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The role of oil and gas in the development of the global economy

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Abstract: This paper is concerned with the role of oil and gas in the development of the global economy. Its focus is on the context in which oil and gas producers in both established and developing countries must frame their policies in order to optimize the benefits of producing such resources. It begins by outlining a brief history of the issue over the last 25 years. It considers oil and gas as factor inputs, their role in global trade, the role of oil prices in the macro-economy and the impact of the geopolitics of oil and gas over the same period. The paper then considers various conventional views of the future of oil and gas in the primary energy mix, trying to explain why there is a tendency towards consensus in the different forecasts. Finally, it seeks to challenge these conventional views of the future by examining the various drivers behind them, and to show why the future may prove to be very different from what is expected and how this may change the context in which producers must frame their policy responses.

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1 Introduction

The purpose of this paper is to explain recent developments in energy, particularly those that have led to lower oil prices, and to argue that lower prices may well be the norm going forward. For low- and middle-income countries that were anticipating significant revenues from oil and gas when expected prices were much higher, this will require a number of adjustments. In particular, they will have to lower their spending levels and seek alternative sources of revenue. They must also make plans to manage the macro-economic consequences of lower revenues. Above all, they must give (even more) serious consideration to policies that will help to diversify their economies away from dependence on hydrocarbon revenues and away from expectations of such dependence.

The paper is structured as follows: Section 2 provides a brief history of the role of energy in the global economy over the last 25 years. It considers oil and gas as factor inputs, their role in global trade, the role of oil prices in the macro-economy, and the impact of the geopolitics of oil and gas over the same period. Section 3 considers various conventional views of the future of oil and gas in the primary energy mix, trying to explain why there is a tendency towards consensus in the different forecasts. The following sections seek to challenge these conventional views by examining the relative importance of the various drivers of the future—economic and technological (Section 4) and geopolitical (Section 5)—and to show why the future may prove to be very different from what is expected and how this may change the context in which producers must frame their policy responses. Finally, Section 5 offers some conclusions.

Box 1: Warnings on the analysis

Oil and gas have played an important role in global economic development over the last 25 years. However, trying to analyse that role is fraught with problems that must be borne in mind as the analysis unfolds. First, because of the wide scope of the subject, generalizations are inevitable—and these are often wrong. In particular, there are enormous variations between countries and between regions and major differences between the developed world of the OECD countries and the emerging market economies, so the best that can be hoped is to give a flavour of the main issues in the principal geographic areas. Second, data on oil and gas—and energy more generally—are extremely unreliable and are constantly being updated as more information becomes available. This paper makes extensive use of the BP *Statistical Review of World Energy* (BP 2016b). This excellent publication is one of the best sources of statistical data and is constantly being revised, but its great virtue is that, as definitions change (e.g. with the break-up of the Soviet bloc, changing membership of OPEC), the history can also be changed in a consistent manner. Finally, much of the analysis is controversial. There is a huge literature in which the issues discussed here have been debated. To give a flavour of its extent, this author produced a survey of the literature on the resource curse that was published by Chatham House in 2015 (Stevens 2015). It covers only one small aspect of this paper but it is 41 pages in length and contains over 200 references. Given the constraints of space and time, only some of the controversies can be considered here, and even those can be treated only in a rather superficial manner.

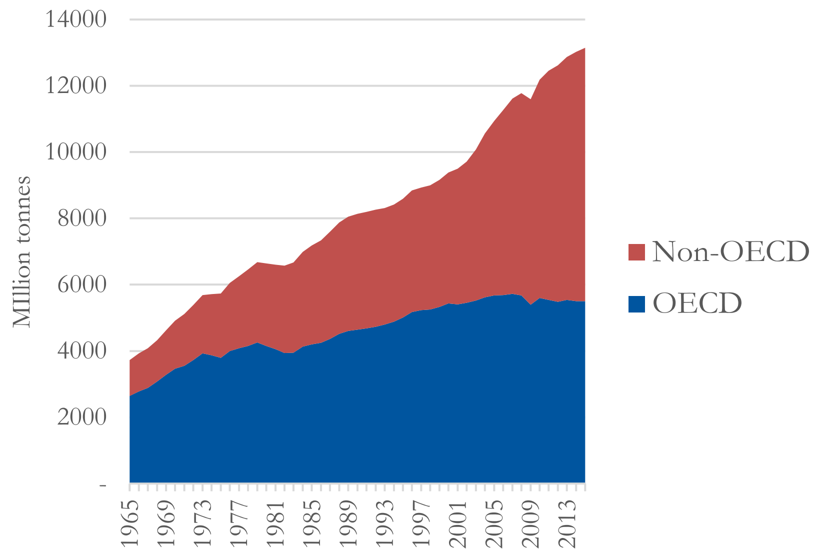
2 Recent history

This section considers some of the background to the present context for producers in established and developing countries, in order to generate the picture that will need to be developed as they face an uncertain future in terms of energy prices.

2.1 Oil and gas as a factor input

Ever since the British Industrial Revolution, energy has been a key factor of production (Landes 1969). Recent history has proved no exception. The pattern of primary commercial energy consumption[1] since 1965 is presented in Figure 1.

Figure 1: World primary commercial energy consumption by region, 1965–2015



Source: BP (2016b).

What is also clear is that, since the start of this century, energy consumption in non-OECD countries has grown strongly, while in OECD countries it peaked in 2004. As explained in Appendix A, this is because of the lagged relationship between prices and energy consumption following the oil shocks of the 1970s. This recent development represents an important part of the story, especially when the future is considered (Sections 4 and 5).

As to fuel mix, Figures 2 and 3 illustrate the patterns since 1965. As can be seen, oil has dominated the mix in this period as a result of its innate advantages: because it is liquid and flows in three-dimensional space, it attracts very large economies of scale;[2] it also has a much higher energy content than other fuels.[3]

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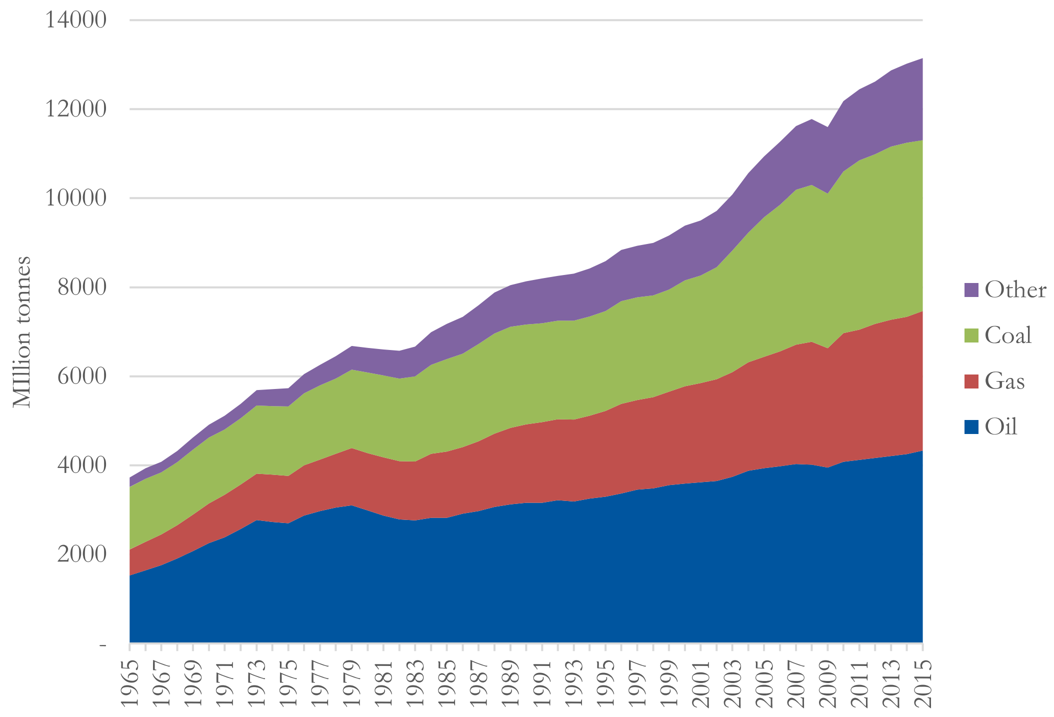
[1] Commercial energy is distinct from traditional energy. Commercial energy can be defined as energy that moves in corporately controlled markets and involves some level of foreign exchange input. This includes coal, oil, gas, nuclear, and modern renewables, including hydro. This is as opposed to traditional energy, which either moves in small local markets or is non-commercial and involves no foreign exchange input. This includes wood, charcoal, and animal and vegetable residues (Stevens and Pearson 1984). Because of the lack of accurate statistics, traditional energy is not included in the data, although in many parts of the developing world, those fuels constitute the majority of primary energy consumption.

[2] The capital cost of a storage tank is a function of surface area and its output a function of capacity. There exists an exponential relationship between the two. Doubling the dimensions of a tank halves the average cost of storage. Tanks in various shapes and forms—pipelines, oil tankers, refineries, etc.—dominate the oil industry.

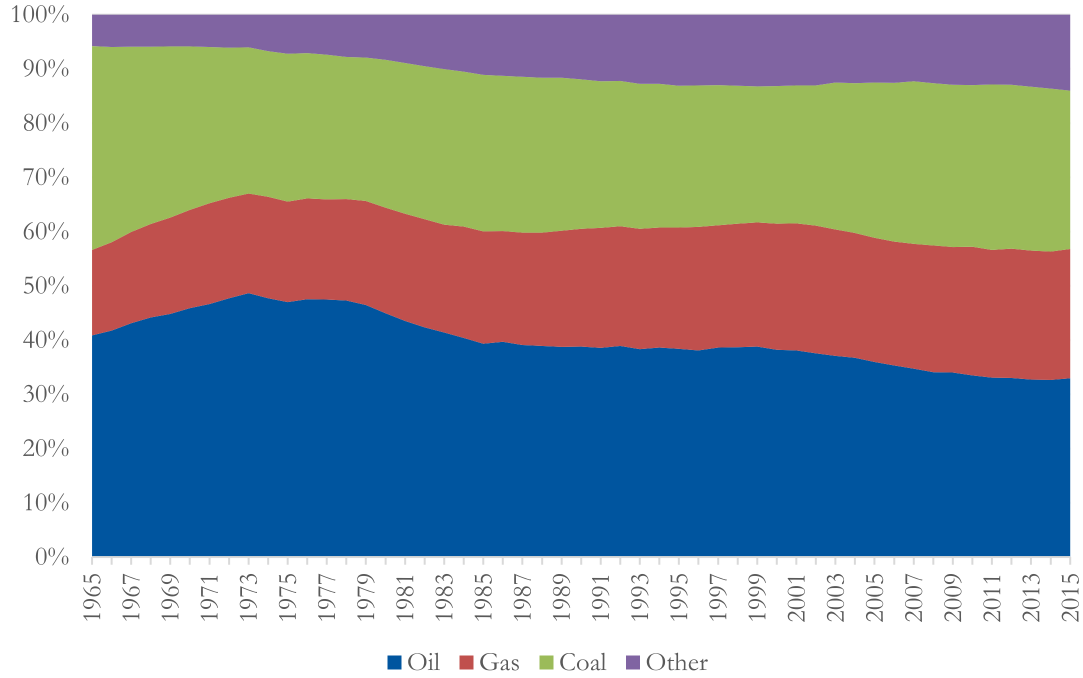
[3] A tonne of oil contains 1.5 times more energy than a tonne of hard coal and a cubic metre of oil contains vastly more energy than a cubic metre of gas.

Figure 2: Global commercial primary energy consumption, 1965–2015



Source: BP (2016b).

Figure 3: Global primary energy consumption excluding FSU gas, 1965–2015

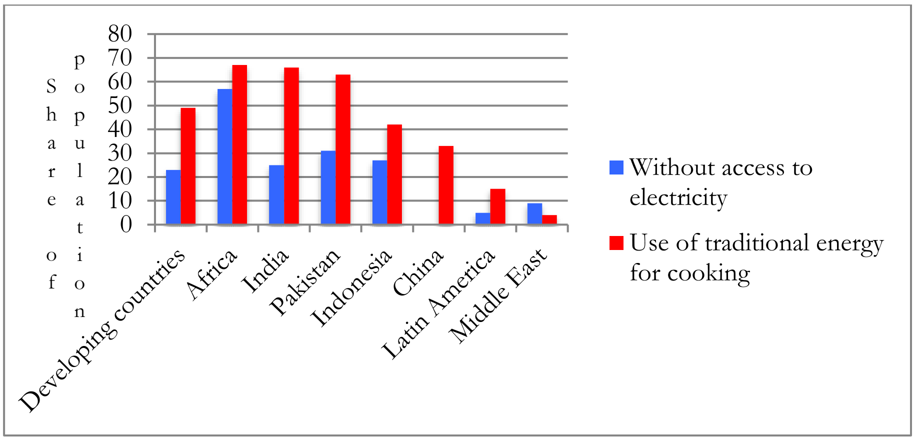


Source: BP (2016b).

The effects of the oil price shocks of the 1970s were to push oil out of the static sector (power generation), where it was replaced initially by coal and gas. However, until recently, oil retained its favoured position in the transport sector, while gas remained a constrained fuel, limited by its high transportation costs.[4] Moreover, the use of gas in the power sector was proscribed by regulation in the US and the EU between 1975 and 1990.[5] In emerging market economies, its domestic development by the (foreign) companies that had discovered the gas was also constrained in the face of non-convertible currencies. Thus, gas earned only revenue that the foreign company could not remit back to its shareholders

However, despite the growing use of commercial energy, the world faced considerable fuel poverty. Figure 4 illustrates the size of populations without access to electricity and those without access to modern cooking fuels. It is interesting to observe that the Millennium Development Goals did not relate at all to energy. However, the Sustainable Development Goals explicitly refer to energy.[6] As will be discussed, this has important implications for the future of oil and gas in the development process, not least because the price of solar electricity is falling more rapidly than expected..

Figure 4: Energy poverty by region, 2011



Source: IEA (2013).

2.2 Oil and gas in global trade

Oil and gas are major internationally traded commodities. Figure 5 shows the proportion of traded oil consumed and the way that this trade has been increasing this century. Because of economies of scale, transporting oil and oil products is extremely easy and extremely cheap. This goes a long way to explaining why oil is an internationally traded commodity with a unified market, while gas remains traded in regional markets (see Appendix B).

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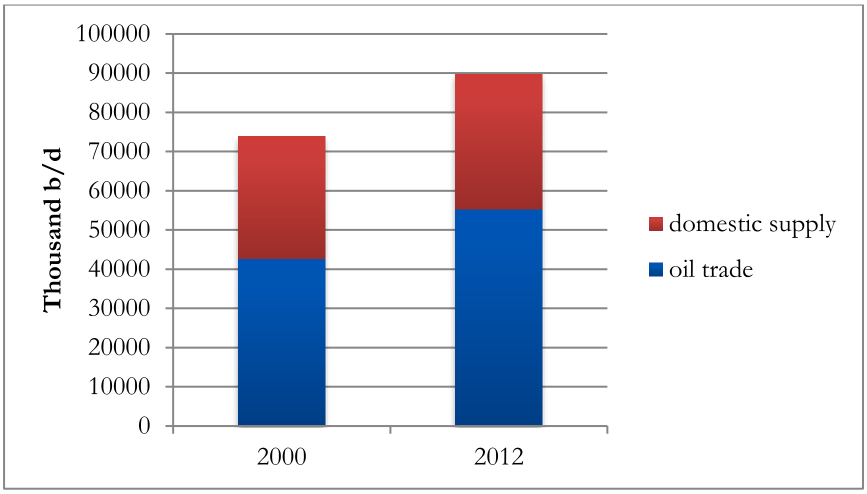
[4] Because of its low energy content, gas is a high-volume, low-value commodity, which severely limits its geographic market.

[5] Gas was seen as a premium fuel and the view was taken that it should be preserved for premium markets; it was considered too valuable to burn in power stations.

[6] The seventh development goal is to ensure 'access to affordable, reliable, sustainable and modern energy for all' (UN 2015).

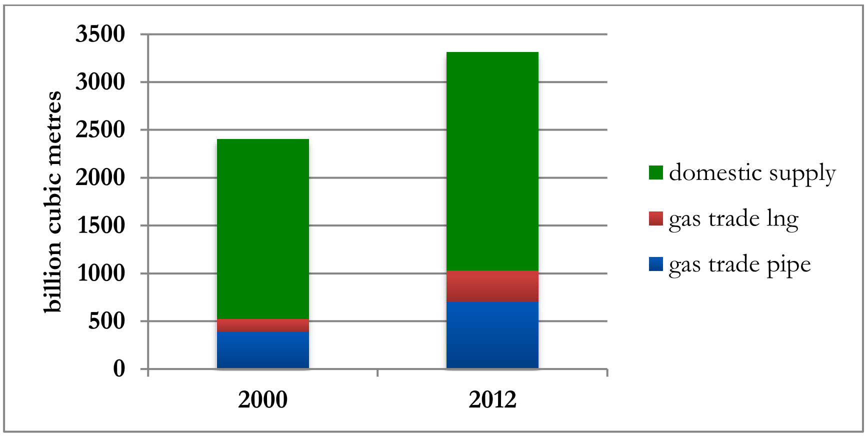
Figure 5: International oil trade



Source: BP (2016b).

By contrast, gas suffers from what has become known as 'the tyranny of distance'. As can be seen from Figure 6, a much smaller proportion of consumption is traded internationally, although this has been growing since 2000.

Figure 6: International gas trade



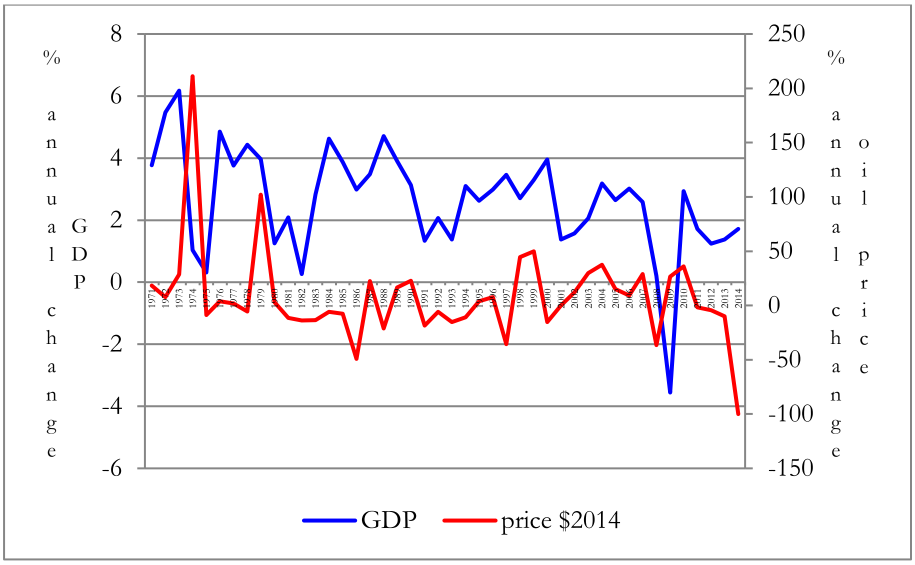
Source: BP (2016b).

For many countries, the oil and gas trade makes a significant contribution to the current account in the balance of payments. In particular, a number of oil exporters are dependent upon oil exports for their foreign exchange.

2.3 Prices and the macro economy

Ever since the oil price shocks of the 1970s, attention has been paid to the relationship between oil prices and global GDP growth. Casual observation of Figure 7 suggests that the changes in oil prices in the 1970s and 1980s did affect economic growth in OECD countries. There are good economic grounds to expect this negative relationship. Higher oil prices shifted income from the OECD to the OPEC countries. The OECD countries had a much higher propensity to consume than the OPEC countries, which in this period lacked the institutional capacity to spend the whole of their windfall revenues, a large proportion of which were simply left in Western banks. Thus, global aggregate demand fell, leading to an economic recession.[7]

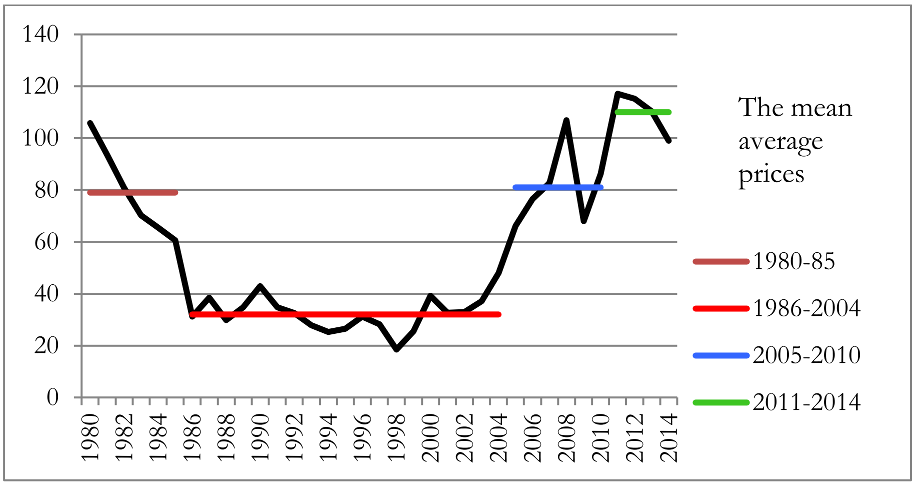
Figure 7: OECD GDP growth and oil prices, 1971–2014



Source: Oil prices, BP (2016b); GDP, World Bank Databank (accessed October 2016).

The more recent oil price patterns can be seen in Figures 8 and 9. Figure 10 shows the 'collapse' in oil prices after June 2014. It is important to put this into its historical context. As can be seen, complaints heard over the last couple of years about 'low' oil prices (i.e. below US$40 per barrel) are clearly misplaced given that the average price of Brent in real terms between 1986 and 2004 was only US$33 per barrel. Post 2004, oil prices experienced an apparently inexorable rise. As will be developed below, this had important implications for oil-exporting countries.

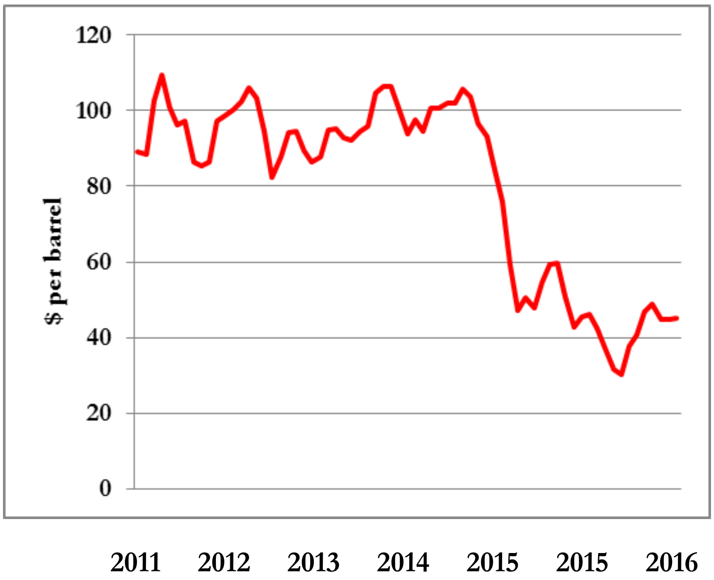
Figure 8: Crude oil prices, 1980–2014 (Brent 2014 US$)



Source: BP (2016b).

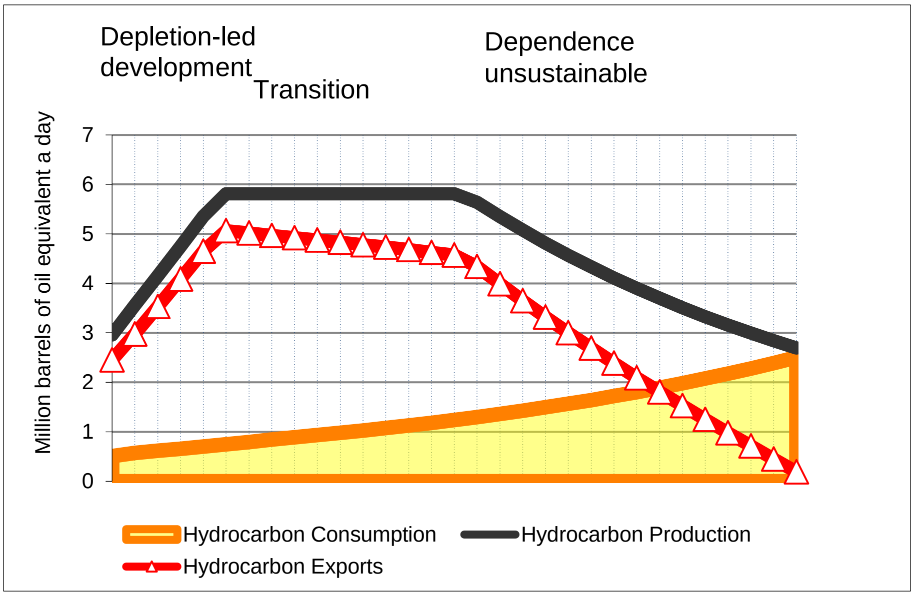
[7] This is a very simplistic explanation. There were many other factors in play and the precise relationship between oil prices and global GDP has been much debated in the economics literature.

Figure 9: Recent patterns of oil prices



Source: BP (2016).

Figure 10: Depletion and development



Source: Mitchell and Stevens (2008).

The higher prices seen in all natural resources from 2004 to 2014 have brought the issue of the 'resource curse' back into the policy debate (Stevens and Lahn 2015).

Linked to the debate on the resource curse has also been a revived interest in economic diversification in countries dependent upon oil and gas revenues. The key point here is that oil revenue is not income. Rather, it simply represents the re-shuffling of the nation's portfolio of assets. Figure 10 typifies the production profile of an oil producer.

In the initial stages, production provides financial resources, which should be used to promote economic development. Production then reaches a plateau.[8] In this transition phase, it is crucial that the financial resources released by producing the oil are used to create an alternative income-producing asset. Eventually, production will decline as a result of natural depletion. For export earnings, this process is accelerated as domestic consumption rises. In this stage—'Dependence unsustainable' in Figure 10—it is no longer feasible to rely on oil revenues to support the rest of the economy. Therefore, oil-dominated economies should aim from the very early stage of production to diversify away from dependence on oil revenues. The success or otherwise of this strategy can be measured by the non-hydrocarbon fiscal deficit.[9]

2.4 Geopolitics and their economic impact

Geopolitics and oil are inextricably linked. There are two oil markets: the wet barrel market, where real barrels of crude oil are bought and sold; and the paper barrel market, where promises (written on paper) to deliver or take delivery of oil are exchanged. Understanding the wet barrel market requires Economics 101. Understanding the paper barrel market requires Psychology 101. The relationship between the two markets is complex and controversial but comes down to issues of perception. Those negotiating contracts in the wet barrel market will look to the paper barrel market to get an indication of what prices might be. Those in the paper barrel market deciding where to invest will look to the wet barrel market for signs of surplus or shortage.

There are two problems here that aggravate oil price volatility. First, many of those playing in the paper markets do not really understand the oil industry and frequently misread the state of the wet barrel market, often assuming shortages when there are none.[10] The second source of price volatility is that perceptions can change in the blink of an eye—and, with them, prices.

In this context it is easy to see the relevance of geopolitics in terms of recent price history. Any loss of oil supplies as a result of geopolitical events such as a war has affected physical supply in the wet barrel market. Wars and rumours of war have also affected expectations in the paper barrel market. Politics have clearly affected government policy (Stevens et al. 2013). Security of supply concerns drive the energy policies of energy-importing nations, which in turn affect energy consumption levels and the energy mix. Equally, security of demand concerns drive the depletion policies of producer governments and the rise (or fall) of resource nationalism. Figure 11, using the number of arbitration cases as a proxy[11], measures the extent of resource nationalism. As can be seen, this century there has been a significant rise in resource nationalism, which has coincided with the upturn of the commodity super-cycle.

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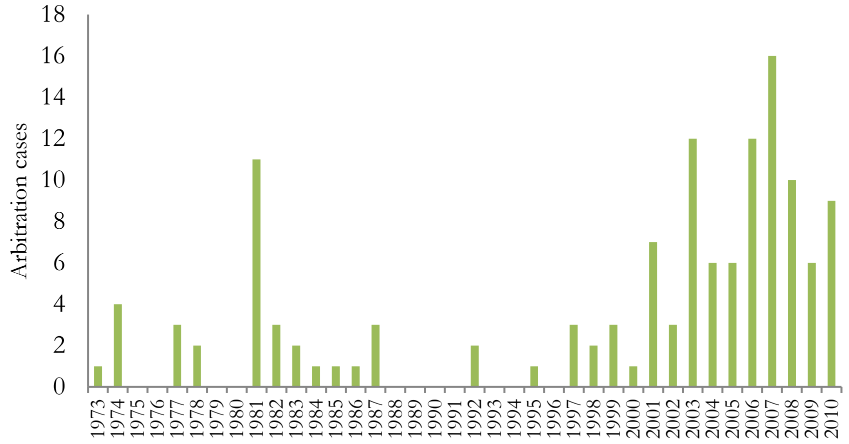
[8] The idea that production will somehow peak, rather than reach a plateau, is totally unrealistic. The infrastructure needed to produce the oil is expensive and the economics only work if it is at full capacity. Therefore, the idea that infrastructure would be built to accommodate a short-lived peak is not tenable. Thus the production profile inevitably reaches a plateau.

[9] This measures the extent to which a fiscal deficit in the non-oil sector can be funded by oil revenues. A similar measure for foreign exchange is the non-hydrocarbon current account deficit.

[10] This may sound improbable, but a similar situation exists in foreign exchange markets—known as 'scapegoat theory' (Bacchetta and Van Wincoop 2004). Economists trying to predict exchange rates using the usual economic metrics will often get it wrong because those setting the rate, i.e. the traders, look at a totally different set of metrics.

[11] Arbitration cases measured in Figure 11 concern disputes between host governments and companies over the terms of their agreements. The implication is that rising commodity prices create a larger pot, which is worth arguing over.

Figure 11: Number of international arbitrations in the extractives sector

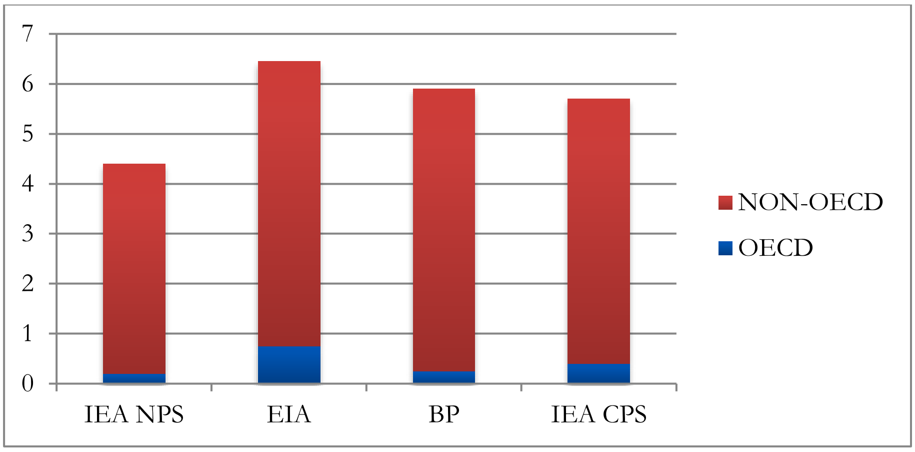


Source: Stevens et.al. (2013).

3 Current conventional views of the future for oil and gas

As indicated at the start of the paper, the future of the energy markets will frame the need for both established and newer producers to develop policies against a background of highly uncertain energy prices. Thus, it is important to begin by considering what the conventional views of this future suggest is the most likely path the markets will take. Figures 12 and 13 give a flavour of views of future energy demand from a variety of sources.

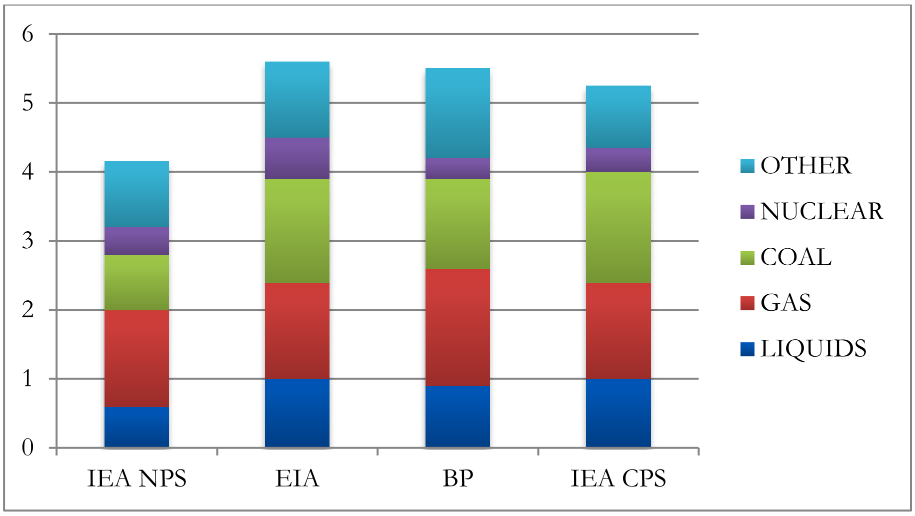
Figure 12: Increases in energy consumption by region, 2010–2035 (billion toe)



Note: IEA NPS is the International Energy Agency's New Policies Scenario (IEA 2013); EIA is the United States Energy Administration's *Annual Energy Outlook* (2016); BP is BP's *Energy Outlook* (2016a); IEA CPS is the International Energy Agency's Current Policies Scenario (IEA 2013).

Source: Derived from BP (2016a).

Figure 13: Increases in energy consumption by fuel, 2010–2035 (billion toe)



Source: Derived from BP (2016b).

The first point to note is that there is fairly strong agreement on the direction of travel. Virtually all of the growth in primary energy demand is thought to be likely to occur in the non-OECD countries, and fossil fuels are thought likely to continue to dominate supply.

It is interesting to speculate why there is such consensus. One explanation is that the forecasters have models (quantitative and qualitative) that are based upon similar drivers. How much certainty there is over these drivers will be discussed in Sections 4 and 5. There are, however, other more controversial explanations. First, there is safety in consensus: if your forecast is wrong, so is everyone else's. Second, there is a serious forecasting problem. Forecasting trends based upon business as usual is fairly straightforward. Forecasting bends in trends can also be done with some imaginative thinking. However, forecasting major discontinuities is next to impossible. Even a brief acquaintance with the history of the energy markets since the 1970s shows that it has been littered with major discontinuities, driven by economic and technological factors as well as by pure accident. There were the three oil price shocks of 1973, 1979, and 1986.[12] There have been various accidents, ranging from Three Mile Island to Chernobyl to Fukushima for nuclear and the Macondo spill for oil. There has been the shale technology revolution that has had such a dramatic impact on oil supplies. The list could go on.

Finally, there is the problem of political and vested interests behind the mutually supporting consensus of most forecasts. The IEA, for example, was created to persuade oil-importing OECD countries to reduce their dependence on imported oil.[13] Projecting shortages in the future might be seen as a good way to encourage consumer governments to take steps to reduce dependence. Equally, the oil companies have a vested interest in persuading their shareholders that oil demand will continue to increase and that better times in the market lie just ahead (Stevens 2016).

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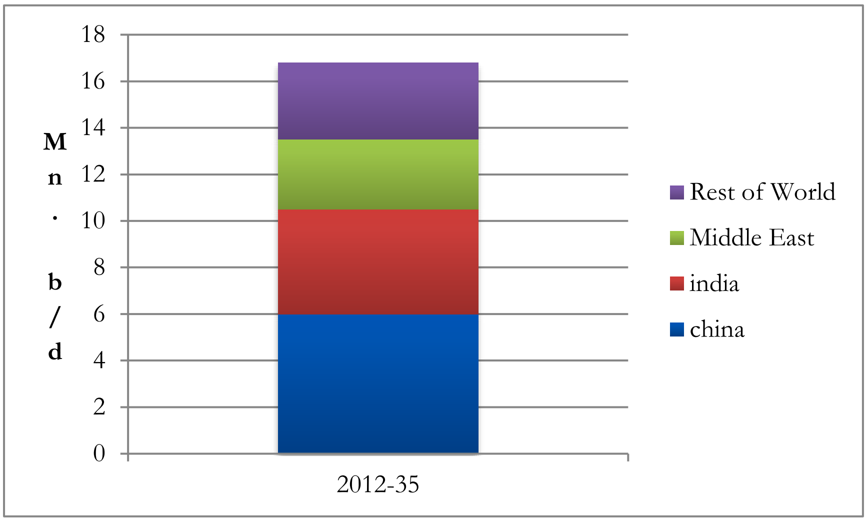
[12] Since the large price rises of 1973 and 1979 were called 'shocks' because consumers were suddenly and dramatically hurt, the price collapse of 1986, which suddenly and dramatically hurt the producers, should rightly also be labelled a 'shock'. The difference may be that the 1986 price collapse was entirely predictable, given that higher prices generate feedback loops, lowering demand and increasing supply (Stevens 1982). Similarly, the price collapse since June 2014 was also predictable (Stevens and Hulbert 2012). That said, the precise timing in both cases was unknowable.

[13] It is worth remembering that the IEA was created in 1974 as Henry Kissinger's response to the perceived growing power of OPEC.

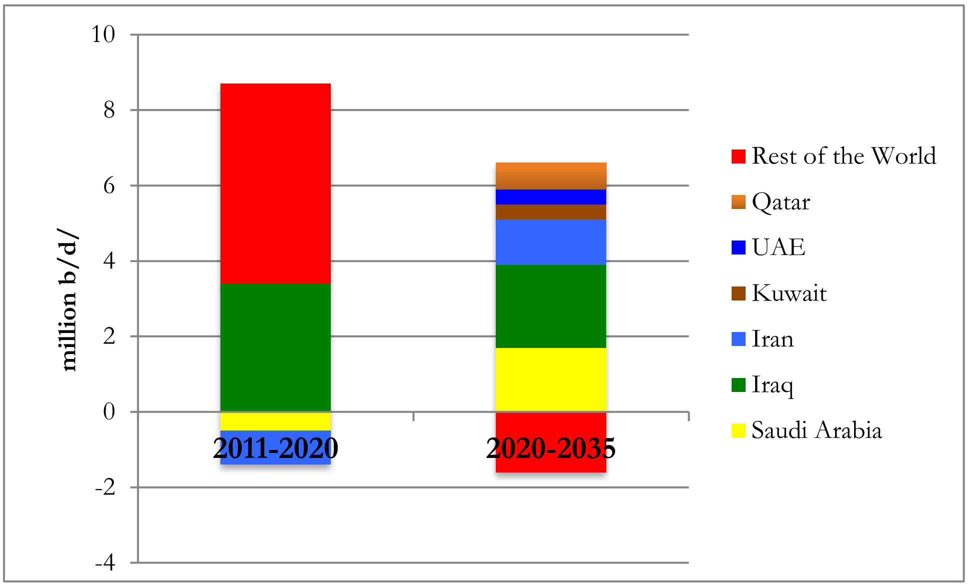
Within these energy forecasts, it is useful to consider those specifically for oil, given that many low- and middle-income countries are hoping that future oil production will provide them with significant benefits. Figure 14 illustrates the thinking on future oil demand from the IEA's New Policies Scenario, published in 2013. Figure 15 illustrates the thinking on future supply.[14]

Figure 14: Regional sources of oil demand growth, 2012–2035



Source: IEA (2013).

Figure 15: Sources of crude oil growth



Source: IEA (2013).

[14] A number of criticisms can be made of the IEA's forecasts of oil demand and supply. For example, on the demand side, the dominant position given to China, India, and the Middle East in future levels of demand arises from a strong history of demand growth over the last 25 years. However, in all three cases, this has occurred in the context of highly subsidized final product prices. As will be developed below, this policy context has been changing and these changes raise serious doubts about such projections. On the supply side, the dominant position of Iraq in future oil supply growth seems extremely unrealistic, given the present desperate state of that country.

Such consensus views of a business-as-usual future are in danger of giving false expectations to oil and gas producers. The next two sections consider why these conventional views of the future might be wrong, thereby forcing the established and newer producers to consider carefully their future policy options. Section 4 looks at economic and technological concerns and Section 5 considers geopolitical threats to such futures.

4 Drivers of future trends: what economic and technical factors might derail conventional views of the future?

As suggested in Section 3, the consensus associated with forecasts of energy supply and demand in part arises because the forecasters tend to take similar views of the drivers behind the forecasts. However, as indicated, the history of the energy markets has been characterized by frequent deviations from the expected path. This section considers what factors might cause the future drivers of supply and demand to be different from today's expectations.

4.1 Technology

Invention and innovation are embedded in the forecasts.[15] There are three particular areas where change could affect the way the future unfolds: carbon capture and storage (CCS); the development of batteries; and the spread of shale technology.

CCS

CCS is a well established technology whereby very large reserves of hydrocarbons can be burnt without aggravating climate change. However, the costs and adoption problems associated with it are considerable. First, capturing carbon adds significantly to the cost of power generation. Second, capturing carbon from small-scale emitters poses serious problems. Third, storage faces many problems, not least that of preventing leakage. In the United States, for example, the complexity of property rights to the sub-soil makes it unclear as to where responsibility lies for maintaining the storage once the CO_2 has been injected underground.

Battery technology

Improvements in battery technology would greatly help to overcome the key problem with renewables: namely that of intermittency. Technological developments could make batteries smaller, quicker to charge, and cheaper. A good example of possible change relates to electric vehicles. A large stock of electric vehicle could provide considerable storage. Modern metering technology means that electric vehicles could supply power to the grid and their owners be paid for it.[16] Furthermore, if roads could be built with induction strips, electric vehicles could charge while travelling.[17]

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[15] The difference between invention and innovation is that invention has strong elements of being a random process. Innovation, which is the spread of an invention, on the other hand, has clear socio-economic and political drivers. However, the distinction is not always so clear-cut.

[16] For example, in Western Europe the average daily car journey is less than 20 km. Assuming a battery capacity of 100 km (which is roughly the current level), that leaves considerable flexibility to use car batteries for storage.

[17] Offering a 'longitude prize' might be one way to generate changes to the technology for CCS and batteries. At the start of the 18th century, the great scientific question was how to determine where you were at sea. Latitude could be determined by measuring the angle of the sun, but estimating longitude required an accurate timepiece to establish the

Shale technology

The shale technology revolution has the capability to transform the prospects for oil and gas supply. In the US, it has already led to a dramatic increase in oil supply and an equally impressive increase in the domestic supply of gas.[18] The revolution was due to the development of horizontal drilling and hydraulic fracturing.[19] A key question is how far this technology can be used outside the US to produce similarly dramatic increases in supply. Certainly, there are ample technically recoverable resources of shale hydrocarbon globally. However, there are many barriers to converting these resources into producing capacity.

Table 1 outlines the conditions present in the US that facilitated the shale technology revolution. By contrast, it also shows that these conditions are for the most part not present in the UK, and a similar story is true for most other parts of the world.

Of course, shale technology is constantly changing and improving. Many of the characteristics that are not currently present outside the US could become available as a result of improved technology and institutional changes.[20] For example, a major barrier to using hydraulic fracturing in Europe is concern over the impact on water supplies and the danger of contamination of aquifers. Currently, experiments are under way to use sonic waves rather than water and chemicals to frack the rocks; if successful, this alternative technology might allay these fears.

Changes in any of these and other technologies could obviously seriously affect the consensus view of the future embodied in the forecast described in Section 3.

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time at the port of origin. In 1714, the British government offered a significant prize for whoever came up with such a clock. It was eventually awarded to John Harrison in 1793 (Sobel 2011). The COP21 meeting in Paris in December 2015 created the institutions that could make a similar prize feasible in the two areas of CCS and batteries: the Mission Innovation group of 20 governments, which launched a global initiative to accelerate clean energy innovation; and the Breakthrough Energy Coalition, a global group of 28 high-net-worth investors from 10 countries committed to the initiatives of Mission Innovation.

[18] Between 2008 and 2015, oil production increased from 6.8 mn b/d to 12.7 mn b/d and gas production between 2005 to 2015 increased from 511 bcm to 767 bcm (BP 2016b).

[19] There were other technical aspects of the revolution, such as the development of three- and four-dimensional seismic modelling and coil tube drilling.

[20] The collapse in oil prices after June 2014 has generated large cost savings and improved efficiency in the US industry.

Table 1: Factors facilitating the 'shale technology revolution' in the United States

United States	**United Kingdom**
Geology	
There were large, shallow, material plays, implying large, technically recoverable resources, much of the shale having a low clay content, making it easier to fracture.	Shale deposits reported to have high clay content
The shale gas had a high liquids content, which greatly enhanced the economics of the operations, especially at a time when gas prices were low.	Not known at this stage
Research	
After many years of oil and gas drilling, plenty of drill core data were publicly available to allow explorers to find the 'sweet spots' on the plays.	No such data
In 1982 the US government, through the Gas Technology Institute, began extensive funding of R&D into 'low permeability hydrocarbon-bearing formations'. The results were widely disseminated to the industry.	No such funding available
Regulation	
The 1980 Energy Act gave tax credits amounting to 50 cents per million BTUs and introduced the Intangible Drilling Cost Expensing Rule, which covered (typically) over 70% of the well development costs. These economic incentives were very important in the early stages of the industry, which then consisted of small, relatively cash-strapped entrepreneurial companies.	The government is only now considering introducing some tax breaks
The 2005 Energy Act explicitly excluded hydraulic fracturing from the Environmental Protection Agency's Clean Water Act—the so-called 'Cheney-Halliburton Loophole'. Many shale gas operations were therefore carried out without environmental impact assessments.	Strong environmental legislation
Property rights in the United States make shale gas the property of the landowner, creating a strong financial incentive for private owners to permit the disruption associated with shale operations. Also, the population is used to being in proximity to oil and gas operations.	Not applicable
The system is used to licensing large areas for exploration with fairly vague work programme commitments, which is needed when dealing with shale plays.	Not applicable
Nature of the gas market	
Pipeline access is based upon 'common carriage', so gas producers have at least some access to pipelines, transforming the economics of shale gas production. The US also has a very large and extensive gas pipeline grid.	Third party access.
The US is a 'commodity supply gas market', i.e. a lot of buyers and sellers and good price transparency. Gas is easy to sell.	Not as easy as in the US
The US domestic gas market experienced strongly rising prices in the period after 2002, culminating in a price over $10 per thousand cubic feet in May 2008.	Not applicable
Industry	
The industry was dominated by small, entrepreneurial companies, so-called 'momma and poppa' companies.	Not applicable
The majority of the work was done by a dynamic, highly competitive service industry. At the height of the Barnet Play in 2008, 199 rigs were operating.	Not applicable
The capital markets are willing to provide risk finance for oil and gas activities.	Not applicable

Source: Stevens (2013).

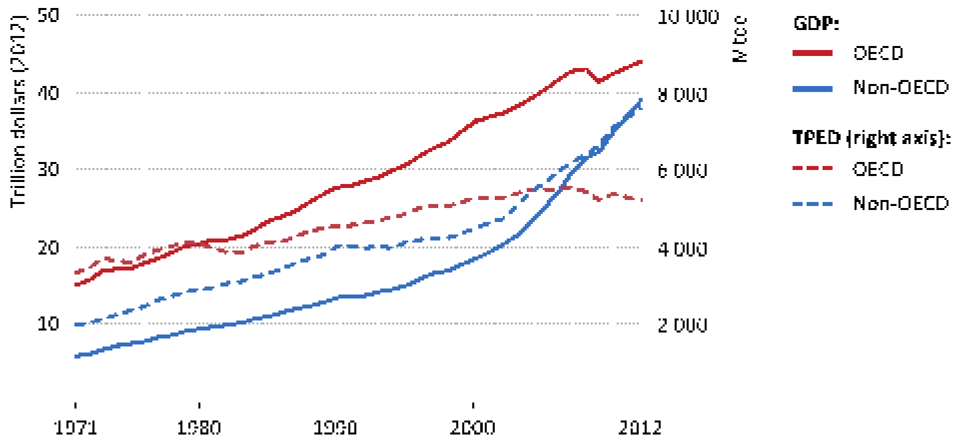
4.2 Incomes

Another driver of future energy demand is income, i.e. GDP growth. According to the conventional forecasts, GDP is expected to continue to grow and, with it, energy demand.[21] This view is potentially flawed in two important respects.

First, it is perfectly possible to imagine a GDP outcome that is very different from continued growth. Two possible discontinuities loom large. The first is another global financial crisis along the lines of the one that followed the collapse of Lehman Brothers in 2008. The second is a dramatic implosion of the Chinese economy under the combined effects of economic stagnation, the collapse of the political system in the face of serious internal conflict, and political reform failing to keep pace with economic liberalization.

Second, the relationship between GDP growth and energy demand is not as simple as is generally assumed. Figure 16 shows the history of the relationship between GDP and oil demand. This illustrates the fact that, whereas in non-OECD countries rapidly rising GDP has been accompanied by rapidly rising energy demand, in OECD countries rising GDP has been associated with declining total primary energy demand—in other words, with improving energy efficiency. All the forecasts include the potential for improved energy efficiency, but they fail to recognize that this is a factor that could disturb the historical relationship between energy demand and incomes. Moreover, energy efficiency is largely driven by prices and, as discussed in Section 5.3, the higher prices seen since 2004 (Figure 8) could well be sowing the seeds of much greater energy efficiency. Greater efficiency will also be driven by improvements in technology relating to energy consumption.[22] The scope for improving energy efficiency is huge—one has only to compare Japanese energy consumption with that of other countries.

Figure 16: Primary energy demand and GDP

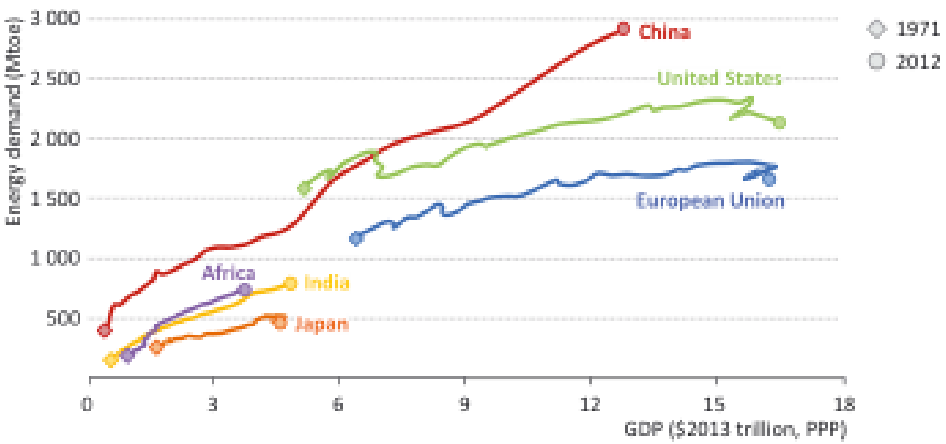


Source: IEA (2013).

[21] The GDP growth figures underlying the energy demand growth forecasts are fairly consistent, though generally quite conservative.

[22] A good example here would be improvements in the metering of electricity that would allow consumers to see precisely what each appliance costs to run. A basic assumption in economics is that the quantity demanded is a function of price. However, most consumers have little or no idea what it costs per hour to run even basic appliances. If that information were to become widely available, it would likely have a significant impact on consumer behaviour.

Figure 17: Japanese energy efficiency compared with others



Source: IEA (2013).

4.3 Energy pricing

Domestic prices are the result of the combined influences of international prices and domestic energy pricing policy. In the forecasts, generally only the international crude oil price is forecast. Forecasting crude oil prices has always been notoriously difficult (Huntington 1994). However, in any case, for both demand and supply, this price is misleading.

For demand forecasts, it is misleading because what matters is the final price paid by the consumer. This requires a view of what sales and other taxes will be imposed by the relevant government—and taxing oil products is a tax collector's dream, since oil products are involved in all sections of the economy. In the short term, demand is very price-inelastic, which means that high tax rates can be imposed without having much impact on the quantity sold. Moreover, collecting the tax is extremely low cost. For many years, many OECD country governments have taken advantage of all these factors to impose high levels of sales and other taxes on oil-related products to raise revenue. Over the last few years, many other governments have also come to realize this potential source of revenue. However, when the crude oil price collapsed after June 2014, many governments increased sales taxes to compensate for the lost revenue. Therefore, product prices did not fall in line with crude prices. At the same time, countries where oil products were subsidized reduced the level of subsidies. The result is that oil product prices to the final consumer are now likely to be much higher than those assumed in many of the forecasts.

For supply forecasts as well, the crude price can be misleading. For producers what matters is the price they receive after the fiscal system has taken its share of the economic rent. Lower prices, for example, can be offset by an easing of the fiscal terms.

There is another supply-side complication that appears to be neglected by most forecasters. A consequence of the collapse of oil prices since June 2014 has been a reduction in investment in upstream activities. The international oil companies, faced with a reduction in their cash flows, have been responsible for this (Stevens 2016). On 14 January 2016, the *Financial Times* reported that Wood Mackenzie had estimated that private oil companies had shelved US$400 billion worth of upstream projects. This involved 68 significant projects, which would have accounted for 27 billion barrels of reserves—equivalent to the reserves of Norway, Brazil, and Oman combined.

A similar story of reduced investment applies to the national oil companies (NOCs), which account for the bulk of the global crude oil supply. This is simply because their governments are desperate to secure increased revenues to buy off the political discontent of their populations, as seen in the 'Arab uprisings' that began in Tunisia at the start of 2011. In effect, the NOCs are being increasingly starved of funds. Upstream oil is a business where it is necessary to run in order to stand still, as all fields have a natural depletion rate. Globally this averages around 5–7 per cent per annum. Thus, lower investment in upstream production capacity now gives rise to the possibility in the future that, if oil demand continues to increase—as all the forecasts predict—the oil market will face a sudden supply shortage, leading to possible price spikes within five to ten years. Even if there are no physical shortages, the paper barrel market traditionally gets nervous when spare capacity falls, which means it could impose a 'fear premium' on oil prices.

Obviously, the future of crude prices does matter; and this could well disrupt the consensus forecast discussed in Section 3. When OPEC decided not to cut production in November 2014, the crude price was in effect launched onto the competitive market for the first time since 1928. The result, as can be seen from Figure 9, has been a collapse in price, due to serious oversupply leading to a record increase in oil inventories.

A key factor here is the level of ceiling and floor prices. The floor price is the short-run marginal cost (the variable cost) of the highest-cost producer. Leaving aside Canadian oil sands, which are too small to make a difference globally, it is US tight oil production that has the highest costs and therefore determines the floor price. The current cost of US tight oil production is not known for sure because the technology is constantly improving, allowing for cost reduction as a result of improved efficiency. However, putting it at around US$25–30 per barrel is not unreasonable.

The ceiling price is currently set by the 'fracklog'. This refers to the large number of wells in the US that have been drilled but not completed. They were drilled because the terms of their leases required drilling but they were not fracked because prices were too low. Since the end of May 2016, oil prices have shown signs of recovery. This has been partly because of supply disruptions caused by one-off events,[23] but also because of signs that the Saudi strategy is finally working as inventories fall and oil supplies tighten. However, as prices rise—probably when they reach between US$50 and US$60—these wells will be completed and new supply will quickly enter the market, relieving any signs of shortage and cutting off further price rises.

All this suggests that, in the absence of any major geopolitical event, oil prices will remain below US$60–70 for a number of years.

4.4 Climate change policies[24]

Another area where the consensus energy forecasts may be misguided lies in the aftermath of COP21. The Paris Agreement created a legally binding framework due to come into force in 2020, once the 55 countries accounting for over 55 per cent of global emissions have acceded to it. The agreement includes three long-term goals: (i) to limit 'the increase in the global average temperature to well below 2°C above pre-industrial levels'; (ii) 'to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels'; and (iii) to achieve 'a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century'. In pursuit of these goals, parties are obliged to submit 'intended nationally determined

[23] Nigerian production has been reduced as a result of political disruptions; some 1 mn b/d has been lost as a result of the Canadian forest fires; and Libyan production continues to face politically induced problems.

[24] This section relies heavily on Stevens (2016).

contributions' (INDCs), setting out their pledges for climate action, and to review these every five years.

Current estimates are that the collective impact of the INDCs submitted, as of 1 October 2015, which cover 146 countries, will have a 50 per cent probability of limiting the forecast global temperature rise to 2.7 °C by 2100, with a range of 2.2 °C to 3.4 °C. Subsequent submissions should take the total number of INDCs to 160, covering 187 countries. They would slow global emissions growth in the period 2010–2030 by approximately one-third in comparison with 1990–2010. To increase the likelihood of maintaining global warming below 2 °C over the 21st century (with CO_2-equivalent concentrations in the atmosphere in 2100 of about 450 parts per million or less) would mean a global reduction of 40–70 per cent of greenhouse gas emissions by 2050, which would require much deeper emissions cuts than most countries are planning. To address the gap between current action and what is necessary to stay below 2 °C, a 'facilitative dialogue' will be held in 2018 to give parties the opportunity to confirm or update their INDCs when the agreement becomes effective in 2020. The first formal review will begin in 2023, leading to new INDCs.

It is entirely understandable that the implications of this new and major global agenda for the energy forecasts described in Section 3 are far from clear. Much will depend upon the extent to which the INDCs compete with each other. This not only will affect total energy consumption but, above all, will determine the likely future energy mix. The debate about unburnable carbon is already well under way (Helm 2015; McGlade and Ekins 2015; Stevens 2016) but its outcome is uncertain, as are its implications for future energy consumption.

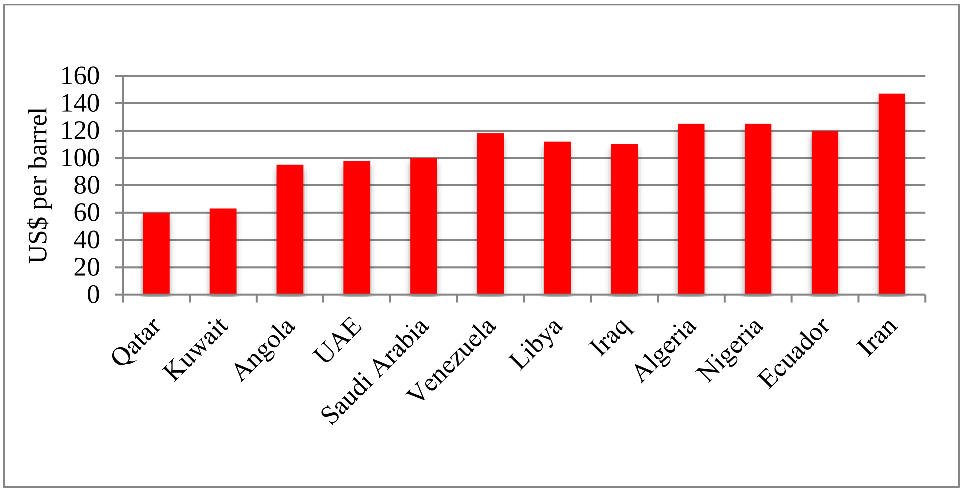
5 Drivers of future trends: how geopolitics may derail the conventional views of the future

This paper has so far reviewed the extremely challenging global economic context in which policy decisions by the established and newer developing country oil and gas producers need to be made.[25] It is a clear reminder of the inherent economic challenges of engaging with the global oil and gas markets. However, those challenges do not end with the various economic and technological arguments. In addition, all oil and gas producers need to frame their decisions in the light of a volatile and changing global political economy. Hence this section assesses some of the main features of the current geopolitics of oil and gas, especially in the Middle East.

Obviously, there is a long list of possible events that could derail the forecasts in terms of their impact on supply and expectations. However, two areas of uncertainty dominate. These are the impact of the current low prices and the parlous state of the Middle East.

[25] Other papers prepared under the project on 'Extractives for development (E4D)' examine various components of those policy choices in greater detail.

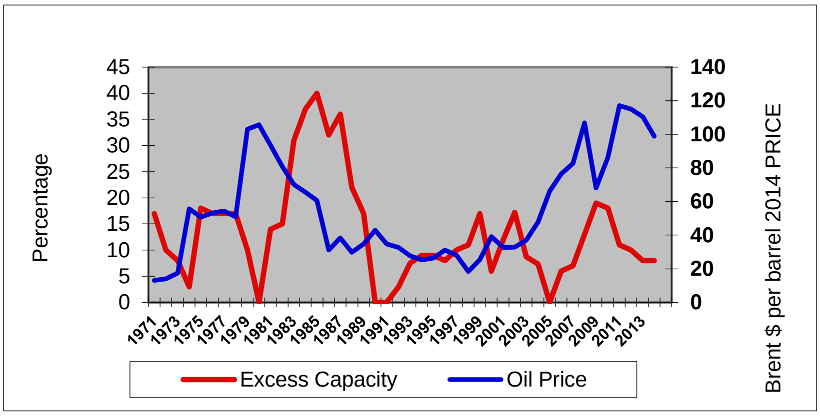
Figure 18: OPEC median budgetary break-even price, 2014



Source: Ali Aissaoui (2014).

Figure 18 illustrates estimates of the budgetary break-even oil prices for OPEC members in the summer of 2014, i.e. shortly before the oil price collapse.[26] The weighted average for OPEC was US$102 per barrel. Given the much lower prices experienced since the start of 2015, many countries face serious budgetary constraints. Some countries (largely Saudi Arabia, Kuwait, UAE, and Qatar) have accumulated financial cushions. However, the rest had little protection, which means that their governments are now struggling to find the revenues necessary to buy off the sort of domestic political dissent that triggered the Arab Uprisings at the start of 2011. Many producers face serious political challenges, which in some cases—such as Venezuela and Nigeria—threaten the very existence of the state. This could easily affect their future ability to supply global markets. Such geopolitical disruptions in turn could well frighten the paper barrel markets and lead to higher prices. In this context a key question is how far Saudi Arabia—as the dominant global producer—will be willing to maintain spare crude oil-producing capacity.

Figure 19: OPEC spare capacity and oil prices, 1971–2014



Note: Excess capacity refers to capacity that can be produced very quickly.

Source: Oil price, BP (2016b); excess capacity, author's estimates.

[26] The budgetary break-even price is the oil price that would provide sufficient revenue to balance the national budget given expenditure plans and other sources of revenue.

As Figure 19 illustrates, the level of spare capacity to produce crude oil has been a crucial part of the oil market story and goes a long way to explaining the historical pattern of prices. When spare capacity gets close to zero, the market becomes highly vulnerable to price spikes. Since the summer of 1985, a central pillar of Saudi Arabia's oil policy has been to maintain spare capacity (of the order of 2–2.5 million barrels per day) in order to calm markets in the event of geopolitical supply disruptions.[27] Since the summer of 2014, Saudi policy has changed, moving away from administering and controlling the market to maintaining market share. This is in an effort to force the supply curve to go the right way for the first time since 1928: the low-cost producers supplying first and increasingly higher-cost producers supplying the residual.[28] What is currently uncertain is how far Saudi Arabia, with its new oil policy, will want to maintain or succeed in maintaining spare capacity, thereby protecting the market from geopolitical outages.[29]

The second major geopolitical issue that could affect the energy forecasts is the state of the Middle East and North Africa region (MENA). For reasons too complex to explain in this short paper, the Middle East and North Africa are in turmoil. It is necessary to go back to 1918—the end of World War I and the collapse of the Ottoman Empire—to find a period of similar uncertainty in that region.

One dimension of this uncertainty is the deterioration of relations between Saudi Arabia and Iran. Iran, coming out of a sanctions regime following the Joint Comprehensive Plan of Action (JCPOA) agreement on its nuclear programme in 2015, is now determined to restore its crude exports to pre-sanctions levels and beyond, in direct conflict with Saudi Arabia's determination not to cede market share. Indeed, it was this development—combined with a general perception of 'Shi'a encirclement' within the Kingdom in 2015, President Assad in Syria appearing to secure his position, Iran developing a détente with the United States, and the Houthi involvement in Yemen growing—that caused Saudi Arabia to cease its swing role and begin instead to protect its own market share. This sense of threat, real or otherwise, also encouraged the new regime of King Salman, fronted by his son Mohammad, to adopt a more aggressive foreign policy.

One consequence of these geopolitical developments has been that accommodating Iran's return to the oil market (which initially appeared acceptable to Saudi Arabia) is no longer an option. The agreement at the Doha meeting between OPEC and non-OPEC producers on 17 April 2016 to cap production but exclude Iran from such restrictions (which had in fact been made weeks beforehand) was suddenly no longer acceptable to Saudi Arabia. On the morning of the actual meeting it was announced that without Iranian compliance with the decision to cap production there could be no deal.

This is dangerous politically for the MENA region. Iran is already deeply frustrated by what it sees (with some justification) as the US's reneging on the JCPOA nuclear deal, insofar as the US Office of Foreign Assets Control has threatened to impose heavy fines on banks operating in the US (which covers virtually all major banks, American or otherwise) and continued to impose sanctions

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[27] As can be seen from Figure 19, when the Iraqi invasion of Kuwait caused a loss of almost 6 mn b/d as a result of UN-imposed sanctions, the increase in price was greatly muted by Saudi Arabia's ability to replace the lost crude from its own spare capacity.

[28] It was in 1928 that the major oil companies met at Achnacarry Castle in Scotland and formulated the 'As-Is' Agreement, which began the process of administering the oil market and controlling prices. This system remained in place until the 1970s, when OPEC took over the control of the market (Stevens 2012).

[29] Although the official line from Saudi Aramco is that maintenance of spare capacity is a political decision, in reality a good business case can be made for carrying spare capacity. Because it tends to be utilized when prices have spiked as a result of political turmoil, the supply can be sold at these higher prices, thereby raising revenue.

on any company dealing with the Iranian Revolutionary Guard Corps (IRGC). This is especially significant, since the IRGC could be covertly involved in almost any Iranian business operation. If Iran's frustration is not assuaged, might it jump before it is pushed and abrogate the JCPOA nuclear deal? Given its ability to cause significant mischief in the region, this could well prove to be another factor serving to derail many of the energy forecasts that have determined the current consensus view on the future of oil and gas markets.

6 Conclusions

The future of the oil and gas markets looks very different from the picture the experiences of the last 15 years have led us to expect. Thus, many oil and gas producers, especially in the developing world, need to adjust their expectations and adapt their policy options. Expectations of great wealth at the top of the commodity super-cycle are no longer realistic. There are many reasons to think that oil and gas will not be produced at the levels expected by many low- and middle-income countries and that, even if production does not disappoint, the consequent revenues to their governments will prove illusory. At the very least, this will require them to rethink how to manage the expectations of their peoples, which have been inflated to unrealistic levels.

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Appendix A: The nature of energy consumption decisions

Energy consumption is the result of a three-stage decision by the energy consumer. Energy demand is a derived demand. Nobody wants a bag of coal or a barrel of oil. What they require are energy services—light, heat, and work. To secure these it is necessary to input the primary energy into an energy-using appliance that converts the useable energy into useful energy. The key to energy consumption is therefore the energy-using appliance stock—things such as boilers and cars. The first stage in the decision-making process is whether to buy the energy-using appliance. While the price of the appliance matters, of greater importance is the buyer's income. This becomes a self-feeding process. The higher the income, the more appliances are bought, and the more appliances are bought, the higher the output and hence the income.

The next question, once the decision to buy the appliance has been taken, is what type of appliance to buy. There are two options. The first relates to the type of fuel used by the appliance. For example, raising steam under a boiler can be done using a variety of fuels. However, the choice may be technically constrained. Putting coal into a Boeing 747 will not get it off the runway. The second choice concerns efficiency. Fuel-efficient appliances tend to be more expensive, so there is a trade-off between a higher purchase price and the saving on the fuel bill. Once these first two decisions have been taken, the stock of appliances is fixed in the short term. It can take a long time to change this—either by turning over the stock of appliances[30] or by retrofitting.

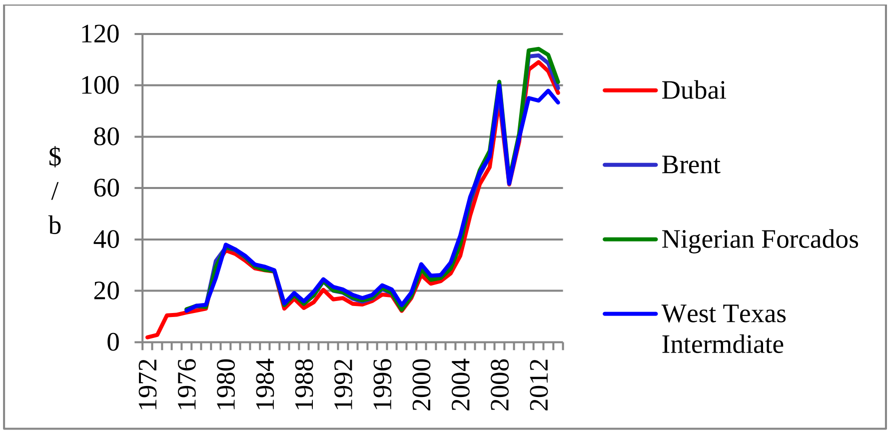
The final decision that determines energy consumption is the capacity utilization of the appliance stock: How many miles are to be driven? How high or low is the thermostat to be set? In the short run, given the fixed appliance stock, there is limited scope for discretion. Some under-utilization of the stock is possible and might be viewed as conservation, i.e. doing the same thing with less energy, which is desirable. However, real under-utilization could be seen as deprivation, which is undesirable. Thus the slowing in energy consumption seen in OECD countries (Figure 1) is the eventual result of the oil shocks of the 1970s working through the system. The peak reflects the fact that appliance efficiency has outstripped the increase in the stock of appliances. By contrast, the dramatic rise in consumption in non-OECD countries is the result of rising incomes increasing the stock of appliances—as well as of highly subsidized energy prices in many non-OECD countries, as explained elsewhere in this paper, which meant that (i) there was no incentive to buy more efficient appliances and (ii) capacity utilization was not constrained.

[30] For example, it would take over 15 years to change completely the stock of cars (known as the car parc [sic]), and even longer to refurbish the stock of buildings

Appendix B: Oil and gas pricing: regional vs. global markets

Changes in the levels of international trade affect the balance between global and regional markets and the patterns seen in these markets as between oil and gas. This is reflected in the differences in regional prices for gas and oil, as illustrated in Figures B1 and B2.

Figure B1: Regional oil prices, 1972–2014

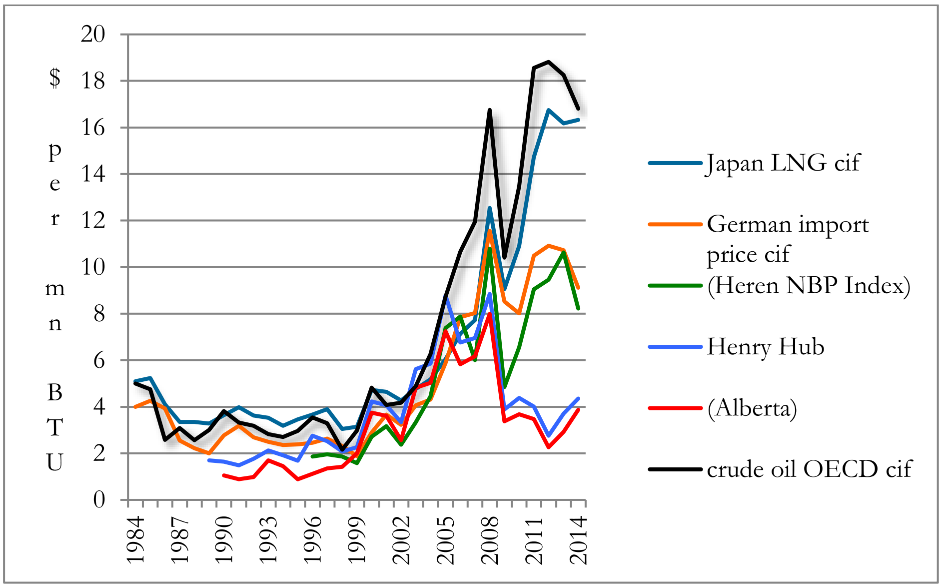


Source: BP (2016b).

Because oil is cheap to transport, only small differences in regional prices are needed to induce physical arbitrage, which causes regional disparities in price to converge. The break in this pattern seen after 2010 arose because the shale technology revolution in the US led to a significant increase in US tight oil production in a context where oil exports were not allowed.

By contrast, gas is expensive to transport and so very large price differentials are required at a regional level before physical arbitrage generates convergence—compounded by the contractual link between gas prices and oil prices—as can be clearly seen from Figure B2.

Figure B2: Regional gas prices, 1984–2014



Source: BP (2016b).

In project supply markets[31], gas prices are directly linked to oil prices simply because there is no identifiable benchmark price. This has been relevant for both Asia and mainland Europe. In Europe, the link has increasingly been broken and pricing is determined by gas-to-gas competition in various gas trading hubs. However, it remains the norm in Asia, although even there gas sales contracts are showing signs of moving away from the oil price link (Stern 2016). Regional gas markets have also been strongly affected by the shale gas revolution in the US, which goes some way towards explaining the increasing disconnection between North American prices (Henry Hub and Alberta) seen in Figure B2.

[31] There are two kinds of gas market. In a commodity supply market there are many gas transactions and there is a transparent 'gas price'. In a project supply market there are few gas transactions and there is little or no transparency on gas prices. Globally, until a few years ago, only North America and the UK were commodity supply markets; the rest of the world was a project supply market.