The Future of Asian LNG

Challenges and Opportunities for Policy Makers

A Joint Project of the Institute of Energy Economics Japan (IEEJ) and the Energy Policy Research Foundation, Inc. (EPRINC)

October 2017

The Institute of Energy Economics, Japan

ABOUT THE IEEJ – EPRINC JOINT PROJECT

The Institute of Energy Economics Japan (IEEJ) and the Energy Policy Research Foundation, Inc. (EPRINC) have undertaken a joint assessment of the future role of liquefied natural gas (LNG) in Asian power and fuel markets. Among the more important objectives of this joint effort are identifying recent trends and longer-term uncertainties in Asian natural gas markets and the potential role of U.S. LNG exports in serving those markets. The project was also tasked with identifying market-based policy initiatives that would expand natural gas use throughout Asia. This supports regional efforts to promote fuel diversity, improve air quality, and address longer-term climate risks. The research and survey project includes specific recommendations for policy makers and other stakeholders on strategies to both support LNG demand in Asia and to improve the competitiveness of U.S. natural gas in the region. The policy recommendations in this report are expected to be discussed at the 6th LNG Producer Consumer Conference scheduled for October 18, 2017 in Tokyo, Japan. The project has received financial support from the governments of both Japan and the United States.

The two organizations have reached out to a wide range of experts, government officials, and market participants through a series of workshops. The initial workshop of industry experts, policy research organizations (think tanks), and experts was held in Washington, D.C. on July 20, 2017. A subsequent meeting in Tokyo was held on July 28, 2017 with Japanese industry executives, followed by a third meeting in Bangkok on August 29, 2017 with representatives from existing and prospective Asian demand centers. The Economic Research Institute for ASEAN and East Asia (ERIA) participated in the Tokyo meeting in July, and also hosted the Bangkok meeting. IEEJ and EPRINC held a final workshop in Washington on September 8, 2017. In preparing this report, IEEJ and EPRINC have drawn upon the workshop presentations, ongoing research and assessments in our respective organizations, communications with LNG experts in and out of industry, and government officials.

An important focus of the IEEJ-EPRINC research effort is to understand the dynamics of longer-term Asian LNG demand, the capacity of the U.S. resource base to expand natural gas production, strategies that can improve the price competitiveness of U.S. LNG exports, in addition to identification of policy initiatives to address structural demand constraints often prevalent in emerging Asian LNG markets. New LNG demand centers are likely to emerge in both Asian power markets and industrial centers, but their number and magnitude remain uncertain. Many of these markets are highly competitive as they can be served by alternative fuels and pipelined natural gas deliveries. It is therefore critical to help transform the uncertainty over Asia's LNG demand into real demand. This research delves into the challenges that might hamper sustainable development of LNG demand in Asia, and provides possible recommendations to overcome the challenges.

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ABOUT IEEJ

The Institute of Energy Economics, Japan (IEEJ) was established in June 1966. The aim of its establishment is to carry on research activities specialized in the area of energy from the viewpoint of the national economy as a whole. This is done in a bid to contribute to sound development of the Japanese energy-supplying and energy-consuming industries and to the improvement of people's life in the country. IEEJ accomplishes this by objectively analyzing energy problems and providing basic data, information, and reports necessary for the formulation of policies. With the diversification of social needs, IEEJ has expanded its scope of research activities to include such topics as environmental problems and international cooperation closely related to energy. In October 1984, the Energy Data and Modeling Center (EDMC) was established as an IEEJ-affiliated organization to carry out such tasks as the development of energy databases, building of various energy models, and econometric analyses of energy. In July 1999, EDMC was merged into IEEJ and began operating as an IEEJ division under the same name, i.e., the Energy Data and Modeling Center.

IEEJ has provided data and information related to energy, environment, Middle East, and other research topics as a non-profit organization.

ABOUT EPRINC

The Energy Policy Research Foundation, Inc. (EPRINC) was founded in 1944, and is a not-for-profit, non-partisan organization that studies energy economics and policy issues with special emphasis on oil, natural gas, and petroleum product markets. EPRINC is routinely called upon to testify before Congress

as well as providing briefings for government officials and legislators. Its research and presentations are circulated widely without charge through postings on its website. EPRINC's popular Embassy Series convenes periodic meetings and discussions with the Washington diplomatic community, industry experts and policy makers on topical issues in energy policy.

EPRINC has been a source of expertise for numerous government studies, and both its chairman and president have participated in major assessments undertaken by the National Petroleum Council. In recent years, EPRINC has undertaken long-term assessments of the economic and strategic implications of the North American petroleum renaissance, reviews of the role of renewable fuels in the transportation sector, and evaluations of the economic contribution of petroleum infrastructure to the national economy. Most recently, EPRINC has been engaged on an assessment of the future of U.S. LNG exports to Asia and the growing importance of an integrated North American energy market.

EPRINC receives undirected research support from the private sector and foundations, and it has undertaken directed research from the U.S. government from both the U.S. Department of Energy and the

U.S. Department of Defense. EPRINC publications can be found on its website: www.eprinc.org.

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Key Findings

The global LNG market is undergoing a sustained and fundamental transformation. A combination of forces led by the revolution in shale gas production in the U.S., rising global LNG use, diverging natural gas and crude oil prices, and demand shifts from traditional Northeast Asian countries (Japan, Korea and Taiwan) to China, Southeast Asia and South Asia present new challenges and opportunities for producing and consuming regions. The LNG market is already experiencing rising competition from the U.S. and Australia in a market traditionally reliant upon suppliers from Asia and Middle East. While new competitive forces bring challenges to producers, the development of a broad-based liquid and flexible LNG market can deliver substantial economic, environmental and energy security benefits throughout the region. The challenge ahead for policy makers in securing the widespread benefits of rising supplies of LNG is to transform potential LNG demand in Asia into real demand. Whether the U.S. can play an integral role in Asian LNG market is dependent not only on the pace and magnitude of LNG demand growth in Asia, but also on sustaining a cost competitive position for U.S. LNG exports. U.S. policymakers, recognizing the vast indigenous natural gas reserves and advances in extraction technologies, are pursuing a supportive strategy to ensure that production growth and LNG exports are both predictable and sustainable.

The Institute of Energy Economics Japan (IEEJ) and the Energy Policy Research Foundation, Inc. (EPRINC) undertook an assessment of future LNG demand growth in Asia and strategies to improve the competitiveness of U.S. LNG exports in the region. The two organizations reached out to nearly 100 experts, government officials and market participants through a series of workshops in Washington D.C., Tokyo, and Bangkok. We also engaged our own research teams and the project received support from Economic Research Institute for ASEAN and East Asia (ERIA), as well as the U.S. and Japanese governments. Policy recommendations are presented as part of this study for consideration by stakeholders. These findings also are expected to provide food for thought at the 6th LNG Producer Consumer Conference to be held on October 18, 2017 in Tokyo, Japan. The key findings are as follows:

- The U.S. natural gas resource base is big and getting bigger. Advances in extraction technologies show continued improvements indicating that U.S. natural gas output could rise by substantial additional volumes at costs below $4 mcf.

- The U.S. regulatory framework for natural gas production, distribution and construction of processing facilities, including LNG export plants, has been largely efficient, but persistent and important challenges remain and these challenges pose risks to the rapid expansion of LNG export facilities.

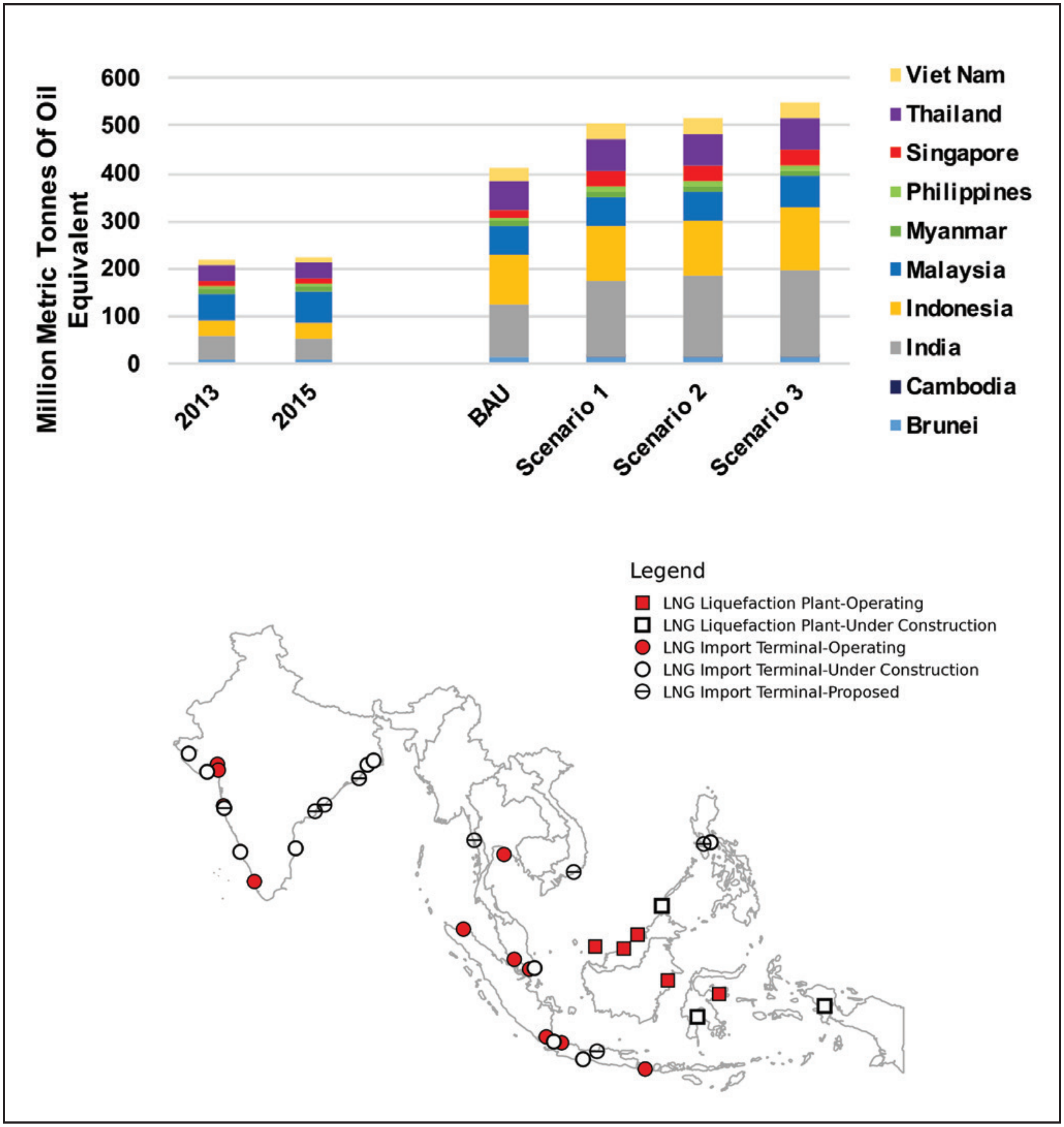
- Natural gas market in Asia has significant potential and could grow 2.5 times between now and 2030. Meeting this demand growth will require about $80 billion in LNG infrastructure investment in ASEAN and India combined[1] (Figure-ES).

- While historic Asian LNG demand centers, Japan, Korea, and Taiwan are likely to experience modest or declining demand growth, emerging Asian LNG importers such as China, India, and other new emerging Asian countries will see rising demand for LNG. The base case assumption of the region's LNG demand will reach 350 million metric tons in 2030.

[1]Outcomes of the 11th East Asia Summit Energy Ministers Meeting, September 28, 2017. "LNG supply chain" includes LNG terminal, pipeline, satellite facilities and ISO container, but does not include upstream development, liquefaction facilities or gas-fired power plants. Additional $80 to $130 billion will be required for new-build gas-fired power plant construction.

EXECUTIVE SUMMARY Key Findings and Policy Recommendations (continued)

Figure ES
Natural Gas Demand
Potential and Required LNG Infrastructures in ASEAN and India through 2030



Source: Economic Research Institute for ASEAN and East Asia (ERIA) IEEJ-EPRINC

EXECUTIVE SUMMARY Key Findings and Policy Recommendations (continued)

Summary of Major Policy Recommendations

The IEEJ – EPRINC assessment of the Future of LNG in Asia recommends relevant stakeholders undertake the following initiatives to support a growing market for LNG in Asia:

▸ *Developing more liquid and flexible LNG market:*
- Removal of LNG destination restrictions in LNG contracts among all market participants to stimulate spot markets and price discovery.
- Hold close dialogue between producers and consumers to determine the long-run requirements and policy instruments to promote competition and LNG growth.

▸ *Sustaining competitive US LNG export platform:*
- Streamline the regulatory process, including LNG export approval process and environmental reviews to foster predictable and efficient buildout of U.S. LNG export capacity.
- Provide clarification of U.S. revocation risk on LNG exports to lower trade insurance costs.

▸ *Cost effective and Long-Term Access to the Panama Canal:*
- Engage the Panama Canal Authority to support long-term and cost effective movement of LNG vessels to and from Asia to North America.

▸ *Providing financial support:*
- Engage their export credit agencies, including Japan Bank for International Cooperation (JBIC), Nippon Export and Investment Insurance (NEXI), U.S. Export-Import Bank (Ex-Im), Overseas Private Investment Cooperation (OPIC), development agencies, and multilateral development banks, to increase supports for LNG projects to address long-term credit risks.

▸ *Capacity building:*
- Provide capacity building program, which covers technical standards, safety guidelines and environmental regulations, for government and industries in emerging LNG importing countries in Asia.

▸ *Assisting policy developments in Asia:*
- Help structure energy mix targets and policy planning so that Asian countries could take full advantage of natural gas.

LNG Working Group July 20, 2017

INTRODUCTION

The U.S. petroleum renaissance has brought about a substantial expansion of natural gas production that has been driven by technological advances which provide access to previously unrecoverable resources. Because of this, since 2009 the United States has been the world's largest producer of natural gas. Natural gas production in the continental United States has increased from less than 50 billion cubic feet a day (Bcf/d)[2] in 2005 to an estimated 73 Bcf/d in 2017. A sound regulatory program that permits continued exploration and development of petroleum resources, widespread private ownership of property rights, combined with adequate expansion of U.S. natural gas infrastructure supports expectations that U.S. natural gas output is likely to reach 84 Bcf/d by 2020[3].

Expansion of the U.S. natural gas resource base offers considerable potential to further develop both LNG and pipeline exports, and contribute to higher economic growth in the national economy. Traditional Asian LNG consuming countries such as Japan, South Korea and Taiwan, and other countries in Southeast Asia (Indonesia, Malaysia, Singapore, Philippines, among others) and South Asia (India, Bangladesh, Pakistan) as well as China offer new markets, or expansions to existing markets, for natural gas. Natural gas is a fuel source that can contribute to improved air quality and lower emissions of carbon dioxide and reduce long-term climate risks. China, which has been a modest importer of LNG to date also represents a potential new market for substantially higher volumes.

Considerable expansion of LNG demand is possible over the long-term in Asia. On the 28th of September this year, East Asia Summit Energy Ministers welcomed the ongoing study by the ERIA which indicated that natural gas demand in the EAS region could grow 2.5 times between now and 2030 and will require about $80 billion in LNG supply chain investments to meet this demand[4]. However, development of long-term demand in Asia will require supportive government policies and solutions to address important cost challenges and regulatory constraints. A central objective in this collaborative effort is to identify the critical obstacles that constrain natural gas use in Asia, and how these obstacles can be overcome. Framed differently: what strategies are available that can convert potential demand in Asia into actual demand?

Government policies will play a critical role in the future development of Asian LNG markets. Policy support is necessary to reduce investment risks in new LNG infrastructure developments in many of emerging Asian countries. Financial support and export assistance measures will also play an important role in Asia, particularly for countries which present high credit risks. Technical support would also help Asian countries that have little experience in the LNG business as they embark on LNG imports. This joint research effort recognizes that world LNG markets are heading towards more liquidity and transparency, but these markets are yet to mimic, and may never fully replicate, the open and extensive trading patterns prevalent in the global oil market. Asian natural gas markets are undergoing an important transition, and much of this new market dynamic could be affected by prospects of growing LNG exports from the U.S. This research delves into the challenges that might hamper sustainable development of LNG demand in Asia, and provides possible recommendations to overcome the challenges.

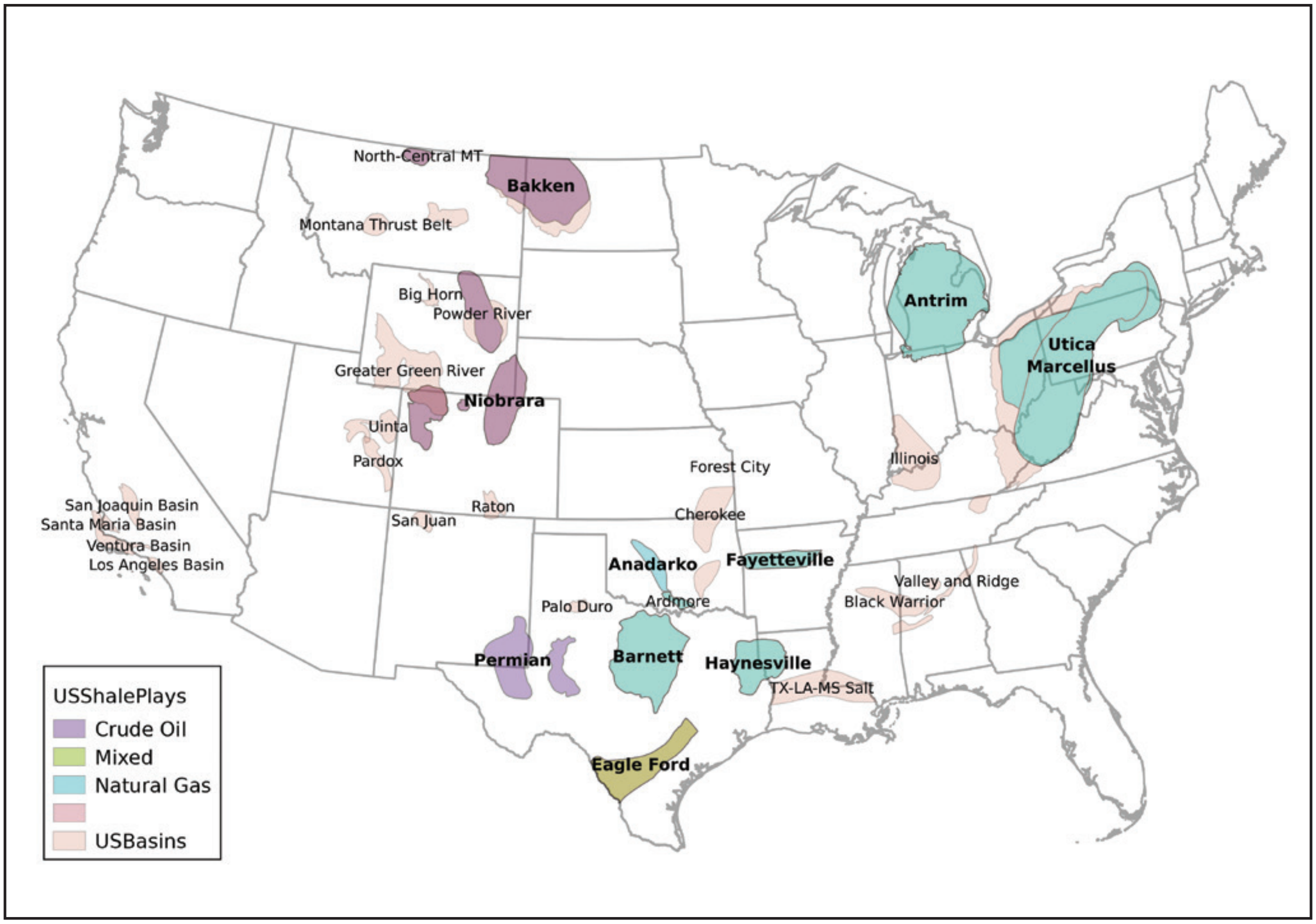
[2]Bcf/d is approximately 7.6 million tons of LNG per year.

[3]U.S. Energy Information Agency Annual Energy Outlook 2017: *Table: Natural Gas Supply, Disposition, and Prices.* https://www.eia.gov/outlooks/aeo/data/browser/#/?id=13-AEO2017&region=0-0&cases=ref2017&start=2015&end=2050&f=A&linechart=ref2017-d120816a.3-13-AEO2017~ref2017-d120816a.6-13-AEO2017~ref2017-d120816a.23-13-AEO2017&ctype=linechart&sourcekey=0

[4]Outcomes of the 11th East Asia Summit Energy Ministers Meeting, September 28, 2017.

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE

Figure 1
Main U.S. Shale Basins and Plays



Analysis Based on EIA Data — IEEJ-EPRINC

Prospects for Expansion of the U.S. Natural Gas Production Platform

The growth in U.S. natural gas supply is supported by technological advances and a growing hydrocarbon reserve base which has seen sustained additions since 2004. The remarkable and rapid growth in U.S. gas reserves is the direct result of developments in both the art and science of horizontal drilling and hydraulic fracturing that has permitted access to reserves in so-called unconventional formations. As shown in Figure 1,U.S. oil and gas reserves are found not only in the traditional oil and gas producing regions of Texas, Louisiana, and Oklahoma, but also in Pennsylvania, Ohio, West Virginia, North Dakota, and other regions of the continental U.S.

Oil and gas reserves are defined as that portion of a mineral or hydrocarbon resource that can be commercially extracted and/or produced (hence, “proven”). It is a subset of a larger resource endowment. Through involved but standardized procedures, certifying organizations make regular assessments and determinations. These are then used as a basis for making decisions such as the financing, construction, and other matters related to project development.

U.S. natural gas reserves reached an initial peak of 201.7 trillion cubic feet (Tcf) in 1982 before declining to 164 Tcf in 1998. Since then, the U.S. Energy Information Administration (EIA) estimates that domestic dry proved natural gas reserves have almost doubled, and are now estimated at 324 Tcf, most which is tied to additions from certified recoverable shale gas formations.

However, reserves alone do not fully describe the potential size of the resource. They are only that portion of the resource that has been validated and certified. According to the Potential Gas Committee,

U.S. technically recoverable natural gas resources are estimated to be 3,141 Tcf as of year-end 2016 – an increase of 10 percent since the year-end 2014 report. When combined with EIA proved reserves estimates, the U.S. future supply of natural gas now represents highest combined future supply of natural gas ever. A summary of the conclusions of the Potential Gas Committee is shown in Table 1.

Table 1
U.S. Natural Gas Resource Assessment, Comparison of 2016 with 2014

Resource Category	Mean Values, trillion cubic feet (Tcf)		Change from 2014 to 2016	
	2016	2014	Tcf	%
Traditional Gas Resources:				
Probable resources (current fields)	993.8	848.4		
Possible resources (new fields)	1,056.9	930.1		
Speculative resources (frontier)	607.5	586.1		
Total	2,658.3	2,356.8	301.5	12.8
Coalbed Gas Resources:				
Probable resources (current fields)	15.0	14.2		
Possible resources (new fields)	48.0	48.3		
Speculative resources (frontier)	95.7	95.7		
Total	158.7	158.1	0.6	0.4
Grand Total Potential Resources	2,817.0	2,514.9	302.1	12.0
Proved gas reserves (EIA)	324.3	338.3		
U.S. Future Gas Supply	3,141.3	2,853.2	288.1	10.1

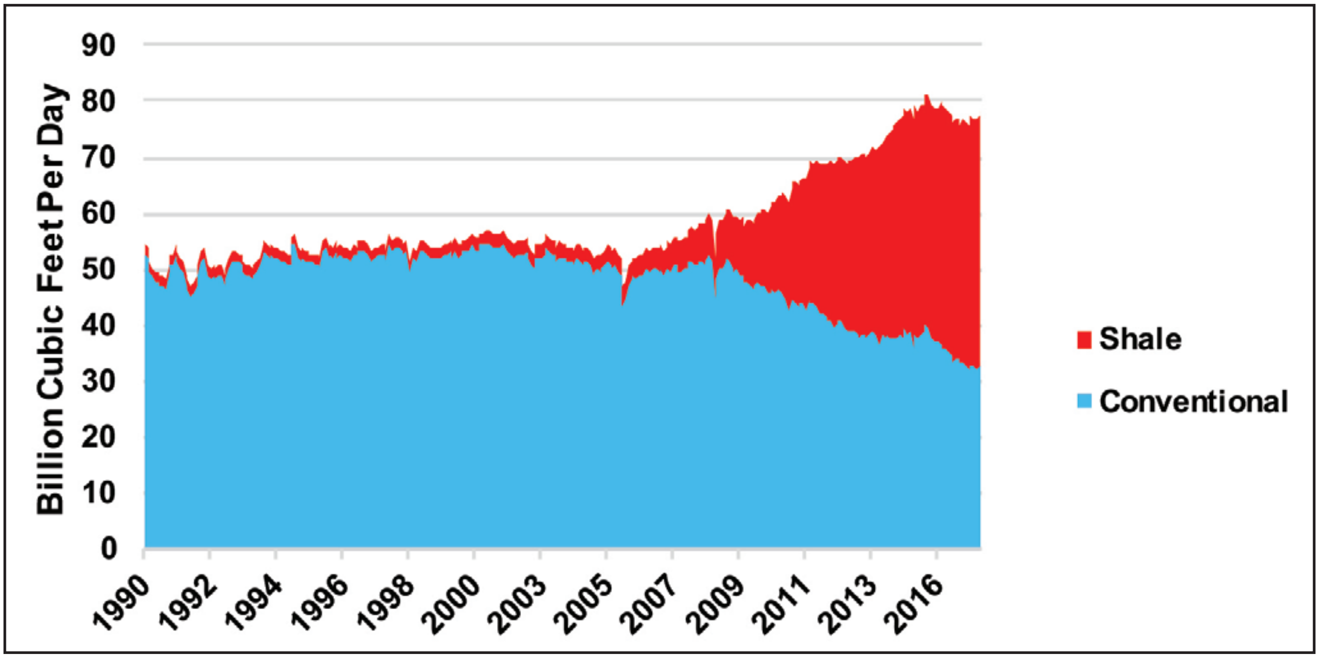
Source: Dr. Alexei V. Milkov, Potential Gas Committee, Colorado School of Mines[5] IEEJ-EPRINC

The resource assessment of the Potential Gas Committee is clearly supported by the growth in natural gas production from unconventional plays. Shale gas produced with hydraulic fracturing technology now accounts for approximately two-thirds of U.S. natural gas production. Access to shale formations in the U.S. has enabled natural gas producers to grow production from 30 Bcf/d in 2006 to 73.3 Bcf/d by mid-2017, and EIA expects production to rise to over 76 Bcf/d in 2018 (Figure 2).

[5]Millkov, Alexei V. "Potential Supply of Natural Gas in the United States: Report of the Potential Gas Committee (December 31, 2016)." *Potential Gas Agency, Colorado School of Mines*, July 2017.

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Figure 2
Monthly U.S. Natural Gas Production: Conventional vs Shale



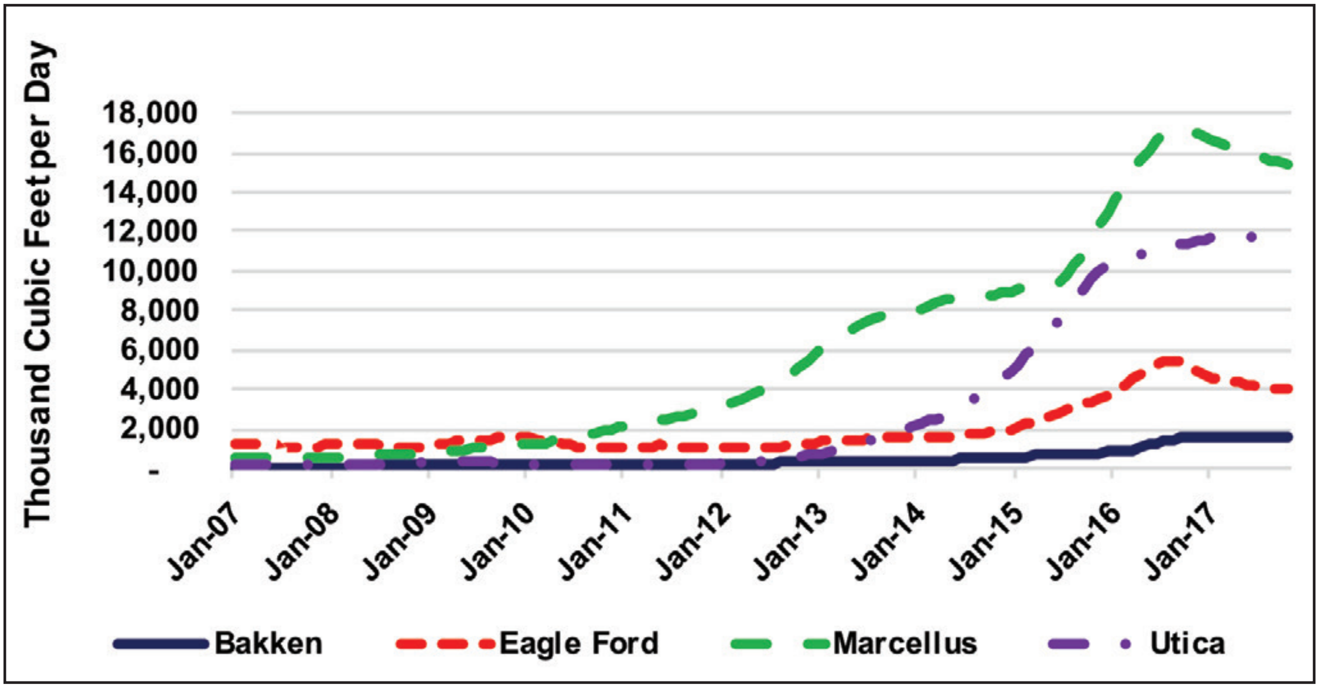
Analysis Based on EIA Data IEEJ-EPRINC

Cost and Technology Considerations for Expanding U.S. Natural Gas Production

The productivity of horizontal drilling rigs has been well documented by EIA and many independent studies of the U.S. petroleum sector. These productivity gains have translated into a growing capacity of the U.S. resource base to support rising production of natural gas even as wellhead prices have declined. Shale producers have shown that they can expand production at prices as low as $2 per thousand cubic feet (mcf). In addition, a combination of improved drilling efficiencies, advances in extraction technology, and rising reserve additions all point to the prospect that large volumes of domestic natural gas can be produced at costs below $4/mcf, and potentially at even lower costs. Continued improvement and development of shale extraction technology, combined with expanding knowledge of the various geologies of the different resource plays, will enable shale gas production growth for years to come. Note, as shown in Figure 3, the U.S. natural gas industry raised productivity per well in unconventional plays from 5 to 15 times over the last 5 years.

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Figure 3
U.S. Major Plays: Natural Gas Production per Rig



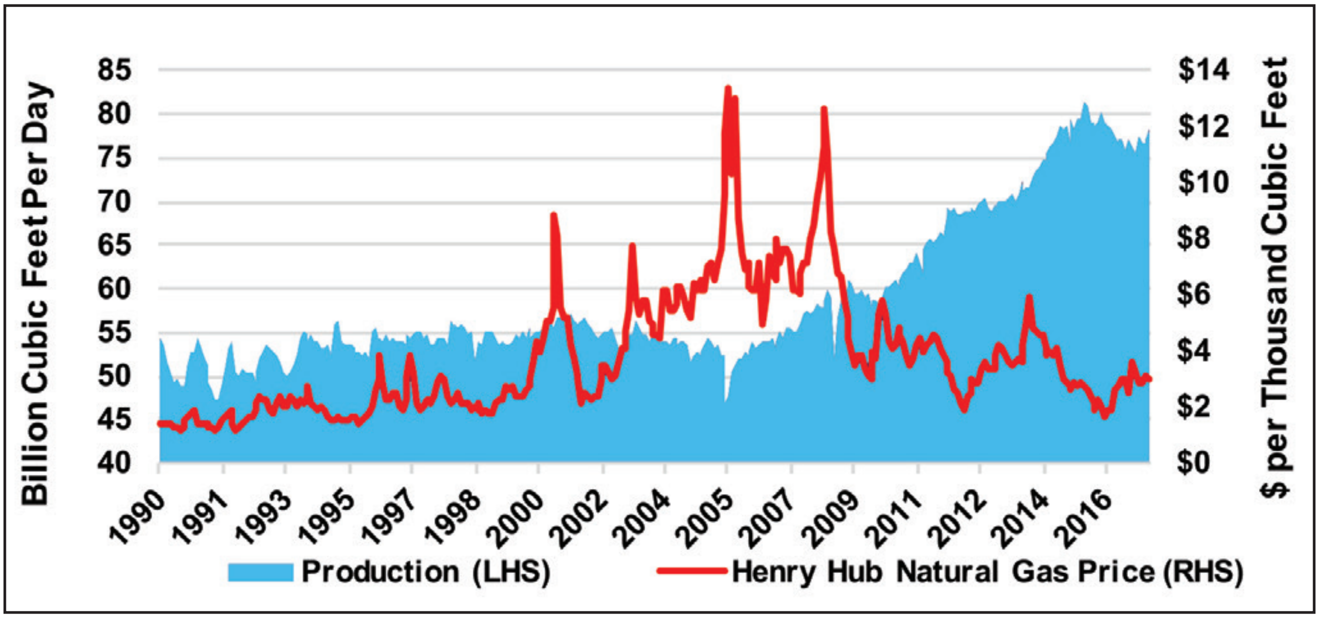
Analysis Based on EIA Data IEEJ-EPRINC

The sustained performance of the U.S. unconventional gas resource is shown in Figure 4 below. Note that U.S. natural gas production continued to expand even as natural gas prices declined to $2/ mcf in late 2015.

There was some flattening and even a mild downturn in U.S. natural gas production from the middle of 2015 through late 2016. But this was tied to delays in moving gas supplies out of the Marcellus to domestic processing centers and export markets. Although prices have recovered somewhat and are now approximately $3/mcf for 2017, shale gas output will continue to expand and take a growing percentage of total U.S. natural gas production.

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Figure 4
Monthly U.S. Natural Gas Production (LHS) Vs Henry Hub Price (RHS)



Analysis Based on EIA Data — IEEJ-EPRINC

The size of the unconventional natural gas resource base combined with continuing emergence of new extraction technologies and improved efficiencies in drilling operations all point to significant production growth in the coming decades. An expansion of 40 Bcf/d (14.6 Tcf/yr) by 2040, or 50 percent above current production is well within the potential of the U.S. oil and gas industry[6]. Natural gas production in the United States is more likely to be limited by inadequate demand than a lack of advances in technology or growth of the resource base.

An often overlooked but important feature of U.S. natural gas production is the high degree of efficiency and liquidity across the entire value chain. Although not entirely unique, the development of U.S. natural gas resources is distributed among many players, subject to constant cost reductions and technology improvements, rapid infrastructure expansion (with some notable exceptions), and government oversight is mostly (but not always) efficient.

Additionally, the U.S. natural gas market is segmented across its supply chain. Exploration and production entities are generally separate from distribution (pipeline & LNG) and storage operations, and the latter is separate from utilities which make deliveries to final points of consumption.

Lastly, the U.S. market is characterized by widespread transparency in the reporting of gas pipeline capacity utilization, tariffs, and prices at market hubs. There is also broad liquidity in both physical and financial markets. This is due in part to the consistent and coherent regulation and enforcement from government agencies such as the Federal Regulatory Commission (FERC), the Commodity Futures Trading Commission (CFTC), and the Securities and Exchange Commission (SEC).

[6] U.S. Energy Information Agency Annual Energy Outlook 2017: *Table: Natural Gas Supply, Disposition, and Prices.* https://www.eia.gov/outlooks/aeo/data/browser/#/?id=13-AEO2017&region=0-0&cases=ref2017&start=2015&end=2050&f=A&linechart=ref2017-d120816a.3-13-AEO2017~ref2017-d120816a.6-13-AEO2017~ref2017-d120816a.23-13-AEO2017&ctype=linechart&sourcekey=0

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

U.S. LNG Exports: Addressing Regulatory Challenges

Liquefied natural gas export projects face a range of obstacles in moving from a business concept to an operating reality. The projects are lumpy, i.e., project times are long, decision-making is intermittent but intense in those periods, and they require large capital commitments of $10 billion or more for a fully functioning plant. Although most LNG export projects face relatively modest technical risks (the industry is now well experienced in building export facilities), most of these projects face substantial regulatory and financial risks as large sums of capital are tied up before any revenue is realized from first delivery.

In the U.S., the U.S. Department of Energy (DOE) Office of Fossil Energy, and the Federal Energy Regulatory Commission (FERC), an independent regulatory agency, are the primary national authorities having permitting and regulatory oversight with respect to LNG plants. Other agencies, both at the national and state levels, also are involved with regulatory authority over port facilities, LNG vessels, and public lands. Each agency has different responsibilities in the permitting process.

DOE is responsible for making public interest determinations on LNG exports. FERC is the primary national regulator regarding safety and environmental reviews. However, DOE's approvals are necessary for any export project, and generally occur early in the regulatory review process. LNG export approvals are separated into two mutually exclusive categories based upon which countries are the designated buyers. Countries with which the U.S. has a Free Trade Agreement (FTA) receive licenses with only minimal review. Export licenses for countries which do not have an FTA require more extensive assessments and evaluations. In its review, DOE's responsibility is to determine whether the expected LNG exports are in the "public interest."

However, this notion is vague because it is not defined in the Natural Gas Act. Nevertheless, in fulfilling its regulatory role, DOE makes considerable effort to document the economic benefits to the U.S. from higher volumes of LNG exports to non-FTA countries.

Some critics of the DOE review process have called for legislation to remove the agency's regulatory authority over LNG exports given a growing consensus on the large size of the U.S. resource base. Nevertheless, DOE's regulatory program is likely to remain in place.

DOE has also undertaken regulatory changes to improve the efficiency of its review process. In the past, DOE granted conditional export licenses with the stipulation that they would receive final export approval once the applicant received safety and environmental approvals for the project from FERC. To streamline the process, DOE modified the order in which it evaluated non-FTA requests, giving priority to non-FTA export licenses requests for projects that completed initial reviews from FERC, specifically the so-called pre-filing review.

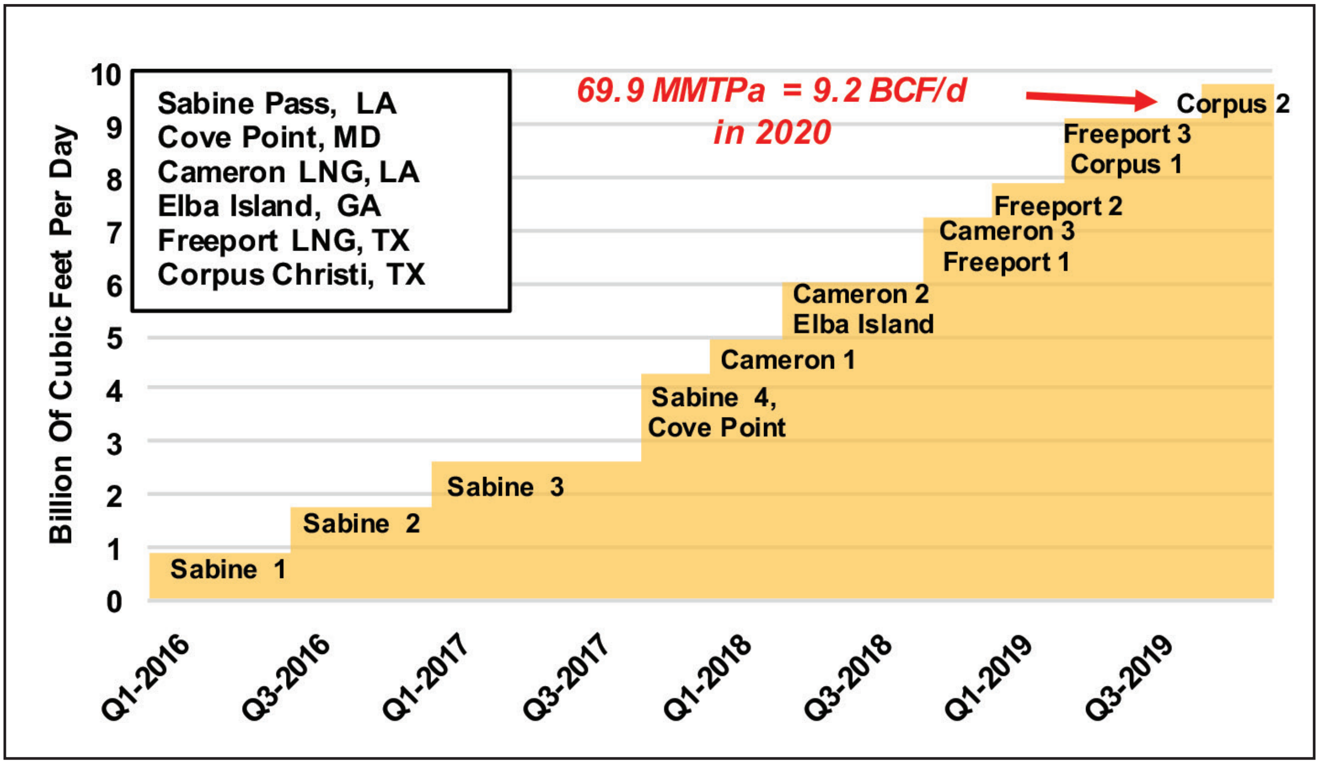
FERC pre-filing is a period of at least six months in which the applicants are in communication with FERC. The purpose is to resolve basic issues before the official filing process begins. Pre-filing also provides an early opportunity for outlining the project details and before a public comment period, and is finished when the proper documentation is completed and submitted. This documentation includes more than a dozen full reports covering construction and environmental impacts of the project. The DOE initiative on undertaking LNG export reviews for applicants that have completed the pre-filing review gives priority to those projects more likely to reach Final Investment Decision (FID).

DOE also has received considerable criticism that it has overcommitted U.S. natural gas supplies to the LNG market. As of September 2017, DOE has approved a combined FTA and non-FTA export approvals of approximately 21 Bcf/d (160 MMt/yr). However, the outlook for projects that have gone to FID is considerably more modest, and the pace at which this new capacity will be available remains uncertain. For the near-term, as shown in Figure 5, the U.S. is unlikely to export more than 10.25 Bcf/d (70 MMT/yr) by 2020, and these volumes are subject to adjustment as exporters calibrate the pace at which new liquefaction trains are constructed and commissioned[7].

[7]https://www.eia.gov/todayinenergy/detail.php?id=32412

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Figure 5
U.S. LNG Exports are Growing: Projects Approved and Commissioned or Under Construction



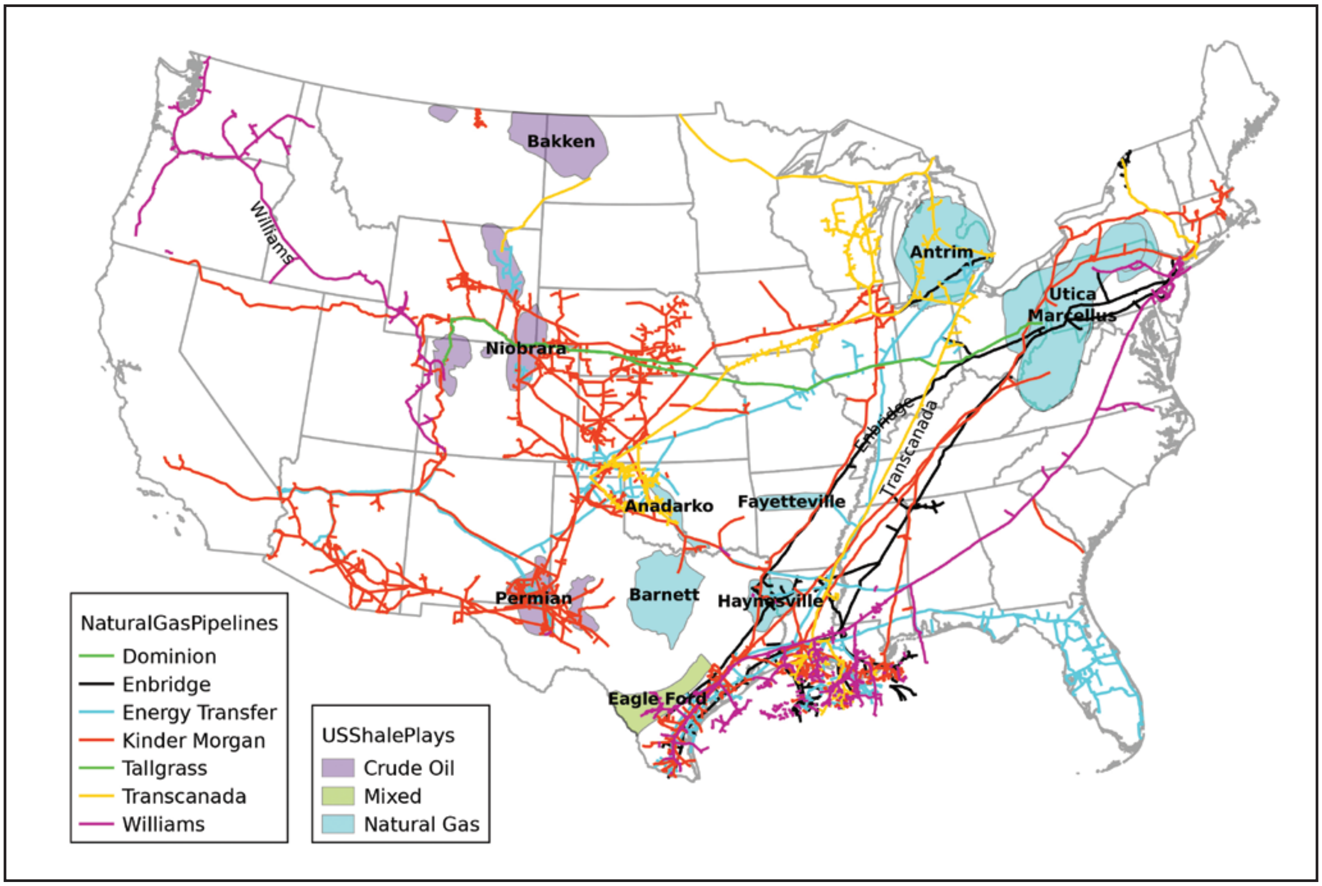
Analysis Based on EIA Data

IEEJ-EPRINC

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Once produced, natural gas must be transported to LNG export facilities through the interstate natural gas pipeline network. As shown in Figure 6, natural gas moves from producing regions and processing facilities to consuming urban areas, international pipeline transit points, as well as LNG export facilities.

Figure 6
U.S. Natural Gas Pipeline Network



Source: EIA IEEJ-EPRINC

The U.S. has about 300,000 miles of natural gas transmission pipelines. These pipelines move large volumes of natural gas from producing regions to consuming centers and exporting operations. In the last twenty years, this number has varied little from year to year. However, as older producing regions are depleted and new ones are identified and commissioned, either existing pipelines need to be repurposed or new ones need to be built.

Recent estimates place the requirement for new pipelines at between 1,500 and 2,000 miles per year. This is expected to require at least $10 billion per year in project financing.

U.S. natural gas market regulation began with the 1938 Natural Gas Act, covering the whole IEEJ-EPRINC supply chain from production to interstate pipeline transmission. It has gone through several reforms, with the most recent one enacted in 1992. Notably in regulatory jargon, Order No. 636 (or, more simply, Rule 636) is a 1992 rule that affects interstate pipelines and is administered and enforced by FERC. It has made the industry more competitive, shifting pipeline construction risk onto the pipeline companies themselves. Despite this shift, pipeline companies have not only survived, but they have also thrived. There has been some change in the terms of transmission contract durations with a move to shorter terms; but overall, it has made the whole pipeline business more efficient and nimble.

Currently, new natural gas pipeline

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

construction faces several regulatory challenges. With the October 2015 enactment of the Clean Power Plan (CPP), fugitive methane emissions (leaks) from pipelines and other distribution infrastructure came under the jurisdiction of the EPA. Various other related regulations have been promulgated and implemented, and pipeline companies have adjusted accordingly.In addition, pipeline integrity rules have been strengthened and are leading to more frequent inspections.

In the U.S., there are more than 400 active natural gas storage facilities with a combined total capacity of 4.8 Tcf. Many of these have been in use for over thirty years, and are now facing increased regulatory oversight. Notably, a large 2015 gas leak incident in southern California has shifted and enhanced regulatory authority for these storage facilities to U.S. DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA). The majority of the pipeline and storage industry expects that significant new and revised operating rules will be put in place.

Although the regulatory process for approval of LNG facilities is well understood, the regulatory process for the construction of new pipelines to bring rising volumes of natural gas to LNG facilities and other markets must be both predictable and efficient to deliver LNG feedstock at the lowest cost. Local opposition and judicial intervention have raised regulatory and legal risks in building out new natural gas pipeline capacity, in some cases raising uncertainties as construction is prolonged and commissioning times are delayed.

Competitiveness of US LNG Exporters

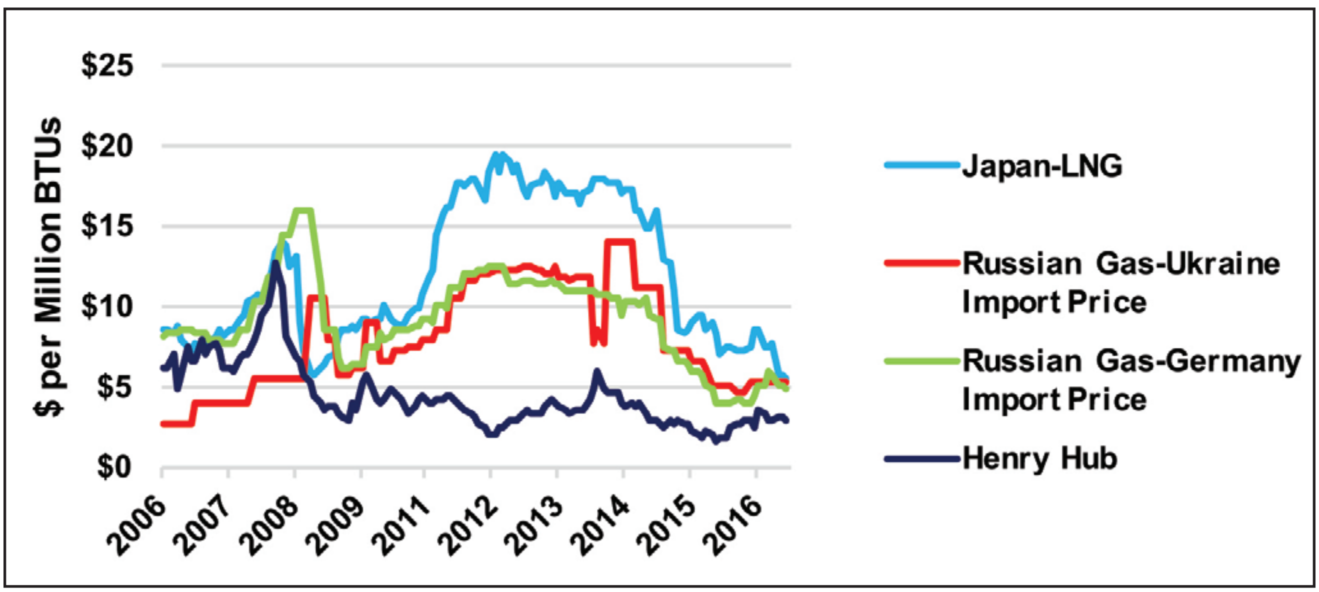
U.S. LNG export capacity is likely to reach approximately 10.25 Bcf/d by 2020. Figure 7 shows trends in LNG spot prices in four global markets since 2006. The combination of recent declining LNG spot prices and global LNG surplus has raised concerns regarding the competitiveness of the U.S. LNG in Asian markets. However, spot prices do not reflect the actual value of LNG trade as most transacted volumes remain tied to long-term contracts.

Why U.S. LNG Exports Matter: Economic Value

LNG exports generate considerable value to the national economy. The economic gain occurs because the U.S. can produce a product that will make a claim on foreign resources far above its cost of production, resulting in wealth transfers from other countries to the U.S.

As export markets grow, opportunities emerge to expand investment to meet foreign demand.

Figure 7
Global Natural Gas Prices in Four Regions



Analysis Based on IMF Data IEEJ-EPRINC

Foreign purchasers also benefit as additional supplies of natural gas on world markets provide opportunities to substitute away from more costly energy and/or meet higher environmental standards.

Opponents of natural gas exports have raised concerns that the large LNG export volumes authorized by DOE would return North America to an era of price and supply volatility. Note that from 2008 to 2017 the price of natural gas at Henry Hub fell from over $10/mcf to less than $3/mcf, providing large-scale savings to consumers and new opportunities for value-added processing.

In addition, some U.S. manufacturing enterprises have raised concerns that natural gas exports should be constrained in order not to harm the competitiveness and growth potential of U.S. manufacturers. The consideration in this case is that these natural gas supplies should instead be "saved" for domestic manufacturers who could then export a more valuable product. It is also sometimes argued that the national economy would be better off in terms of employment, and the net gain to the economy would be higher if natural gas exports were limited. These conclusions are not supported by economic analysis.

The problem with the argument that project approvals should be tied to job creation is that capital cannot be and, unless mandated by the government, is not allocated based on the number of jobs it creates. Instead, capital is allocated on its ability to generate value, i.e., positive rates of return.

It is investment in high return projects that provides the foundation for economic expansion and job growth. Allocating investment strictly on its capacity to provide a short-term increase in employment is counter-productive. Allocating capital to less valuable projects or through constraints imposed by the government will reduce productivity and economic growth.

Also, exports contribute to employment growth. Research from the Tuck School of Business has pointed out that exporting companies are on average more profitable, highly productive, and pay about 10 to 14 percent more in salaries than companies that just sell in the domestic market[8].

An assertion raised by some U.S. manufacturers is that diverting natural gas exports to domestic use not only provides for more employment, but also actually delivers higher added value to the national economy through constraints on U.S. LNG exports. A claim is made that natural gas used in manufacturing raises the economic benefit eight times above the value of the natural gas used as exports[9].

However, official U.S. data do not support this view. The U.S. Department of Commerce Bureau of Economic Analysis (BEA) estimates that the average GDP growth multiplier for all manufacturing is approximately two. This means that a $1 increase in manufactured goods production results in a $2 benefit to the overall U.S. economy.

The U.S. Bureau of Economic Analysis (BEA) estimates the GDP multipliers for oil and gas extraction, chemical manufacturing, and plastics and rubber production are 1.7, 2.4, and 2.3, respectively. Some petrochemical manufacturers have claimed that the GDP multiplier is only 1 for LNG exports. This neglects the benefits of GDP growth from the LNG export industry which would include additional jobs, tax revenues, and likely increased domestic gas production. The increased gas production would have potential benefits to the chemicals industry through higher volumes of national gas liquids (e.g., ethane, propane, butane, and lease condensates), common byproducts of natural gas production in many U.S. petroleum plays.

It is common for companies to announce a large number of projects, particularly as a hedging strategy when permits to construct and operate facilities are difficult to obtain. As previously stated, not all projects will go to FID. It is also important to distinguish between projects that have received approval to proceed from government authorities, and those projects that can raise the necessary capital to reach FID.

[8]Feenstra, Robert C., Benjamin R. Mandel, Marshall B. Reinsdorf and Matthew J. Slaughter. 2013. "Effects of Terms of Trade Gains and Tariff Changes on the Measurement of US Productivity Growth." *American Economic Journal: Economic Policy*, 5(1):59-93.

[9]see http://www.americasenergyadvantage.org/info/growing-the-economy.

PERFORMANCE OF THE U.S. NATURAL GAS RESOURCE BASE continued

Growing Importance of U.S. LNG Exports to Asia: Security and Foreign Policy Considerations

The United States is an Asia-Pacific power, and its political, economic and security interests in the region are deep-rooted, as are its commitments to regional stability and prosperity. Supporting U.S. national security interests in Asia requires large amounts of military forces to sustain freedom of navigation and open trading routes. In addition, allies are essential to bring strategic reach across a vast ocean. While Japan remains the centerpiece of the U.S. alliance in the Asia Pacific region, Korea and many countries in Southeast Asia provide a durable, important, and mutually beneficial alliance structure.

The prospect of the U.S. as a new and growing supplier of LNG in Asia offers considerable opportunity to strengthen U.S. alliances in the region by delivering geographic diversity in fuel sourcing, more competition in energy markets, and enhanced energy security. LNG is often a replacement for crude oil, diesel fuel, and coal used for the generation of electric power. Through this substitution, LNG also offers considerable potential to play an important role in lowering greenhouse gas (GHG) emissions and improving local air quality.

Historically, the energy security risk facing the U.S. and its allies was the direct result of a concentration of low cost reserves in insecure and unstable regions of the world, particularly the Middle East. This reliance, largely on crude oil imports, posed two important risks: (i) supplies could be disrupted from war or terrorism, causing prices to spike leading to large economic losses and even security risks; or (ii) a small number of producers could restrain output, thereby imposing large wealth transfers from consuming countries. The surge in U.S. crude oil production combined with the prospects for rising LNG exports has provided world oil and natural gas markets with a new and stable production platform outside of petroleum production centers that are subject to disruption in world supplies from national policy, war and terrorism.

As pointed out in a recent working paper by the National Bureau of Asian Research (NBR)[10], the Asian LNG market is much more diversified than the crude oil market. Japan, the world's largest LNG consumer, imported 83.3 MMt in 2016 to address the lost power capacity from the Fukushima Daiichi nuclear disaster. Nevertheless, LNG imports into Japan are more diversified than crude oil imports, with 63percent coming from Australia and Southeast Asia and about 24 percent from the Middle East. Of this 24 percent Qatar provides about 15 percent. In contrast, Japan continues to rely on the Middle East for over 85percent of its crude oil imports. This comparison between oil and LNG highlights the importance of LNG from the viewpoint of energy security.

LNG DEMAND IN ASIA

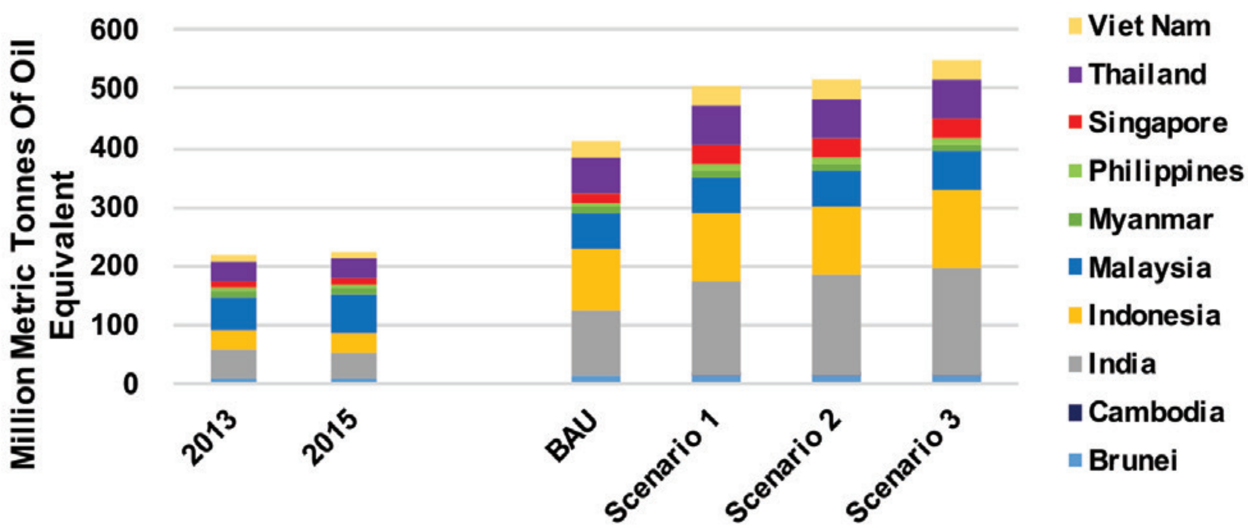
Potential LNG Demand Outlook in Asia

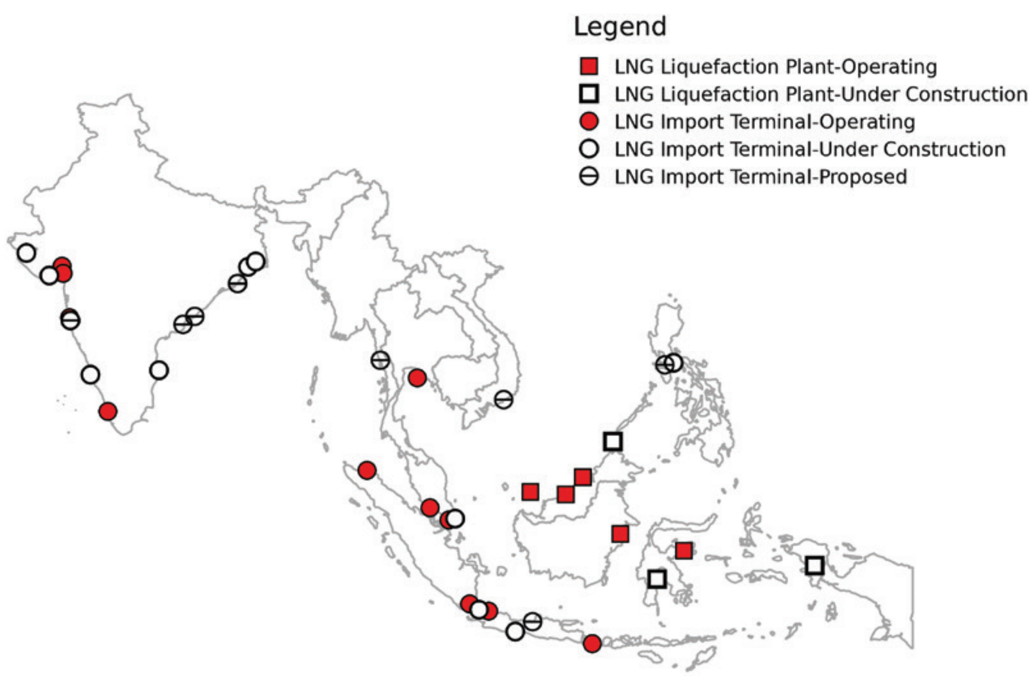
Asia will lead the growth of global energy demand as a whole, and natural gas demand is no exception. Promotion of natural gas has been increasingly drawing the attention of Asian governments. On the 28th September of this year, East Asia Summit Energy Ministers were "mindful of the pivotal role of natural gas for sustainable growth of the region, [and] noted the importance to energy security of developing a liquid, transparent and secure LNG market." The ERIA study that was reported to these ministers indicated that natural gas demand in the EAS region could grow 2.5 times between now and 2030 and will require about $80 billion in LNG supply chain investments to meet this demand (Figure 8). Because the amount does not include associated investments for gas-fired power generation, the total amount would be much larger. Additional $80 to $130 billion will be required for new-built gas-fired power plant construction. Asian countries are keen to accelerate to (i) promote investments in related infrastructure,

[10]See Jeremy Maxie and Tatsuo Masuda, *Allied Energy Security: The Role of U.S. Oil and LNG Exports in U.S. Relations with Japan and South Korea.* National Bureau of Asian Research, Working Paper, June 19, 2017.

LNG DEMAND IN ASIA continued

Figure 8
Natural Gas Demand
Potential and Required LNG Infrastructures in ASEAN and India through 2030





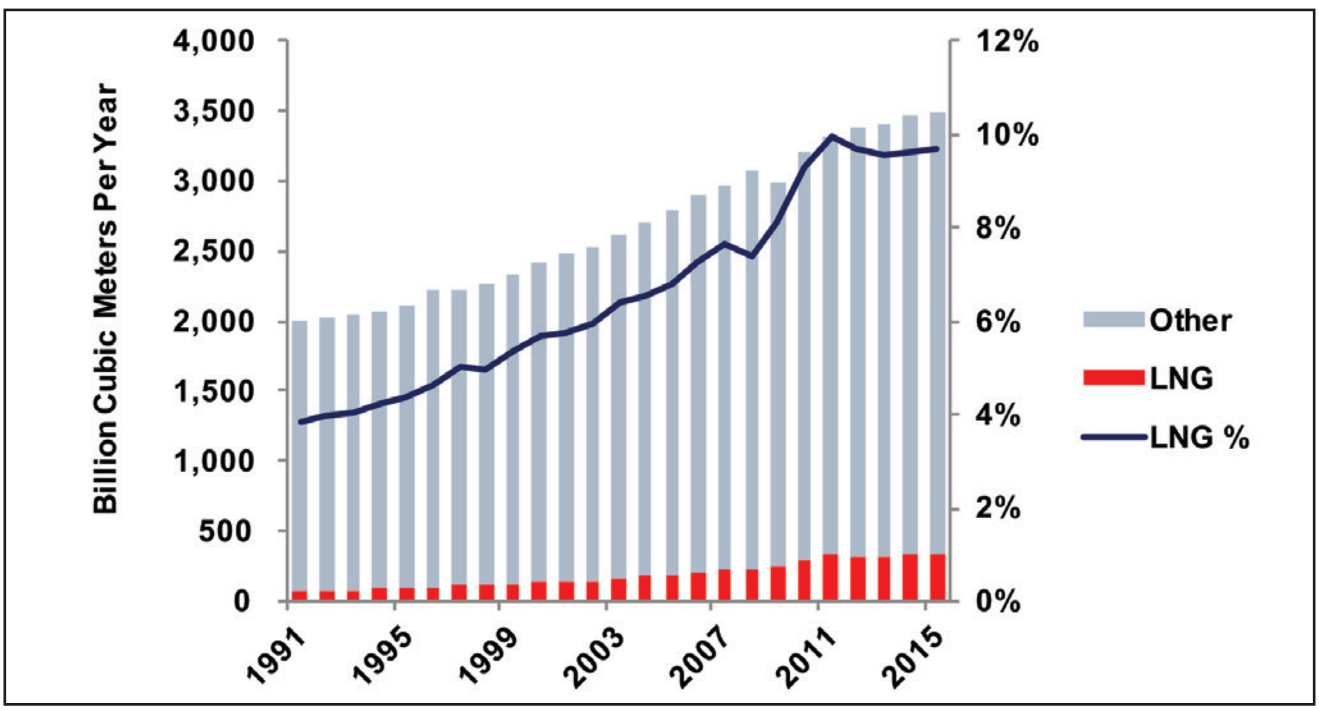
Source: Economic Research Institute for ASEAN and East Asia (ERIA) IEEJ-EPRINC equipment, and services which advance a secure LNG supply to users with investments in sectors such as upstream, transportation, regasification, pipelines and energy-use including gas-fired power plants, and (ii) provide capacity building for the development of laws and regulation and for gas bunkering, gas-co- generation, and small-scale distribution to islands.

Because Asia produced more than 60 percent of the world's coal in 2016, the region traditionally has consumed a significant amount of it to meet its growing energy demand, particularly in the power sector. However, worsening air pollution, growing CO2 emissions, as well as the lack of public acceptance of coal fired power plants have made it increasingly difficult to continue to use coal. Because of this, natural gas, along with renewable energy sources, are expected to play a far greater role in Asia's energy mix in the coming decades. To meet the Intended National Determined Contribution (INDC) target agreed in the Paris Accord, natural gas will be one of the critical options to reduce CO2 emissions[11].

As shown in Figure 8 above, LNG is becoming an important source of natural gas supply in Asia. Although LNG still makes up only about 10 percent of total global natural gas supplies, its demand in Asia has surged since the early 2010s (Figure 9 below), mainly driven by developing countries such as China, India, and other emerging Asian countries, rather than traditional importers like Japan, Korea, and Taiwan (JKT).

At one time, LNG was regarded as an expensive and technically complicated fuel to develop. However, rapidly growing domestic energy demands, declining or stagnant domestic natural gas production, the urgent need to control CO2 emissions, domestic air and water pollution, and the drop in spot LNG prices in the last two years have made Asian countries more willing to consider

Figure 9
World Natural Gas &LNG Supply (1991-2016)



Analysis Based on BP Data

IEEJ-EPRINC

[11]Intended Nationally Determined Contributions (INDCs) identify the post-2020 voluntary national climate targets, including mitigation and adaptation, which countries committed to and which will become a binding Nationally Determined Contributions (NDC) when a country ratifies the Paris Agreement.

the benefits of LNG imports. Also, diversifying energy sources to include LNG is gaining recognition as a beneficial strategy to enhance energy security of many Asian countries.

The advent of FSRUs (Floating Storage Regasification Units) has significantly lowered the threshold for introducing LNG to new markets. Because the installation of an FSRU does not require land or on-site construction, it can significantly shorten the construction period of an LNG receiving facility and reduce initial investment costs. Indonesia and Malaysia have already started importing LNG utilizing FSRUs, and Myanmar and Bangladesh are also in the process of configuring FSRUs into their countries' natural gas supply infrastructures.

Demand Outlook of Major Importing Country and Region

Japan, Korea, and Taiwan (JKT)

Japan has been the largest LNG importer in the world and this is expected to continue through 2030, even though its demand will slowly decline. This is due to a contraction in total energy demand brought on by a declining population, the recommissioning of nuclear power plants, and displacement of traditional fuels by increased amounts of renewable energy introduced into the power mix. We expect slow but steady growth in city gas demand, mainly in the industrial sector; however, its growth is not sufficient to make up for the decline of other consumption sectors. Japanese LNG demand is expected to be in the range of 65 to 80 MMt through 2030, depending on the number of nuclear units that will be restarted. Despite this, given the significant volume of LNG for which contracts will be required to be renewed in the next decade, Japanese utilities will continue to play a significant role in the patterns of contracts which could possibly affect the trading of the Asian LNG players.

Korea is also one of the traditional Asian LNG importers. Korean LNG demand is expected to steadily increase through 2030, reaching 45 to 55 MMt. One of the primary uncertainties regarding future Korean LNG demand is the country's energy policy. In June 2016, newly elected President Moon Jae-In announced his government's new nuclear policy, seeking to decommission nuclear power units that are over 40 years old by 2040. He also mandated the cancellation of new coal-fired power plant construction so renewable energy could expand its share in the country's power mix. While a drastic change in the country's LNG demand is not likely to happen in the near-term, in the longer-term, the policy can significantly determine the country's energy mix and LNG demand.

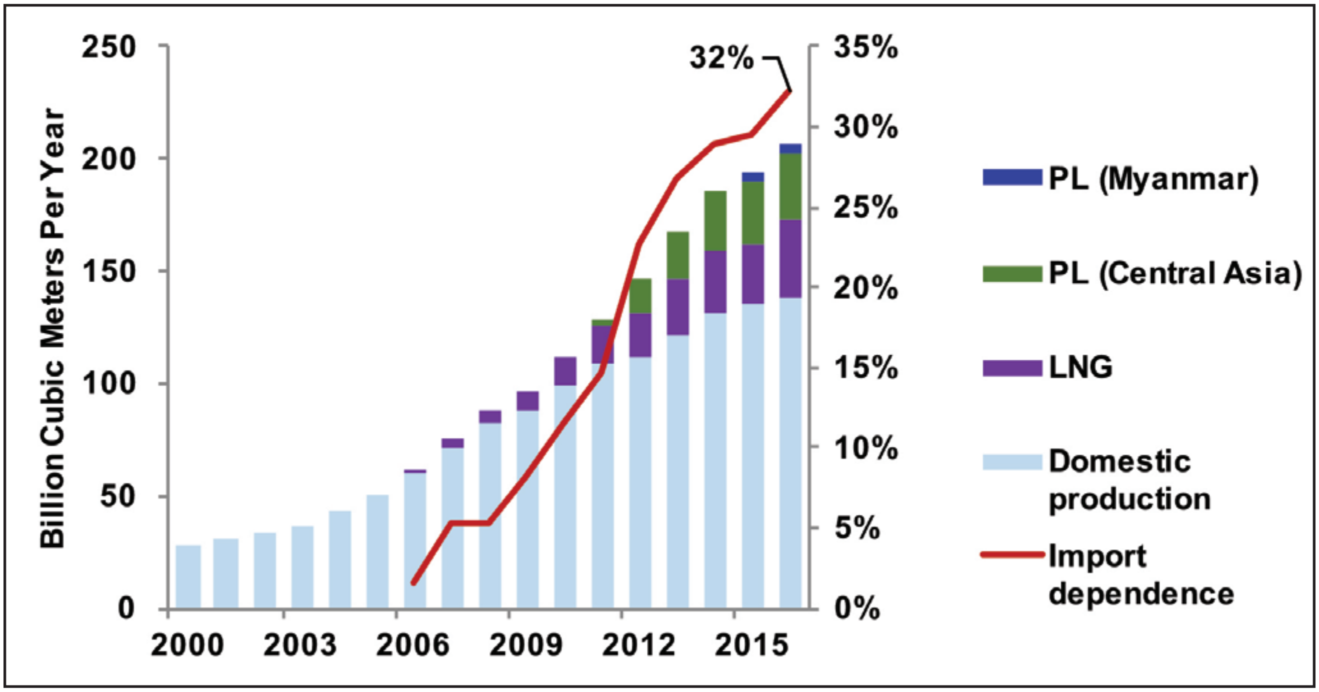
Regarding Taiwan, its energy demand is also expected to grow, mainly driven by its power requirements. Newly elected President Tsai has decided to close all of the six existing nuclear power units by 2025, just like Korea did. Taiwan is also aiming to raise the share of renewable energy in its power generation mix; nevertheless, it is still likely to import more LNG to meet its growing power demand despite the development of renewable power generation capabilities. Taiwan's LNG demand by 2035 is expected to be 20 to 30 MMt.

China

Future LNG demand in China is highly uncertain. According to 2016 data, China is now the world's third largest LNG importer, giving it a large presence in the international LNG market. But LNG makes up only 16 percent of the country's total natural gas supply, and natural gas is only 6 percent of the total energy demand in China. These figures suggest that, despite its increasing presence and influence in the international LNG market, LNG provides only 1 percent of the country's total energy supply. Because of the small share, the demand for LNG can change significantly depending upon several factors.

The most significant near-term variable in natural gas demand is the pace of Chinese economic growth. This is because natural gas use is concentrated in the electric power and industrial sectors. These sectors tend to expand in periods of higher economic growth and contract when the economy slows down. Other uses for natural gas, largely in residential sector, are less dependent upon the pace of economic growth and

Figure 10
Chinese Natural Gas & LNG Supplies



Source: IEEJ calculation based on BP (2017) and GIIGNL (2017). PL refers to pipeline gas. IEEJ-EPRINC

are relatively unimportant in the entire demand outlook for natural gas.

Policy is also an important factor. The surge in China's LNG imports in 2016 (Figure 10) is largely a reaction to the Chinese government's restrictions on coal consumption to address the country's air pollution problem. Development of its natural gas resources also affects the country's natural gas supply/demand balance and thus the expected volume of future LNG requirements. Development of China's unconventional gas resources in particular is a critical factor in forecasting its natural gas import volumes.

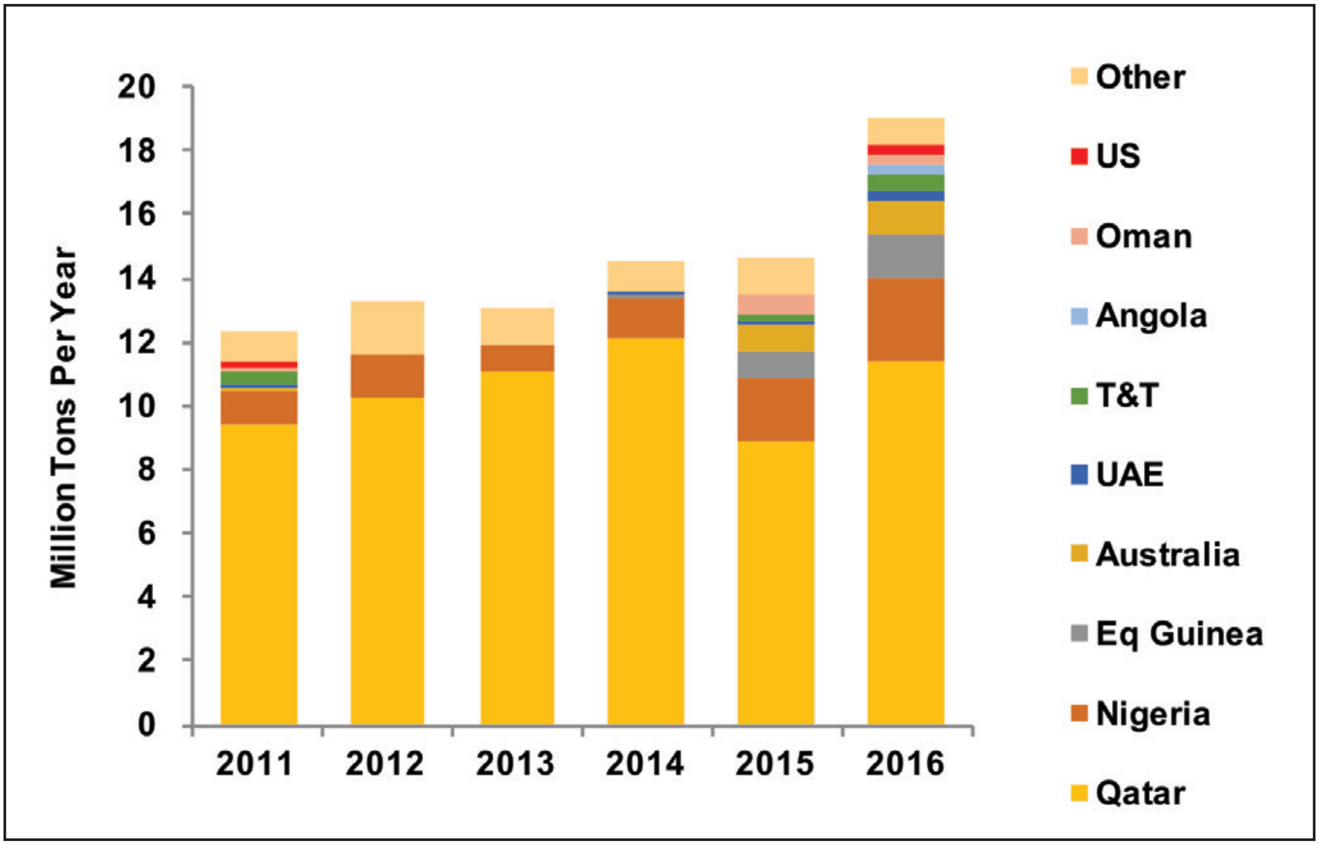
The last critical uncertainty regarding China's potential LNG demand growth is the timing and size of Russian natural gas pipeline imports. Based on their 2014 agreement, China is scheduled to receive Russian natural gas imported through the Power of Siberia pipeline in 2019. The volume is projected to be 38 Bcm per year, the equivalent of 28 MMt of LNG. But it is still uncertain whether the supply will begin as planned. The supplied volume is also uncertain as it is not likely to reach peak volume in the short-term due to the yet unavailable quantities of Russian natural gas. If there are significant delays in the project, China will need to turn to global LNG markets to make up the volume shortfall. Given these uncertainties, it is estimated that China's LNG demand through 2030 will be between 60 and 100 MMt.

India

India is another country whose LNG demand grew significantly in 2016. As shown in Figure 11, India historically imported most of its LNG through long-term contracts, almost all from Qatar. Any possible future renegotiation of Qatari LNG contracts could lower India's LNG purchases under long-term contract and would increase its procurement of less expensive spot cargos.

The largest LNG users in India are oil refineries, followed by the fertilizer industry, and then other industrial users. Each of these Indian consuming sectors is very price-sensitive and has access to and utilizes other energy sources besides imported LNG depending on price and availability. LNG is also used for power generation; but due to subsidized electricity prices, imported LNG is still

Figure 11
India's LNG Imports by Origin



Analysis Based on GIIGNL Data IEEJ-EPRINC

not a preferred fuel even with the low LNG import price environment of the past two years.

Unlike China, India does not have pipeline imports. There have been ongoing plans for an international pipeline to source natural gas from Turkmenistan and Iran. However, because of security and geopolitical concerns, these projects have not progressed, and it is expected that they will not materialize in the near-to-medium term.

Because Indian demand is highly price-elastic, global LNG market balances and price levels will influence India's LNG import decisions. In addition, there is little pipeline infrastructure from India's LNG import terminals. Until adequate pipeline infrastructure is in place, LNG consumption will be limited to the country's coastal areas. IEEJ expects that the country's demand will grow from 45 to 60 MMt by 2030.

ASEAN

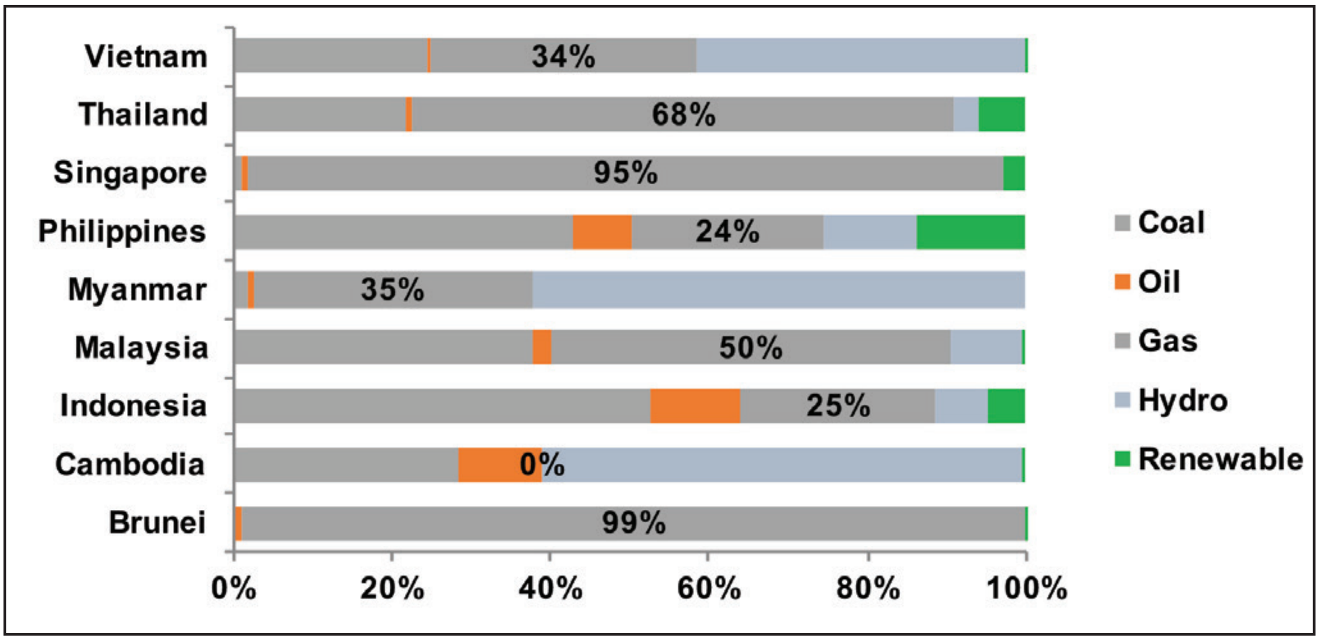
At one time, ASEAN was a major LNG exporting region. But due to declining domestic natural gas production and increasing domestic energy demands, three ASEAN countries, primarily Indonesia, Malaysia, Singapore, have been importing LNG for some time. While it is forecast that ASEAN as a region will continue to be a net natural gas exporter through 2030, it is likely that the region's LNG imports are expected to grow.

The primary ASEAN LNG demand sectors will be the power and industrial ones. As shown in Figure 12 below, natural gas is already a major fuel for power generation in many ASEAN countries. Because of sustained growth in the power sector and the public preference for cleaner fuels, natural gas will continue as one of preferred choices for new power generation requirements. The latest Indonesian power development plan that was published in March 2017 seeks to raise the share of natural gas-fired power generation from just under 25 percent in 2015 to almost 27 percent in 2026; this is expected to be achieved through the reduction in oil and coal consumption.

In Thailand, the share of natural gas in the power mix (68 percent in 2015) is likely to remain high at over 50 percent despite the depletion of domestic natural gas supplies. Natural gas demand remains strong in Thailand because of public opposition to the construction of new coal-fired power plants. As a result, LNG is likely to continue to be and to grow as the primary power generation fuel in Thailand.

Similarly, in the Philippines a combination of depleted and stagnant natural gas fields has caused the country to secure alternative natural

Figure 12
Power Generation Mix of ASEAN Countries



Analysis Based on IEA Data IEEJ-EPRINC

gas supplies. As an example, because the service contract of the Malampaya gas field will expire in 2024, production there will stop. For this and similar reasons, LNG is its most likely alternative, with plans to begin LNG imports as early as 2023.

Similar requirements may arise in Malaysia and Myanmar in the near future, since their respective natural gas production has matured and is declining. In these countries, it is relatively easy to import LNG because the infrastructure for natural gas supply is already developed and in operation.

In addition, ASEAN is becoming a key market of smaller scale LNG projects. In archipelagic countries such as Indonesia and Philippines, many islands have been using oil products for power generation for a long time, and thus replacing old and inefficient oil-fired power generation with more efficient natural gas systems is seen as being feasible. The largest barrier of extending small scale LNG to smaller islands is cost. The way sufficient demand is aggregated and generated, therefore, is critical in extending the small-scale LNG supply network in ASEAN. LNG demand in this area will rise from 45 to 70 MMt by 2030.

South Asia

LNG demand in South Asia (Pakistan, Bangladesh and Sri Lanka, in particular) has attracted considerable attention in recent years, raising the region's significance with respect to future global LNG demand. Pakistan increased its

LNG DEMAND IN ASIA continued

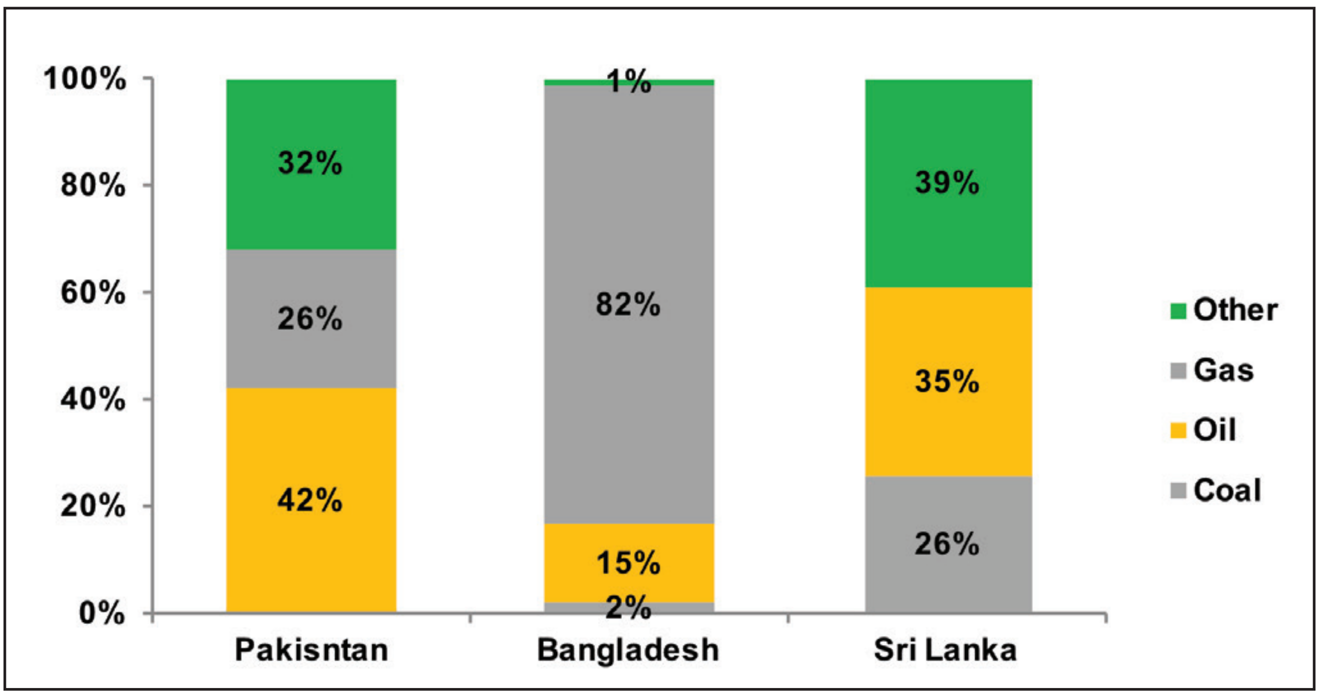
LNG imports to almost 3 MMt in the past two years, and its demand growth is expected to continue. Bangladesh plans to import LNG in 2018 to address its severe energy supply shortage problem due in part to stagnant domestic natural gas production. Sri Lanka also has plans to import LNG utilizing FSRUs.

Besides sustained increases in domestic energy demand, South Asian countries share two common attributes. The first is their high dependence on oil for power generation as shown in Figure 13. Most of the fuel is fuel oil or diesel whose prices are linked to those for international crude oil. If LNG prices fall below those of crude oil, replacing oil with LNG becomes economically pragmatic.

The second attribute that both countries share is that they are natural gas producers. However, these two countries' future natural gas production does not appear to be promising. In Pakistan, natural gas production peaked in 2012, and has since slowly declined.

In Bangladesh, while domestic production is still growing, its growth rate is lagging the higher rate of natural gas demand growth. But there is considerable uncertainty as to when production growth will resume. Therefore, it is necessary for these two countries to find additional natural gas supplies. One positive factor for them is that like some other ASEAN countries, they already have substantial natural gas infrastructure in place that will improve prospects for raising LNG imports. To satisfy future demand, Pakistan's LNG imports are expected to grow from 10 to 15 MMt, and Bangladesh's from 5 to 10 MMt by 2030.

Figure 13
Power Generation Mix in Pakistan, Bangladesh, Sri Lanka (2015)



Analysis Based on IEA Data — IEEJ-EPRINC

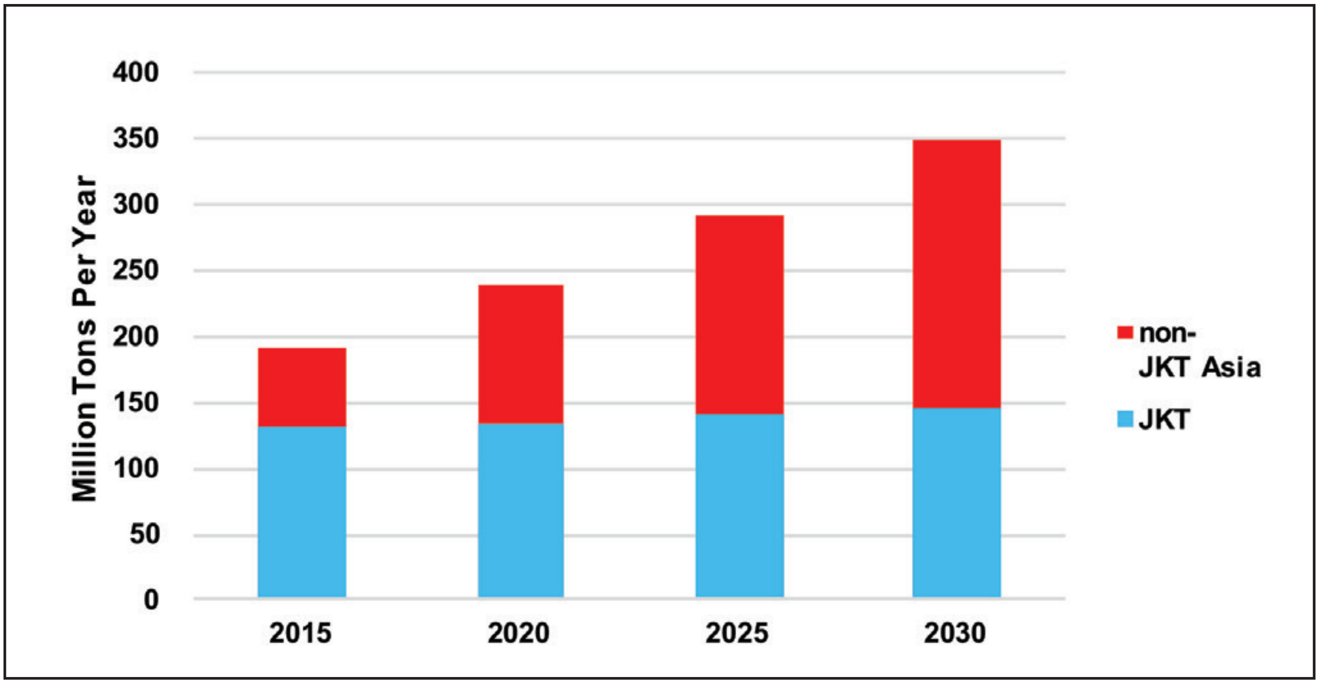
CHALLENGES IN EXPANDING LNG DEMAND IN ASIA

Growing Need for Flexible Supply

In the Asian LNG market, the market structure is rapidly changing, and traditional trading practices are on the way out. In particular, supply flexibility is becoming more important to accommodate growing regional and seasonal demand.

There are several factors that highlight the importance of supply flexibility in the future LNG market. First, the center of Asian LNG demand is shifting away from the traditional JKT (Japan, Korea, and Taiwan) market toward emerging economies such as China, India, and other developing Asian countries (Figure 13). The demand patterns and importers' procurement behavior of these countries are very different from those of traditional JKT markets, and the Asian LNG market is expected to change as a result of shifting procurement requirements.

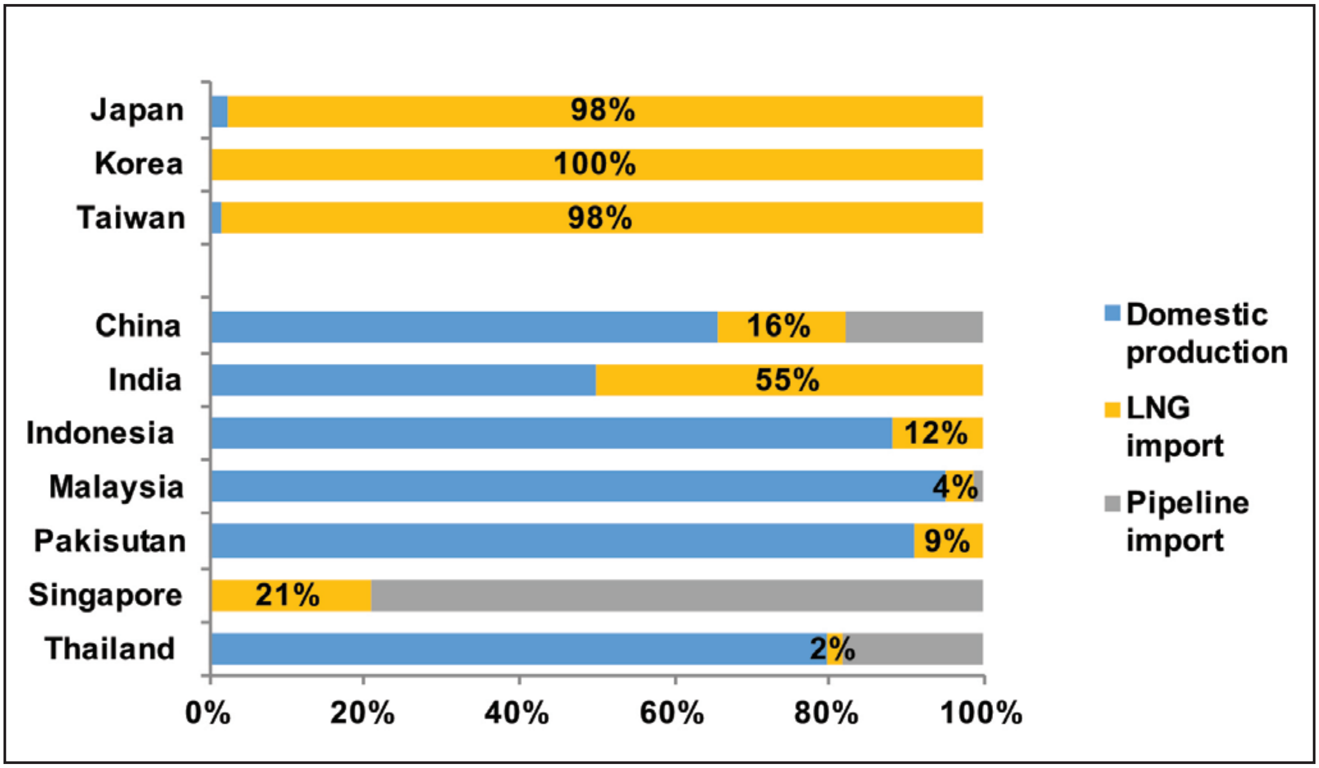
Figure 14
LNG Demand Outlook in Asia



Source: IEEJ estimate IEEJ-EPRINC

In many emerging Asian countries, power tariffs are regulated and subsidized. Because of this, many emerging countries can only increase their LNG intake when import prices are low. Also, unlike JKT countries, many of these emerging countries have either domestic coal or natural gas resources. In the aggregate, these emerging countries have alternative supplies that traditional JKT do not have (Figure 15). This availability of alternatives provides these emerging importers with more options of natural gas supply, and make their LNG demand more price-elastic.

Figure 15
LNG in the Total Natural Gas Supply in Asia (as of 2016)



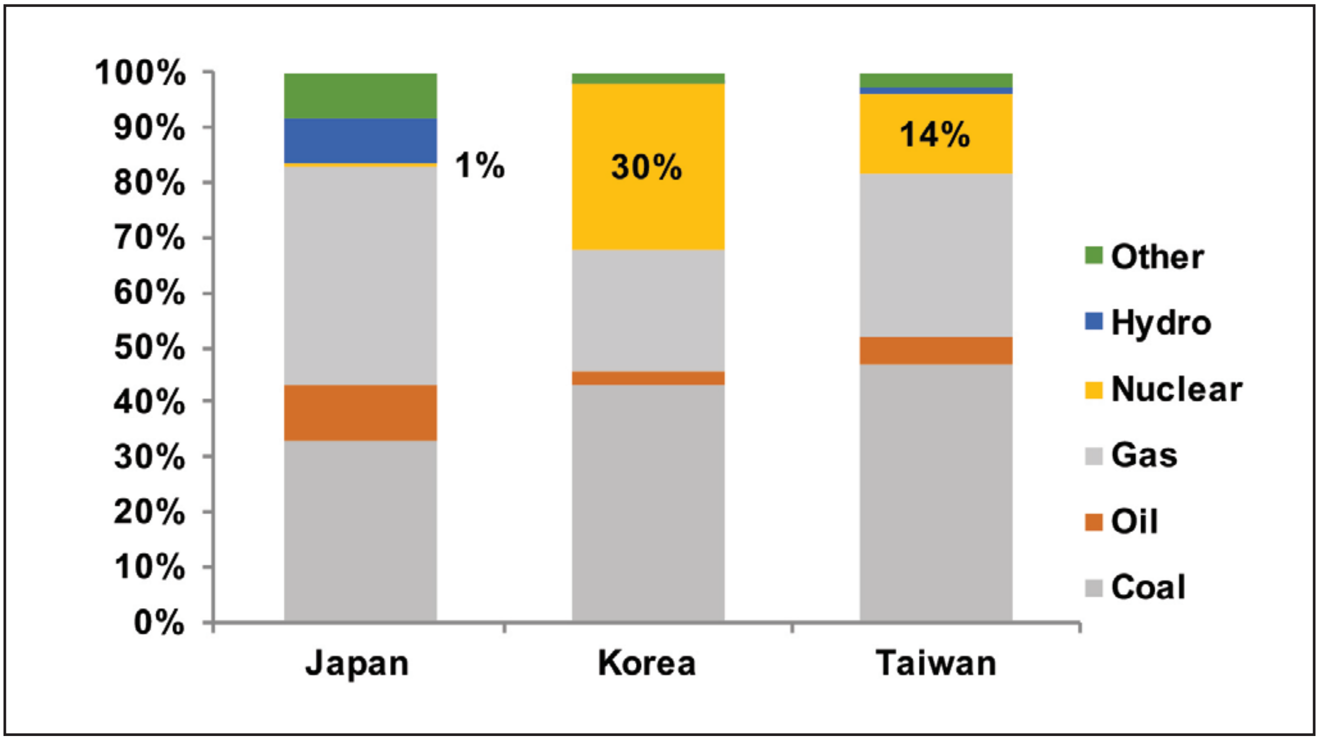
Source: BP (2017) with IEEJ estimate IEEJ-EPRINC

In the traditional JKT markets, there are also new uncertainties that require more supply flexibility. The first one is nuclear power generation. In Japan, the Japanese government published its energy (power) mix target in 2015, and plans to raise the share of nuclear from 20 to 22 percent by 2030. If this target is achieved, Japanese power sector LNG demand will inevitably decline. However, the pace of unit restarts is highly uncertain. In Korea and Taiwan, as noted earlier, nuclear policies of the new administrations increase uncertainties in the future LNG demand.

Another uncertainty in JKT markets is market liberalization (Figure 16). In Japan, the power market and gas market were fully liberalized in 2016 and 2017, respectively. Korea also plans to liberalize its larger customers' market in 2025. Liberalization itself does not directly affect the country's total LNG demand. But in these liberalized markets, each utility now faces competition from new market entrants, and their supply to final customers has begun to be affected. It is too early to assess how these market liberalization policies will affect the behaviors of market participants, but because incumbent utilities may not be able to maintain their existing customers, these utilities are increasingly showing interest in flexible spot and short-term cargo procurement.

While the demand for more flexible supply grows, there are signs that the supply side is also responding to the new requirement. An increasing number of LNG players are evolving into portfolio

Figure 16
Shares of JKT Power Generation Mix (2015)



Source: IEA (2017) IEEJ-EPRINC

players that have multiple and flexible supply sources, and can optimize their cargo supplies to meet various customer demand patterns. Not only Western majors such as Shell, BP, or ExxonMobil, but even state-owned companies such as Gazprom and Petronas are adopting this business model. An advantage of this model is that, because the portfolio players have a greater number of supply options, they can respond more easily to meet flexible demand requirements.

One other important aspect with respect to LNG supplies is the increasing amounts of U.S. LNG. As is widely known, U.S. LNG does not have any destination restrictions. It will play a greater role in these new LNG markets that demand more flexible supply terms. The tolling business model, which is adopted in some of the U.S. liquefaction projects, collects liquefaction fees for produced LNG and allows various market participants to use some of the liquefaction capacity in a more flexible manner depending on market conditions.

Financing Constraints

Another significant challenge in expanding LNG demand in Asia is insufficient financial sources for market development. As noted earlier, the ERIA study indicated that natural gas demand in the EAS region could potentially expand 2.5 times between now and 2030 and will require about $80 billion in LNG supply chain investments to meet this demand.

In emerging Asian countries, however, it is usually difficult to attract sufficient private sector financing for natural gas infrastructure investments because of the lack of the credit-worthiness of the owners of the LNG infrastructures and LNG buyers, high country credit risk, currency risk, its regulated market structure and so on.

In these Asian countries, potential local participants in any LNG businesses undertaking are often sub-sovereign entities such as state-owned companies or local governments. Financing a project that includes these sorts of sub-sovereign entities can add to the risk potential as such entities are often not sufficiently credit-worthy. This issue applies not only to the initial investment stage but also to regular operational stage of the LNG imports. Because of its large size of LNG cargo, the amount of a single voyage of LNG shipment sometimes reaches $30 million. This is a significant amount for LNG importers and procurement activities also requires sufficient credit guarantee.

Currency risk is also a big problem for potential investors. Needless to say, infrastructure investment requires a significant upfront investment, and some portion of the investment is made with local currency. Investors will be inevitably exposed to currency risk in such an investment. Currency risk exists at operational stage, as well. In most cases, end-users or buyers of LNG are the local households or the business owners who use gas for heat, cooking etc. and use electricity generated by gas. Because the gas rates and electricity expenses, which are the revenue of the LNG project owners, are usually paid by local currency, foreign financial providers to LNG projects and LNG sellers are also exposed to currency risk.

Because currency risk is usually not covered by ECA's financial support scheme, managing of this risk can become a significant burden, especially in a country where its foreign exchange market is not liquid. If such currency risk cannot be properly managed, investment from foreign players may be discouraged.

Country risk is another source of concern for future investors. According to the country risk classification by Organization of Economic Cooperation and Development (OECD), some of the existing and future LNG importing countries are assessed to have higher country risks (Table 2). Beyond this high country risk environment, the selling price of natural gas is often regulated and sometimes even fixed at a certain price regardless of the market price movements in many of Asian countries. Thus, the margin environment is not attractive for private investors.

Because of these domestic market conditions and high country risk, securing sufficient financial resources only from private sources is usually very difficult. Financial support by the local government, export credit agencies (ECA) of investor's country, or multilateral development banks (MDB) plays an important part.

In current LNG markets, there is considerable

Table 2
Country Risk Assessment of Selected Asian Countries

	Large = High risk Small = Low risk
Singapore	0
China	2
Malaysia	2
India	3
Indonesia	3
Philippines	3
Thailand	3
Bangladesh	5
Vietnam	5
Cambodia	6
Myanmar	6
Sri Lanka	6
Pakistan	7

Source: Organization of Economic Cooperation and Development (2017) IEEJ-EPRINC interest in concurrently developing infrastructure and securing demand. While there are financial techniques and systems for each of these activities, there is no one integrated system that can be applied to these two business activities. Financial mechanisms, therefore, have not developed to the extent that they can accommodate the latest requirements of LNG business development in potential emerging market Asian LNG importers.

Lack of Clear and Efficient Policy and Regulatory System

While there are various risks to building and operating LNG projects, policies and regulations that target emerging Asian countries to reduce these risks are not well developed. Marketing (demand) risk in emerging Asia is far larger than in the traditional JKT markets as mentioned above. In Thailand, for example, LNG is regarded as a "balancer" to meet the fluctuating residual demand in the power sector. Domestically produced natural gas has priority for power generation, followed by coal and renewable energy sources. LNG is used to meet the residual demand, which is always fluctuating and often unpredictable. In this sort of environment, LNG infrastructure investments are exposed to significant market risk. Unless governments present clear policy direction regarding LNG utilization, the market risk will remain a concern for domestic and foreign investors.

There are also political and regulatory risks to consider. In emerging Asian countries, decision-making or approval processes required for infrastructure development tend to be delayed for a variety of reasons, including but not limited to the lack of clear guidelines or sufficient human resources in the relevant department. In most Asian countries, natural gas projects are not necessarily given the highest priority, and procedures for relevant approval and decision-making by governments are often slow.

Political Risks in LNG Exporting Countries

Political risk also exists in exporting countries.

Geopolitical risk has long been seen as a potential threat to stable LNG supply from Middle Eastern LNG exporters, even though they have been very reliable and stable LNG suppliers to Asia so far. Recent conflicts between Qatar and other Gulf countries such as Saudi Arabia and United Arab Emirates, however, elevate already high geopolitical uncertainties. Because Qatar is the largest LNG supplier to Asia, any unexpected disruption can generate considerable negative impacts.

Another potential political risk for importing countries is known as revocation risk from the U.S. U.S. LNG exports to non-FTA countries such as India or Japan require thorough reviews and approvals from the DOE. Even after approval, DOE reserves the right to revoke a license in an extraordinary condition, and this causes a least the perception of revocation risk for some Asian importers of U.S. LNG. Given the ample natural gas resources and supply brought on by the shale revolution, it is not likely this sort of an "extraordinary condition" will actually emerge. However, existence of such risks will continue to be a source of concern for Asian LNG importers as the presence of the U.S. LNG is expected to grow in the coming years.

Cost Competitiveness

LNG faces some important challenges in competing with coal fired power generation throughout Asia. In head to head competition with coal imports, LNG can often compete favorably if it is used in advanced combined cycle power generation. However, the perception in many Asian countries is that LNG is a "luxury" fuel and this is clearly the case if LNG is competing with domestically produced coal. In addition, the regulatory structure in many Asian countries restricts more expensive fuel by holding the power tariff to very low levels and there is inadequate accounting for environmental advantages of LNG.

U.S. LNG has a unique challenge in this regard due to its long distance to Asia. Assuming the LNG is produced and shipped based on the Henry Hub price, its landed cost will be approximately $8 for one million British thermal units (MMbtu) in Asia if Henry Hub price is traded at $3/MMbtu. Liquefaction, transportation, and handling costs are approximately $5/MMbtu, combined. Because long-term LNG contract prices in Asia are approximately $7/MMbtu (when indexed to crude oil prices at $55/bbl) and Asian LNG spot prices in 2Q2017 were below $6/MMbtu, U.S. LNG cannot be competitive under current Asian LNG market conditions. Potential constraints to moving cargos through the Panama Canal may cause another set of challenges.

If the U.S. exporters are to play a large role in the Asian LNG market, all three critical components of U.S. competitiveness will require attention; (i) the capacity of the U.S. natural gas resource base to expand output to meet rising export demand, (ii) the efficient build-out of the transportation infrastructure to move natural gas production to coastal liquefaction processing facilities, and (iii) the timely and cost-efficient construction of liquefaction facilities. It is no doubt that the U.S. LNG will bring numerous benefits to the future Asian LNG market. To accelerate the realization of the benefits, the U.S. government and industry will need to ensure a positive policy environment cost improvements across the entire LNG value chain.

Capacity Building

Many Asian countries have no experience importing LNG and, therefore, it is a new challenge. There is a dearth of expertise to operate and manage LNG imports both in industry and government. Understanding of commercial aspects of LNG trading must be cultivated. Because importing LNG requires a significant amount of capital commitments both in infrastructure development and actual cargo procurements, deep understanding about how the LNG business is operated is critically important. There are insufficient amounts of people in many Asian countries who understand the commercial practice or contractual provisions of LNG very well. On the government side, this shortage of expertise may cause delays of required approval process in starting LNG imports. Capacity building in commercial aspects from contractual provisions to procurement activities, scheduling operations, trading arrangements will facilitate the smooth introduction of LNG in Asia. Acquiring and maintaining expertise regarding safety and environmental preservation is also necessary. In many Asian countries, public acceptance of energy infrastructure is increasingly difficult to obtain. Because LNG handling is different from that of oil or coal, there are only a limited number of human resources in this area exist in Asia.

Also, specialized knowledge of relevant rules and regulation are still short in the government sector in some Asian countries. While the need to import LNG is growing rapidly, the development of required rules and regulations is lagging in many emerging importing countries. Lack of required expertise in the government side prohibits a smooth processing of approvals and decision-makings to import LNG.

POLICY RECOMMENDATIONS

1. Developing a More Liquid and Flexible LNG Market.

Developing a liquid and flexible LNG market will ensure a rational pricing LNG and promote LNG use in Asia. In this regard, realizing the visions of the LNG Market Development Strategy published in 2015 by Japan's Ministry of Economy, Trade, and Industry (METI) will help to realize more liquid and flexible market. The strategy emphasizes tradability, price discovery, and open infrastructure as the three major elements of the future LNG market, and specifies actions by the government and industry. To achieve the vision in the context of the Asian LNG market, developing LNG demand and changing trading practices need to be pursued simultaneously. Such two-track actions will accelerate progress toward the envisioned LNG market proposed by the strategy.

▸ *Removal of Destination Restriction:* Although exports of U.S. LNG do not carry destination clauses, removal of all destination restrictions around the world is essential to create a globally integrated LNG market. Market players, particularly purchasing entities, should continue to work in a committed fashion to further relax or remove the restrictions in their long-term contracts. The study conducted and published by Japan Fair Trade Commissions (JFTC) in June 2017 will be an important guidance for negotiating terms between sellers and buyers globally.

▸ *Engage Gas and Power Businesses in Asia:* The U.S. and Japanese companies are encouraged to work actively with gas and power businesses in Asia. Because utilities have long-term experience in handling LNG and operating gas and power facilities, their technical and operational expertise will help greatly to expand the use of LNG. Both Japan and the U.S. governments should support this move through ECA finance, human development support, etc.

▸ *Consumer – Producer Dialogue:* : Energy security has two sides: security of demand and security of supply. The development of the global LNG market will undoubtedly contribute to both sides of energy security. The governments and companies of LNG consuming and producing countries are encouraged to hold close dialogue to determine the long-run requirements and policy instruments to promote competition and LNG demand growth.

2. Sustaining Competitive U.S. LNG Export Platform.

Whether the U.S. can play an integral role in serving these markets is dependent not only on the pace and magnitude of LNG demand across the growing Asian LNG market, but sustaining a cost competitive position in Asia for U.S. LNG exports. As documented in the IEEJ-EPRINC assessment, the U.S. natural gas production platform is both prolific and efficient, and it benefits considerably from rising volumes of associated natural gas from the production of crude oil from unconventional resources. As a result, U.S. natural gas production has seen sustained increases in output and adoption of cost- efficient technologies. World gas markets are highly competitive and government policies alone cannot guarantee that U.S. producers will be price competitive in all markets. However, smart regulation is essential to establish the conditions for a vibrant, efficient, flexible, and technologically advanced industry that can deliver rising volumes of exports, economic value to the national economy, and environmental protection.

The administration has recognized the importance of regulatory reform, and has issued general guidance on public infrastructure reviews and permits for roads, bridges, and waterways. This reform initiative for permitting and environmental reviews should be extended for essential infrastructure and the construction of facilities necessary for the expansion of U.S. natural gas production and exports.

Among the more important initiatives of the administration that should be extended to the natural gas sector are:

▸ *Accountability and Best Practices:* Agencies responsible for permitting and undertaking environmental reviews of natural gas pipeline projects and LNG export facilities should have both

POLICY RECOMMENDATIONS continued

their review function and performance tracked and measured. The review role of federal agencies should be an integral part of their mission and given high-level attention. Best practices should be identified and adopted by other agencies undertaking similar reviews. DOE's regulatory success in permitting LNG exports is a case in point.

▸ *Improvement of LNG Exports Approval*: While the DOE's approval of LNG exports is generally considered to be a success, there is still room for improvement. Asian stakeholders ask DOE to consider that exports of LNG to Japan and other Asian countries that coincide with U.S. national interest are deemed to be in the public interest under the Natural Gas Act, as natural gas exports to free trade agreement countries are. It should be acknowledged that any form of revocation risk to the LNG facilities can disturb the participation of potential investors. Also, we welcome the DOE's proposal on expedited approval for small-scale natural gas exports including LNG. This proposal should be implemented promptly so that the small-scale LNG exports to Asian markets can be also approved in an expeditious manner.

▸ *Single Approval Window:* While the FERC generally excels in providing timely and comprehensive project reviews, others in the full LNG export value chain can require proponents to navigate complex and uncertain federal environmental review and permitting processes. Uncertainty and regulatory risk rises if the project involves pipelines and facilities requiring rights-of-way on federal lands. As pointed out in the administration's infrastructure initiative, "The Federal Government is capable of navigating its own bureaucracy and designating a single entity with responsibility for shepherding each project through the review and permitting process." Moving LNG projects to a single approval window would reduce regulatory risk associated with project approval.

▸ *Judicial Reform:* The current standards of judicial review force federal agencies to spend unnecessary time and resources attempting to make a permit or other environmental document litigation- proof. While Congress wanted the agencies to take a "hard look" at environmental consequences as required by the National Environmental Policy Act (NEPA), the current process involves substantial and costly risks from project delays with often little added value in understanding the environmental risks of a proposed project. While ultimately the federal environmental review process may require a legislative remedy, the executive branch should issue guidance on what constitutes an adequate environmental review.

▸ *Adequate Funding of Regulatory Reviews:* Review agencies require personnel and budget to complete reviews in a timely manner. The administration's program to make agencies accountable should also include a review of their capacity to complete reviews in a timely manner and strategies to move resources to other agencies as the regulatory demand shifts from agency to agency. The regulatory review process is often uneven and resources need to be moved in conjunction with workload patterns.

3. Cost Effective and Long-Term Access to the Panama Canal

The pricing (tolls) and regulatory structure for ship movements by the Panama Canal Authority (ACP) are outside the jurisdiction on the United States and Japan. However, in recent years, ACP has been active with U.S. and many foreign port authorities in concluding agreements on joint marketing plans to support so-called all-water routes from Asia to North America. While these activities are generally commercial and involve joint marketing activities, they also involve extensive data exchanges, market studies, and training. Although DOE has a central role in regulating LNG exports, it can also bring extensive knowledge of world LNG markets and long-term growth of LNG vessel movements to any sort of consultation or discussion on trade impediments.

POLICY RECOMMENDATIONS continued

▸ *Direct Engagement with ACP:* DOE and related Japanese ministry/ministries should directly engage the ACP to develop formal data exchanges and research sharing on the future of LNG trade and strategies to support long-term and cost effective movement of LNG vessels to and from Asia to North America.

4. Promoting Competitive and Transparent LNG Markets

Historically, short-term trading of LNG volumes has not been large compared to the size of the markets they serve, and consequently, price arbitration has not played an important role in establishing transparent and competitive price discovery. A vibrant and highly competitive Asian LNG market offers the best opportunity for expanding LNG use throughout the region. Standard trading rules and contracts, transparent price discovery, and futures exchanges all promote greater risk diversification and more opportunities for market growth. Market structures which limit competition work in the opposite direction.

▸ *Monitoring of LNG Trading Practices:* The Japan Fair Trade Commission (JFTC) has concluded that certain practices among LNG suppliers and consumers, notably destination restrictions, are likely to have competition-restraining effect, and are likely to be in violation of Japanese competition law. In addition, under certain circumstances, long-term "take or pay provisions" which exceed capital recovery are also likely to be in violation of Japanese competition law. JFTC should keep monitoring the LNG market and take strict actions against any violations of the Japanese Anti-Monopoly Act.

5. Addressing Financial Constraints in Emerging Asian Markets

Unlike oil or coal production and distribution, natural gas requires extensive investment in infrastructure. Because of this, securing sufficient finance from private sources is more challenging.

Financing natural gas infrastructure requires a certain type of public support that has a long-term perspective.

▸ *Financial Supports by Public Financial Sources:* Japan Bank for International Cooperation (JBIC), Nippon Export Insurance (NEXI), and Japan Oil, Gas, and Metals National Corporation (JOGMEC) already have considerable expertise in this area, having provided extensive financing in energy infrastructure development in Asia. These institutions should play a far more important role in natural gas infrastructure development by expanding the scope of eligible development projects for financing, including providing new services such as financing with local currencies. U.S. institutions such as the U.S. Export- Import Bank (Ex-Im), U.S. Trade and Development Agency (USTDA), and Overseas Private Investment Cooperation (OPIC) should be more involved in LNG projects.

▸ *Collaborating with Multilateral Development Banks (MDBs):* Collaborating with multilateral development banks (MDB) such as the World Bank (WB) and Asian Development Bank (ADB) is also important. With extensive expertise and experience in financing infrastructure projects, the WB and ADB should become more important supporters in the effort to develop infrastructure. These institutions will be able to provide support for LNG infrastructure development and trade finance for LNG procurement.

There are several financing tools that MDBs can use for energy infrastructure development. While loans under concessional condition such as ADB's Climate Finance may be provided only to renewable energy projects, MDBs can actively support financing natural gas projects with other financial mechanisms as long as they reduce CO2 emission by replacing coal or improving energy efficiency. MDBs should also play a role in coordinating multi-lateral efforts be co-financing LNG projects in Asia. International Finance Corporation (IFC), an organization of the World Bank Group, and several agencies (Japan International Cooperation Agency (JICA), CDC Group plc (United Kingdom), Deutsche Investitions- und Entwicklungsgesellschaft mbH (Germany), Nederlandse Financierings - Maatschappij voor Ontwikkelingslanden N.V. (Netherland)) have announced that they will jointly provide loans to the FSRU installment project in Bangladesh. Such co-financing among MDBs and agencies should be important to share risks so that infrastructure could be successfully developed in Asia.

6. Assisting Policy Development in Asia

Governments in Asia should also play a significant role in expanding LNG demand. A clear policy commitment to expand natural gas use is also an essential task for governments in Asia to develop LNG demand. This is because in Asia government direction is very critical in determining the balance of various energy sources as energy markets are often regulated, and state-owned entities are the major energy suppliers. The U.S. and Japanese governments should discuss with governments in emerging LNG import countries on the following policy issues:

▸ *Assist in Providing Energy Mix Targets:* To realize potential and "un-priced" benefits of natural gas such as its clean nature among fossil fuels and supply source diversification benefits, governments in Asia should structure their energy mix to reflect the value of an energy market that addresses both environmental and security objectives. Such target setting will help to internalize the externality of the value of natural gas. Clear government policy and plans for the future natural gas use will reduce the investment risks for prospective investors. The U.S. and Japanese government should consult and assist the Asian governments in making the future demand outlook by sector and plan of infrastructures development to complete the energy mix target.

▸ *Review of Cabotage Regulation:* In some Asian countries, regulations concerning the flag of a vessel (a.k.a. cabotage regulations) that connects to local LNG infrastructure should be reconsidered. In particular, the U.S. and Japanese governments should discuss and seek to relax or remove with Asian governments those cabotage regulations that are applied to FSRUs.

7. Capacity Building

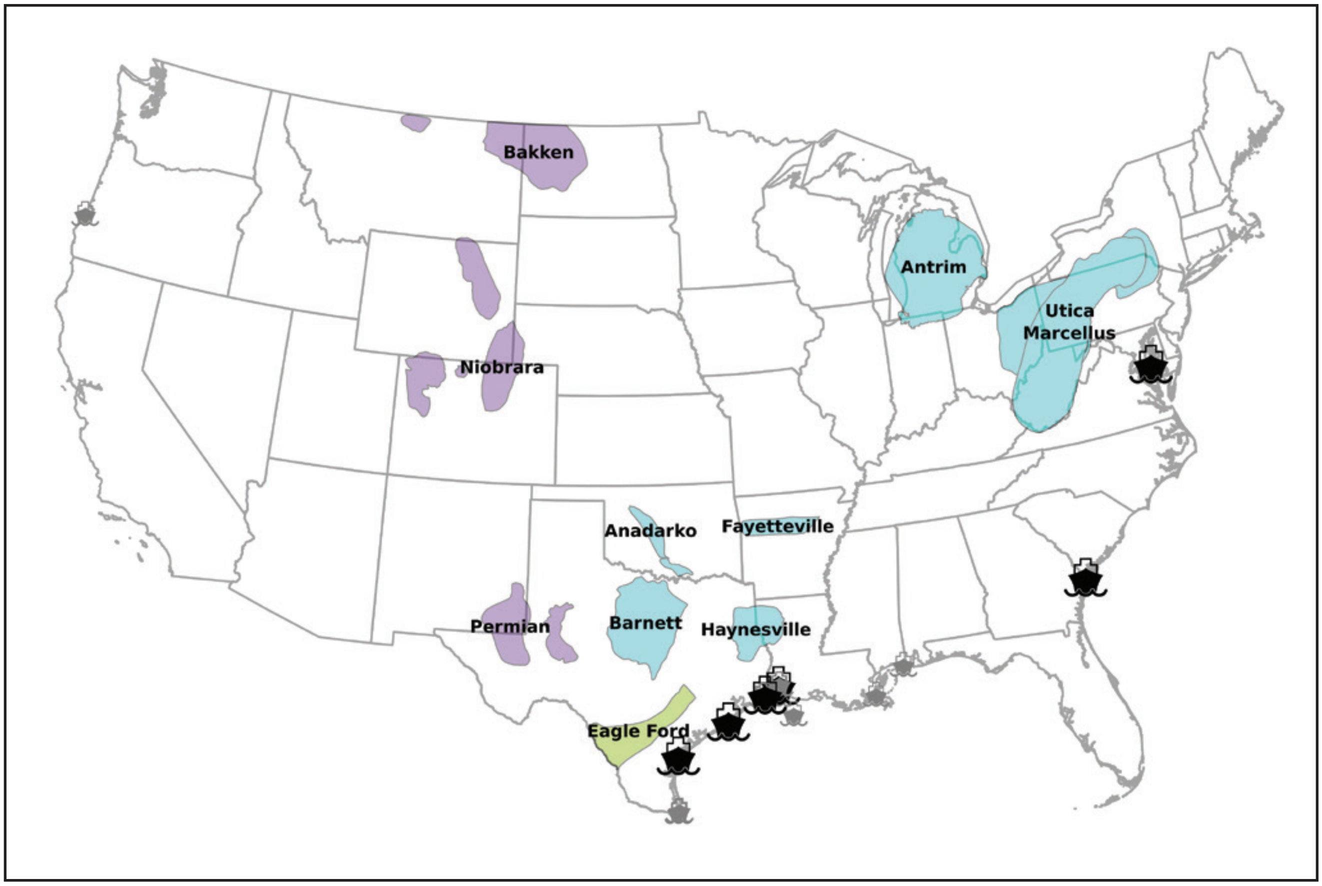
Lack of human resources and expertise in utilizing LNG, has been one of the biggest hurdles to this. Both the U.S. and Japanese governments have engaged in various capacity building programs in energy and infrastructure developments so far. But the two governments should enlarge the scope of the program, re-design the curriculum, and become more actively involved in collaborating with Asian government to develop an effective capacity building program.

▸ *Providing Training to Government and Industrial Officials in Asia:* Capacity building programs including training programs and technical assistance should be conducted by relevant U.S. and Japanese agencies. Topics that can be included in this training and technical assistance could cover policy, regulations, technologies, technical standards, operational safety guidelines, environmental regulation, and financing, among others.

▸ *Regulatory Development:* Relevant agencies of the U.S. and Japanese governments should help Asian governments to develop a regulatory system in receiving and utilizing LNG. Environmental regulation is one of the key areas in this regard. A clear and consistent environmental regulatory system would clarify the role and the task of project investors, and facilitate investment through lowered regulatory risk. Another important regulatory area concerns safety regulations. Training programs on safety issues would help Asian governments to develop a well-organized safety regulations to monitor operational safety to avoid unexpected accidents.

APPENDIX

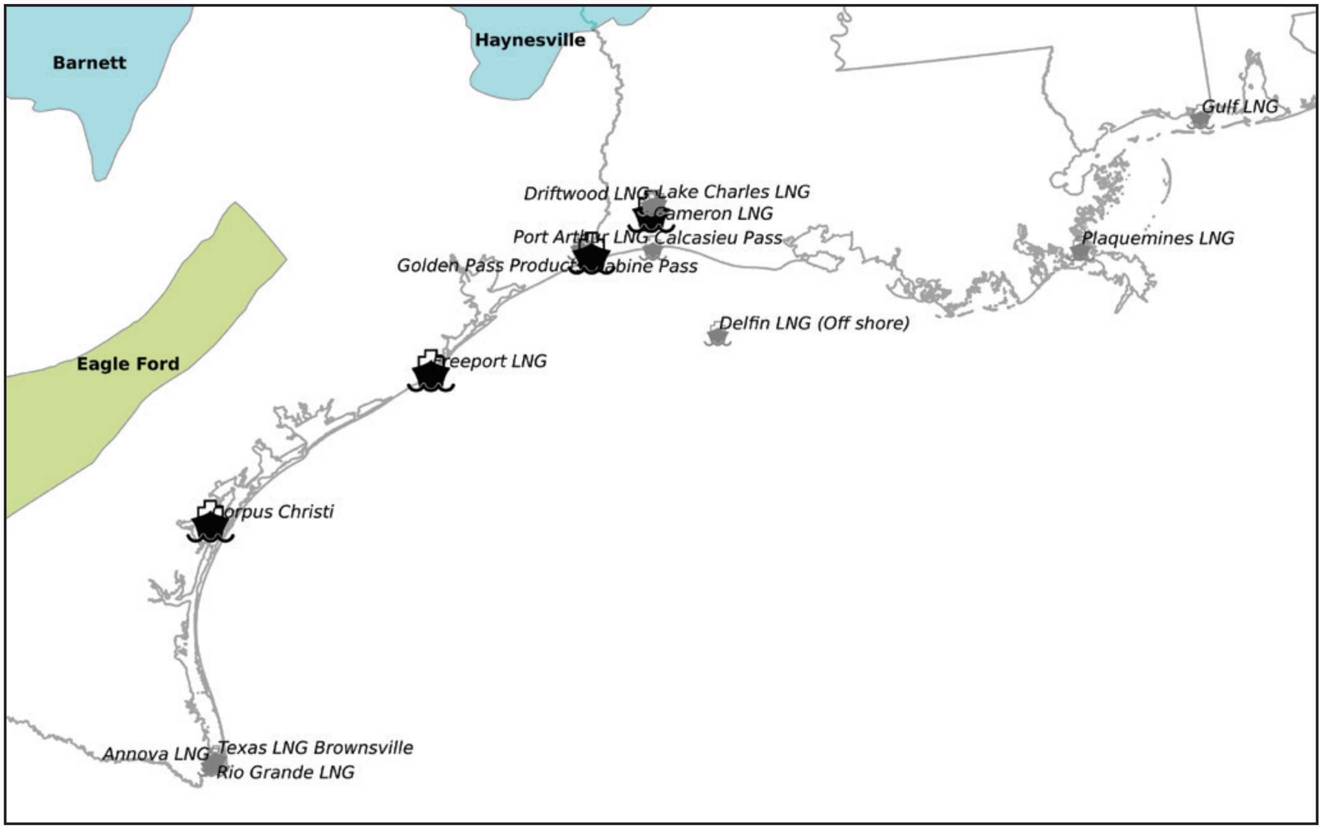
Figure 17
U.S. Shale Plays and CNG Plants
Black= Under Construction or Commissioned   Grey=Proposed



Analysis Based on EIA, USDA, and RFA Data   IEEJ-EPRINC

APPENDIX continued

Figure 18
U.S. Gulf Coast Shale Plays and LNG Plants
Black= Under Construction or Commissioned   Grey=Proposed



Analysis Based on EIA, Company Data

IEEJ-EPRINC

APPENDIX continued

Table 3
U.S. LNG Export Projects

LNG Export Project	Owner	State	MTP/a	BCF/d	Initial Export Target Date	FERC/MARAD Filing Date	Status of LNG Contracts
Commission Or Under Construction							
Sabine Pass (Trains 1-4)	Cheniere Energy	LA	20.0	2.6	Q1-2016	01/31/2011	Fully Subscribed
Cove Point LNG	Dominion Resources	MD	6.2	0.8	Q4-2017	04/01/2013	Fully Subscribed
Cameron LNG (Trains 1-3)	Sempra and Partners	LA	16.0	2.1	Q1-2018	12/07/2012	Fully Subscribed
Elba Island	Kinder Morgan	GA	2.6	0.3	Q2-2018	03/10/2014	Fully Subscribed
Freeport LNG (Trains 1-3)	Freeport LNG	TX	15.0	2.0	Q4-2018	08/31/2012	Fully Subscribed
Corpus Christi (Trains 1-2)	Cheniere Energy	TX	10.0	1.3	Q2-2019	08/31/2012	T1 & T2 Fully Subscribed
	Cheniere Energy		30.0	3.9			
	Dominion Resources		6.2	0.8			
	Sempra and Partners		16.0	2.1			
	Kinder Morgan		2.6	0.3			
	Freeport LNG		15.0	2.0			
Approved Expansions							
Corpus Christi (Train 3)	Cheniere Energy	TX	15.0	2.0	Q2-2020	08/31/2012	T1 & T2 Fully Subscribed
Sabine Pass (Trains 5-6)	Cheniere Energy	LA	10.0	1.3	Q3-2020	09/30/2013	T5 Fully Subscribed
Cameron LNG (Trains 4-5)	Sempra and Partners	LA	10.0	1.3	Q4-2020	09/28/2015	Unknown
Corpus Christi (Trains 4-5)	Cheniere Energy	TX	10.0	1.3	Q1-2020	06/09/2015	Unknown
Freeport LNG (Train 4)	Freeport LNG	TX	5.0	0.7	Q4-2020	06/03/2015	Unknown
In Various Proposed Stages							
Driftwood LNG	Tellurian	LA	26.0	3.4	Q2-2020	05/11/2016	Unknown
Golden Pass Products	Qatar Petroleum, Exxon	TX	15.6	2.1	Q2-2021	07/07/2014	Unknown
Calcasieu Pass	Venture Global LNG	LA	10.8	1.4	Q2-2021	09/04/2015	Partially Subscribed
G2 LNG	G2 LNG	LA	14.0	1.8	Q2-2021	12/23/2015	Unknown
Plaquemines LNG	Venture Global LNG	LA	10.0	1.3	Q2-2021	03/31/2017	Unknown
Rio Grande LNG	NextDecade	TX	27.0	3.6	Q1-2022	05/05/2016	Unknown
Annova LNG	Exelon	TX	6.0	0.8	Q1-2022	07/13/2016	Unknown
Delfin LNG (Off shore)	Fairwood LNG	LA	13.0	1.7	Q2-2022	05/08/2015	Unknown
Texas LNG Brownsville	Texas LNG	TX	2.0	0.3	Q2-2022	03/31/2016	Unknown
Port Arthur LNG	Sempra, Woodside	TX	13.5	1.8	Q2-2023	11/29/2016	Unknown
Alaska LNG	State of Alaska & Partners	AK	19.0	2.5	Q2-2024	09/12/2014	Unknown
Lake Charles LNG 4	Energy Transfer, Shell (BG)	LA	16.5	2.2	Jnknown	03/25/2014	Unknown
Magnolia LNG	LNG Ltd.	LA	8.0	1.1	Jnknown	04/30/2014	Partially Subscribed
Gulf LNG	Kinder Morgan and Partners	MS	11.0	1.4	Jnknown	06/19/2015	Unknown
Eagle LNG	Eagle LNG Partners (Ferus)	FL	1.0	0.1	Jnknown	01/31/2017	Unknown
Jordan Cove LNG	Veresen	OR	7.8	1.0	Jnknown	02/10/2017	Unknown
SCT&E LNG	SCT&E LNG	LA	15.75	0.0	Jnknown	Proposed	Unknown
Port Comfort LNG	Lloyds Energy	TX	9.6	0.0	Jnknown	Proposed	Unknown
Totals							
Commissioned Or Under Construction			69.9	9.2			
Approved Expansions			50.0	6.6			
In Various Proposed Stages			226.5	26.5			
Grand Total			346.3	42.2			

Analysis Based on Company Sources, LNG Allies Data

IEEJ-EPRINC

APPENDIX continued

Table 4
ASEAN & India LNG Projects

LNG Export Project	Owner	City	Province	Country	MTP/a	BCF/d	Startup Year
Liquefaction Plants							
Operating							
Brunei LNG	Brunei LNG	Bandar Seri	Brunei Muara	Brunei	7.2	0.9	1973
Bontang LNG	PT Baddak	Bontang	East Kalimantan	Indonesia	21.6	2.8	1987
Donggi-Senoro LNG	Sulawesi LNG	Batui	Central Sulawesi	Indonesia	2.0	0.3	2015
Tangguh LNG	Tangguh JV	Tangguh	West Papua	Indonesia	7.6	1.0	2009
Kanowit PFLNG	Petronas	Offshore	Sarowak	Malaysia	1.2	0.2	2017
Malaysia LNG	Petronas	Offshore	`	Malaysia	25.7	3.4	1983
Under Construction							
Sengkang LNG	South Sulawesi	Sengkang	South Sulawesi	Indonesia	2.0	0.3	2019
Tangguh LNG	Tangguh JV	Tangguh	West Papua	Indonesia	3.8	0.5	2020
Rotan PFLNG	Petronas	Offshore	Sabah	Malaysia	1.5	0.2	2018
Import Terminals							
Operating							
Dabhol LNG	Ratnagiri G&P	Dahol	Maharashtra	India	5.0	0.7	2012
Dahej LNG	Petronet	Dahej	Gujurat	India	15.0	2.0	2004
Hazira LNG	Shell	Hazira	Gujurat	India	5.0	0.7	2005
Kochi LNG	Petronet	Kochi	Kerala	India	5.0	0.7	2013
Arun LNG	Pertamina	Lhokseumawe	Sumatra	Indonesia	3.0	0.4	2015
Bali FSRU LNG	Gas Entec	Denpasar	Bali	Indonesia	0.4	0.0	2016
Lampung FSRU	PGN	Lampung	Lampung	Indonesia	1.8	0.2	2013
West Java FSRU	Pertamina	Tipar	West Java	Indonesia	3.0	0.4	2012
Melaka LNG	Petronas	Melaka	Melaka	Malaysia	3.8	0.5	2013
Singapore LNG	SLNG	Jurong	Jurong	Singapore	3.5	0.5	2013
PTT LNG	PTT LNG	Bangkok	Bangkok	Thailand	5.0	0.7	2022
Under Construction							
Digha FSRU LNG	HEECPL	Digha	West Bengal	India	3.0	0.4	2020
Ennore LNG	Indian Oil	Chennai	Tamil Nadu	India	7.5	1.0	2018
Haldia LNG	Essar	Haldia	West Bengal	India	1.0	0.1	2020
Jaigarh FSRU LNG	HEECPL	Jaigarh	Maharashtra	India	3.5	0.5	2018
Mangalore LNG	MRPL	Mangalore	Karnataka	India	2.5	0.3	2019
Mundra LNG	GSPC LNG	Mundra	Gujurat	India	5.0	0.7	2021
Pipavav FSRU LNG	Swan LNG	Pipav	Gujurat	India	5.0	0.7	2020
Banten LNG	PGN	Cilegon	Banten	Indonesia	4.0	0.5	2019
Bojonegara FSRU LNG	Pertamina	Bojonegara	Central Java	Indonesia	1.2	0.2	2018
Pengerang LNG	Dialog LNG	Pengerang	Johor	Malaysia	5.0	0.7	2019
Pagbilao LNG	EWC	Pagbilao	Quezon	Philippines	3.0	0.4	2020
Singapore LNG	SLNG	Jurong	Jurong	Singapore	4.9	0.6	2018
PTT LNG	PTT LNG	Bangkok	Bangkok	Thailand	4.9	0.6	2018
Proposed							
Gangavaram LNG	Petronet	Gangavaram	Andra Pradessh	India	5.0	0.7	2021
Mumbai FSRU LNG	GDF Suez	Mumbai	Maharashtra	India	5.0	0.7	2018
Semarang FSRU LNG	Pertamina	Cilacap	Central Java	Indonesia	3.0	0.4	2019
Dawei LNG	Dawei LNG	Dawei	Tanintharyi	Myanmar	4.0	0.5	2021
Batangas LNG	PNOC	Batangas	Batangas	Philippines	5.0	0.7	2020
Son My LNG	PetroVietnam	Son My	Binh Thuan	Vietnam	3.6	0.5	2023
Postponed							
Kakinada FSRU LNG	IOC	Kakinada	Andra Pradessh	India	5.0	0.7	
Paradip FSRU LNG	GAIL	Paradip	Odisha	India	4.0	0.5	
ThiVai LNG	PetroVietnam	Vung Tau	Ba Ria Vung Tau	Vietnam	1.0	0.1	
Totals							
Liquefaction Plants							
– Operating					65.3	8.6	
– Under Construction					7.3	1.0	
					72.6	9.6	
Import Terminals							
– Operating					50.5	6.6	
– Under Construction					50.5	6.6	
– Proposed					25.6	3.4	
– Postponed					10.0	1.3	
					136.6	18.0	

Analysis Based on Company, Country, IEA Data IEEJ-EPRINC

TABLE OF ABBREVIATIONS

Government Ministries, Departments, and Agencies

METI	Japan's Ministry of Trade, Economy, and Industry
BEA	U.S. Bureau of Economic Analysis
CFTC	U.S. Commodity Futures Trading Commission
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIA	U.S. Energy Information Administration
FERC	U.S. Federal Energy Regulatory Commission

Development Banks and Related Agencies

ADB	Asian Development Bank
Ex-Im	U.S. Export-Import Bank
ECA	Export Credit Agency
IFC	International Finance Corporation
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
NEXI	Nippon Export and Investment Insurance
OPIC	Overseas Private Investment Cooperation
WB	World Bank

Policy Research Organizations and Related Entities

IEEJ	Institute of Energy Economics, Japan
EPRINC	Energy Policy Research Foundation, Inc.
ERIA	Economic Research Institute for ASEAN and East Asia
EDMC	IEEJ Energy Data and Modeling Center
NBR	National Bureau of Asian Research
IEA	International Energy Agency

Intergovernmental Economic Organizations

ASEAN	Association of Southeast Asian Nations
OECD	Organization for Economic Co-operation and Development

Regional Designations

EAS	East Asia Summit
JKT	Japan, Korea, and Taiwan

Natural Gas-Related Terms

LNG	Liquefied Natural Gas
FSRU	Floating, Storage, and Regasification Unit

Metrics

Bcf	Billion Cubic Feet
Bcf/d	Billion Cubic Feet per Day
mcf	Thousand Cubic Feet
MMBtu	Million British Thermal Units
MMT	Million Metric Tonnes
Mtpa	Million Metric Tonnes Per Annum
Tcf	Trillion Cubic Feet

Abbreviations Not Elsewhere Classified

CPP	Clean Power Plan
FID	Final Investment Decision
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GIIGNL	International Group of Liquefied Natural Gas Importers
INDC	Intended National Determined Contribution
MDB	Multi-lateral Development Bank

NOTES ABOUT THIS PUBLICATION

Typography

Text font is Melior. A twentieth century modern face commissioned by Stempel and designed by Hermann Zapf in 1952; it is based on his thoughts about the squared-off circle known as the super-ellipse. The type was originally intended as a newspaper text face by Linotype.

Section heads as well as figure and table titles font is Gill Sans. The successful Gill Sans was issued by Monotype in 1928 to 1930. The roots of Gill Sans can be traced to the typeface that Gill's teacher, Edward Johnston, designed for the signage of the London Underground Railway in 1918. ... Gill Sans is a humanist sans serif with some geometric touches in its structures.

Figures and tables font is Arial. The Arial typeface is one of the most widely used designs of the last 30 years. Drawn in 1982 by Monotype Imaging designers Robin Nicholas and Patricia Saunders. It is often used in place of Helvetica which is a Swiss font designed in 1957. Both fonts are known for their legibility.

Photography

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