

Market Size, Demand and Development for LNG fuel in the USA

Where to place your small-mid scale LNG Business

Robert Imonikhe



INTRODUCTION

The emerging opportunity

The growth of the domestic US natural gas market has opened up a new realm of possibilities for energy consumers. Some are already capitalizing on Liquefied Natural Gas (LNG) to make savings, attracted by the prospect of a cheaper, less volatile fuel source. Government and corporate fleets have been the earliest adopters, seeking to improve their environmental profile as well as reduce costs. Now, an increasing number of trucking businesses are converting their fleets to run on LNG. Beyond these markets, the potential applications to save fuel costs by using LNG are widespread. High Horse Power (HHP) requirements in the rail, marine, mining and drilling industries are also seeking to realise the benefits of this emerging fuel source.

However, in order for the potential of LNG to be realised across these industries, greater infrastructure investment is essential. The scale of the need is striking, as revealed in a previous FC Business Intelligence report, Dale Lewis, Director of Strategic Analysis at railroad company CSX, estimates that it would take more than 100 new plants, producing at the 400,000 GPD level, to displace one third of the diesel burned as a fuel in the US by heavy trucks and freight railroads. Analysis from NGV engineering firm Westport also highlights the need for investment in liquefaction plants, projecting that by 2025 global liquefaction requirement will reach 40m tons per annum.

Recognising the need to develop small and mid scale LNG liquefaction infrastructure, an increasing number of gas producers, suppliers, utilities and private enterprises are planning and building new facilities. These developers will help provide the missing link between the potential in the US energy market and the reality of cheaper fuel and energy independence.

*Small and Mid Scale LNG Liquefaction plants in the US**



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INTRODUCTION TO OUR INTERVIEWEES

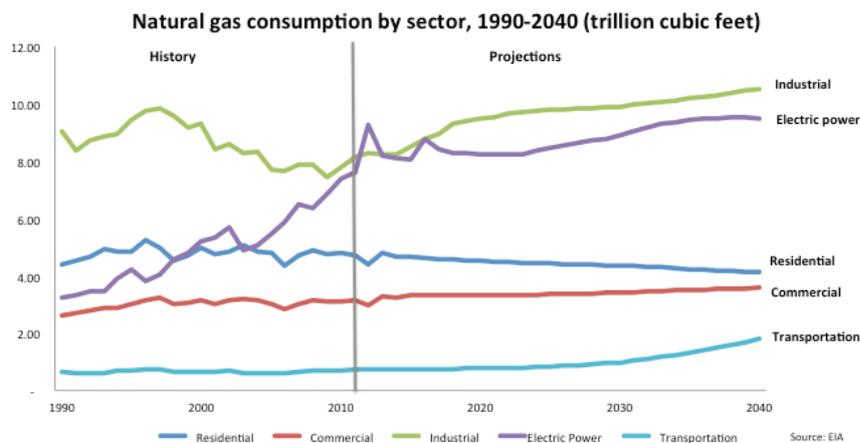
**Planned and operational small and mid scale liquefaction facilities in the US, where the location has been made public or disclosed to FC Business Intelligence.*

Map key	Name	Location	LNG production	Stage
1	Noble Energy	Weld County, Colorado	100,000 gal/day	P
2	APNG Topock LNG Plant	Arizona	86,000 gal/day	E
3	Clean Energy California Plant	Boron, California	160,000 gal/day	O
4	The Pickens Plant	Willis, Texas	100,000 gal/day	O
5	Shell, Geismar	Geismar, Louisiana	250,000	P
6	Shell, Sarnia	Sarnia, Ontario	250,000	P
7	Stabilis Energy	Eagle Ford Shale	100,000 / 250,000	R
8	Stabilis Energy	West Texas	100,000 / 250,000	S
9	Stabilis Energy	The Bakken	100,000 / 250,000	S
10	Stabilis Energy	Western Oklahoma	100,000 / 250,000	S
11	Stabilis Energy	Haynesville, East Texas	100,000 / 250,000	S
12	Grande Prairie	Elmworth, Canada	190,000 litres/day	C
13	Colony Energy Partners	Reno	180,000 gal/day (initial)	P
14	Spectrum LNG	Prudhoe Bay, Alaska	100,000 gal/day	P
15	Spectrum LNG	Ehrenberg, Arizona	60,000 gal/day	O
16	Exxon LaBarge	Shute Creek, WY	60,000 gal/day	O
17	Prometheus Bowerman LFG to LNG	California	5,000 gal/day	O

P = Planned, E = Expansion, O = Operational, S = Site Selection, C = Construction R = Reg. approvals
*Details disclosed/available

Target markets

Overall, the US consumes 35bn gallons of diesel per year, which suggests a huge potential market for cheaper alternative fuels such as LNG. Analysts have wide ranging opinions over how much of this could be displaced by natural gas, Citigroup anticipate natural gas demand in transport to reach 2.2bcfd by 2020, while a Reuters poll of analysts is less ambitious, expecting 1.2bcfd. Most expect a gradual rise in usage of natural gas in the transportation sector, in line with EIA predictions. Adoption will then ramp up next decade, as infrastructure becomes more widely embedded.



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Whatever the curve of adoption, the LNG fuel industry needs to reach critical mass of infrastructure to persuade operators in certain segments to switch over. In trucking, major investors are partnering with filling station operators to orchestrate nationwide LNG filling networks. In this sector, as with marine, rail and drilling, the availability of LNG to supply the network is a keystone. However, identifying where to locate LNG liquefaction facilities is not straightforward. Infrastructure investors need to evaluate a number of key criteria, including competition, regulatory

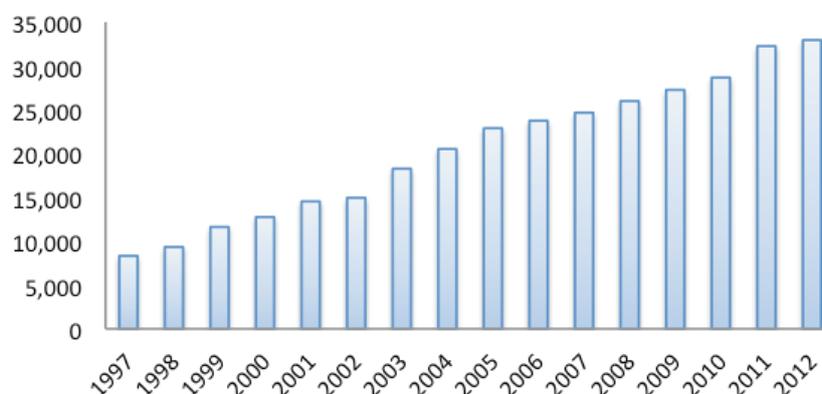
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challenges, site availability, delivery methods and their target segment. Each market has its own individual challenges and a different growth trajectory, which has to be considered separately. Opinions also vary as to the most attractive route of entry. For example, Steven Stump, Vice President Business Development at Stabilis Energy, says his firm is targeting, 'off road, high horsepower oil power equipment.' They are adopting this strategy on the basis that, 'probably the fastest growing engine application' for LNG fuel is 'drilling rigs and frack pumps.' In contrast, Matt Schmitt, VP of Project Development at Colony Energy Partners told FC Business Intelligence that 'maritime markets look to be the early large adopters, then rail and mining.' He says that, 'highway trucking will be a slow build that will eventually take over the other markets, but maybe not until next decade.' The marine industry is attractive given the potential scale of demand from individual vessel operators. In order to be economically viable, liquefaction facilities need to run at a high proportion of capacity, which means securing large-scale early adopters. Industrial applications, mining and drilling are also ripe for penetration.

Highway Trucking

**U.S. Natural Gas Vehicle Fuel Consumption
MMcf**



As the chart shows, vehicle use of natural gas has grown steadily over the last fifteen years, reaching 32 billion cubic feet in 2012. Uptake has gathered pace in the heavy trucking industry. Most notable of recent transitions is UPS, who announced that they will expand their fleet of 112 heavy 18 wheelers running on LNG to 800 by the end of 2014. Such high profile adoption of LNG as a fuel for heavy trucking should pave the way for others to follow suit.

While LNG trucks come with a premium of \$40,000 to \$80,000 dollars, some argue that heavy users can make these costs back within one or two years. In addition, given the abundance of natural gas reserves in the US and that currently it can cost \$1.50 to \$2.00 less per diesel gallon equivalent, there is significant room for prices to increase and the economics for conversion to still be favourable. Not all are convinced that savings will become apparent so quickly though, the CFO of UPS stated that to cover the upfront cost of replacing diesel with a cheaper

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fuel, 'it still takes seven or eight years.'

Developing infrastructure to support these new LNG trucks is the next major hurdle. According to a recent New York Times article, citing the Energy Department as its source, as of May 2012 there were only 53 LNG fuelling stations in the US, compared to 157,000 fuelling stations selling gasoline. Analysts estimate that it will take about \$60 billion to build a critical mass of LNG filling stations across the country.

Locating in proximity to busy trucking routes forms a basis for investment strategy. Cross-comparing the below image, which shows traffic volumes of heavy trucks across the US, with the availability of LNG refuelling infrastructure, offers a good starting point for those selecting sites for LNG liquefaction plants.

Truck traffic volumes in the US



Clean Energy Fuels has been one of the first movers in providing a network of LNG fuelling stations, with 70 stations completed at the end of last year and a further 80 planned this year. With two liquefaction plants (one planned and one operational) Clean Energy Fuels will control both stages of the supply chain: production and marketing

Clean Energy Fuels 'Natural Gas Highway'



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Another company investing heavily in US LNG fuelling infrastructure is Chinese-owned ENN. They have plans to build up to 500 LNG stations, and have partnered with a small Utah company, CH4 Energy, to create a joint venture trading as Blu LNG. ENN has ambitions of building LNG plants in the future.

Shell is also investing in both LNG liquefaction and refuelling infrastructure. The two liquefaction plants it plans to build will be the basis for two new LNG refuelling networks: in the Gulf Coast Corridor (Texas and Louisiana), and the Great Lakes Corridor. Shell has partnered with Travel Centres of America on plans to develop a commercial LNG fuelling network. Initial plans are mapped below.

Shell and Travel Centres of America proposed LNG fuelling network



Estimates vary as to the pace of growth for LNG as a trucking fuel. Citigroup, forecasts that 30% of the heavy truck fleet will switch to LNG by the end of the decade, while others within the industry are less optimistic. Whatever the rate of growth, with more than 26 million trucks in the US consuming around 50bn gallons of fuel a year, the potential size of the market is staggering.

Marine

The major catalyst for change in the marine fuel market is environmental regulation enacted by the International Maritime Organisation (IMO). As covered in the January 2013 FC Business Intelligence report on LNG as a Marine Fuel, stricter emissions controls are incentivising ship operators to seek alternative fuels.

According to Marcel LaRoche, marine manager for western Canada for Lloyd's Register, there are approximately 30 LNG powered vessels in service worldwide today, and another 30 in design or construction. There are also 400 dual fuel vessels that can run on traditional fuel or LNG.

As with the trucking industry, the economics of using LNG are compelling, even with variables such as energy prices and regulatory risk taken in to account. Now, infrastructure is the key lynchpin to support the adoption of LNG for bunkering. Developing infrastructure for bunkering is set

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to be a challenging process. This is one reason for the US Maritime Administration recently offering a \$500,000 grant for a comprehensive study on the issues associated with LNG bunkering.

At present, the liquefaction infrastructure for coastal and waterway marine use of LNG is very limited. While adoption is set to grow, there are significant challenges to the business model of developing LNG liquefaction facilities for marine vessels. According to environmental consultants, MJ Bradley & Assoc. 'the practical minimum for cost-effective LNG production would be a plant sized for 100,000 gallons of LNG a day, operated at an average utilization of at least 80%. If dedicated to the marine market, such a plant would need a client base of about seven Great Lakes bulk carriers, 24 ferries or 38 tugs, to be economically viable.'

According to a report by the American Clean Skies Foundation, there are a number of markets that are ripe for marine LNG infrastructure development. These include the Great Lakes, the Central Atlantic Coast, the Northwest Pacific Coast and the Gulf Coast. The key to developing these regions is forming close partnerships between ship operators, bunkering providers and LNG suppliers. Shell, for example, has partnered with Edison Chouest to supply LNG in the Gulf of Mexico, and has also invested in bunkering for the Great Lakes, expecting its first marine customer to be Interlake Steamship Co.

Rail

The US rail industry faces one of its biggest turning points since the switchover from steam to diesel. Utilising LNG has the potential to drastically reduce fuel costs in the sector, though operators are tentative with concerns over the economics, safety and logistics of transitioning.

The railway industry is in the embryonic stages of adopting LNG, though there has been notable headway. In March, the largest railroad in the US, BSNF, announced that it will test running locomotives on LNG.

The outcome of the trial could have a significant impact on sentiment across the industry. The Berkshire Hathaway owned company burns 1.3bn gallons of diesel per year, and plans to make a decision in 2014 whether to begin switching its fleet of 6,900 locomotives to natural gas. Rail accounts for 6% of diesel burned in the US, which represents a sizeable potential revenue source for LNG producers.

Two of the other major railway carriers are also working on the possibility of using LNG to fuel their locomotives. Both Union Pacific and Norfolk Southern are in talks with manufacturers over LNG. Union Pacific used 1.09bn gallons of diesel last year alone; at an average price of \$3.22 a gallon, according to SEC filings.

A transition could take up to ten years for major rail carriers. Smaller carriers would be expected to follow if the infrastructure develops in line with demand. The role for liquefaction facilities will become clearer in 2014, when BSNF decides whether or not it will go down the LNG route, and other major operators also take a stance.

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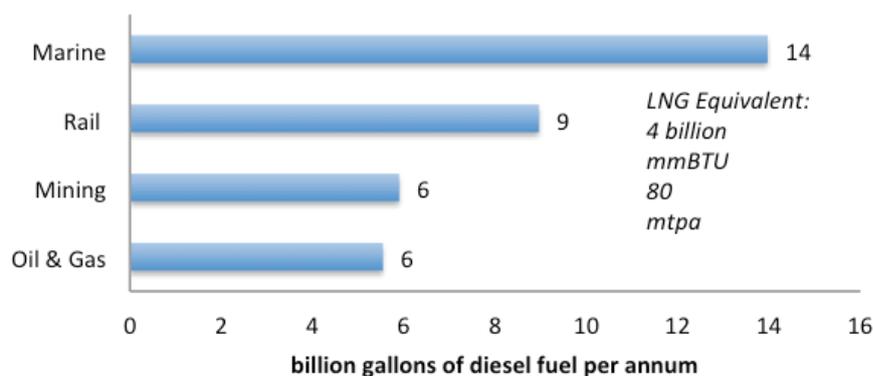
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While the rail industry has barely dipped its toes in the water of LNG fuel, the dominance of a handful of large-scale players presents an ideal scenario for suppliers. The transition, if it takes place, will happen in partnership with suppliers and manufacturers. Lucrative long-term contracts could be offered to those firms who offer the right solutions to the juggernauts of US rail.

Remote HHP applications: drilling rigs and mining

Global High Horsepower Fuel Consumption billion US gallons of diesel fuel per annum



Source: UN Energy Statistics Database, Westport analysis

LNG is gaining momentum fast in the exploration and production space as a cheaper, more environmentally friendly alternative fuel. Speaking at an investor conference held in June 2013 by Zeus Intelligence, the chief executives of American Power Group and Prometheus energy reported that about 70 of Americas 1,200 land-based drilling rigs are now powered with gas from LNG. While there are many influential factors to consider, the simple fact that even the operators of oil drilling rigs prefer to run on LNG rather than diesel, compounds the case for LNG conversion. Prometheus Energy CEO Jim Avalis estimates that demand from industrial consumers such as mines and power producers is about 120,000 gal/day at present though will climb rapidly to 1.6m gal/day by 2018. According to LNG World News, the majority of this demand is expected to come from rigs and hydraulic fracturing pumps in the Marcellus, Eagle Ford, Permian, Rockies and Mid Continent.

LNG producers see a huge opportunity emerging to supply remote high horse power demand. LNG has economic benefits, meets emissions requirements and also has logistical benefits, such as range and refuelling speed that make it an ideal fuel solution in these markets. Stabilis Energy is scheduled to invest in five liquefaction facilities targeting the oilfield, marine and rail fuel markets. As analysis from natural gas engineering firm Westport shows, the global opportunity in these four key markets is 4 billion mmBTU of LNG. Given that fuel usage in all of these sectors in the US is high as a proportion of global consumption, the immediate opportunity for firms like Stabilis is strong.

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Key small and mid-scale liquefaction projects under development

Project: Noble Energy, Weld Country

Operator: Noble Energy

Location: Weld County, Colorado

LNG production: 100,000 gal/day

Cost: \$45m

Status: Construction. Due for completion end of 2014

Application: Drilling rigs and heavy equipment



About the project

Noble Energy, a major oil and gas producer in the Denver-Julesburg Basin, has begun construction of an LNG liquefaction plant alongside a new natural gas plant the company is also building. Noble plans to use the LNG to run the company's drilling rigs and other heavy equipment in the DJ Basin. The company also has plans to sell LNG to other companies operating in the vicinity. Chart Industries has been commissioned to build the plant, which should be operational by the end of 2014.

Project: Topock LNG Plant

Operator: Applied Natural Gas Fuels

Location: Topock Arizona

LNG production: 180,000 gal/day

Cost: Not disclosed

Status: Expansion. Due for completion early 2014

Application: Trucks and high horsepower markets, including drilling rigs



About the project

In April 2013 Applied Natural Gas Fuels announced that it is doubling liquefaction capacity at its Topock LNG facility from 90,000 gal/day to 180,000 gal/day in response to rising demand. Applied's fleet of 34 LNG tankers serves customers across the southwest of the US. Applied CEO, Cem Hacioglu, has reportedly said that they are looking to site additional LNG production facilities in other parts of the country.

Project: Shell, Geismar

Operator: Shell

Location: Geismar, Louisiana

LNG production: 250,000 gal/day

Cost: Not disclosed

Status: Regulatory Permissions.

Application: Marine, Drilling, Trucking



About the project

Shell is planning a natural gas liquefaction plant in Geismar, targeting commercial transportation customers. Shell will transport the LNG along the Mississippi river and Gulf Intercoastal Waterway to Texas and Louisi-

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ana. Shell will also supply LNG offshore in the Gulf of Mexico, thanks to an agreement with Edison Chouest. Edison Chouest will provide North America's first LNG barging and refuelling operation at its Port Fourchon facilities.

Project: Stabilis Energy - Five Separate Sites

Operator: Stabilis Energy

Location: Various sites

LNG production: 100,000 gal/ day and 250,000 gal/day

Cost: Not disclosed

Status: Regulatory approvals and site selection

Application: Drilling rigs and fracking equipment

About the project

Stabilis Energy, a holding company focussed on LNG infrastructure investments, is planning to build five separate LNG facilities in the US over the next three years. The first plant, due to be online by the first quarter of 2015, will be located in the Eagle Ford Shale region, between San Antonio and Corpus Christi. Steve Stump, Vice President, Business Development of Stabilis Energy informs FC Business Intelligence that the company already own the land and are ready to begin construction as soon as regulatory approvals are complete. The remaining four projects are in the site selection phase. Probably sites are West Texas (midland Odessa area), The Bakken, Western Oklahoma and Haynesville, East Texas.

Project: Elmworth

Operator: Ferus LNG and Encana Natural Gas

Location: Elmworth, Canada

LNG production: 190,000 litres/day

Cost: Not disclosed

Status: Construction. Completion due first quarter of 2014

Application: High-horsepower engines used in drilling rigs, pressure pumping services and heavy-duty highway and off-road trucks

About the project

Encana Corporation, one of the largest Natural Gas producers in the US and Ferus LNG, a leader in LNG fuelling solutions, are building a liquefaction plant near Grand Prairie in Alberta. It's a pioneering project in Canada for supplying LNG for HHP applications. In addition to selling the fuel externally, both companies use LNG for their internal operations.

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Project: Spectrum Alaska

Operator: Spectrum LNG

Location: Prudhoe Bay, Alaska

LNG production: 100,000 gal/day upgradeable to 400,000 g

Cost: \$30m (estimated phase one)

Status: Planning. Completion due either Q4 2013 or Q2 2014

Application: Drilling rigs, mines, trucks, power plants, small g
tion systems.



About the project

Spectrum Alaska, which already operates a 60,000 gal/day plant in Ehrenberg Arizona, plan to build a second facility in Prudhoe Bay, Alaska. The new plant aims to deliver cheaper fuel to Fairbanks in Alaska, where current prices are high. The project is awaiting approval from the local authority. One other firm is also reportedly competing for the contract.

Outlook

As a proportion of the potential addressable market, the consumption of LNG for fuel in the US is still relatively small. Most analysts expect a steady increase in the significance of LNG, rising to a greater proportion of overall energy demand over the next decade.

The need to develop small and mid scale LNG liquefaction facilities should not be underestimated though. In general, the markets targeted by small and mid scale liquefaction facilities are those for long-distance or remote applications, where the prospect of a small modular LNG liquefaction facility located at or near the operators base is not by itself a viable solution. This creates a necessity for the development of more liquefaction facilities to support nationwide infrastructure.

In highway trucking, there is potential for a rapid increase in the pace of adoption, if currently under-development infrastructure networks compel more operators to take notice. This represents probably the largest potential market for LNG, though it will most likely take longer to develop than companies like Shell, ENN and Clean Energy Fuels hope for.

In the marine space, adoption is likely to ramp up more and more quickly as emissions regulations tighten along the schedule already set out by the International Maritime Organisation. The opportunity to secure large-scale supply contracts offers an ideal market for liquefaction plants.

The development of the rail market for LNG will depend on decisions made by a few major carriers. Perhaps the most immediately attractive market for LNG suppliers is the exploration and production field, where drilling rigs and fracturing pumps are switching from diesel to LNG, achieving rapid payback times and significant savings.

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