peaking power stations. Natural gas will have limited use in baseload generation, as explicitly mentioned in the Blue Sky policy that there will be "no new natural gas cogeneration projects."

As for the heating segment, the 2017 Clean Heating Plan aims to replace *sanmei* with four types of heating sources: natural gas, electric heating, "clean coal" and renewable sources. The clean heating mix is expected to achieve 50% penetration in northern regions by replacing 74 million tonnes of dispersed coal, including its use in low-efficiency and small coal boilers by 2019. By 2021, the clean heating penetration is to reach 70%, replacing 150 million tonnes of dispersed coal. More specifically in the 2+26 cities, in 2019 the clean heating rate should be more than 90%, while in rural areas it should be 40%. By 2021, heating needs in the 2+26 urban districts must be fully met with clean heating systems, while all coal-fired boilers under 35 tonnes of capacity must be eliminated. In rural areas, clean heating should achieve at least 60% penetration.

Based on fuel availability and price, "clean coal" is likely to account for the largest share of the clean heating mix in urban districts. Natural gas heating in cities is likely to grow by 50%, while "clean coal" will nearly triple from 2016 levels by 2021[28]. By contrast in rural areas, dispersed coal will remain the predominant heating fuel but its share will be reduced with the introduction of renewable energy.

By volume of coal, rural households account for only 5% of national coal demand, but this usage segment contributes to a disproportionately high 40% share of overall PM 2.5 emissions[29]. The replacement of dispersed coal with cleaner heating would significantly contribute to the improvement of environmental quality and health. At the same time coal is the single largest source of energy for rural households, accounting for 76% of their annual energy use. The massive overhaul of dispersed

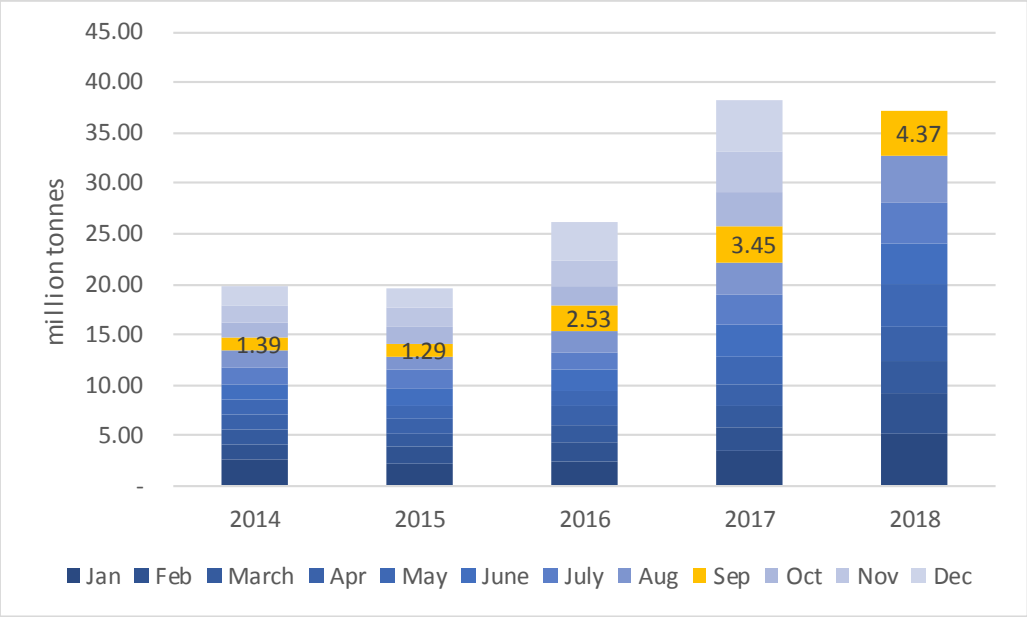
[26] IEA, "Global Gas Security Review 2018", p. 26
[27] *Ibidem*.
[28] IHS Markit, Jenny Yang, "The Power of Policy", Presentation: February 2, 2018, Tokyo.
[29] PwC Strategy&, "Natural Gas Application Opportunities in China" 2017, p. 44
https://www.strategyand.pwc.com/media/file/Natural-Gas-Application-Opportunities-in-China-2017.pdf

coal faces colossal economic and structural challenges, which must be carefully handled under a coordinated energy plan to ensure that people are not left without heating in the winter again.

6-6 Impact on international markets

Faced with constraints on piped imports and limited domestic production in the winter 2017/18, China took to the international LNG market to meet its surge in demand. China's LNG imports grew by 46% y-o-y from 26.15 million tonnes in 2016 to 38.29 million tonnes in 2017. Monthly imports have been rising annually, reaching the all-time highest levels in 2018. In the first nine months of 2018, China imported almost as much LNG as in the entire year 2017.

Figure 6-6 China monthly LNG import volumes, 2014-2018



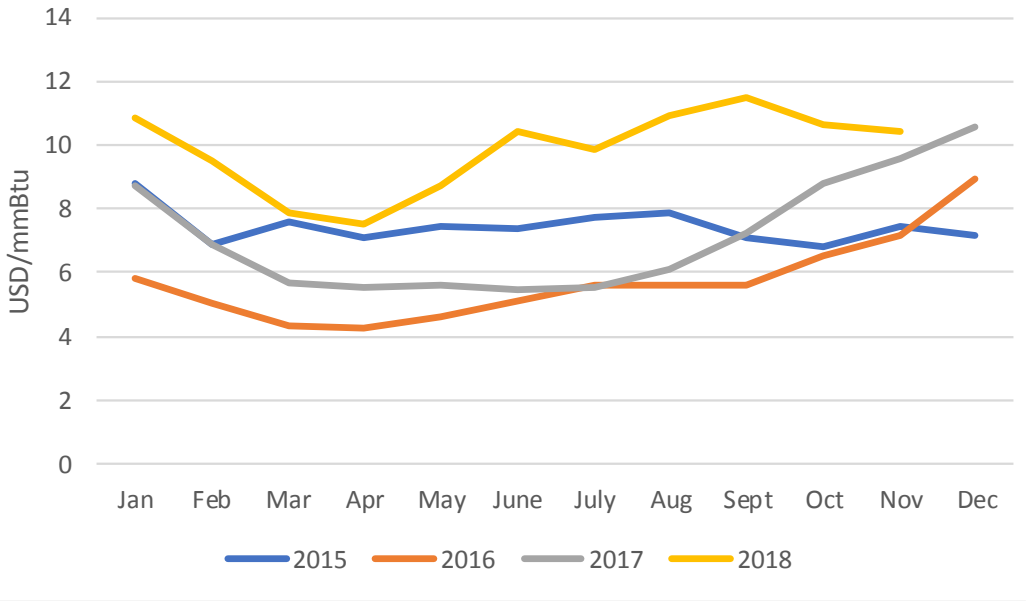
Source: Compiled from General Administration of Customs, PRC

The year 2017 saw a record high in spot purchases at the expense of term contracts – nearly 20% of LNG imports were spot purchases. Much like other buyers in Asia, China is showing a preference for shorter and more flexible contracts. Notably because to its lack of storage and distribution bottlenecks, China has been turning to the international spot market to meet its demand volatility. In the future if the expansion of the domestic buffer measures fails to keep up with the growing seasonality of demand, an expanded presence on the international market can be expected.

The increasing appetite for LNG in China and among regional buyers is reflected in Northeast Asian spot LNG prices that rose towards the end of 2017 and throughout the following year remained at the record highest since 2015. The price rose in April 2018 from around 7 USD/MMBtu and remained at 10 USD/MMBtu or higher between June and November. After China imposed 10% tariffs on the

imports of US LNG in September 2018 there have been additional concerns about the potential tightening of the market as Chinese buyers turn to other sellers. Despite these fears, prices stabilized at around 10 USD in November 2018. The prices in winter 2018/19 are expected to remain high in response to demand that generally picks up in the winter. By contrast to last year there will be less volatility from China due to stockpiling of gas over the summer and no new deadlines for gas switching targets set for this year.

Figure 6-7 Asia monthly average LNG spot prices, 2015-2018



Source: compiled by IEEJ from price reporting agencies

6-7 Conclusion

China's natural gas consumption is set to expand thanks to policies that promote its usage in the industrial, clean heating, power generation and transportation segments. Going forward, the key issues that need to be resolved are gas supply security, price stability and competitiveness with coal. The disruptive supply shortage of winter 2017/18 raised concerns about the reliability of natural gas among many end-users and could lead them to choose alternatives. Despite recent upgrades in coal fired technology, its general use in power generation, electricity and heating remains more hazardous to health and the environment compared with natural gas. As such, policies have to reflect externalities in the pricing of fuels while encouraging investment in China's clean energy development.

Recent experiences have highlighted for China the urgent need to strengthen its upstream and midstream supply capacity. The government and state-owned companies are actively implementing measures to increase domestic production and diversify imports, notably by expanding terminal

capacity and securing new supply contracts. Natural gas storage is a priority and the government is urging private sector involvement. The gas flow bottlenecks towards the north are addressed by strengthening interconnections and an expanding fleet of LNG delivery trucks.

China's dramatic shift to gas and its growing presence on the LNG import scene has so far been reflected in the regional spot pricing. However, if China manages to buffer domestic demand with increased storage and distribution capacity, as well as the diversification of supply, it will have less impact on regional prices in the future.

Section 7. Conclusions and main takeaways

In 2017, about 57% of global natural gas consumption took place in the APEC region. Moreover, gas accounted for at least 10% of TPES in all APEC economies, except in three (Chile, China and Philippines). US gas consumption grew by 29% (148 Mtoe) while China has increased by 264% (124 Mtoe). They are the largest contributors to the APEC region demand growth. Overall, electricity remains the main growth driver in the APEC region, but industry also increased rapidly. This contrasts with global gas demand growth, where industrial demand accounted for the largest growth sector.

APEC gas production increased 26% in the last decade, while its share remained stable at around 57% of world's production. The US surpassed Russia in 2012 as the world's largest producer. Moreover, APEC members not only account for most of global gas demand but also three of the world's four largest gas producers are APEC members (US, Russia and Canada). During the last decade, the US, Russia, China and Australia were the largest contributors to APEC production growth. Conversely, Mexico's production shrank by 40% (17 Mtoe) in the same period, the largest production decline of the 21 APEC member economies.

In terms of natural gas trade, APEC remains a net exporter region, mostly driven by Russian piped exports to Europe. However, only 25% of gas production in APEC economies is exported outside the APEC region. Most APEC members have active gas trade with the exception of Viet Nam, Philippines and New Zealand. Additionally, Russia remains the world's largest gas exporter. Nevertheless, the US more than tripled its natural gas exports including pipeline deliveries and LNG exports from 2007 to 2017. APEC gas imports represented 42% of world imports. Japan was the largest natural gas and LNG importer in the world in 2017. However, China was the fastest growing importer in the world, with LNG accounting for 57% of its gas imports.

While, globally most natural gas is still traded via pipeline, LNG trade has grown quite fast, and the APEC region is at the very core of this trend. From 2007-17, APEC LNG exports grew annually by 6.7% while world LNG exports grew by 6.0%. Australian LNG exports more than tripled in 10 years, leading growth both in the APEC region and globally. In addition, US LNG exports more than quadrupled compared with 2016, as most of the first wave of liquefaction projects on the Gulf Coast were operational in 2017. At the same time, LNG imports to APEC represented 72% of global imports, with 14 members importing LNG. Japan remains the largest LNG importer, despite falling demand since 2014. China became the second world's largest importer in 2017 with an impressive 35 Mtpa growth from 2007-17.

APEC gas demand is projected to increase by an average 1.8% to 1 900 Mtoe by 2021. This growth is driven by increasing demand in all APEC economies, with only the exception of New Zealand and Japan. On the other hand, demand growth continues to be driven mainly by the US and China. On the supply side, APEC gas production increases to almost 2 000 Mtoe by 2021. Combined production in United States, Russia, China and Australia increases by more than 230 Mtoe by 2021. Conversely, gas

production in Mexico, Indonesia and Thailand decreases steadily by 2021. In terms of trade, both piped and LNG imports to China almost double towards 2021, while North-east Asia and South-east Asia see growth in their gas imports, predominantly via LNG. US natural gas exports more than double from 2017 to 2021, with most growth in exported LNG but also steady growth on piped exports to Mexico. Russian gas exports also increase robustly with volumes to Europe similar to the ones seen in the past five years and incremental exports going towards China, once the Power of Siberia pipeline is commissioned.

In conclusion, with 57% of global gas consumption and production, APEC members are at the centre of global natural gas dynamics. China and the US are driving gas demand growth. While the shale revolution has substantially changed gas demand in the US, the impact of US LNG exports is still relatively limited compared with its potential. China gas demand will keep growing to become the world's largest gas importer and later the biggest LNG importer in the next five years. After sluggish developments of new LNG projects in recent years, linked to low LNG prices in Asia, the supply and demand balance could become tight in the early 2020s as demand in China and Southeast Asia continues to grow. As a result, three dynamics demand special attention in the next years: Russian piped and LNG exports to China; China's actions on increasing domestic pipeline infrastructure, further regasification and storage capacity as well as pricing mechanisms; and US LNG exports and their competitiveness in global markets, particularly in Northeast Asia and China versus Europe.

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