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NATURAL GAS SECURITY IN APEC

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Foreword

This study is part of the Oil and Gas Security Studies (OGSS), which could provide useful information to APEC economies on significant developments and vital issues related to gas security. Traditional discussions on energy security have been mainly aimed at ensuring oil supply security, while due attention has not been paid to natural gas security. Yet as natural gas consumption has increased in the Asia-Pacific Economic Cooperation (APEC) economies and a larger number of economies is expected to start liquefied natural gas (LNG) imports in the near future, security of natural gas supply needs to be dealt with as one of the core issues in the APEC's energy security agenda. As LNG exports from the lower 48 states in the United States started in February this year, APEC should also consider how to maximise the benefits of this new natural gas supply to its gas supply security. This study assesses potential risks in natural gas supply both in the short-term and long-term, and examines what kind of countermeasures will be possible to avoid or minimise such risks.

I am hopeful that the APEC economies will learn something from the series of OGSS research studies and that they will serve as an impetus for them to re-examine their policies, plans and programs to further strengthen their respective oil and gas supply security measures. The information from these studies may offer plausible approaches and options that the APEC economies could consider as individual members in addressing any supply disruptions or emergencies, as well as how APEC could deepen cooperation for a possible region-wide energy security framework.

I would like to express my sincere gratitude to the authors and contributors for spending time and effort in doing this research study. However, I would like to emphasize that the contents and views in this independent research project only reflect those of the authors and not necessarily of APERC. The contents and information from this study might change in the future because of unforeseen external events, and the changes or improvements in the individual economy's policy agenda and framework on gas security.

Finally, rest assured that APERC will continuously conduct OGSS to serve its purpose of aiding the governments and policymakers in APEC in addressing the oil and gas security issues in the region.

Takato OJIMI
President
Asia Pacific Energy Research Centre

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Table of Contents

List of Figures and Tables

Figures

Tables

Abbreviation and Acronyms

Abbreviations

Bcm	Billion Cubic Metre
Btce	Billion Tonne of Coal Equivalent
Btoe	Billion Tonne of Oil Equivalent
MT	Million Tonne
MTPA	Million Tonnes per Annum
Toe	Tonne of Oil Equivalent
TWh	Terawatt-Hour

Acronyms

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
CO_2	Carbon Dioxide
CBM	Coalbed Methane
CIS	Commonwealth of Independent States
DES	Delivered Ex Ship
ECT	Energy Charter Treaty
EIA	Energy Information Administration
EWG	Energy Working Group
EC	European Commission
EMM	Energy Ministerial Meeting
EUROSTAT	European Statistics
EU	European Union
FID	Final investment decision
FSRU	Floating Storage and Regasification Unit
GPS	Global Petroleum Survey
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GIIGNL	International Group of Liquefied Natural Gas Importers
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IEF	International Energy Forum
IGU	International Gas Union
JGA	Japan Gas Association
JODI	Joint Organizations Data Initiative
JOE	Japan OTC Exchange
LNG	Liquefied Natural Gas
METI	Ministry of Economy, Trade, and Industry of Japan
MOF	Ministry of Finance of Japan
NBP	National Balancing Point
OGSI	Oil and Gas Security Initiative
OECD	Organization for Economic Co-operation and Development
OLADE	Latin American Energy Organization

OPEC	Organization of Petroleum Exporting Countries
RGT	Regasification Terminal
SGX	Singapore Exchange
TAGP	Trans-ASEAN Gas Pipeline
TEPCO	Tokyo Electric Power Company
TOCOM	Tokyo Commodity Exchange
TTF	Title Transfer Facility
UAE	United Arab Emirates
UNSD	United Nations Statistics Division
USD	U.S. Dollar
WEF	World Economic Forum
WGI	World Governance Index

Executive Summary

Debates on energy security have so far focused primarily on the stable supply of oil. However, amidst the rapid growth of demand for natural gas in the Asia-Pacific region in recent years, it has also become necessary to fully consider and examine the problem of ensuring a stable supply of natural gas, just like for oil. This report reviews the current situation of natural gas security in key economies and regions of the world from both quantitative and narrative perspectives, with the purpose of providing a comprehensive summary of the potential risk factors and measures for the future.

Gas security is becoming an increasingly important policy issue in the Asia-Pacific region. There are several reasons for this development. Firstly, in addition to the continued growth in demand for natural gas in the Asia-Pacific region, the trade volume of natural gas is also increasing. As a result, ensuring the stability of transportation routes is gradually becoming a serious problem. Furthermore, significant events in connection with gas security have been occurring in recent years, including disputes over gas trade between Russia and Ukraine, and rapid growth in liquefied natural gas (LNG) demand after the Great East Japan Earthquake. These events have shown gas security risk is real, and the need for effective management of such a potential gas supply shortage. There are also concerns over inadequate supply in the future due to the impact of a downturn in oil prices in recent years, leading to a stagnation in investment in the upstream sector. In light of these factors, there are plans in China, Japan and Southeast Asia to liberalize the gas market. Attention is now turning towards how a balance will be struck between such liberalization and the stable supply of gas.

Gas security can be defined as "having a supply of a sufficient volume of gas at a stable price for performing sound economic management." Gas security has several unique properties that oil security does not have. One of these is the physical property of the extreme difficulty of transportation. For this reason, natural gas is characterized by the security-related disadvantage of significantly limited procurement options in times of emergency, as compared with oil and coal. As a corollary of the first property, massive capital investment is required in the transportation of gas. To secure these investment resources, natural gas trading is frequently carried out based on long-term contracts. As the spot market for gas is not as developed as the spot market for oil, this can result in the problem of limited procurement options in times of emergency. On the other hand, as natural gas resources are more geographically dispersed than oil resources, and being used alongside other forms of energy in a wide variety of sectors, it is relatively easy to substitute other forms of energy even if supply were disrupted. This is one of the security-related advantages of natural gas.

There are five main gas security measures: diversification of supply sources and supply routes, improving supply flexibility, improving market liquidity, international cooperation, and managing demand. First, with regard to diversification of supply sources and supply routes, the initiatives put in place by Europe are the best known. As a result of disputes over gas trade between Russia and

Ukraine, Europe has suffered from interruptions in its gas supply several times in the 2000s and after. The diversification of gas supply sources has become a serious issue in the formulation of energy policies. The introduction of LNG, development of natural gas supply pipelines from the Caspian Sea, and strengthening ties with gas-producing economies in North Africa are some of the measures that are under deliberation. Even in China, in addition to increasing domestic gas production, efforts are also underway to construct pipelines not only from Central Asia and Myanmar, but also from Russia. LNG receiving terminals are successively being constructed in the coastal regions.

Europe is also leading the way in initiatives to improve supply flexibility. Since the early 2000s, Europe has shared a common understanding that improving supply flexibility contributes to the stability of gas supply. In 2000, the competition authorities of Europe conducted an investigation into the possibility that destination clauses included in LNG import contracts may constitute an act of restricting competition. After the investigation, there was heightened awareness toward the problem of destination clauses included in long-term gas contracts. Thereafter, Europe began to treat restrictions on destination in natural gas trading contracts as a problem for fair market competition, thereby contributing to significant improvements in the flexibility of natural gas supply. Although clauses that restrict the destination are currently included in the long-term LNG contracts for trading in Asia, many buyers have been requesting sellers to abolish such provisions. Hence, there is growing interest in the future of contract negotiations going forward.

In improving market liquidity, the wholesale trading sector has been visibly revitalised through the unbundling of assets accompanying the liberalization of the gas market in Europe. This has greatly improved the liquidity of the gas market. In Japan, with the aim of improving the liquidity of international LNG trading, ongoing efforts are being made to establish hub prices that serve as an index during trading.

Demand management is a relatively long-term measure, and promoting energy conservation is the representative measure that is most frequently put forward as a demand management measure. For instance, promoting energy conservation efforts and reducing energy consumption across the whole of the economy not only contribute to gas security, but to the overall energy security for other energy sources. In this respect, Europe and Japan have established quantitative targets and are enforcing energy conservation policies toward the attainment of these targets. Other demand management measures include the supply-side aspect of developing infrastructure that can enable fuel conversion and, at the micro level, introducing contracts that allow for the temporary suspension of energy supply during times of emergency in sectors where such conversion to other fuels is possible. These are also effective means for securing supply flexibility.

Finally, international cooperation on gas security is an area where there is still much room for development going forward. Specifically, the sharing of knowhow to manage gas supply shortage problems by international institutions such as the International Energy Agency (IEA), as well as the enactment of the Energy Charter Treaty (ECT), and other international efforts to protect investments in the energy sector are examples of effective international cooperation measures that

are also applicable to the gas security sector. In the Asia-Pacific Economic Cooperation (APEC), the Energy Working Group (EWG) was established in 1989 to provide a space for sharing discussions on various problems related to energy security. In addition, the collection and organization of data on gas demand undertaken by the Joint Organisations Data Initiative (JODI), a project that also involves organisations, such as the United Nations Statistics Division (UNSD) and European Statistics (Eurostat), makes it possible to capture information on the status of gas demand in a timely manner. In this way, it can be expected to contribute to improving gas security. The ASEAN Petroleum Security Agreement, which was updated and signed by the member states in 2009 (first signed in 1986), could include gas security as a support to its Trans-ASEAN Gas Pipeline (TAGP) System Project and in consideration of increasing gas demand of most the members.

One of the implications drawn from the discussions covered in this report, as the basic approach towards gas security policies, is to establish a framework that can maximise the benefits of the market mechanism in natural gas supply. On top of that, policy measures should be put in place for aspects that require a policy response. Today, the global natural gas market is experiencing highly dynamic changes, including advancements in the shale revolution on the supply side and the popularization of the Floating Storage and Regasification Unit (FSRU) on the demand side. There is also much uncertainty with regard to the future trends for oil prices, which have an impact on investments in the upstream sector. To ensure gas security, the policymaking body should also monitor the situation, and basically, refrain from unnecessary intervention in areas that can be resolved through the market mechanism.

An important policy measure for gas security is promoting investment. While this is also a matter that should basically be entrusted to the workings of the market mechanism, government involvement is needed in areas where the market mechanism alone cannot adequately resolve the issues. Securing sufficient investments for the natural gas sector in the future is a critical precondition particularly for gas security in the APEC region. Enhancing stable production capability is an important prerequisite for ensuring stable supply in the future, while securing investment in supply-side infrastructure, such as diverse supply sources and pipelines, is also vital towards achieving diversification of supply sources. Some specific examples include the development of investment-related laws and regulations, and preferential tax treatment to promote investment. For governments, establishing a master plan concerning the supply of gas over the long-term, to some extent, can also be effective in mitigating future policy risk and mobilising domestic resources beginning with the respective relevant government ministries.

The third measure is the development of international networks. In economies that have developed supply networks of pipelines for the supply of natural gas, it is possible to diversify supply routes by developing international supply networks, thereby further enhancing gas security. This is because by making this network extensive and interactive, and by pooling demand and supply, it is possible to increase the number of viable options even in situations of unexpected supply interruptions or demand fluctuations. The diversification of supply sources is key to gas security. As efforts and negotiations between governments are vital in the development of such international pipelines, discussions concerning the development of even more international

pipelines should be conducted with an open-minded attitude among member economies of APEC, where demand for gas is expected to grow in the future.

Fourthly, the liquidity of trade related to the supply of LNG should be enhanced, and an active spot market should be developed. As it is not economically realistic to stockpile vast volumes of LNG over the long-term, diversifying the supply sources of LNG and developing a fluid spot market are the primary solutions toward securing LNG supply security. The greatest barrier toward the formation of such a spot market is destination clauses that are included in long-term contracts, which currently make up the majority of LNG supply contracts. Due to growing concerns over liquidity in recent years, there have been cases where such provisions on the port of destination have been abolished or relaxed. Nevertheless, many long-term contracts still contain destination clauses, and this in turn imposes restrictions on fluid spot trading.

It is also important to give consideration to demand security. While this report focuses on a review of gas security mainly from the perspectives of consuming and importing economies, the APEC region also encompasses world-leading natural gas producers and exporters such as Australia and Russia. Although securing stable gas supply is an issue that helps both producing and consuming economies, gas security must be mutually complementary and beneficial to producer and consumer to begin with. To this end, in ensuring gas security, it is necessary for both the producing and consuming economies to fulfil their respective duties. Ideally, the consumer economies should periodically disseminate information about forecasts on natural gas demand in their own economies, and at the same time, share information on the direction and contents of gas usage policies with gas-producing economies as far as possible.

Finally, it is important to develop a means to show the status of gas security in a quantitative manner. It is sometimes difficult to assess if measures to be implemented in the future will produce actual benefits. To resolve this issue, a set of objective evaluation criteria should be drawn up to assess the means by which gas security can be improved, and how to measure the status of that improvement. Chapter 2 of this study offers a proposal for establishing and measuring such an evaluation criteria. The governments of the respective economies should also develop a set of clearly-defined and objective indicators that can support the formulation of consistent gas security policies.

Chapter 1. Definition of Gas Security

1.1 The Importance of Gas Security: Why is Gas Security a Problem Today?

Energy security is a global phenomenon that each economy faces regardless of its economic attributes. This report aims to examine the current state of gas security in the APEC region, as well as the initiatives that have been taken to improve the situation, including policy proposals to be considered for the future.

Why is there a need for APEC to take up the problem of gas security? Why is gas security becoming increasingly important in the natural gas markets of the Asia-Pacific region? The answer to these questions can be broadly divided into the following five reasons: growth in demand, increase in trade volume, occurrence of supply interruption incidents, progress in liberalization, and slowdown in investment.

1.1.1 Growth in Demand in the Asia-Pacific Region

One of the measures in addressing energy security is diversification of primary energy supply. Natural gas has become a popular fuel for most of the APEC economies as a viable option to diversify energy supply, which now provides a significant contribution in their energy supply portfolios. Among the advantages of natural gas over other fossil fuels (oil and coal) is lower carbon dioxide emission. And meeting the economies' obligations under the international climate change agreements encourages greater use of natural gas. Likewise, the technical development in producing shale gas boosts world gas supply, and the infrastructure development (like in LNG) facilitated national and international contracts to deliver natural gas to the Asia-Pacific region.

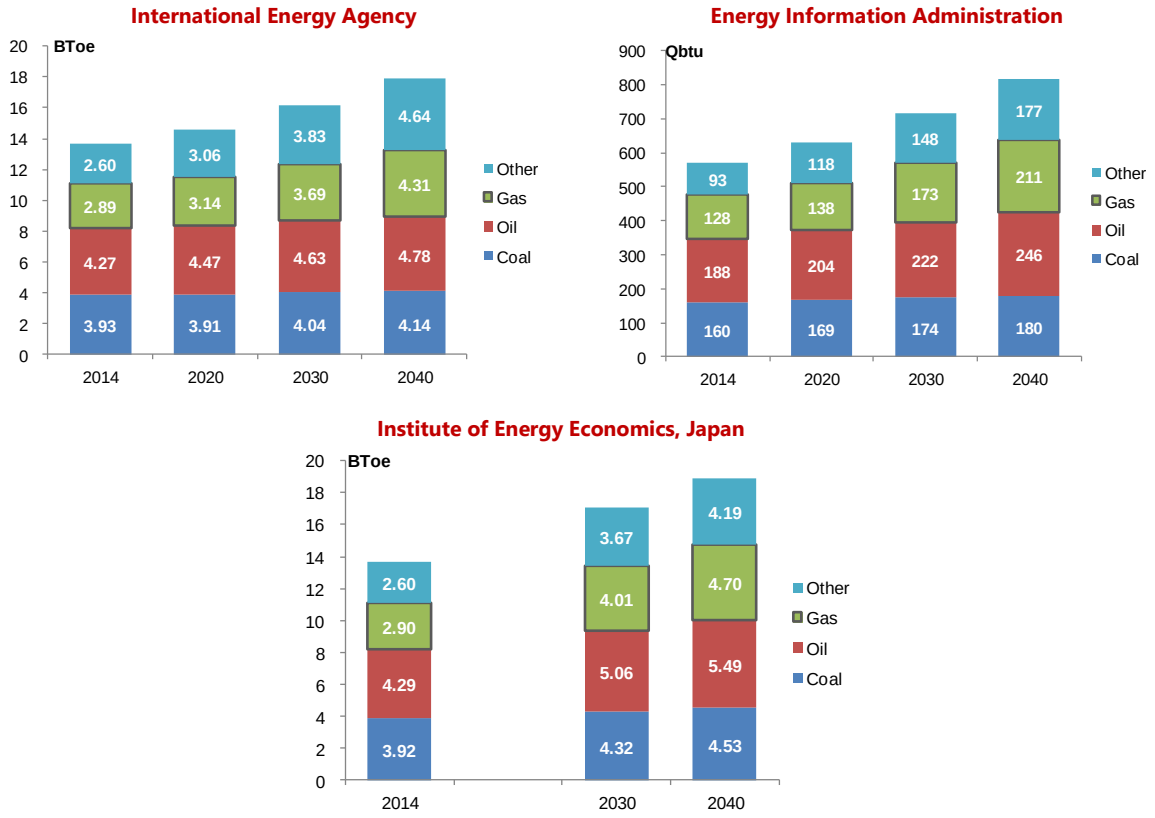
Future global demand for natural gas is seen to exhibit the highest growth rate among fossil fuels. By 2040, natural gas is expected to surpass coal and become the second most important energy source after oil. Figure 1.1 shows the breakdown of global energy supply, projected by the International Energy Agency (IEA), the Energy Information Administration (EIA) of the United States, and IEEJ in their latest forecast publication. All of these agencies predict that natural gas would become the second most important energy source after oil by 2040.

Such growth in the demand for natural gas will, of course, also make headway in the APEC region. APEC covers many economies that are expected to experience significant growth in demand for natural gas, such as in China, the Association of Southeast Asian Nations (ASEAN), and North America. Hence, demand for natural gas will grow at a faster pace than the global energy demand. Figure 1.2 shows the forecast for natural gas demand in the APEC region,[1] which is expected to demonstrate a much higher growth rate at 2.1% annually compared with global natural gas demand (15%-19% annually). With such high growth, securing a stable supply of

[1] Based on the 6th APEC Energy Demand and Supply Outlook produced by the Asia Pacific Energy Research Centre (APERC).

natural gas in the APEC region takes on much greater importance than in any other regions in the world.

Figure 1.1 • Forecast of Primary Energy Supply in the World by Various Agencies, 2014-2040



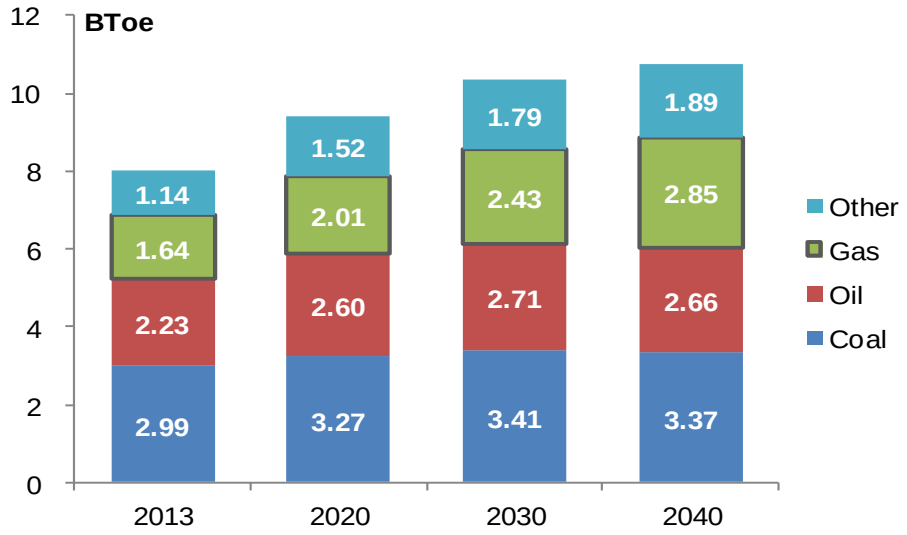
Source: IEA (2016 a), EIA (2016), IEEJ (2016)

There are several reasons for the high natural gas demand growth in the APEC region. One of these is the significant growth of energy demand in the region, specifically from emerging economies such as China and the economies in ASEAN and in South America, which are projected to achieve a high economic growth rate in the future. While the growing demand for energy is covered not only by natural gas, but also other energy sources including oil, coal, nuclear power, and renewable energy, limitations in the environmental aspects in recent years (which will be explained later in this report) has meant that demand for natural gas in particular is growing significantly.

The second reason is the heightened interest in environmental issues, with natural gas the cleanest among fossil fuels expected to contribute to greenhouse gas (GHG) emission reduction. Under the Paris Agreement concluded in December 2015, the respective APEC members are also under pressure to achieve the targets they have set for reducing greenhouse gas emissions. The amount of carbon dioxide (CO_2) produced by natural gas per unit of heat generated is 43% lower than that of coal (source, JGA 2016). Thus, promoting the use of natural gas could be described as the most realistic and reasonable measure for advancing efforts to reducing emissions. With this, natural gas has an increasing and important role to achieve in the realisation of GHG emission reduction. In China, policies have been put in place to reduce the use of coal-fired thermal power,

with the objective of resolving the issue of air pollution arising as a result of excessive dependency on coal-fired thermal power. In fact, boilers that are powered by coal will no longer be permitted for use by 2020 in Beijing City. In India, which also faces the problem of air pollution, similar policies restricting the use of coal may be enacted in the future. There is a strong possibility that natural gas, as an alternative energy source for coal, will play an even more significant role going forward in these economies.

Figure 1.2 • Forecast of Primary Energy Supply in the APEC Region, 2013-2040



Source: APERC (2016)

The third reason is the dramatic increase in the quantity of resources brought about by the shale revolution. As many commentaries and explanations have already been published on the impact of the so-called "shale revolution" on the global natural gas market, this study will not touch on the benefits of shale gas.[2] The remarkable increase in the quantity of resources brought about by the shale revolution and the accompanying easing of the demand and supply balance have reduced global natural gas prices, making this energy resource even more accessible not only for developed economies, but also for emerging ones. In particular, the fall in LNG prices due to the easing of the global demand and supply balance helped to open up LNG markets in China and ASEAN, thereby contributing significantly to the growth in gas demand in the APEC region.

The fourth reason is the growing use of the Floating Storage Regasification Unit (FSRU) in consuming economies. Many of the ASEAN economies are promoting the adoption of LNG, and FSRU has already been one of the technologies chosen. Although FSRU faces limitations in terms of the scale of its receiving capability in comparison with conventional onshore receiving terminals, it offers great benefits as it eliminates the need to obtain land for the construction of an onshore

[2] APERC has also summarized the impact of shale revolution in the following reports. Juan Roberto Lozano-Maya, *"The United States experience as a reference of success for shale gas development: The case of Mexico," Energy Policy* (2013). Juan Roberto Lozano-Maya, *"Looking through the prism of shale gas development: Towards a holistic framework for analysis," Energy Research & Social Science* (June 2016). Asia Pacific Energy Research Centre, *Pathways to Shale Gas Development in Asia-Pacific* (November 2015).

terminal, and effectively reduces the construction period. Given these benefits, widespread use of FSRU has significantly lowered the hurdles for the introduction of LNG even in economies that have never used LNG before. In fact, in 2015, 8.0% of the world's LNG is estimated to have been introduced through FSRU. One could say that it is a technology that has made immense contribution to expanding the natural gas market through LNG.

Lastly, the convenience the natural gas itself offers is another factor behind the growth in demand. For natural gas, once the pipeline has been constructed, energy can be used simply by controlling the flow. It does not generate ash after combustion in the way that coal does, nor does it require inventory control in the way that kerosene and LPG do. Besides that, the nature of natural gas-fired power plants that allow flexibility in meeting base, intermediate or peak demand makes the fuel a very versatile option. In these aspects, it is a friendly and convenient source of energy. If living standards continue to rise alongside with economic growth, people could possibly begin using natural gas once they find value in the convenience that it provides, even if it is slightly more expensive than the other forms of energy. Going forward, the convenience that gas offers could become one of the key driving forces behind market expansion in emerging economies in the Asia-Pacific region, where national income and living standards are expected to rise.

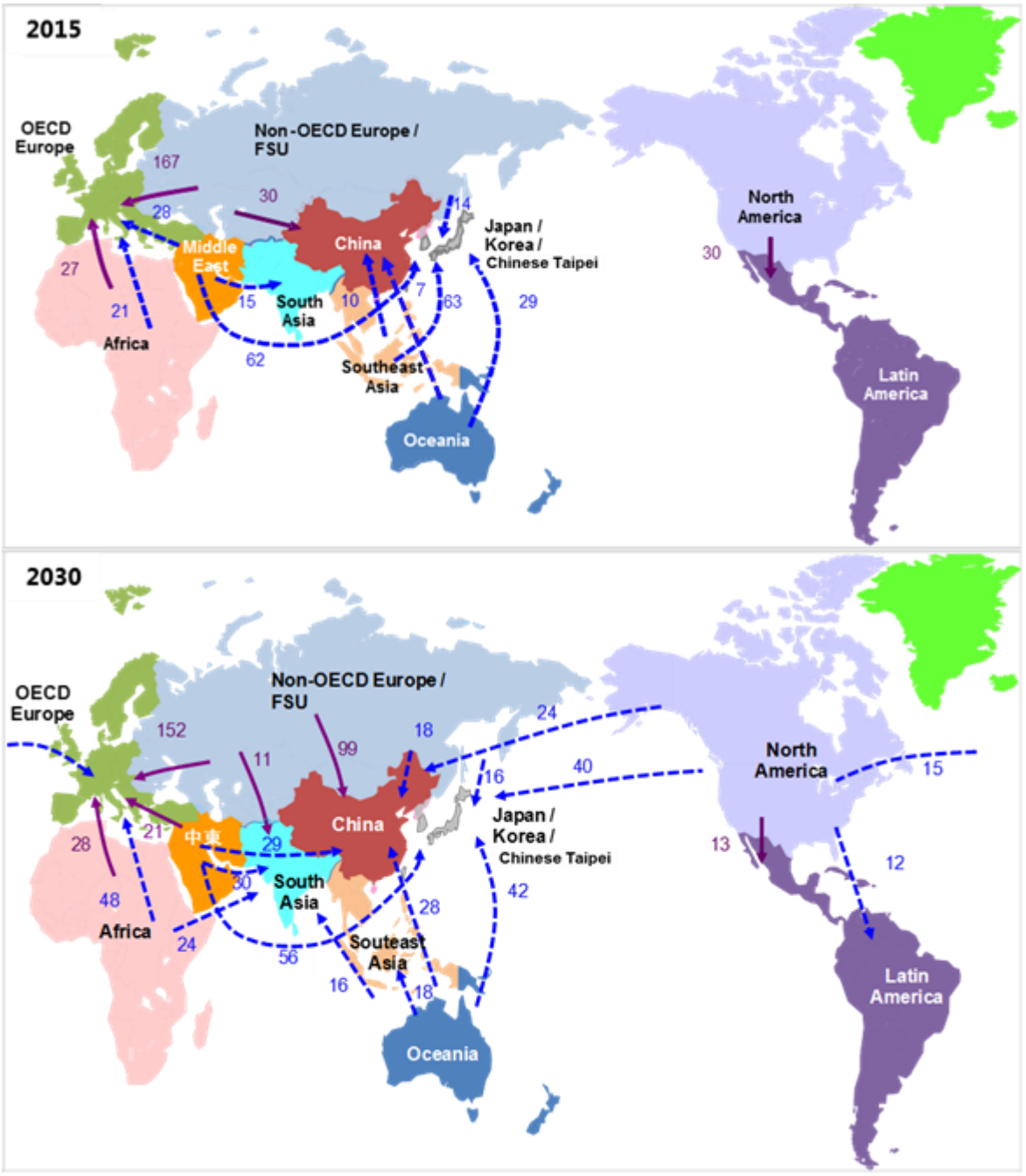
1.1.2 Increase in Trade Volume in the Region

In recent years, the increase in trade volume in the APEC region is the reason behind the growing concern on gas security. Figures 1.3 shows the trade volumes for natural gas in key regions of the world in 2015 and the forecast in 2030. Trade volume along the primary natural gas trade routes in the Asia-Pacific region is expected to increase by approximately 1.8 times from 2015 to 2030, from 238 billion cubic metres (Bcm) to 426 Bcm. This increase in natural gas trade volume in the region is the result of growth in exports from the United States with the continued impact of the shale revolution, as well as the increase in import volume in emerging markets (i.e., China and the ASEAN region). China is forecasted to increase its natural gas demand by fourfold until 2040 and is expected to be the second largest LNG importer before the decade's end. Japan is the Asia's largest LNG importer with almost half of the region's LNG imports, or about 37% of global LNG imports. Korea followed next with a 23% share to total Asia LNG imports, while China required 10% and Chinese Taipei 7.0%. Although this forecast covers only the primary trade routes in the region and not all trade volumes, the others (trade volumes and trade flows) not included are also certainly expected to increase in the future. An example of such other trade flows include LNG trade within the ASEAN region (from Indonesia to other parts of Indonesia or to Singapore, Malaysia, etc.).

Supply interruption from gas-producing economies is not the only risk that contributes to the supply disruption; risk factors are also present in transporting the gas to consumers. For example, the gas supply interruptions that happened in Europe in mid- and end-2000's were because of these two factors. As gas trade becomes increasingly globalised, with trade volume increasing every year, the accompanying risks related to stable supply will continue to grow. Since LNG trade

is expected to increase even further in the region, it will become even more important to ensure the security of LNG tankers during their passage.

Figure 1.3 • Current and Projected Natural Gas Trade Volumes in Key Regions of the World, in Bcm, 2015 and 2030



Source: IEEJ (2016)

1.1.3 Occurrence of Actual Security Events

Cuts in Gas Supply between Russia and Ukraine

Although there were many gas supply disruptions that happened around the world, only a few incidents made governments revaluate their gas supply security. Among the recent events that caught international attention on gas security issues was the cut in natural gas supply from Russia to Ukraine, which occurred in January 2006 and January 2009. As preceding studies[3] have already been conducted on the detailed background leading up to this event, a brief overview will be provided here.

Russia is the largest natural gas supplier to Europe. Much of its supply is exported through third-party arrangement with some economies using pipeline networks (like with Ukraine) before reaching the end-consumers in Europe. Russia does not only supplies gas to Europe, but also to its neighbouring economies of the former Soviet Union and Eastern Europe through the same pipelines as the ones that go to Europe. Beginning from the fall of 2005, Russia and Ukraine were engaged in negotiations on natural gas prices for 2006 and beyond. However, the negotiation became challenging for both parties due to different stances on gas pricing. As the negotiations did not reach a conclusion by 31 December 2005 when the existing contract ended, Russia cut the natural gas supply by the volume equivalent to its supply to Ukraine, while continuing to supply natural gas to Europe. However, as Ukraine continued to claim the same volume of natural gas that it had been consuming, the volume of natural gas supply that reached the European markets at the downstream end of the pipelines was consequently reduced. Of course, this cut in pipeline gas supply was strongly condemned by Europe. Thereafter, Russia and Ukraine entered into talks once again and reached a consensus on the prices, which eventually resulted in the delivery of the original supply volume (03 January 2006). However, the reduction in natural gas supply during the peak demand period in winter was an unexpected event for Europe, and instantly gave rise to concerns about the stability of natural gas supply from Russia.

In 2008, negotiations on natural gas prices between Russia and Ukraine met with difficulty once again, lasting until 2009. On 01 January 2009, Russia once again suspended its natural gas supply to Ukraine. Russia alleged that Ukraine was siphoning natural gas supply intended for Europe, and took a drastic move of cutting off all pipeline gas supply to Ukraine, including supply bound for Europe. In response to the serious disruption of natural gas supply, the European Union (EU), which had adopted a wait-and-see attitude up to that point, intervened to mediate between Russia and Ukraine. As a result of this arbitration, Russia and Ukraine reached an agreement on a new price level on 18 January 2009, and gas supply was resumed the next day. The interruption to natural gas supply that occurred in 2009 was different from the previous supply disruption (2006) in the sense that Russia not only intentionally cut off the supply of natural gas to Ukraine, but also to Europe, making it a far more serious supply disruption event for Europe.

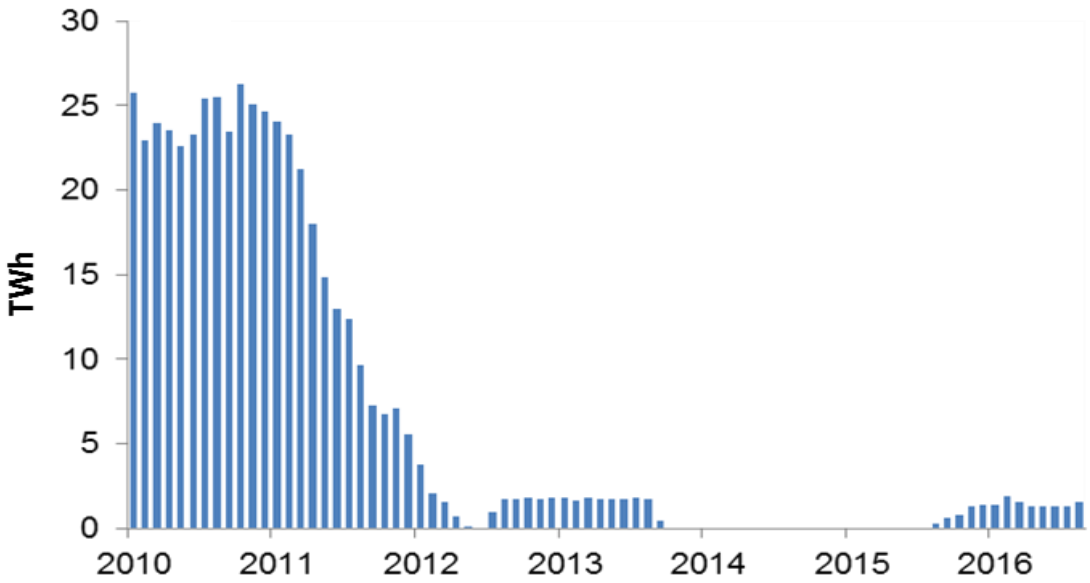
[3] Jonathan Stern, "The Russian-Ukrainian gas crisis of January 2006" (January 2006) Oxford Institute for Energy Studies. Jim Nichol, Steven Woehrel, Bernard A. Gelb, "Russia's Cutoff of Natural Gas to Ukraine: Context and Implications," CRS Report for Congress (February 2006). Simon Pirani, Jonathan Stern and Katja Yafimava, "The Russo-Ukrainian gas dispute of January 2009: a comprehensive assessment," Oxford Institute for Energy Studies. Jennifer L. Bovair and Edward C. Chow, "The European Gas Crisis," (January 2009) Center for Strategic and International Studies.

Even after the 2009 incident, natural gas supply from Russia to Ukraine was on and off, suspended from June to October 2014 and July to October 2015 over unpaid gas charges. However, these supply disruptions to Ukraine had limited impact on natural gas supply to Europe because they did not occur during the peak demand period (such as in 2009), and because direct export routes—such as the Nord Stream pipeline that directly connects Russia and Germany—had been constructed from Russia to Europe without going through a third-party economy. Nevertheless, Europe remains strongly concerned about the stability of gas supply from Russia, and this has become an important incentive to put in place gas security measures.

Rapid Growth in LNG Demand in Japan after the Great East Japan Earthquake[4]

The Great East Japan Earthquake that struck in March 2011 triggered a rapid increase in LNG demand of the economy as a result of the shutdown of nuclear power plants. Although the event may be different, in the sense that the problem is about securing adequate supply of natural gas to meet the level of demand, it is also necessary to plan ahead for gas security that may arise as a result of demand-side factors or unforeseen circumstances.

Figure 1.4 • Amount of Nuclear Power Generated in Japan, 2010-2016



Source: METI (2016)

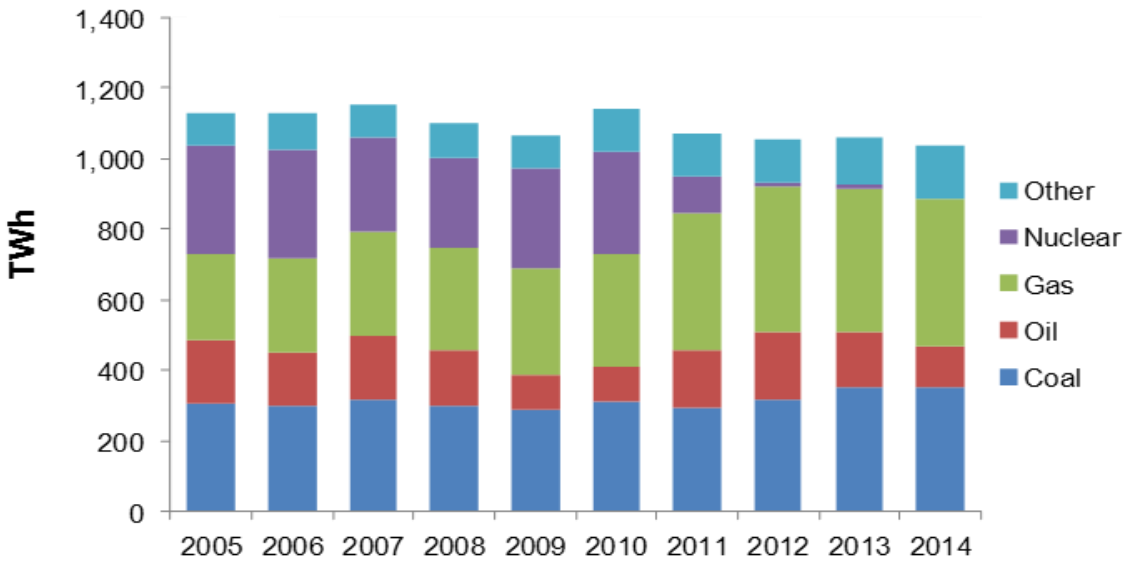
The Great Earthquake caused a complete power outage at the Fukushima Daiichi Nuclear Power Station operated by the Tokyo Electric Power Company (TEPCO), making it impossible to cool the inside of the nuclear reactor. The result was a hydrogen explosion that posed the risk of widespread radiation emissions. In response, the Japanese government enacted a policy forbidding the operation of all nuclear power plants that were in operation in the economy at the

[4] Details about LNG procurement by Japan during the Great East Japan Earthquake are available from the IEA (2016b).

time, unless they were able to meet the newly established safety standards. Consequently, the utilization capacity of nuclear power plants in Japan declined rapidly throughout 2012 (Figure 1.4).

To make up for the losses of the nuclear power plants, all non-nuclear power plants were operated at full capacity. During this period, the gas-fired power plants significantly increased their operating rate (Figure 1.5), from 319 Terawatt-hour (TWh) of power generation in 2010 to 388 TWh in 2011, and 420 TWh in 2014 when generation from nuclear power plants stopped. The gas-fired power plants in Japan had been utilised as a "base-to-middle-load" power source prior to the earthquake. Compared with coal-fired thermal power, which was a base-load power source and already operating at close to full capacity, natural gas-fired power plants still had spare capacity to expand operation. Moreover, with crude oil price exceeding $100/bbl, it also incurred lower fuel costs than oil-fired power generation. Thus, natural gas was the most utilized power generation source due to its ability to provide electricity at a better efficiency as well as flexibility.

Figure 1.5 • Amount of Power Generated in Japan by Source, 2005-2014



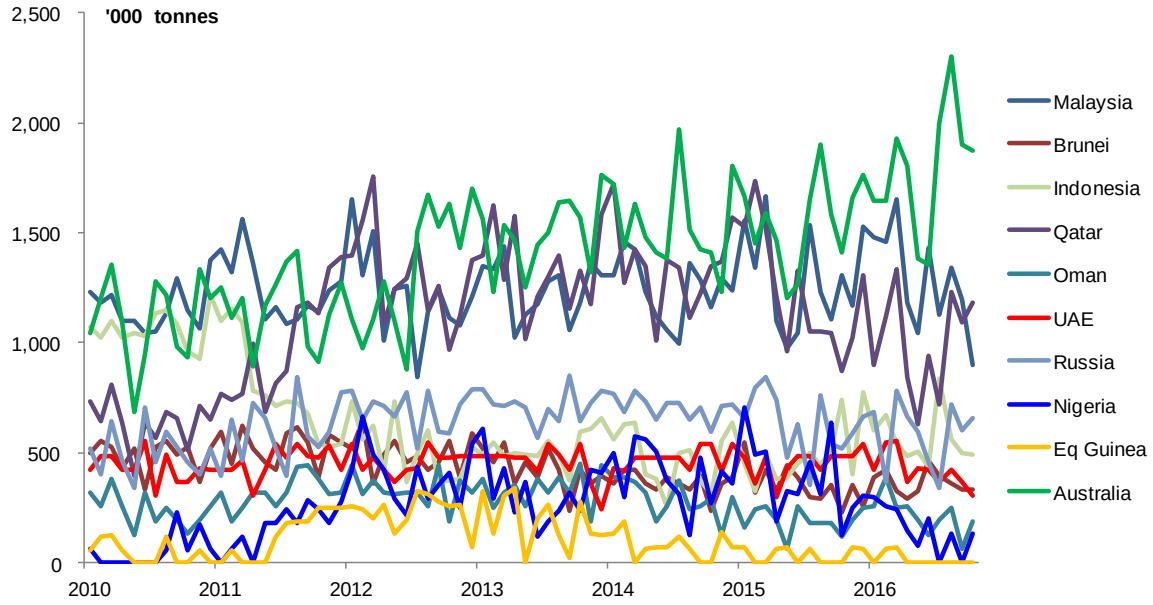
Source: IEEJ

As Japan is dependent upon imported LNG to meet most of its domestic natural gas demand, rapid growth in LNG importation was unavoidable. The volume of LNG import increased from 70 million tonnes (MT) in 2010 (before the earthquake struck) to 87.31 MT in 2012 when the nuclear power plants began to suspend operations. Thereafter, it continued increasing to reach the peak level of 88.51 MT in 2014. Much of that import growth consisted of LNG produced in the Middle East, including Qatar and Oman, as well as LNG produced in Nigeria and other parts of Africa (Figure 1.6).

Much of the additional LNG imports by Japan were procured through spot trading. However, LNG that is traded in the international LNG market (on a spot basis) is usually not produced for spot trading purposes alone. This LNG supply is usually bound for a predetermined market but is

then diverted through individual negotiations. A large portion of the LNG produced in Qatar and Africa is transported to markets in Europe and the United States. As these markets also receive supplies through piped gas in addition to LNG, it is relatively easy to divert the LNG supply to other markets. In particular, the period of the Great Earthquake coincided with the start of operation of large-scale LNG terminals in Qatar to produce LNG for Europe and the United States so the presence of many LNG markets that allowed for such diversions of LNG supply turned out to be the silver lining for Japan. Hypothetically, if the demand and supply balance in the international LNG market was tight and many of the sellers were committed to other buyers based on long-term contracts, it is unclear if the international LNG market could absorb the increase in demand when a similar case of rapid increase in gas requirement occurs. Hence, from the perspective of ensuring gas security, it is vital to develop a market that is physically able to secure a sufficient volume of LNG even under such situations of rapid surge in demand, (regardless if prices are to increase). As LNG import volumes are expected to increase in the Asia-Pacific market, it will become increasingly important to develop a highly fluid LNG market.

Figure 1.6 • Japan's LNG Import Volume by Economy, 2010-2016



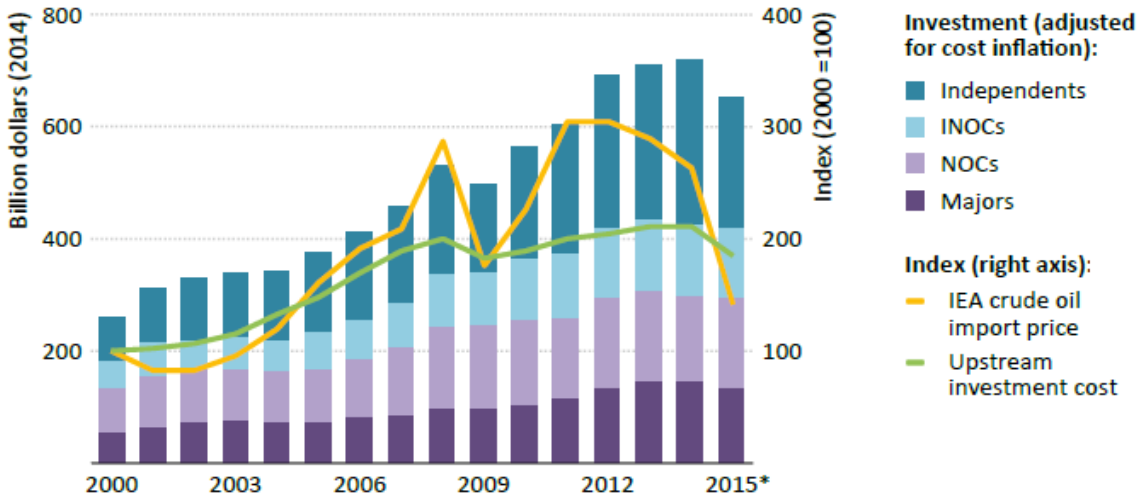
Source: MOF (2016)

1.1.4 Decline in Investment

Another reason behind the heightened interest in securing a stable supply of gas is the decline in investment caused by some factors, such as the easing of the demand and supply balance, and low oil prices. The decline in investment may cause an adverse impact to future gas supply capability and as demand is expected to increase in the future, it could lead to negative impact on the stability of prices as well as on the demand and supply balance of natural gas over the medium- to long-term. Although natural gas supply capability currently exceeds the demand in the world, this easing of the demand and supply balance happened due to a market cycle. As such, it is difficult to say if this situation of supply exceeding demand will definitely continue in the future.

When investments in the upstream sector have declined rapidly across the world after 2014 as oil prices began to fall (Figure 1.7[5]), it was highly possible that a demand and supply imbalance would occur and cause problems in securing supplies of natural gas at stable prices. Oil and gas companies reacted to the low oil prices by heavily cutting their capital expenditures on upstream. In 2015, some non-OPEC oil companies decreased their upstream investment by more than 20%, affecting the medium-term outlook not only for oil but also for gas, which could also experience delay in production flow (IEA, 2015b).

Figure 1.7 • Investment in the Upstream Sector Worldwide, 2000-2015



Source: IEA (2015)

The decline in upstream investment also poses a serious problem in the LNG market. Figure 1.8 shows the investment decisions made for LNG projects globally. Similar to the situation for investment in the upstream sector, the investment decisions made for LNG likewise dropped significantly. Many existing LNG supply agreements are long-term contracts whose selling price is linked to a crude oil price (oil index). As the price of natural gas is tied to a volatile international crude oil prices, boom and bust cycle might be possible in the world LNG market.

Oil indexation has been the practice for several decades in pricing imported natural gas in Europe and in Asia. It was introduced in 1960s to provide a pricing mechanism and incentive for natural gas use over oil-based fuels (ECS, 2007). It played a critical role in the development of natural gas during its infant stage. However, gas price based on an oil index is now being questioned and criticised as it does not reflect the gas market fundamentals.

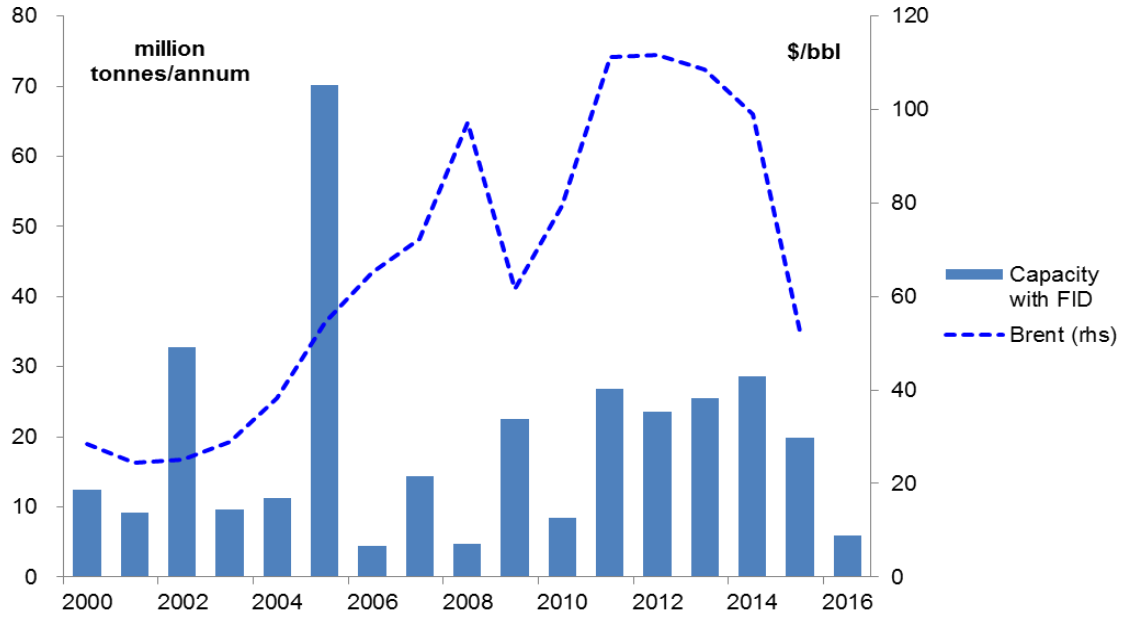
Due to the price drop of crude oil price since the summer of 2014, final investment decisions (FID) for a number of LNG projects have already been deferred or totally shelved as the price of LNG could not cover the capital costs of putting up a new LNG plant. In 2016, the only LNG-related investment carried out was the Tangguh Project in Indonesia. Many experts assess that

[5] Figure 1.7 shows both nominal and real investment cost.

the current liquefaction facilities will still be enough to cover global LNG demand until 2020. In 2014, global LNG liquefaction stood at 291 million tonnes per annum (Mtpa) of which around 40% was located in the APEC region. Global capacity was increased to 301 MTPA in 2015 with the commercial operations of the 8.5 Mtpa Queensland Curtis LNG in Australia and the 2 Mtpa Donggi-Senoro plant in Indonesia (IGU, 2016).

As LNG demand in Asia is expected to increase in the future, and if the low investment scenario continues, securing a stable supply of gas and LNG will be a challenge for the Asia-Pacific market. The challenge is how to enable FIDs for LNG projects to prevent the possible tightening of LNG markets.

Figure 1.8 • Investment Decisions for LNG Markets Worldwide, 2000-2016



Source: IEEJ

1.1.5 Progress in Liberalisation

The natural gas market has become increasingly liberalised in Asia in recent years. However, there is the possibility that this progress (liberalisation) may have an impact on the stable supply of gas. In China, plans are underway to unbundle the supply chain of the domestic gas market that has been under the monopolistic control of the state-owned oil companies, and in particular, to establish separate independent companies that will operate the pipeline. By unbundling the supply-chain, China aims to attract more private-sector investors into the gas market. In Japan, the market has been undergoing liberalisation in phases since 1995. The retail market that also covers residential use, which is the last remaining market under regional monopoly, will be liberalised. Korea is now drawing up plans to liberalise the domestic gas market currently monopolized by the Korea Gas Corporation.

Although market liberalization will promote more efficient markets and more competition among suppliers (which should not be in conflict with the objective of having a secure and stable supply of gas), such efficiency improvement in the gas supply chain could make some investors reluctant to invest in supply infrastructure, which in turn would bring about a loss in reserve supply capacity. This could also lead to the elimination of redundancy in the supply chain that may increase the gas supply security risk in case of an unexpected supply disruption.

Another possibility is that if gas industry players are unable to generate short-term profits, there is a probably that some business operations may end up being terminated. Moreover, although care is taken to prevent retail prices from fluctuating excessively under the existing gas pricing systems, progress in liberalisation brings with it the risk of increased price volatility, and this may consequently damage the interests of the end-consumer.

The pursuit of efficiency through liberalization can sometimes have the opposite effect on security. To achieve gas security, it is necessary to have a certain degree of surplus with respect to the supply infrastructure, and it is not ideal to increase the range of price fluctuation excessively. However, as efficiency is expected to improve due to liberalisation, such infrastructure surplus capacity is gradually reduced, and the range of price fluctuation also inevitably increases. Of course, achieving security and liberalisation share the common goal of maximizing benefits for the end-consumer.

For this reason, it is important to push forward with liberalisation with a balanced approach, taking into consideration the conflicting aspects of the two – promoting both efficiency and security. Liberalization should be pursued in parallel with maintaining sustainable investments. For instance, third party access should be gradually instituted and applied to facilities that have already recovered or almost recovered their capital investments. A radical introduction of third party access to all facilities may discourage investment. Likewise, industrial unbundling should be adopted in a step-by-step manner, from accounting to legal unbundling, and ownership unbundling in order to avoid drastic change in industrial structure causing deferred investments.

1.2 Definition of Gas Security

1.2.1 Important Factors of Gas Security: What are the Elements that should be protected?

Gas security can be defined as “having a supply of a sufficient volume of gas at a stable price by performing sound economic management.” Generally, gas security is often treated as a part of energy security.

Energy security is a concept that became widespread as one of the areas of energy policy after the oil crisis of the 1970s. It is used to be presented as an issue of ensuring a stable supply of oil in particular. However, recent concepts of energy security are becoming more comprehensive focusing not only on oil, but increasingly including coal, natural gas, nuclear power

and other forms of energy. The different stages of supply covered in the concept are no longer limited to the production phase, but include elements such as the transportation component of energy to reach the end-consumer, environmental sustainability and price stability. The concept of energy security is increasingly being perceived as a multifaceted concept that covers many elements. In the process of the evolution of energy security into a broader concept, gas security is gaining stronger recognition for its importance as a constituent field of energy security.

1.2.2 Characteristics of Natural Gas Supply Security

In considering measures to strengthen gas security, it is vital to also gain a comprehensive understanding of the unique properties of gas security (or natural gas itself).

Physical Properties of Natural Gas

Natural gas, unlike oil or coal, is difficult to transport. For this reason, it is necessary to construct pipelines across the entire route of conveyance, from the wellhead where it is produced to the final destination where it is consumed. Besides pipelines, gas can be transported as LNG for long distances. The gas must be cooled to a temperature of -162°C or below until it enters the liquid state before it is shipped to the consumer. This makes it possible to transport it as LNG on railways, trucks, or tankers. To do so, however, it is first necessary to construct liquefaction facilities (for exporters), and regasification facilities (for importers) in order to convert the LNG back into its gaseous state. It is also necessary to construct pipelines to transport the gas from the regasification facility to the end-consumer. Although it is possible to receive supplies of oil and coal from a relatively larger number of alternative sources if sudden supply interruptions happen, the same measures cannot be applied on gas due to its unique physical properties. In the case of gas, supplies can only be received at locations where there are pipelines connected to gas production or natural gas liquefaction facilities.

Moreover, gas is also characterized by its property of being difficult to store at ordinary temperature. Coal can be stored in a coal storage yard while oil can be stored in tanks that meet certain requirements. Gas, on the other hand, will be emitted into the atmosphere at ordinary temperature, and therefore, can only be stored in a depleted gas field or a sealed structure such as a salt bed. Although LNG can be stored in a tank, the LNG tank must be equipped with equipment that keeps the tank at an ultra-low temperature so that the LNG will not vaporise, and the tank must be made from a special steel that can hold such low-temperature liquids over a long period of time. This incurs extremely high construction and transportation costs. Thus, storage of natural gas would be difficult if the location is not equipped with an underground structure for gas storage at room temperature, as described above. Compared with oil and coal, there are limited options when there is a need to respond to emergency situations.

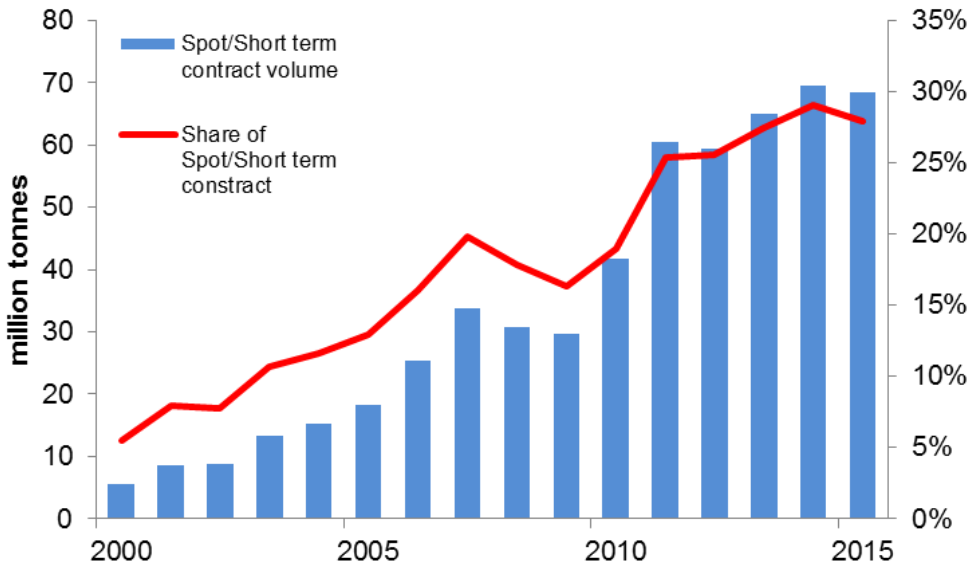
Need for Heavy Investment and Less Redundancy in the Supply Chain

As explained above, it is necessary to develop infrastructure to transport gas due to its physical properties. As such, heavy investment is required in order to utilize gas. In particular, the construction of LNG liquefaction facilities necessitates investment to the tune of billions of dollars. Besides liquefaction facilities, other facilities such as LNG tankers, regasification facilities for receiving terminals and LNG storage tanks will also need huge investment. Due to these factors, investors will only invest to meet certain demand. This means that, except in cases of unexpected market fluctuations, redundancy of supply capacity tends to be small, and even a small supply disruption can cause a significant security impact on consumers.

Inadequate Market Liquidity

As the trading of natural gas calls for the heavy investment as mentioned earlier, there are many cases where the natural gas is traded with fixed customers through long-term contracts in order to secure the funds required for the production investment. In other words, a long-term contract provides assurance for the supplier to secure needed investment. For LNG in particular, which requires greater investment as compared with pipeline gas, long-term contracts spanning periods as long as 40 years have been in existence since trading began in the 1960s. Today, most of the contract terms are for 10 to 20 years; even so, considering that the standard period for short-term crude oil contracts is about one year, LNG could be described as a business that is exceptionally long-term in nature. Further, a destination clause is included in such long-term contracts, thereby forbidding the LNG buyer to resell the LNG to a third party without authorization from the seller. Under this destination clause, in principle, LNG that is traded based on long-term contracts must be transported to the regasification facility owned by the buyer. Under such circumstances, it is difficult to establish a spot market for the trading of LNG.

Figure 1.9 • Short-term/Spot Trading Volume in International LNG Market, 2000-2015



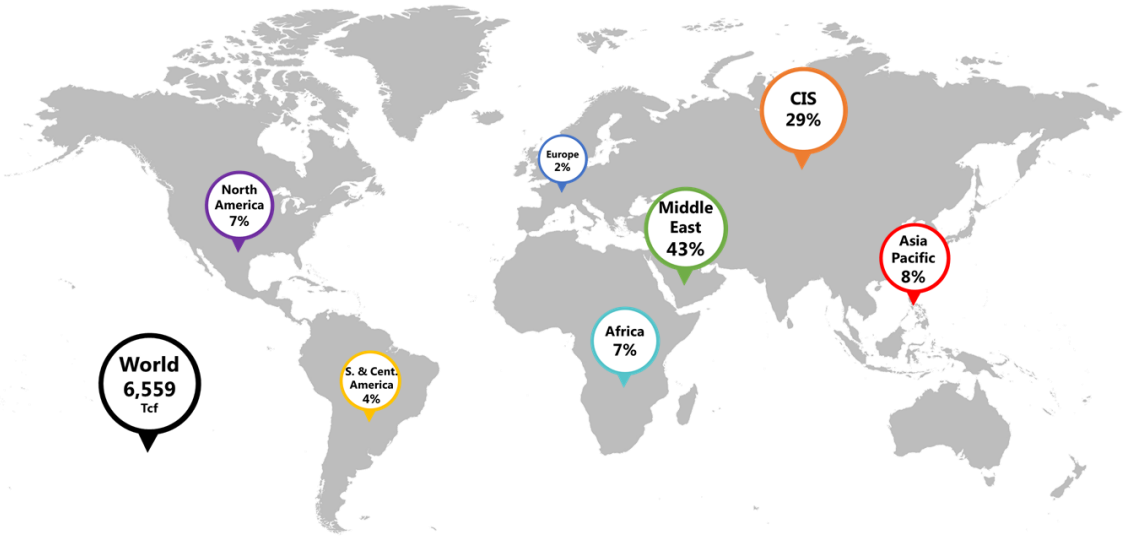
Source: GIIGNL (2016)

However, trading based on formats other than long-term contracts has gradually been on the rise recently. As shown in Figure 1.9, close to 30% of LNG is traded through spot trading or short-term contracts. However, as explained above, there are many cases where such short-term trading is also treated as spot trading when it involves the diversion of LNG bound for predetermined markets; it is not a situation where large volumes of cargo, supplied to the market for spot trading, are traded actively. From the perspective of market liquidity, the international LNG market lags far behind the international coal and oil markets. When consumer economies are hit by a rapid increase in demand, they are very likely to encounter difficulties in procuring a large volume of additional supply through spot trading on the market.

Better supply and demand diversity

Although all three points discussed above are important in ensuring the gas security, the location of the gas production plays an equally, if not more, important role in ensuring stable supply. Firstly, the geographical reserves of the resource are widely distributed. As shown in Figure 1.10, while 43% of the world's oil reserves are in the Middle East region, gas is also found in the former Soviet Union region (Commonwealth of Independent States - CIS). Recently, as a result of the shale revolution, North America has an increasing amount of reserves. With diverse sources of gas reserves globally, natural gas has an advantage from a security viewpoint, as its reserves are not concentrated in a specific region.

Figure 1.10 • Natural Gas Reserves in Regions of the World, 2016

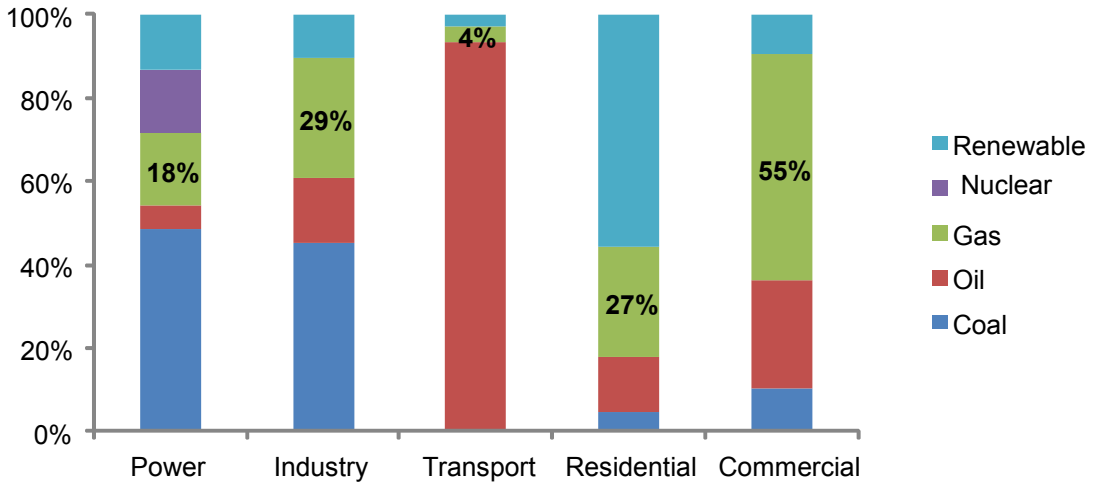


Source: BP (2016)

A second advantage is the diverse range of sectors that can utilize gas. Figure 1.11 shows the world's gas demand by sector. Gas is used alongside other forms of energy in a wide range of sectors including power generation, industrial, commercial and residential, and as petrochemical raw material. If the supply of oil, for example, is disrupted, it would have a profound effect on the transportation sector due to its large utilization share in this sector. Conversely, if gas supply is disrupted, it can be substituted for relatively easily with other forms of energy such as oil or coal.

The fact that it is not utilized as a dominant form of energy in a particular sector helps to minimize the impact of a disruption in gas supply.

Figure 1.11 • Energy Sources of Energy Utilization by Sectors of the World, 2015



Source: IEA (2016c)

Chapter 2. Measuring Gas Supply Security

As discussed in Chapter 1, there are many factors that influence gas security. As gas security becomes a multifaceted concept that covers many elements, it is necessary to understand different the factors that influence supply. Since the gas supply system is complex, many uncertainties and factors may affect supply security. For example, risks of political instability, technical/technology limitations and economics are among the factors that can potentially pose supply security risk for the economy.

Some studies have been done to gauge energy security. The World Economic Forum (WEF) published the **'Global Energy Architecture Performance Index,'** with the primary focus on 'energy trilemma' covering: (1) economic growth and development; (2) environmental sustainability; and, energy security and access. The Institute of Energy Economics, Japan also published a number of studies related to energy security like the study on **'An Analysis of Major Countries Energy Security Policies and Conditions,'** which examined the seven main indicators of energy security – primary energy self-sufficiency, diversification of import sources, diversification of energy sources, transportation risk, domestic risk management, demand conservation, and supply interruption risk management (IEEJ, 2011).

The Asia Pacific Energy Research Centre (APERC) also produced a study that focuses solely on oil and gas security indexation, which aimed at quantifying the risks in the supply chain – from production to transportation of oil and gas – and to have a better understanding on the underlying gas supply security risks. In this study, PESTLE[6] was utilised to depict almost all aspects of supply risk factors. The study considered a combination of 28 sub-indicators for gas (for both piped gas and LNG) to assess the overall gas supply security risks. These sub-indicators were used to measure the level of risks in each PESTLE indicator (based on the appropriateness of the sub-indicators to each of the PESTLE indicators). The study used a scale of 0% to 100% for each indicator and sub-indicator, where 0% means no risk, while 100% has the highest risk[7]. Some data for the indexation were derived from well-established and publicly available global indices, such as the World Governance Index (WGI) and 'Ease of Doing Business' released by the World Bank, and the Global Petroleum Survey (GPS) by Fraser Institute, among others, in order to establish the security index.[8] Likewise, the indexation study divided the sub-indicators further into two groups, the internal and external factors (APERC, 2017).

This chapter presents some of the factors that may affect energy security in the APEC region covering the period 2000-2014 using a number of indicators/sub-indicators considered in the Oil and Gas Security Indexation study. Specifically, this chapter focuses only on 11 indicators (or sub-indicators) under internal factors and three indicators (sub-indicators) as external factors in gas supply security risk. For the internal factors, the indicators include: primary energy diversity; gas

[6] The PESTLE acronym stands for political, economic, social, technical, legal and environmental.
[7] Also used 0.01 to 1.00 for the Herfindahl-Hirschman Index (HHI).
[8] Cedigaz data (gas security indexation) is the only data that was used from a subscription service.

share of primary energy; gas intensity; gas per capita; gas self-sufficiency; gas import diversity; reserves/production ratio; regasification terminal (RGT) utilisation rate; transnational gas pipeline utilisation rate; natural gas underground storage over demand, and international agreement on gas security. On the other hand, the external factors cover chokepoints, exporters' political stability, and LNG export terminal utilisation. Indexation is used in measuring gas supply security risk per indicator.

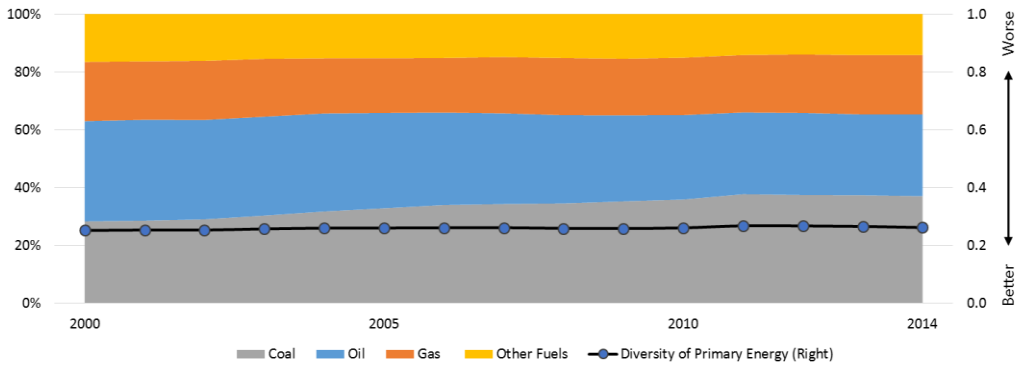
A few of the indices for total APEC were estimated by getting the average index (score) of all the member economies, among which is the international emergency supply agreements on gas. Likewise, a simple average was used to come up with the overall index score (without assigning any weights to indicators and groupings into internal and external factors). (For the methodology in determining the index value, please refer to Oil and Gas Security Indexation Study).

However, it should be noted that the factors presented here change over time (and thus the security indices) depending on the economies' circumstances. APEC economies have different priorities in looking at the supply risks, or may have identified a hierarchy of risks depending on their production/supply capacities, existing policies, infrastructure and even financing, among others.

2.1 Natural Gas Supply Situation and Security in APEC

APEC has contributed significantly to global economy, representing more than 50% of world's gross domestic product (GDP) (around 59%), and almost half (49%) of global trade (source: APEC). The region also consumed about 60% of global energy as four of the world's largest energy consumers are APEC member economies – China; Japan; Russia; and the United States. Likewise, the region is also a host to largest LNG importers – China; Japan; Korea; and Chinese Taipei.

Figure 2.1 • Gas Share in Primary Energy and Diversity of Primary Energy Supply Mix, 2000-2014



Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.0 to 1.0), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.61. A higher HHI means a high concentration in one or a few sources. HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.

From 2000-2014, the region's primary energy supply increased annually at 2.4%, on average, with natural gas supply requirement also grew at the same rate and much faster than oil (only at 1.0%). In the same period, more than half of the APEC economies (14 economies[9]) displayed increasing share of natural gas in their respective primary energy supply requirements. Despite the expanding share of natural gas in some economies, the region's diversity index for its primary energy mix slightly went up to 0.26 HHI in 2014 from 0.25 HHI in 2000 as shown in Figure 2.1. However, it could be said that the region's primary energy is well-diversified as it is within the 'moderate-low concentration' (between the range of 0.21-0.40 HHI), which on the point of view of energy security, brings greater supply security. Thus, the security index for the primary energy diversity indicator is low (at 26% index in 2014).

Table 2.1 • Diversity Index for Primary Energy Supply Mix by Economy, 2000 and 2014

Economies	Diversity Index of Primary Energy Mix	
	2000	2014
Australia	0.33	0.30
Brunei Darussalam	0.65	0.72
Canada	0.25	0.26
Chile	0.27	0.25
China	0.42	0.47
Hong Kong, China	0.34	0.46
Indonesia	0.28	0.24
Japan	0.32	0.32
Korea	0.36	0.27
Malaysia	0.40	0.35
Mexico	0.43	0.38
New Zealand	0.24	0.22
Papua New Guinea	0.67	0.60
Peru	0.42	0.32
Philippines	0.28	0.23
Russia	0.35	0.35
Singapore	0.87	0.51
Chinese Taipei	0.35	0.31
Thailand	0.27	0.25
United States	0.34	0.23
Viet Nam	0.25	0.25
APEC	**0.25**	**0.26**

Sources: APERC analysis and IEA World Energy Statistics 2015.
Note: In the diversity index (0.01 to 1.00 HHI), the lower the number the more diversified the sources of primary energy supply.

Table 2.1 shows the diversity index of the primary energy supply mix by economy. About two-thirds of the APEC economies demonstrated improvements in their respective diversity index for primary energy mix (declining diversity index). Brunei Darussalam obtained the highest diversity index at 0.72 HHI in 2014 (0.65 in 2000) as its primary energy is heavily dependent on gas.

[9] Australia; Brunei Darussalam; Canada; China; Japan; Korea; Mexico; Peru; the Philippines; Singapore; Chinese Taipei; Thailand; United States; and Viet Nam.

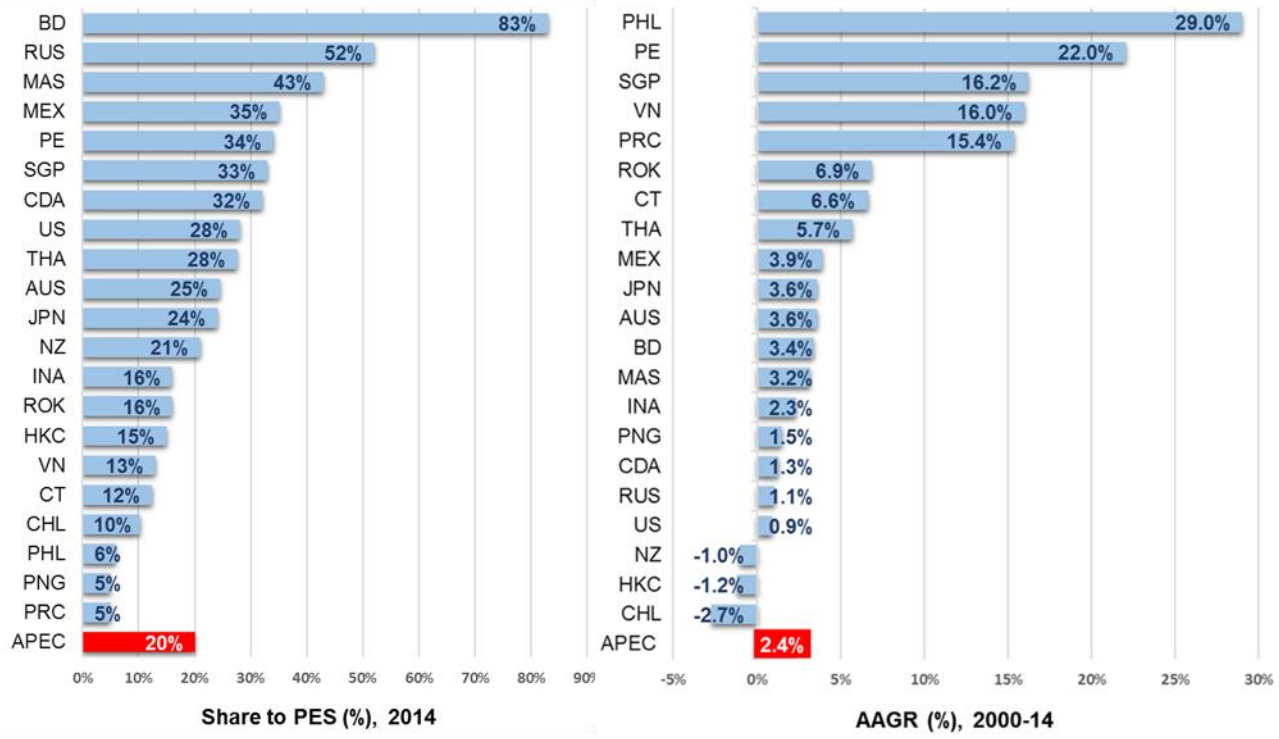
New Zealand had the most diverse primary energy supply with 0.22 HHI in 2014. However, 16 economies still managed to secure a moderate-low concentration category in their primary energy portfolios.

Singapore displayed the largest reduction in the diversity index (although still high), about 40% improvement (from 2000 level), while the United States came second with 32% improvement; Peru had 25% improvement; and Korea, 24%. A deeper analysis revealed that the increasing share of gas played a significant role in the diversification efforts of energy supply sources by some economies, such as: Korea; Mexico; Peru; the Philippines; Singapore; Chinese Taipei; and the United States.

It is projected that gas share (under the business-as-usual scenario of the APEC Energy Outlook, 6th Edition) reaches 26% in 2040, surpassing oil with only 25% share. Gas demand for power, growing at an annual rate of 2.7% until 2040, pushes gas to expand its share of the primary energy mix. Such growth in gas consumption is higher than coal demand for power, only 1.2% annually.

2.1.1 Gas Share, Intensity and Per Capita

Figure 2.2 • Gas Share in Primary Energy by Economy and Growth Rate

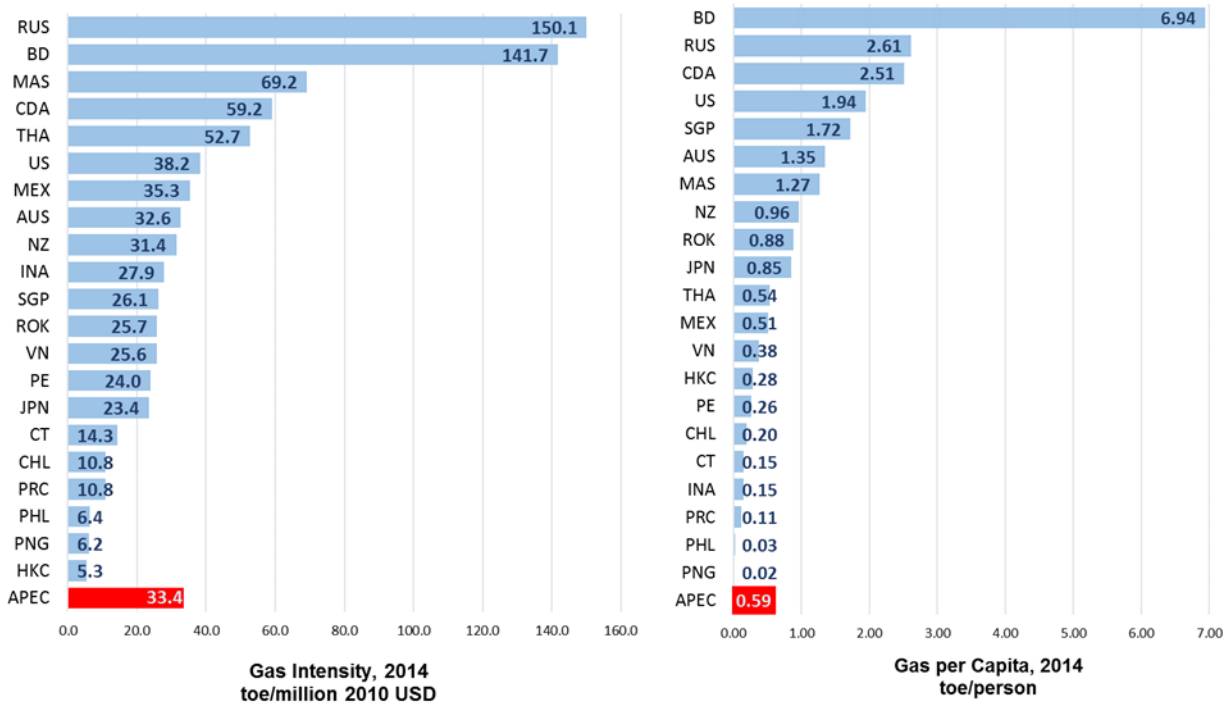


Sources: APERC analysis and IEA World Energy Statistics 2015.

Overall, natural gas had maintained its share of total APEC primary energy supply at 20% annually (2000-2014). Twelve economies showed a higher share of gas in the primary energy

than the APEC total of 20% as a result of increased demand for gas for most of the economies, such as China with 15% annual growth rate; Singapore with 16%; Viet Nam with 16%; Peru with 20%; and the Philippines with 29% (Figure 2.2). Only three economies exhibited decreasing demand in gas – Chile; Hong Kong, China; and New Zealand. Chile's gas demand displayed a downward trend at a rate of 2.7% resulting from a decrease in demand for power generation and a portion on non-energy application. Gas demand for power had declined due to displacement from coal (and to some extent from renewables). The same reason was also observed for Hong Kong, China (declining gas demand for power from increased coal generation). In the case of New Zealand, the falling share of gas was caused by higher utilisation of renewables in power generation.

Figure 2.3 • Gas Intensity and Per Capita, 2014



Sources: APERC analysis, IEA World Energy Statistics 2015, and World Bank

Although gas secured a steady share (primary energy), the total APEC gas intensity fell by 18%, 33.0 toe/million 2010 USD in 2014 from 40.5 toe/million 2010 USD in 2000, which led to a decline in the security index (a decrease in risk) for this indicator (52% in 2014; 59% in 2000). The decline in intensity was due to faster growth in GDP compared with gas consumption. Over the years, the total APEC GDP increased almost 4.0% annually, while gas consumption only grew at 2.4% a year. It should be noted that the index for this indicator is determined based on the highest and lowest gas intensity level of total APEC over the historical period (2000-2014)[10].

[10] In determining the security index for gas intensity, the highest and lowest gas intensity levels among APEC economies were considered, the highest intensity level was treated as having the highest risk (this method is used in order to establish the highest and lowest benchmarks in APEC. For the economy, the index was computed by using the highest and lowest intensity levels recorded by the economy from 2000-2014 as maximum and minimum benchmarks, and compared with the highest and lowest intensity levels recorded among APEC economies on each particular year. Similar methodology is applied to gas per capita index.

Nine of the APEC members had demonstrated declining intensity – Canada with 9.0% reduction; Chile with 60%; Hong Kong, China with 49%; Indonesia with 32%; Malaysia with 21%; New Zealand with 39%; Papua New Guinea with 39%; Russia with 32%; and, the United States with 12%. Among the economies, Russia, being the second largest gas producer in the APEC region next to the United States, had the highest gas intensity at 150 tonne of oil equivalent/million 2010 USD of gross domestic product (GDP) (toe/million 2010 USD) in 2014 although at a decreasing trend. Hong Kong, China had the lowest intensity at 5.3 toe/million 2010 USD (Figure 2.3). Almost half of the APEC economies had higher intensity levels than APEC total.

However, when it comes to gas per capita, APEC displayed an increasing trend, up by 26% in 2014 with 0.59 toe/capita from 0.47 toe/capita in 2000 (with the exception of 2009 because of the global financial and economic crisis). The increase in gas per capita was attributed to slower growth in total APEC population, 0.7% annually (compared with the growth in gas consumption) As such, the security index for this indicator rose by 10 percentage points, from only 44% in 2000 to 54% in 2014. Gas consumption per capita showed a stronger rebound post-2009 as gas demand increased rapidly in China, Japan (triggered by Fukushima incident that prompted Japan to switch from nuclear to LNG), Russia and the United States (both Russia and the United States are major gas producers and consumers). Only four economies showed a declining per capita level, specifically those economies with decreasing gas demand. Similar methodology used in gas intensity was applied in estimating the risk index for per capita level.

2.1.2 Reserves/Production Ratio and Self-Sufficiency Level

APEC is a host to the world's largest gas producers with significant amount of gas reserves, such as the United States; Russia; Canada; and China. The United States provided 21% to global gas production in 2014, while Russia shared 17%; Canada 4.7%; and China 3.9%[11] (BP, 2016).

Over the historical period, the total APEC gas reserves/production ratio went down to 39.8 years in 2014 from 41.6 years in 2000, which triggered the risk index for this indicator to go up, from 2.0% in 2000 to 6.0% in 2014 (although still at very low level)[12]. The reason for such a decrease was due to a higher growth rate in gas production (1.8%) compared with the growth in reserves (1.5%). With huge reserves available in some members, APEC is expected to continue to be self-sufficient in the near future. Table 2.2 shows the different R/P ratios in the APEC economies.

Notwithstanding its huge production, the United States remains a net gas importer considering its large domestic requirements. However, with shale gas resources, the amount of gas imports went down by 30% in 2014 (from the 2000 level), while export volumes rose by about fivefold in the same period. This also resulted in improved gas self-sufficiency level for the United States, from 82% in 2000 to 97% in 2014 based on total gas production over demand as domestic gas production increased. On the other hand, China was a gas exporter until 2006 but started to

[11] Other APEC economies with significant gas production are: Australia; Brunei Darussalam; Indonesia; Malaysia; Peru; Thailand; and Viet Nam.
[12] In order to create the index, the highest R/P ratio recorded by the economy between 2000-2014 served as the benchmark.

import with growing domestic demand for gas. China's gas imports shot up significantly, a fourteenfold increase, from 3.7 Bcm in 2007 to 52.1 Bcm in 2014. Russia's gas production had been expanding during the 14-year period with an increase of 10% a year. The production level in Canada declined by 7.0% following reduced exports to the United States.

Russia enjoyed a high reserves/production ratio at 86.8 years, followed by Australia with 63.0 years and Papua New Guinea with 57.1 years. However, in terms of growth, Papua New Guinea exhibited the largest expansion, with more than 50% increase (from 36.5 years in 2000) due to recorded additional reserves. With shale gas reserves, the United States also improved its ratio by almost 50% (from 10.0 years to 14.9 years in 2014), and Canada 36% (from 10.0 years in 2000 to 13.9 in 2014).

Table 2.2 • Reserves/Production Ratio (Number of Years), 2014

Economies	Reserves/Production Ratio
Australia	63.0
Brunei Darussalam	23.9
Canada	13.9
Chile	8.1
China	20.0
Hong Kong, China	0.0
Indonesia	39.1
Japan	11.0
Korea	3.7
Malaysia	41.2
Mexico	7.8
New Zealand	13.1
Papua New Guinea	57.1
Peru	28.3
Philippines	16.5
Russia	86.8
Singapore	0.0
Chinese Taipei	10.0
Thailand	7.0
United States	14.9
Viet Nam	21.2
APEC	**39.8**

Sources: APERC analysis and Cedigaz database

The APEC gas self-sufficiency level remained at 100%, and thus the risk index is at the lowest level during the 14-year period (Table 2.3). Nearly half of the APEC members continued to have 100% self-sufficiency level (Australia; Brunei Darussalam; Canada; Indonesia; Malaysia; New

Zealand; Papua New Guinea; Peru; the Philippines; Russia; and Viet Nam). Seven economies are net gas exporters and four economies have no imports as local production is enough to meet domestic demand. Papua New Guinea started to export its gas in 2014. There were also significant reductions in gas self-sufficiency level in some economies. As China became a net importer, its self-sufficiency level was down to 71% in 2014 from 100% in 2000. Self-sufficiency in Mexico and Thailand also declined as gas demand increased much faster than domestic production. Only the United States improved its self-sufficiency level as discussed above. However, some economies, the Philippines and Viet Nam will soon to import gas in the form of LNG and thus will affect their respective self-sufficiency levels.

Table 2.3 • Gas Self-Sufficiency (%), 2000 and 2014

Economies	Gas Self-Sufficiency Level (%)		Net Exporter/ Net Importer
	2000	2014	
Australia	100	100	Net Exporter
Brunei Darussalam	100	100	Net Exporter
Canada	100	100	Net Exporter
Indonesia	100	100	Net Exporter
Malaysia	100	100	Net Exporter
Papua New Guinea	100	100	Net Exporter
Russia	100	100	Net Exporter
New Zealand	100	100	No Imports
Peru	100	100	No Imports
Philippines	100	100	No Imports
Viet Nam	100	100	No Imports
China	100	71	Net Importer
Mexico	92	62	Net Importer
Thailand	90	75	Net Importer
USA	82	97	Net Importer
Chile	31	19	Net Importer
Chinese Taipei	11	2	Net Importer
Japan	3	2	Net Importer
Hong Kong	0	0	Net Importer
Korea	0	1	Net Importer
Singapore	0	0	Net Importer
APEC	**100**	**100**	**Net Exporter**

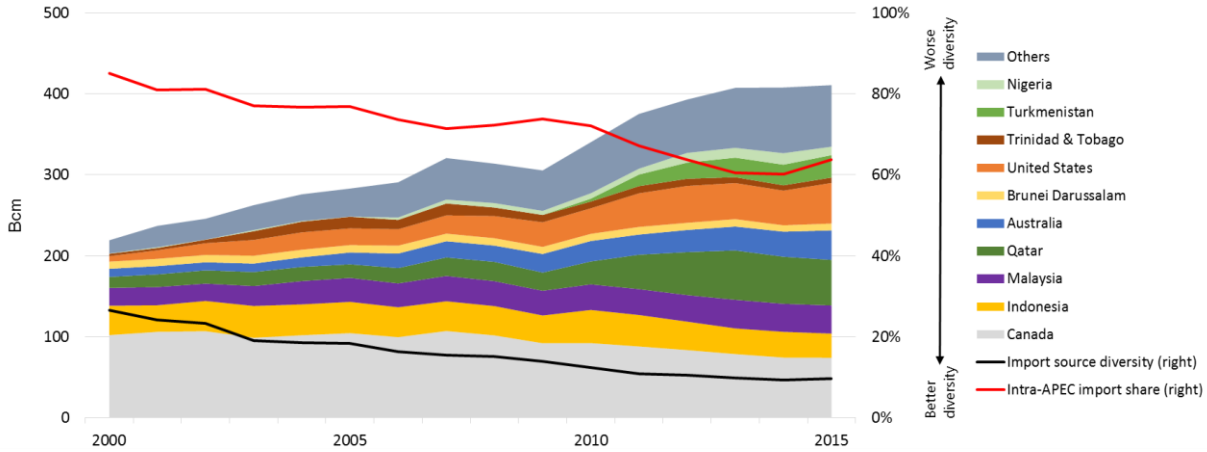
Sources: APERC analysis and IEA World Energy Statistics 2015.

The APEC region produces more gas than it consumes, which makes APEC a net gas exporter. However, further production disaggregation among economies reveals a different picture, particularly for resource energy poor economies, such as Japan and Korea, and resource rich economies, such as Russia and Australia.

2.1.3 Natural Gas Import Sources

In 2015, total gas imports in the APEC region (piped gas and LNG) stood at 410 Bcm (407 Bcm in 2014), which almost doubled the 2000 level (219 Bcm). Six APEC economies almost constantly appeared as top import sources (covering piped gas and LNG) for the region – Australia; Brunei Darussalam; Canada; Indonesia; Malaysia; and the United States (Figure 2.4). In 2000, these major import sources (intra-APEC trade) supplied 85% of gas imports, but gradually declined to 64% in 2015 (60% in 2014).

Figure 2.4 • Imports Sources, Diversity Index and Intra-APEC Import Share, 2000-2014



Source: APERC analysis and Cedigaz database.
Note: In the import diversity (0% to 100%), the lower the number the more diversified the sources of primary energy supply. The Herfindahl-Hirschman Index (HHI) is used to measure diversity of primary energy supply. HHI is an economic concept applied to assess market share or market concentration. . For this study, the HHI is modified such that the range (index) of high concentration was adjusted from its original >0.25 to >0.61. A higher HHI means a high concentration in one or a few sources. An HHI of 0.20 and below is considered low concentration, 0.21-0.40 is moderate-low concentration, 0.41-0.60 mid-concentration, and 0.61-0.80 is moderate-high concentration, and 0.81 and above is high concentration.[13]

The share of LNG imports from Southeast Asia (specifically from Indonesia and Brunei Darussalam) had declined over the years as new LNG producers such as Papua New Guinea entered the market, and LNG production from Qatar and Australia expanded. In 2000, the member economies from Southeast Asia (Brunei Darussalam; Indonesia; and Malaysia) provided an aggregate share of 30% to the region's total gas import demand (or 63% of total LNG imports). The dropped to 18% in 2015 (same share in 2014) resulted from increased shares of Qatar and Australia imports. The contribution from Qatar expanded to 14% of total gas imports in 2014 and 2015 from only 6.0% in 2000. Generally, APEC has been dependent on two regions for LNG supply, with the Middle East and North Africa (MENA) and the Southeast Asia regions supplying around 34% and 28% of LNG consumption in 2015 (37% and 27% in 2014) , respectively. Australia's share of total LNG exports to the APEC region also went up from 10% in 2000 to 16% in 2015 (13% in

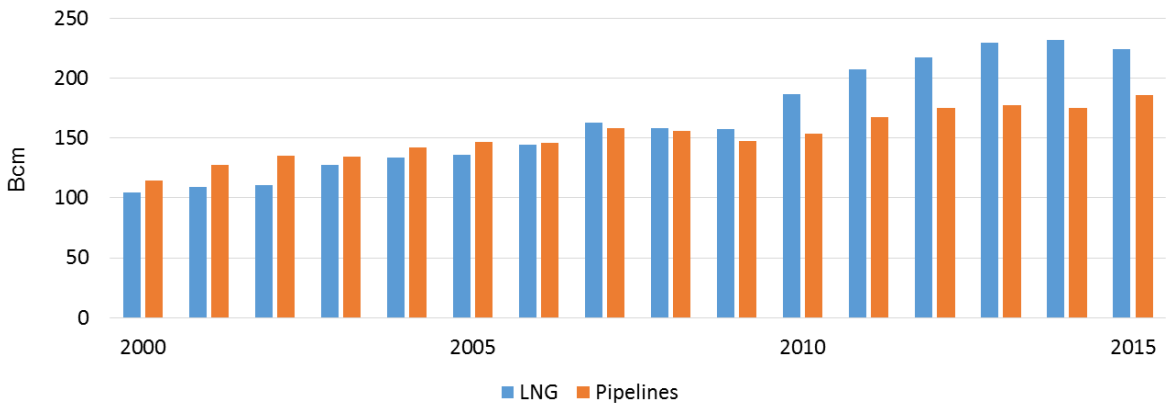
[13] HHI can be translated to percent, such that 0.20 means 20%. The reason for adjusting the HHI value (not adopting the Horizontal Merger Guidelines by the U.S. Department of Justice and Federal Trade Commission) is because the number of competitors in energy markets (import sources) is small compared with industry. Originally, an HHI of > 0.25 (or > 25%) is already considered as "highly concentrated."

2014). Likewise, the shale gas revolution also brought increased exports from the United States to the region, in particular piped gas exports to Canada and Mexico, from only 5.0 Bcm in 2000 to 50 Bcm in 2015 (42 Bcm in 2014). With the completion of the Central Asia-China Gas Pipeline that connects Turkmenistan, Uzbekistan and Kazakhstan gas fields to China in 2010, Turkmenistan became a major gas exporter to the region (CNPC, 2016).

On gas import source diversity, APEC was able to improve this indicator with an index of 0.10 HHI in 2015 (0.09 HHI in 2014) from 0.26 HHI in 2000 (diversity is based on share of import sources) with increasing number of import sources. APEC imported gas from 17 economies (including from APEC economies) in 2000 and gradually nearly doubled that number reaching 32 economies in 2014.[14]

Almost all economies with gas imports improved their import diversity index. For instance, China initially sourced its gas imports only from Australia (LNG form) in 2006 (when it started to import gas) and gradually diversified import sources reaching around 20 economies in 2015. China sources piped gas from Kazakhstan, Myanmar, Turkmenistan, and Uzbekistan. Japan also made some improvements in its diversity index from 0.20 HHI in 2000 down to 0.13 HHI in 2015. On the other hand, from one source of gas import (Malaysia), Singapore expanded its import sources to six economies (including Indonesia as another source for piped gas). The diversity index of Mexico, being heavy dependent on piped gas from the United States, began importing LNG in 2006, resulting in improved diversity index (1.0 HHI in 2000 to 0.53 HHI in 2015).

Figure 2.5 • LNG vs Piped Gas Exports to APEC, 2000-2015 (Bcm)



Source: APERC analysis and Cedigaz database.

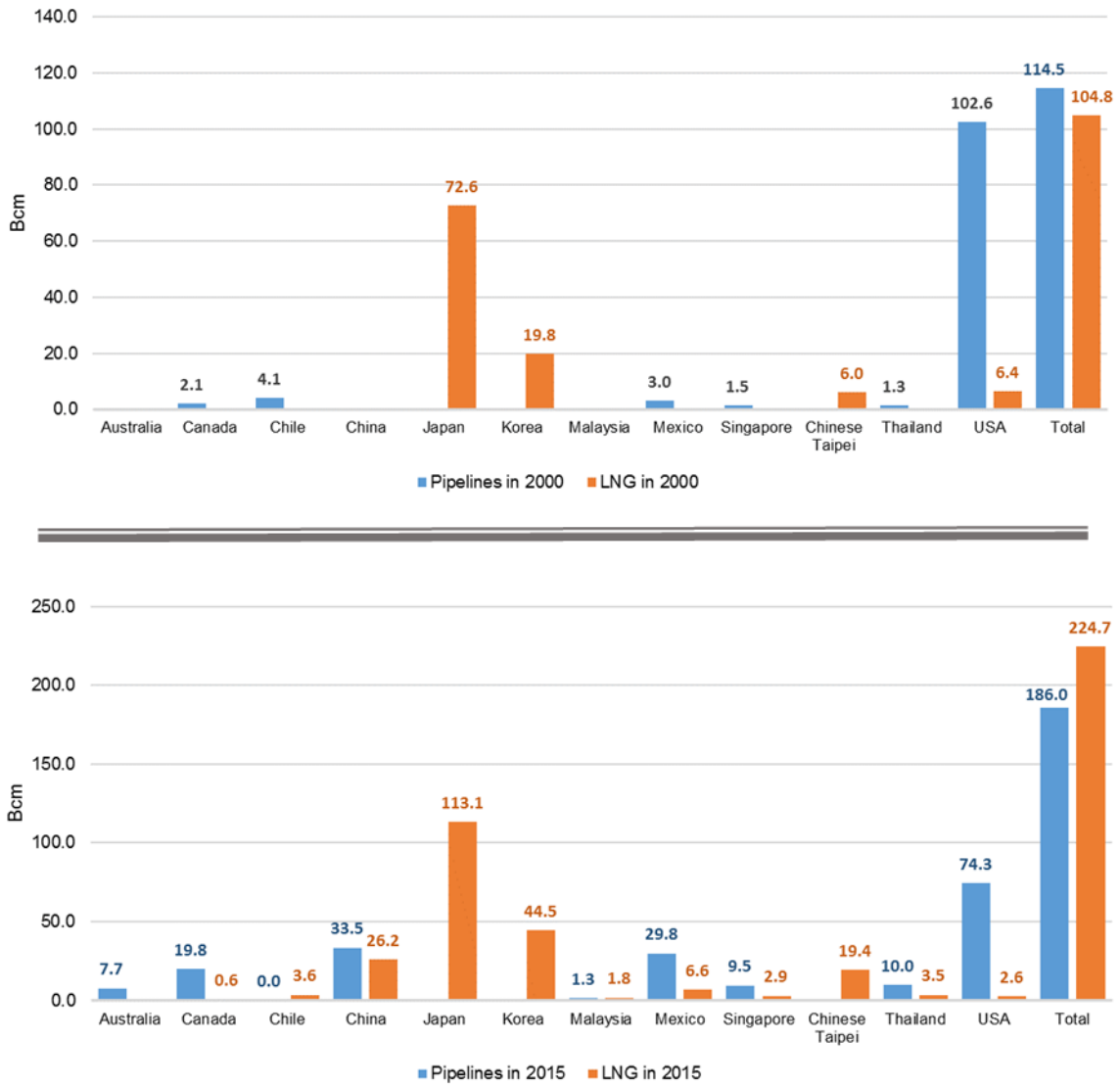
In 2007, LNG surpassed piped gas as the main source of gas import in the APEC region (Figure 2.5) providing 51% of total gas imports (from only 48% in 2000). The gap widened post 2010 because of higher gas production in the United States that subsequently reduced its gas imports through pipelines, and the Fukushima incident in 2011, prompted Japan to switch from nuclear to

[14] Detailed analysis of import sources for each economy is discussed in Oil and Gas Security Indexation published by APERC: http://publications.apec.org/publication-detail.php?pub_id=1838.

gas, thus increasing its LNG imports. The LNG contribution expanded to 54% in 2015 (57% in 2014) of total imports and may further increase as some economies are building LNG receiving terminals (such as the Philippines and Viet Nam) to receive LNG in the near future.

Of 12 economies with gas imports, eight economies have both piped gas and LNG imports, one with only piped gas (Australia) and three with only LNG imports (Japan, Korea and Chinese Taipei) (Figure 2.6). In 2015, most of those economies that have both these mode of imports still relied more on piped gas imports. More than 95% of gas imports of Canada and the United States was piped gas, around 80% for Mexico, over 70% for Singapore and Thailand, and 56% for China. Only Chile shifted away from piped gas to LNG imports because of declining production from Argentina. Chile sourced its piped gas imports from Argentina.

Figure 2.6 • LNG and Piped Gas Imports by Economy, 2000 and 2015 (Bcm)



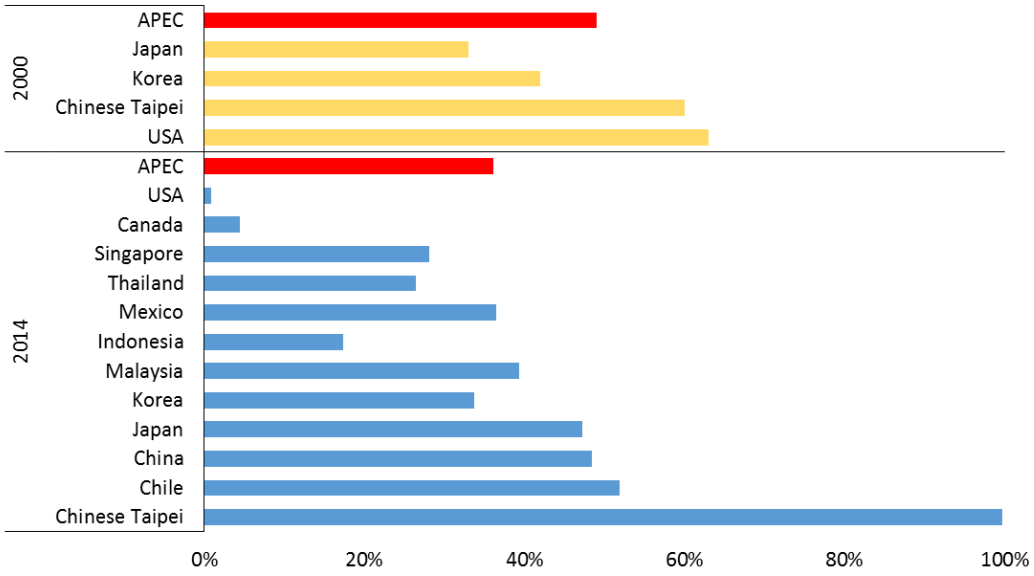
Source: APERC analysis and Cedigaz database.

2.1.4 Natural Gas Infrastructure

In 2000, only four economies had regasification terminals (RGTs) (Japan; Korea; Chinese Taipei; and the United States) to receive LNG imports with total capacity of 288 Bcm/year (209 MTPA) (Figure 2.7). During that year, the United States and Chinese Taipei both had more than 50% RGT utilisation rates, 63% and 60%, respectively, while Japan had 33% and Korea 43%. Over the historical period, other economies built their RGTs bringing the number of APEC members with LNG receiving facilities to 12 economies. For instance, China and Mexico received their first LNG imports in 2006; Canada and Chile in 2009; Thailand in 2011; and Indonesia; Malaysia; and Singapore in 2013. In 2014, total RGT capacity in the region more than doubled from the 2000 level, around 730 Bcm/year (529 MTPA), around 70% of global regasification capacity. Japan hosts nearly 35% of the total RGT capacity in the region, while the United States holds 26%.

With more half of APEC members with RGTs, the overall APEC RGT utilisation rate went down to 36% in 2014 (from almost 50% in 2000), thus improving the security index for this indicator. This trend will continue in the future with new RGTs expected in the Philippines and Viet Nam soon. The increase in the total RGT capacity could help reduce the gas supply security risk (although a further examination for each economy may show a different result).

Figure 2.7 • Regasification Terminal Utilisation Rate (%), 2000 and 2014



Source: APERC analysis and Cedigaz database.

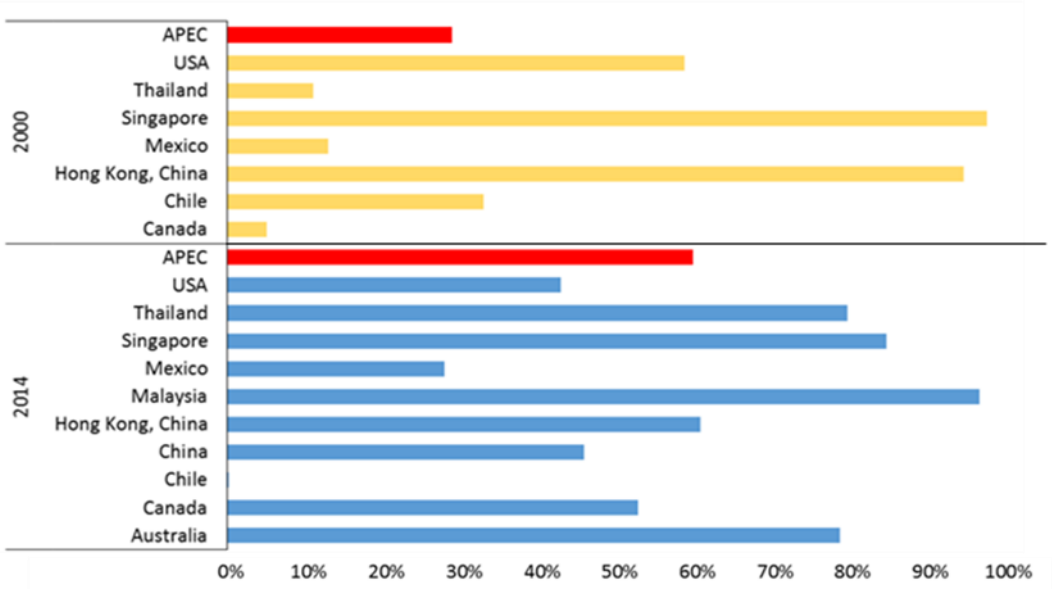
Availability of a regasification facility strengthens supply security as it is one of the means to diversify energy sources and options for an economy. However, it also poses a security concern for economies if RGTs are operating at or near full capacity because no buffer or spare capacity is available once there is an unexpected increase in demand. A good case in point is Japan during Fukushima incident. Having excess available capacity, Japan was able to import more LNG to meet the increase in gas demand (specifically for power), resulting in a rise in its RGT utilisation level from 39% in 2010 and 44% in 2011 to 48% in 2012. However, looking at the RGT utilisation rate

of Japan, several factors may have contributed to the low usage level. These include limited liquefaction capacity available globally, thus not enough LNG that can be sent to these regasification terminals; and lack of pipeline integration that connects major supply and demand centres to deliver gas across Japan. Some of the regasification terminals in the western part of Japan could not be fully utilised during the Fukushima accident in the absence of a pipeline system.

Among the pioneering economies, Chinese Taipei significantly increased its regasification utilisation rate, reaching full capacity in 2014 as gas demand increased faster than additional RGT capacity. On the other hand, due to increased domestic production, which led to decreased imports, the United States reduced its RGT utilisation to 1.0% in 2014 (from 63% in 2000).

In the same manner, the transnational gas pipeline is an option for some economies to import gas. In 2000, only seven economies had transnational gas pipeline. Among them, Hong Kong, China and Singapore operated their transnational pipelines at nearly full capacity, 95% and 98%, respectively (Figure 2.8). Malaysia built its transnational gas pipeline in 2003 to import gas from Indonesia, and Australia in 2006 to deliver gas from its Joint Petroleum Development Area (JPDA) with Timor Leste, which is used mainly for re-export in the form of LNG. China received piped gas in 2010, specifically from Turkmenistan through the Central Asian Gas Pipeline (CAGP), [15] Uzbekistan in 2012, and Myanmar in 2013. China will also secure gas imports from Russia in 2019 with the signing of gas supply agreement between the two economies in 2014.

Figure 2.8 • Transnational Gas Pipeline Utilisation Rate (%), 2000 and 2014



Source: APERC analysis and Cedigaz database.
Note: Pipeline import excludes Russia's data. Most of the gas that was recorded as exports to Russia served as a transit point before the gas was delivered to Europe.

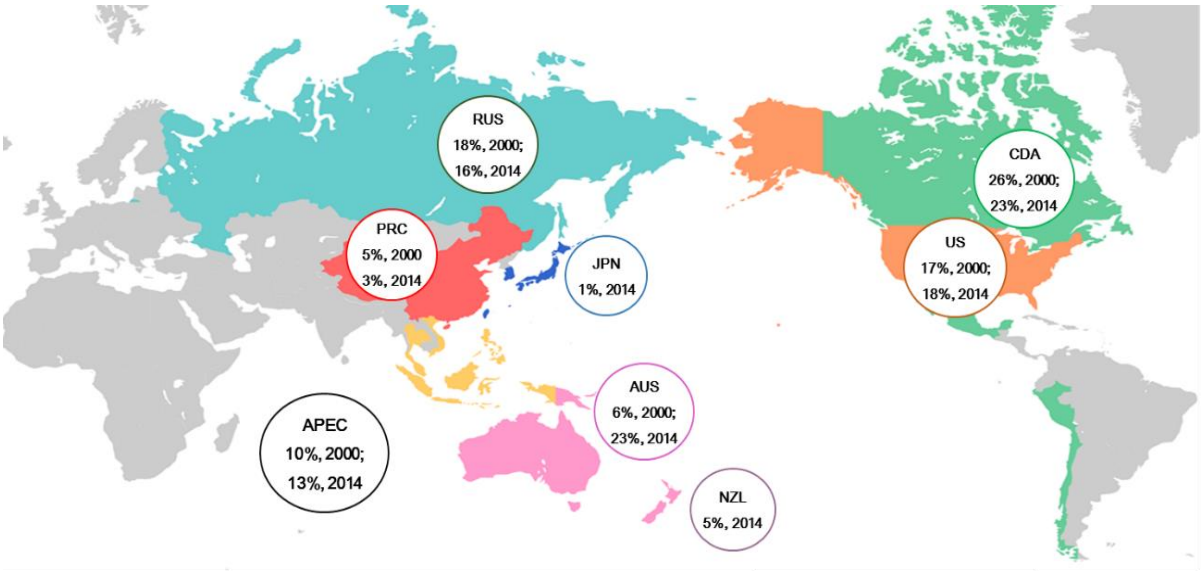
[15] CAGP connects to Turkmenistan, Uzbekistan and Kazakhstan through three parallel lines and began transporting gas in 2010, specifically from Turkmenistan.

With increased imports of piped gas in some economies, the total APEC transnational pipeline utilisation rate rose by about twofold, from only 29% in 2000 to 60% in 2014, which eventually result in an increase in the security index for this indicator. Higher utilisation rates were noted for Australia (79%); Malaysia (97%); Singapore (85%); and Thailand (80%). Chile's utilisation rate significantly fell to less than 1.0% in 2014 (from 33% in 2000) caused by a drastic decline of gas imports from Argentina via pipeline, increased LNG imports, and declining gas demand. With the development of an RGT in 2009, Chile started receiving LNG imports. The United States likewise reduced its transnational pipeline utilisation rate (from 59% in 2000 to 43% in 2014) due to a decrease in gas imports.

The presence of underground gas storage facilities is also a factor in reducing the risk in gas supply security, as additional supply may be stored during off-peak periods and withdrawn when there is high gas demand. It may be said that usage of underground gas storage usage is closely related to season variations, as gas is withdrawn during winter season (with high gas demand for heating). For instance, in the year of Polar Vortex in 2014, the United States sharply drew down gas from its storage facilities due to higher than normal gas demand (API, 2016).

Only five economies had underground storage facility in 2000 with total aggregate capacity of about 200 Bcm, more than 50% of which was located in the United States. Russia had the second largest capacity contributing 33% of total APEC, while Canada had 11% (Figure 2.9). Given the huge gas consumption, the storage capacity of the United States and Russia could only accommodate 17%-18% of their respective domestic gas demands. Canada's storage capacity could stock gas equivalent to 26% of its gas demand. On the other hand, Australia's and China's storage facility (each around 1.0% of total APEC storage capacity) could provide 5.0%-6.0% of their gas demands.

Figure 2.9 • Underground Storage Capacity Over Demand (%), 2000 and 2014



Source: Cedigaz database.

The construction and operation of gas storage facilities in Japan in 2009 and New Zealand in 2011 coupled with additional or capacity expansion from those economies that have existing gas storage improved the risk index for this indicator. Total APEC gas storage increased by 20% from 2000 to 2014 (which stood at 240 Bcm), which could be translated to 13% of the region's gas demand (from only 10% in 2000). Almost 60% of additional gas storage in 2014 (from the 2000 level) came from the United States. Such increased storage capacity reduces the risk index by 3.0 percentage points for total APEC, from 90% in 2000 to 87% in 2014.

These natural gas related infrastructures, such as regasification facilities, transnational gas pipelines, and underground gas storage, are critical to meet the growing demand of the APEC economies, as well as strengthening gas emergency preparedness. In the Oil and Gas Security Indexation Study, the presence of gas infrastructure reduced the supply security risk for the economies, having one or more of these facilities. About six economies have both RGT and transnational pipelines (Canada; China; Malaysia; Mexico; Singapore; Thailand; and the United States. Meanwhile, only Canada; China; and the United States all have these three types of gas infrastructure.

2.1.5 International Agreement on Gas Security

For the International Agreement on Gas Security indicator, one of the measures in the Oil and Gas Security Indexation Study, APEC received a high index result, around 60%. It might be assumed that the ASEAN Petroleum Security Agreement (APSA) may also include natural gas in the event of supply disruptions considering that one of the program areas under this regional cooperation is the Trans-ASEAN Gas Pipeline system (TAGP). Only seven APEC economies are covered by APSA. The TAGP aims to connect existing and planned gas pipeline infrastructure within the ASEAN region to transport gas across borders that would enhance greater security of gas supply (ASEAN Centre for Energy). APSA was signed in 1986 in Manila by 10 ASEAN members as a covenant that establishes a petroleum supply sharing scheme with the primary objective of assisting member state(s) in time of supply emergencies or disruptions. APSA was updated and signed in 2009, ratified by all ASEAN members and took effect in March 2013. To date, the Operationalisation Manual of the Coordinated Emergency Response Measure has been undergoing a review.

The IEA-International Energy Program (IEA-IEP), which six of the APEC economies are also members of, has yet to develop an agreement on gas security. The rest of APEC economies have not entered into any international or regional agreement on gas supply security (or even on oil security).

Due to the limited number of economies with such a supply security agreement on gas emergencies, this indicator received a high risk index. However, those economies with a huge gas supply surplus (production and reserves) are assigned with only a 50% index (not 100% index) for this indicator. If all APEC members have entered into a gas supply security agreement, this could strengthen the gas security index for the region. In the Oil and Gas Security Indexation Study,

having gas security agreements for all APEC could reduce the risk index by 15 percentage points under the political indicator (PESTLE analysis) (APERC, 2017).

2.1.6 External Factors for Gas Security

Three indicators are considered as external risks for gas security in the APEC region – chokepoints, exporters' stability and LNG liquefaction utilisation rate. Global maritime transit chokepoints are crucial in energy security, and thus assessment is also needed to determine the level of security from import sources passing through these chokepoints. For the APEC region, fewer chokepoints are seen for gas than oil, as a significant portion of the total gas imports is through pipeline. Around 32 economies exported gas to APEC economies (23 economies exporting gas in the form of LNG), which include intra-APEC. In 2014, about 57% of total gas imports was LNG, and the rest through pipelines (mainly in Canada; China; Mexico; and the United States). LNG exports to APEC pass through six chokepoints, about one-third of which transits in the Strait of Malacca, 28% using Bab El Mandab, 24% coming from the Strait of Hormuz, and the rest transports through the Panama Canal, Cape of Good Hope, and even Suez Canal as shown in (Figure 2.10)[16]. The calculation of the risks is based on the political stability risks of adjacent economies surrounding the chokepoints using the Worldwide Governance Indicator (WGI) Report[17] by the World Bank (WB, 2016). Any political turmoil from the surrounding economies could disrupt or block the maritime transit (chokepoints) resulting in possible supply cut (or stoppage) from exporters.

Overall, the chokepoints risk (as an indicator) for APEC is still at a low level, from 3.0% in 2000 to 7.0% index in 2014. The increase in chokepoint risk was triggered by the increases in imports from Nigeria, Yemen, Oman and Qatar, among others. One of the advantages of LNG producers from the APEC region is the absence of chokepoints. Russia also plans to export LNG to East Asia using the Artic Sea route (APERC, 2017).

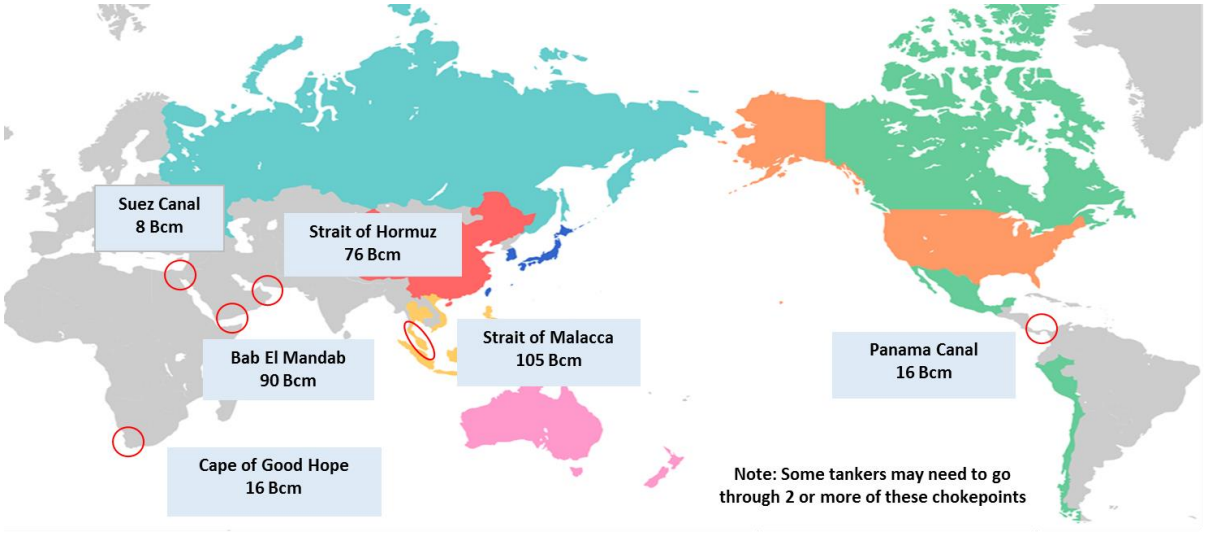
On exporter's stability (also using WGI), gas had higher risk on this indicator, which stood at 51% in 2014, although at a declining trend (57% in 2000). Among the reasons for a high risk index was the higher concentration of import sources (compared with oil). The top five exporters of gas provided around 60% of total gas imports (while in oil, the top five exporters only supplied 50%) (APERC, 2017). Likewise, more than 30% of LNG imports came from MENA region, of which some of the exporters received a high index from WGI on political stability. It could be said that lower diversity of import sources could make the exporter's stability indicator skewed towards the major gas exporters. The risk associated with the exporters is based on their shares to total gas imports.

[16] The total volume of LNG imports as presented in the graph may not add up to total LNG imports of APEC as some tankers need to go through two or more chokepoints.

[17] Worldwide Governance Indicators (WGI) assesses the political stability and absence of violence/terrorism (among the six sub-indices) in different economies as published by the World Bank. The WGI uses the scale of -2.5 (weak) to 2.5 (strong) governance performance. For the WGI sub-index, the risk score is set (transformed) as 0 to 1, where 1 (100%) is the riskiest (equivalent to -2.5 in WGI) and 0 (0%) is the least risky (equivalent to 2.5 in WGI).

For instance, China has 26 gas imports sources,[18] and the risk for each gas exporter was weighted based on its share to total imports.

Figure 2.10 • Chokepoints for LNG Transit Routes to APEC, 2014



Source: Cedigaz database.
Note: The Strait of Hormuz is surrounded by Iran, UAE and Oman; Bab-El Mandab by Yemen, Djibouti, Eretria and Somalia; Strait of Malacca by Indonesia; Malaysia; Singapore; and Thailand; Suez Canal by Egypt; Panama Canal by Panama; and, Cape of Good Hope by South Africa.

Considering that more than 50% of gas imports is in LNG form, it is also equally important to look at the capacity and utilisation rate of liquefaction facilities of LNG exporters to the region, as these may pose security concern. As liquefaction capacity had become more constrained, the liquefaction utilisation rate increased from 49% in 2000 to 64% in 2014. If such an increasing trend continues, exporters may not have much spare capacity to meet and react to unforeseen rise in gas demand. However, several LNG projects are expected to be completed and operational by 2020, which would reduce the risk in the near term from limited liquefaction capacity. Yet, some energy analysts have apprehensions on additional liquefaction capacity post 2020. Currently, 25 of 26 liquefaction terminals under construction globally are located in APEC economies. Also, new LNG liquefaction projects have been proposed in Australia; Canada; Indonesia; Malaysia; Russia; and the United States (IGU, 2015).

2.2 Overall Gas Supply Security Risk in APEC

The region's gas security situation is stable with low exposure to supply disruptions.[19] The index increased by 1.0 percentage point during the historical period, from 18% risk index in 2000 to 19% index in 2014 (Figure 2.11) using the 14 supply security indicators as explained above. By grouping, the internal factors (about 80% of the total risk is based on the number of internal indicators over total indicators) received an average of 29% risk index (a moderate-low exposure),

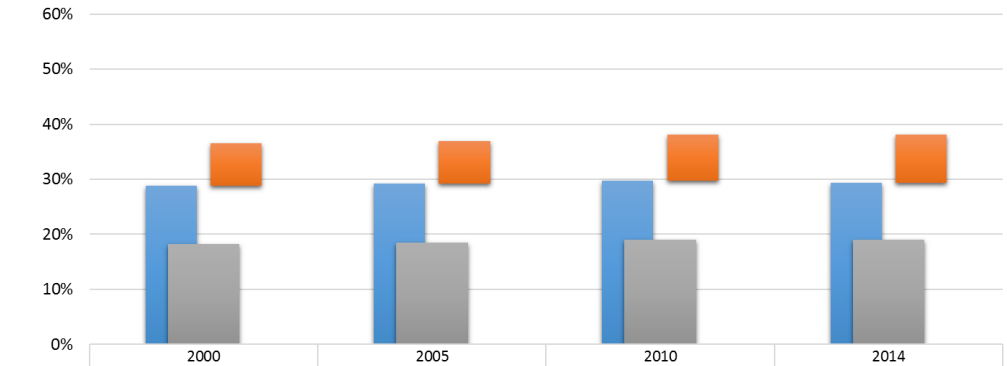
[18] Based on Cedigaz Database.
[19] By economy, risk index may provide different results. Some economies (net importers) may assign higher weights or importance on external factors.

while the external factors obtained 8.0% risk index, on average. The supply security index recorded the lowest risk in 2009, which could partly attributed to weaker gas demand as a result of the global economic crisis during 2008-2009. Among the internal factors that prevented the security risk to increase were gas self-sufficiency, reserves-production ratio, and gas import diversity. The region made remarkable improvement in gas import diversity (with a reduction of 16-percentage point in risk index).

On the other hand, gas-related infrastructure indicators showed higher indices – specifically on underground gas storage, as only seven economies so far have put up such storage facility. With this, total storage capacity in the region can provide or stock gas supply equivalent only to 13% of total gas demand. Further, due to increasing gas demand, utilisation rate of transnational pipelines was on upward trends, thereby increasing the security risk. The absence of international agreements on gas security for most of the economies also contributed to gas security risk.

Assessing the external factors that may affect gas security, risk on chokepoints still got a low index as more than 40% of total gas imports are through transnational pipeline. However, risk from exporter's stability had high index at 50%, although APEC realised some improvements due to diversification efforts. The utilisation rate of liquefaction facilities of LNG exporters to APEC could be a security concern for some members relying heavily on LNG imports for their gas domestic requirement. Utilisation rates steadily increased at 2.0% on a year-on-year basis as export volume grew much faster than liquefaction capacity additions.

Figure 2.11 • Total APEC Gas Security Index, 2000-2014



	2000	2005	2010	2014
External	8%	8%	8%	9%
Internal	29%	29%	30%	29%
Total Ave	18%	18%	19%	19%

Source: APERC analysis
Note: In the gas security index (1.0% to 100.0%), a lower index means less vulnerability to any gas supply disruption/crisis. A security index of 20% and below is considered low exposure to supply disruption, 21%-40% is moderate-low exposure, 41%-60% mid-exposure, 61%-80% moderate-high exposure, and 81% and above is high exposure.

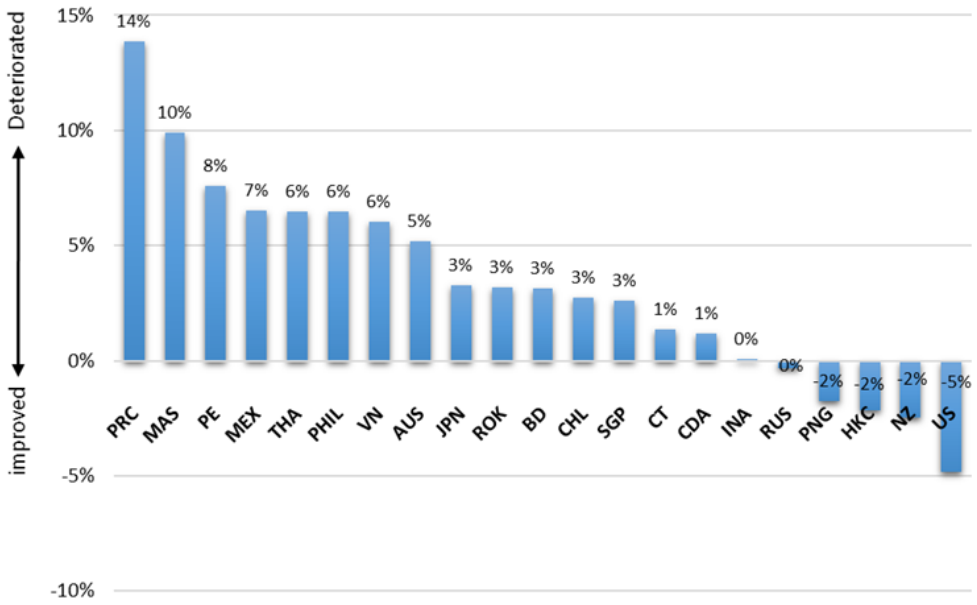
By economy (Figure 2.12 and Annex I), increases in security risks were recorded in those economies with high gas demand growth and from economies that started to import gas. About 70% of APEC members (15 economies) increased their risk indices, while five economies exhibited declining risk and one had stable risk index (same level in 2000 and 2014). Both China and

Malaysia, which started to import gas, increased their risk indices by at least 10 percentage points over the historical period. China's risk index on self-sufficiency level went up by 29.0 percentage points coupled with an increased gas supply requirement, which triggered the indices for gas intensity and per capita to go up significantly. Following an increase in imports, utilisation rates for both RGTs and transnational gas pipeline likewise went up, thus contributing to increasing the security risks.

Malaysia is one of the cases in which a net gas producer still demonstrates an increase in risk as production areas are far from demand centres, which subsequently resulted in gas imports to meet a portion of their domestic requirement. Although Malaysia is 100% self-sufficient in gas based on production over demand, gas importation resulted in security risks, specifically related to infrastructure, and a significant increase in utilisation rates for both RGT and transnational gas pipeline. Another case in point is Australia (with a 7.0 percentage increase in its risk index) due to imports from joint developments with Timor Leste (Timor Leste/Australia JDPA). However, removing such imports from the equation (as imports from Timor Leste are for re-export) lowers the increase in risk to 3.0 percentage points in (from 11% in 2000 to 14% in 2014, instead of 18%).

On the other hand, some of the economies with high growth in gas demand displayed an increase in the risk index by more than 5.0 percentage points – Peru; the Philippines; Singapore; and Viet Nam. These economies exhibited a large surge in the gas share to primary energy supply, gas intensity and per capita indices. The rise in the security index for Mexico and Thailand together with others (Japan; Korea; and Chinese Taipei) was because of increasing imports that also led to expanding the utilisation level of gas infrastructure.[20]

Figure 2.12 • Changes in Gas Security Index, 2000-2014 (Percentage Point)



Source: APERC analysis

[20] Detailed analysis of security index per economy is discussed in the Oil and Gas Security Indexation Study published by APERC.

Economies with decreasing risks were Hong Kong, China; New Zealand; Papua New Guinea; Russia; and the United States. Indonesia's risk index remained at the same level as in 2000. One of the factors that pushed down the risk index for Papua New Guinea; Russia; and the United States was the improvement in the gas reserves-production ratio. The decreasing security risk of Papua New Guinea was also caused by lower gas demand. Improvement in the reserves-production ratio of the United States from shale gas boosted domestic production and reduced the volume of imports, thus increasing the self-sufficiency level. The declining imports brought down utilisation rate for RGT and transnational pipelines. For Indonesia and Russia, the growth in gas per capita was offset by the improvement in the reserves-production ratio.

Lower and decreasing gas demand influenced the decreased in risk index for Hong Kong, China and New Zealand. Indonesia; New Zealand; and Russia had the lowest risk index in 2014 (at 11%).

2.3 Application of Indicators and Index

There are several indicators that each economy can use to assess the level of gas supply security risk, which should not be limited to the indicators presented in this chapter. It is critical for economies to identify which among the security indicators should be prioritised and needed utmost attention to strengthen gas supply security. Likewise, economies may put higher importance (by applying weights) to some indicators based on their respective domestic circumstances. For instance, economies that are highly dependent on gas imports may focus more on external indicators or factors, and thus higher weights for these indicators offer different supply security index results. But the application of weights should not distort the index (scores) towards unrealistic results.

Monitoring the progress of the selected security indicators is also important for the government and policymakers to assess and enhance measures, programs, policies and investments related to gas supply security. A diversification policy on import sources may be instituted, for example, setting the maximum share of each exporter to total import volume (e.g. only up to 20% maximum share per exporter). The government may also look at the necessary investments to put up RGTs and other gas related infrastructure as ways to have a stable gas supply. As such, it is paramount for government to formulate and put in place a right investment framework. Further, as gas demand and gas intensity are expected to rise in the future, in particular in developing economies as well as in those economies with huge gas resources, there is also a need to accelerate the energy efficiency agenda in their respective energy policies in order to improve the supply risk. With the right policies coupled with the development in energy efficient technologies, economies may realise a significant reduction in energy intensity and energy consumption.

It is recognised that each economy may have different set of issues and/or challenges in addressing supply security. Given the different needs and characteristics of each economy, assessment of supply security using indicators (and thus the index) must be flexible based on the

domestic situation, but should not drift away from its primary purpose of objectively gauging (the economy's strengths and weaknesses) factors underlying supply security risks. An area for future work is developing agreed APEC-wide weights on the security indicators.

Chapter 3. Gas Security Measures

This chapter covers case studies mainly in Europe, China and Japan with respect to specific gas security measures, and provides an overview on the types of measures implemented and their purpose. The actual security measures that can be considered are: 1) diversification of supply sources and supply routes; 2) improving supply flexibility; 3) improving market liquidity; 4) demand management; 5) international cooperation; and 6) development of statistical data.

3.1 Diversification of Supply Sources and Supply Routes

3.1.1 Europe

Diversification of Supply Sources

In Europe, the need to diversify supply sources in order to strengthen energy security was initially discussed under the first energy policy paper by the EU titled ***'Green Paper – Towards a European Strategy for the Security of Energy Supply'*** published in December 2000. Said paper raised the problems with gas supply in Europe, which among others are the price formula that is linked to oil product prices, fixed trade relations based on long-term contracts and a series of rigid trading conditions known as the "*Take or Pay Provision*." It also set forth concerns over the fact that a small number of dominant oil corporations in some economies, such as Russia, Norway and Algeria, have key control over the supply of natural gas.

The Green Paper also described the importance of the relationship with Russia, and explained the importance of maintaining a good relationship with this major supplier as the gas market is rigid and there is limited competition among the exporters. This policy of placing importance on relations with Russia was similarly expressed by the European Commission (EC) through the designation of the Nord Stream natural gas pipeline linking Russia and Germany as an important infrastructure project in Europe under the Trans-European Network for Energy in December 2000. Although over-reliance on a specific supply source was identified as one of the major security concerns, the EU feels that construction of a pipeline that directly connects Russia and Germany contributes greatly to improving the stability of gas supply.

However, Europe experienced an interruption to its gas supply in January 2006 because of the conflict between Russia and Ukraine, and similar gas disruption occurred again in 2009. These events triggered a change in the policy direction of the EU's gas security toward reducing its dependence on Russia. The first gas security regulation provided by the EU was ***'Security of Gas Supply Regulation,'*** published in October 2010. Under this regulation, member states of the EU were required to formulate both a Preventative Action Plan and an Emergency Plan. The former covers the development of systems that can secure an adequate gas supply for critical sectors (for residential use, medical use, etc.), and the implementation of risk assessments concerning gas security. Meanwhile, the latter covers post-event measures in the event of a serious incident. The

regulations were updated in February 2016 with the addition of new response measures for the respective economies, including flexible multilateral arrangements during emergency situations and the development of international infrastructure for that purpose.

It is important for the respective economies to embark on the goal of achieving the N-1 Principle in the risk assessment mandated under this regulation. The N-1 Principle entails the development of systems that allow the peak demand (energy utilisation) of important sectors in the economy (for residential use, medical use, etc.) in the past 10 years to be fulfilled even in situations of supply disruption equivalent to the maximum import capacity of the economy through available capacity from other supply sources. That is, the economy's total domestic gas production capacity and the volume that can be withdrawn from domestic reserves, as well as the pipeline/LNG import capacity will have all to be considered. There is a need to develop systems that can secure the minimum level of gas supply required, even in the hypothetical situation of a serious supply cut, by securing diverse supply sources without depending overly on specific supply sources.

Thereafter, as a result of Russia's invasion of Crimea, a part of Ukrainian territory, in February 2014, relations between the EU and Russia deteriorated further, and the region's strong dependence on Russia for energy supply came to be perceived as a serious problem once again within the EU. Although the EU depends on imports from outside region for 90% of its total crude oil supply and 66% of natural gas supply, most economies in the region depend entirely on Russia as a major source of natural gas imports (EC, 2014). To cope with this situation, the EC formulated the European Energy Security Strategy in June 2014 as a comprehensive energy security strategy for the EU (EC, 2014). This strategy outlined the measures for overcoming problems with the long-term and stable supply of energy, which include: 1) Improving energy efficiency; 2) Completing the renewable energy market, and developing infrastructure network; and 3) Strengthening response capability during emergencies. Likewise, the strategy offered a strong reaffirmation of the policy that seeks to reduce dependence on external imports by promoting the use of renewable energy and energy conservation in the region, strengthen the resilience of energy supply by developing supply infrastructure within the region and diversify the import sources of natural gas and other forms of energy as much as possible.

Constructing New Pipelines as a Supply Route Diversification Measure

The European Energy Security Strategy drawn up by the EC points out the need to diversify supply routes as a part of oil and natural gas supply security measures. Of these, the focus has been placed on the Southern Corridor pipeline construction project that contributes to the diversification of natural gas supply sources in Central and Southeast Europe. This project covers the construction of a pipeline to transport 10 bcm/year of natural gas (target volume by 2019-2020) from supply sources in Azerbaijan, Turkmenistan and Iraq to Europe, and there are also plans to expand the transportation capacity of this pipeline to 80-100 bcm/year in the future. However, there appears to be no marked progress with regard to the construction plan for this pipeline at

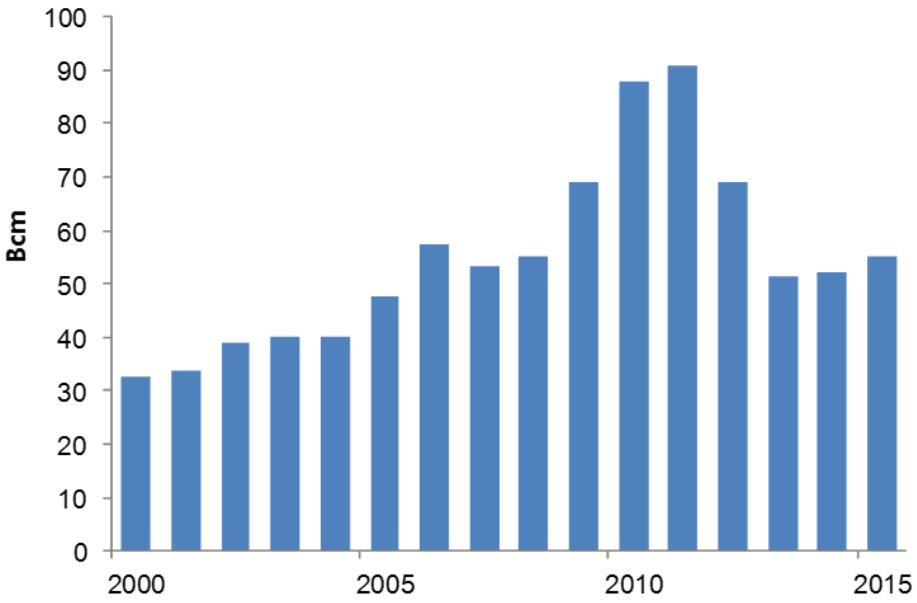
this point in time. This is because the project competes with the existing pipeline route that transports gas from Russia to the southern part of Europe, and it is difficult to coordinate the pipeline construction costs and traffic volume as this pipeline route crosses many economies.

On the other hand, the Mediterranean natural gas hub is a vision that seeks to achieve diversification of supply sources in the southern part of Europe. The EC has been engaging in dialogues with economies in the Middle East and North Africa toward energy cooperation with the aim of revitalizing LNG or natural gas trade in Algeria, which holds rich natural gas resources, and in the circum-Mediterranean region including Egypt and Israel, where there has been advancement in the discovery and development of gas fields in recent years.

LNG as a Supply Source/Supply Route Diversification Measure

In addition to the diversification of supply sources and supply routes through the construction of the new pipelines described above, there has also been growing interest in diversification through the introduction of LNG in the EU in recent years. European corporations are currently in negotiations on supply contracts for new LNG projects that are underway in North America, Australia, Qatar and East Africa. With respect to imports from the United States in particular, the EC is also attempting to provide diplomatic support for plans to import LNG produced in the United States through the Transatlantic Trade and Investment Partnership that it is negotiating with the United States government.

Figure 3.1 • Changes in LNG Import Volumes in Europe, 2000-2015



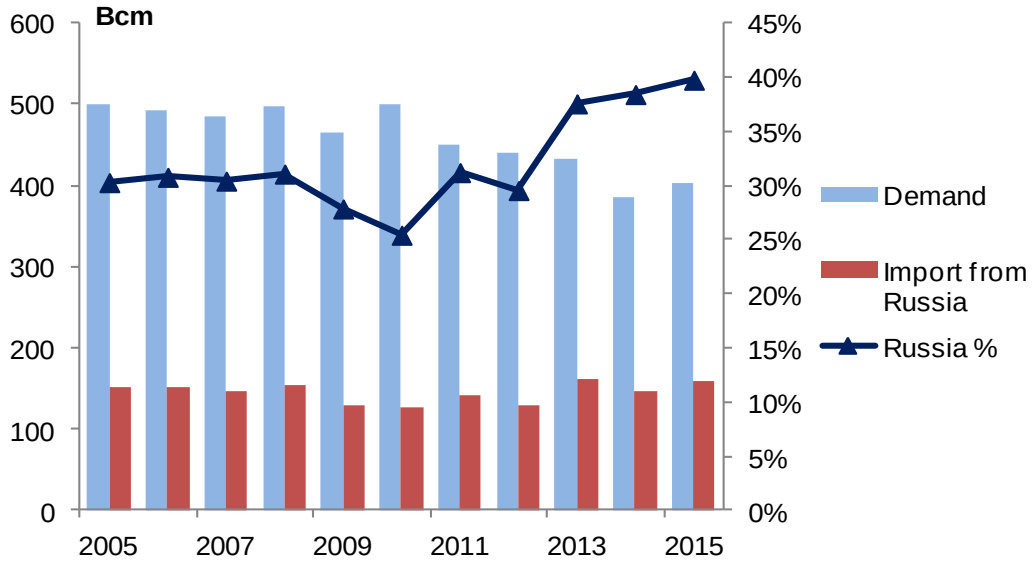
Source: GIIGNL (2016)

Apart from these efforts, a policy paper on the promotion of LNG utilization in Europe, titled ***'EU Strategy for Liquefied Natural Gas and Gas Storage,'*** was published in February 2016. This paper was drawn up based on the assessment that it would be possible to reduce energy cost by actively importing LNG, as a result of the benefits of diversifying supply sources through the

expansion in LNG imports, alongside the continued easing of global demand and supply balance for LNG. The strategy outlined in the paper incorporates the following policies: 1) construct LNG-receiving infrastructure in appropriate locations within the region; 2) enable proper transmission of price signals that reflect natural gas demand and supply in each economy by further improving the liquidity of the natural gas market in the region; and, 3) build a more flexible international LNG market through cooperation with supplier economies and other importers.

The volume of LNG imports in Europe entered a slump from the beginning of 2010 (Figure 3.1). The major contributing factors for this include the economic recession resulting from the European financial crisis, and the downturn in demand for LNG due to the drop in coal and pipeline gas prices. Going forward, there is strong possibility that demand will recover in Europe as LNG prices decline due to easing in the LNG demand and supply balance and the fall in oil prices.

Figure 3.2 • Europe's Dependency on Gas Import from Russia, 2005-2015



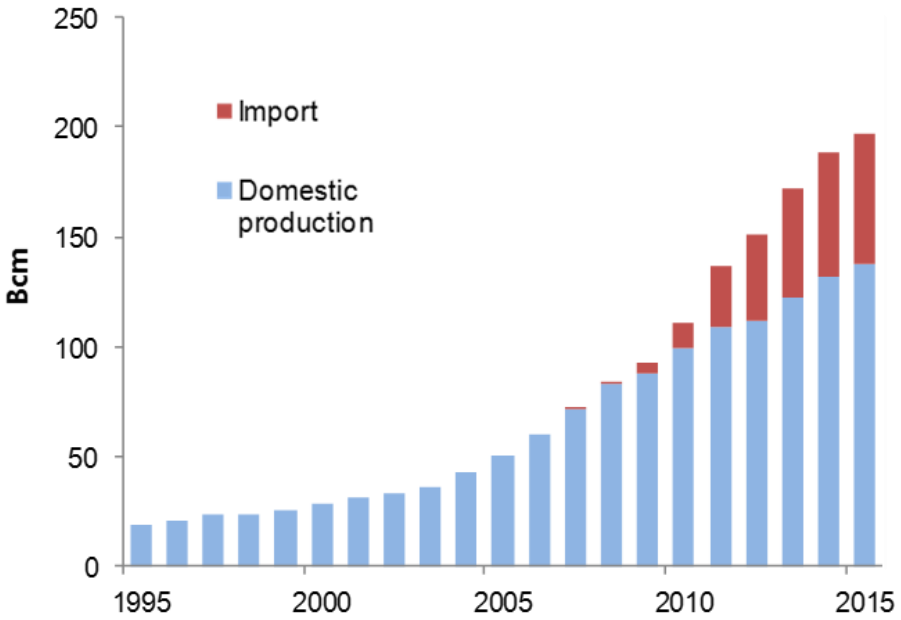
Source: BP (2016)

Although Europe has set a target to reduce dependency on Russia's gas import by diversifying of supply sources and supply routes, in reality, the opposite happened in European economies (Figure 3.2). Although Russia had many conflicts with Ukraine (which is a pipeline transit economy) over negotiations on gas contracts, which led to cutting off the supply of natural gas, Russia has never once engaged in such serious conflict with its counterparts in Europe that resulted in supply cut. As Europe has been importing natural gas from the former Soviet Union since the Cold War era, many energy industries in Europe are of the opinion that Russia is a very reliable gas supplier. While LNG produced by the United States is expected to flow into the European market, Russia will remain a major natural gas supplier to Europe due to its cost competitiveness. However, to what extent these policies by EU will reduce the dependence on gas imports from Russia remain to be seen.

3.1.2 China

China has traditionally relied on domestic coal for a large part of its energy supply, and only began to tackle the issue of natural gas supply security after the second half of the 2000s. China's use of natural gas has expanded as a result of an increase in domestically-produced gas. As domestic demand expanded rapidly, existing production was not enough to meet demand, which subsequently forced China to import natural gas starting in 2006. Thereafter, despite growth in domestic production, it was still not enough to cover the higher growth in demand, leading to a rapid rise in import volume (Figure 3.3). Hence, there are growing concerns over gas security in China.

Figure 3.3 • China's Natural Gas Supply by Sources, 1995-2015



Source: BP (2016)

Like Europe, China used the same approach by diversifying supply sources and supply routes. The specific supply sources and supply routes include pipeline supply from Central Asia and Myanmar as well as building LNG-receiving terminals along the coastal regions. There are also plans to commence pipeline imports from Russia, which targeted for completion in 2019. With regard to pipeline supply from Central Asia, the Central Asia-China Gas Pipeline that leads from Turkmenistan, passing through Uzbekistan and Kazakhstan to China, has been completed. This pipeline is connected to the Second West-East Gas Pipeline that spans from China's Xinjiang Uyghur Autonomous Region to Guangdong province and Shanghai. In order to distribute the gas further a system has been established to supply gas imported from Turkmenistan to the major consumer areas of Beijing and Shanghai. In October 2013, import pipelines from Myanmar (Bay of Bengal gas fields) reaching to the southwestern part of China including Kunming (Yunnan province) and Nanning (Guangxi Zhuang Autonomous Region) also commenced operation.

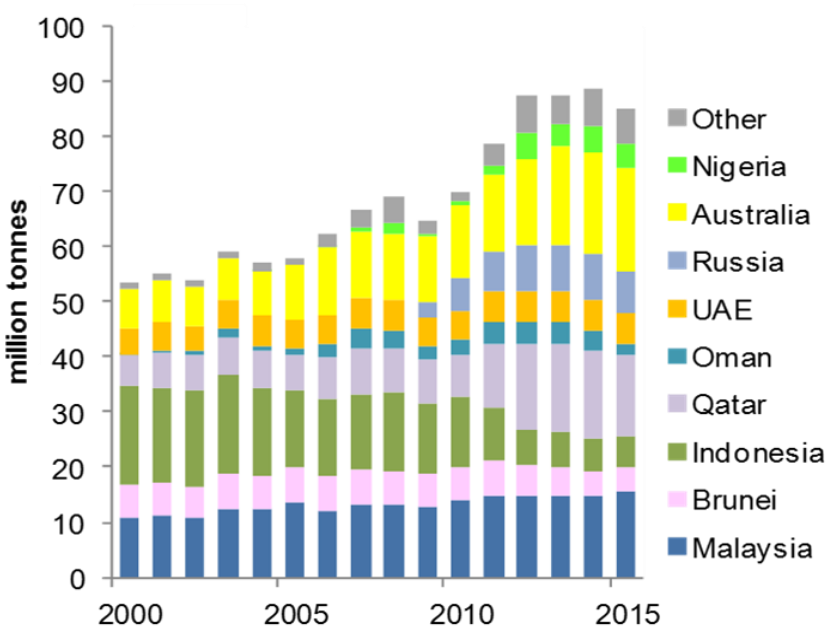
In addition, China also plans a natural gas pipeline project with Russia. Since the 1990s, multiple routes have been considered for natural gas imports from Russia, including East Siberia, the Republic of Sakha and Sakhalin. Negotiations on pipeline routes and prices between the two economies lasted for a long time, but eventually reached a final agreement during President Putin's visit to China in March 2006. They decided to lay two pipelines from East Siberia and West Siberia (Eastern Route and Western Route) into China with projected volume of 60-80 Bcm of per year. Of these, the pipeline along the Eastern Route, named "Power of Siberia," has transportation capacity of 38 Bcm per year, construction is currently underway toward the target of commencing operation in 2019.

Apart from such pipeline imports, China has also moved forward on the construction of LNG-receiving terminals to cover the steadily increasing natural gas demand on its southeastern coast. As of November 2016, 14 terminals were in operation (total receiving capacity stood at 48.8 MT or 66 Bcm), and an additional five are under construction, with total receiving capacity of 11 MT or 15 Bcm. The receiving terminals that are currently in operation import LNG under long-term contracts from economies such as Australia, Malaysia, Indonesia, Qatar and Papua New Guinea, as well as through spot trading and portfolio contracts. As a result of these initiatives, China's natural gas imports in 2015 (combined total for pipeline gas and LNG) were sourced from Turkmenistan (46%), Australia (12%), Qatar (11%), Malaysia (7.0%) and Indonesia (6.0%).

3.1.3 Japan

LNG Supply Sources

Figure 3.4 • Japan's LNG Import Sources, 2000-2015



Source: MOF (2016)

Japan's gas supply almost fully relies on LNG imports with very small domestic production and without an international pipeline connection. For Japan, diversification of natural gas supply sources could be described as virtually synonymous with diversification of LNG supply sources. Japan began importing LNG in 1969, but the nature of these imports differ greatly from its crude oil supply. The LNG suppliers have been traditionally diversified, and many of them are outside the Middle East region. In fact, a number of Japan's LNG suppliers were economies with relatively stable political conditions, and were geographically close to Japan. These included the United States (Alaska) (from 1969), Brunei (from 1973), Indonesia (from 1977), Malaysia (from 1982) and Australia (from 1989) (Figure 3.4). To date, Japan has not put in place any specific measures to diversify LNG supply sources that are worthy of mentioning. However, LNG imports originating from the United States are expected to increase in the future, and thus import sources are expected to become more diversified.

Pipeline Construction

While all of Japan's natural gas imports are currently imported as LNG, it has also considered receiving supplies of pipeline gas from Russia through Sakhalin. The history of oil and natural gas development in Sakhalin can be traced back to the 1970s, but specific projects began to show actual progress only in the 1990s after the collapse of the Soviet Union, when international oil companies successively began to conclude product-sharing contracts with the Russian government. Of these, the Sakhalin-1 Project led by ExxonMobil aimed to export pipeline gas to neighbouring Asian economies, while the Sakhalin-2 Project of Shell aimed to export LNG. Although ExxonMobil has planned to export gas through pipelines to Japan, which has the closest geographical proximity and with huge demand, it has never been actually realised. This is because many of the buyers in Japan had already developed LNG import infrastructure, and were unmotivated to develop new infrastructure for importing gas through pipelines. Moreover, in the actual laying out of the pipelines, it would not be possible to achieve economic efficiency without laying the pipelines all the way to the major consumption area, such as Tokyo. Further, given the Japanese electricity and gas market structure where regional supplier are responsible for supply in their respective areas, sharing the cost of the pipelines among suppliers seems far-fetched due to its complexity in determining usage fees.

On the other hand, partly because of advancements in liberalisation in the domestic electricity and gas markets after April 2016, it also became difficult for electricity and gas companies in the private sector to invest in large-scale projects such as those involving the construction of international pipelines. It would be difficult to proceed with the construction of these pipelines without the government support.

3.2 Improving Supply Flexibility

Generally, natural gas trade tends to become inflexible in long-term. However, depending on the demand and supply situation of the buyers, establishing a trading system that enables the flexible adjustment of destination and trade volumes can have the effect of enhancing gas security.

3.2.1 Europe

Europe has also led the way in promoting initiatives toward improving flexibility in contract terms for natural gas trading, where there are typically many rigid contract terms and conditions. In particular, the destination clause in long-term contracts for natural gas trading has the effect of restricting natural gas spot trading, and is a major barrier in promoting increased flexibility in trading. Since the start of the 2000s, the EC's Directorate-General for Competition has begun to make decisions supporting the termination of such destination clauses (EC, 2007). In July 2002, EC secured the abolition of the clause that restricts the selling of natural gas from the Norwegian companies, the Statoil and Norsk Hydro. In December of the same year, the EC reached an agreement with Nigeria LNG to abolish the destination clauses that were included in long-term contracts that it had concluded with European buyers earlier, and to also exclude it from new contracts (EC, 2002). In October 2003, through arbitration by the EC, the Italian company Eni and Russian company Gazprom reached a settlement allowing for the resale of natural gas produced in Russia and imported by Eni based on existing contracts (EC, 2003). The following year (October 2004), EC decided that clauses drawn up by the French company GDF forbidding its customers, the Italian companies Eni and Enel, from sell of its gas within France constituted as an anti-competitive practice and violated the competition laws. EC even pronounced that the inclusion of destination clauses in natural gas trading was an illegal act. When the Russian company Gazprom recently introduced clauses in its gas sale contracts that forbid the resale of gas to economies in Central and Eastern Europe, the EC decided that such an act constituted unfair pricing as it segregated the market. Through the series of decisions made by the Directorate-General for Competition, an increasingly flexible trading arrangement is gradually taking root in Europe with the non-inclusion of destination clauses in natural gas trading contracts.

3.2.2 Japan

Even in Japan's natural gas market, where natural gas is mainly supplied through LNG, it is becoming increasingly important to improve the flexibility of natural gas supply. The need for flexibility is increasing because demand uncertainties are growing for conventional LNG buyers. After 2011, Japan began further liberalizing the electricity and gas industries. The retail sector that caters small consumers was completely liberalised in 2016 for the electricity industry, and gas market is expected to follow in 2017.

Traditionally, Japanese electricity and gas companies procured resources to meet most of the demand through long-term contracts that include restrictions on destination. If demand declines as a result of liberalisation, the industry would be faced with excess LNG procurement. Consequently, it is difficult for electricity and gas businesses to draw up forecasts for LNG procurement. Hence, there is a growing need for such businesses to increase procurement through short-term contracts and spot trading, and to improve the flexibility of trade volumes in the case of long-term contracts.

The Japanese government published its LNG Market Strategy in May 2015. The strategy aims to ensure 1) tradability, 2) open infrastructure, and 3) price discovery in the international LNG market. Removal of destination clauses is expected to enhance tradability. Thus, coordination and collaboration with governments of other LNG importers such as China, Korea, India, and EU are being proposed. In addition, at the time of the writing of this paper (early March 2017), it has been reported that the Japan Fair Trade Commission is conducting an investigation into whether destination restrictions in LNG trading are in violation of the Antimonopoly Act.

3.3 Formation of High-Liquidity Markets

In addition to flexibility in natural gas trading, high market liquidity is desirable for gas security. If market participants with diverse backgrounds are actively trading among themselves, the market would enjoy the advantage of being able to easily procure additional resources even in cases of unexpected supply disruptions. Market liquidity is particularly important to generate trading in the spot market.

3.3.1 Europe

To achieve a natural gas market with liquidity, it is first necessary to develop infrastructure that can enable diverse sellers and buyers to engage in gas trading. However, the respective economies of Europe had historically conducted active energy trade among themselves, and an extensive pipeline network had already been developed. The total length of transportation and distribution pipelines in Europe was 2,240,000 km as of 2014 (Eurogas, 2015) (Figure 3.5), and there are underground storage facilities in 130 locations, as well as LNG facilities for peak shaving in five locations. Gas storage capacity has reached 112 Bcm, which is equivalent to 29% of the demand for 2014, and plays a part in fulfilling the demand adjustment function in the region.

Alongside with such infrastructure development, the growing liberalisation of the gas market also contributed to improving the liquidity of trading in the European market. Prior to liberalisation, the United Kingdom and France monopolised the gas market through their respective state-owned enterprises, the former British Gas and Gaz de France. Despite the presence of many distribution and retail businesses in Germany, Italy and Spain, the wholesale sector received supplies exclusively from several major gas suppliers such as the former Ruhrgas, RWE, Eni and Gas Natural. During this period, demand and supply adjustments were made internally within a vertically integrated supply-chain. However, the vertically-integrated business structure was broken down during the liberalisation process, and the entry of new businesses led to the revitalisation of wholesale trade.

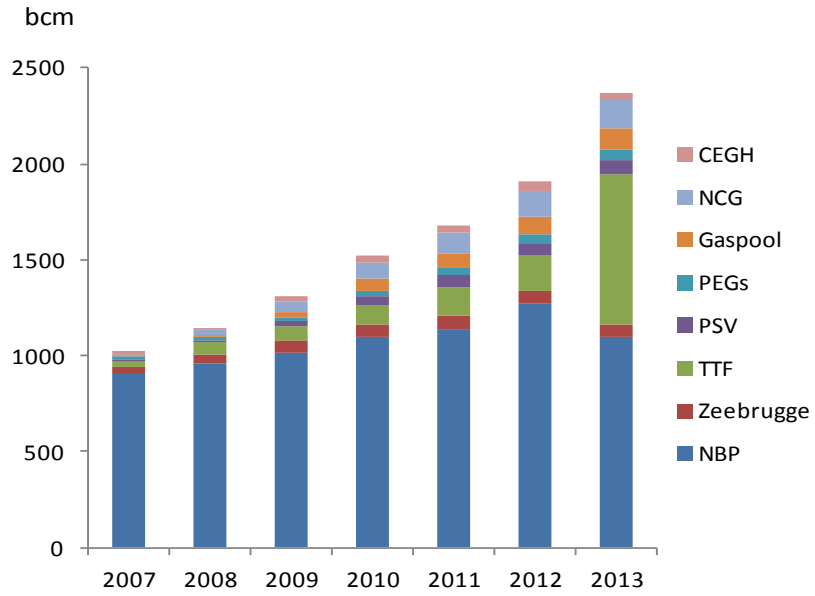
Figure 3.5 • Gas Pipelines in Europe, 2015

Source: Eurogas (2015)

The establishment of so-called **'trading hub prices'** further encouraged wholesale trading. Trading hub prices enable all market participants to properly reflect demand and supply in prices. They helped to determine a "baseline" trading price and made it easier for more market participants to engage in trade. Further, the development of a futures market to hedge such hub prices also helped to increase trade liquidity by encouraging diverse players to enter the market. The United Kingdom, which spearheaded the liberalisation movement in the gas market, began to liberalise in 1982. The former British Gas was privatised in 1986, management and ownership were separated for the gas transportation business in 1997 and the retail market was completely liberalised in 1998. During this period, a surplus arose in natural gas supply in the second half of the 1990s, and the National Balancing Point (NBP), which is a wholesale trading hub, emerged in the search for a gas sales destination by producers. Hence, wholesale trading prices at NBP became an index of gas prices for the United Kingdom. Following the United Kingdom's initiative, economies in continental Europe also successively pushed forward on the liberalisation of the gas market, and gas trading hubs were established in various parts of the region including the Netherlands (Title Transfer Facility (TTF)), Belgium (Zeebrugge) and Germany (Gaspool) (Figure 3.6). The natural gas trade volume in these hubs is expanding year by year; of these, NBP generates the largest trade volume, and is currently regarded as a representative price index not only for the United Kingdom, but for the whole of Europe.

The establishment of natural gas trading hub and the timely dissemination of prices that reflect the market fundamentals can contribute to providing gas producers with the incentive to develop gas fields/increase production or reduce production corresponding to price fluctuations. This trading hub likewise provides supplier businesses with the incentive to invest in transportation and storage infrastructure, and encouraging gas consumers to consume energy based on the relative prices of gas and other fuels. Such indirectly contributes to improving supply security.

Figure 3.6 • Trade Volume in Europe's Gas Hub, 2007-2013



Source: IEA (2014)

3.3.2 Japan

In Japan, steps toward building such highly-liquid markets have also been observed. Originally, the supply of gas in Japan's gas market was monopolised by the gas businesses in each region operating as public utility operators. After the start of liberalisation of the gas industry in 1995 and lasting until 2006, the scope of liberalisation was expanded in phases, extending from large to small consumers. By April 2017, most consumer markets including the market for residential use will be liberalised, and there are also expectations for the revitalisation of the wholesale market. Also, the introduction of third-party access to LNG-receiving terminals is being reviewed and implementation of the following systems are under consideration: 1) Without justifiable reason (presence of excess capacity, quality control, security assurance), it is not permitted to turn down a request from a third-party to use an LNG terminal; and, 2) Facility usage fees and the validity of these justifiable reasons will be monitored by a monitoring committee.

On the establishment of hubs that reflect LNG demand and supply in Asia, the Ministry of Economy, Trade and Industry (METI) has taken a lead role to explore the potential for establishing LNG trading hubs in Japan, such as the start of over-the-counter trading for LNG in the Tokyo Commodity Exchange (TOCOM). As a part of such efforts, reviews are underway about the

establishment for an ideal platform that can improve the reliability of information and mitigate the risk of price manipulation. An ideal platform ensures anonymity in order to grasp demand and supply conditions in a timely manner and provide information on contract prices or quotes that are reassuring to businesses in disseminating price information.

3.4 Demand Control

Discussions thus far in this chapter have mainly focused on supply side measures such as diversification and flexibility. Market liquidity also concerns supply flexibility, at least from the importer's point of view. Theoretically, if these measures fail to secure stable supply, demand must be reduced to accommodate shorter supply. While storage could provide some relief in such a case, demand control might be introduced to deal with the supply shortage. Demand control mainly concerns three elements: energy efficiency, fuel switching and interruptible contracts.

Usually energy efficiency is aimed at inhibiting energy spending and greenhouse gas emissions but it could address security of supply by holding down demand growth. Energy efficiency is a traditional countermeasure to address energy security for importing economies. While classic examples include Japan's Energy Conservation Law of 1979, major importing economies have each implemented their respective energy efficiency policies. In the pre-shale revolution era, the U.S. Energy Policy Act 2005 provided a $1.3 billion tax reduction for conservation and energy efficiency. The EU regards energy efficiency as the most immediate element within a European energy security policy, and targets improving energy efficiency by 20% by 2020 (EC 2017). Facing rising dependency on fossil fuels for power generation, Japan stresses efficiency in coal and gas-fired power stations, as well as other demand sectors (METI 2014). China, too, is increasingly focusing on energy efficiency. The latest Five Year Plan is aimed at limiting energy consumption in 2020 to 5 billion tonnes of coal equivalent (Btce) (3.5 billion tonnes of oil equivalent [Btoe]) in 2020.

Fuel switching is another measure to curb the demand. In the long-term, diversification of energy use offers a solution to uncontrolled demand surges. The diversification away from oil, especially in Europe and Japan after the oil crises in the 1970s, is a typical example. For immediate gas supply stability, industrial consumers and power plants with dual fuel equipment can switch to a different fuel, typically to oil. Dual fuel power generation, usually oil and gas, was once common, especially in the US. While the capacity of gas-fired power plants was 33.40GW in 1990, oil/gas dual-fired power plant capacity was 131.71GW in the same year. However, with the increase in combined-cycle gas turbine capacity, which cannot accommodate dual fuels system, dual fuel power plant capacity gradually vanished.

An interruptible contract is an agreement that allows an energy supplier to interrupt energy supply with agreed customers at certain period of time. The IEA values interruptible contracts of natural gas, because they offer flexibility at a lower cost rather than storage (IEA 2004). While this type of contract is widely used in economies of the Organisation for Economic Co-operation and

Development (OECD) for gas and electricity supply, it can be regarded as a last resort for minimizing the impact of a supply cut. In the case of an emergency, gas supply to interruptible consumers (typically large-scale industry users or power plants) will be cut in order for the non-interruptible consumers (typically household users) to have continuous supply.

3.5 International Cooperation

Countermeasures to deal with energy supply security issue are often in the sphere of energy policy or industry practice. Energy security challenges are inherently international in scope, and thus cannot be addressed by national governments alone (Martin and Harrje 2005).[21] This is reasonable given the fact that security of supply is usually discussed in terms of international energy trades.

Energy cooperation includes a wide range of objectives and forms: it could be implemented for energy security, energy technology transfer, nuclear safety, global warming and others; it could be bilateral and multilateral, and could be between importers or exporters. While there exist a large number of bilateral energy cooperation agreements between exporters and importers, there are largely regarded as an instrument for overseas resource development. Thus, the focus will be on major institutionalised multilateral energy cooperation schemes that include energy security in their scope.

The first of this kind was the establishment of the IEA by major energy importing economies in 1974. At the initiative of the United States, the IEA was formed in response to the damaging economic effects of the Arab oil embargo in 1973. The IEA was important because it was the first attempt to coordinate multilateral energy policies, although such coordination was often difficult. Initially, the IEA focused on an oil-sharing plan that would be implemented among member economies in the case of emergency, but it expanded its role into energy sources including natural gas, although gas stockpiling obligations have not been introduced to date.

Another example of energy cooperation is the Energy Charter Treaty (ECT) that was enacted in 1998. The origin of the ECT was a proposal in 1990 by the Netherlands that cooperation in the energy sector could catalyse and accelerate the economic recovery in Eastern Europe and the former Union of Soviet Socialist Republics (USSR) (IEA 1994).[22] The ECT is more ambitious and wide ranging than the IEA, as it seeks to define a legal framework for investment, transit, trade, consumption and environmental protection within the energy sector (Andrew-Spped 2004).[23] Meanwhile, to many economies in Western Europe, the charter offered the prospect of securing long-term energy flows from the former Soviet Union. The Charter itself states that it provides a multilateral framework for energy cooperation that is unique under international law, and the

[21] Martin and Harrje, "The International Energy Agency," in Kalicki J. H. and Goldwyn D. L. (eds.), *Energy & Security – Toward a New Foreign Policy Strategy*, 2005, Woodrow Wilson Center Press, Washington D.C.
[22] IEA, *The Energy Charter Treaty: A description of its provisions*, 1994, OECD/IEA, Paris
[23] Andrews-Speed, " A European Approach to Energy Security", in Godement et al (eds.), *Asia and Europe – Cooperating for Energy Security*, 2004, Institut français des relations internationales, Paris.

strategic value of these rules is likely to increase in the context of efforts to build a legal foundation for global energy security (ECS 2004).[24]

With robust demand growth, Asian economies are indeed concerned about energy security. The first major energy cooperation scheme in the region was the Energy Working Group (EWG) of APEC established in 1989. The EWG developed the Energy Security Initiative in 2000, which includes four different aspects of the energy security in the region, namely sea-lane security, real-time information sharing, the Joint Oil Data Initiative (JODI) and energy emergency response arrangements. It should be noted that these measures bear considerable resemblances to those of the IEA. Energy emergency response arrangements originate from the IEA's corresponding initiative, and JODI was implemented in cooperation with the IEA and other organizations. The APEC Energy Ministerial Meeting (EMM) in 2014 recognised four critical elements of energy security and sustainable development, namely: diversified energy supply and stable demand, safe energy transportation routes, innovation in energy technologies and effective fora to discuss energy policy.

APERC implements the Oil and Gas Security Initiative (OGSI), a unique initiative for the Asia-Pacific region's oil and gas security, by sharing information, expertise and best practices on oil and gas security. APERC publishes a bi-monthly newsletter about the latest issues in oil and gas security (Oil and Gas Security Newsletter under the Oil and Gas Security Network or OGSN), and research studies related to oil and gas security (Oil and Gas Security Studies or OGSS). Meanwhile, the emergency preparedness exercises (under the Oil and Gas Exercise or OGSE) assess an economy's response measures and strategies in the event of supply disruptions and recommend ways to improve them.

ASEAN is developing an Operationalisation Manual for the APSA-CERM to make it more responsive during the emergency situations, be it a regional or individual economy supply emergency. The Manual describes and identifies a common framework for cooperation and coordination among ASEAN members in emergency preparedness and response measures both during normal times and in any event of supply disruptions (source: ERIA). As explained above, APSA may also cover gas security, considering that one of the cooperation areas within this region is related to transnational pipeline network integration among ASEAN members.

3.6 Statistics Development

Energy statistics by themselves cannot increase supply or decrease demand. However, they could contribute to gas supply security by improving the transparency of the demand and supply situation.

[24] Energy Charter Secretariat, *The Energy Charter Treaty and Related Documents*, 2004, Brussels.

Following the launch of JODI in 2001, APEC, Eurostat, the IEA, the International Energy Forum (IEF), the Latin American Energy Organization (OLADE), OPEC, and the United Nations (UN) established a similar initiative in 2012 for gas under the name of JODI-Gas to improve gas statistics coverage and frequency. Although there is different data availability between economies, improving statistics accuracy and frequency is expected to enhance gas market transparency.

Chapter 4. Conclusions

This chapter summarizes the implications of future gas security policies in the APEC region based on the points discussed.

4.1 Utilise the Market Mechanism

Firstly, the basic stance of gas security policy should be to establish a framework that can maximize the benefits of the market mechanism, as well as to put in place policy measures where such policy response is necessary.

As discussed in Chapter 3, improving flexibility in market trading and improving market liquidity hold the key to enhancing gas security. While natural gas trading, which requires heavy infrastructure investment, tends to have a rigid character, it is still possible to establish a system that can supply natural gas to the areas where it is most needed even in cases of unforeseen fluctuations in demand and supply. This could be realised by improving the flexibility of trading style. Through the presence of liquid international markets that can facilitate the free trading of gas by diverse market participants, it would also be possible to secure additional supplies through the market in situations of unforeseen supply disruptions.

Recent efforts to create a price benchmark in the Asia-Pacific natural gas market have a potential to facilitate active trading of LNG in Asia. Japan launched an OTC market[25] (Japan OTC Exchange [JOE]) in September 2014 for Delivered Ex Ship (DES) Japan LNG price at TOCOM.[26] TOCOM aims to make the LNG market price as a benchmark of the Asian LNG market. China also set up a natural gas trading platform (futures market) in Shanghai (Shanghai Petroleum and Natural gas Exchange [SHPGX]),[27] and Singapore started a similar market through the Singapore Exchange (SGX).[28] As observed in the European experience, creation of a natural gas hub price facilitates more spot trading and eventually contributes to natural gas security by enhancing market liquidity.

Further, with respect to domestic market systems, many APEC member economies have set regulated prices in domestic natural gas and electricity markets. However, it may not be possible to secure sufficient investment for supply infrastructure based on prices that were artificially set to a low level. As such, it would be ideal to make the transition toward a more rational price system that reflects the market fundamentals of the international market.

On the other hand, there are also policies that cannot be implemented if matters are left to the market mechanism. For example, to achieve the diversification of supply sources and supply routes including the promotion of investment in supply infrastructure, it is important for the government to

[25] Commodity Futures Market
[26] The first trading of LNG derivatives linked to the Rim DES Japan LNG was held in March 2016.
[27] SHPGX was launched in July 2015.
[28] In January 2016, the first trade of a derivatives contract using the FOB Singapore SGX LNG Index Group (SLInG) price index was conducted (source: Freshfields Bruckhaus Deringer LLP).

be involved, when and where necessary. The construction of international import pipelines, such as the attempts made by China and Europe, in particular, requires coordination at the diplomatic level between governments. Likewise, in the promotion of energy conservation in the economy as a demand-side measure, the government also plays a very significant role in aspects such as establishing and monitoring energy conservation targets. Gas security measures should be promoted through the basic policy of harnessing the market mechanism, and at the same time, based on the principle of government involvement in areas where security goals cannot be achieved through the workings of the market mechanism alone.

4.2 Promote Investment

The most important policy measure is to promote investment related to the stable supply of natural gas. To secure a stable supply of natural gas, it is vital to develop infrastructure with adequate production capacity, and which can bring supplies to end-consumers. Natural gas demand in the APEC region is expected to increase with a particularly high rate of growth in comparison with the rest of the world. For this reason, ensuring that sufficient investment is injected into the natural gas sector is a goal of special importance toward achieving gas security in the APEC region.

In diversifying supply sources, which is vitally important in achieving gas security, it is necessary to develop international pipelines and LNG-receiving terminals. Governments have an important role to play in the development of such large-scale infrastructure. Specifically, they play a key role in aspects such as developing investment-related laws and regulations, providing financial support such as financing for investment projects with low interest rates, and offering preferential tax treatment to promote investment. By providing a coherent and consistent policy through the formulation of a long-term master plan for gas supply, governments can also mitigate the risk of future policy changes and effectively deploy domestic resources, beginning with the relevant ministries and agencies.

LNG is expected to take on an increasingly important role in the supply of natural gas in the APEC region. However, partly due to the decline in crude oil prices since the second half of 2014, investment in new LNG projects has been delayed. With respect to such investments in LNG production capacity, the demand and supply balance in the market, crude oil prices in the international market, as well as trends in LNG prices are some of the more restrictive factors. It would be ideal for gas-producing and gas-consuming economies to promote investment by engaging periodically in close exchange of information concerning these factors.

4.3 Accelerate the Development of an International Network

In economies where supply networks have been developed for the supply of natural gas through pipelines, gas security can be further strengthened through the development of an international supply network. This is because, by making the network more extensive and interactive and by pooling demand and supply, such a network can offer economies more response options in situations of unexpected supply disruption of demand and supply fluctuations. The gas security policy for the EU published in

February 2016 also sets forth the development of an international pipeline network and an interface between governments for times of emergency as one of the core initiatives.[29]

Specific examples of networks developed in the APEC region include the "Power of Siberia" pipeline project between China and Russia, strengthening of pipeline capacity between the United States and Mexico, and development of pipelines in the ASEAN region. In particular, with the opening of a pipeline between Russia and China, where natural gas demand is expected to rise significantly, which will enable the supply of a large volume of natural gas (planned volume of 38 Bcm per year), China would gain its fifth supply option after its existing options of domestic gas, LNG imports, pipeline gas imports from Central Asia and pipeline gas imports from Myanmar. This contributes significantly to the diversification of supply sources. For Russia as well, the ability to diversify its sales destinations by increasing the export of pipeline gas not only to Europe, but also to Asia, gives it the advantage of achieving demand-side security. With respect to the development of a pipeline network in ASEAN, if an international pipeline network is developed in economies where the scale of domestic natural gas demand is not large enough to justify the construction of LNG-receiving terminals, such economies would also be able to reap the benefit of receiving natural gas supplies.

In the development of such international pipelines, there may also be economies that are cautious about depending on other economies for importing gas supplies through pipelines. However, the diversification of supply sources is key to gas security, and it would be a good idea for the respective economies to adopt a positive attitude toward this initiative. Moreover, as it is difficult for corporations to negotiate the development of international pipelines, negotiations and initiatives among governments are vital toward the realisation of this idea. With the forecast growth in gas demand in the region, APEC member economies should also take a more open-minded approach toward the development of international pipelines.

The development of the FSRU may also contribute to promoting linkages (not only internationally but domestically). An FSRU can be moved easily to a place where there is high demand for regasification of LNG, and get it to market faster. Likewise, an FSRU costs less than building an onshore regasification facility or a pipeline. The only drawback of FSRU is that it has less capacity compared with a conventional onshore facility.

Similarly, the floating LNG (FLNG) vessel, which serves as a floating liquefaction and storage unit specifically for offshore gas discoveries, provides a cheaper option for liquefaction and it can also transport LNG to areas or economies needing LNG supply. FLNG also allows remote or small fields to be developed economically (Oil and Gas Investment Bulletin). Although FLNG is not mentioned in the previous chapters, it offers a viable option to expanding the international network. The world's first FLNG unit to go on stream was the Satu vessel developed and operated by Petronas of Malaysia. The Satu FLNG vessel with a capacity of 1.2 Mtpa produced its first drop of LNG in December 2016 (UT, 2017).

[29] EC, "Proposal for a Regulation of the European Parliament and the Council concerning measures to safeguard the security of gas supply and repealing Regulation," February 2016.

4.4 Maximise the Merits of LNG

LNG demand is expected to grow in the Asia-Pacific market in future. Compared with pipeline gas, LNG has physical properties that allow it to be traded more flexibly. Its merit is that as long as the receiving infrastructure is developed, it can be shipped to any part of the world. Through the shale revolution in the United States and the discovery of new gas fields in Africa, many new projects have sprung up, and there is great potential on the supply side. Although the emergence of shale gas-based LNG had significant impacts in terms of enhanced flexibility in LNG trading, a new wave of Australian LNG, including those based on coalbed methane (CBM) is expanding to have a far larger impact in the Asian market, as it provides a large physical supply. On the demand side as well, the popularization of the FSRU has helped immensely in bringing down the barriers to the introduction of LNG. Creating a market that can take the most advantage of LNG can also contribute significantly to gas security in the Asia-Pacific region.

Special efforts should be made to improve supply flexibility and market liquidity. A major problem for flexibility is the destination clause included in long-term contracts. With the heightened interest in liquidity in recent years, there have been many cases where this destination clause has been either abolished or relaxed. However, restrictions on destination are still included in many long-term contracts, and these impose restrictions on the liquidity of spot trading. The EU has already declared destination clauses illegal, and the Japan Fair Trade Commission is investigating the legal validity of such clauses in Japan. The secretariat of the ECT, which is aimed at securing stable energy trade and investment, has also expressed its views that destination clauses in existing long-term LNG contracts are not consistent with current commercial practices (Rusnak 2016). The abolition of the destination clause, which plays a vitally important role in achieving supply security of LNG, calls for coordination and cooperation among the governments of both gas-producing and gas-consuming economies.

Furthermore, with respect to ensuring liquidity, it is important to create a spot market where active trading takes place constantly, as in the international oil market or international coal market, and where it is possible to easily procure additional LNG in the event of an emergency. In promoting investment, if a spot market exists that enables the sale of LNG at market prices in cases where there is excess LNG production, it may then also be possible to facilitate the financing of new projects more easily by reducing the volume risk of the LNG plant.

As the region is a host to a large number of LNG producers, expanding intra-APEC LNG trade would be also beneficial due to the absence of chokepoint risks as mentioned in Chapter 2. However, APEC economies should strengthen cooperation in addressing rising piracy incidents, in particular along the Strait of Malaca as one of the major routes for LNG imports (APERC, 2017).

4.5 Achieve Demand-Side Security at the Same Time

Up till this point, this report has mainly considered gas security from the perspectives of the consumer and importing economies. However, there are also world-leading producer and exporting economies in the APEC region, such as Australia and Russia. Achieving stable gas supply is an

important issue for both the producers and the consumers, and gas security should be mutually complementary and beneficial to both producers and consumers.

From the perspective of the producer and exporting economies, it would be ideal to sell the natural gas and LNG produced in the economy at stable prices that are commensurate with the amount of investment required for development and production. The demand-side security is of the greatest interest to producer and exporting economies. Hence, it is necessary obtain even more accurate information at least on current and future demand. Through the JODI-Gas initiative that is currently being implemented with the participation of 84 economies, the development of such statistics concerning the trends of natural gas demand is progressing gradually but steadily. From the perspective of the seller, in the hypothetical situation that a buyer cannot be found through a long-term contract, it would be possible to minimize the risk of not finding a physical buyer if a highly-liquid spot market were developed. In this sense, the creation of an active spot market can be beneficial to the seller as well. Accordingly, by increasing the opportunities for dialogue between producers and consumers in the future, it is important to share information on forecasts of future demand, as well as to develop a spot market with a high level of liquidity. In cases where adequate investment cannot be secured because of uncertainty about the future outlook, another option that should be considered is the provision of financial support by the government of the consumer economy.

Furthermore, supply security in producing countries is an equally important issue. In Indonesia, for instance, because domestic gas demand is growing, some of the exported supply needed to be diverted to domestic supply to meet the increasing domestic demand. For the reason, UAE and Malaysia started to import LNG even while they exported a significant amount of LNG to meet the requirement of its long-term contract. Supply security is no longer an issue only for gas importers but also for gas exporters. Such gas supply shortages in gas exporting countries may cause political discontent among those countries' people because they tend to believe that natural gas exports cause increase in domestic natural gas prices. In Queensland, Australia, while the natural gas price used to be determined by the domestic market balance, the price is now affected by the international market through LNG exports. This causes opposition among local residents to gas exports. Supply issues for domestic consumers in gas producing countries tend to be overlooked, but ensuring a stable supply to domestic consumers is also an integral part of natural gas security.

4.6 Formulate Objective Standards and Indicators on Gas Security

It may not be possible to clearly assess the current conditions and determine the benefits of improvement measures not only for gas security, but for energy security measures as a whole. Hence, there are also cases where it is sometimes difficult to assess whether the measures that are currently being implemented are appropriate. For this reason, objective assessment criteria should be drawn up on how to improve gas security, and how to measure the status of these improvement measures. Chapter 2 of this study is one such attempt to establish and measure such supply security using some indicators, but the governments of the respective economies should also develop clear and objective standards for the establishment of coherent and consistent gas security policies.

In this respect, the EU is taking the lead on initiatives. The "Proposal for a Regulation of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing Regulation," formulated in 2016, lists the items to be included in gas security measures that member states should put in place going forward. By the end of March 2017, the respective economies are required to report on their respective policy measures to the EC. Specifically, details include the scale of demand in the residential use sector, which should receive the greatest protection in gas security, the scale of peak demand in each economy, declaration of a state of emergency and preventative measures in the event of an emergency, emergency response in an actual event of an emergency, and development of networks and cooperation proposals with neighbouring economies. While it may not be suitable to request member economies of APEC to put in place such stringent and detailed measures, it may be beneficial to organize the measures corresponding to the actual conditions of gas supply in the APEC region.

4.7 Formulate a Regional Natural Gas Security Framework Agreement

Although energy security is at the forefront of energy cooperation in the region as espoused in the APEC Energy Security Initiative, the APEC Leaders may also consider formulating a Natural Gas Security Framework (may be together with oil in one security framework) to further strengthen regional gas supply security. Considering that a regional agreement lowers the supply security risks (as discussed in Chapter 2), the development of a security framework as part of regional energy cooperation within APEC could certainly improve gas supply security, specifically for those economies with limited resources and high dependence on imports. Such a framework could cover possible supply sharing during supply disruptions, be it domestically or regionally, and other security measures such as, strengthening long-term policy responses and emergency measures and strategies.

ANNEX I

Economy	Year	Internal Indicators (Index), in Percent										
		PES Diveristy	Gas Share of PES	Gas Intensity	Gas Per Capita	Self-Sufficiency	Import Diversity	R/P Ratio	RGT Utilisation	Gas Pipeline Utilisation	Gas Storage	Int'l Agrmt
AUS	2000	33%	18%	51%	46%	0%	0%	16%	0%	0%	94%	50%
	2014	30%	25%	59%	60%	0%	50%	24%	0%	79%	77%	50%
BD	2000	65%	78%	59%	86%	0%	0%	0%	0%	0%	100%	50%
	2014	72%	83%	95%	94%	0%	0%	31%	0%	0%	100%	50%
CDA	2000	0.25	29%	64%	69%	0%	100%	29%	0%	5%	53%	50%
	2014	0.26	32%	65%	68%	0%	95%	4%	4%	53%	77%	50%
CHL	2000	27%	21%	49%	42%	69%	100%	0%	0%	33%	100%	100%
	2014	25%	10%	21%	25%	81%	85%	17%	52%	0%	100%	100%
PRC	2000	42%	2%	26%	7%	0%	0%	0%	0%	0%	95%	100%
	2014	47%	5%	54%	51%	29%	24%	60%	48%	46%	97%	100%
HKC	2000	34%	18%	52%	44%	100%	100%	0%	0%	95%	100%	50%
	2014	46%	15%	27%	34%	100%	100%	0%	0%	61%	100%	50%
INA	2000	28%	17%	58%	40%	0%	0%	16%	0%	0%	100%	50%
	2014	24%	16%	42%	46%	0%	0%	15%	17%	0%	100%	50%
JPN	2000	32%	13%	37%	35%	97%	20%	1%	33%	0%	100%	100%
	2014	32%	24%	58%	56%	98%	13%	30%	47%	0%	97%	100%
ROK	2000	36%	9%	34%	22%	100%	27%	0%	42%	0%	100%	100%
	2014	27%	16%	52%	51%	97%	18%	60%	34%	0%	100%	100%
MAS	2000	40%	51%	69%	48%	0%	0%	8%	0%	0%	100%	50%
	2014	35%	43%	62%	55%	0%	33%	18%	39%	97%	100%	50%
MEX	2000	43%	24%	43%	36%	6%	100%	0%	0%	13%	100%	50%
	2014	38%	32%	59%	50%	38%	53%	65%	36%	28%	100%	50%
NZ	2000	24%	30%	61%	60%	0%	0%	43%	0%	100%	100%	50%
	2014	22%	21%	41%	42%	0%	0%	27%	0%	100%	95%	50%
PNG	2000	67%	7%	42%	43%	0%	0%	99%	0%	0%	100%	50%
	2014	60%	3%	19%	28%	0%	0%	98%	0%	0%	100%	50%
PE	2000	42%	4%	7%	4%	0%	0%	0%	0%	0%	100%	50%
	2014	32%	34%	58%	52%	0%	0%	94%	0%	0%	100%	50%
PHL	2000	28%	0%	0%	0%	0%	0%	0%	0%	0%	100%	50%
	2014	23%	6%	37%	44%	0%	0%	100%	0%	0%	100%	50%
RUS	2000	35%	51%	100%	58%	0%	0%	3%	0%	0%	82%	0%
	2014	35%	52%	84%	66%	0%	0%	0%	0%	0%	84%	0%
SGP	2000	87%	6%	14%	11%	100%	100%	0%	0%	98%	100%	50%
	2014	51%	33%	59%	62%	100%	47%	0%	28%	85%	100%	50%
CT	2000	35%	7%	32%	23%	89%	52%	36%	60%	0%	100%	100%
	2014	31%	12%	50%	48%	98%	28%	27%	100%	0%	100%	100%
THA	2000	27%	24%	51%	28%	10%	100%	16%	0%	11%	100%	50%
	2014	25%	28%	67%	54%	23%	70%	72%	26%	80%	100%	50%
US	2000	34%	24%	60%	66%	18%	88%	37%	63%	59%	59%	50%
	2014	23%	28%	57%	63%	3%	96%	7%	1%	43%	43%	50%
VN	2000	25%	4%	15%	7%	0%	0%	12%	0%	0%	100%	50%
	2014	26%	13%	53%	53%	0%	0%	86%	0%	0%	100%	50%
APEC	2000	25%	21%	59%	44%	0%	25%	2%	49%	29%	90%	60%
	2014	26%	20%	52%	54%	0%	9%	6%	36%	60%	87%	60%

Note:

- *Index value ranges from 0% - 100%, where 0% means the lowest risk (or no risk) and 100% is the highest risk.*
- *Hong Kong, China is given 50% in international agreement on gas security indicator being a part of and highly dependent on China for gas supply.*
- *Despite the absence of an international agreement on gas security, Russia is given 0% index for this indicator due to its huge gas reserves.*
- *Other economies without any international agreements but producing 100% of their gas supply for domestic consumption (self-reliant on gas supply with substantial amount of gas reserves) are assigned a 50% index for this indicator. For APEC-ASEAN economies, 50% index is assumed for international agreement on gas security because of APSA, which may also cover gas security as explained in Chapter 2.*

Economy	Year	External Indicators (Index), in Percent			Overall Supply Security Index		
		Chokepoints	Exporter's Stability	LNG export Terminal Utilisation	Internal Factors	External Factors	Ave. Security Index
AUS	2000	0%	0%	0%	22%	32%	11%
	2014	0%	54%	0%	0%	4%	18%
BD	2000	0%	0%	0%	31%	0%	16%
	2014	0%	0%	0%	38%	0%	19%
CDA	2000	0%	30%	0%	32%	2%	17%
	2014	0%	37%	0%	34%	3%	18%
CHL	2000	0%	49%	0%	39%	4%	21%
	2014	9%	45%	98%	37%	11%	24%
PRC	2000	0%	0%	0%	19%	0%	10%
	2014	6%	47%	45%	40%	70%	24%
HKC	2000	0%	0%	0%	35%	0%	21%
	2014	0%	0%	0%	31%	0%	19%
INA	2000	0%	0%	0%	22%	0%	11%
	2014	0%	0%	0%	22%	0%	11%
JPN	2000	6%	50%	89%	33%	10%	22%
	2014	11%	42%	94%	40%	10%	25%
ROK	2000	10%	57%	94%	34%	11%	23%
	2014	18%	49%	95%	40%	12%	26%
MAS	2000	0%	0%	0%	26%	0%	13%
	2014	11%	62%	37%	38%	8%	23%
MEX	2000	0%	30%	0%	30%	2%	16%
	2014	1%	45%	28%	39%	5%	22%
NZ	2000	0%	0%	0%	25%	0%	12%
	2014	0%	0%	0%	21%	0%	11%
PNG	2000	0%	0%	0%	29%	0%	15%
	2014	0%	0%	0%	26%	0%	13%
PE	2000	0%	0%	0%	15%	0%	7%
	2014	0%	0%	0%	30%	0%	15%
PHL	2000	0%	0%	0%	13%	0%	6%
	2014	0%	0%	0%	26%	0%	13%
RUS	2000	0%	0%	0%	24%	0%	12%
	2014	0%	0%	0%	23%	0%	11%
SGP	2000	0%	49%	0%	40%	4%	22%
	2014	3%	55%	15%	44%	5%	25%
CT	2000	0%	74%	100%	38%	12%	25%
	2014	14%	40%	96%	42%	11%	27%
THA	2000	0%	84%	0%	30%	6%	18%
	2014	4%	66%	16%	43%	6%	24%
US	2000	0%	29%	6%	42%	2%	22%
	2014	0%	27%	2%	32%	3%	17%
VN	2000	0%	0%	0%	15%	0%	8%
	2014	0%	0%	0%	27%	0%	14%
APEC	2000	3%	56%	49%	29%	8%	18%
	2014	7%	51%	64%	29%	9%	19%

Note:

- *Hong Kong, China's Index value on exporters' stability is assumed to be 0% as the only exporter of gas is China.*

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