The Impact of Gas on Refining: A Double-edged Sword?

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Shale formations in the United States have yielded large and increasing amounts of oil and gas through the process of hydraulic fracturing, or 'fracking'. Many other countries around the world are rolling out plans to repeat the US experiment. Because fracking is a controversial technology, it is unclear at this stage which countries will allow it, but those countries such as India and China which face the greatest growth in transportation fuel demand, also have large shale formations and are seeking to maximise use of the resource.

In this article, we argue that the advent of tight oil and shale gas has the potential to turn the dynamics and economics of fossil fuel supply on its head, not only in the USA but elsewhere, and represents a potential Black Swan event for the global refining sector.

The International Energy Agency headlined its 2011 World Energy Outlook 'Are we entering a golden age of gas?' It said unconventional natural gas resources are now as large as the conventional and projected that the share of gas in primary energy demand would rise from 21 percent to 25 percent by 2035. In its 2013 Annual Energy Outlook, the Energy Information Administration of the Department of Energy projected that the United States will transition from a net importer to a net exporter of natural gas, largely as a result of shale plays, although the EIA was less bullish than some studies which envisaged a US self-sufficient in oil and gas by 2020. Many companies are bullish on the prospects for tight oil and shale gas; for instance, BP's 2030 outlook projects that 'from 2011 to 2030, shale gas more than trebles and tight oil grows

more than six-fold. Together they will account for almost a fifth of the increase in global energy supply to 2030'.

The potential short-term benefits of shale for the manufacturing sector as a whole, including the refining and petrochemical sectors, have been extensively documented. The shale revolution benefits the refining sector in the USA by reducing the cost of refinery processes. The benefits are twofold.

Tight gas and shale gas provide a relatively cheap supply of methane that can be used to generate power within the refinery, freeing up fuel oil which can then be upgraded to make higher value products such as gasoline, kerosene and diesel. Methane can also be used to generate more hydrogen in the refinery's hydrogen plant, which can then be used to bring down desulphurisation costs of the higher value products.

Meanwhile, tight oil is typically light and sweet in quality, providing abundant supplies of light sweet crude oil to refineries which, in the past, have been geared to using heavier imported crude oils that require much more intensive processing. Although US refiners have invested billions of dollars in upgrading capacity to allow them to process heavy and ultra-heavy crude oils, because tight oil is typically very light in quality, it can be used to reduce the processing severity at secondary units, as well as to back out imported light sweet crudes in the US refining slate.

Further downstream, ethane derived as a by-product from shale gas production is being used as a relatively cheap feedstock in the petrochemical sector, reinvigorating that sector in the USA and prompting petrochemical companies to lobby the Obama administration to prevent further LNG exports. Cheniere's Sabine Pass LNG plant is the only one to have received an export licence so far, but petrochemical companies are worried that allowing further exports after the plants starts up in late 2015 will force up domestic gas prices. The most cost effective additions of petrochemical capacity in recent years have been of ethane-based petrochemical plants in the Middle East, but the advent of cheap natural gas opens a significant possibility of a renaissance of the fortunes of the petrochemical sector in the west, which has traditionally used relatively costly naphtha or Liquefied Petroleum Gas from within the refining process.

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Cheap gas also, of course, has direct benefits for the electricity sector and other energy-intensive industries such as steel and ceramics.

These developments have come after years of investment by the refining sector in coking and hydrocracking technologies which have assumed that the crude stock will become ever heavier, based on the premise that the Middle East, which has the biggest oil reserves, will gradually become more dominant in the supply mix. In 2013, US crude oil imports from traditional light sweet suppliers such as Nigeria and Algeria have also declined. So a final benefit of shale resources is that they reduce import dependence, improving the bargaining position of US refiners when importing crude oil.

Double-edged Sword

While the short-term benefits of tight oil and shale gas have been extolled by the refining sector, the long-term impacts of vast amounts of relatively low-priced gas on the sector have been less observed. Shale gas could potentially prove a double-edged sword for a refining industry that already faces overcapacity problems, particularly in the Atlantic Basin where shrinking demand and competing product flows look set to put European refiners under intense pressure in the future.

Currently more than two-thirds of all oil use is in the transportation sector, but the availability of cheap natural gas opens the door to a greater use of gas in the vehicle fleet and in marine transportation. New refineries being developed in Latin America and the Middle East, ambitious upgrading plans in Russia and the prospect of US exports currently being sold into Latin America being diverted to Europe as countries such as Brazil develop their own capacity, represent a looming 'perfect storm' for the industry.

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The potential loss of market share in the energy mix of liquids to gas, particularly given tightening environmental constraints which have already encouraged biofuels at the expense of oil products, represents a further threat to the already beleaguered European refining sector.

How quickly this will happen is up for debate. Gas in transport has been much talked about for years, but it has always been a revolution that is about to happen rather than one that is actually underway.

In the road transportation sector, gas can be delivered to vehicles either as Compressed Natural Gas (CNG) or for larger heavy-duty vehicles as Liquefied Natural gas (LNG); or as Liquefied Petroleum Gas (LPG). The first two processes use methane: in CNG, the methane is compressed; whereas in LNG, the methane is supercooled to below -162 degrees Centigrade to make a usable fuel. In the case of LPG, the propanes and butanes derived from the distillation of crude oil are generally isolated from the liquid streams in the refinery and from there can be either used in gasoline production, sold as petrochemical feedstock or bottled for use in stoves and heating appliances, or as a fuel for cars and other vehicles. Although some LPGs are naturally occurring, most are a product of the refining process, whereas CNG and LNG substitute molecules (gasoline and diesel) that would be derived from the refining process.

CNG is already widely used in vehicles in a few emerging market countries. Passenger vehicle conversions to CNG can be done cheaply by adding a tank in the boot of the car, allowing dual-fuelling with gasoline; while buses and medium-duty vehicles are increasingly seen as environmentally desirable in public transport fleets.

For LNG, the main uses are in large trucks and mobile plant and machinery such as earth-moving equipment and so on. There is also potential that LNG

will be used as a replacement for diesel in locomotives on the railways. Meanwhile, in the marine sector, LNG is being considered as a potential alternative to diesel and fuel oil, the two oil products that are currently used as marine bunkers.

While slow fleet turnover rates make a substantial rise in gas-fuelled vehicle use unlikely in the near term, the pace of change in the marine sector may be more rapid.

At the bottom of the barrel, heavy fuel oil has always been the mainstay of marine transportation fuels for tankers and large ocean-going vessels, also providing refiners with a sink for unwanted sulphur, while products such as diesel have tended to be used in auxiliary systems to provide lighting and heat on board, or for smaller vessels geared to passenger transportation or for use in local waters.

The fleet of vessels that is currently fuelled by LNG is tiny. Outside the 100 LNG tankers that use the gas as a fuel, it consists of 20–25 passenger ferries and coastal vessels in Scandinavia, mostly in Norway and Sweden which have the only fuelling facilities. But steps are afoot to change that.

The European Union in January 2013 released a plan for boosting the use of gas in transport, which includes plans for LNG refuelling stations to be installed in 139 maritime and inland ports on the Trans European Core Network by 2020 and 2025 respectively. The proposals were made in a working paper *Actions towards a comprehensive EU framework on LNG for shipping*.

The EU action plan contains binding targets but member states will decide the appropriate policy instruments to attract private sector investment. The EU will work with the European Maritime Safety Agency to provide a comprehensive set of rules, standards and guidelines for LNG provision, bunkering and use in shipping by the end of 2014.

The action plan is intended to boost the infrastructure available to deliver LNG as a fuel to ships, whose demand for clean fuels will be boosted by new rules on emissions that go into effect in less than two years.

Meanwhile, from the start of 2015, ships operating in Emissions Control Areas (ECAs) will be subject to much tighter limits on emissions from bunker fuels, which looks set to push owners towards LNG-fuelled and dual-fuelled vessels in the years ahead to take advantage of the large gap between oil and gas prices. Sulphur limits in marine fuels have already been tightened from 4.5 percent maximum to 3.5 percent worldwide, and to 1 percent in the ECAs. From 2015, a 0.1 percent limit will be imposed in ECA regions, and from 2020 a 0.5 percent limit will apply worldwide, subject to a technical review in 2018. Nitrous oxide limits will also be tightened.

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The upcoming tighter rules on emissions have prompted many ship-owners to look more actively at the costs of switching to gas. Diesel is lighter and less polluting than fuel oil, but the downside is that it is more expensive. Based on current prices, LNG is economic as a bunker fuel in the United States and in Europe, although the case for tankers using LNG is marginal in Asia where LNG spot prices hit record highs in 2013. So 2015 is likely to be a watershed in the long-running debate about whether gas would be a better fuel for ships than oil.

Regulatory Uncertainty

Most analysis of the potential role of gas in the fuels sector is based on projections of the future spot price of different fuels based on forecasts of the long-run marginal cost of the competing fuels. The reality is that government decisions play a major role in setting the retail prices of such fuels. Gasoline and diesel pump prices range from below spot prices in such regions as the Middle East to well above in Europe, where taxes and duties might form as much as two-thirds of the cost to the motorist. Thus the impact of gaseous fuels in different geographical regions will depend crucially on government decisions on the level of subsidy or fuel tax imposed for the individual fuels.

Thus, as well as the market risk inherent in all commodity pricing decisions, regulatory uncertainty also potentially has a bearing on the uptake of gas in the fuels sector.

It is notable that the countries where the penetration of NGVs is greatest are ones where the car fleet is relatively new, and where the government has a strong say in the energy mix. Among the countries with the largest NGV fleets, just five countries (Pakistan, Iran, Argentina, Brazil and India) make up 70 percent of the world's NGV fleet by vehicle numbers. Together with China, Italy, Ukraine, Colombia and Thailand, they make up 89 percent of the world's NGV fleet by vehicle numbers, based on data from the Natural Gas Vehicles Association.

The profile of NGV fleets differs between the emerging markets and the developed economies. In the former, typically, the NGV fleet comprises – at least based on vehicle numbers, which include low consumption vehicles such as three-wheelers/tuk tuks – light duty vehicles which are typically owned by individuals. Of course, such countries may also have large public fleets, for instance in India where city bus fleets are typically fuelled by CNG. In developed economies, however, the bulk of NGVs by vehicle numbers are medium and heavy duty vehicles and the light duty vehicle fleet is generally relatively small. The medium and heavy duty vehicles typically comprise trucks and buses owned by companies and local authorities, sometimes reflecting a desire to show off environmental credentials rather than simply acting in response to price considerations.

This balance could change. Political economy is a crucial factor in the allocation of subsidies in emerging markets. Many governments have either shifted or are in the process of switching their subsidy support away from 'expensive fuels' such as oil to 'cheaper' ones like gas.

For this reason, the high proportion of dual-fuelled vehicles in those countries where the market penetration of gas-fuelling is greatest is significant.

In the emerging markets, which are experiencing rapid growth in the private vehicle fleet, gas-fuelled vehicles are typically conventional cars which have been converted to be able to use gas for cost reasons. The cost of conversion has dropped to the equivalent of just $50 in some countries, so dual-fuel capability in passenger vehicles is cheap and can be achieved much faster than vehicle

turnover trends typically allow.

A major uncertainty for refiners building costly upgrading capacity is whether to gear new units towards diesel production or to gasoline production. A trend towards dual-fuelling in vehicles has potential implications for which oil products to maximise.

Vehicle ownership and use are increasing globally, and despite all the concern that vehicle emissions are contributing to global warming, environmental pressures have done nothing to reverse this trend. Slow fleet turnover patterns make it unlikely that the market share of conventional liquid fuels will significantly reduce in the developed countries in the coming years. On average, people keep their cars for at least several years, and typically are conservative in their choice of replacement vehicles. If there is a shift, it is likely to be as much towards electric hybrids rather than gas fuelling. The perception that gas-fuelling infrastructure is limited may take longer to shift than the reality of how many stations can deliver LPG or CNG.

However, in emerging markets with young populations, high population growth, rapidly rising real income, where many people are new to car ownership, the old rules may not apply. Where the infrastructure for car-fuelling is growing rapidly, adding CNG or LPG pumps is less of an issue than in retrofitting filling stations geared to delivering liquid fuels.

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Gasoline hybrid vehicles are easier and cheaper to make than diesel hybrids, so hybrid NGVs and conversions tend to have gasoline as their liquid fuel. Of the NGVs on the market, most of the models manufactured by the likes of Fiat and other manufacturers targeting the Alternative Fuelled Vehicle market are gasoline hybrids. This is the case even in the European Union, where diesel taxes have typically been much lower than those for gasoline.

One of the biggest choices faced by a refinery is whether to build conversion capacity, and which sort of conversion capacity to build. Although there are many types of configuration, and a great deal of flexibility in operation once the investment decision has been made, a basic choice is whether to install cracking capacity, generally through a fluid catalytic cracker or FCC, which optimises gasoline production; or to go down the coker-hydrocracker route, which typically facilitates production of low sulphur diesel. In recent years, based on very bullish projections of diesel demand in the emerging markets, the coker hydrocracker has been more in favour after many years in which FCCs were the default technology.

We have outlined that cheap shale gas has had a positive impact on refineries by lowering their fuel costs, but also that gas in transport represented a potential threat to the market share of liquid fuels. A third more subtle impact of cheap gas may be that it encourages the use of gasoline hybrid vehicles at the expense of diesel vehicles. This would particularly be the case if oil prices remain above $100/barrel and the US experiment with fracking was repeated in other countries. If the use of LNG in marine bunkers were also to displace diesel in the marine sector, there could over time be a marked shift in end-use demand towards the light end of the barrel. ■