LNG at the crossroads

Identifying key drivers and questions for an industry in flux

Deloitte Center *for* Energy Solutions

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Executive summary

The volume of liquefied natural gas (LNG) traded globally has quadrupled in the last two decades and is set to double in the next two. Future supply will come heavily from the United States and Australia, with demand coming from many of the traditional players in Europe and Asia. As volumes continue to increase, the market has potential to reach critical mass, leading to shifts in the countries and companies involved and how the market is structured. These developments hinge on maximizing the strengths and opportunities of the LNG value chain, while reducing the impact of the strategic weaknesses and threats from external developments. Seven key factors are expected to drive how the LNG industry will grow, including:

- **Global economic growth:** LNG consumption is driven by global growth in Europe and Southeast Asia. A slip in regional growth, particularly in China, would flatten natural gas demand in key importing countries.
- **Energy efficiency:** Energy intensity of global growth has declined over the last few decades as high energy prices and environmental concerns have driven the adoption of higher efficiency technologies.
- **Excess capacity:** New capacity coming online in US and Australia is weighing down on an already saturated market. As few as one in twenty planned projects may be needed to meet demand through 2035 and only those with lower costs, direct access to markets, and signed buyers will move forward.
- **Shipping costs:** Shortening the trading distance with more flexible contracts and widening of the Panama Canal can reduce the cost of shipping, driving an increase in volumes as incremental margins improve. This will reduce the natural gas price differential required to drive investment.
- **New markets:** Japan and South Korea import half of all LNG volumes, historically paying a premium over shipments in the Atlantic basin. Growth in trade will require new LNG regasification facilities to be built in more countries to meet growing global fuel needs.
- **New end users:** LNG is traditionally consumed for utility-scale power generation, but LNG as an alternative transport fuel for shipping, trains, or trucks as well a power source for remote small-scale grids, will provide a long tail of potential demand growth.
- **Market liquidity:** Floating liquefaction and regasification combined with new countries building both import and export capacity, can transform the current contract-dependent market into one that provides trading opportunity through transparent gas benchmarks and a flexible spot market.

This is the first of several papers highlighting different elements of the industry. Upcoming work includes Deloitte MarketPoint's analysis of US impact on the global LNG market fundamentals, the geology and geography of North American natural gas exports, and the impact of a fully globalized and liquid LNG market.

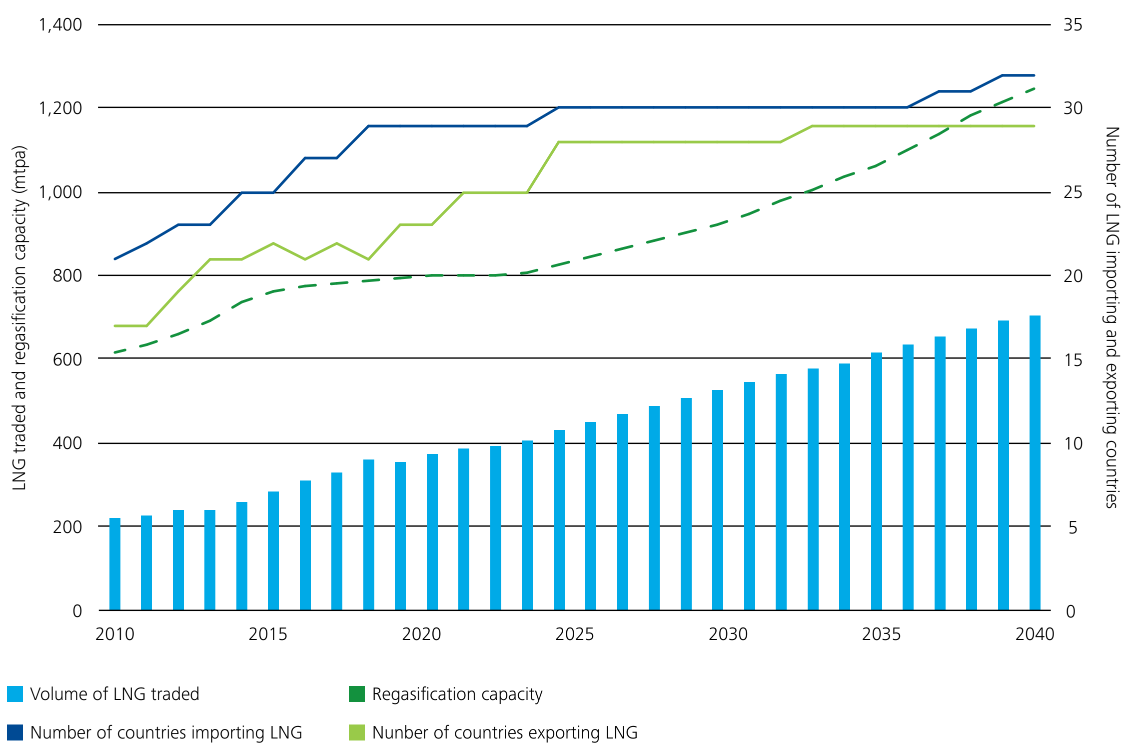
50 Years of trade and counting: LNG 1964-2014 and beyond

According to the International Gas Union's *2015 World LNG Report*, over 241 million tonnes per annum (mtpa) of liquefied natural gas (LNG) were shipped in 2014[1]—a slight uptick from the year before and close to the prior peak in 2011. Despite volumes exported remaining flat over the last five years, total LNG production has grown tremendously over a longer period—quadrupling over the last two decades and roughly doubling its market share from 5% to 10% of natural gas consumed.[2] In fact, Qatar exports larger quantities today than all countries combined in 1995.[3] This is a far cry from the *Methane Princess's* first voyage from Algeria to the United Kingdom in 1964.

Waterborne LNG was developed to meet what was a relatively straightforward issue—gas had been discovered in large quantities in places like North Africa, far from densely populated demand areas in the developed world, particularly Europe. Depending on the distance and terrain, pipelines can be used to transport gas to market. However, as distances grow or issues like mountain ranges and large bodies of water occur, pipelines become uneconomic. Shipping provides a logical alternative, similar to transporting crude oil via tankers, by using specialized vessels configured to transport supercooled natural gas in liquid form. Until the 1960s, shipping natural gas proved insurmountable, at least on a commercial level. While there were several LNG shipments prior to the *Princess's* 1964 Algeria-to-UK trip, it was first to establish a firm contracted route.

Ultimately, the challenge of transporting LNG comes down to volume. Natural gas requires on the order of 1,000 times the space as crude oil on an energy equivalent basis.

Figure 1. LNG trade volumes and trading countries by year



Source: Deloitte MarketPoint

By cooling the gas from room temperature to roughly 260 degrees Fahrenheit below zero, it takes up only one six hundredth of its original volume, making shipping as technically feasible, albeit more expensive, as shipping crude oil or refined products.

Historically, Japan has driven demand, in its quest to replace dependence on imported oil after the price and supply shocks of the 1970s, along with other Southeast Asian countries, like South Korea and Taiwan, becoming significant importers afterward. Trade grew strongly though the 2000s, with more buyers and sellers entering the market. However, a combination of the financial crisis and record new capacity being commissioned led to a supply glut by the end of the decade.

Since 2011, high oil prices and abundant reserves improved the economics of exporting and importing LNG, driving investment in a new wave of liquefaction projects. Since many long-term contracts are linked to oil, the recent drop in oil prices has had pass-through effects on LNG prices to the large markets in Asia and Europe. This, combined with lower-than-expected global demand growth, has driven down both oil-linked contract prices and spot prices, narrowing price differentials between the three distinct major markets: the Americas, Europe, and Asia. This glut may persist as near-term economic growth remains uncertain and a new wave of supply capacity comes on stream in the United States and Australia between 2015 and 2020.

Despite these headwinds, the tremendous LNG supply growth will continue over the next five years as new facilities, currently under construction, come online in the US and Australia including the world's largest offshore facility, Shell's *Prelude FLNG*,[4] as well as five American facilities along the Atlantic and Gulf Coasts.[5] BP's *World Energy Outlook* forecasts LNG supply growth of 7.8% per annum between 2013 and 2020.[6] Beyond that, there is potential for additional sources of supply—the opening of Iran's extensive known gas reserves to international investment, Canadian Pacific Coast liquefaction facilities supplied from prolific shale resources, East African LNG producing from recent discoveries in Mozambique and Tanzania, new projects in the United States and Australia, along with brownfield expansions of existing plants.

Demand growth is expected to be just as robust, with BP forecasting demand to be more or less in line with supply over the next ten to twenty years (although, BP's outlook hinges on strong market growth in Asian and European countries). While expectations of power generation growth in the developed and developing world differ, natural gas consumption growth will hinge on increasing underlying economic growth. The International Monetary Fund (IMF) downgraded its 2015 global GDP growth outlook to 3.3% in July,[7] a 0.2% reduction from its January outlook. And while it is expected to accelerate in the near term, downward revisions notably in several of the BRICS countries (Brazil, India, China, and South Africa) increase the risk of underperformance. With that said, the strong forecasted LNG demand growth may need to be tempered, extending the current glut into next decade.

Even with this near-term uncertainty in LNG demand, potential supplies are vast, and the long-term prospects are sound. While the price for spot cargoes imported to Japan on contract dropped year-on-year from US$11.60 per million British thermal units (mmbtu) to US$7.40 per mmbtu in December 2015,[8] the trade is driven by long-term expectations of high demand, particularly in South East Asia, and low natural gas prices in key producing areas like the US and the Middle East. Continued trade growth requires sufficient pricing arbitrage opportunities combined with security of investment over long periods of time. Lower development costs in areas like the US, access to technologies (including micro and floating LNG), as well as more market opportunities like a flexible, liquid spot market can provide sufficient catalysis to drive growth in excess of what has been seen in the last five years.

At this point, there is potential for divergence—that is to say, the LNG industry could retrench, focusing on liquefaction and transport for a fixed fee with utility-like returns. Or, perhaps the increases in supply, potential for long-term demand, and a flexible web of transport options could catalyze a broader, globalized industry with higher level of activity, market specialization, and a robust and liquid spot market. This all depends on companies taking advantage of the new sources of gas (North America, Africa, Middle East, or Oceania) and building a business on transparent pricing based on natural gas supply and demand with a potential for sustained pricing convergence, net of transport, between the three major markets.

Rapid growth amplifies business fundamentals

To highlight the range of feasible outcomes for the LNG business over the next 10 years, we have laid out a strength, weakness, opportunities, and threat (SWOT) analysis. With over 50 years of shipments, the LNG industry's characteristics are well understood, but will not necessarily remain the same. Key changes in the business landscape will alter the equation, with the potential to further expand the market and shift the underlying foundation. And while a SWOT analysis is most often used to discuss the company-level position, it is equally applicable to industry segments like LNG relative to others, as we do here.

Strengths

LNG delivers value by commercializing "stranded" gas assets, typically far from existing infrastructure or in areas with limited indigenous demand—in the case of the US, the large amount of surplus gas unlocked by new technologies. That resource potential has increased as new gas fields are discovered and more countries build-out regasification infrastructure. For example, gas reserves well in excess of 100 tcf have been discovered in offshore Mozambique and Tanzania,[9] but there is limited existing domestic consumption.[10] Operators face similar challenges in other frontier and emerging basins like the South American Atlantic Margin as well as in the Levant, off the coast of Israel and Cyprus.

Additionally, countries with existing gas production and domestic markets may opt for LNG if individual projects will exceed infrastructure capacity. For example, ENI's Zohr discovery off the cost of Egypt has the potential to double the country's gas reserves and additional discoveries could lead to Egypt restarting LNG exports. An abrupt turn of face after multiple years of rapid domestic growth exceeded the declining production in 2015. The Russian firm Gazprom produces large quantities of gas, exported both via pipelines and in isolated areas like Sakhalin, via LNG. As companies explore farther from population centers, LNG will become essential to commercializing any gas discoveries. For example, Novatek is planning to export gas from the South-Tambeyskoye field via the Yamal peninsula LNG mega-project adjacent to the Kara Sea in the Russian Arctic.

Due to the high upfront costs and long production life, 70 to 80 percent of offtake capacity is typically pre-sold. This lowers the risk of investment, which opens access to more risk averse sources of capital. For companies managing a broad spectrum of oil and gas assets, LNG provides more predictable cash flows and diversification from the traditional exploration and production business. Not only does this limit the liquefier's risk, it also diversifies end users' gas supply and reduces shortage risks. This is particularly important for countries in Eastern Europe, like Lithuania, which face political impediments to stable imports from Russia.

Weaknesses

Cost overruns and delays have negatively impacted LNG projects globally. For example, the Oil & Gas Journal reported in September that Inpex's Ichthys LNG project in Australia has been delayed three-quarters of a year, and projected costs will likely increase by up to US$3.4 billion, roughly 10%.[11] Projects like Gorgon LNG in Australia faced more significant headwinds. This is not just a regional phenomenon. Oxford Institute for Energy Studies indicated global per unit development costs over the last decade have risen three-fold, from US$300 per tpa to US$1,200 per tpa, driven by more complex and remote projects, compounding industry-wide challenges with cost inflation.[12] Beyond pure cost escalation, operators are targeting increasingly isolated or smaller fields, which may drive cost per unit of capacity further upward. Admittedly, the impact is unclear, as the International Gas Union has noted in their 2015 report several other factors outside remoteness will also impact on cost, limiting the correlation.[13] Cost overruns can have a large, negative impact on returns since the delivered price is independent on the cost of supply, with oil linkages providing price transparency by exposing producers to a highly volatile commodity.

Opportunities

Growth potential stems from two factors—the large amount of low cost gas discovered in the last decade and technology improvements that unlock value from increasingly smaller fields and markets. For example, the US Energy Information Administration (EIA) estimated the United States had 354 trillion cubic feet of proven natural gas reserves at year-end 2013, roughly double the nadir in the 1990s, despite rising production.[14] Other regions, including East Africa and Pacific Canada, have seen dramatic increases in gas potential. There is sufficient supply to meet future increases in demand from multiple avenues, including not only the typical power generation, but also for alternative uses like small scale re-gas for isolated markets or transport fuel for heavy-duty trucks, railroads and shipping, where displacement of diesel can be an economic proposition with additional environmental benefits. And affordable prices will spur demand from all sources, large and small. Firms that can take advantage of LNG's optionality to flexibly source gas, as well as navigate the contracting and supply chain challenges, have a large potential market to tap into. Not only that, but the potential market continues to grow as the number of countries with import and regasification capacity increases.

Threats

Historically, LNG prices have been linked to oil. With Brent prices roughly halving over the first half of 2015, the high delivered price necessary to offset operational issues (e.g., gas sourcing, delays, costs) have been eliminated. Furthermore, Deloitte MarketPoint reference case forecasts crude prices remaining below US$80 per barrel in 2015 real terms over the next ten years.[15] With Australian LNG projects delayed and a wave of US projects reaching completion this year, near-term supply growth will outstrip demand growth just as both contracted and spot prices have dropped dramatically. Low prices and higher volatility will prevent smaller players from entering the market and limit optionality for portfolio players to effectively dispatch cargoes while maximizing the benefits of vertical integration—all potentially contributing to a supply crunch in the early to mid-2020s, as well as deferring the development of a more robust market.

Facing tighter supplies, importers may overcome geopolitical hurdles to expand existing pipeline networks, and construct new ones connected to large reserves in the Middle East and Russia. Moreover, importers like China have abundant undeveloped shale resources, which may prove economic if LNG supply is constrained and domestic prices rise. This could lead to a secular drop in demand over the longer term.

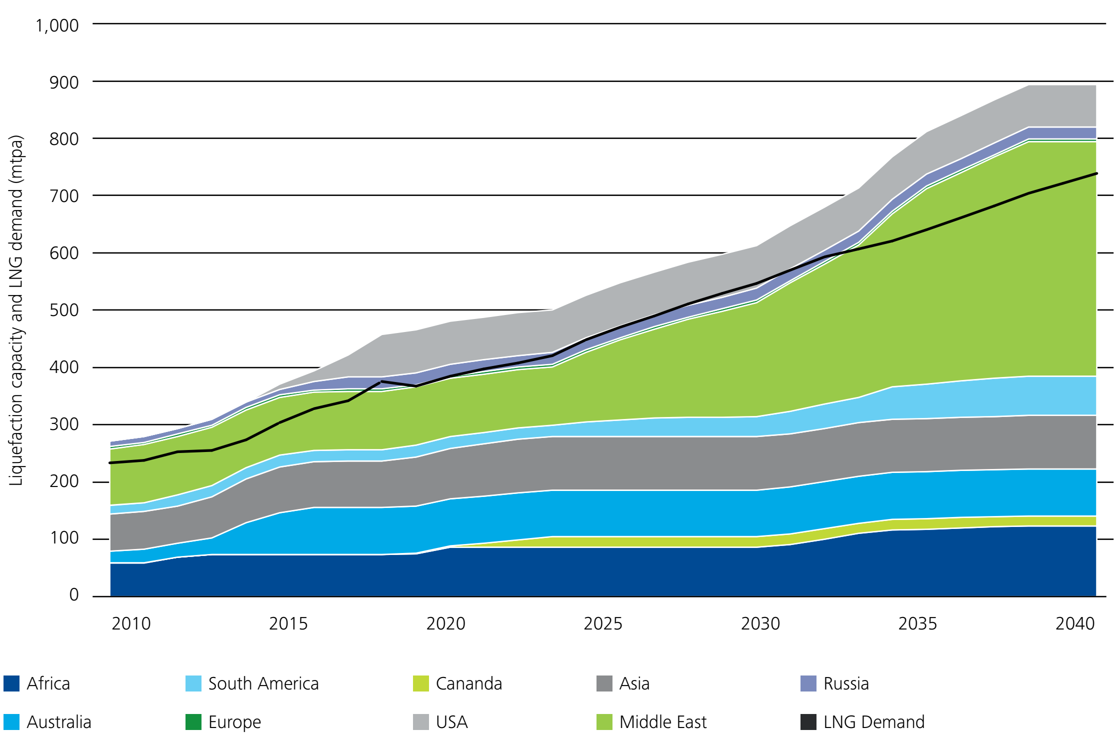
Putting it all together

Generally speaking, recent trends in the industry have moved towards accelerating change. For example, more liquefaction capacity will be added in the next two years than in the last five. Moreover, Japan has restarted two nuclear powers plants since the Fukushima disaster led to shutting down nuclear plants. This caused a 12% year-on-year increase in LNG imports[16] and the startups could lead to a similar contraction in imports over the near-term. Rapid changes require projects to be agile, which is not an LNG mega-project's forte. Moreover, pricing linked to the price of oil, be it Brent or Japanese Customs Cleared (JCC), decouples the cost of production from realized prices. And while moving towards a cost of supply based pricing could limit the net-revenue risk, as the price of oil has dropped, interest in moving the price basis has waned. The existing take or pay contracts do provide producers with some surety of capacity, but with the excess spot cargoes on the market and low oi-linked prices, the profitability of these facilities is threatened.

What is more concerning for producers is the high utilization needed for solid financial return is not iron clad, even with contract in hand. It is in fact possible at least in some contracts for the buyer to defer cargoes. For example, the Times of India reported "India has deferred taking deliveries of at least 20 shiploads of expensive LNG from its main supplier Qatar and wants a rate cut matching the 60 percent fall in international rates."[17] Any deferrals will, of course, result in reduced capacity utilization or additional volumes entering the spot market, weighing down prices and exacerbating the profitability challenges.

Fortunately for LNG investors, the longevity of liquefaction facilities minimizes the total revenue exposure at any given point in time. While today's low prices do threaten investment, there is potential for a medium-term supply crunch if new capacity is underbuilt, which would improve the pricing outlook for spot cargoes. Beyond that, today's low oil prices will result in lower supply growth, contributing to higher prices later—lifting contract LNG prices as well. Unlike the US onshore shale game, price volatility can be problematic for LNG exporters, but not necessarily value-destructive over the project lifecycle. A liquefaction plant has opportunities to make up lost margins today with increased contract and spot transactions when demand increases and prices rise.

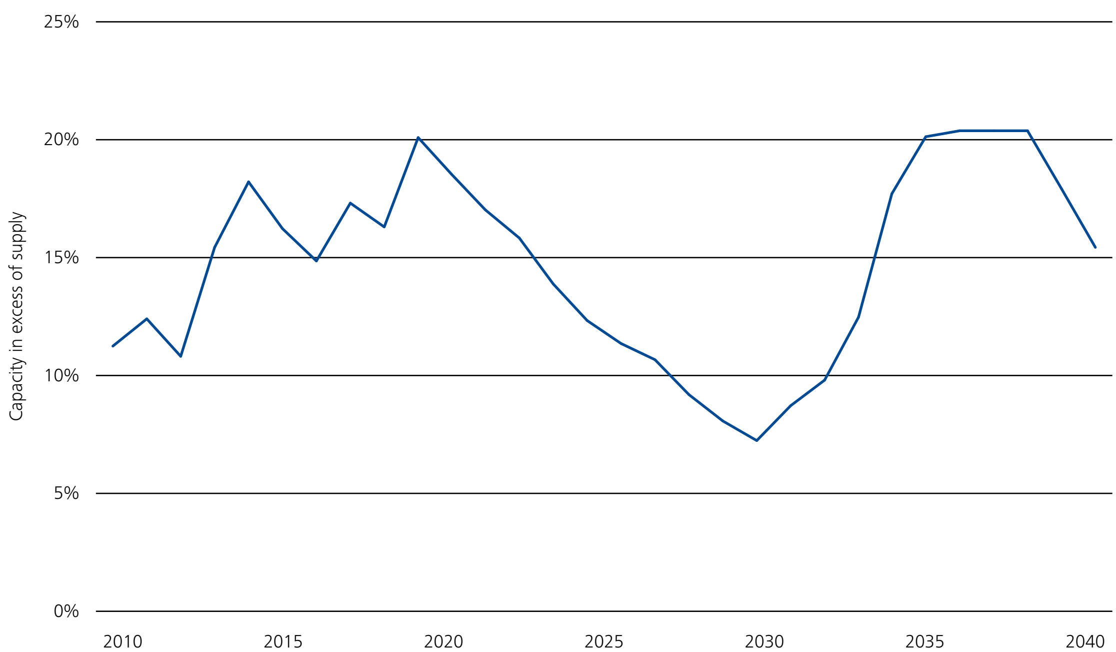
Figure 2.1 Liquefaction capacity by country and global demand 2011-2040



Source: Deloitte MarketPoint

So, volatility may not threaten existing liquefaction facilities, but increased uncertainty could limit or delay investment in the next wave of projects—be it in the US, Canada, Africa, Australia or elsewhere. Even if the ultimate risk remains the same, visibility at the moment is poor—reducing industry momentum and leaving a large number of potential projects unsanctioned. Waiting is a strategy, albeit an unsatisfying one at best and enervating at worst. Understanding the lay of the land helps contextualize decisions whether that is in the short, medium, or long term.

Figure 2.2 Excess liquefaction capacity 2011-2040



Source: Deloitte MarketPoint

Signposting the key levers in a rapidly shifting industry

A SWOT analysis cannot capture all the risks of any given project as the landscape is susceptible to sudden shifts. It is just as necessary to consider the ongoing vectors of change and anticipate how market movements impact projects over the investment cycle. In broad terms, the major upheaval stems from unexpected changes in demand and supply driven by technical enhancements, political shifts, and market sentiment. Below are seven key factors that may alter the direction and speed of the LNG market's maturity. Ultimately these factors are not binary, but occur across a broad spectrum and are heavily intertwined. The following section describes these factors in greater detail. The future of the LNG industry will play out as a function of how strongly each factor develops and the interplay between them.

Slowing global economic growth

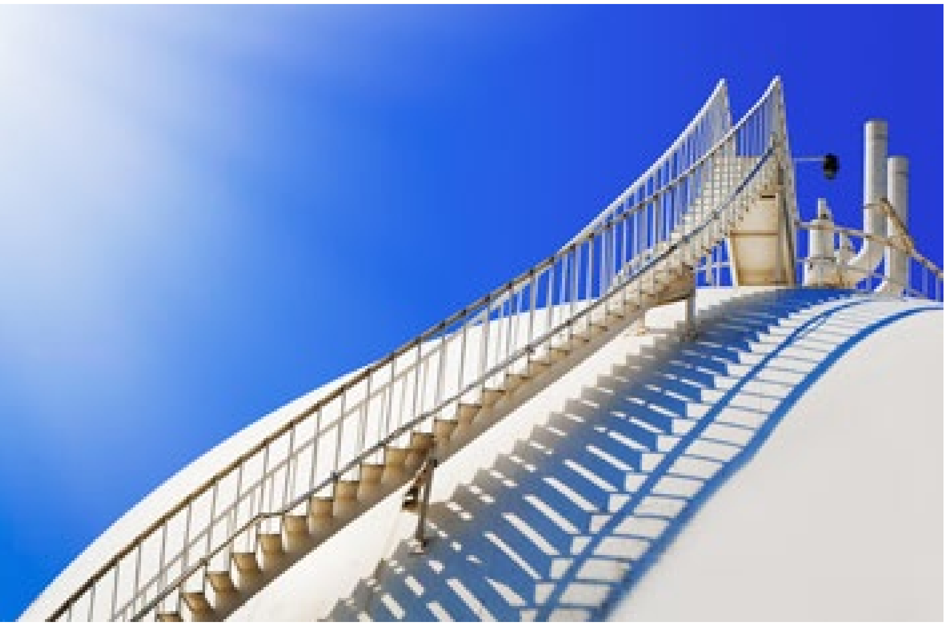
The continued malaise in Europe combined with a slowdown in Southeast Asia will likely weigh against energy demand, particularly LNG consumption. For example, an October 2015 *The Economist* column noted regional growth (excluding Japan) is expected to be 5.8% for the year, a couple percentage points lower than the decadal average. More importantly, the columnist highlighted the several currencies, including the Japanese Yen, have dropped against the dollar.[18] In local terms, this will make LNG cargoes dearer, even as prices have dropped globally, partially offsetting the benefit of lower energy costs. Moreover, the Southeast Asian economies that consume the bulk of LNG shipments are closely interrelated. A reduction in growth in China will reduce demand for goods and services from adjacent countries, reducing manufacturing activity and energy usage in the rest of the region.

Moving past the next couple of years, the medium-term outlook will also be subdued relative to the previous decade. The IMF's recent *World Economic Outlook* cites the economic slowdown over the last five years has led not only to a lower level of economic output versus prior trends, but also a lower overall trend in growth. The Fund estimates for medium-term (i.e., five years ahead) growth have been reduced every year since 2011, with an outsized impact from underperformance in the emerging markets. Annual growth through 2020 is expected to remain moderate, roughly 1.6% in the developed world and 5.2% in emerging economies, though the report notes China's growth could be weaker than anticipated due to a "rebalancing of growth away from investment and toward consumption."[19]

The Economist Intelligence Unit sees a similar trend, with five-year growth running near 3% globally, averaging 2% and 5% for OECD and non-OECD countries respectively.[20] While energy intensity varies from country to country, and over time, lower growth in GDP will strongly correlate with lower growth in LNG consumption. OECD countries are not key to driving future commodity demand—the emerging markets are. Signs of persistent low growth in major importers like Japan, combined with a Chinese slowdown and underperformance of the historical "Asian Tigers" (Hong Kong, Singapore, South Korea, and Taiwan) would indicate the potential for undermining LNG growth in its entirety, leading to capacity utilization dropping as new liquefaction facilities come onstream.

Increased energy efficiency

Not only is there a risk of lower economic growth, the relationship between growth and energy usage has weakened. For example, the International Energy Agency (IEA) estimates China has reduced its energy intensity from just shy of 600 tonnes of oil equivalent per thousand dollars to just north of 200 in 2012, in 2005 dollars.[21] Moreover, the cost per cubic foot of natural gas for LNG importing countries like Japan is much higher than exporters like the US. This provides a higher incentive for efficiency gains and fuel switching. According to an April Reuters article, "Japan is now one of the world's four largest markets for solar panels and a large number of power plants are coming onstream" and "residential solar power production costs have more than halved since 2010."[22] A combination of lower energy requirements combined with low cost renewables could over time reduce the appetite for higher cost natural gas imports.



Furthermore, generators do not have to switch fuels to improve efficiencies. Gas turbines have become increasingly more efficient, providing the same power with less input. Older models could have efficiencies less than 30%, with more recent combined-cycle systems reaching 60%. Even if countries defer expanding their renewable portfolios and retire coal and nuclear plants, they could stem growing natural gas consumption by replacing older gas generation plants. Higher LNG prices will be needed to justify sanctioning much of higher-cost liquefaction. This provides ample incentive to improve efficiencies. Due to the cost and duration of constructing new power plants, demand will only be affected marginally in the near term. With this said, continued growth of natural gas consumption in the power and utilities sector should not be taken as a given—particularly as LNG prices increase and generation technology costs decrease.

Surfeit of pre-FID capacity

Large amounts of potential liquefaction capacity remain unsanctioned as economics are evaluated, buyers are sought, and designs are developed. The International Gas Union's 2015 report counts roughly 100 mtpa capacity of under construction, and another 250 mtpa unsanctioned liquefaction capacity in North America and Australia is expected to start up in the early 2020s,[23] which is the equivalent of BP's total forecasted LNG demand growth through 2035.[24] Moreover, the IGU's count excludes potential commercialization of East African gas. Absent a surge in demand, most of these greenfield projects will not move forward within the next five to ten years, if at all. Companies can still take advantage of excess capacity from underutilization or lower cost brownfield expansions of existing facilities.

These projects are not just unsanctioned, but also high cost. A liquefaction project requiring US$12-15 per mmbtu to breakeven after adjusting for the cost of capital is clearly out of the money in the current environment. But as contract and spot prices begin to rise, there will be a glut of new potential capacity, intensifying the "lumpiness" of the periodic swings of over and under supplied markets. And in all likelihood, this new capacity is not needed to meet demand. Overall volumes traded have remained close to flat for five years despite new facilities coming onstream. Beyond that, new United States and Australian facilities should have excess capacity that could generate spot cargoes if market slack tightens. In all likelihood, high cost projects in regions with limited existing infrastructure will not be sanctioned. Bloomberg, citing IHS, noted only one in twenty planned projects would be needed by 2025.[25] Alternatively, developing larger projects as multiple smaller phases or expanding FLNG could provide new volumes while limiting outsized risk of low marginal demand growth. In practice, the long-term contracting common to the industry should prevent too many new players entering the market since they would simply not be able to generate sufficient interest to reach final investment decision (FID).

Lower transport costs

Profit at the liquefaction plant is not only based on delivered prices, but also the cost of transport, which can vary based on shipping contract and trip duration. So even if prices remain weak, there are opportunities to maintain margins. One way to lower the shipping cost is to simply reduce the trip duration by cutting the distance. Canals are an obvious way to achieve it, and both the Suez and Panama Canals are being expanded, though the Wall Street Journal notes the enlarged Panama Canal will not accommodate the 50-m Q-Flex ships which have 38% higher capacity than the vessels that could make the trip.[26] The higher volumes are necessary to generate economies of scale to reduce transport costs. These routes may only be advantageous to companies limited by existing infrastructure and geology—most notably liquefiers along the US Gulf Coast exporting into Southeast and East Asia.

Better than expanding canals would be increasing the number of LNG liquefaction plants and regasification terminals, as well as introducing delivery contracts with greater flexibility. In this case, gains would not come from reducing the distance between market participants, but by simply allowing marine traffic to flow more logically. Adding export capacity to not just the United States and Australia, but East Africa and along the Pacific Rim, combined with the addition of new regasification terminals, including most recently Egypt, Jordan, Lithuania, Pakistan, and Poland, will provide portfolio players a means of supplying gas at lower costs. This will be limited by the rigidity of existing LNG contracts, but low spot prices and new American and Australian supply has weakened the historical sellers' market, with larger buyers negotiating better terms going forward.

Furthermore, the number of LNG vessels has increased dramatically over the last five years, from 194 in 2005 to over 373 in 2014, with average ship capacity increasing 25% from 130,000 to 161,000 meters cubed.[27] The large increase in shipping capacity has weighed on the market, with Bloomberg reporting in February 2015 charter rates had dropped from a high of US$140,000 per day in 2012 to US$50,000 per day.[28] These rates have dropped further and large number of vessels are expected to enter the market. Morgan Stanley estimates an additional 130 vessels

will be delivered from 2016 through 2020,[29] which will require robust LNG trade growth to maintain demand. Continued weakness in demand for vessels will push rates further downward, allowing LNG liquefiers and buyers to secure long-term low rates. Low rates combined with more efficient routing could significantly improve total margins as shipping can be more than US$2.00 per mmbtu, roughly a third to a quarter of the delivered cost.

Access to new markets

Electricity generation consumes roughly 67% of Japan's and 51% of South Korea's supply of natural gas,[30] the vast majority of which comes from LNG imports. While Japan restarted the first nuclear power plant following the Fukushima disaster on August 12, 2015, and its second on October 21 2015,[31] the power sector will remain a large consumer of natural gas for the foreseeable future. Moreover, natural gas emits close to 30% less CO_2 per Btu than fuel oil,[32] making it a more environmentally palatable fuel. Beyond that, cleaner burning fuels reduce airborne particulate matter. Affordable natural gas could replace residential coal and wood burning, not to mention phase out industrial and commercial use of diesel and fuel oil generators. In many ways this has already been seen in the US as low natural gas prices have contributed to an almost 20% drop in coal consumption from its 2007 peak.[33]

Further diversifying the customer base would lower supplier risk while providing upside potential for continued market growth. One potential source for this, is simply finding new, smaller end users. As Lloyd's List notes, "[intrabasin] trading is set to grow in popularity, reducing tonne miles, but potentially offering opportunities for smaller vessels… [intrabasin] trading could involve US cargoes heading to South America. Or Southeast Asian cargoes carried to importers in that region, or Middle Eastern cargoes shipped short-haul to satisfy rising Middle Eastern demand for LNG."[34] Whether it is delivery via smaller vessels, or essentially a "milk run" by a larger ship, intrabasin trading could push toward developing a more robust regasification network, serving smaller populations currently lacking material access to low-cost energy. Furthermore, smaller populations with more predictable access to affordable natural gas could generate positive knock-on effects with opportunities for fuel-switching and as currently non-existent industrial markets grow and mature. Admittedly, these smaller markets represent only a fraction of existing volumes. While expanding access geographically provides a likely upside in demand, there would be a much greater impact targeting entirely new types of consumers.

New types of end users

There is potential for LNG to expand beyond its traditional sectors as well. For example, Reuters stated Ryo Makimi, the Japanese Director for Oil and Gas at the Ministry of Economy, Trade, and Industry (METI), wants "10 percent of the 300,000 trucks used for long-distance transport to be fueled by LNG soon and a 'substantial' part of the fleet to use gas eventually."[35] With other countries aiming to reduce CO2 and other pollutant emissions, similar goals may become more widespread. And LNG transport fuel is not limited to trucks. In the US, LNG powered rail could lower fuel costs, though according to the EIA the uptake would be relatively slow.[36] Lloyd's Register Marine and the University College London's Energy Institute sees a similar trend for LNG as shipping fuel, with LNG making 11% of the total energy mix, which could potentially be in the tens of millions of tonnes per annum.[37] Today transport is a small but growing source of demand that faces headwinds from lack of refueling infrastructure. A concerted effort to build out LNG bunkering at global ports, particularly outside of Europe, will be needed to make LNG a viable alternative to traditional marine fuel on a global scale.

LNG uptake does not need to be limited to the transport sector. Natural gas fuel cells could widen the electric power market from traditional generators to point generation for end users. While the total market volume limited in the near term to back-up generation, peaking power and other niche uses, lowering costs as development continues could broaden the appeal to isolated or highly mobile populations. But unlike transport, alternative power generation seems unlikely to make up a significant portion of the market in the next five to ten years. That being said, as the emerging markets develop, so the demand for power will increase, particularly in areas remote from existing infrastructure. For example, according to the World Bank, North America consumes roughly 13,000 kilowatt hours per person, double the Euro area and four times the typical average in the developing world. Sub-Saharan Africa has even less access electricity than most, 26% versus over 80% for the world, and a startling low usage of 500 kilowatt hours per person.[38]

Commercializing low-cost, small-scale LNG projects is unlikely in the near-term, but there is massive untapped potential for new end users. If GDP growth is accelerated in the developing world, particularly in Latin America, the Caribbean and Africa, conventional and alternative power generation will converge with the global average. To put this in perspective, the per capita consumption difference between a low income and a middle income country is well over double.

Increase in market liquidity

In 2014, according to the IGU, roughly 70% of all LNG volumes traded via long-term contracts, with balance being spot transactions as well as short and medium-term contracts.[39] While on percentage terms, the oil spot market is roughly similar, the total volumes traded differ in orders of magnitude. Additionally, 1.9 billion tonnes of oil[40] were traded including both spot and termed contracts in 2014 versus only 241 million tonnes of LNG.[41] Another challenge is storage. Boil-off and operating costs make storing LNG impractical and expensive. It is simpler for companies to secure demand via long-term contracts than handle unsold cargoes. The recent drop in prices only intensifies the issues. A thin spot market not only limits opportunities to pick up or offload cargoes, but it also spurs higher volatility. Solving the issue would neither be simple nor tractable for small number of buyers and sellers. There needs to be sufficient critical mass in market participants to generate sustained, higher trade activity both in volume and number of cargoes.

Liquefaction has not been and likely will not be an on-demand service. If supply remains fixed over the short term, demand must become more price-elastic to dampen volatility and flesh out a dynamic short-term market. Increased liquidity is a certainty with new importers, as well as potential for smaller and floating re-gas technology. However, without increased demand in new, smaller markets, and an uptake in micro and portable natural gas technologies, the markets would only be liquid on the margins. Flexible delivery contracts will be necessary to allow market participants to optimize trading strategies and supply chain links. For example, flexible contracts would allow large portfolio players to act as market makers, providing liquidity and balance between geographic markets, meeting the underlying contracts' destinations and volumes. More importantly, liquidity can be characterized as an emergent phenomena, where trading opportunities scale exponentially as new supply and demand hubs lead to drastically more potential routes, incentivizing increased market participation.

The next 50 years: LNG as a global fuel?

A forecast is typically a business-as-usual outlook, or perhaps a consideration of a series of finite scenarios. In the case of both young and mature markets, the impacts of small events like the introduction or adoption of new technologies may play a larger role in the medium to long term than many of the more predictable, and modellable, factors. So in that case, it is prudent to consider both the trend as well as potential disruptions. In the case of LNG over the past 50 years, the gas sources have shifted geographically and geologically; the major players have included NOCs, IOCs, shipping companies and utilities; and prices have fluctuated by a factor of four or five over relatively short periods of time.

The long-term growth of the LNG industry will be dependent on deepening existing relationships with existing consumers and expanding into new sectors, as well as finding more efficient ways to deliver products to wider markets at lower cost, all while attempting to keep supply and demand level. Over the next few months, the Deloitte Center for Energy Solutions will delve deeper into the fundamentals and emerging trends of the LNG trade to highlight how these key drivers will shape the emerging global market. We will look at Deloitte MarketPoint's industry fundamentals analysis, the interplay between geology and geography in North American natural gas, and the impact of a truly globalized and active LNG spot market.

Appendix: North American and Australian liquefaction capacity under construction or proposed

Project	Train	Capacity	Status	Expected start date	DOE/FERC approval	FTA/non-FTA approval	CAN NEB status	Operator	Region	State/ Province
Sabine Pass	1, 2	9	Under construction	2015/2016	DOE/FERC	FTA/non-FTA	N/A	Cheniere	United States	Louisiana
Sabine Pass	3, 4	9	Under construction	2016/2017	DOE/FERC	FTA/non-FTA	N/A	Cheniere	United States	Louisiana
Sabine Pass	5	4.5	Pre-FID	2019	DOE	FTA	N/A	Cheniere	United States	Louisiana
Sabine Pass	6	4.5	Pre-FID	2019	DOE	FTA	N/A	Cheniere	United States	Louisiana
Freeport LNG	1, 2	8.8	Under construction	2018	DOE/FERC	FTA/non-FTA	N/A	Freeport LNG	United States	Texas
Freeport LNG	3	4.4	Pre-FID	2019	DOE/FERC	FTA/non-FTA	N/A	Freeport LNG	United States	Texas
Cameron LNG	1, 2, 3	12	Under construction	2018	DOE/FERC	FTA/non-FTA	N/A	Sempra Energy	United States	Louisiana
Cameron LNG	4, 5	8	Pre-FID	N/A	N/A	N/A	N/A	Sempra Energy	United States	Louisiana
Cove Point LNG	1	4	Under construction	2017	OE/F	FTA/non-FTA	N/A	Dominion Resources	United States	Maryland
Elba Island LNG	1, 2	2.5	Pre-FID	2017	DOE	FTA	N/A	Kinder Morgan	United States	Georgia
Corpus Christi LNG	1, 2, 3	13.5	Pre-FID	2018/2019	DOE/FERC	FTA	N/A	Cheniere Energy	United States	Texas
Magnolia LNG	1, 2, 3, 4	8	Pre-FID	2018/2019	DOE	FTA	N/A	LNG Limited	United States	Louisiana
Texas LNG	1, 2	4	Pre-FID	2018	DOE	FTA	N/A	Texas LNG	United States	Texas
Annova LNG	1, 2, 3, 4, 5, 6	6	Pre-FID	2018	DOE	FTA	N/A	Exelon	United States	Texas
Jordan Cove LNG	1, 2, 3, 4	6	Pre-FID	2019	DOE	FTA/non-FTA	N/A	Veresen	United States	Oregon
Oregon LNG	1, 2,	9	Pre-FID	2019	DOE	FTA/non-FTA	N/A	Oregon LNG	United States	Oregon
Mississippi River LNG	1, 2, 3, 4	2	Pre-FID	2019	DOE	FTA	N/A	Louisiana LNG	United States	Louisiana
Lake Charles LNG	1, 2, 3	15	Pre-FID	2019/2020	DOE	FTA/non-FTA	N/A	Trunkline LN/BG	United States	Louisiana
Golden Pass LNG	1, 2, 3	15.6	Pre-FID	2019/2020	DOE	FTA	N/A	Golden Pass Products	United States	Texas
Gulf LNG	1, 2	5	Pre-FID	2019/2020	DOE	FTA	N/A	Gulf LNG	United States	Mississippi
Calcasieu Pass LNG	1, 2,	10	Pre-FID	2019/2020	DOE	FTA	N/A	Venture Global Partners	United States	Louisiana
South Texas LNG	1, 2	8	Pre-FID	2019/2020	DOE	FTA	N/A	Next Decade Interational	United States	Texas
Gasfin LNG	1	1.5	Pre-FID	2019	DOE	FTA	N/A	Gasfin Development	Trinidad?	
Downeast LNG	1	3	Pre-FID	2019	N/A	N/A	N/A	Downeast LNG	United States	Maine
CE FLNG	1, 2	8	Pre-FID	2019	DOE	FTA	N/A	Cambridge Energy Holdings	United States	Louisiana
Live Oak LNG	1	5	Pre-FID	2019	N/A	N/A	N/A	Parallax Energy	United States	Louisiana
General American LNG	1, 2	8	Pre-FID	2022	N/A	N/A	N/A	General American LNG	United States	Texas

Project	Train	Capacity	Status	Expected start date	DOE/FERC approval	FTA/non-FTA approval	CAN NEB status	Operator	Region	State/ Province
Main Pass energy Hub FLNG	1, 2, 3, 4, 5, 6	24	Pre-FID	N/A	DOE	FTA	N/A	Freeport-McMoRan	United States	Louisiana
Barca FLNG	1, 2, 3	12	Pre-FID	N/A	DOE	FTA	N/A	Barca LNG	United States	Texas
Gulf Coast LNG	1, 2, 3, 4	21	Pre-FID	N/A	DOE	FTA	N/A	Gulf Coast LNG	United States	Texas
Delfin LNG	1, 2, 3, 4	13	Pre-FID	N/A	DOE	FTA	N/A	Delfin LNG	United States	Louisiana
Eos LNG	1, 2, 3	12	Pre-FID	N/A	DOE	FTA	N/A	Eos LNG	United States	Texas
Monkey Island LNG	1, 2, 3, 4, 5, 6	12	Pre-FID	N/A	DOE	FTA	N/A	SCT&E	United States	Louisiana
Alturas LNG	1	1.5	Pre-FID	N/A	DOE	FTA	N/A	WesPac	United States	Texas
Waller Point FLNG	1	1.3	Pre-FID	N/A	DOE	FTA	N/A	Waller Marine	United States	Louisiana
Lavaca Bay FLNG	Unknown	8	Stalled	N/A	DOE	FTA	N/A	Excelerate Energy	United States	Texas
REI Alaska	Unknown	1	Pre-FID	2020	N/A	N/A	N/A	Resources Energy	United States	Alaska
Alaska LNG	1, 2, 3	20	Pre-FID	2024/2025	DOE	FTA	N/A	BP, ConocoPhillips and ExxonMobil	United States	Alaska
LNG Canada	1, 2	12	Pre-FID	2021	N/A	N/A	Approved	Shell	Canada	British Columbia
LNG Canada	3, 4	12	Pre-FID	N/A	N/A	N/A	Approved	Shell	Canada	British Columbia
Kitimat LNG	1	5	Pre-FID	2018	N/A	N/A	Approved	Chevron	Canada	British Columbia
Kitimat LNG	2	5	Pre-FID	N/A	N/A	N/A	Approved	Chevron	Canada	British Columbia
Pacific Northwest LNG	1,2	12	Pre-FID	2019	N/A	N/A	Approved	Petronas	Canada	British Columbia
Pacific Northwest LNG	3	6	Pre-FID	N/A	N/A	N/A	Approved	Petronas	Canada	British Columbia
WCC LNG	1, 2, 3	15	Pre-FID	2024	N/A	N/A	Approved	ExxonMobil	Canada	British Columbia
WCC LNG	4, 5, 6	15	Pre-FID	N/A	N/A	N/A	Approved	ExxonMobil	Canada	British Columbia
Prince Rupert LNG	1, 2	14	Pre-FID	2023	N/A	N/A	Approved	BG	Canada	British Columbia
Prince Rupert LNG	3	7	Pre-FID	N/A	N/A	N/A	Approved	BG	Canada	British Columbia
Wood Fibre LNG	1	2.1	Pre-FID	2017	N/A	N/A	Approved	Pacific Oil and Gas	Canada	British Columbia
Douglas Channel FLNG	1	0.55	Pre-FID	2018	N/A	N/A	Approved	AltaGas	Canada	British Columbia
Kitsault FLNG	1, 2	8	Pre-FID	2018/2019	N/A	N/A	Filed	Kitsault Energy	Canada	British Columbia
Orca FLNG	1	4	Pre-FID	2019	N/A	N/A	Filed	Orca LNG	Canada	British Columbia

Project	Train	Capacity	Status	Expected start date	DOE/FERC approval	FTA/non-FTA approval	CAN NEB status	Operator	Region	State/ Province
Orca FLNG	2, 3, 4, 5, 6	10	Pre-FID	N/A	N/A	N/A	Filed	Orca LNG	Canada	British Columbia
Steelhead LNG	1, 2, 3, 4, 5, 6	30	Pre-FID	2019/2020	N/A	N/A	Filed	Steelhead Group	Canada	British Columbia
Aurora LNG	1, 2	12	Pre-FID	2023	N/A	N/A	Approved	Nexen	Canada	British Columbia
Aurora LNG	3, 5	12	Pre-FID	2028	N/A	N/A	Approved	Nexen	Canada	British Columbia
Stewart Energy LNG	1	5	Pre-FID	2017	N/A	N/A	Not Filed	Stewart Energy	Canada	British Columbia
Stewart Energy LNG	2, 3, 4, 5, 6	25	Pre-FID	N/A	N/A	N/A	Not Filed	Stewart Energy	Canada	British Columbia
Discovery LNG	1, 2, 3, 4	20	Pre-FID	2021/2022/ 2023/2024	N/A	N/A	Filed	Quicksilver Resources	Canada	British Columbia
Grassy Point LNG	1, 2, 3, 4	20	Pre-FID	2021	N/A	N/A	Approved	Woodside	Canada	British Columbia
Cedar FLN	1, 2, 3	14.4	Pre-FID	N/A	N/A	N/A	Filed	Haisla First Nation	Canada	British Columbia
Tilbury LNG	1	3	Pre-FID	N/A	N/A	N/A	Filed	WesPac	Canada	British Columbia
New Time Energy LNG	1	12	Pre-FID	2019	N/A	N/A	Not Filed	New Times Energy	Canada	British Columbia
Triton FLNG	1	2	Pre-FID	N/A	N/A	N/A	Approved	AltaGas	Canada	British Columbia
Goldboro LNG	1, 2	10	Pre-FID	2019/2020	N/A	N/A	Filed	Pierdae Energy	Canada	Nova Scotia
Bear Head LNG	1, 2, 3, 4, 5, 6	12	Pre-FID	2019/2020/2021/ 2022/2023/2024	N/A	N/A	Filed	LNG Limited	Canada	Nova Scotia
Canaport LNG	1	5	Pre-FID	N/A	N/A	N/A	Not Filed	Repsol	Canada	New Brunswick
H-Energy LNG	1, 2, 3	13.5	Pre-FID	2020	N/A	N/A	Not Filed	HEnergy	Canada	Nova Scotia
Saguenay LNG	1, 2	11	Pre-FID	2020	N/A	N/A	Filed	GNL Quebec	Canada	Quebec
Australian Pacific LNG	1, 2	9	Under construction	2015	N/A	N/A	N/A	ConocoPhillips	Australia	Queensland
Australian Pacific LNG	3, 4	9	Pre-FID	N/A	N/A	N/A	N/A	ConocoPhillips	Australia	Queensland
GLNG	1, 2	7.8	Under construction	2015/2016	N/A	N/A	N/A	Santos	Australia	Queensland
Gorgon LNG	1, 2, 3	15.6	Under construction	2015/2106	N/A	N/A	N/A	Chevron	Australia	Western Australia
Gorgon LNG	4	5.2	Pre-FID	N/A	N/A	N/A	N/A	Chevron	Australia	Western Australia
Wheatstone LNG	1, 2	8.9	Under construction	2016/2017	N/A	N/A	N/A	Chevron	Australia	Western Australia
Wheatstone LNG	3, 4	13.35	Pre-FID	N/A	N/A	N/A	N/A	Chevron	Australia	Western Australia
Ichthys	1, 2	8.4	Under construction	2016/2017	N/A	N/A	N/A	INPEX	Australia	Western Australia
Prelude FLNG	1	3.6	Under construction	2017	N/A	N/A	N/A	Shell	Australia	Western Australia

Project	Train	Capacity	Status	Expected start date	DOE/FERC approval	FTA/non-FTA approval	CAN NEB status	Operator	Region	State/ Province
Abbot Point LNG	1	2	Pre-FID	2020	N/A	N/A	N/A	Energy World	Australia	Queensland
Browse FLNG	1, 3	10.8	Pre-FID	2021	N/A	N/A	N/A	Woodside	Australia	Western Australia
Crux FLNG	1	2	Pre-FID	N/A	N/A	N/A	N/A	Shell	Australia	Western Australia
Darwin LNG	2	3.6	Pre-FID	N/A	N/A	N/A	N/A	ConocoPhillips	Australia	Northern Territory
Fisherman's Landing	1	3.8	Pre-FID	N/A	N/A	N/A	N/A	LNG Limited	Australia	Queensland
Scarborough FLNG	1	6.5	Pre-FID	2021	N/A	N/A	N/A	ExxonMobil	Australia	Western Australia
Sunrise FLNG	1	4	Pre-FID	N/A	N/A	N/A	N/A	Shell	Australia	Northern Territory
Timor Sea FLNG	1	3	Pre-FID	N/A	N/A	N/A	N/A	ConocoPhillips	Australia	Northern Territory
Timor Sea LNG	1	3	Pre-FID	N/A	N/A	N/A	N/A	MEO	Australia	Northern Territory
Cash Maple FLNG	1	2	Stalled	N/A	N/A	N/A	N/A	PTT	Australia	Western Australia
Pluto LNG	2, 3	8.6	Stalled	N/A	N/A	N/A	N/A	Woodside	Australia	Western Australia

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Let's talk

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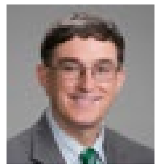

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