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AN OVERVIEW OF GLOBAL LIQUEFIED NATURAL GAS MARKETS AND IMPLICATIONS FOR CANADA

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SUMMARY

Liquefied natural gas (LNG) is a small but growing share of the global natural gas market. Global consumption of natural gas rose by 2.4 per cent between 2005 and 2015. The majority (70 per cent) of consumption relies on indigenous production. Most of the rest comes from pipelines, with LNG-sourced natural gas growing from seven to nine per cent of consumption between 2005 and 2015.

Global LNG imports increased rapidly between 2005 and 2011, rising from 193 to 334 billion cubic metres annually. They have stayed relatively constant since, averaging 324 billion cubic metres annually. Europe and Asia and Oceania are the primary recipients of LNG imports, accounting for 90 per cent of global imports from 2005 to 2015.

An increase in global LNG liquefaction terminals accompanied the rise in imports. From 2005 to 2015, the number of liquefaction terminals increased from 20 terminals in 13 countries to 38 terminals in 20 countries. Total global liquefaction capacity rose by almost 90 per cent, mostly in the Middle East.

The growth in LNG is largely attributable to an increasing mismatch between areas of natural gas supply and demand. As of 2016, the world's natural gas reserves were estimated at 194,782 billion cubic metres, with the Middle East and Russia and Eurasia having the largest shares, respectively.

Despite having smaller reserves, the largest gas-producing region is North America, which accounted for 26 per cent of global production from 2005 to 2015. Production in North America – and specifically the United States – steadily increased over this period as a result of advances in horizontal drilling and hydraulic fracturing and a corresponding surge in shale gas.

More so than other energy sources, the gaseous nature of natural gas has historically made it difficult to trade. This contributed to a rise in regional markets, with corresponding variation in prices. From 2010 to 2015 the LNG price in Asia was significantly higher than natural gas prices in Europe, which were in turn higher than prices in North America. These price differentials incited what was frequently referred to as the “LNG race,” with project proponents seeking to lock-in supply contracts and secure final investment decisions for new LNG liquefaction terminals.

Although price differentials still remain, they have narrowed considerably since the start of the oil price crash in 2014. Lower prices, combined with a growing surplus of LNG liquefaction capacity, has led to a significant slowdown in the approval of new LNG liquefaction terminals in recent years.

Looking ahead, however, another opportunity for LNG development lies on the horizon. Even if governments enact stringent measures to curb greenhouse gas emissions, natural gas production and consumption is expected to keep growing – the only fossil fuel to do so. Forecasts also suggest that the mismatch between areas of supply and demand will continue to become more pronounced.

Production growth in the Middle East, Russia and Eurasia, North America and Africa is forecast to exceed growth in demand. Correspondingly, all three regions are anticipated to have a growing natural gas surplus through to 2040. In contrast, Europe and Asia and Oceania both currently have natural gas deficits that are also forecast to grow.

New infrastructure will be critical to getting natural gas to consumers. While pipelines remain the cheaper option for transporting natural gas, Russia and Eurasia is the only major producing region with significant or planned pipeline access to external demand markets. As a result, it is expected that a second wave of new LNG capacity will be required by the mid-2020s.

Having missed out on the first LNG race, this second development window offers the most promising opportunity for proposed Canadian export facilities to enter the global LNG market. With numerous proposals for new liquefaction terminals on standby around the globe, however, this next wave of LNG development will again be highly competitive. It is therefore important that Canadian firms and investors act now to manage investment risks and position themselves to proceed with proposed projects as soon as the next window opens. Moreover, Canadian governments have an important role in ensuring the stability of policy and regulatory environments underpinning Canada’s attractiveness as an investment destination.

INTRODUCTION

Demand for liquefied natural gas (LNG) is primarily driven by its use as a transportation mode for the export of natural gas via tidewater port facilities.[1] As such, the demand for LNG has strong roots in the international demand for natural gas.

Global natural gas demand is growing and known reserves are more than sufficient for the foreseeable future. However, there is also a growing regional mismatch between areas of increasing demand and increasing supply. Specifically, growing natural gas deficits are forecast for Asia, where natural gas demand is rapidly growing, and for Europe, where growth in natural gas demand is more moderate but significant production declines are expected. In contrast, growing natural gas surpluses are forecast for the Middle East and Russia and Eurasia, which have the world's largest reserves of natural gas, as well as North America where technological advances in natural gas extraction are leading to rapid production increases in the United States.

While natural gas has historically been traded primarily by pipeline, the growing regional mismatch is largely between geographically distinct areas for which the trade of natural gas via pipeline is not feasible or for which pipeline infrastructure does not yet exist. This is expected to lead to a strong increase in global LNG demand among net consuming countries (those for which domestic consumption is greater than domestic production).[2] Net producing countries (those for which domestic production exceeds domestic consumption) have responded with a race to build additional LNG export facilities and to secure associated LNG supply contracts.

Canada is in a unique position within this global context. By virtue of the rapid production increases in the United States, Canada's only export market for natural gas has been shrinking. In addition, inexpensive natural gas produced in the northeast U.S. has been supplanting western Canadian supplies in the eastern Canadian market. As a result, despite significant natural gas reserves and improved extraction technology, Canada's natural gas production has marginally declined over the last decade.

Future sustained growth in natural gas production in Canada is expected to be contingent on producers gaining access to higher priced overseas markets. This in turn is contingent on Canada entering the global LNG market via the construction of LNG export facilities. The past six years have seen numerous proposals for facilities on Canada's East and West coasts. As of April 2018, however, only a single small-scale project had reached a positive final investment decision (FID) and no projects have started construction.

Within this context, this paper provides an overview of the current state of global LNG markets and a brief future outlook. It starts with a short review of historical patterns in international natural gas consumption, supply, trade and pricing. It then provides a summary of the current global LNG market, looking at how demand for LNG imports and liquefaction capacity have evolved in recent years. Last, it looks ahead and considers how the patterns in the natural gas market are expected to change, and the implications of these changes on the global LNG market, as well as the opportunity for Canada within this market.

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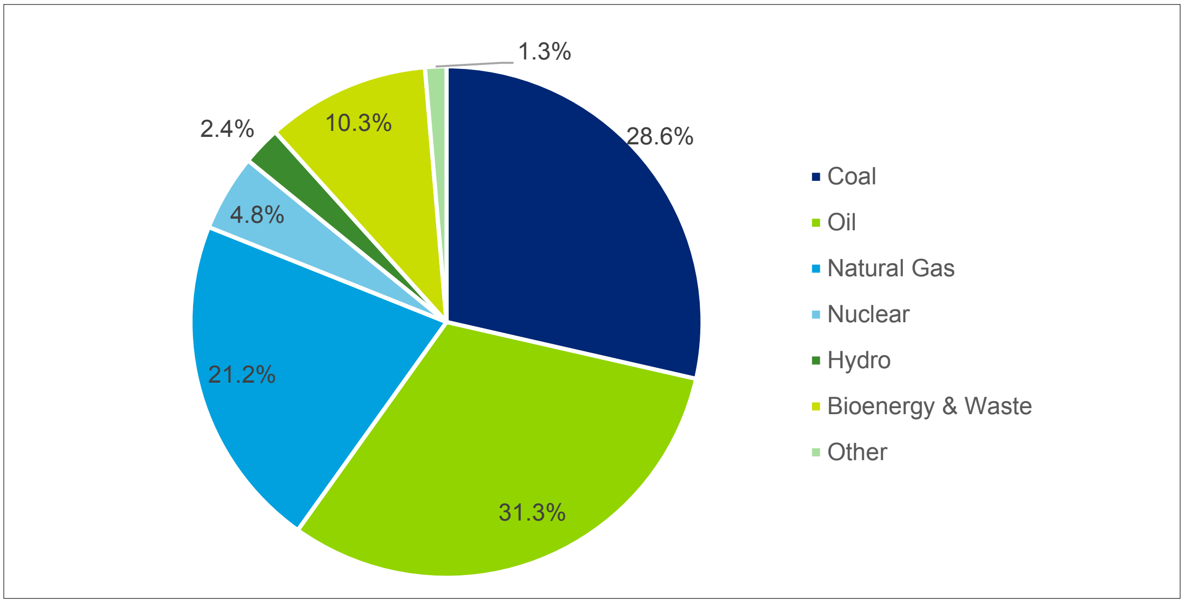
[1] Small amounts of LNG are also used as a transportation fuel in maritime vessels and commercial road transport (trucks), primarily as an alternative to heavy fuel oil and diesel. It is currently a niche market, however, and demand is relatively insignificant. For example, in 2012 LNG demand for the transport sector was less than five billion cubic metres (BCM). In contrast, total LNG trade in 2012 was 319 BCM (Wood Mackenzie 2014; Oxford Institute for Energy Studies 2016; International Energy Agency 2017a).

[2] LNG demand grew from 2005 to 2010, was fairly stagnant from 2010 to 2015 and is predicted to start growing again from 2016 onward (BP 2017; International Energy Agency 2017a).

RECENT TRENDS IN GLOBAL NATURAL GAS CONSUMPTION

Natural gas currently represents a significant proportion of the world's energy use, and its share has been increasing over time. In 2014 it constituted 21 per cent of world primary energy supply, behind coal (29 per cent) and oil (31 per cent) (Figure 1).

FIGURE 1 2014 GLOBAL PRIMARY ENERGY SUPPLY SHARES



Source: International Energy Agency (2017c)

Note: "Other" includes geothermal, solar, wind, other renewables and peat and peat products

Global demand for natural gas rose 2.4 per cent between 2005 and 2015, increasing from 2,866 to 3,571 billion cubic metres (BCM) (Figure 2). Much of this growth has been driven by developing countries in Asia and in the Middle East. Total consumption in the Asia and Oceania region[3] increased by 68 per cent from 2005 to 2015 while consumption in the Middle East[4] increased by 82 per cent. The largest single source of natural gas demand growth was China, where consumption increased by almost 300 per cent (50 to 193 BCM per year) between 2005 and 2015. This is not surprising, given the intense economic growth in China over this period. In contrast, consumption of natural gas increased by only 23 per cent in North America and declined by 18 per cent in Europe[5] over the same 10-year period.

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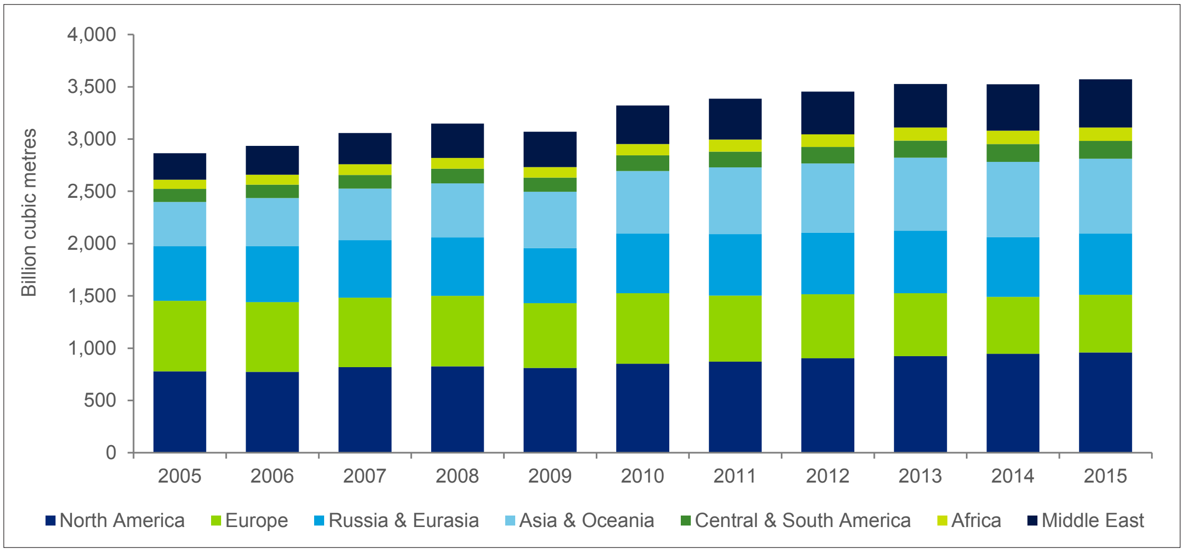
3 We use the International Energy Agency's definition of the Asia and Oceania region, which includes the following countries: Australia, Bangladesh, Brunei Darussalam, China (People's Republic of and Hong Kong), Chinese Taipei, Cambodia, India, Indonesia, Israel, Japan, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, North Korea, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Thailand, Vietnam and Other Asia. Other Asia includes Afghanistan, Bhutan, Cook Islands, Fiji, French Polynesia, Kiribati, Lao People's Democratic Republic, Macau, China, Maldives, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga and Vanuatu.

4 The Middle East region includes the following countries: Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates and Yemen.

5 We define Europe to include continental Europe and Eurasian countries located to the west of Russia. This includes the following countries: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom. We do not include Kosovo as natural gas data is not available.

FIGURE 2 GLOBAL NATURAL GAS CONSUMPTION



Source: International Energy Agency (2017f)

Looking ahead, natural gas can be expected to be a part of the global energy mix for the long term as its end uses continue to diversify. In particular, it is expected to play an important role in preliminary climate action activities as it is a less carbon-intensive alternative to coal for use in both industrial processes and electricity generation.[6] As the development of renewable energy sources has not yet been sufficient to replace fossil fuel sources of energy, natural gas is becoming a bridging fuel that many countries are adopting as part of their transition to cleaner energy sources. Even in the International Energy Agency's (IEA) "Sustainable Development Scenario,"[7] fossil fuels remain at 61 per cent of final energy demand in 2040, with a strong role for natural gas. In particular, natural gas is the only fossil fuel that sees an increase in production (+17 per cent) (Figure 3) and consumption (+19 per cent) relative to 2014. In contrast, production and consumption of coal are forecast to decline by over 50 per cent each while production and consumption of oil are each forecast to decline by nearly 25 per cent.

It is important to note, however, that the potential for sustained, long-run growth in natural gas demand is uncertain and will depend on the future stringency of climate change policies. This is because although natural gas is cleaner than coal it is still a carbon-emitting fossil fuel, and could be subject to future policy action. For example, simulations by the Energy Information Administration (EIA) of the Obama Administration's proposed U.S. Clean Power Plan suggested that in the short term, natural gas would replace a majority of the coal phased out under the Clean Power Plan (U.S. EIA 2015a).[8] In the longer term – 2030 and beyond – however, the EIA forecasted only small shifts in the amount of electricity generated by coal and natural gas. Long-term rising electricity demand would be supported by an expansion in renewable generation technologies, which were forecast to increase their generation capacity by over 80 per cent from 2020 to 2040.

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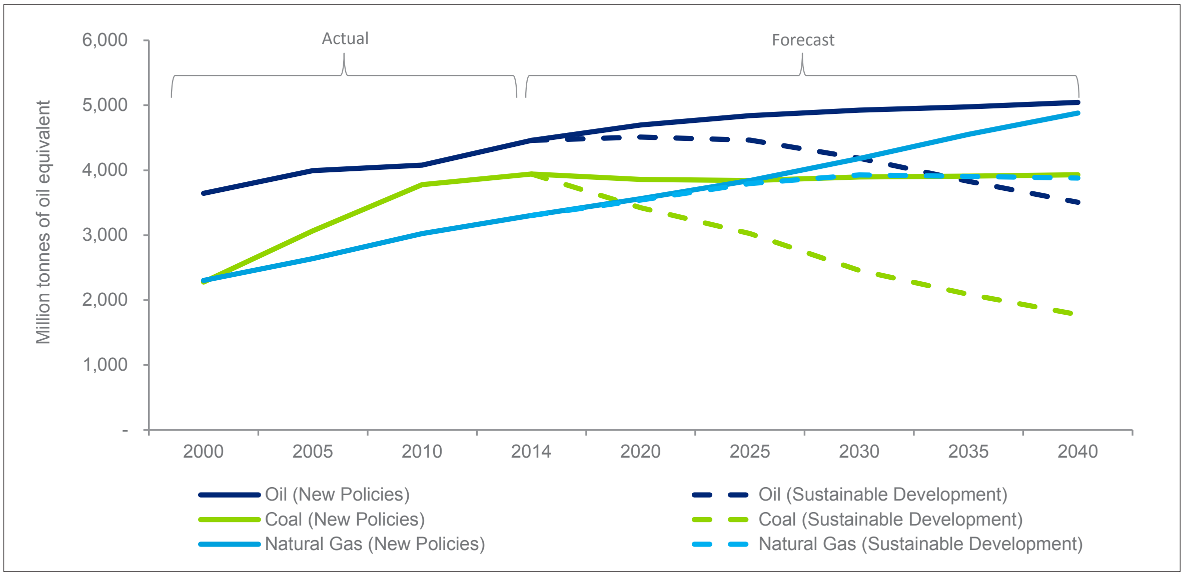
6 For example, estimates from the U.S. Energy Information Administration (EIA) indicate that in the U.S., energy generated by natural gas has 44 per cent fewer carbon dioxide emissions per BTU than energy generated by coal (U.S. EIA 2016a).

7 This scenario assumes policies will be put in place to limit global temperature increases to 2°C, improve energy access in developing countries and reduce air pollution.

8 The U.S. federal government under the Obama Administration developed the Clean Power Plan in 2014 and announced it in 2015. Numerous states quickly challenged its legality in the U.S. Court of Appeals for the District of Columbia, however, and in February 2016 the Supreme Court placed its implementation by the Environmental Protection Agency (EPA) on hold until the lower court reached a decision (Hurley and Volovici 2016). President Donald Trump regularly expressed his opposition to the Clean Power Plan during the 2016 election campaign and in March 2017 signed an executive order requiring the EPA to review the order and to decide whether to suspend, revise or rescind it (White House 2017). The EPA responded to this order in October 2017 when it issued a formal proposal to repeal the Clean Power Plan (U.S. EPA 2017).

FIGURE 3 FOSSIL FUEL PRODUCTION UNDER IEA NEW POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIOS



Source: Author calculations from International Energy Agency (2017b, 2017d, 2017f, 2017g)

The forecasts from the IEA in the World Energy Outlook also clearly demonstrate the expected impact of climate policy stringency on the production and consumption paths of natural gas. In the "New Policies" scenario, which assumes countries introduce and enforce policies to meet previously announced emissions reduction commitments, production and consumption of all fossil fuels are expected to increase between 2015 and 2040. The strongest growth rate is for natural gas, with production forecast to steadily increase at a compound annual rate of 1.5 per cent. In contrast, in the aforementioned "Sustainable Development Scenario," the anticipated compound annual growth rate in natural gas production is significantly lower at 0.5 per cent. Additionally, rather than steadily increasing, natural gas production is forecast to peak in 2030 and then hold relatively constant over the remainder of the forecast period.

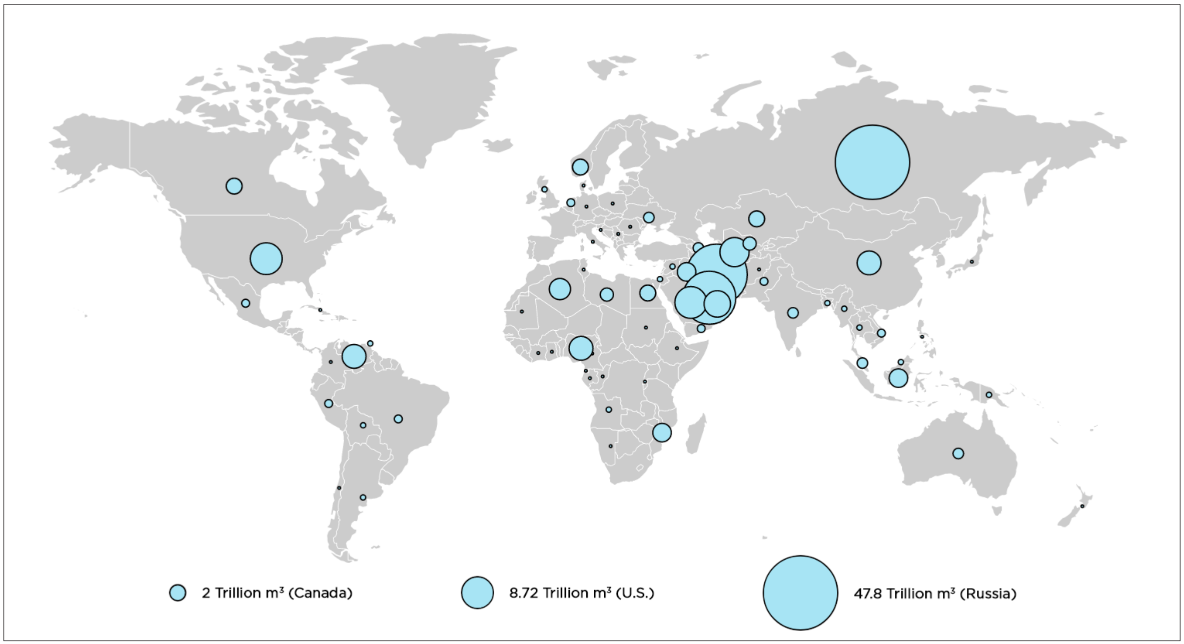
GLOBAL NATURAL GAS SUPPLY

In 2016, global natural gas reserves were 194,782 BCM, according to data from the EIA (U.S. EIA 2017). As depicted in Figure 4, the world's largest natural gas reserves are located in the Middle East (79,804 BCM), and Russia and Eurasia[9] (60,600 BCM). Despite having the world's largest reserves of natural gas, the Middle East lags significantly behind Russia and Eurasia in production. This is largely because natural gas markets are regionally constrained due to an historical lack of infrastructure to facilitate interaction between overseas markets. With substantial pipeline capacity running from Russia to Europe – which has notably smaller natural gas reserves (4,815 BCM in 2016) – Russia and Eurasia have access to a large export market that has historically accounted for approximately 20 per cent of world consumption. The Middle East, in contrast, has very limited natural gas pipeline access to Europe[10] and the majority of its LNG export capacity has only been developed since 2004.

9 We include the following countries in our definition of Russia and Eurasia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, and Uzbekistan.

10 The only natural gas pipeline connecting the Middle East with Europe is the Tabriz-Ankara pipeline that runs from Iran to Turkey.

FIGURE 4 2016 GLOBAL NATURAL GAS RESERVES

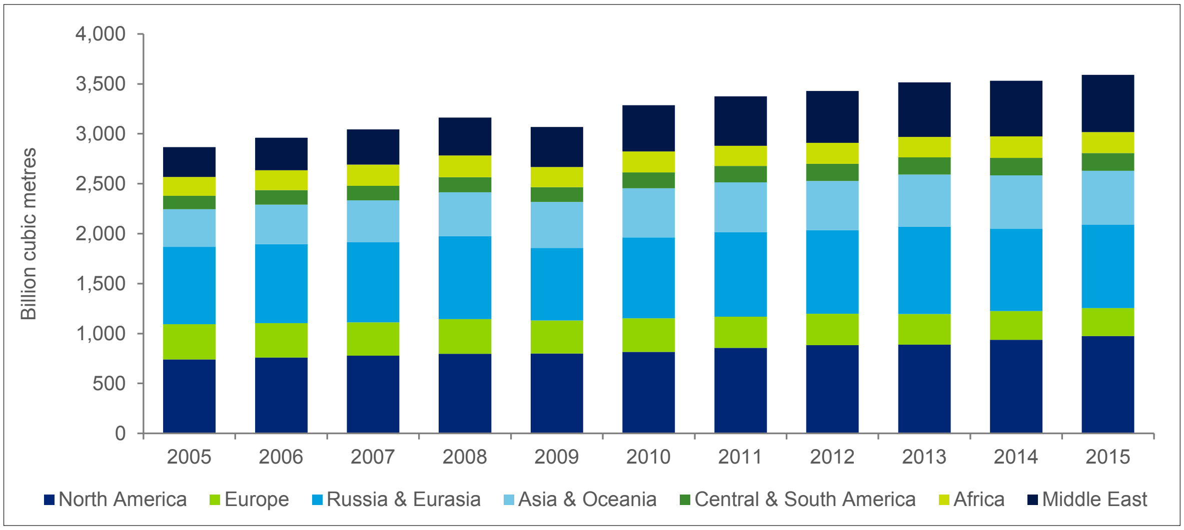


Source: U.S. Energy Information Administration (2017)

Russia and Eurasia is one of the world's largest producing regions of natural gas, accounting for 25 per cent of global production between 2005 and 2015 (IEA 2017f). Production over that period has varied between 725 and 875 BCM per year (Figure 5). The Middle East, in contrast, accounted for only 14 per cent of global natural gas production over this period. Middle East production has been sharply growing, however, rising from 300 BCM in 2005 to 573 BCM in 2015. The Middle East's share of global production correspondingly grew from 10 to 16 per cent. The rise in production has been driven by the increase in demand for natural gas in the Middle East, as well as a sharp increase in LNG export capacity. Specifically, over the period of 2004 to 2011, LNG export capacity in the Middle East increased from 29 to 100.8 million tonnes per annum (MTPA). This corresponds to an increase in natural gas export capacity of approximately 98 BCM.[11]

[11] The Middle East has not added any further LNG export capacity since 2011, nor does it have any LNG export facilities under active construction (International Gas Union, 2017). Qatar announced in July 2017, however, an intention to increase its export capacity by an additional 23 MTPA by 2022 to 2024 (DiChristopher, 2017).

FIGURE 5 GLOBAL NATURAL GAS PRODUCTION



Source: International Energy Agency (2017f)

Narrowly edging out Russia and Eurasia, the world's largest natural gas producing region over the last 10 years is North America. Despite accounting for only six per cent of global reserves (11,950 BCM), North America accounted for 26 per cent of global production from 2005 to 2015. Production steadily increased over this period, rising from 742 to 975 BCM. This increase is largely attributable to the commercialization of horizontal drilling and hydraulic fracturing techniques, and the corresponding boom in shale gas production in the U.S. As noted earlier, Canadian production declined slightly over this same period, predominantly as a result of declining demand for natural gas imports in the U.S.

The Asia and Oceania region is similar to Europe in that it has small natural gas reserves relative to its demand. At 15,325 BCM, reserves in the region account for slightly less than eight per cent of global reserves. With a high demand for natural gas driven by its large population, the region has historically produced more natural gas than the Middle East,[12] accounting for 14 per cent of global production from 2005 to 2015. However, the region is also heavily reliant on external suppliers, with imports of known external origin accounting for 20 to 25 per cent of its consumption in recent years. Unlike Europe, it has limited pipeline connections to areas of significant supply and therefore relies primarily on LNG imports from the Middle East, as well as smaller amounts from Africa and Russia. Looking ahead, shale gas production has the potential to change the market dynamics in the Asia and Oceania region. China is already producing natural gas from its shale gas reserves – the world's largest (U.S. EIA 2015d) – and Australia has significant reserves that it is starting to explore. Total natural gas production in the region (from conventional and shale resources) has been steadily rising, increasing by 44 per cent from 2005 to 2015. When paired with rapid growth in natural gas consumption, however, the region continues to be heavily reliant on external imports.

Looking ahead, infrastructure for natural gas trade will be critical to getting natural gas from source countries to areas of consumption. Pipelines remain the primary delivery mechanism for natural gas but, as seen by historical trade and production patterns, they are constrained by fixed routes that cannot always connect areas of high reserves with areas of high demand. Pipelines can also be challenging to build across international boundaries and oceans. LNG, in contrast, offers the opportunity for exporting countries to access worldwide markets. This provides countries with the additional benefit of the flexibility to adjust deliveries in response to changing international

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[12] The Asia and Oceania region produced more natural gas than the Middle East from 2005 through to 2011. The Middle East surpassed its production in 2012 and has remained higher over the last four years.

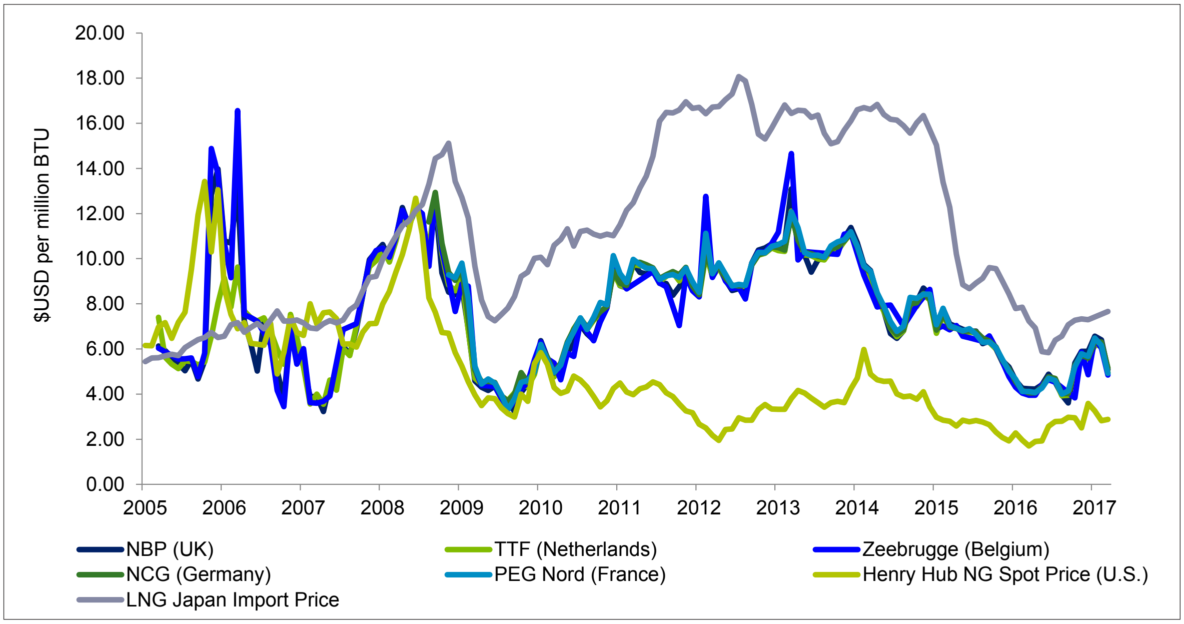
market conditions. However, the feasibility of these adjustments depends on the supply contract structure. Historically, standard LNG supply contracts tended to be high-volume and long-term. However, the market is increasingly moving towards smaller shorter-term contracts (Royal Dutch Shell plc. 2017). This shift represents a trade-off between the certainty of return on investment (under high-volume long-term contracts) towards flexibility to exploit new and changing international market dynamics (under lower-volume shorter-term contracts) (Hartley 2014; Stapczynski 2016). As the IEA has noted, a specific feature that U.S. projects offer is freedom from destination clauses, which is bringing increasing flexibility to LNG markets (IEA 2016).

GLOBAL NATURAL GAS TRADE AND PRICING

The gaseous nature of natural gas makes it more difficult to trade relative to other energy sources. The limited ability to distribute natural gas across major bodies of water via pipelines has constrained interactions between international gas markets and has resulted in price separation between some markets around the world. As a result of this physical constraint regional markets have developed, each with its own pricing point and energy-content characteristics. Monthly natural gas prices for major global pricing points are shown in Figure 6. There is clear volatility and regional variation in the prices, though recently the prices have exhibited greater convergence.

In Canada and the United States, the price of natural gas is determined by competitive markets. The price at any given time depends on production and exploration, storage, weather patterns, transportation constraints, the pricing and availability of competing energy sources, as well as market participants' views of future trends, and potentially other variables not identified here. Natural gas prices reflect an integrated supply-and-demand network, as well as an integrated pipeline network. Notably, increasing production of shale gas resources in recent years has created oversupply conditions and depressed local North American prices below international benchmarks. This has contributed to substantial North American interest in developing LNG export capacity.

FIGURE 6 MONTHLY NATURAL GAS AND LNG PRICES FOR SELECTED HUBS



Source: Bloomberg (2017) and International Monetary Fund (2017)

Note: BTU refers to British Thermal Unit, and is a measure of heat. Historical natural gas monthly average spot prices correspond to the following Bloomberg indices: NBP (NBPGWTHN Index), TTF (TTFGDAHD Index), Zeebrugge (ZEEBWTHN Index), NCG (EGTHDAHD Index) PEG Nord (PNXIGNWD Index), Henry Hub (NGUSHHUB) and Japan LNG (LNGJLNJP). Prices are converted to US dollars using monthly exchange rate averages reported by the International Monetary Fund.

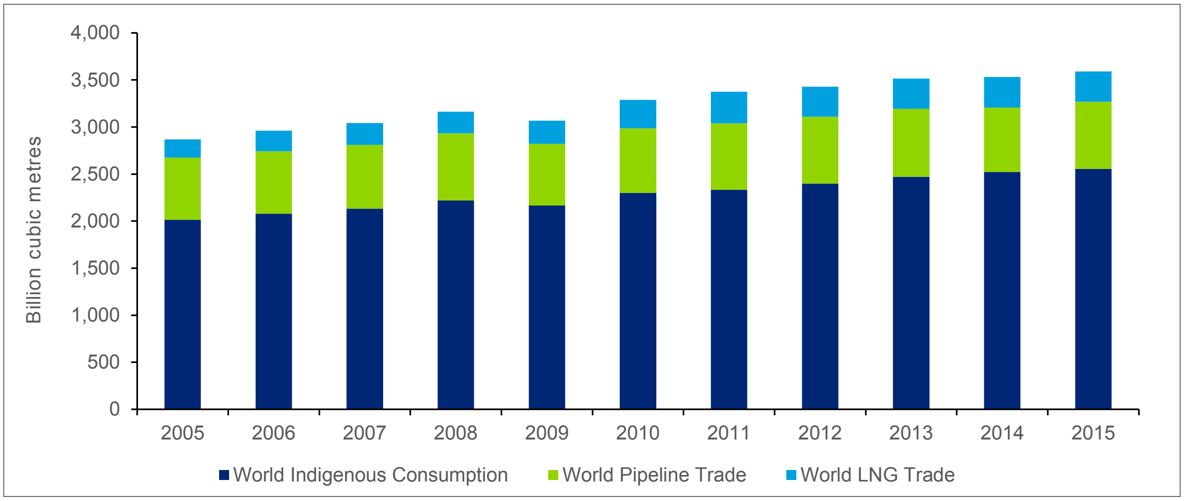
Other regions have historically had less robust markets for natural gas and have subsequently relied more on long-term contracts to set prices.[13] Prior to the last decade, Russian natural gas contracts were predominantly linked to oil prices; however, in recent years such contracts have increasingly introduced elements of hub indexation (linking the contract price to established spot market hub pricing). This has led to a convergence of the Russian supply price and the European spot price as represented by the U.K. National Balancing Point (NBP) price (Dickel et al. 2014). Specifically, Dickel et al. find the Russian markup vs. NBP spot price fell from a recent high of over $100/MCM to $0/MCM between 2009 and 2013.

Following the same trend, prices for LNG have begun to move away from oil price indexing and towards spot market hub-based pricing.[14] This move has largely been driven by the potential of LNG supply from North America, which has promoted the use of the Henry Hub natural gas price (the North American benchmark) as a convenient benchmark against which to hedge LNG contract prices. As an example, Cheniere Energy, an LNG exporter on the U.S. Gulf Coast, has signed contracts where the price of LNG is equal to the sum of 115 per cent of the Henry Hub price plus a flat liquefaction fee (Cheniere Energy 2017).

As noted above, there is a mismatch globally between significant areas of natural gas demand and their productive capacity. Despite this, the majority of global natural gas consumption (approximately 70 per cent) occurs from indigenous production (Figure 7). The majority of the remaining 30 per cent is delivered by pipelines, with LNG-sourced natural gas increasing from seven per cent of consumption in 2005 to nine per cent in 2015.

Figure 8 shows the resultant trade patterns and markets for natural gas. Notably, North and South America engage in limited natural gas trade, either via pipeline or LNG. In contrast, Europe and Asia are substantial demand centres and engage in significant trade. Europe's cohesive geography has led to a reliance on pipeline-borne natural gas trade, whereas Asia relies almost entirely on LNG for natural gas imports. We also see the Middle East's role as a supply hub for LNG; its location enables it to supply both Europe and Asia.

FIGURE 7 GLOBAL NATURAL GAS CONSUMPTION BY SUPPLY SOURCE



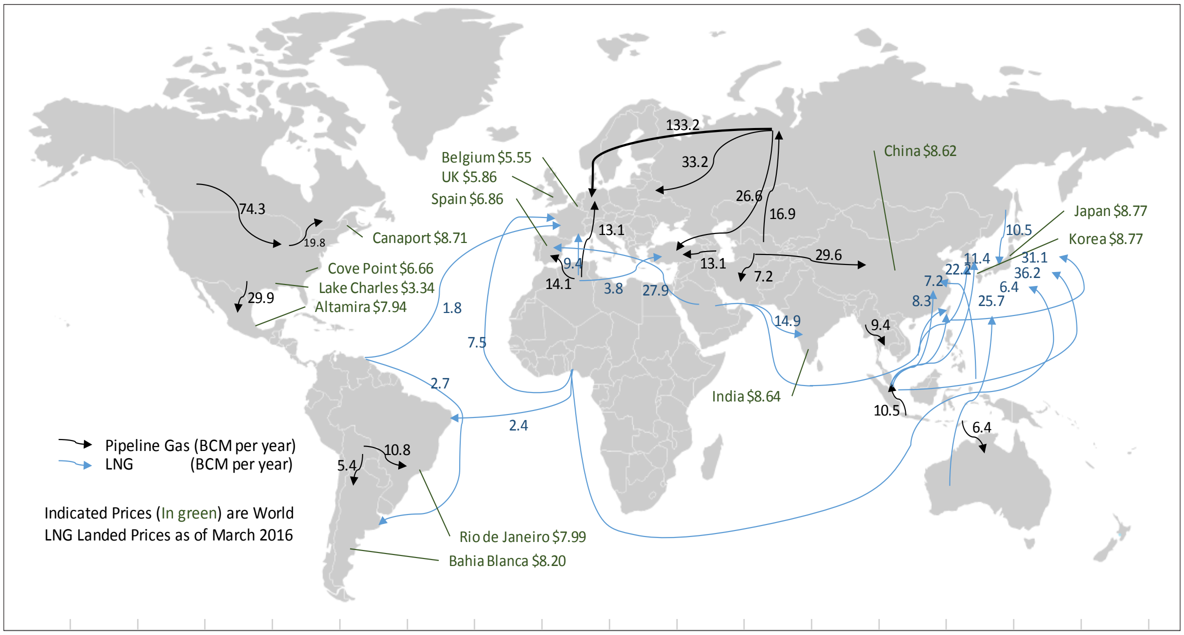
Source: International Energy Agency (2017e, 2017f)

Note: We calculate world indigenous consumption as world indigenous production minus world pipeline trade and world LNG trade. As a result it does not include indigenous consumption from inventory sources.

[13] For an overview of different world pricing mechanisms, see Stern (2012).

[14] Oil price indexing for LNG contracts is a relic of the first LNG contracts between Japan and its suppliers in the 1960s. The primary alternative energy source was oil, leading to the price of LNG being linked to the price of oil on a heat-equivalent basis.

FIGURE 8 2015 GLOBAL NATURAL GAS TRADE FLOWS (BILLION CUBIC METRES) & 2016 LNG PRICES ($USD PER MILLION BTU)



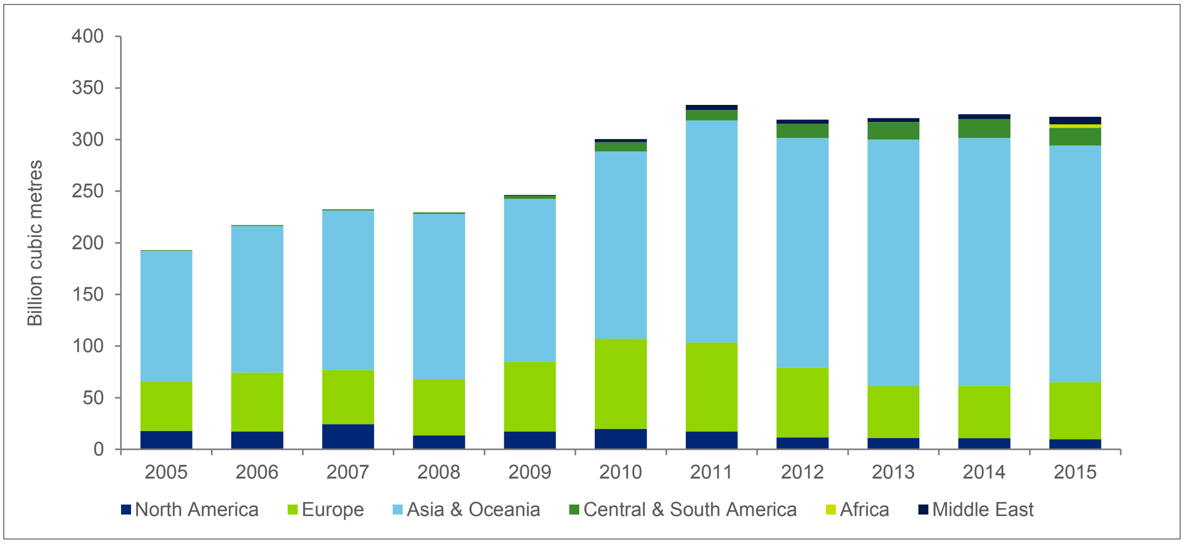
Source: Trade Flows: BP (2016). Prices: Federal Energy Regulatory Commission (2016).

Note: The above figure does not show minor trade movements of natural gas and LNG.

GLOBAL LNG MARKETS

Global LNG imports increased rapidly from 2005 to 2011, rising from 193 to 334 BCM annually (Figure 9). LNG imports have stayed relatively constant since then, averaging 324 BCM annually over the period of 2011 to 2015. The rise in LNG demand has been supported by a sharp increase in global LNG liquefaction terminals. Specifically, from 2005 to 2015 the number of liquefaction terminals increased from 20 terminals in 13 countries to 38 terminals in 20 countries. As shown in Figure 10, global liquefaction capacity correspondingly increased by over 90 per cent, rising from 175 to 340 MTPA (corresponding to approximately 239 to 462 BCM of natural gas annually). The majority of this growth was observed in the Middle East and has helped to ease the market access constraint that the region previously faced. Strong growth has also been observed in Asia and Oceania, where demand for LNG is high, and in Africa which – similar to the Middle East – has significant regional reserves and a lack of pipeline access to regions with high demand.

FIGURE 9 GLOBAL LNG IMPORTS

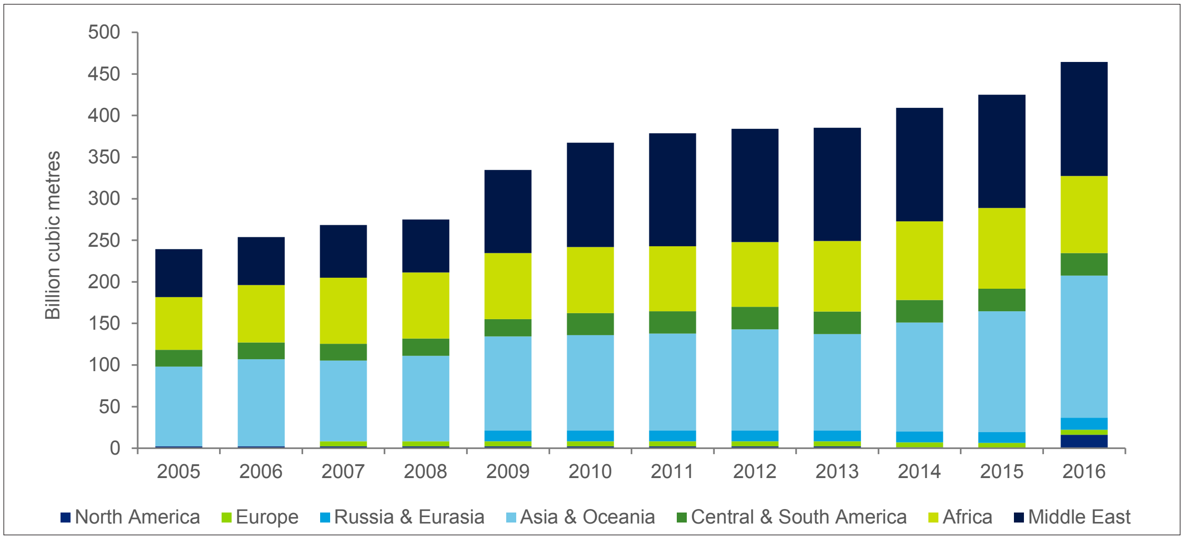


Source: International Energy Agency (2017e)

Note: Russia & Eurasia is not shown in the figure as the region did not have any LNG imports from 2005 to 2015.

The primary regions that import LNG are Europe, and Asia and Oceania. Together, these regions accounted for 90 per cent of global LNG demand over the period of 2005 to 2015. Prior to 2011, significant growth in LNG demand was observed in both Europe and Asia. Specifically, demand in Europe increased by 79 per cent from 2005 to 2011, while demand in Asia increased by 71 per cent. Since 2011 LNG demand in Asia has continued to rise, increasing by an additional seven per cent. Demand in Europe, in contrast, has contracted, declining by close to 40 per cent since 2011. European imports of LNG in 2015 were only 15 per cent higher than imports in 2005.

FIGURE 10 GLOBAL LNG LIQUEFACTION CAPACITY



Source: GIIGNL (2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017)

Note: The indicated capacity figures include all global facilities outside of Libya. Libya (3.2 MTPA) is excluded as its facility was severely damaged in the country's 2011 civil war (U.S. EIA 2015b) and has not produced any LNG since then. Similar to Libya, Yemen's export facility (6.7 MTPA) stopped operating in April 2015 as a result of civil war. Its capacity has been counted, however, as although there is no indication of when the facility might come back online, there are also no confirmed reports that it is not intact. A number of facilities around the world are in good repair but are not operating due to a lack of natural gas supply. Most notably, the Damietta facility in Egypt has not been operational since 2012. The Idku LNG facility in Egypt similarly did not operate in 2015 as a result of Egypt's supply shortage but restarted with a small number of shipments in 2016. Last, the Kenai LNG project in Alaska did not export any cargoes in 2016 (IGU 2017).

Increases in European LNG demand were most evident in 2006 and again in 2009 and 2010. European consumption of natural gas over this period was erratic – it was relatively constant from 2005 to 2006, fell in 2008 and 2009 and grew in 2010 – suggesting changing consumption was not a main determinant in the growth of LNG demand. Rather, these increases were largely driven by the opening of new regasification terminals – in the United Kingdom in 2005 and in both Italy and the United Kingdom in 2009 – in response to declining indigenous production. A portion of the latter increases can also likely be linked back to the January 2009 conflict between Russia and Ukraine during which Russia cut off pipeline natural gas exports to Ukraine for nearly a three-week period (Perani, Stern and Yafimava 2009). As 80 per cent of Russian natural gas pipeline exports to Europe transited through Ukraine at this time, this significantly reduced Russian supply to other European countries. The decline in European LNG imports since 2011 can be explained in part by a return to Russian imports, largely enabled by the 2011 completion of the Nord Stream pipeline, which runs from Russia to Germany via the Baltic Sea. Additionally, European natural gas demand was declining from 2010 to 2014 while LNG demand and LNG prices were rising in Asia. As a result, LNG exporters preferred Asia as a target market.

The steady growth in LNG imports in Asia and Oceania is attributable to steadily increasing natural gas consumption. This in turn is attributable to two factors. First is the rapid industrialization, and accompanying growing natural gas demand, of developing economies in Asia – most notably China and India. Second is the Fukushima Daichi nuclear incident that occurred in the aftermath of the March 2011 Tōhoku earthquake and tsunami. Japan shut down its nuclear power facilities after the incident and its total primary energy supply shifted drastically, moving from 15 per cent nuclear and 17 per cent natural gas in 2010 to six per cent nuclear and 22 per cent natural gas in 2011 (IEA 2017c). Accordingly, Japan's imports of LNG increased by 18 per cent from 2010 to 2011 and continued to rise steadily through to 2014 (IEA 2017a). From 2014 to 2015 LNG demand in Japan decreased by six per cent. This decline in LNG demand corresponded to the continued expansion of Japan's renewable energy sources (IEA 2017c), as well as the restart in 2015 of two of Japan's nuclear reactors (U.S. EIA 2016b).

Despite the rapid rise in global LNG demand since 2005 it remains a relatively small portion of total natural gas trade. Specifically, from 2005 to 2009 LNG accounted for approximately 25 per cent of the total annual global trade in natural gas. The short-lived increase in European demand for LNG in 2010, followed by the longer term bump-up in Japan's demand for LNG in 2011 has increased LNG's market share in recent years to close to one-third. With future global growth in natural gas demand forecast to be concentrated in the Asia and Oceania region – and with only limited pipeline capacity connecting this region with large producers within the region and with producers in the Middle East and Russia and Eurasia – the proportion of global natural gas trade through LNG is expected to steadily increase in the years ahead (BP 2017).

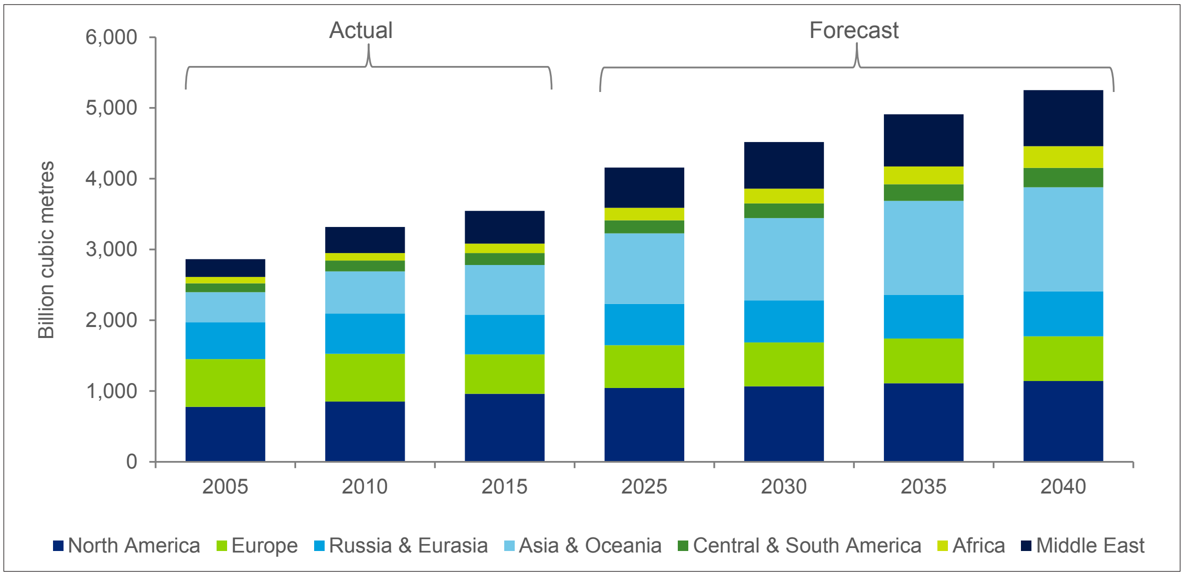
GLOBAL NATURAL GAS OUTLOOK

Future demand for natural gas will be influenced by a number of factors, most notably the rate of economic growth in developing economies, the strength of climate commitments in both developing and developed countries, and country-level decisions around future reliance on nuclear power. As noted earlier, the largest determinant is likely to be the strength of climate commitments, and in particular, the extent to which natural gas is used as a bridging fuel versus the speed at which countries transition towards renewable and other non-carbon emitting sources of energy, or emissions-reducing technologies are installed. The IEA considers three scenarios for future energy demand in its World Energy Outlook. In the least stringent "Current Policies Scenario,"[15] natural gas consumption is forecast to reach 5,700 BCM in 2040, a 61 per cent increase relative to 2015. In contrast, in the most stringent "Sustainable Development Scenario," natural gas consumption is forecast to reach only 4,200 BCM in 2040, an increase of 19 per cent relative to 2015.

The reference case and "middle ground" scenario in the IEA's World Energy Outlook is the "New Policies Scenario."[16] In this scenario, natural gas consumption is forecast to grow by nearly 50 per cent between 2015 and 2040, reaching 5,300 BCM in 2040. Within this scenario, the largest driver of natural gas demand growth is economic growth in developing economies. Specifically, in Asia and Oceania total demand for natural gas is forecast to more than double from 2015 to 2040, rising by 770 BCM. Over two thirds of this increase is driven by rising demand in China and India. Although significantly smaller consumers, similarly strong growth rates are expected in the Middle East (+72 per cent/+333 BCM), Africa (+134 per cent/+175 BCM) and Central and South America (+60 per cent/+102 BCM) (Figure 11). In Russia and Eurasia natural gas consumption is forecast to increase by only 13 per cent (+73 BCM). When excluding Russia, however, where natural gas consumption is forecast to grow only marginally over the next 25 years, the expected growth rate for this region increases to 41 per cent.

The impact of climate commitments within the "New Policies Scenario" is most noticeable in the more moderate upward trend of natural gas consumption in regions dominated by developed countries. In particular, consumption in Europe is forecast to rise by 13 per cent from 2015 to 2040. While this is only a small increase, it is a reversal of the downward trend that saw European natural gas consumption fall by 18 per cent from 2005 to 2015. In North America, natural gas consumption is forecast to grow by 19 per cent. This is consistent with the expectation that electricity generation in both the United States and Canada will make a significant shift from coal to natural gas (National Energy Board 2016; U.S. EIA 2018).

FIGURE 11 GLOBAL NATURAL GAS DEMAND OUTLOOK



Sources: International Energy Agency (2017d, 2017f)

Note: This outlook corresponds to the IEA's "New Policies Scenario" which assumes that all policies and implementing measures that affect energy markets and which were either adopted or declared as of mid-2017 are put into effect.

15 The "Current Policies Scenario" accounts for the impact of only those climate policies that have been "firmly enacted as of mid-2017." It is primarily meant to serve as a benchmark path against which the impact of more stringent policies can be measured (IEA 2017d).

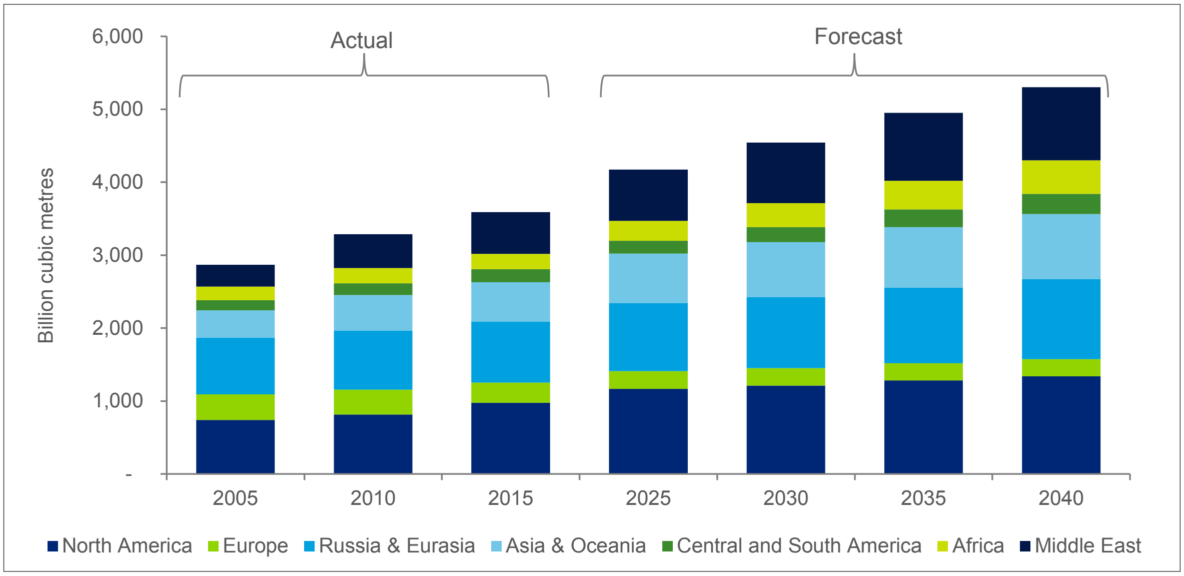
16 The "New Policies Scenario" assumes all policies and implementing measures that affect energy markets and which were either adopted or declared as of mid-2017 are put into effect.

The largest natural gas-producing regions are expected to continue to be North America and Russia and Eurasia, which are forecast to account for an average of 25 per cent and 21 per cent of global production in 2040 respectively (Figure 12). North American production is anticipated to grow faster than North American demand. Although the majority of natural gas will be consumed domestically over the entire forecast period, the amount available for export is expected to increase steadily, rising from only one per cent in 2015 to 15 per cent in 2040 (Figure 13). The majority of these exports will be in the form of LNG.

In Russia and Eurasia production is similarly expected to grow faster than consumption. The availability of natural gas for export is forecast to increase from an average of 33 per cent of production in 2015 to 42 per cent of production in 2040. Although Russia is expanding its export capacity through the construction of LNG liquefaction facilities and new pipelines,[17] the majority of these exports will most likely target Europe via existing pipeline infrastructure.

The other main producing regions of natural gas are expected to be Asia and Oceania at an average of 17 per cent of global natural gas production in 2040, and the Middle East at an average of 19 per cent. In keeping with recent trends, production growth in Asia and Oceania will be insufficient to keep up with the region's growing demand. The shortfall in regional production relative to regional demand is forecast to increase from 30 per cent in 2015 to 65 per cent in 2040. Although there are some plans to extend pipeline infrastructure in the region, due to its geography it is likely to rely primarily on imports in the form of LNG. The opposite scenario is present in the Middle East where production in the region is expected to consistently exceed demand by approximately 20 per cent. Again, due to the region's geography and a limited number of pipelines the majority of this excess production will likely be exported as LNG to either Europe or Asia and Oceania.

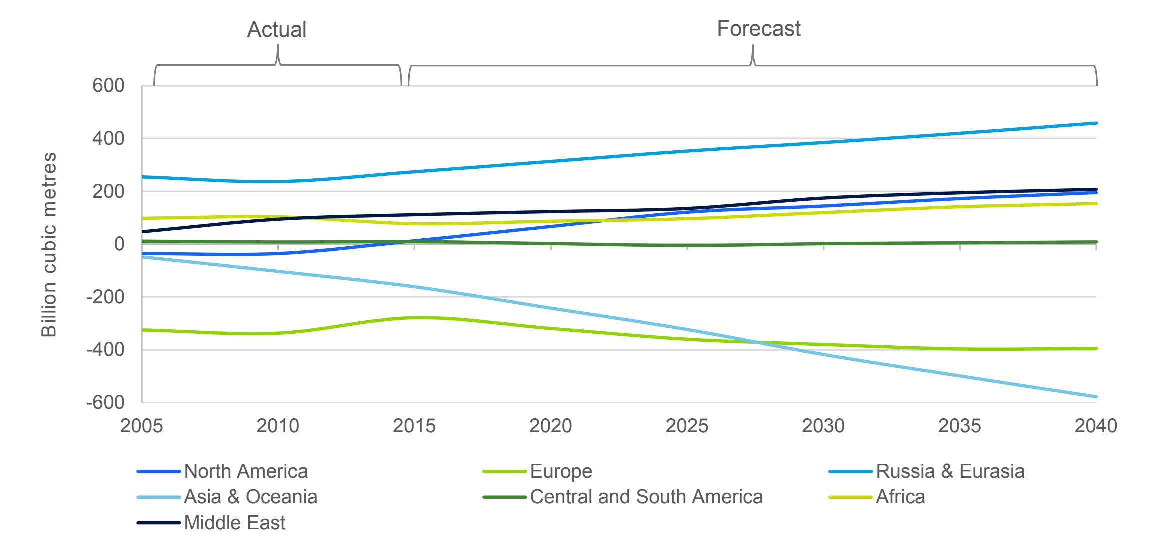
FIGURE 12 GLOBAL NATURAL GAS PRODUCTION OUTLOOK



Source: International Energy Agency (2017d, 2017f)

17 Russia, for example, is considering two new natural gas export pipelines to China. For more information, see Henderson (2014).

FIGURE 13 ACTUAL AND PROJECTED REGIONAL NATURAL GAS SURPLUS (+) AND DEFICIT (-) BY REGION



Source: International Energy Agency (2017d, 2017f)

Note: The World Energy Outlook 2017 does not provide a forecast for production and consumption of natural gas in 2020. The 2020 values as shown on the figure are therefore estimates, and are equal to the average of the observed surplus (deficit) for a region in 2015 and the forecast surplus (deficit) for a region in 2025.

Natural gas production is also forecast to grow in Central and South America. It maintains a near identical pace to consumption growth, however, and the natural gas surplus/deficit in the region remains close to zero over the entire forecast period.

The projection for Africa is a modest but growing trend in the region's natural gas production and the availability of that production for export. However, this projected trend faces considerable uncertainty, largely due to the substantial barriers to investment and growing domestic demand in Algeria. Algeria is Africa's largest producer and exporter of natural gas. Algerian domestic natural gas consumption continues to grow due to a sustained government policy of low domestic prices. This in turn has weakened the outlook for production growth as the low domestic prices have not provided investment incentives to further exploit domestic resources (Aissaoui 2016). This growing concern is already reflected in the historical trend of regional exports from Africa. Between 2010 and 2015, weak production growth in Africa has fallen well short of the growth in regional demand, leading to a 20 per cent reduction in overall exports from the region, falling from 103 to 80 BCM (IEA 2016). North Africa also has a pipeline link to Europe which, taken together with the pessimistic view of Algerian production, suggests that LNG exports from Africa will at most play only a minor role in global LNG trade in the near future. That said, however, Mozambique has been subject to investment interest, and could be a significant source of African supply in the mid- to late-2020s.[18]

The only region where natural gas production is expected to decrease over the forecast period is in Europe. With consumption in this region forecast to grow, the shortfall in regional production relative to regional demand is forecast to rise from 100 per cent in 2015 to 168 per cent in 2040. The degree to which Europe turns to LNG as a future supply source will likely depend largely on the export infrastructure that is developed globally over the next number of years. In particular, in addition to significant existing pipeline infrastructure connecting Europe with Russia and Eurasia, the Middle East and North Africa, there are a number of new pipelines either under

[18] For example, the Mozambique LNG project's (12 MTPA) FID is expected in 2018 (Tsukimori 2017), and the Coral South project (3.3 MTPA) has signed long-term contracts for the project's entire capacity and made its FID in June 2017 (Eni Inc. 2017). The Mozambique project, if it proceeds, will be a large supplier within Africa, but overall Africa will remain a relatively small player.

active development or consideration.[19] As natural gas is less expensive to transport by pipeline, a significant growth in pipeline export capacity could limit the growth potential for LNG.

The largest determinant of future natural gas supply is likely to be the extent to which tight and shale gas reserves are developed. Public and political acceptance of hydraulic fracturing to develop these resources has thus far been inconsistent around the world and continues to evolve. Various jurisdictions within North America and Europe have enacted moratoriums or bans on fracking in light of potential evidence that the practice may contribute to minor local earthquakes (BC Oil and Gas Commission 2014) and groundwater contamination (U.S. EPA 2015). While continued development of shale and other unconventional gas resources has the potential to create future natural gas supply that is in significant excess of demand, if concern over hydraulic fracturing techniques becomes more widespread then future anticipated production growth may be significantly tempered.

GLOBAL LNG OUTLOOK

As noted a number of times throughout this paper, many natural gas-producing regions have abundant resource reserves and production capacity relative to domestic demand. This imbalance can be exacerbated by constrained access to international markets that traditional pipelines cannot reach. Of the four world regions that are forecast to have future natural gas production that significantly exceeds demand – Russia and Eurasia, the Middle East, Africa and North America – only Russia and Eurasia has significant or planned pipeline access to external demand markets.

Shipping natural gas as LNG is costlier than pipeline transport, primarily because of the significant financial investments that are required to develop LNG liquefaction, regasification and transportation capabilities. However, it is often the only option for producers that either do not have connections to international natural gas pipelines or want to reach overseas markets for which pipeline transport is not an option.

While a small number of countries have had LNG production capabilities for decades – most notably Algeria, the United Arab Emirates, Brunei, Indonesia and Malaysia – the vast majority of current global LNG export capacity (75 per cent) has come online only since 1999. New market entrants are facing domestic over-supply and are seeking new markets for their natural gas. The country with the world's largest LNG export capacity, for example, is Qatar. It opened its first terminal with two liquefaction trains and 6.4 MTPA of export capacity in 1997. It has added six additional terminals and 12 liquefaction trains since then and had a total LNG export capacity in 2014 of 77 MTPA (corresponding to approximately 105 BCM of natural gas), accounting for just under 25 per cent of the global total. It has correspondingly ramped up its LNG exports by nearly 30 times – from 3.5 BCM of natural gas in 1997 to nearly 100 BCM in 2015 (IEA 2017a).

As noted earlier, global LNG export capacity in 2016 was 340 MTPA. This corresponds to a liquefaction capacity of approximately 462 BCM of natural gas. The 2017 edition of the *BP Energy Outlook* forecasts that global liquefaction capacity will increase by two-thirds between 2016 and 2035, reaching approximately 775 BCM per year. Nearly a third of this anticipated growth is attributable to projects currently under development and is expected to be realized by 2020. The majority of the growth in LNG capacity will be realized in the United States (+196 BCM per year) and Australia (+124 BCM per year).

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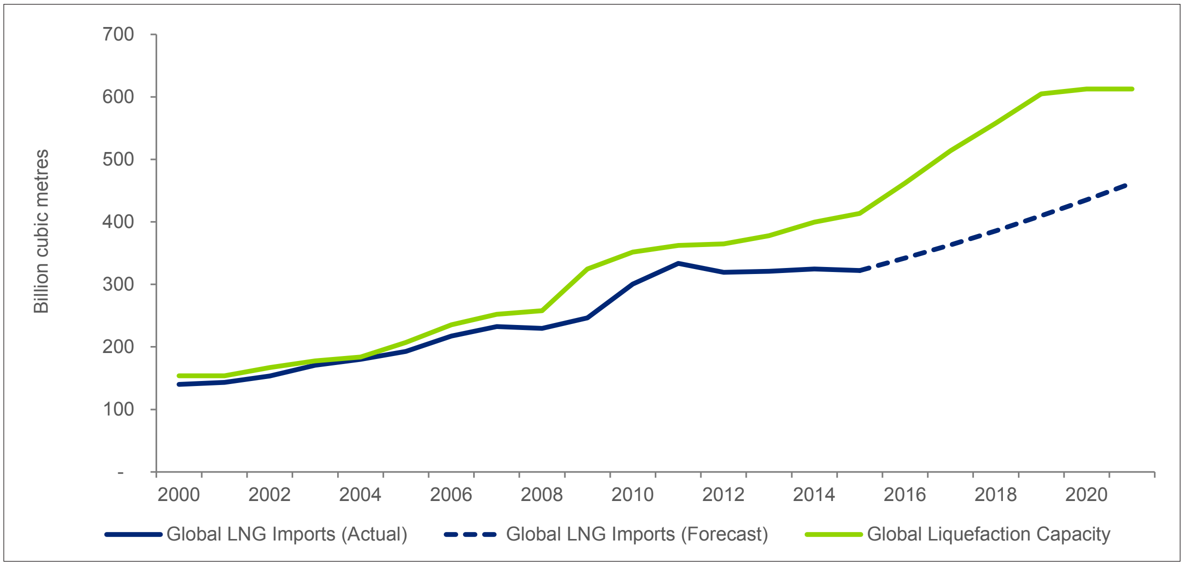
[19] For example, in fall 2015 construction started on three new pipelines that – once connected – will move natural gas from Azerbaijan to Turkey, Italy, Bulgaria and Greece (U.S. EIA 2015c). There are two additional pipeline proposals for southeast Europe, a proposal for a second pipeline from Algeria to Italy, and finally a proposal to twin the existing Nord Stream pipeline that runs under the Baltic Sea and supplies Germany with natural gas from Russia (Nord Stream 2 n.d.).

The large number of entrants to the LNG market over the next few years is expected to lead to rising excess liquefaction capacity. Considering only operating LNG export projects and new projects that were under construction as of March 2017, LNG liquefaction capacity is expected to reach 613 BCM per year in 2020 (IGU 2017).[20] In contrast, the IEA forecasts that LNG demand in 2021 will be around 460 BCM per year. This suggests a widening differential between export capacity and demand over the next four years (Figure 14). Specifically, if we assume that no additional LNG export capacity comes online in 2021, then based on the IEA's projected demand for 2021, liquefaction capacity will exceed demand by over 30 per cent. If LNG demand is stagnant, as was the case from 2010 to 2015, then liquefaction capacity in 2021 will be nearly 50 per cent higher than expected demand. For the differential between LNG demand and liquefaction to close by 2021, demand would need to grow at a compound annualized rate of 11.3 per cent from 2015 to 2021. This is nearly double the annual growth rate of 6.2 per cent that is consistent with the IEA's projection for LNG demand in 2021.

In addition to projects currently under construction, 88 new projects have been proposed worldwide but have not yet reached an FID. A further 12 facilities that are either operating or under construction have proposed expansion plans that are also in the pre-FID stage. Together, these projects represent nearly 900 MTPA (1,200 BCM) in proposed liquefaction capacity (IGU 2017). This is over three times the liquefaction capacity that exists today and far surpasses even the most optimistic forecasts for long-term LNG demand. Further challenging the prospects for new projects is Qatar's announcement in July 2017 of plans to add an additional 23 MTPA (31 BCM of natural gas) of export capacity within the timeframe of 2022 to 2024 (DiChristopher 2017). With the global natural gas market unable to absorb all of the proposed liquefaction capacity it is well accepted that most currently proposed projects will not proceed.

FIGURE 14 FORECAST EXCESS GLOBAL LNG LIQUEFACTION CAPACITY



Source: International Energy Agency (2016, 2017e), International Gas Union (2016)

Note: Global liquefaction capacity includes all LNG projects currently operating plus new projects that were under construction as of March 2017. Forecast global LNG imports are calculated based on the IEA's projection in its *Medium-Term Gas Market Report, 2016* that imports will increase by around 140 BCM between 2015 and 2021. To approximate annual import projections we assume that imports grow at a constant annualized rate of 6.2 per cent between 2015 and 2021.

[20] As of March 2017 there were no projects under construction with expected start dates beyond 2020.

Most of the newly operating, under-construction and proposed liquefaction plants were first proposed or reached FIDs between 2010 and 2015. This period was frequently referred to as the "LNG race" as high LNG prices, particularly in Asia, incited project proponents to race to lock in contracts and move forward with FIDs before prices started to decline with the increase in supply (Marlow and Jang 2014). Precipitated by declining oil prices, the LNG price started to fall drastically in early 2015. In 2016, only two projects made a positive FID, for a combined capacity of 6.3 MTPA (IGU 2017). This followed five straight years (2011 to 2015) during which FIDs were taken on a minimum of 20 MTPA each year[21] and was the lowest level of capacity to receive an FID since 2008 (GIIGNL 2017), marking what is arguably the end of the most recent LNG race.

Despite 19 LNG project proposals on the West Coast and six on the East Coast, Canada was ultimately a non-entity in the LNG race. Rather, Canada is often viewed now as having lost out to the United States, which saw its first LNG export facility start operating in 2016. A second project shipped its first cargo in March 2018 while four additional projects are under construction with expected start dates between late 2018 and 2019. Combined, the United States is expected to have 67.5 MTPA of export capacity in the lower 48 states by 2020,[22] up from zero in 2015. In contrast, as of spring 2018, eight of Canada's proposed projects have been shelved or cancelled, including the Pacific NorthWest LNG project in northwestern British Columbia which had previously reaching a positive provisional FID in June 2015.[23]

The only Canadian project with an FID, announced in November 2016, is Woodfibre LNG, a small-scale export facility (2.1 MTPA) located in Squamish, British Columbia. The project commenced preparation of the site in March 2017 and received its environmental assessment certificate from the B.C. government for construction and operation in July 2017 (Woodfibre LNG 2017). First LNG exports from the project are forecast for 2020. An FID for LNG Canada, also in B.C., is expected later in 2018. In March 2018, the B.C. NDP government stated its plan to roll back the LNG-specific income tax implemented by the previous Liberal government and offer other tax relief (B.C. Office of the Premier 2018). In Nova Scotia, Pieridae Energy filed an application to construct the Goldboro LNG facility with the Nova Scotia Utilities and Review Board, and is also slated to make an FID in 2018 (Goldboro LNG 2018). However, project proponents on the West and East coasts have raised concerns about the impact of carbon pricing, including differences in federal and provincial regulations, and a tariff on imports of pre-fabricated steel modules needed for construction of the facilities (Bennett 2018; Jang 2018; Morgan 2018; Murphy 2018).

Although development of new liquefaction capacity is expected to slow down over the next number of years, there is also the expectation that a second wave of new capacity will be required by the mid-2020s. The BP Energy Outlook, for example, forecasts a "temporary lull" in new liquefaction capacity coming online as new supplies from projects currently under construction are absorbed, but that growth will resume at a "more moderate pace" after this period (BP 2017). Consistent with this outlook is that although a small number of projects were shelved in 2016, the majority of projects that were due to make FIDs have opted to remain under development and defer their FIDs to a later year. After having been left behind in the most recent LNG race, this anticipated second wave now offers the best opportunity for Canada to become an active participant in the global LNG market.

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21 Annual FID capacities are reported in the GIIGNL (International Group of Liquefied Natural Gas Importers) annual reports. These are available from the publications section of the GIIGNL website: http://giignl.org/publications.

22 Authors' calculations based on IGU (2017).

23 Pacific NorthWest LNG was a large-scale project (18 MTPA) proposed for northern British Columbia. The June 2015 FID was conditional on the project receiving approval of the project development agreement by the B.C. legislative assembly and receiving a positive regulatory decision from the government of Canada as a result of its environmental assessment process. The B.C. legislative approval was received in July 2015 but the government of Canada's decision was not announced until September 2016. Although the decision was positive, it was accompanied by 190 conditions. After conducting a total review of the project given the additional conditions, it was announced in July 2017 that the project would be cancelled (Pacific NorthWest LNG 2017).

CONCLUDING REMARKS

Established regional production and consumption trends have placed a growing focus on LNG as a transportation mode for the inter-regional trade of natural gas. In particular, large differentials between global natural gas prices spurred a recent race among countries with current and anticipated natural gas surpluses to establish LNG export capacity. With these large price differentials underpinning investment decisions, FIDs were taken on over 140 MTPA of liquefaction capacity between 2010 and 2016.[24]

Many of the recent FIDs for liquefaction projects in the U.S. are the result of a significant shift in North America's natural gas market. As recently as 2008,[25] forecasts for natural gas supply and demand in North America indicated a substantial shortage, prompting investment in regasification facilities to import LNG. Soon after, however, advances in hydraulic fracturing technology and the shale revolution resulted in the development of new resource plays, and made Canada and the U.S. self-sufficient for many years to come. By converting many of its regasification facilities to export facilities, the U.S. is establishing itself as a major global LNG player. Canada had similar hopes of entering the global LNG market during the most recent wave of development and saw multiple proposals for LNG facilities on both coasts. However, as of April 2018 only a single Canadian project has a positive FID and no projects have started construction.

With international price differentials having narrowed significantly since 2014, and with a surplus of LNG liquefaction capacity forecast through to the early 2020s, proposed Canadian LNG facilities are facing a challenging near-term market in which to gain a foothold. New entry can potentially be supported by the recent movements towards shorter and smaller volume LNG supply contracts. This growing liquidity in international LNG markets has advantages in providing greater flexibility in both demand and supply side natural gas substitution. Particularly in the current environment, however, new LNG facilities represent a significant sunk cost and associated investment risk for exporters and importers.

More promising for proposed Canadian projects is that a second wave of LNG development is likely on the horizon. Natural gas production surpluses continue to grow in North America and Russia and Eurasia, while increasing deficits are forecast for Europe and Asia and Oceania. While Russia and Eurasia will look to remain the dominant suppliers of exported natural gas through existing and new pipeline infrastructure, regional demand and supply imbalances likely cannot be arbitraged through pipelines alone. This will force both producers and consumers to continue looking towards an increasingly liquid international LNG market. However, the introduction of new competitors (and associated new investment) into this international market will again rely heavily on the ability of these individual firms and investors to manage the inherent investment risk. This will become increasingly important as physical investment decisions are made since, at present, the cumulative capacity of proposed investments far outpaces any expected increase in global demand for LNG imports. Proponents of Canadian projects must therefore be prepared to move when the next development window opens, as it is likely to be equally competitive to the one that just closed. Existing policies, however, such as the aforementioned tariff on steel imports, could prevent a Canadian LNG industry from getting off the ground, despite the promise of a new development window.

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[24] Author calculations based on data reported in the GIIGNL annual reports. Archives of annual reports are available at: http://giignl.org/publications.

[25] The International Energy Outlook (IEO) 2008, published by the U.S. Energy Information Administration, forecast that North American demand for natural gas would exceed production by approximately 10 to 13 per cent from 2015 through to 2030 (U.S. EIA 2008). In the IEO 2009 this gap had fallen to a difference of less than five per cent and in IEO 2010 natural gas production in Canada and the U.S. was forecast to exceed demand (U.S. EIA 2009, U.S. EIA 2010).

REFERENCES

Aissaoui, Ali. 2016. "Algerian Gas: Troubling Trends, Troubled Policies." Oxford Institute for Energy Studies OIES Paper NG108 (May). https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/05/Algerian-Gas-Troubling-Trends-Troubled-Policies-NG-108.pdf.

Bennett, Nelson. 2018. "Removing duties could create level LNG playing field." *Richmond News*, April 3. http://www.richmond-news.com/news/removing-duties-could-create-level-lng-playing-field-1.23253431.

BC Oil and Gas Commission. 2014. "Investigation of Observed Seismicity in the Montney Trend." December. https://www.bcogc.ca/node/12291/download.

Bloomberg. 2017. Natural Gas Price Indices (database). Accessed July 2017.

British Columbia Office of the Premier. 2018. "New framework for natural gas development puts focus on economic and climate targets." *News release*. March 22. https://news.gov.bc.ca/releases/2018PREM0012-000480.

BP. 2016. "BP Statistical Review of World Energy." June. https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf.

———. 2017. "BP Energy Outlook 2017 Edition." https://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2017/bp-energy-outlook-2017.pdf.

Cheniere Energy. 2017. "Corporate Presentation, June 2017." http://phx.corporate-ir.net/phoenix.zhtml?c=101667&p=irol-presentations.

DiChristopher, Tom. 2017. "Qatar Just Threw a Wrench into Trump's Plan for U.S. 'Energy Dominance'." *CNBC*. July 4. https://www.cnbc.com/2017/07/04/qatar-to-boost-lng-exports-throwing-a-wrench-in-trumps-energy-plans.html.

Dickel, Ralf, Elham Hassanzadeh, James Henderson, Anouk Honoré, Laura El-Katiri, Simon Pirani, Howard Rogers, Jonathan Stern, and KatjaYafimava. 2014. "Reducing European Dependence on Russian Gas." Oxford Institute for Energy Studies OIES Paper NG92 (October). https://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/10/NG-92.pdf.

Eni Inc. 2017. "Eni Launches Coral South Project in Mozambique." *Press Release*. June 1. https://www.eni.com/en_IT/media/2017/06/eni-launches-coral-south-project-in-mozambique.

Goldboro LNG. 2018. "Application to the NSUARB." April 18. http://goldborolng.com/2018/04/application-to-the-nsuarb/.

Federal Energy Regulatory Commission. 2016. "National Natural Gas Market Overview: World LNG Landed Prices March 2016." https://www.ferc.gov/market-oversight/mkt-gas/overview/2016/03-2016-ngas-ovr-archive.pdf.

Hartley, Peter. 2014. "The Future of Long-Term LNG Contracts." *RICE Initiative for the Study of Economics working paper 14-022*. https://economics.rice.edu/rise/working-papers/future-long-term-lng-contractsBP.

Henderson, James. 2014. "The Commercial and Political Logic for the Altai Pipeline," *Oxford Energy Comment.* The Oxford Institute for Energy Studies. December. http://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/12/The-Commercial-and-Political-Logic-for-the-Altai-Pipeline-GPC-4.pdf.

Hurley, Lawrence and Valerie Volcovici, 2016. "U.S. Supreme Court Blocks Obama's Clean Power Plan," *Scientific American*. Feb. 9. https://www.scientificamerican.com/article/u-s-supreme-court-blocks-obama-s-clean-power-plan/.

International Energy Agency [IEA]. 2016. *Medium-Term Gas Market Report 2016*. OECD Publishing, Paris. http://dx.doi.org/10.1787/23070277.

———. 2017a. *Natural Gas Information 2017*. Aug. 18. OECD Publishing, Paris. http://www.iea.org/bookshop/745-Natural_Gas_Information_2017.

———. 2017b. "World – Coal Supply." IEA Coal Information Statistics (database). Accessed February 2017. http://dx.doi.org.ezproxy.lib.ucalgary.ca/10.1787/data-00465-en

———. 2017c. "World Energy Balances." IEA World Energy Statistics and Balances (database). Accessed February 2017. http://dx.doi.org/10.1787/data-00512-en.

———. 2017d. *World Energy Outlook 2017*. IEA, Paris. Nov. 16. http://dx.doi.org/10.1787/weo-2017-en.

———. 2017e. "World – Natural Gas Imports by Origin." IEA Natural Gas Information Statistics (database). Accessed February 2017. http://dx.doi.org/10.1787/data-00555-en.

———. 2017f. "World – Natural Gas Statistics." IEA Natural Gas Information Statistics (database). Accessed February 2017. http://dx.doi.org/10.1787/data-00482-en.

———. 2017g. "World Oil Statistics." IEA Oil Information Statistics (database). Accessed February 2017. http://dx.doi.org/10.1787/data-00474-en.

International Gas Union [IGU]. 2016. "2016 World LNG Report." April. http://www.igu.org/publications/2016-world-lng-report.

———. 2017. "2017 World LNG Report." April. http://www.igu.org/sites/default/files/103419-World_IGU_Report_no%20crops.pdf.

International Group of Liquefied Natural Gas Importers [GIIGNL]. 2006. "The LNG Industry in 2005." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/gnl_2005.pdf.

———. 2007. "The LNG Industry in 2006." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2006.pdf.

———. 2008. "The LNG Industry in 2007." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2007.pdf.

———. 2009. "The LNG Industry in 2008." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2008.pdf.

———. 2010. "The LNG Industry in 2009." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2009.pdf.

———. 2011. "The LNG Industry in 2010." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2010.pdf.

———. 2012. "The LNG Industry in 2011." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2011.pdf.

———. 2013. "The LNG Industry in 2012." http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2012.pdf.

———. 2014. “The LNG Industry in 2013.” https://giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_fv.pdf.

———. 2015. “The LNG Industry in 2014.” http://giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_2015_annual_report.pdf.

———. 2016. “The LNG Industry in 2015.” http://giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_2016_annual_report.pdf.

———. 2017. “The LNG Industry in 2016.” http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_2017_annual_report_0.pdf.

International Monetary Fund. 2017. “IMF Exchange Rates.” Accessed September 2017. Available from: https://www.imf.org/external/np/fin/ert/GUI/Pages/CountryDataBase.aspx.

Jang, Brent. 2018. “Federal government to rule on spat between steel fabricators, LNG Canada.” *The Globe and Mail*. January 23. https://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/federal-government-to-rule-on-spat-between-steel-fabricators-lng-canada/article37712245/.

Marlow, Iain and Brent Jang. 2014. “The LNG Race: The Lessons Canada Can Learn from Australia.” *The Globe and Mail*. April 12. http://www.theglobeandmail.com/report-on-business/international-business/the-lng-race-the-lessons-canada-can-learn-from-australia/article17946509/?page=all.

Morgan, Geoffrey. 2018. “A US$200B LNG opportunity awaits, but Canada might miss the boat — again.” *Financial Post*. February 26. http://business.financialpost.com/commodities/energy/a-us200b-lng-opportunity-awaits-but-canada-might-miss-the-boat-again.

Murphy, Helen. 2018. “Promising conditions have Goldboro LNG on track for final investment decision in 2018.” *Guysborough Journal*. Accessed April. http://www.guysboroughjournal.com/article1.php?ID=333.

National Energy Board. 2016. *Canada’s Energy Future 2016: Supply and Demand Projections to 2040.* January. http://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016/index-eng.html.

Nord Stream 2. 2017. “The Pipeline: Nord Stream 2 Builds on Proven Success.” Accessed July. http://www.nord-stream2.com/our-project/pipeline/.

Oxford Institute for Energy Studies. 2016. “LNG Markets: The Great Reconfiguration.” *Oxford Energy Forum*. Issue 106. https://www.oxfordenergy.org/publications/oxford-energy-forum-issue-106/.

Pacific NorthWest LNG. 2017. “Pacific NorthWest LNG Project Not Proceeding,” *News Release*. July 25. http://www.pacificnorthwestlng.com/media/NewsRelease-Backgrounder-PNWLNG-July25-2017.pdf.

Perani, Simon, Jonathan Stern, and Katja Yafimava. 2009. “The Russo-Ukrainian Gas Dispute of January 2009: A Comprehensive Assessment.” Oxford Institute for Energy Studies working paper NG 27 (February). http://www.oxfordenergy.org/wpcms/wp-content/uploads/2010/11/NG27-TheRussoUkrainianGasDisputeofJanuary2009AComprehensiveAssessment-JonathanSternSimonPiraniKatjaYafimava-2009.pdf.

Royal Dutch Shell plc. 2017. “LNG Outlook.” https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook/lng-outlook-2017/_jcr_content/par/textimage_1374226056.stream/1490189885482/516845c6c67687f21ff02bec2d330b97c91840f9ffa9e4348e7b875683215aaf/shell-lng-outlook2017-slides-master-march2017.pdf.

Stapczynski, Stephen. 2016. "Japan Said to Review if LNG Contracts Barring Resale Violate Law," *Bloomberg*. July 13. https://www.bloomberg.com/news/articles/2016-07-14/japan-said-to-review-if-lng-contracts-barring-resale-violate-law-iqlr1xu7.

Stern, Jonathan, ed. 2012. *The Pricing of Internationally Traded Gas*. Oxford: Oxford University Press.

Tsukimori, Osamu. 2017. "Japan's Mitsui Expects FID on Mozambique LNG Project in April-June 2018." *Reuters*. April 4. http://www.reuters.com/article/us-japan-gastech-mitsui-idUSKBN1761J4.

U.S. Environmental Protection Agency [U.S. EPA]. 2015. *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources (External Review Draft)*. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-15/047. http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651.

———. 2017. "EPA Takes Another Step To Advance President Trump's American First Strategy, Proposed Repeal of 'Clean Power Plan.'" *News Release*. October 10. https://www.epa.gov/newsreleases/epa-takes-another-step-advance-president-trumps-america-first-strategy-proposes-repeal.

U.S. Energy Information Administration [U.S. EIA]. 2008. *International Energy Outlook 2008*. September. http://www.eia.gov/forecasts/archive/ieo08/pdf/0484(2008).pdf.

———. 2009. *International Energy Outlook 2009*. May. http://www.eia.gov/forecasts/archive/ieo09/pdf/0484(2009).pdf.

———. 2010. *International Energy Outlook 2010.* July. http://www.eia.gov/forecasts/archive/ieo10/pdf/0484(2010).pdf.

———. 2015a. "Analysis of the Impacts of the Clean Power Plan." May. http://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf.

———. 2015b. "Country Analysis Brief: Libya." Nov. 19. https://www.eia.gov/beta/international/analysis_includes/countries_long/Libya/libya.pdf.

———. 2015c. "Natural Gas Pipelines Under Construction will Move Gas from Azerbaijan to Suthern Europe." *Today in Energy*. Oct. 14. http://www.eia.gov/todayinenergy/detail.cfm?id=23332.

———. 2015d. "World Shale Resource Assessments." Last modified Sept. 24. Accessed July 2017. http://www.eia.gov/analysis/studies/worldshalegas/.

———. 2016a. "Carbon Dioxide Emissions Coefficients." Feb. 2. https://www.eia.gov/environment/emissions/co2_vol_mass.cfm.

———. 2016b. "Five and a Half Years after Fukushima, 3 of Japan's 54 Nuclear Reactors are Operating." *Today in Energy*. Sept. 13. http://www.eia.gov/todayinenergy/detail.php?id=27912.

———. 2017. "International Energy Statistics: Natural Gas Reserves" (database). Accessed July 2017. .

———. 2018. "Annual Energy Outlook 2018." Feb. 6. Accessed May 2018. Available from: https://www.eia.gov/outlooks/aeo/index.php.

White House. 2017. "Presidential Executive Order on Promoting Energy Independence and Economic Growth." March 27. https://www.whitehouse.gov/the-press-office/2017/03/28/presidential-executive-order-promoting-energy-independence-and-economi-1.

Wood Mackenzie. 2014. Global Gas Demand in the Transport Sector Could Grow to over 160 bcm. Jan. 29. https://www.woodmac.com/media-centre/11859795.

Woodfibre LNG. 2017. "Woodfibre LNG: The Project." *Woodfibre LNG Newsletter* 4(2), August. https://www.woodfibrelng.ca/wp-content/uploads/2017/08/WF17_16-Newsletter_11.pdf.

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