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Global Liquefied Natural Gas Supply: An Introduction for Public Utility Commissioners

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Introduction

Natural gas has a variety of direct uses ranging from fuel for generating electric power to residential, transportation, commercial and industrial applications. Being high in embedded energy, an abundant domestic fuel source and the cleanest burning fossil fuel, natural gas has several economic, environmental and national security benefits that have made it increasingly important to State regulators. However, price volatility and the threat of supply disruptions for natural gas have brought attention to the fact that this energy resource, like many others, can benefit from a diverse portfolio of sources including imported Liquefied Natural Gas, or LNG, an area of increased interest in the past decade. With natural gas demand projected to steadily increase in the coming years, LNG may be an important part of the US natural gas market by providing a supply alternative that allows source diversity, meets spot market demand, serves important local uses, and creates storage alternatives. This primer explores the supply dimensions of LNG: where it comes from, what it costs, and what factors may make it an important resource for State Commissions to consider.

What is LNG?

Natural gas is a combustible, gaseous mixture of simple hydrocarbon compounds, mostly methane, usually found in deep underground reservoirs or porous and permeable rocks. LNG is natural gas that has been cooled to -256°F (-161°C) at atmospheric pressure to condense it to a liquid state in a process called "liquefaction." In this state, natural gas fills about 1/600 the volume of its gaseous state, making it more economical to transport long distances, such as between continents, in specially designed ocean vessels. When it arrives at its destination, LNG can be used as an alternative transportation fuel or heated and allowed to expand to its original gaseous state in a process known as "regasification" to be used for heating, cooking and generating electricity, among other industrial uses.

LNG In the US

On average over the last 30 years LNG has provided between 1% and 3% of yearly US natural gas demand.[1] Though today LNG accounts for about 1.5% of all natural gas consumed in the US and "natural gas production in North America is projected to gradually increase through 2025, [as] consumption has begun to outpace available domestic natural gas supply."[2]

Increasing domestic production of natural gas and fluctuating global demand have helped keep North American LNG prices lower than in Asian and European markets.[3] As a result, US LNG imports are currently at a point of little to no growth. This may

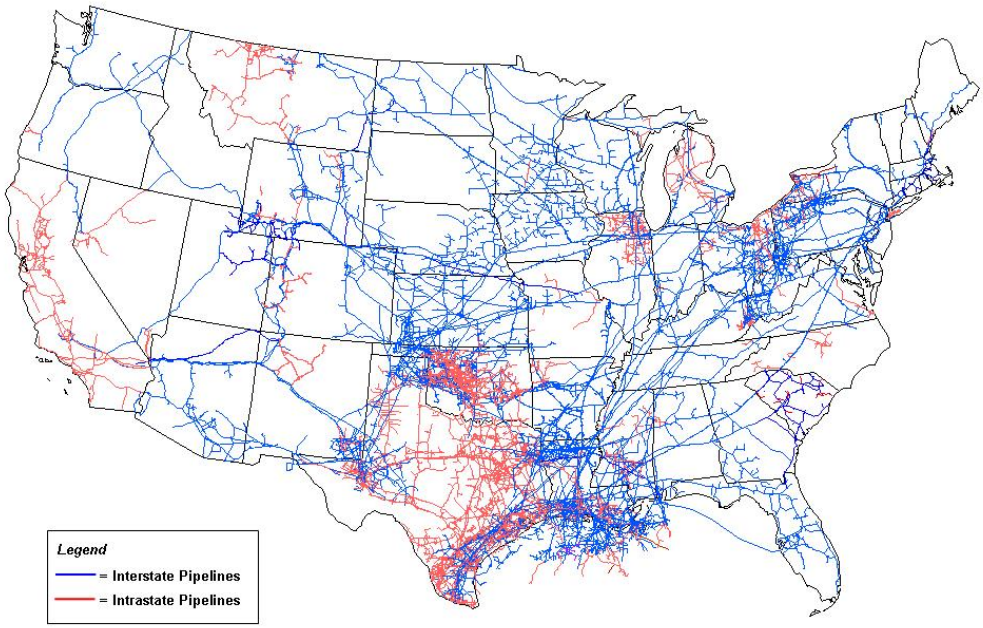
[1] EIA, *What role does liquefied natural gas (LNG) play as an energy source for the United States?*, July 2009. http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm
[2] DOE/NARUC, *Liquefied Natural Gas: Understanding the Basic Facts*, August 2005. http://www.fe.doe.gov/programs/oilgas/publications/lng/LNG_primerupd.pdf
[3] EEI, *Liquefied Natural Gas infrastructure in the Unites States: A Capacity Adequacy Study*

suggest that one limiting factor for US LNG demand is price. LNG can be more expensive than domestically-produced gas that is transported by pipeline and because it is subject to international market trading it is more difficult to create policies that help mitigate price impacts for US consumers. However, while liquefaction, transportation and regasification increase the overall price of LNG, higher natural gas prices coupled with technological advancements that drive down the cost of LNG have all helped make LNG more competitive in recent years.[4] In fact, improvements in LNG technology and costs may allow production of natural gas deposits that previously have been economically unviable.

US LNG Infrastructure

As of April 2009 there are nine existing LNG terminals in the US.[5] However, that number represents less than a third of the potential LNG terminals under US jurisdiction in the coming years. There are currently 22 additional proposed terminals, 18 of which have been approved by the FERC and four already under construction. These LNG terminals connect to an extensive existing natural gas infrastructure within the US. Once onshore there are over 305,000 miles of natural gas interstate pipeline with 24 hubs, or market centers, that provide interconnections, and over 400 underground storage facilities that can be utilized to transport the imported gas (see *Figure 1*).[6]

***Figure 1*: US Natural Gas Pipeline Network, 2009**

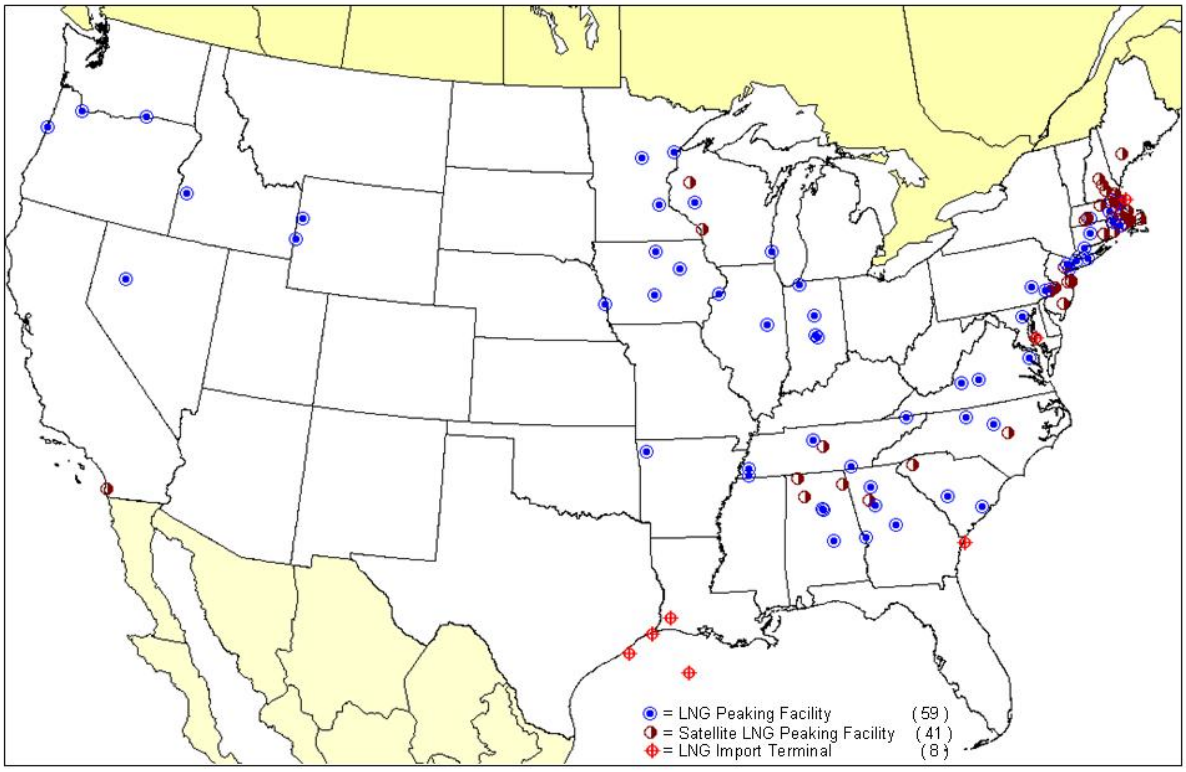


(source: EIA, 2008)

[4] EIA, *US LNG Markets and Uses: June 2004 Update*, June 2004. http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2004/lng/lng2004.pdf
[5] FERC, Liquefied Natural Gas (LNG), September 2009. http://www.ferc.gov/industries/lng.asp
[6] Energy Information Administration (EIA), *About US Natural Gas Pipelines*, "US Pipelines," http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html

Connected via those pipelines, there are 59 LNG peaking facilities and 41 satellite LNG peaking facilities.[7] The peaking, or peak-shaving, facilities store surplus natural gas that can be used to meet 'peak demand' of natural gas consumption at a later time. LNG storage also enables use of LNG as an alternative transportation fuel, several US facilities store LNG specifically for this purpose.

***Figure 2*: US LNG Peaking Shaving and Import Facilities, 2008**



(source: EIA, 2008)

US capacity to receive LNG imports has continued to grow considerably over the last decade (see *Figure 3*). This capacity combined with extensive pipeline infrastructure has already begun to increases LNG supply access to the US market and may help make LNG more stable and cost-efficient source of natural gas. In fact, US import and storage capacity in light of global LNG oversupply, discussed below, is currently allowing the US to become a market of last resort for LNG.[8] As the only country with significant gas storage capacity, LNG suppliers are selling LNG into the US market at the Henry Hub price, well below European and Asian market prices, because there is simply too much LNG and no other place to store it.

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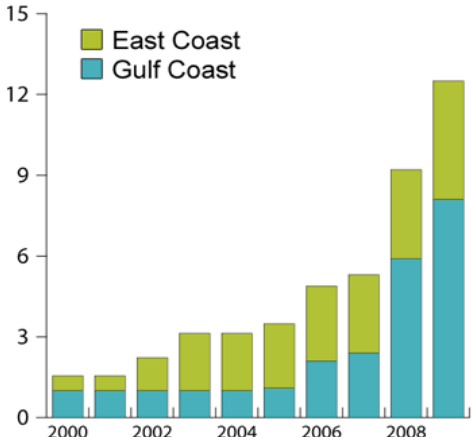
[7] EIA, *About US Natural Gas Pipelines- Transporting Natural Gas,* www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/lngpeakshaving_map.html

[8] Inside FERC, "Liquefied Natural Gas: US to continue as Market of last resort for LNG until demand meets supply, says exec," Platts, September 21, 2009.

Overall, the ability to reliably import LNG at a consistent price and store the gas, especially when domestic prices are volatile, may ultimately prove to be the key factor for the success of LNG in the US market.

Figure 3: **US Capacity to Receive LNG Imports, 2000-2009 (billion cubic**



(source: EIA, 2008)

An Overview of the Global LNG Market

As of 2009, there are 26 existing liquefaction, or export, terminals located in 15 countries around the world (see *Table 1*).[9] Regasification, or import, terminals are located in 18 countries for a total of 60 facilities worldwide (see *Table 2*). Over 200 additional liquefaction and regasification projects are either proposed or under construction.

Table 1: **Countries that Export LNG**

(year represents start up date of earliest liquefaction terminal)

Algeria, Republic of (1971)
Australia, Commonwealth of (1989)
Brunei, State of (1972)
Equatorial Guinea, Republic of (2007)
Egypt, Arab Republic of (2004)
Indonesia, Republic of (1977)
Libya (1970)
Malaysia (1983)
Nigeria, Federal Republic of (1999)
Norway, Kingdom of (2007)
Oman, Sultanate of (2000)
Qatar, State of (1997)
Trinidad and Tobago, Republic of (1999)
United Arab Emirates (1977)
United States of America (1969)

(source: CA Energy Commission, 2008)

Table 2: **Countries that Import LNG**

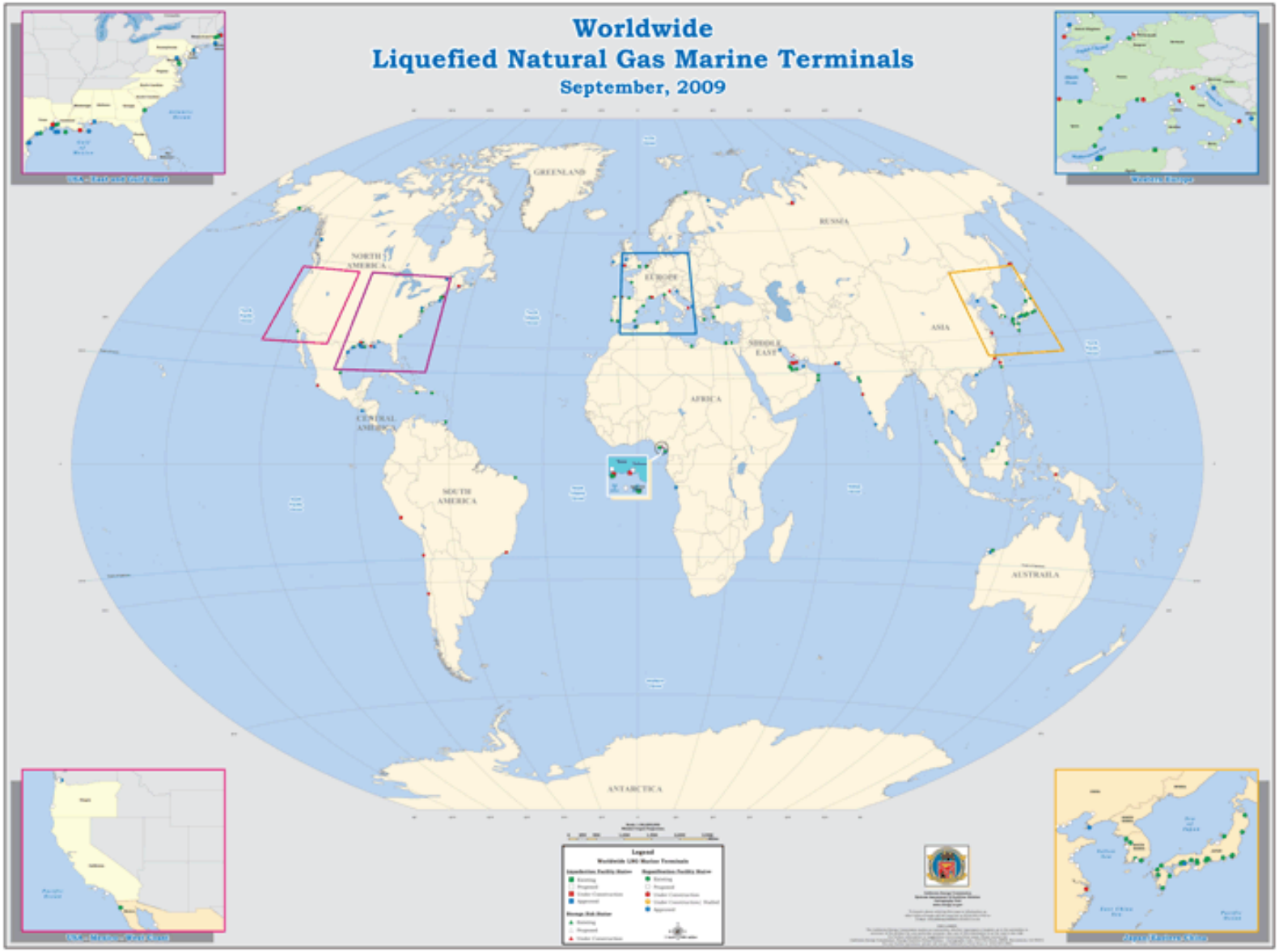
(year represents start up date of earliest regasification terminal)

Belgium, Kingdom of (1987)
China, People's Republic of (2006)
Dominican Republic (2003)
France (1972)
Greece (2000)
India, Republic of (2004)
Italy (1971)
Japan (1969)
Mexico (2006)
Portugal (2003)
Puerto Rico, Commonwealth of (2000)
South Korea, Republic of (1986)
Spain, Kingdom of (1969)
Taiwan (1990)
Turkey, Republic of (1992)
United Kingdom (2005)
United States of America (1971)

(source: CA Energy Commission, 2008)

[9] CA Energy Commission, 2008. http://www.energy.ca.gov/lng/international.html

***Figure 4*: Worldwide LNG Facilities**



(source: CA Energy Commission, 2009)

Understanding the Global LNG Market

Declining gas demand in the face of continued investment in LNG infrastructure has resulted in a global LNG supply surge. According to industry analysis, supply-demand ratios should begin to balance out over the next several years as global LNG trade is expected to increase up to 48% by 2012.[10] This growth is expected to come mostly from Asia, particularly China and India, but because of the inherent global nature of LNG trade it is important to consider the ramifications of geography and regional markets in order to understand how and why this growth will occur.

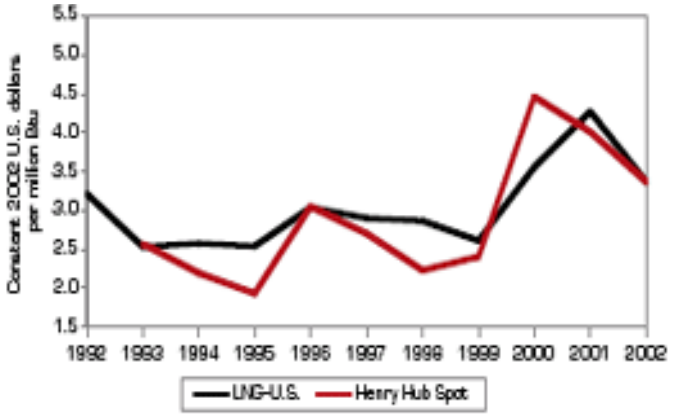
LNG Market Development and Pricing

When analyzing the global LNG market, it is helpful to distinguish the difference between how markets have developed over time. For example, countries in the Atlantic basin, such as Europe and the US, for the most part have existing pipeline infrastructure and access to either domestic or land-based natural gas supplies.[11] Countries in the Pacific basin such as Japan, South Korea and Taiwan, on the other hand, general have little or no existing pipeline infrastructure and little or no access to domestic or land-based natural gas. Thus in the last three decades, while LNG imports have grown rapidly in the Pacific Basin, imports in the Atlantic basin have experienced a much slower and reserved growth rate.

LNG prices are tied to competing fuel prices[12] based on the preferred pricing structure of the market in which you are operating.[13] Three examples are listed below:

US- LNG prices are tied to pipeline natural gas prices. Pricing can either be determined by long-term contract or short-term sales based on Henry Hub prices (see *Figure 5*). Given the high volatility of the US natural gas market, there is quite a bit of risk in selling LNG into the US market from a pricing standpoint.

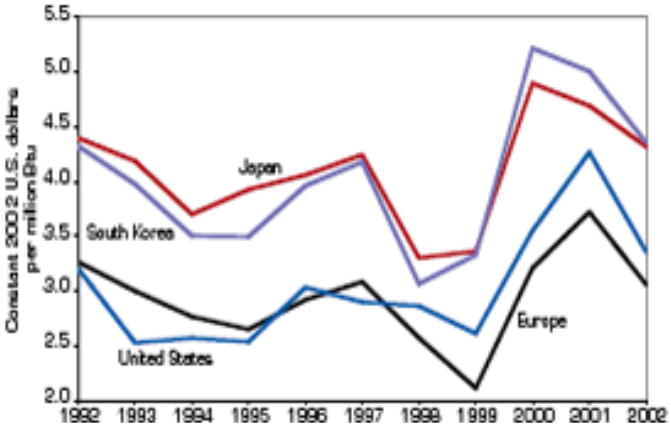
***Figure 5*: LNG Import Prices and Henry Hub Spot Prices in the US, 1992-2002**



(source: EIA, 2003)

[10] IHS CERA, *Global LNG: No Immediate Return To Balance Market Briefing Report*, October 5, 2009.
[11] EIA, *The Global Liquefied Natural Gas Market: Status and Outlook*, Dec 2003, http://www.eia.doe.gov/oiaf/analysispaper/global/lngmarket.html
[12] In general LNG prices are calculated via one of two methods: a) free on board (fob) or b) delivered ex-ship (des). Fob pricing allows buyers more control over the landing price and the option to trade surplus LNG cargos; most sales today are fob.
[13] EIA, *The Global Liquefied Natural Gas Market: Status and Outlook*

***Figure 6*: Global LNG Import Prices, 1992-2002**



(source: EIA, 2003)

Europe- Price is often benchmarked low-sulfur residual fuel oil. Recently LNG prices have begun to be tied to natural gas spot and future market prices.

Asia- LNG price is linked to imported crude oil. This pricing structure generally includes a base price plus an adjustment factor, leading to some of the highest LNG sale prices in the world.

Given these characteristics it is easy to see how demand has helped drive higher prices in the Pacific basin, US$4/MMBtu for the Pacific basin and US$3/MMBtu for the Atlantic basin respectively.[14] However, it is important to note that LNG and pipeline gas "hubs" are emerging in many places and this may lead to price convergence in the future.

Contracts

LNG purchasing contracts come in two general varieties: long-term and short-term.[15] Historically, long-term contracts have been the driver behind LNG markets, providing supply security for buyers while ensuring a market for suppliers. These 20-25 year contracts often included clauses that prevented buyers from reselling to third parties and ensured that the entire cargo would be purchased. However, recent trends show greater flexibility in contract terms, including length, price and volume. This has led to a shift in business models for buyers and sellers. Several traditional sellers, such as BP and Shell, have been expanding their business models to include leasing capacity at terminals and becoming involved in trading. A number of new buyers have emerged and traditional buyers have begun looking into investment in production and transport.

Short-term contracts have a number of potential advantages for both sellers and buyers. For example, short-term sales:

a) lower the risk for new producers to enter the market by removing the long-term production commitments,
b) allow greater response to market demand (i.e. seasonal demand),
c) give greater flexibility to commit ships as needed, and
d) may allow 3rd party sales to help LNG reach new markets.

[14] EIA, *The Global Liquefied Natural Gas Market: Status and Outlook*
[15] EIA, *The Global Liquefied Natural Gas Market: Status and Outlook*

Shorter contract may also lead to lower prices, as they allow new suppliers to compete in the established market and enable suppliers to factor in lower operational costs due to technological advancements.

The Context: US Natural Gas Market

In addition to the global infrastructure and supply issues considered above, demand for LNG in the US is affected strongly by trends in the domestic natural gas market.

Domestic Natural Gas Supply

According to EIA's 2009 Energy outlook, domestic production of natural gas is expected to increase significantly by 2030.[16] The overall growth will be characterized by an increase from 18.6 trillion cubic feet in 2006 to 20.0 trillion cubic feet in 2022, followed by a slight decline to 19.5 trillion cubic feet by 2030. Of the domestic natural gas resources, it is expected that the majority of this supply will come from unconventional onshore sources. There are several important components to keep in mind when projecting US natural gas supply in the coming decade. One such factor is the Alaska natural gas pipeline. With an expected completion date in 2020, this pipeline is predicted to increase domestic production by 2.0 trillion cubic feet with steady production through 2030. Another significant domestic resource is "unconventional" natural gas held in shale formations. Recent discoveries in the United States, as well as technological advancements in hydraulic fracturing technology and horizontal drilling, have opened the possibility that new sources of shale gas could lead to substantial increases in reserves of US natural gas.

US Natural Gas Imports

The US currently receives the majority of its natural gas imports via pipeline from Canada, 3,585,728 million cubic feet.[17] While Mexico provides an additional 43,314 million cubic feet, all other imported natural gas arrives to the US in the form of LNG, a total of 351,699 million cubic feet of LNG. Of these three sources, Mexico provides the lowest cost source of gas at 7.62 dollars per thousand cubic feet, while Canada prices in at 8.56 dollars per thousand cubic feet and the average cost of imported LNG is about 10.03 dollars per thousand cubic feet.

Extended Outlook for LNG in the US

Natural gas is the cleanest burning fossil fuel and may play an important role in diversifying US fuel sources under carbon legislation. Despite an expected increase in domestic natural gas production in the coming years, LNG may remain an important part of the US natural gas market for a number of reasons. As an imported fuel, LNG can supplement domestic supply to meet demand in times of domestic resource scarcity.

[16] EIA, Annual Energy Outlook 2008 (Early Release), "Energy Production and Imports," http://www.eia.doe.gov/oiaf/aeo/production.html

[17] EIA, *US Natural Gas Imports by Country*, September 2009. http://tonto.eia.doe.gov/dnav/ng/ng_move_impc_s1_a.htm

Nationally, this can help ensure a diverse gas supply portfolio. LNG can also help meet US demand and moderate the affordability of natural gas by enabling peak shaving, leveling out spot market prices and increasing the resiliency and reliability of natural gas supply in the US. Perhaps equally important is its role in ensuring local and regional supplies in the event of economic or emergency-related supply disruption: when a pipeline no longer supplies gas sufficient to meet demand, LNG creates alternatives.

Nonetheless, understanding the global LNG market is crucial to predicting the current and potential future role of LNG in the US natural gas market. Technological advancements, short-term sale trends and increased competition in the LNG global market may cause LNG prices to become more and more competitive with domestic natural gas prices. As the regulators of both the direct-use gas utilities and of electricity providers who depend on gas for fuel, it may be critical for Commissions to understand the factors that determine the price and availability of this commodity.

Where can I find out more?

This primer was developed by Bevan Flansburg and Miles Keogh of the Grants & Research Department of the National Association of Regulatory Utility Commissioners (NARUC) with funding from the US Department of Energy. Oversight on this primer was provided by Commissioner Timothy Simon, Karen Shea, and Paul Phillips of the State of California Public Utilities Commission. A special thanks to Christopher Freitas of the DOE Office of Fossil Energy for his insight and guidance in preparing this document. Information was drawn from sources published in recent years as well input from experts in the field. More information can be found using the links below.

About the DOE/NARUC LNG Partnership

The DOE/NARUC LNG Partnership, a collaboration between the National Association of Regulatory Utility Commissioners and the US Department of Energy, is currently in its sixth year. This *Partnership* is designed to educate energy decision makers and the public about LNG in order to enhance communications with stakeholders to ensure responsible development of state and regional strategies relating to LNG education, resource development and deployment. For more information on LNG and the Partnership please visit http://fossil.energy.gov/programs/oilgas/storage/index.html or http://naruc.org.

The LNG Partnership has sponsored three other reports: a LNG White Paper *Importing Liquefied natural Gas: A State Regulator's Perspective*; *Liquefied Natural Gas: Understanding the Basic Facts*; and *Model Liquefied Natural Gas Communications Plan for States*. All of these documents are available at www.naruc.org/domestic.

Resources

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Inside FERC, "Liquefied Natural Gas: US to continue as Market of last resort for LNG until demand meets supply, says exec," Platts, September 21, 2009.

For copies of this publication, please contact Miles Keogh (mkeogh@naruc.org) or Bevan Flansburg (bflansburg@naruc.org).