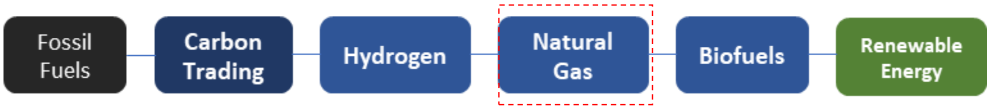
Natural Gas Primer



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In our third installation of our Clean Energy series, we look at natural gas.

This paper serves as an elementary primer for understanding the basics of the natural gas market.

The role of natural gas in decarbonisation

Demand for natural gas-fired power generation has gained considerable traction over the past decade and is likely to continue increasing over the coming years. Natural gas is one of the most accepted hydrocarbon alternatives to middle distillates due to its low carbon intensity and is seen as the fossil fuel of choice for fulfilling decarbonisation targets. Policies to encourage the take-up of natural gas over coal will likely continue in the next decade, especially with increasingly vibrant carbon markets globally.

Why care about natural gas?

The move from fossil fuel combustion to clean energy cannot occur overnight – natural gas, hydrogen and biofuels will be used in varying degrees as intermediate fuels. Hence, despite the non-zero carbon nature of natural gas, its relatively lower emissions among hydrocarbons and industry maturity leaves it as a key fuel in global decarbonization efforts.

Compared to biofuels and hydrogen, the market for natural gas is already sufficiently well developed and matured. There exists physical infrastructure to effectively extract, process, transport and store natural gas. Financial markets for hedging natural gas as a commodity is also deep, with futures, options and swaps available.

Part 1: Natural gas supply

Conventional natural gas

What is natural gas?
Natural gas is a hydrocarbon and primarily composed of methane gas, which is made of one carbon atom and four hydrogen atoms (CH_4). With only one carbon atom in its atomic makeup, natural gas has the lowest carbon intensity among fossil fuels and thus burns the most cleanly. Consequently, natural gas is used for many applications, ranging from firing power generators to cooking and residential heating.

Where is conventional natural gas found?
Conventional natural gas is mainly found in gas wells and oil wells. A gas well mostly produces natural gas. An oil well, while principally producing oil, may also produce gas as a by-product – this is termed "associated gas".

Before the advancements in gas technology, oil companies had no use for associated gas. The gas was flared, creating unwanted carbon emissions. Oil and gas regulators in many countries have now mostly discouraged flaring, if not banning them outright.

Flaring of natural gas at an oil field
Picture source: USA Today

Unconventional natural gas

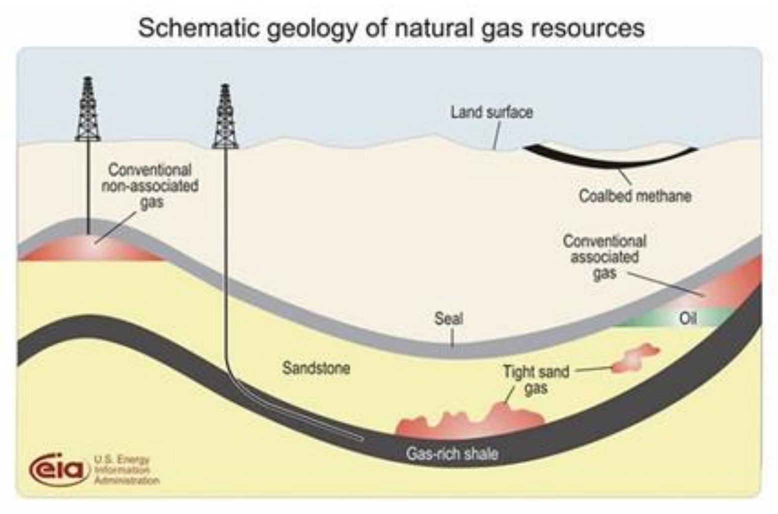
The shale boom changed the landscape of natural gas.
Traditional natural gas is produced from conventional gas resources, located in geological basins made of porous and permeable rock. Drilling into these rocks allow the capture of natural gas. Up till the early 2000s, global production of natural gas has been done in this manner.

Advancements in technology allowed production of natural gas from new sources. These include coal seams (coalbed methane), shale, and tight sands. Most of the US unconventional gas production comes from shale and tight sands.

1) **Shale:** Shale gas is natural gas found in fine-grained sedimentary rock with low permeability, otherwise known as shale. In the past, extraction of gas from shale formations has proved challenging. In the past decade, technological advancements in horizontal drilling and hydraulic fracturing have enabled producers to access unconventional gas resources, notably in shale formations.

2) **Tight sands:** Tight sands gas is natural gas found in low permeability sandstone reservoirs that produces primarily dry natural gas. Permeability of these reservoirs are so low that gas will not naturally flow at economic production rates unless it receives large stimulation treatments of special recovery processes.

3) **Coalbed methane:** Coalbed methane (CBM) is natural gas trapped in coal seams. Water in the coalbed is removed, creating fracture pressures which releases the gas found in the coal.



Picture source: US EIA

Implications of increase in unconventional gas supply

The boom in unconventional gas supply has had several implications, particularly for the US.

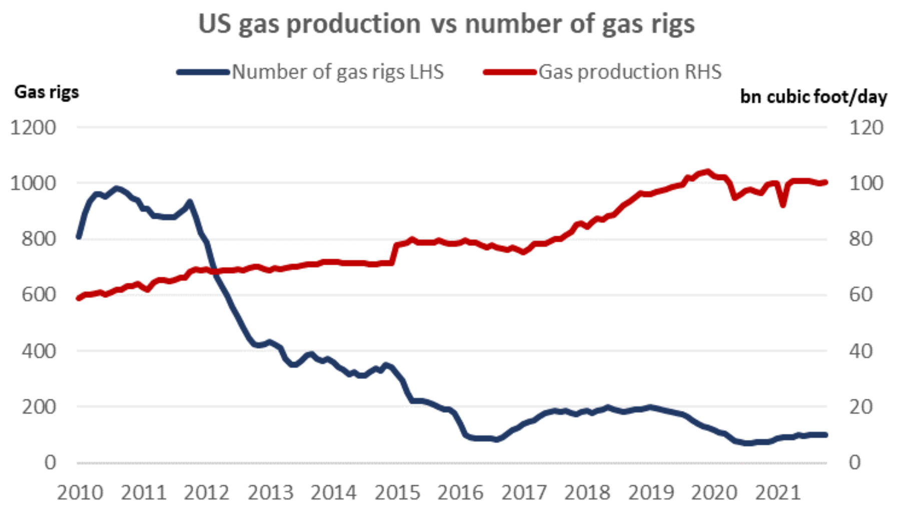
a) The increased gas output has kept global prices low globally, especially after 2010.

b) It allowed the US to turn net exporter of gas in 2017 – the first time since 1953.

c) Consumer prices for gas is also significantly lower in the US than in Europe and Japan.

d) Exploration efforts in traditional drilling have been shifted to oil field discovery over gas fields, given the low price of gas.

Even though the number of gas rigs have continued to decline, total gas production has continued to increase due to shale gas. This is because horizontal drilling produces more gas per rig, resulting in a breakdown in historical correlation between total gas produced vis-à-vis the total number of gas rigs.



US gas production is up although the number of gas rigs have been falling.
Source: Bloomberg, Baker Hughes, US EIA, OCBC

Natural gas liquids

Rich vs dry natural gas.
Raw natural gas could be classified as either “rich” or “dry”. Rich natural gas contains significant levels of natural gas liquids (NGLs) – ethane, propane and pentane – mixed with methane. NGLs are valuable by-products and provide gas producers additional profits when separated and sold.

Dry natural gas contains mostly methane. They may occur naturally or after NGLs are remove from wet gas. Dry gas can then be suitably used as fuel in power generation.

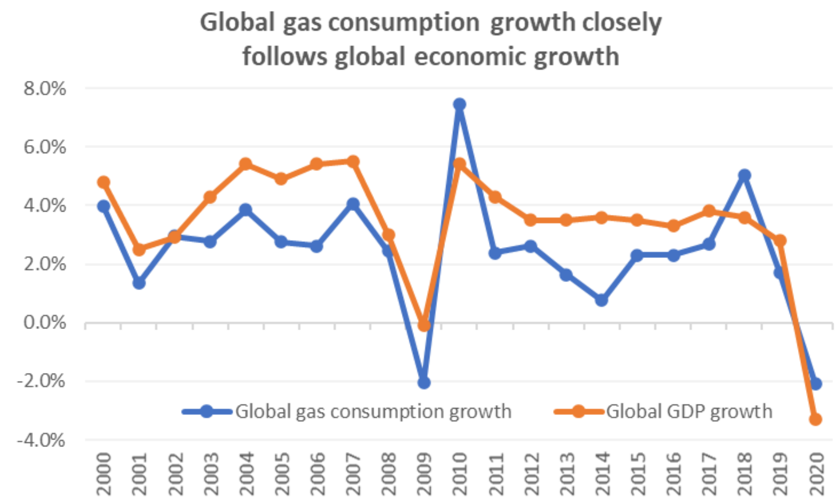
Shale gas also typically contains a larger proportion of NGLs, which adds to shale gas well margins. NGLs, which are normally used in plastic manufacturing, have prices that correlate closer to those of oil than natural gas. As such, the margin of shale gas may sustain even if natural gas prices are low, especially if NGL prices remain supported. In turn, this adds to further natural gas supply from continued shale gas output, keeping gas prices depressed.

Part 2: Natural gas demand

Short-term vs long-term demand

Long-term: Over the long-term, natural gas demand is driven by macroeconomic factors, including economic and population growth, environmental policy, technological change and prices of substitute fuels.

a) Economic growth: Higher economic growth results in higher demand from power plants, industrial activity and commercial entities. Gas consumption normally dips during periods of economic slack.
b) Environmental policy: Increasing regulations on carbon emissions have raised demand for natural gas. Most economies have increased the use of gas-fired generators in the past decade while simultaneously retiring coal-fired power plants.
c) Price of substitute fuels: Long-term capital investments on power plants are a function of the expected costs of alternative fuels. For example, expectations of higher costs from a coal-fired power plant (due to tighter carbon emissions) may result in preference of gas-fired plants.



Source: BP Statistical Review, IMF, Bloomberg, OCBC

Short-term: In the short term, weather expectations are the most significant factor influencing short-term natural gas demand. Forecasts of extremely hot summers or bitterly cold winters can send demand – and consequently prices – through the roof. Demand from such weather events can endure considerably wild swings in any given day.

Unexpected surge in weather-related demand is normally compounded by logistical constraints from pipelines. Gas can only be delivered as quickly as existing pipeline infrastructure allows, which are normally full during unpredictable weather challenges.

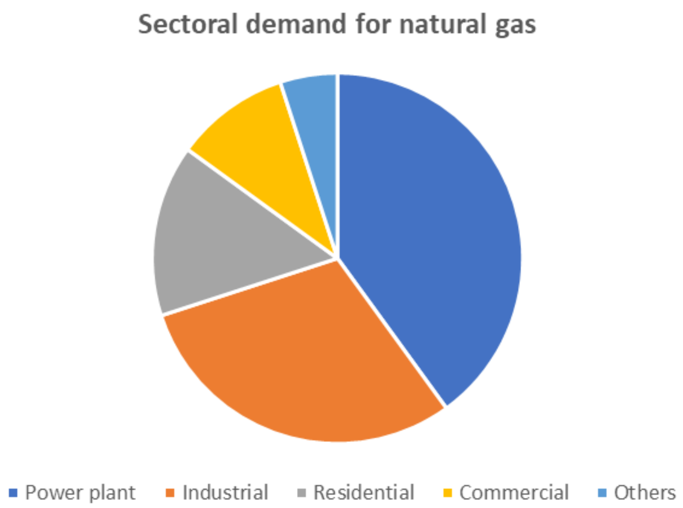
Sector demand

Power Generation (40%): Seasonally, power plants consume most natural gas during summer (for air-conditioning) and winter (for heating and lighting). Gas-fired power plants are increasingly preferred by power generators as they emit lesser carbon emissions than coal. In addition, gas-fired plants can control their output more flexibly by turning on or off their gas taps; coal, once ignited, cannot be put out.

Industrial (30%): Natural gas is used as feedstock for the production of, among many, fertilizers, steel, glass and hydrogen gas.

Residential (15%): 15% of total natural gas are consumed by the residential sector, mainly for heating and cooking. Interestingly, gas used in this sector has remained fairly constant, due to increasing energy efficiency in many household appliances.

Commercial (10%): Commercial entities like hotels and restaurants require the use of natural gas for air-conditioning and heating purposes. Like the residential sector, demand from this sector tends to be seasonal.



Part 3: Natural gas transportation

Comparing pipelines and LNG markets

Transportation plays a big role in natural gas supply chain.
While logistics are typically a small portion of a commodity supply chain, it is a highly critical component for natural gas. As one of the few gaseous commodities, natural gas is difficult to transport and prone to bottlenecks.

Natural gas is transported mainly in two manners: pipelines across land, or liquefied natural gas (LNG) over waters. It is estimated that about 60-70% of global natural gas is moved via pipelines, while the remaining is transported as LNG.

A gas pipeline in China
Picture source: hydrocarbonds-technology.com

Pipelines
On extraction, natural gas is moved via pipelines to processing plants. On processing completion, the natural gas is sent via large-diameter, high-pressure steel pipelines to storage industrial users, local distribution companies (LDCs) or storage facilities. LDCs deliver the natural gas in reduced flows via smaller pipelines to homes and businesses.

LDCs may own and operate the pipeline network that carry gas from them to end-consumers, including residential, (smaller) power generators and industrial users. Larger power generators and industrial customers may opt to receive gas directly from a major pipeline. In any case, an efficient gas distribution network needs to be robust and well connected to diversify consumers' reliance on any one particular pipeline. A well-diversified pipeline improves supply reliability, in turn lowering volatility of local gas prices, especially during peak demand periods. Pipeline owners very often seek to ensure their pipelines are running at close to full capacity to minimise idleness; hence, they also play the role of marketing gas.

Liquefied natural gas (LNG)
LNG is natural gas cooled to -160degC. A volumetric reduction of 600 times compared to its natural gaseous state allows LNG to be economically transported in LNG vessels to locations which have little pipeline access to production sources due to geographical constraints. Globally, there are 642 LNG vessels as of end 2020.

An LNG vessel.
Picture source: LNG Trading Asia

At present, the main market for internationally traded LNG is to be found in JKTC (Japan, Korea, Taiwan, China), which accounts for about 60% of global LNG demand. Europe is second at about 20%. The importance of the JKTC LNG market has resulted in the creation of a JKM spot LNG price, developed by S&P Global Platts. JKM prices may differ materially from that in Europe (TTF) or US Henry Hub.

Unlike pipeline gas, LNG cargoes are more flexible given the higher mobility of vessels, allowing them to land in the highest-priced markets. Liquefaction and shipping form the bulk of LNG supply chain costs.

Part 4: The market for natural gas

Gas markets are still localized in nature, although increasingly less so. Unlike the oil market, the gas market remains very much localized in nature. In oil markets, agents actively trade the marginal barrel for active price discovery – such a market, however, is less pertinent for the gas market. For example, an inland power plant in central Asia is not able to accept LNG shipments if there are no regasification facilities – a thorough infrastructure need to be present for that to happen.

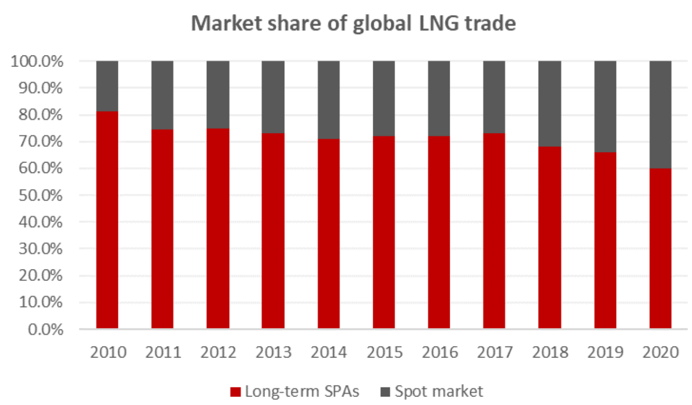
The constraints of gas infrastructure hence limit gas trade to localized terms. In the LNG market, this is constrained by the ability to source funds for regasification facilities; for pipeline gas, the limitations would be land contiguity and pipeline infrastructure.

Asian LNG markets are reliant on long-term sales & purchase agreements.

The unique nature of the LNG market – particularly, the amount of infrastructure development regarding liquefaction complexes which typically costs $10bn or more – have resulted in the dominance of long-term sales & purchase agreements (SPAs) in the LNG market. This is particularly evident in Asian consumers of LNG.

The securing of long-term SPAs is often a prerequisite for many LNG markets, especially in Asia. The relatively more matured markets of the US and Europe, however, has evolved into one where the spot market is more dominant, although their LNG imports are lesser than Asia.

In 2020, 60% of global LNG supply are provisioned under long-term SPAs. The remaining 40% are traded on a spot basis, according to data from the International Group of Liquefied Natural Gas Importers (GIIGNL). This is double the share from a decade ago. The market share for LNG spot trading is expected to continue increasing as the Asian market matures, following in the footsteps of the European gas market.



Source: GIIGNL, OCBC

Benchmark prices for natural gas

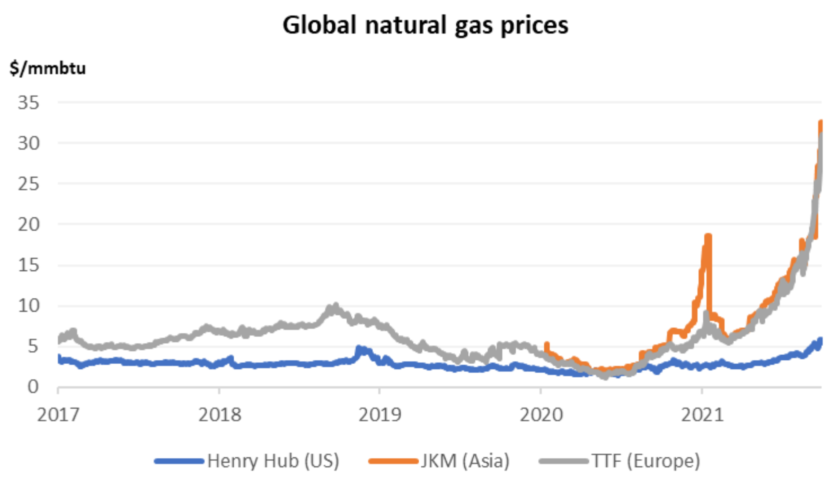
There are three benchmark prices for natural gas.

Henry Hub (US): Henry Hub in Louisiana is connected to four intrastate and nine interstate pipelines and is the official physical delivery point for natural gas futures traded on NYMEX. Henry Hub reflects market-clearing prices for natural gas based on actual demand and supply dynamics of natural gas as a standalone commodity.

Title Transfer Facility or TTF (Europe): Based in the Netherlands, the TTF has in recent years emerged as Europe's main benchmark for gas prices.

Japan-Korea Marker or JKM (Asia): Developed by S&P Global Platts, the JKM price reflects spot prices of LNG cargo into the Japan-South Korea-China-Taiwan (JKCT) region.

In a globalized market such as crude oil, Brent and WTI prices have tended to move with a very tight correlation. But the natural gas market has shown periods of extreme widening of spreads among the three benchmarks, which may take months to revert. This is evident in the graph below.



Source: Bloomberg, S&P Global Platts, OCBC

Part 5: Introduction to trading spark spreads

What are spark spreads?
Spark spreads measure the profitability of power plants in the same way crack spreads reflect an oil refinery's margin. The price of electricity, natural gas, coal and carbon permits are all inextricably linked to spark spreads.

Types of spark spreads.
Spark spread measures the margin of electricity generation using natural gas. While prices for electricity and gas are observable, assumptions are made for the heating rate (HR). Clean spark spread is spark spread with an added consideration of carbon costs, which are subtracted from the original spark spread.

Similarly, dark spread is the margin of electricity generation using coal, while clean dark spread takes into account the cost of carbon permits.

Spark spread = $P_{electricity} - P_{gas} * HR_{gas}$
Clean spark spread = $P_{electricity} - P_{gas} * HR_{gas} - P_{carbon} * EI_{gas}$
Dark spread = $P_{electricity} - P_{coal} * HR_{coal}$
Clean spark spread = $P_{electricity} - P_{coal} * HR_{coal} - P_{carbon} * EI_{coal}$

Where P= price
HR = heating rate (amount of input needed to produce one unit of electricity, measured in mmbtu/Mwh)
EI = carbon emission intensity (kg CO2 per mmbtu)

Trading spark spreads
Taking a long position in a spark spread is essentially betting that gains in the downstream electricity market will outpace that of upstream input prices, which typically occurs in periods of economic boom. Conversely, a squeeze on input prices due to supply shocks could result in a decline in spark spreads.

Rearranging spark spreads to derive the theoretical cost of carbon.

Assume a power plant is able to switch freely between natural gas and coal to fire its generators, and further assume the other variables stay constant. Then the theoretical price of carbon at which a power plant is indifferent between using natural gas or coal is given by:

$$\text{Pcarbon} = \frac{Pgas * \text{HRgas} - \text{Pcoal} * \text{HRcoal}}{EIcoal - EIgas}$$

If the traded price of carbon is higher than its theoretical value, a power plant would prefer using natural gas. Similarly, if the traded price of carbon is lower than its derived value, a power plant would gravitate using coal.

Summary

Gas-fired power plants emit lesser carbon emissions than coal plants due to the light carbon intensity of natural gas. Although its combustion still results in a positive net carbon emission, natural gas is accepted as a hydrocarbon alternative to middle distillates. Demand for gas from power plants globally is expected to continue growing in the coming decade.

In the long term, demand for natural gas is determined by economic growth, environmental policies and expectations of future prices of competing fuels. In the short term, however, demand is mostly led by weather expectations. Adverse weather patterns can swing daily demand of natural gas wildly.

The natural gas market remains very localized in nature due to the unique nature of costly infrastructure needed. This is especially so for Asian LNG markets, where more than half of gas supply is still contracted under long-term SPAs. More active localized spot markets may be found in the US and Europe. Henry Hub, TTF and JKM prices may significantly deviate from each other as a result of the non-globalized property of the gas market. As the Asian market matures, we expect spot trading of gas to become more prominent.

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