The Extinguishing of the Lights

a report by

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ignis fatuus, n., 'foolish fire'; 'Will-o'-the-wisp'; phosphorescent light due to spontaneous combustion of gas from decaying organic matter; delusive hope or gain – *The Concise Oxford Dictionary*.

A peasant travelling home at dusk spots a bright light ahead of him. He follows a little figure with a lantern until he is standing on the edge of a vast chasm. The lantern-carrying figure leaps over the chasm, laughs maliciously and blows out the light, leaving the peasant on the edge of a precipice in pitch darkness.

The world stands on the edge of a looming chasm following the peak in the production of natural gas, having travelled by benefit of its fire to the edge, fearing – though denying – the extinguishing of the lights.

Climate Change

The world's population hears daily warnings of climate change driven by carbon emissions from fossil fuels. Although the rhetoric demands energy savings and a move to low-carbon energy sources, it fails to warn of a worse fate – global economic collapse by mid-century due to resource depletion. Due to the lowering concentrations of the sources of energy and materials, the fall in the efficiency of capital denies universal salvation. The will-o'-the-wisp of exponential growth leads us with low-energy light bulbs over the political bogs of the Intergovernmental Panel on Climate Change (IPCC), Kyoto, Stern and Hadley, all of which erroneously assume ample fuel reserves, to the edge of the chasm in which the population die off.

There are solutions for those countries able to short-circuit the climate change debate and forge a low-energy society, based on a modicum of energy use from sustainable sources, such as sun, wind and sea currents.[1]

Liquefied Natural Gas

Gas requires pressure pipelines for overland transmission to its markets or pre-processing to liquefied natural gas (LNG) for ship transport, in comparison to crude oil, which can be loaded directly to ocean tankers and transported for processing at the consumer country.

An example of an LNG venture is the Sakhalin Island project off Eastern Siberia, developed by a consortium of Shell, Mitsui and Mitsubishi, but now with Russian state equity. Oil and gas from offshore platforms to the north of the island will be pipelined for 800km – the whole length of the island – to an ice-free port in the south, where an oil export terminal and gas liquefaction plant will be built. The frozen gas will be exported in special ships to Japan, Korea, China and the US.

As a further example, ExxonMobil is liquefying and shipping LNG from Qatar in the Gulf to Asia, as it is uneconomic to ship to America. Supplies for the UK are mainly expected to derive from North Africa. Australia exports LNG from the Northwest Shelf to Guangdong in China, Japan and South Korea. LNG activity is growing fast.

Location of Gas Fields and Markets

The three countries of North America (the US, Canada and Mexico) share a network of pipelines supplying them with 29% of global natural gas production. This is currently drawn from gas fields on the continent itself, but with an indigenous gas depletion rate of around 10% per annum, many terminals for importing LNG are under construction. North America is not so fortunate as to be supplied from an overland pipeline and, for augmentation of indigenous gas, LNG supplies from Eastern Russia, Africa, the Gulf, Indonesia and Western Australia are planned. Korea and Japan expect to benefit mostly from the Sakhalin project and, as they are neighbouring countries, they will enjoy a cost advantage over the US.

In Europe, the Russian Federation, the dominant supplier, will have to double its natural gas production to supply its neighbours, thus increasing its depletion rate. A further factor is that Russia itself consumes 71% of its gas production; while this has expanded by 15% over the last 10 years, domestic consumption has increased by 23% over the same period. If Russia enjoys economic growth, it will require an increasing proportion of its own gas for the internal market, restricting its ability to export. So although the EU expects to be supplied from pipelines from Russia, it will have to be augmented with LNG by ship.[2] The UK will be at the penultimate end of the pipeline from Russia, which may mean that if there is a shortage or outage, it will be severely disadvantaged. Only Ireland is more unfortunately placed.

The remoteness of the markets from the gas fields means that a large number of gas tankers will be required to maintain supplies. Due to the warming of the liquefied gas during shipment, some gas has to be vented during the journey to avoid an over-pressure in the insulated tanks. The released gas is used to power the ship's propulsion gas turbines, but some will inevitably be released. For shipments to the US from Australia or the Gulf, losses of around 4–6% can be expected.

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Although the liquefaction of the gas enables use to be made of 'stranded' gas, remote from its markets, there is a loss of energy amounting to around 15% of the raw gas feed, depending on the impurities in the gas that have to be removed before liquefaction. The feed gas may contain carbon dioxide (CO_2) and hydrogen sulfide (H_2S), the removal of which leaves the gas wet, so that before liquefaction it has to be dried. Propane, butane and pentane are removed by fractionation, leaving ethane and methane to be liquefied. The propane and butane are stored and shipped in separate tanks, while the pentane is injected into crude oil (if it occurs with the gas). The separation processes are not 100% efficient and some of the higher carbon gases remain in the LNG.

Gas Substitution for Oil

As oil reserves are exhausted, world markets will begin to exploit the potential source of chemicals and liquid fuels in natural gas. In anticipation of this, the oil and gas industries have invested in processes able to convert natural gas into liquid products, the so-called Gas-to-Liquid (GTL) technology.

Some of the remotely occurring gas will be converted to liquid fuels in GTL plants adjacent to the gas fields. The problem will be deciding whether it will be more viable to convert the gas to liquid fuels able to be shipped in normal oil tankers or to liquefy it for shipping in specialised LNG tankers to an unloading terminal for regasification and addition to a gas supply network.

In 2003, BP commissioned a 300 barrels/day pilot plant in Nikiski, Alaska able to convert natural gas to synthetic diesel, jet fuel, naphtha and synthetic lube stock. Apparently, it was successful, but BP has no plans for GTL processing of the Alaskan North Slope gas and may favour other stranded gas locations for subsequent liquid fuels production.

The processes able to make liquid fuels will have to be sited on the gas fields to be economic, otherwise there would be double processing: one to LNG for transportation and then, after transportation, regasification to GTL.

The conversion thermal efficiency of GTL processes is theoretically only 55%, which will be lower in practice. Having been shipped as LNG and reduced in quantity by the liquefaction and transportation losses, it seems unlikely that further losses could be accepted if thereafter the gas were to be further converted to liquid fuels in a GTL process, as the overall thermal efficiency would be less than 40%.

As the 'booked' crude oil reserves of the major companies decline, gas reserves are converted from a volumetric value to a liquid oil equivalent. The conversion is based on a comparison of the heating values of crude oil and natural gas. Depending on the efficiency of the particular exploitation technology employed, the thermal oil equivalents should be downgraded accordingly.

Oil Equivalent Reserves

The major oil companies are in transition to becoming gas majors and are already converting their natural gas reserves to 'barrels of oil equivalent' in order to boost their 'booked' overall reserves. The conversion factor employed is given in the small print in their annual reports. ExxonMobil uses 6 million cubic feet = 1,000 barrels crude oil, while BP uses 5.8 billion cubic feet = 1 million barrels.[3]

For the last three years, BP has estimated the global gas reserves to be around 6,350 trillion cubic feet (tcf), which at, say, 5.9tcf per million barrels equates to an equivalent of 1,080 billion barrels of oil, i.e. 1,080 gigabarrels (Gboe). With natural gas production of 266.4 billion cubic feet a day (or 97tcf a year), this gives a reserves/production ratio (R/P) of 65 years. The use of the R/P ratio is questionable as it assumes that production remains the same until it falls off entirely. Global gas production rose 2.5% in 2005 and is likely to rise further with increased activity in LNG.

The oil equivalent of natural gas used in the company statements on 'booked' reserves is based on comparative heating values, but needs to be tempered by taking into account the use to which it will be put. Crude oil is readily transported and refined with overall small losses of the order of 5%, while, in the conversion of natural gas to LNG or to liquid fuels for transportation, losses vary from 15 to 50%. GTL processes exhibit around 55% theoretical thermal efficiency, so that it makes no sense to feed them with imported LNG, already subject to a 15% loss.

The natural gas reserves estimates therefore have to be revised downwards in accordance with the use to which the gas is put. In the case of LNG, the reserves from which they originate should be downgraded by at least 15%, while those devoted to GTL should be downgraded by 50%. Splitting the difference would downgrade the entire reserves by, say, 25%. Assuming, after taking this into account, that growth in consumption will escalate exponentially, the peak in natural gas production predicted for 2020 by the Association for the Study of Oil and Gas (ASPO)[4] seems a real possibility. This does not mean that it runs out by 2020, but that production runs down thereafter. A possible course of oil, gas and coal production prospects is plotted in *Figure 1*.

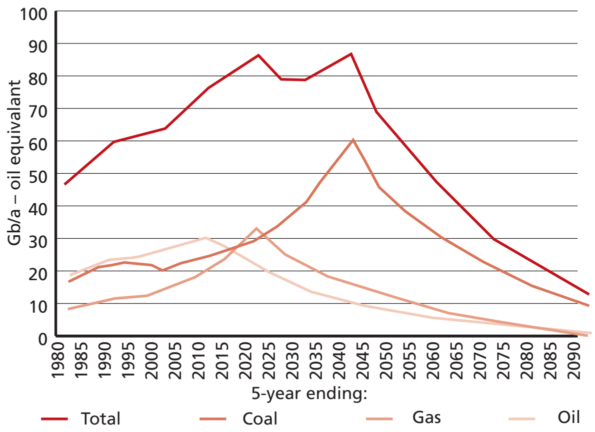
Liquefied Natural Gas Import Terminals

Two basic configurations are possible: one is to offload the LNG into shore-based bulk storage tanks, followed by regasification and pressurisation to feed into gas pipeline networks; the other is to perform the regasification offshore and bring the gas onshore by submerged pipeline. This can be achieved by equipping the LNG tanker with suitable process equipment. This has the disadvantage that the tanker is held during unloading and the supply can be interrupted when it is exchanged. The solution is to build an offshore island on which storage tanks and the regasification plant can be mounted.

The second option is preferred because of the safety implications of pumping and storing large quantities of liquid gas near to populated areas. In congested harbours and waterways, the LNG tankers are a hazard, as leaks can lead to vapour cloud combustion or explosions.

The Australian company BHP Billiton proposed building a floating LNG terminal 14 miles off the coast of California, so that the gas would come ashore already regasified by pipeline, but in its present form the plan has been rejected by the State Lands and California Coast Commissions. In contrast, Excelerate Energy of

Figure 1: Fossil Fuels – Annual Production



Texas is in the final stages of development of its Teesside Gas Port LNG importation project off the northeast coast of the UK. This utilises a fleet of Energy Bridge™ Regasification Vessels (EBRVs) that can deliver natural gas at high pressure through a mid-ship manifold directly into a local pipeline system. To avoid interruptions to supply, a constant provision of EBRVs has to be arranged.

Once a LNG tanker is filled and has embarked, its destination can be determined by those offering the highest price for the cargo. This means that that a terminal must be able to take tankers from a variety of sources, so that, of the above, the preferred solution must be the offshore island able to compensate for the vagaries of the market by having storage facilities.

Safety Aspects of Liquefied Natural Gas

The escape of 300 tonnes of petrol from a storage tank in the Buncefield fuel tank depot near Hemel Hempstead in the UK in 2005 resulted in a massive vapour cloud explosion. The storage of large quantities of LNG in the vicinity of communities and harbour facilities requires careful consideration. It has been assumed that the resulting vapour cloud when LNG is released is more likely to burn back rather than explode. Some argue that the degree of confinement of a cloud between buildings and tankers has an effect on the likelihood of it exploding.

The issue was raised after a vapour cloud explosion occurred at the Skikda LNG export terminal in Algeria in 2004. A final report on the cause has not so far been published, but it could relate to the composition of the Mediterranean LNG, which contains more than usual proportions of ethane and propane, making a vapour cloud explosion rather more likely to occur than a burnback.[5]

LNG importers need to be able to buy their supplies from a variety of sources. Once a tanker is filled with its cargo and is at sea, its contents can be bartered for the best price so that the choice for the importer will be limited. The addition of unlike batches of LNG to storage tanks can cause a 'rollover', leading to an over-pressure and the lifting of relief valves. It will be difficult to reject offers of LNG originating in the Mediterranean or from other fields in cases where unwarranted concentrations of higher carbon components are present.

On reflection, the use of a floating offshore island, where LNG can be stored and gasified before being sent ashore by pipeline, seems the safest and most practical alternative. If a leak of LNG does result in a fire or explosion, although the circumstances could be severe, at least such an event would be isolated from the general population.[6] From a safety viewpoint, the offshore island with importation, storage and regasification facilities offers the best alternative.

Conclusion

LNG supplementation of natural gas supplies appears to offer only a 10- to 20-year moratorium on a coming energy crisis. The inefficiencies resulting from the purification, liquefaction and transport of otherwise 'stranded' gas results in a diminution of its reserves.

While offering an alternative source of liquid fuels, the adoption of GTL processes will result in a more severe reduction in the reserves compared with a direct use as natural gas. The 'booked' reserves of the major petroleum companies should be adjusted downwards in accordance with the use to which the gas is put.

The importation of LNG to boost failing national gas supplies will be counterproductive if used entirely to maintain 'business-as-usual', rather than allow a breathing space for the introduction of a genuine low-energy life-style. ■

The world stands on the edge of a looming chasm following the peak in the production of natural gas, having travelled by benefit of its fire to the edge, fearing – though denying – the extinguishing of the lights.

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