FIFTY YEARS OF GLOBAL LNG Racing to an Inflection Point



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Liquefied Natural Gas (LNG) has experienced remarkable developments in commercialization and export capacity in a span of just 50 years. In this paper, Professor Craig Pirrong probes where the industry is headed as oil-based pricing becomes a relic of the past. His analysis describes a potential revolution in LNG pricing and contracting mechanisms that will rely on trading firms and commodity markets to secure supply and manage risk.

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INTRODUCTION

2014 marks a watershed year (no pun intended) in the LNG business: fifty years have passed since the first purpose-built LNG vessel, the *Methane Princess*, set sail from Algeria with a cargo of super-cooled gas. Moreover, the industry arguably stands at an inflection point: impending huge surges in capacity, a potential revolution in contracting practices, and geopolitical and policy volatility are likely to transform the LNG sector over the next ten years, let alone the next 50.

The most profound looming changes will be to the ways that LNG is bought and sold. Heretofore, market participants have relied on long-term contracts, with oil-linked pricing terms. Once upon a time, this made economic sense as a way for market participants to achieve security of supply and demand. However, fundamental developments have largely de-linked oil and gas prices, and as a result, oil-linked prices send misleading signals about supply and demand, and create frictions between buyers and sellers because prices do not accurately reflect values. Thus, traditional LNG pricing mechanisms have become an increasingly costly and dysfunctional anachronism.

Fortunately, experiences in other commodities, including those that like LNG involve large, long-lived capital investments, have shown that markets can also provide security, and do so in a much more flexible and efficient way. As spot LNG markets become more liquid, producers and consumers can transact on these markets, or by using contracts with prices derived from these markets, as their counterparts in pipeline gas, petroleum, and iron ore have done.

And indeed, the dynamics of liquidity mean that this transition can be very rapid. Liquidity tends not to grow gradually and linearly. When a spot market reaches a critical mass of liquidity, as is occurring due to the organic growth of the LNG market, there is a rapid shift to a near complete reliance on either spot markets or contracts with prices based on spot prices. The LNG market stands upon the cusp of such a change, and rather than fear it, market participants should embrace it. Security through markets will provide the foundation of continued growth in LNG.

THE BIRTH AND INEXORABLE GROWTH OF GLOBAL LNG

EVOLUTION OF THE LNG MARKET

Although 1964 is the Year Zero of the modern, globalized LNG industry, it can trace its roots back more than a century when famous scientists, including Michael Faraday, began experiments with liquefying gasses. Halting steps to commercialization began in the first half of the last century. The first LNG plant was built in 1940 by the East Ohio Gas Company to provide surge capacity for its heating customers. The waterborne LNG business dates from the mid-1950s, when Continental Oil and (believe it or not) the famous (and malodorous!) Union Stockyards in Chicago created a venture to liquefy

natural gas on the Gulf Coast and barge it to Chicago where it was to be used as both a refrigerant and a fuel for food processing. The United States Food and Drug Administration was less than enamored with the idea, however, and failed to issue a permit.

Continental Oil was undaunted, and looked for alternative markets for LNG. Britain was undergoing a severe fuel shortage, and contracted with Continental to supply LNG. In January, 1959, a

converted ship, the aptly named *Methane Pioneer*, set sail from Louisiana to Britain with the first seaborne LNG cargo, thereby proving the commercial feasibility of the concept and setting the course followed by the *Methane Princess* a few years later.

The subsequent history of the industry can be traced relatively quickly through a few charts. The growth in supply over the years is best illustrated by Figure 1, which depicts the aggregate cumulative liquefaction capacity by year from 1964 to 2012. In the early years, growth was extremely rapid. The annual growth rate in capacity from 1964 to 1978 was 380 percent.

There was something of a hiatus in the growth of capacity in the 1980s and 1990s. No major projects came on line between 1983 and 1989, and there was another gap from 1989 to 1995. Capacity growth from 1980 to 1996 averaged only 4.7 percent per annum. The rate increased in the late-1990s with the entry of Trinidad and especially Qatar as major producers. From 1996 to 2006, the growth rate in capacity doubled to 9.6 percent annually.

The initial growth in LNG capacity occurred in MENA (Algeria and Abu Dhabi) and South Asia (Brunei and Indonesia). In the 1980s,

Malaysia and Australia developed as major producers. In the late 1990s, a major change occurred with Qatar's emergence as a dominant force in the marketplace. The 1990s also saw the first major supplier in the Western Hemisphere: Trinidad and Tobago.

Figures 2 and 3 illustrate the evolution of the market since 1990 using a different metric. Figure 2 depicts gas exports by major LNG countries. Note that Algeria, Indonesia, and Malaysia were the dominant export countries in 1990, and maintained relatively constant exports in the subsequent 22 years. The spectacular

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emergence of Qatar is evident in the graph. It is even more evident in Figure 3, which graphs export market shares. In 1990, Algeria, Indonesia, and Malaysia accounted for about 81 percent of the exports of the 15 countries considered: by 2012, this share had fallen to 32 percent, which is smaller than Qatar's share (33 percent) alone.

On the demand side, although Europe was the initial destination for large-scale LNG shipments,

very rapidly Asia, and especially Japan, emerged as the predominant demand region. This is illustrated in Figure 4, which depicts regasification capacity shares across major importing countries going back to 1964, and in Figure 5, which shows country shares of LNG imports for major importing countries for 1993-2009. Note that in the early-1990s, Japan, South Korea, and Taiwan accounted for approximately 75 percent of LNG imports, but their share had fallen to slightly above 50 percent in 2009. The entry of China and India as buyers kept the overall Asian share at approximately 70 percent: the Chinese and Indian shares are expected to increase appreciably in the coming years. In Europe, Belgium, Italy, Spain, and France have maintained a relatively constant share hovering around 20 percent.









FIGURE 1 — LIQUEFACTION CAPACITY, 1964-2013



FIGURE 3 — GAS EXPORT SHARES BY COUNTRY, 1990-2012





THE FUTURE: PRODUCTION AND CONSUMPTION

oil consumption is expected to grow by less than 1 percent per The world now stands on the cusp of another major surge in capacity. A large project in Papua New Guinea has recently come annum, and coal by only a little more than 1 percent. Thus, gas, on line. At present, there are seven major projects under construction and particularly LNG, will represent a large and growing fraction of energy consumption. in Australia, with others underway in Colombia, Indonesia, and

Malaysia. The increase in Australian production will be particularly This anticipated growth is driven by several factors. Gas dramatic: projects scheduled to be completed by 2018 will add 61.4 consumption overall is expected to rise because (1) electricity's share million metric tons of capacity to Australia's existing 24.4 million of energy consumption is expected to continue to increase; (2) gas metric tons. Projects with capacity in excess of existing world is primarily used to generate power; and (3) environmental capacity are currently in the planning stages. Others, particularly in considerations will continue to induce substitution away from dirtier

Africa and Canada, are being explored as well. Although not all of these will come to fruition, it is evident that LNG capacity is set to increase dramatically in future years. Based on a variety of sources about projects currently under construction or planned with a high likelihood of being economically feasible, accounting firm Ernst & Young estimates liquefaction capacity will grow by almost 50 percent in the next ten years.

One major source of new capacity will be the United States, which had been a very early in the next ten years. participant in the LNG market, but which then

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largely stood on the sidelines for decades. In the mid-2000s, it appeared that the US would become a major force in the market, but as a buyer. Concerns about a looming gas shortage made it seem inevitable that the US would become a major importer, but the shale revolution turned the gas world upside down. Now several firms are racing to develop export facilities: 20 companies have filed applications to export LNG. The first of these (Cheniere's Sabine Pass trains) is set to come on line next year, and the firm has already contracted to sell this gas to major importers in Asia. This additional supply will be needed, given anticipated increases

in demand. According to BP's Energy Outlook 2035, consumption of natural gas is expected to rise most rapidly of all the fossil fuels, averaging about 1.9 percent per year. This growth will be driven by many factors, most notably the need for a clean burning, relatively low-carbon fuel for power generation. Moreover, BP forecasts that LNG will grow twice as rapidly as gas consumption overall. In contrast,

fuels (specifically coal) towards cleaner burning gas. LNG will benefit disproportionately because the main area of gas demand growth (due to rapid growth in electricity consumption as well as industrial demand growth) will occur in Asia, and notably China, which are short of gas.

PRICING: FROM LONG-TERM TO SPOT

From its inception, the LNG industry has been based on longterm contracts between suppliers and buyers. The typical contract is of 20-25 years in duration, and has been so since the first Algerian contracts. These contracts have been instrumental in securing the capital necessary to construct what are very expensive, and long-lived, assets.

Long-term contracts typically require a mechanism to permit prices to adjust to reflect changing market conditions, and LNG contracts are no exception. In the early stages of the LNG industry, it competed with oil as a fuel for power generation. This, and the fact that especially post-1973 a liquid and relatively transparent spot market for oil had developed, made it natural to use oil prices to determine prices under LNG contracts (sometimes augmented with re-opening clauses).

This mechanism is currently under strain. In fact, it is becoming a barbarous relic. It once served a valuable purpose but in the future, if unchecked, it could impede and distort the development of the LNG business.

This reflects the evolution of energy markets in past decades. Demand for oil and gas has become segmented, with oil becoming predominantly a transportation fuel and relatively unimportant as an input in power generation, and with LNG being used primarily as a fuel in electricity generation. Moreover,

whereas oil production has largely plateaued (with some exceptions in North America), gas production (especially in North America) has increased dramatically. Together, these developments have led to a de-linking of the price of oil and the value of gas. This de-linking is strikingly evident in the regions with vibrant spot markets for gas, such as the Henry Hub in the US and the National Balancing Point in the UK. Over the past several years, North American gas prices and oil prices have been negatively correlated, and even though European hub prices have remained (weakly) positively correlated with oil prices, there have been large divergences between the prices of oil and European hub gas on a BTU-equivalent basis.

Prices that are de-linked from fundamentals send the wrong signals to producers and consumers, leading to bad production, consumption, and investment decisions. These bad decisions destroy value.

Moreover, misalignment of price and value creates tensions between buyers and sellers in oil-linked contracts: when contract prices and values diverge substantially, one party has a strong incentive to push for contract changes (which can lead to substantial bargaining, litigation, and transactions costs), or to attempt to escape the contract altogether. This is most evident in contract disputes between Russia and its major European customers of pipeline gas, but similar conflicts are appearing in the LNG markets as well. Such battles are wasteful, and value destroying.

The industry is therefore groping towards alternatives to oil-based pricing, and several parallel developments are underway. The impending emergence of the US as a major exporter, and as the likely source of supplies at the margin to Asia (and remember that

The shift away from oil-based pricing can be made, will be made, and must be made.

it is the margin where values are determined), makes Henry Hub-based pricing economically sensible, and several Henry Hub-based contracts have been negotiated. Such contracts not only reduce the potential for misalignments between value and price in long-term contracts, but they permit buyers to tap into the liquid and deep natural gas derivatives markets in the US to manage their price risks. Similar mechanisms are feasible for Europe, where pricing hubs exist, and

are becoming progressively more liquid.

Yet other pricing mechanisms are likely to become increasingly viable in the near to medium term. In particular, the increasing spot trade in LNG cargoes holds out the prospect for the development of a new pricing mechanism, especially in Asia. In 2000, only about 6 percent of LNG volumes were in spot or short-term contracts (defined as maturities of four years or less): by 2013, this share had increased to 27.4 percent. Platts' Japan Korea Marker (JKM), introduced in late-2009, has taken advantage of this rising spot trade to provide a transparent pricing benchmark for Asian LNG.

Although only a handful of spot cargoes trade each day (Platts estimates 20 percent of volumes are traded spot), it must be remembered that liquidity is not linear. There is a virtuous cycle of liquidity, in which more spot and short-term trading makes market participants more confident in their ability to buy and sell spot, which leads to more spot trading and liquidity, which leads to even greater participation and liquidity. Once a critical mass of spot trading is achieved, the market is likely to "tip" rapidly to spot-based pricing mechanisms, even in long-term contracts. What's more, the development of liquid and transparent spot markets permits the development of robust and derivatives markets that facilitate the transfer of price risk. Market participants can have their cake and eat it, too: prices that adjust to reflect supply and demand fundamentals (and which thereby provide the right incentives) and reduction in price risk through hedging.

One challenge to a smooth transition is the creation of reliable price benchmarks. Commodity markets have been plagued in recent years by controversies over the design of price benchmarks, and alleged manipulations of them. Early and ongoing industry initiatives to create and police LNG price benchmarks, including participation by producers, consumers, traders, and price reporting agencies, will be crucial in the creation of reliable and transparent pricing mechanisms that can support spot-based contract pricing and effective derivatives contracts.

Some market participants have expressed concern that the existing spot benchmark, JKM, has exhibited substantial volatility. Two points must be made in reply. First, to the extent that this volatility reflects the modest liquidity of what is still a developing market, the virtuous cycle described above will reduce this source of "excess" volatility, and quickly, once the tipping point is reached. Second, and crucially, this price volatility also plausibly reflects volatility in LNG values. This value volatility is precisely why it is necessary to transition from rigid pricing mechanisms that do not reflect rapidly shifting values to flexible spot price-based ones that do.

The shift away from oil-based pricing can be made, will be made, and must be made. As long as the industry relies on oil to price gas, it will resemble the drunk who looks for his keys under the streetlamp not because that's where he lost them, but because that's where the light is best. The oil lamp burns bright, but does not illuminate the right places.





SECURING SUPPLY THROUGH THE MARKET

For those concerned about such a seemingly seismic shift, I say: than marketers. Spot and term markets for physical gas developed other commodity markets have seen the future, and it works. in which consumers, producers, and trader-intermediaries bought Buyers and sellers of these commodities have learned that markets and sold gas to match supply and demand. Producers became can provide security of supply and demand, and permit the confident that there would always be a ready market for their gas, management of price risks, and do so in a far more supple way than and consumers became confident that they would be able to meet traditional long-term contracts do. their needs, even in the face of extreme weather shocks. Markets Three particularly apposite examples are natural gas in the United provided security of demand and supply during a tumultuous period States in the 1990s, the oil market in the late-1970s and early-1980s, in which prices rose and fell dramatically due to dramatic changes and the iron ore market in recent years. Although the specific details in the supply-demand balance: prices were in the \$2 range in the differ, these examples have several common features, including most 1990s, spiked to about \$14 in the mid-2000s when demand notably a misalignment of contract prices and commodity values, outstripped supply, before plunging to below \$2 in 2012 as shale gas a diversity of supply and demand sources, and volatile fundamental supplies surged.

market conditions. Each of these features made rigid long-term contract pricing mechanisms illadapted for prevailing market conditions. These conditions exist in LNG today, and are likely to persist into the future, thereby setting the stage for a similar shift in pricing mechanisms as occurred with these other commodities.

The transition from long-term contracts to market-based mechanisms occurred rapidly in the US natural gas market post-deregulation in the early-1990s. The natural gas market in the US was

highly regulated, with wellhead price controls. The energy price markets. These paper markets permitted producers and consumers to manage their price risks independently of the process of buying shocks of the 1970s led to changes in the price control regime that resulted in a baroque pricing system, with the price of gas varying or selling physical gas. This unbundling of the movement of methane widely depending on the vintage of the producing well. Moreover, from the management of price risks facilitated the ability of capital to secure supplies, gas consumers entered into long-term contracts and banking markets to finance a drilling boom in the United States. with pipelines, which in turn purchased gas from producers under A similarly rapid evolution occurred in the oil market starting in the long-term take-or-pay contracts. Declines in gas values in the midlate-1970s. The 1960s and 1970s had seen an evolution of the oil market 1980s due to the collapse in the price of oil caused a severe misalignment from "posted prices" set by the "Seven Sister" oil companies to one in between these values and contract prices, which imposed substantial which governments sold to oil companies (including independents) at "official selling prices" under long-term contracts. Due to the substantial burdens on buyers and resulted in a surge in costly litigation. In response, US government regulators implemented a series of changes, fundamental volatility during this period, the value of oil in the (relatively culminating in Order No. 636 (by the Federal Energy Regulatory limited) open market exceeded contract prices. This induced suppliers Commission) which unbundled the sale and transportation of gas. (notably the OPEC countries with the exception of Saudi Arabia) to Pipelines became purely common carrier transporters of gas, rather abandon long-term contracts, and market oil almost exclusively through



Markets can provide security of supply and demand, and permit the management of price risks.

This process worked well in part because there was a diverse set of suppliers and demanders, which permitted the creation of a deep, liquid, and flexible spot market. Moreover, as the market was deregulated, specialized trading firms entered to assist consumers to tap multiple sources of supply, and to permit producers to access large numbers of customers.

What's more, derivatives markets—"paper markets" in futures, options, and swapsdeveloped in parallel to the spot and term physical spot and short-term contracts at negotiated prices. Soon the entire market tipped from one in which spot transactions were the exception to one in which spot transactions were the rule.

Like in the US natural gas market, buyers found that the spot market offered a security of supply, and sellers found that it provided security of demand. Indeed, whereas prior to the development of the spot market the upstream and downstream oil sectors were tightly integrated because of the inability of refiners to obtain crude through market channels, the development of the spot market made it possible for refiners to supply their operations from a diverse set of producers. This reduced the benefits of vertical integration that tied a refinery to a particular upstream supply source, and as a consequence the oil industry became less integrated in the spot market era. This provides a striking illustration of how the development of liquid physical markets can provide security of supply that renders unnecessary contractual and organizational measures intended to guarantee access to vital inputs.

As in the US gas market, the existence of diverse sets of producers and consumers of oil created a degree of competition that created this security. No buyer (seller) was tied to a small set of sellers (buyers): each could draw on a relatively large set of firms and countries competing for their business. Further, trading firms entered

the oil market, and provided the service of allowing buyers and sellers to access efficiently a broad array of suppliers and customers, respectively. And again, deep, liquid, and competitive derivatives markets grew in parallel with the physical spot markets. These markets permit the management of price risks independently from the process of buying and selling physical oil.

A more current case provides a final example. Historically, iron ore was sold under contracts between miners and steelmakers, and prices were determined annually as a result of a painstaking negotiating process. Very little ore was sold on a spot basis. However, extreme market fluctuations in the 2007-2010 period put this structure under extreme stress. First, a boom in demand originating primarily in China caused the value of ore (as indicated by the few spot trades) to rise substantially above the contract prices, and miners looked for ways to sell at the higher spot prices. Then, the Great Financial Crisis that began in late-2008 caused the value of ore to plunge below contract prices: several steelmakers defaulted on their contracts. Consequently, miners and Japanese steel firms pushed for a fundamental change in the pricing mechanism for ore, and after some resistance, Chinese firms went along. A larger fraction of ore was sold spot, but importantly, contracts between steel firms and miners began to use spot prices to determine the prices in their supply contracts. In a period of a few years, the business switched from negotiated prices to spot-based pricing.

As in US natural gas and oil, trading firms are helping to secure supply and demand by allowing buyers and sellers to access a broad array of producers and customers. Again in parallel with the process that occurred in the other markets, derivatives markets in iron ore are growing rapidly: open interest in cleared iron ore swaps has increased more than ten-fold in the last four years (over which time the market tipped to spot-based pricing).

The experiences in US natural gas, crude oil, and iron ore demonstrate that expensive, durable investments in specialized capital are completely compatible with spot market pricing complemented by market risk transfer mechanisms. In essence, liquid markets create security of supply and security of demand. It is likely that the LNG industry will undergo a similar evolution, and due to the non-linear nature of liquidity, this evolution will not be gradual, but will be of the "punctuated equilibrium" variety, marked by a rapid transition away from oil-based pricing. The lesson for LNG is clear: trust in the force of the markets.

Several factors will support this transition. First, the increasing diversity of supply sources, and the resulting increase in production, will increase competition and give consumers access to a broader set of producers.

Second, trading firms can and will facilitate the efficient matching of producers and consumers. Trading firms help free buyers (sellers) from having to rely on a small set of producers (customers). When buyers must rely on a small set of sellers, and vice versa, long-term contracts with rigid pricing mechanisms are a sensible way of securing supply and demand. This is not true when liquid markets, intermediated by traders, expand the set of potential counterparties.

Third, variations in supply and demand that will inevitably occur over

The lesson for LNG is clear: trust in the force of the markets.

the long lives of LNG investments are most efficiently handled when prices can adjust. There are major uncertainties regarding the course of future demand, including uncertainties over future Chinese demand (will the Chinese growth model change?), the unclear prospects for a growth recovery in Japan, and geopolitical risks. On the supply side, there are uncertainties over the completion dates of large LNG

projects, and policy uncertainty in the US. Moreover, the "lumpiness" of LNG projects results in large surges in capacity that can lead to short-term supply gluts: such capacity booms and busts are characteristic of many commodity industries. Rigid prices impede efficient responses to these cycles, and often exacerbate them.

Increasing liquidity in the spot market, in combination with other factors, will undermine other traditional terms in LNG contracts, including notably destination clauses. The development of new supply regions (notably North America and Africa) and the growth of demand in China, India, and perhaps Europe, combined with the unpredictability of demand and supply, will give rise to greater optionality in matching buyers and sellers of LNG. Liquid spot markets will facilitate the identification and exploitation of profitable diversion opportunities. Optionality creates value that can be split between producers and consumers, and contract terms will evolve to maximize this value to their mutual benefit.



CONCLUSION

In sum, the LNG industry has experienced remarkable growth and development in the half-century since the *Methane Princess* set off on the first of its more than 500 voyages. The future holds the prospect of continued growth in volume and diversification of supply sources. These developments will be a continuation of a process that has been ongoing since the industry began.

In contrast to the steady process of supply and demand growth, LNG pricing, trading, and contracting practices will likely soon undergo a radical transformation. The industry stands at the brink of an inflection point that will likely see a rapid transition to flexible marketbased pricing mechanisms and the reliance on markets and trading to secure supply and demand and manage price risks. This will represent a change as revolutionary as the first voyage of the *Methane Princess* 50 years ago. If the first 50 years of global LNG history is a story of technology and capital, the beginning of the next 50 years will be a story of markets and institutions.



ABOUT THE AUTHOR

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