LIQUEFIED NATURAL GAS UNCERTAINTY ISSUES

DRAFT STAFF PAPER

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Abstract

California energy policy has long recognized the importance of maintaining access to reliable supplies of natural gas, including liquified natural gas (LNG). However, U.S. LNG imports in 2008 were significantly lower than the amounts that market experts projected several years ago. The decline in LNG imports can be attributed to a range of market developments, both global and domestic. U.S. and West Coast LNG terminal development appears to be slowing, and there is a growing sense that the United States may not need to rely on LNG to make up previously projected supply deficits. Uncertainties that affect LNG markets include greenhouse gas regulation, domestic natural gas supply, and changes in domestic and global market dynamics.

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Keywords: Liquefied natural gas, LNG, carbon footprint, natural gas, liquefaction, regasification, import, export, geopolitics

Introduction

California energy policy has long recognized the importance of maintaining access to reliable supplies of natural gas. The ability to heat and light California's homes depends on this important source of energy. In previous *Integrated Energy Policy Reports (IEPRs)*, that recognition translated into general support by the California Energy Commission (Energy Commission) for importing liquefied natural gas (LNG) as a way to offset declining domestic production of natural gas and to diversify supply. In the *2007 IEPR,* staff projected that as much as 20 percent of North American natural gas requirements might be met with LNG by 2017. The *2007 Final Natural Gas Market Assessment* discussed some of the uncertainties associated with those projections, but did not comprehensively characterize those uncertainties.[1] For the *2009 IEPR*, staff is concentrating on bringing into focus key uncertain market issues and developing insight into the range of potential outcomes.

The key questions around LNG are the following:

- What is the global potential?
- How much of it can be expected to come to the United States?
- How might the future diverge from current expectations?

United States LNG imports in 2008 were significantly lower than the amounts projected by Energy Commission staff and others, owing to a range of market developments, both global and domestic. In addition, U.S. and West Coast LNG terminal development appears to be slowing, and there is a new sense that the United States may not need to rely on LNG to make up previously projected supply deficits. This paper reviews those developments. It describes the status of North American import facilities and the factors that will further change the quantity and price of potential LNG imports. It elucidates the link between LNG and domestic production in meeting the state's supply needs and identifies factors that require monitoring. Additionally, it provides information about the "gas quality" characteristics of LNG and its carbon footprint. Throughout, the paper attempts to describe the opinions of a variety of experts and highlight areas of agreement and disagreement among them.

Highlights

- LNG imports to the United States have fallen drastically from the peak set in 2007 and are significantly below projections from the *2007 IEPR*. This is in part the result of higher U. S. and world energy prices seen in mid-2008 that finally led to increased domestic

[1] California Energy Commission, *2007 Final Natural Gas Market Assessment*, December 2007, CEC-200-2007-009-SF.

production, reducing the need for LNG. At the same time, higher world prices for LNG made LNG exports to the United States economically unattractive.

- The bevy of LNG facilities previously proposed for California has been reduced to two, only one of which has filed applications for permits. California, however, has potential new sources of natural gas with pipeline projects on the horizon and an existing LNG import facility in Baja, Mexico.
- Additional LNG export facilities are scheduled to come on-line this year in the face of declining demand for natural gas worldwide. For this reason, some industry experts believe an increase in LNG imports to the United States will occur by the end of the year.
- LNG tends to contain higher-Btu-content hydrocarbons that have not been processed out as is typically done with domestically produced natural gas. This can cause increased particulate emissions and has raised some health and environmental concerns about the use of LNG.
- There appears to be a growing consensus that the carbon footprint for LNG, on a lifecycle basis, is smaller than that of coal-fired generation.
- It remains unclear how much LNG will come to the United States in both the short-term and long-term future.

Recent LNG Deliveries Into the United States

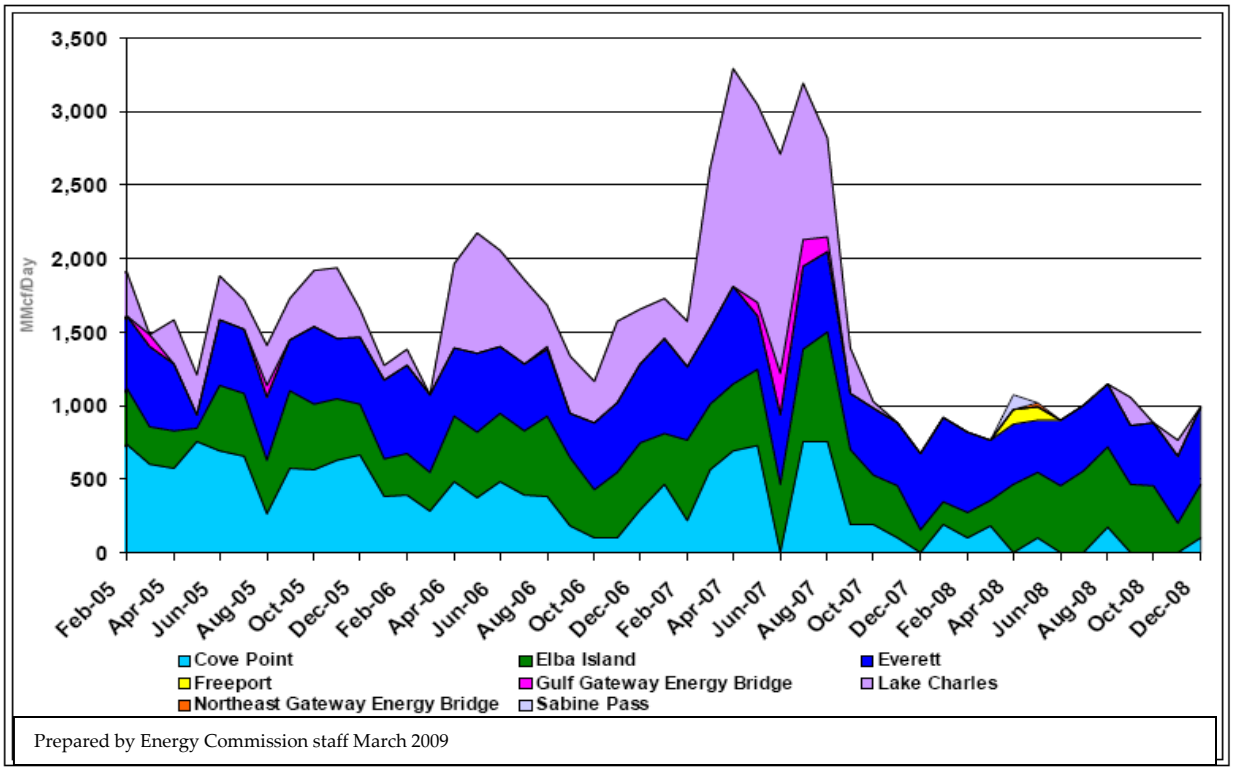
Recent developments in the LNG deliveries into the United States provide a useful starting point for this review. The pattern of those deliveries is not what many analysts expected. After averaging around 750 million to 800 million cubic feet (MMcf) per day from 1999 to 2003, LNG deliveries to the United States increased by about 1 billion cubic feet (Bcf) per day to average roughly 1,700 MMcf per day from 2003 to 2006. Deliveries then suddenly increased by approximately another 1 Bcf per day in summer 2007, reaching a peak of approximately 3.3 Bcf per day. This peak quantity represented roughly 5 percent of average daily U.S. demand during those months. In 2008, deliveries returned to about the 1 Bcf-per-day level, a 200 percent decline compared to the summer 2007 peak. The increase in deliveries for 2003 to 2006 largely reflected increased terminal capacity as global LNG trade expanded. Various industry assessments projected continued increases in LNG deliveries to the United States to make up projected deficits between demand and North American natural gas production.

Figure 1 shows monthly LNG imports broken down by U.S. receiving terminal between February 2005 and December 2008. The figure shows that much of the increase in deliveries and the subsequent decrease occurred at Lake Charles, Louisiana. Deliveries into Everett, Massachusetts, and Elba Island, Georgia, have been least affected. Newer terminals, such as the Gateway Energy Bridges, Freeport (Texas) and Sabine Pass (Louisiana), have experienced deliveries only during the 2007 peak and have remained largely (but not

entirely) unused since. Note that deliveries into Everett and Elba Island tend to be purchases of natural gas made under long-term contracts of Atlantic basin LNG, such as gas from Algeria and Nigeria. The new Gulf Coast terminals largely have been contracted as tolling facilities under which a natural gas marketer owns rights to the capacity and brings cargoes from time to time depending on prevailing global LNG prices.

Table 1 lists the total LNG receipts by each facility for 2007 and 2008. The figures and the table amply demonstrate the significant increase and subsequent decrease in LNG deliveries into the United States.

Figure 1: U.S. LNG Imports by Terminal (MMcf/Day)



Source: EIA data

Several factors help explain why LNG imports decreased so significantly. The first is that natural gas production from shale fields in the United States unexpectedly grew very quickly in 2008. The new source of domestic production lowered prices and displaced the need for LNG. The second is that while natural gas prices in mid-2008 were high relative to world LNG prices, they were not high enough to attract LNG to the United States. The high natural gas prices in 2008 did spur investments in technology that resulted in production growth from unconventional sources. A third is that the 2007 spike in LNG imports to the

United States occurred in part because European storage capacity, which is generally lower than U.S. natural gas storage capacity, was full. During the summer months of 2007, LNG exporters had no place to sell the gas but to the United States. Fourth, world LNG supply has not grown as expected because of high production costs and geopolitical disruptions in key exporting countries.

Table 1: LNG Imports by Terminal (Billion Cubic Feet)

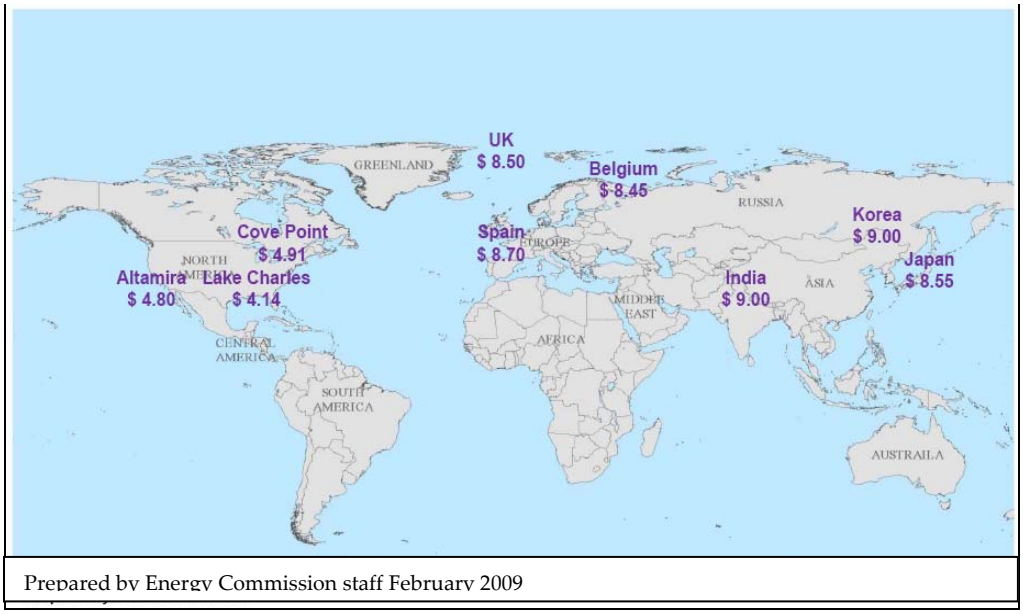
City	2007	2008
Cove Point	142.4	25.9
Elba Island	167.4	135.7
Everett	184.1	165.3
Gulf Gateway Energy Bridge	20.1	
Lake Charles	246.1	8.9
Freeport		5.7
Northeast Gateway Energy Bridge		0.9
Sabine Pass		3.0
Total	760.1	345.4

Source: EIA data

Figure 2 shows the estimated landed prices for LNG imports in January 2009. These prices were compiled using data from a February 2009 *Market Snapshot: Western States Version*.[2] The landed prices for the Asian market (Japan, Korea) are significantly higher than those shown for LNG terminals in the United States and Mexico. Producers of LNG are located closer to the Asian market. The resulting lower transportation costs allow producers to maximize profit margins by selling their LNG in Asian markets.

[2] Federal Energy Regulatory Commission, *OE Energy Market Snapshot: Western States Version January 2009 Data*: http://www.ferc.gov/market-oversight/mkt-snp-sht/2009/02-2009-snapshot-west.pdf

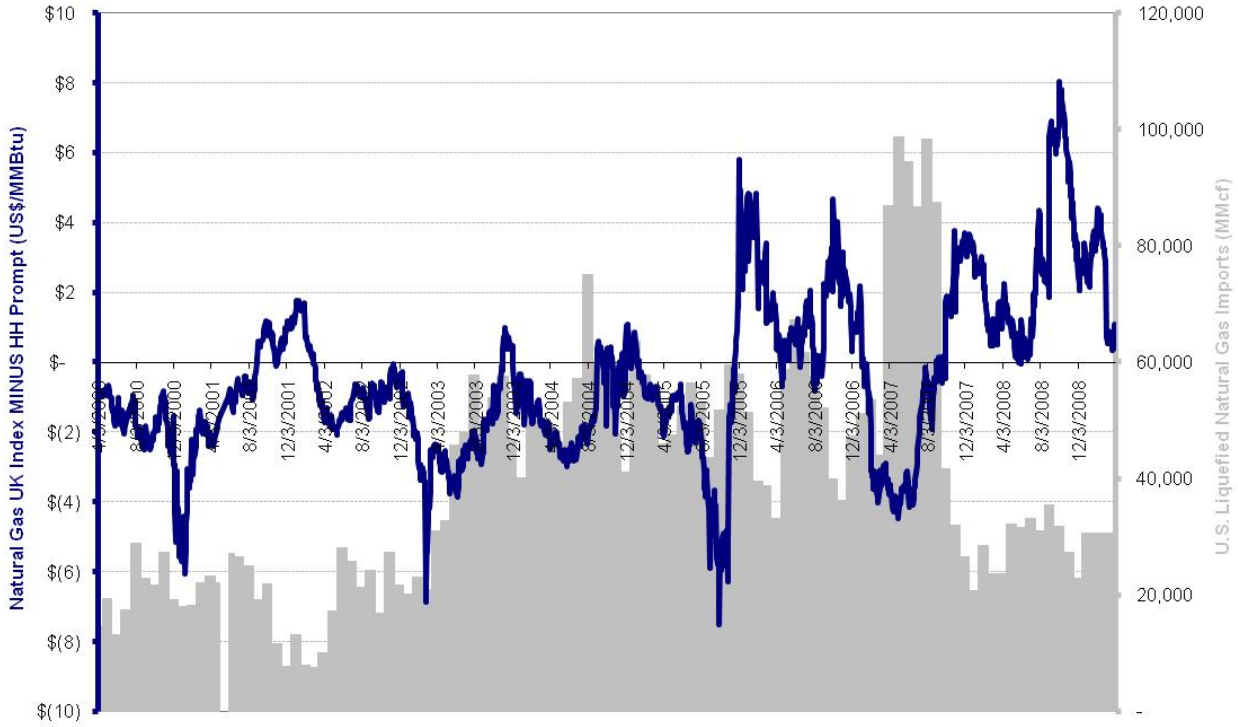
Figure 2: World Landed LNG Prices



Source: FERC data

The market benchmark often cited for European natural gas prices is the United Kingdom's "National Balancing Point" or NBP. **Figure 3** juxtaposes the difference between NBP prices and Henry Hub prices against U.S. LNG imports. Henry Hub, located in Erath, Louisiana, is the pricing point for natural gas futures contract traded on the New York Mercantile Exchange (NYMEX). The figure shows how, particularly beginning in 2007, U.S. LNG deliveries increase when Henry Hub prices are higher than NBP prices.

Figure 3: U.S. LNG Imports Versus UK Minus U.S. $/MMBtu Spread



Source: RW Beck using data from EIA, NYMEX and Oanda

Background on LNG

LNG is the liquid form of natural gas when cooled to minus 260 degrees Fahrenheit. LNG occupies 1/600th the space of natural gas in its vapor form. LNG is usually made at liquefaction export facilities and shipped over water in specially designed tankers (**Figure 4**). It is then regasified, generally by warming it back to ambient air temperatures. Upon return to its normal, gaseous state, it can be fed into the local natural gas pipeline systems.

Figure 4: LNG Tanker

Source: Institute for the Analysis of Global Security

California and LNG

California's history with LNG dates back to 1972. Despite several attempts, no LNG project has successfully gained all of its permits and proceeded to construction in California.

In 1972 Western LNG Terminal Company proposed to build an LNG receiving facility at Point Conception in southern California. While the project was federally approved, the application was later rescinded after the project was later deemed uneconomic.

In 1977 the Legislature passed the LNG Terminal Act (repealed in 1987), which required the California Coastal Commission to identify and rank possible LNG sites and provide the information to the California Public Utilities Commission.

In 2002 Shell Energy and the Bechtel Corporation proposed to construct an LNG facility at Mare Island, a former naval shipyard in San Pablo Bay near the Carquinez Strait. Considerable citizen opposition, particularly to the notion of LNG tankers sailing under the Golden Gate and Richmond-San Rafael Bridges, prompted the withdrawal of this project.

In 2004 the Cabrillo Deepwater Port LNG Facility was proposed off the coast of Malibu. The California Coastal Commission and the State Lands Commission rejected the project, citing failure to meet environmental standards. The facility's application was rejected in a letter from the Governor and other state agencies. Governor Schwarzenegger's letter stated: "LNG is important to California's energy future, and I believe an offshore LNG facility can be constructed along the coast that meets California's stringent environmental standards."

In 2008, Woodside Energy withdrew its application for the Ocean Way LNG terminal, stating that should market conditions improve, they would apply again in the future.

Two other potential LNG importers have announced their desires to build facilities:

Clearwater Port is a facility that would be located 12.6 miles offshore of Oxnard. An application was filed with the U.S. Coast Guard/MARAD and the California State Lands Commission on June 30, 2006.

Port Esperanza is another import facility that would be located 15 miles seaward of the Port of Long Beach. Esperanza Energy, LLC, announced its project in March 2007, but has yet to file an application.

LNG Around the World

LNG exists largely because of the location of natural gas reserves relative to demand around the world and the availability of shipping and liquefaction technology. Reserves are located in places where there is insufficient local demand to consume the gas. The availability of liquefaction and shipping technology makes it economic to produce the gas, liquefy it, and ship it to other markets.

The LNG market aligns itself into the Atlantic Basin and Pacific Basin markets. The United States sits in between, with the West Coast closer to Pacific-sourced LNG and the East and Gulf Coasts participating in the Atlantic basin market. Key characteristics of these markets and factors affecting LNG access for the United States are described below. While these markets are different relative to each other and to the U.S. market, one key driver is that their relative deficits of domestic supply or local production to demand is much greater than in the United States.

In 2008 the United States produced 20.57 trillion cubic feet (Tcf) of natural gas and consumed 23.2 Tcf.[3] **Table 2** shows how much LNG the United States received for 2008.

Table 2: U.S. LNG Imports by Exporting Country (Bcf)

Source	2008
Egypt	54.8
Nigeria	12.0
Norway	17.5
Qatar	3.1
Trinidad	264.3
Total	351.7

Source: EIA Data

[3] Energy Information Administration, Natural Gas U.S. Data: http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html.

Asian Market

Japan and South Korea import more LNG than any other country in the world. These industrialized countries have virtually no domestic natural gas production. Japan also has no coal production, and South Korea has only a very small amount.[4] Each has very little domestically produced crude oil. Thus, their choice is between importing LNG and importing crude oil. As a result, Asian LNG contracts are typically tied to the price of crude oil. Japan alone accounts for about 40 percent of global LNG imports, and it uses the gas to produce as much as 65 percent of its electricity generation. Load growth must be met with increased LNG imports. Supplies of LNG usually come to the Asian market from Pacific Rim countries, but this market sometimes receives LNG shipments from counties in the Atlantic Basin.

In the near term, energy demand in all countries is down due to the financial crisis and ensuing global economic recession. Demand for LNG will be further reduced by the restart of Japan's largest nuclear reactor in mid-2009. Tokyo Electric Power Company's 8,200 MW Kashiwazaki Kariwa nuclear reactor was taken offline for inspection after an earthquake in July 2007. The inspection revealed the plant had been shaken beyond its design standard and, as a result, the plant was closed to implement seismic safety enhancements. To replace the power generated at the plant, Japan imported approximately 6 percent more LNG.

Reactivation of this nuclear plant should further curb demand for LNG in Japan. Tokyo Electric Power released a statement that they expect to receive LNG equivalent to 2.3 Bcf/d for the April 2009-March 2010 fiscal year. This estimate is down 5.8 percent from original receipt estimates. Decreased LNG demand from Japan will free up supplies for the rest of the world.

European Market

Europe is the second largest LNG consuming region in the world. Europe uses a mixture of crude oil, pipelined natural gas, and LNG for its energy needs and produces approximately one-third of its electricity using natural gas – a higher percentage than the 21 percent the United States uses. Domestic production of natural gas in Europe had been steadily declining over the years. The difference has been made up by LNG imports and pipelined natural gas from Russia. LNG accounts for about 10 percent of Europe's natural gas supply, most of it from Algeria, Nigeria, Egypt, and other Atlantic Basin countries. The price of natural gas in Europe is typically linked to the price of oil products and crude oil.

Russia provides approximately 25 percent of European natural gas imports. Since 80 percent of Russian natural gas exports to Europe flow through Ukraine, a 2008 dispute between Russia and Ukraine interrupted natural gas flows to Europe causing severe problems. This

[4] National Energy Board (2009). *Liquefied Natural Gas: A Canadian Perspective*. Page 8.

dispute has moved European nations to purchase more LNG from other nations to reduce reliance on Russia as a source of natural gas.

North American Market

North America's natural gas market is different than other markets in the world. North America produces close to 90 percent of the natural gas it uses and has a well-developed pipeline transportation grid to move gas supplies from producing basins to consumer markets.[5]

According to some sources, including Energy Commission staff's *2007 Final Natural Gas Market Assessment*, natural gas prices in the United States are affected to some extent by the price of crude oil. In addition, the natural gas market in the United States was deregulated sooner than in Europe. Furthermore, most the United States' supply is produced domestically rather than imported. For these reasons, natural gas prices are not as strongly linked to oil in the United States as they are in Asia or Europe. Natural gas prices in the United States tend to follow the general pattern of oil prices, but rise or fall around their Btu-equivalent based on the relative balance of domestic natural gas supply relative to demand. For example, while natural gas prices rose, following oil prices upwards, in 2007 and 2008, they didn't rise as much as oil prices on a per-Btu basis.

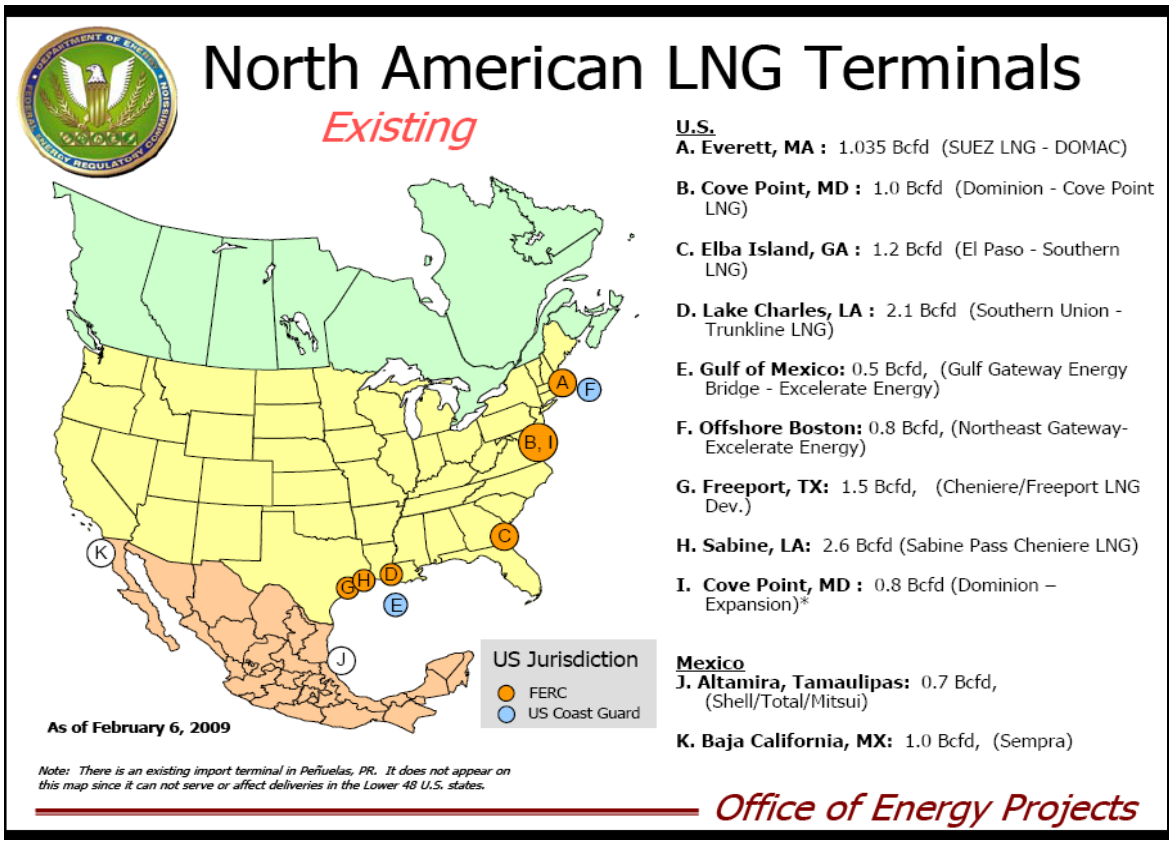
The United States also has more underground gas storage than Europe. Once European storage facilities fill and have no further capacity, as shown in 2007, storage capacity can make the United States a potential destination for LNG supply.

U.S. and West Coast LNG Terminal Update

Currently there are eight LNG import facilities in the United States, all located along the East Coast and in the Gulf of Mexico (**Figure 5**). **Figure 5** shows existing LNG facilities in the lower 48 states of the United States and in Mexico.

[5] Energy Information Administration, *Annual Energy Outlook 2009.*

Figure 5: U.S. LNG Terminals



Source: FERC data

The Kenai LNG terminal (not featured in **Figure 5**) in Alaska is currently the only facility in North America permitted to export LNG. Some LNG terminal owners in the United States are seeking permission to export LNG. Cheniere Energy submitted an application to DOE and to the Federal Energy Regulatory Commission (FERC) requesting permission for its LNG receiving terminal at Sabine Pass, Louisiana, to export LNG. Cheniere wrote the following in its application to FERC (September 1, 2008):

> *"Blanket export authorization would afford [Cheniere] the ability to purchase cargoes of LNG at current LNG prices with the intent that such LNG subsequently would be exported to a foreign market at a later date. In the event that U.S. market prices were to rise to the point where domestic sale of LNG held in storage was economic, the LNG would then be readily available for U.S. consumption."*[6]

Freeport LNG in Texas made a similar request to export LNG supplies delivered to it from abroad. According to Freeport's request to FERC on August 18, 2008:

[6] FERC Docket CP04-47.

"Given the global increase in demand for LNG and the concurrent disparity in natural gas prices in the United States relative to global markets, it is unclear when a constant and continuing supply of foreign sourced LNG will begin to arrive at the Freeport LNG facility and other U.S. import terminals."[7]

FERC has approved the request in the environmental assessment related to Cheniere's application.

The level of demand for natural gas contributes to viewing the United States not only as an importer, but also as an exporter of LNG. The current recession has resulted in no appreciable growth in natural gas demand – demand in the industrial sector has actually decreased. As a result, natural gas prices are steadily declining—currently under $4.00 per MMbtu. In reaction to the decline in revenues, low natural gas prices, the world financial crisis, and difficultly obtaining credit, producers have scaled back their 2009 well drilling plans. In addition, low prices of natural gas are no incentive for spot shipments of LNG to find its way to the United States. Other countries such as Japan have attracted most supplies of LNG because they are willing to pay more than what it is offered in the United States.

LNG on the West Coast

Potential importers of LNG to the West Coast are slowly withdrawing from the market. Just in 2008 and early 2009, two applicants withdrew their proposal for an LNG import facility in California. The circumstances behind these withdrawals were quite different. On June 8, 2008, Sound Energy Solutions officially withdrew its plan to build an LNG regasification facility in Long Beach. This came after the Long Beach Board of Harbor stopped work the environmental impact report (EIR), thus cancelling plans for the project. A Superior Court judge issued a preliminary ruling upholding Long Beach's rejection of the proposed LNG terminal, and Sound Energy Solutions withdrew its application before a final ruling could be made the court system.

On January 15, 2009, Woodside Energy suspended its proposal to build the Ocean Way LNG Terminal off the coast of Los Angeles, effectively putting an end to the plans for a regasification facility. Should Woodside Energy decide to come back and try again, the application process must start from the beginning. The project initially stalled in 2008 as the applicants responded to several questions from the U.S. Coast Guard. Then, the market for natural gas changed dramatically. Domestic production soared, demand declined, and the price for natural gas plummeted. During their withdrawal, Woodside Energy issued the following statement:

"The current conditions were not right for the proposed development. We still believe in the long-term value of (LNG) as a new source of clean, reliable and secure energy for Los

[7] Natural Gas Intelligence, *Global Prices Have Freeport LNG Looking to Export, August 18, 2008.*

Angeles, but we acknowledge the impact of the current market and have notified the regulatory agencies that we are withdrawing our application for the time being."[8]

Two potential developers have announced their desires to build projects in California. Esperanza Energy has proposed to build an LNG receiving terminal off the coast of Southern California, but has yet to submit an official application. The project is on hold.

The other LNG project proposed for California is the Clear Water Port LNG terminal by Northern Star Natural Gas. While an official application had been submitted and deemed complete, the applicant is currently responding to data gaps to complete the EIR/EIS. No significant progress has been made in the last six months to the project through the application process. No definite word has been given on the outlook of this project.

In Oregon there are three proposed LNG projects that have submitted an application. One project in particular has spurred discussions on how LNG projects are approved in the United States. On September 18, 2009, FERC issued an approval for the Bradwood Landing project, making it the first U.S. West Coast LNG terminal to receive a certificate order. This approval set off a firestorm of protest from state and local officials. In response to the protest, FERC granted a rehearing request for the Bradwood Landing project. Subsequently on January 15, 2009, FERC upheld its initial approval decision. This prompted the State of Oregon to file a petition with the Ninth Circuit Court of Appeals asking that FERC's approval of Bradwood Landing be overturned. These actions have raised the questions of whether FERC can issue the required federal certificate for a project before the developer can get a state permit under the Clean Water Act.

Perhaps no single project on the West Coast has revealed the upheaval in natural gas market than Kitimat LNG. Kitimat LNG was originally proposed to be an LNG import facility on the west coast of Canada. The project received both local and federal approval and seemed poised to begin construction on the regasification terminal. Then in September 2008, the project sponsors decided that it would be in their best interest to convert the project to a liquefaction export terminal instead of an import facility. Kitimat would use natural gas from Canada's sedimentary basins to supply the liquefaction terminal. Mitsubishi has already signed onto the project with plans of bringing LNG to the Japanese market. The applicants gave the following reasons to go in this new direction:

"Fundamental changes altering the global natural gas market have made exporting LNG more economically viable than importing it…Rising gas demand in Asia, as well as rapidly increasing gas supplies in North America from non-traditional plays have led to

[8] *Platts LNG Daily* (Volume 6/Number 10, Thursday, January 15, 2009). "Australia's Woodside drops plans for California terminal."

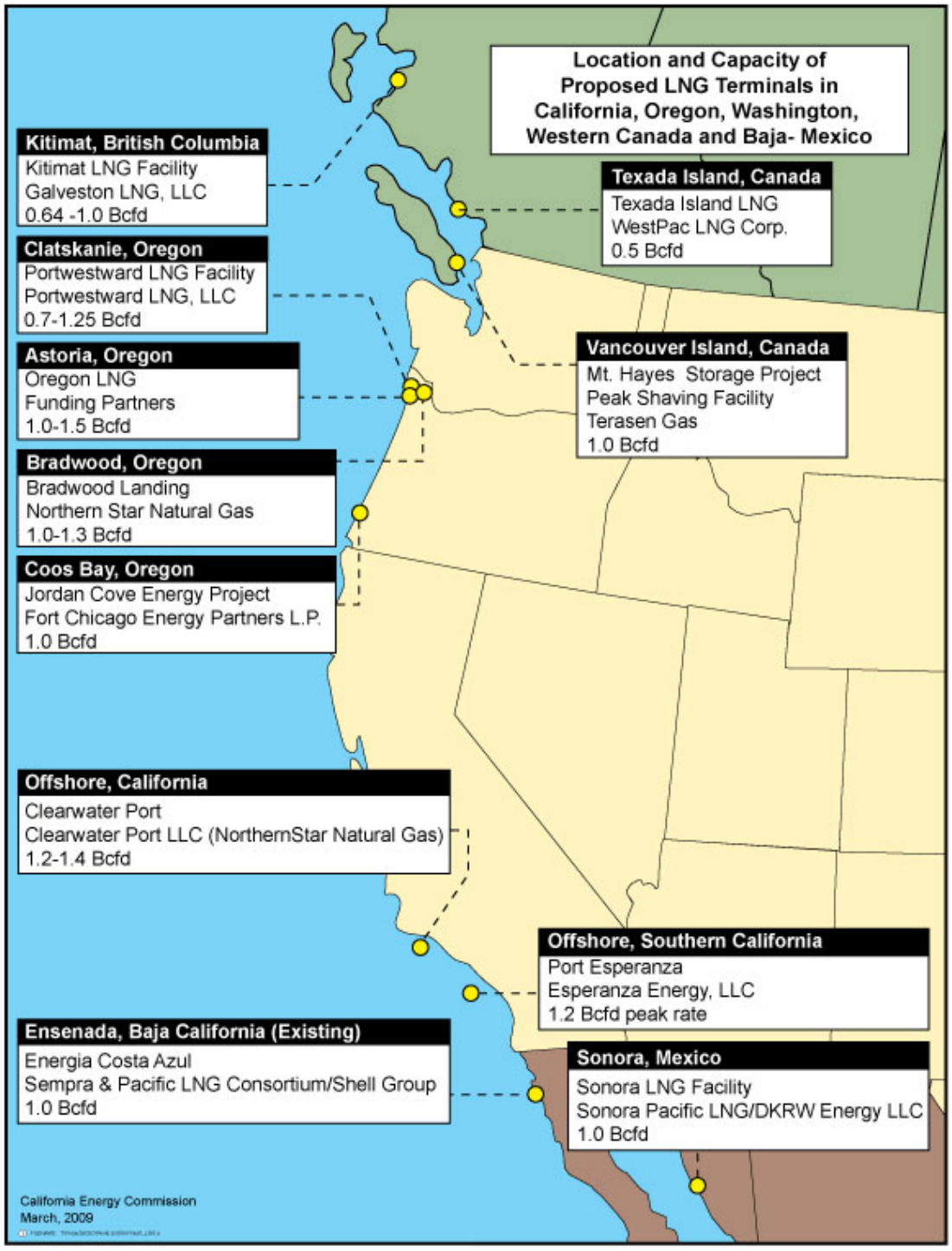
significantly higher natural gas prices in Asia than North America, a compelling opportunity for companies looking to export LNG from North America to Asia."[9]

The other LNG import terminal proposed for the west coast of Canada, WestPac terminal, has been put on hold. The sponsors of the project have postponed moving forward with their proposal because of uncertainties with climate change and emissions regulations in British Columbia.

In May 2008, Sempra Energy declared that Costa Azul was ready, making it the first LNG receipt facility in the West Coast. Located on the Pacific Coast of Mexico, the LNG terminal has received three cargo ships for commissioning and maintenance purposes and has been deemed fully functional. The natural gas output capacity for the facility is 1.0 Bcf/d, and it has already been permitted to expand to 2.5 Bcf/d if the facility owners choose to do so. The natural gas output capacity supply has been fully contracted with Mexico's state Federal Electricity Commission (Comisión Federal de Electricidad) set to receive about 0.15 Bcf/d for the next 15 years. The rest of the natural gas output capacity has been sold to a trading entity which will market the remaining gas. Already the direction on the Baja pipeline has been reversed so that natural gas can flow north into Southern California. The terminal is fully owned by Sempra LNG, but half of the capacity has been leased to Royal Dutch Shell, which plans to supply LNG from the new Sakhalin 2 terminal located in far-east Russia. Sempra will supply the other half of the facility's capacity with LNG from Indonesia's Tanguuh terminal. Both liquefaction facilities, Sakhalin 2 and Tanguuh, are being commissioned, and it is expected that commercial operation for Costa Azul will begin in May 2008. **Figure 6** shows all the proposed and existing LNG facilities along the western coasts of California, Canada, and Baja California, Mexico.

[9] *Platts LNG Daily* (Volume 5/Number 183, Monday, September 22, 2008). "Canada's Kitimat project now proposes to export LNG, not import."

Figure 6: West Coast LNG Projects



Source: Energy Commission website

Looking Ahead for LNG

Geopolitics

The Russian-Ukraine dispute raised the notion that Russia seeks to create an OPEC-style cartel. Staff's LNG consultant for the *2007 Final Natural Gas Assessment*, Jim Jensen, opined that he did not believe creation of such a cartel was feasible. In 2007, the Qatari Energy Minister said his country was not interested in creating a cartel. In 2008, Russia's Vladamir Putin said that he was aware of consumer concern about the creation of a cartel but that such fears were "groundless."[10] The Russian goal is to coordinate "decisions, exchange information, and do their best to ensure uninterrupted hydrocarbon supplies on global markets." Both Putin and his energy minister have alluded to the idea that speculation was responsible for the run-up in world oil prices in 2007 and 2008 and that one of their goals is to assure reasonable prices. The reality is that a substantial portion of Russia's budget is provided by natural gas exports. Some industry experts have speculated that Russia seeks to exert more control over the regional price of natural gas.

The effect of the dispute with Ukraine and the likelihood that Europe will seek to import more LNG in place of Russian pipeline supply may be overblown. In the eyes of some analysts, Russia's position in the dispute was valid: The commodity price paid by Ukraine was less than what was being paid by Western European customers and was a vestige of Soviet-regime pricing mechanisms. When oil prices fell in the second half of 2008, Russia was anxious to reprice the Ukranian contract before oil prices fell further. This view also cites Ukraine as trying to drag Western Europe to their defense by siphoning off supplies intended for Western Europe and claiming Russia had shut the valve. This episode ended in late January with Ukraine agreeing to a price much closer to that being paid by Western Europe.

New Liquefaction and Regasification Capacity

Worldwide regasification capacity has always been greater than worldwide liquefaction capacity. This has led to the intense price competition for LNG supplies around the globe. This trend will persist in the near future with planned capacity (both regasification and liquefaction) to come on-line in the next few years. Many reagasification facilities outside the United States operate on a seasonal basis and have little storage capacity. To capture some of the higher prices that exist in varying markets, many liquefaction facilities reserve supplies for sale through short term contracts and spot markets. To help reach distant markets, LNG fleet size has been expanded with very large tankers. The growth in fleet size has served to further integrate markets around the world. According to the Canadian National Energy Board (NEB), worldwide regasification capacity is expected to double over

[10] Novosti article 11/11/08: http://en.rian.ru/russia/20081111/118252725.html.

the next six years.[11] Most of the added regasification capacity is proposed for the Atlantic basin.

Liquefaction facilities usually require more time, finances, and government support to be built. The tight credit market from the current global recession could further slow the development of new liquefaction facilities. Roughly 6 Bcf/d of new liquefaction capacity is expected to come on-line around the world in the next six years. **Table 3** shows that currently Qatar is the largest producer of LNG for the Atlantic basin, while Indonesia produces the most LNG for the Pacific basin. **Table 4** shows that currently the Asian market has the most capacity to consume LNG, while the Americas have the most storage capacity.

Table 3: World Liquefaction Capacity

Region	Capacity (billion cf/yr)
Algeria Total	**1,008.09**
Australia Total	**964.26**
Brunei	326.29
Egypt Total	**618.49**
Equatorial Guinea	379.86
Indonesia Total	**1,412.30**
Libya	34.09
Malaysia Total	**1,105.49**
Nigeria	1,071.40
Norway	249.83
Oman Total	**482.13**
Qatar Total	**1,319.77**
Russia	467.52
Trinidad and Tobago	730.50
United Arab Emirates	292.20
United States	73.05
Grand Total	**17,445.80**

Source: Platts Data, February 2009

[11] National Energy Board (2009). *Liquefied Natural Gas: A Canadian Perspective.* Page 16.

Table 4: World Regasification and Storage Capacity

Market	Peak Capacity (Bcf/d)	Storage (Bcf)
Americas Total	14.01	25.81
Asia Total	31.85	0.65
Europe Total	11.21	0.16
Grand Total	57.07	26.63

Source: Platts Data, February 2009

Outlook for California

Looking ahead, California will have more options for sources of natural gas supply. Currently there are three pipeline projects that should significantly increase the flow of natural gas to California. The Ruby Pipeline project is planning to deliver natural gas from Opal, Wyoming, to California at a rate of 1.2 Bcf/d. This pipeline is scheduled to be in service by 2011 and will deliver natural gas to Malin, Oregon. Another pipeline project, Sunstone Pipeline, plans to deliver 1.2 Bcf/d of natural gas from Opal, Wyoming to Stansfield, Oregon. This pipeline is planned to be on-line in 2011 and could displace much natural gas in Oregon, thus freeing up supplies for California. The Kern River pipeline expansion project will increase delivery of natural gas from Wyoming to Southern California by 0.2 Bcf/d. The expansion of the existing pipeline is scheduled to be completed in 2010.

The construction of the Costa Azul LNG Terminal was completed last year and still awaits the first of its deliveries. LNG is available, but suppliers at the moment are reluctant to enter the lower-priced Pacific Coast market. When supply does start to flow, North Baja Mexico will have first choice to receive up to 300 MMcf/d to meet its industrial and power plant needs. Any excess in supply would add to California's supply mix. Under normal conditions, this would lead to price competition for market share. However, LNG is a price taker (does not set price), and with the reluctance for deliveries to the Pacific Coast, it is unclear what kind of impact Costa Azul will have on supply and price.

Bradwood Landing is an LNG import facility proposed to be built along the Columbia River in Oregon. The facility is planned to have a natural gas output capacity of 1.3 Bcf/d and has already gained federal approval. If constructed, this facility would have the potential to bring much added natural gas supply to the West Coast, thus making more natural gas available for California. However, this project has come under much opposition from both state and local agencies. The project applicants are still in the process of gaining local land and water use permits.

LNG and Natural Gas Quality

LNG usually comes from countries where there is little or no local natural gas market. These countries also often have little or no market for the heavier liquid hydrocarbons such as butane, propane, and ethane that are commonly produced as part of the natural gas stream. These liquid hydrocarbons have a higher Btu content than pure methane. Here in the United States, these liquids are often (but not always) processed out of natural gas near the point of production before it enters the interstate pipeline system. Gas that retains these higher Btu-content hydrocarbons burns hotter. The industry often describes this characteristic by using the Wobbe Index.

The Wobbe Index is a technical specification that refers to the heating value of natural gas. A high index number indicates a higher heating value. In response to concerns about unprocessed LNG entering the gas stream, the California Public Utilities Commission (CPUC) in 2006 adopted a Wobbe Index of 1,385, slightly higher than the average Wobbe Index of domestically produced natural gas sold in California.[12]

Some tests have shown that equipment burning natural gas with a higher Wobbe Index emits more nitrogen oxide. Nitrogen oxide is known to cause ozone and fine particulate pollution. There have been additional concerns about fire safety and equipment durability when hotter burning natural gas is used. For these reasons the South Coast Air Quality Management District (SCAQMD) has opposed the CPUC raising of the Wobbe Index number.

The SCAQMD proposed a Wobbe Index number of 1,360. Virtually none of the LNG likely to come to California would meet this requirement without processing to remove the higher heat content liquid hydrocarbons. The additional cost to treat the produced natural gas would likely be passed along to consumers and/or make the netback to producers from LNG sales to California less economically attractive.

Carbon Footprint of LNG

The study of lifecycle (from natural gas source to combustion) greenhouse gas (GHG) emissions for LNG is still relatively new, requiring more, in-depth analysis. However some recent reports have emerged that begin to clarify how LNG compares with other sources of energy when considering GHG emissions. While there are some uncertainties in this formative area of study, there does seem to be growing consensus on certain points. When compared with coal, it is generally believed that the carbon footprint for LNG is significantly smaller. It has long been known that domestically produced natural gas emits much less greenhouse gases than coal. LNG has the added processes of liquefaction, shipping and regasification. Even with these additional processes, the carbon footprint of

[12] South Coast Air Quality Management District (2007). *AQMD Sues PUC to Protect Public Health and Prevent Increased Air Pollution From "Hot Gas". January 23. 2007*.

LNG is still found to be less than that of coal. These findings were produced in a study by Carnegie Mellon University where the life cycle emissions of LNG, North American natural gas and coal were modeled.[13] Similar results were found by PACE in a study conducted for the Center For Liquefied Natural Gas.[14]

Uncertainties arise when the carbon footprint of LNG is compared with that of domestic natural gas. The Carnegie Mellon study found LNG emissions to be 28 percent higher than that of domestic natural gas. A study done by the U.S. Department of Energy National Energy Technology came to the same conclusion but placed the carbon emissions of LNG closer to that of natural gas.[15] Both studies concluded that LNG had higher emissions due to the amount of energy expended during the liquefaction process and during shipping. A study by Advanced Resources International and ICF International for Sempra LNG raises an interesting point when comparing the carbon footprint of LNG to that of natural gas.[16] In this study, the greenhouse gas emissions of LNG were found to be almost equal to that of natural gas. The reason offered is that the resources supplying liquefaction facilities are significantly more productive than the wells supplying domestic natural gas. LNG liquefaction facilities tend to be very close to a natural gas resource, which further reduces the amount of energy expended during transmission according to this study.

Expert Views on the Future of LNG

In its March 2009 *Short Term Energy Outlook*, the U.S. Energy Information Administration (EIA) projected that the United States will import 380 Bcf in 2009. This is slightly more than the 352 Bcf amount imported last year. In 2010, the EIA expects supply to the United States to increase to the year-end amount of 410 Bcf as global supply projects ramp up. **Figure 7** compares EIA's forecast of U.S. LNG imports to that of Waterborne Energy through the end of 2009. This graph illustrates how widely forecasts on projected LNG imports can vary.

Wood Mackenzie predicts that North America will see substantial increases in LNG imports increasing from 1.7 Bcf/d in 2009 to reach 4 Bcf/d in 2014.[17] Wood Mackenzie attributes this

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[13] Jamarillo,P.; W. Griffin; H. Matthew, "Comparative Life-Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electric Generation," *Environmental Science and Technology* 2007, Vol. 41, No. 17, 6290.

[14] PACE (2009). *Life Cycle Assessment of GHG Emissions from LNG and Coal Fired Generation Scenarios: Assumptions and Results*.

[15] U.S. Department of Energy, *Life-Cycle Analysis of Greenhouse Gas Emissions for Hydrogen Fuel Production in the United States From LNG and Coal*, November 2005

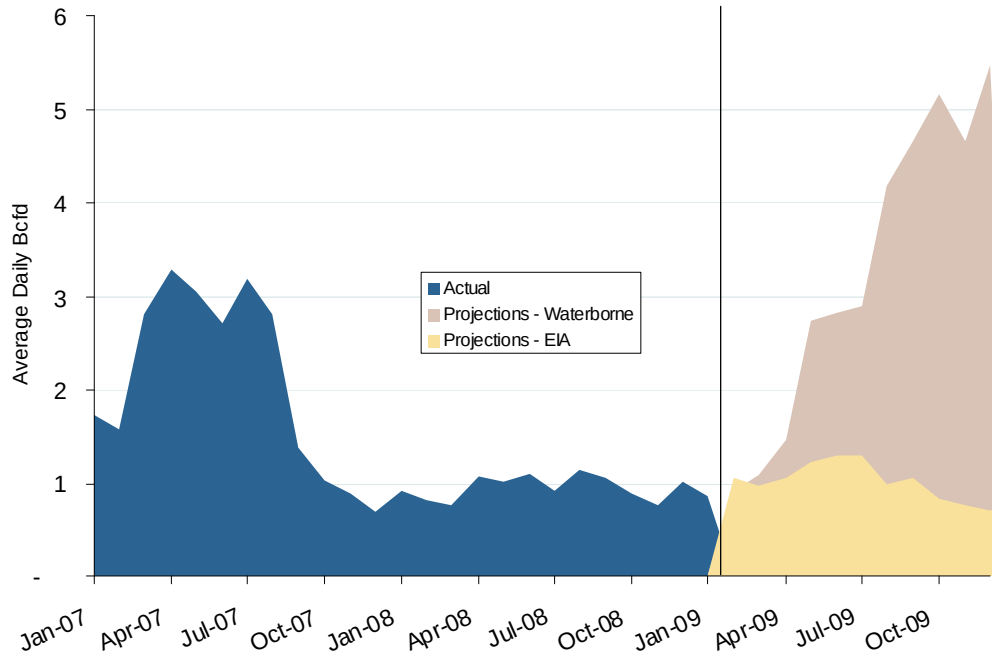
[16] Advanced Resources International, Inc. and ICF International (2008). *Greenhouse Gas Life-Cycle Emissions Study: Fuel Life-Cycle of U.S. Natural Gas Supplies and International LNG.*

[17] *Platts LNG Daily* (Volume 6/Number 10, Thursday, January 15, 2009). "North American LNG imports to jump 147% by 2014: Wood Mackenzie."

increase to the fact that the United States has vastly more storage capacity compared to the rest of the world. The United States will be viewed as a "global sink" for LNG when demand lags in other countries. Waterborne Energy similarly predicts higher LNG imports to the United States. They point to a projected 30 percent increase in world liquefaction capacity by the end of 2009.[18]

Other analysts are pessimistic about the prospects of significant volumes of LNG coming to the United States. Barclays Capital, an international investment bank, predicts a combined 15 percent decrease in LNG demand from Asia and Europe.[19] If LNG production increases this year as planned, there will be 4.2 Bcf/d of surplus LNG by the year's end. The United States, with its large storage base and flexible pipeline system, is viewed as the ideal destination for this excess LNG. However, Barclays Capital points out that any LNG that arrives to the United States will only add downward pressure to already low domestic natural gas prices. The end result will be that neither the United States nor Europe will be able to take all the excess LNG supplies.

Figure 7: EIA Versus Waterborne Energy Projections for U.S. LNG Imports



Source: FERC Market Snapshot February 2009

[18] Business Publications, *Waterborne Energy Projects Global LNG Production to Increase by 30 Percent in 2009*, December 19, 2008, http://findarticles.com/p/articles/mi_m0EIN/is_2008_Dec_19/ai_n31139536/

[19] *Platts LNG Daily* (Volume 6/Number 37, Wednesday, February 25, 2009). "Markets bracing for possible LNG glut this year: analysts."

Summary

The variety of uncertain factors depicted in this LNG report with respect to domestic and global natural gas markets make it enormously difficult to predict how much LNG will be imported into the United States and how much will serve California. Changes in any one of those factors would cause reality to be different than predicted. This report attempted to identify and discuss the key uncertainties identified by staff and to highlight recent analysis and information concerning each. Among the factors discussed herein:

- The relationship of U.S. natural gas prices to oil prices and associated Asian and European market prices.
- The quantity of natural gas to be produced from shale reserves and what the price of that gas will be.
- The relative balance of U.S. supply relative to demand and the associated relationship between domestic natural gas prices versus oil prices.
- The level of demand for natural gas in the United States and abroad during and after the economic recession.
- The relative balance of liquefaction facilities to regasification facilities and LNG tankers.
- What additional LNG terminals might be constructed on the West Coast.
- What additional pipelines might be constructed to the West Coast.
- How the life-cycle carbon emissions for LNG compare to that of coal-fired generation and how they might be addressed.

Ignoring these uncertainties, the current trend is that LNG is not coming to the United States because domestic natural gas prices are too low relative to world natural gas prices, which are more closely linked to crude oil prices. The gap between U.S. prices and world prices may be a function of natural gas shale deposits that have finally allowed U.S. natural gas supply to increase. In the meantime, the immediate rush to develop U.S. LNG terminals has slowed. Some terminals are asking for export authority, although except for the Kitimat terminal in British Columbia, most are simply asking to export gas that arrived as LNG. Any immediate increase seen in LNG deliveries is more likely to occur as European-destined LNG seeks a home once their storage facilities become constrained, or as demand in Japan responds to the recession and to the restart of the Kashiwazaki Kariwa nuclear reactor.

Issues

The worldwide LNG market has changed such that much uncertainty now exists looking forward. Staff would like to present the follow questions for discussion:

- What factors help to determine landed LNG prices in the United States, Europe, and Asia?
- How much LNG could be available to U.S. importers given the large price differences between the United States, European, and Asian markets?
- What other non-economic factors could drive the development of LNG?
- What are the prospects that natural gas exporting countries could develop into an energy cartel similar to OPEC?
- What is the relative balance of liquefaction and regasification facilities and LNG tankers available to transport the gas?
- What additional LNG terminals may be constructed on the West Coast?
- Could natural gas from shale formations displace the importation of LNG into the United States and Canada?
- How do life-cycle carbon emissions LNG compare to that of coal-fired generation, and how should they be addressed by regulators?

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