The Rapid Pivot to Gas

February 2020

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EXECUTIVE SUMMARY

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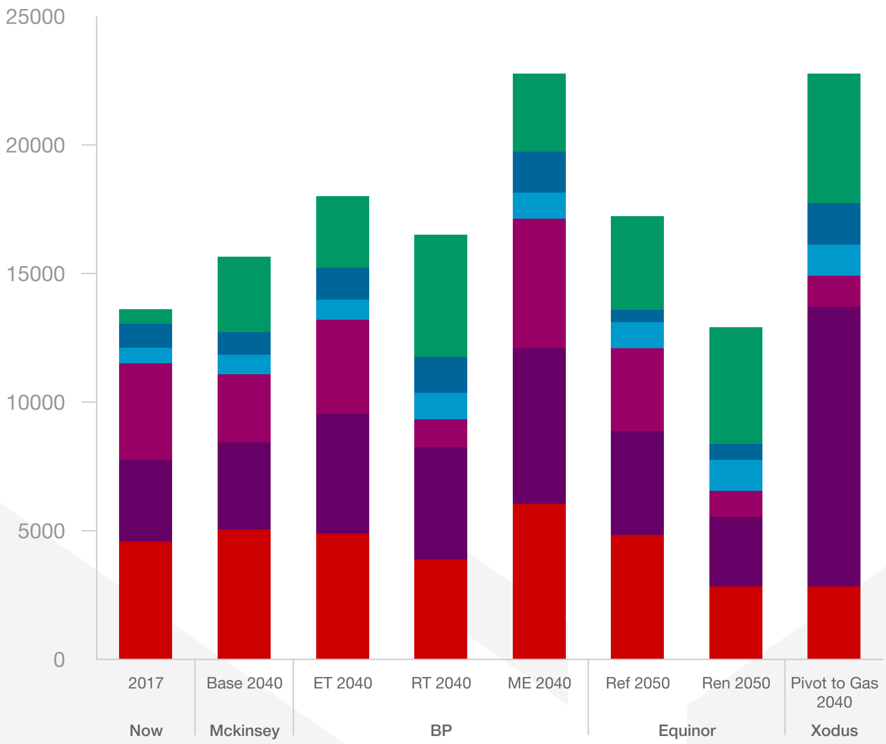
Multiple views of the future energy landscape have been provided recently – BP, McKinsey, IMF and Equinor, to name a few.

A common theme is that energy use could switch from petroleum liquids products to electrical energy quite rapidly. Much of the literature produced to date examines the impact of a primary energy supply that pivots away from oil and coal, and towards renewables to varying extents. We have reviewed the range of forecasts provided and concluded that a significant and rapid pivot to natural gas will be required, in addition to a huge growth in wind and solar power. This paper examines how this may take place, and the effect this would have on the E&P industry. We demonstrate that global energy demand will continue to increase, driven by economic growth in non-OECD countries, and that much of that increased demand will be fulfilled by natural gas.

Under this ‘pivot to gas’ scenario, approximately $20 trillion dollars would need to be spent on natural gas exploration and production over the next two decades. This scenario will require significant advancements in technology to use the gas responsibly, including capture and storage of the Carbon Dioxide produced (CCS). Even with the phasing out of coal and oil, and a rapid increase in renewables, Carbon Dioxide emissions would continue to increase until 2025 before starting to decline. In the short to medium term we envisage a continued increase in Liquified Natural Gas (LNG) related spending for liquefaction, Floating LNG, import terminals, and vessels. However, the long-term effect on the wider LNG market is less certain as more gas is consumed locally by the growing non-OECD economies. To date, although a pivot to gas is widely talked about, none of the major oil companies have significantly altered their ratio of gas vs oil produced. However, all acknowledge that this is required.



Total Global Energy Consumption
Mtoe / year

- *Renewables*
- *Hydro*
- *Nuclear*
- *Coal*
- *Gas*
- *Oil*

Note
‘Renewables’ includes biofuels which is mostly solid biofuels, also known as burning of wood in less developed societies. It is a matter of debate as to whether this is CO_2 neutral. The contribution of wind and solar to the ‘Renewables’ bar is a much smaller fraction.

INTRODUCTION

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2.1 Background

Much has been made of the world's primary energy transitions, from wood to coal to oil, interspersed with an aborted switch to nuclear, and now to natural gas as a waystation to renewables and perhaps hydrogen.

The drive for the current transition is the impact on climate from CO_2 emissions, rather than any immediate lack of oil or coal reserves. The pivot to gas will be a forced choice for want of an alternative that can provide cleaner energy at the volume required to sustain a growing world population with an increasing per capita energy demand. Energy efficiency can and will help, but absolute declines in energy demand are very rare and typically related to severe economic setbacks. The last such occurrence was around 2008-2010. It is important to be clear that electricity is not a primary energy source, electricity is generated from primary energy sources and is essentially a medium for distributing that energy.

2.2 Inertia

The problem with paradigm shifts in how we consume energy is that in reality, the present system means that significant inertia is embedded.

For many sectors of the economy, there is no simple switch from one energy source to another, as both installed production and consumption capacity cannot be dismantled or converted overnight. An example is the mooted change of central heating in UK homes from gas-fired boilers to electricity. Transitions may take decades and even then, historically it has been more about how the relative positions of energy sources vary in the entire complex, than about phasing out sources. There was a continuous growth of coal consumption during the rapid rise of oil. Phasing in of natural gas has so far not led to reduced oil consumption. Relatively speaking, changes have occurred. In absolute terms, everything just kept growing. The incentive to abandon entire industries and supply chains has not existed previously, and may not in the coming energy transition. While destroying an existing system and replacing with something new would be positive from a pure cash-flow accounting GDP perspective, it would be a drag on the global economy overall, with huge levels of debt required to finance it.

2.3 Scale

Another element easily overlooked in energy transition stories, is the issue of scale.

At each make-over of the primary energy sources driving our economic system, the scale of the transition has become much bigger than at the previous transition. Coal started to become dominant in the early 1900s, when total primary energy supply was around 1,100 million tonnes of oil equivalent each year (Mtoe/year). Total biomass made up around 530 Mtoe of that, and coal around 600 Mtoe. When oil moved to dominance in the 1970s, coal consumption had risen to 1,450 Mtoe/year, out of total primary energy supply of close to 5,700 Mtoe/year. Now that gas is to become dominant, oil consumption has risen to 4,400 Mtoe/year and total primary energy supply to 14,000 Mtoe/year. The numbers are simply mindboggling. What is even more impressive is that industry has actually delivered the capacity in relatively short time periods, typically a few decades.

The basic reality is that per capita energy consumption has been growing relentlessly for decades. In 1860, it is estimated that per capita consumption was around 0.5 Mtoe/year. By 1950 this had grown to nearly 1 Mtoe/year, and to 1.84 Mtoe/year currently. The only major reversals of the relentless growth have occurred during major wars and depressions, with 2009 being the latest example.

With the above in mind, we have developed our 'pivot to gas' view, laying out a plausible forecast for the next 20 years where the need for more cheap energy leads to a large increase in demand for natural gas. More so than most would anticipate.

METHODOLOGY

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3.1 Total Energy Use

There are two main drivers for more energy: a) there are more people on the planet, and b) increasing wealth.

The latest United Nations (UN) estimate of human population is 7.7 billion in 2019, up from 6.1 billion in 2000. The UN expects further growth to 9.2 billion by 2040. Most of the additional people will be in Africa and Asia, while Europe is projected to see its population fall.

Our projection of primary energy demand is based on these UN projections of the development of the human population and a trend extrapolation of per capita primary energy use. The trend extrapolation is split into OECD and non-OECD countries, reflecting the world's wealth disparity and propensity to consume. Over the past 25 years, on average non-OECD per capita primary energy consumption has grown at just over 2.0% annually. In the OECD, on average, per capita consumption has fallen by about 0.2% annually in the same period. These growth rates have been used to project future primary energy demand by region.

Under this projection, the absolute numbers increase from 1.3 Mtoe/capita in the non-OECD in 2018 to 2.0 Mtoe/capita in 2040. In the OECD, per capita consumption declines from 4.4 Mtoe/capita to 4.1 Mtoe/capita. This level for the OECD was last observed in the 1970s. Global average Mtoe/capita consumption grows from 1.8 to 2.35 Mtoe/capita by 2040. This is a direct consequence of the changing population mix. The UN projects the OECD population to grow from 1.3 billion people in 2018 to just short of 1.4 billion people in 2040, whereas the non-OECD population grows from 6.3 billion in 2018 to 7.8 billion in 2040.

Based on these numbers, the overall primary energy consumption will surge from 14,300 Mtoe/year in 2018 to 21,500 Mtoe/year in 2040. As the non-OECD countries becomes wealthier, enabled by increased access to energy, their consumption increases from 8,200 Mtoe/year to 15,800 Mtoe, whereas the OECD only increases marginally from 5,600 Mtoe/year to 5,700 Mtoe. The effects of the larger number of people in the non-OECD easily offsets the efforts undertaken in the OECD to become more efficient. To radically lower global consumption would therefore require a significant reduction in the already low energy demand per capita in non-OECD countries, which would in turn imply limited economic growth and therefore prosperity. Whether that is equitable for the people living in those countries is beyond the scope of this paper, but we consider that it is an unlikely outcome.

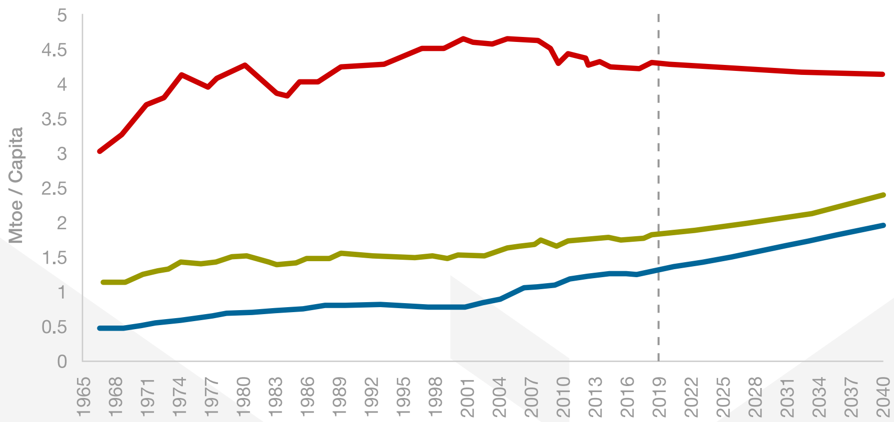

Figure 1
Per capita primary energy consumption, OECD, non-OECD, World, 1965-2040, Mtoe / year / capita

OECD
Non-OECD
World

Sources: BP, UN and Xodus for projections

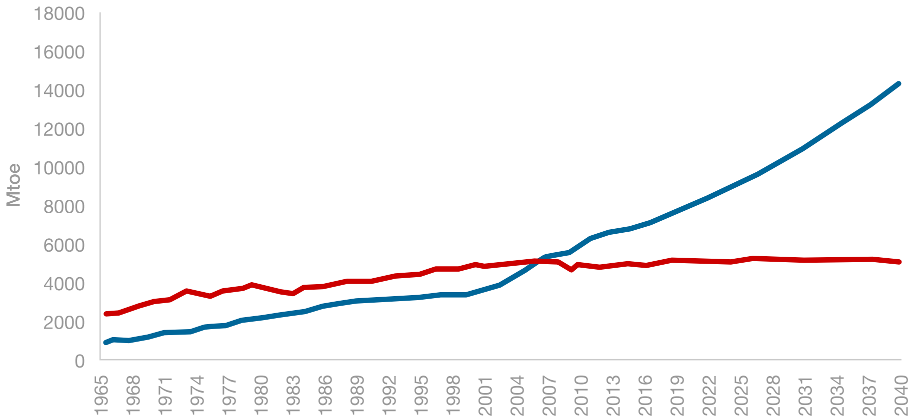

Figure 2
Primary energy consumption OECD and non-OECD, 1965-2040

OECD
Non-OECD

Sources: BP, UN and Xodus for projections

3.2 Energy Mix

The starting point for our projection of how a rapid pivot to gas might occur starts with a decline in coal consumption for environmental reasons, and an unprecedented reduction in oil (liquid hydrocarbons) consumption as transport and other major users rapidly convert to electricity produced from alternative primary sources of energy.

We postulate that conventional crude oil and coal could decline to 1,500 Mtoe/year and 1,200 Mtoe/year respectively by 2040. This is 56% and 68% below 2018 levels. Unconventional oil and other liquids such as NGL's are projected to increase over the entire period and reach 1,325 Mtoe/year. Nuclear energy is projected to increase by 2.5% per year, to reach 1,200 Mtoe/year, assuming no major change in policies and public perception take place. And even if there was a substantial move back to nuclear, then the time required to plan, approve, build and commission new nuclear stations will mean no significant change in nuclear supply over the next 20 years. The same applies to any breakthrough in nuclear fusion that may occur. Hydroelectricity is expected to continue to grow slowly and reach 1,585 Mtoe/year.

Aggressive growth rates have been assumed for renewables, in particular for wind and solar. In addition to sustained installation of capacity, the uptime and efficiency of new capacity is projected to keep improving for the next 20 years, so that net energy delivered per unit of capacity installed increases continuously. Solar is projected to reach 875 Mtoe/year and Wind 1,055 Mtoe/year, up from 62 Mtoe/year and 82 Mtoe/year in 2016 respectively.

Biofuels, solid and liquid, are projected to reach 1,780 Mtoe/year, up from 1,290 Mtoe/year in 2016. Note that solid biofuels are mostly the traditional burning of wood for cooking and heating in less developed societies.

We have assumed that natural gas supplies the difference between the total demand and the sum of other sources described above; the gap filler so to speak. Natural gas consumption is estimated to have been around 3,800 Mtoe/year in 2018. In this projection, consumption is set to grow 2.5 times by 2040 to some 10,000 Mtoe, accounting for 50% of all primary energy consumption and 73% of the fossil fuel component.

When thinking about sources of primary energy, it is not a question of either/or, it is a question of what can reach scale fast enough to meet continued demand growth.

Overall, our methodology can be summarised as:

1. Continued rapid growth in total primary energy demand
2. Rapid growth in Renewables (Wind and Solar)
3. Coal use will be minimised
4. Oil consumption will be minimised (in line with rapid electrification of land transport)
5. Nuclear and Hydroelectric will stay at approx. the same relative amount as now
6. Natural gas will need to grow to fill the gap

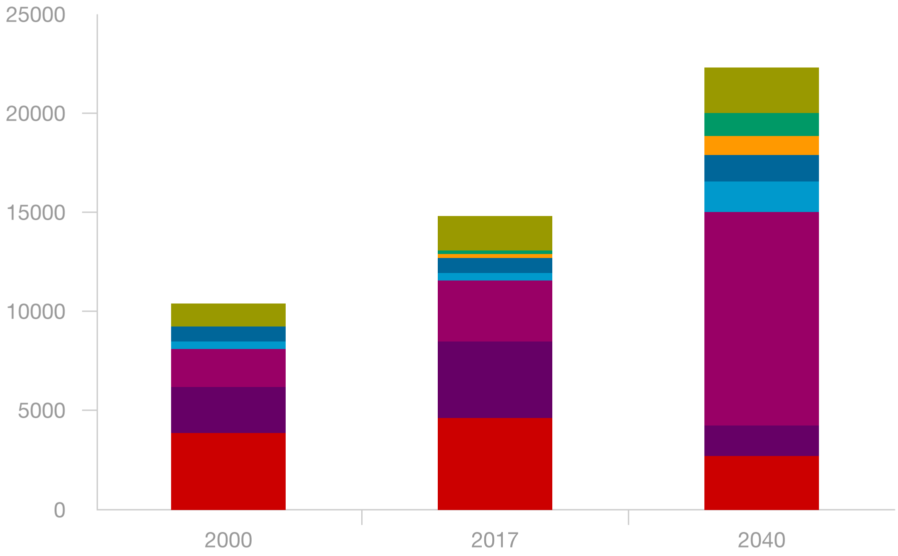

Figure 3

Primary energy supply by source type, 2000, 2017 and 2040, Mtoe / year

Sources: IEA, BP for historical and Xodus for projections

The overall share of natural gas rises to 50%, while coal drops to 6% and oil to 13%. Fossil fuels combined drop to 69%, down from 81% in 2017. Solar and Wind increase to 4% and 5% of total primary energy supply, up from 0.5% and 0.7% respectively in 2017.

Growing natural gas threefold in just over 20 years looks like an impossible task. But there are historical precedents regarding energy supply over the past 150-200 years. From the perspective of someone in 1945, the subsequent roll-out of the oil industry would have appeared equally as unlikely as the natural gas roll-out described here appears to us today. Yet, in just over 15 years, global oil production tripled from 350 Mtoe/year, and then tripled again from 1,000 Mtoe/year to 3,000 Mtoe/year between 1960 and the mid-1970s.

While the circumstances of the oil industry in the 1950s and 1960s are clearly different to the natural gas industry today, there is already a large natural gas industry in place today which provides a solid base for expansion, and recent years have shown that dramatic improvements in productivity per well can be made as new technologies are brought to bear.

Renewables, including wind and solar in particular, provide a considerable portion of new energy sources. The growth levels assumed by Xodus for these energy sources will also be a challenge. Their use is geared to power generation, and while substantial electrification is anticipated, other media for delivering energy are required by different industries. In addition, the nature of wind and solar means they are an intermittent energy source.

Back-up capacity from other energy sources remains a requirement until such time as electricity storage on a huge scale is possible. Insofar as existing back-up excess capacity exists, the marginal cost of maintaining that to support renewable energy generation will be moderate. However, if and when back-up capacity needs to be constructed specifically to support renewables, the costs should be integrally added to the renewables cost.

3.3 Energy Forecasts Comparisons

The overall energy demand we propose is higher than most scenarios envisage, but in agreement with the overall demand posited by BP in the 'More Energy' (ME) scenario in their 2019 outlook.

This gives a figure of 22,600 Mtoe/year, which is approximately 30% more than most of the scenarios described by a range of oil companies and agencies. The qualitative rationale for this higher figure is that the under-developed parts of the world will be moving towards what we might call a European middle-class standard of living and energy consumption. This process is already advanced in China and underway in India, but there remain parts of the world, notably sub-Saharan Africa, where the process has barely started.

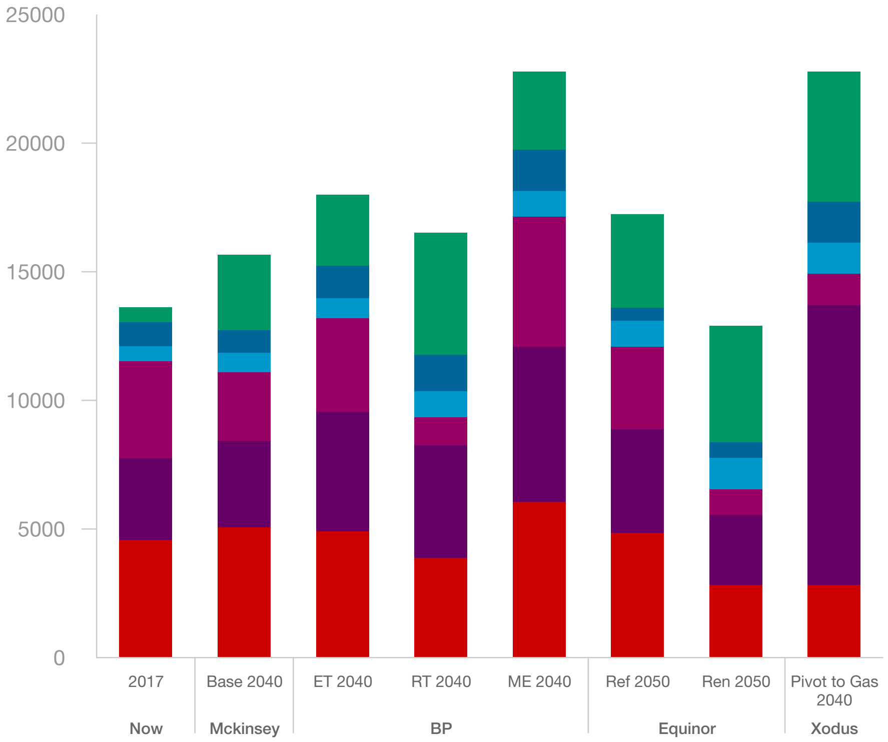

Figure 4

Comparison of energy outlooks

Total Global Energy Consumption (Mtoe / year)

Looking at some of the other forecasts, the McKinsey view assumes a rapid global electrification takes place leading to large efficiency gains and therefore lower total energy demand. Gas plays a small part with the current increase tapering off. Renewables increase substantially, although not as much as in our view. Oil demand is broadly a 'mid-case' compared to the other energy views provided.

The McKinsey view is similar to the BP 'Rapid Transition' view albeit the BP RT view assumes larger total energy demand, a larger role for gas and a much larger increase in renewables largely at the expense of coal. The BP 'Evolving Transition' (ET) represents BP's mid-case in terms of total energy demand in between the 'Rapid Transition' (RT) and 'More Energy' (ME) views.

Equinor provides forecasts up to 2050. The 'Renewal' (Ren) forecast is what needs to happen to limit global temperature increase to 2°C, assuming no technology implemented to scrub, capture and store CO_2, and would be viewed by most commentators as an unlikely scenario. It requires oil and coal demand to be now in decline, with gas peaking around 2030. The 'Reform' (Ref) view is akin to BP's 'Evolving Transition' scenario in terms of both motivation and macro-economic factors and indeed produces a not too dissimilar total energy demand and mix.

3.4 Gas Resource

Clearly our 'Pivot to Gas' view relies on sufficient gas being available, cheap and accessible. Gas production is generally considered to be without resource constraints at the global level.

According to the German Federal Institute for Geosciences and Natural Resources (BGR), cumulative historical gas production is about 120 Tcm, which is 13% of the current estimate of ultimately recoverable gas of 957 Tcm, including unconventional and undiscovered resource. These numbers are comparable with estimates from other organizations such as IEA, Cedigaz and BP. This global recoverable resource would take 54 years to deplete at current production levels. The regions with the highest remaining recoverable resource are Russia, the Middle East and Africa.

REGION	PROD (BCM)	CUM PROD (TCM)	RESERVES (TCM)	RESOURCES (TCM)	EUR (TCM)	REMAINING (TCM)	PRODUCED / RESOURCES	RESERVES / PROD (YRS)	ANNUAL DEPLETION
Europe	253	13	3	19	35	23	36%	12.7	8%
CIS	838	31	63	179	274	242	11%	75.5	1%
Africa	207	5	14	80	99	94	5%	69.5	1%
Middle East	629	9	79	56	145	135	6%	126.1	1%
Australasia	565	11	18	132	160	149	7%	31.1	3%
North America	960	44	11	113	168	124	26%	11.6	9%
Latin America	164	4	8	64	76	72	6%	46.7	2%
Total	3616	117	197	643	957	840	12%	54.4	2%

Table 1 – Gas production, reserves and resources (incl. yet to find), all sources (conventional, shale, tight, CBM), TCM
Source: BGR, 2017

Therefore, there are no immediate concerns about availability of natural gas, although significant exploration and development expense and effort will be required to convert all these resources to reserves. What is different though from earlier energy transitions, is that to all intents and purposes, global conventional oil production is plateauing.

Current global depletion of oil stands at over 35% of estimated recoverable resources (BGR, 2017). Oil consumption is also under attack from a political angle, making new oil investments riskier. Whatever is in the ground will ultimately matter less than the appetite for investment. Oil's demise is likely to be a combination of the economics of producing the remaining in-ground resources and the general desire to leave the oil era behind us. Notwithstanding these incentives, there will be prolonged and sustained liquids production. Likewise, coal is seen as a polluting fuel and its use is fiercely discouraged. While market movements may favour coal, regulation will hamper continued use.

Given that coal, oil and natural gas are currently the three main sources of primary energy, the pivot to gas takes place in a unique environment where the two key alternatives to natural gas are subject to stalling or falling demand. It is therefore not just demand growth that natural gas will have to satisfy, but also the reduction in supply of oil and coal.

Part of the replacement will come from renewable sources, such as wind and solar. But, despite the expected huge growth in these, they are unlikely to be able to plug the gaps of falling output and increasing demand by themselves. This is particularly the case while conventional capacity is required to step in when wind or solar are unable to produce electricity as a result of their intermittency.

IMPLICATIONS

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The following sections delve into some of the implications of this modelling for the E&P industry, and provide indications of how the E&P industry will need to adapt. Some of these will be explored in more detail in future papers by Xodus.

4.1 Capital Employed

During the 2000s, and up until 2014, exploration and production costs increased substantially as high oil prices allowed oil companies to invest.

Costs for exploration and development rose to over 25 USD/boe produced, double the costs in 2006. Following the crash in oil prices, there was a realisation by oil companies that cost inflation meant that project returns were not at a satisfactory level to achieve target ROCE, nor to withstand the lower oil prices. Thus, projects were delayed, reworked or cancelled altogether.

This reduced the level of activity and meant that service sector contractors were fighting over relatively few projects and so slashed prices in order to try and maintain activity. By 2018, the tide had turned, and costs had come down to similar levels as in 2006, at around 11-12 USD/boe produced. Looking at the costs of production alone, these jumped between 2006 and 2014, to 13 USD/boe produced. These costs have since come back down to 8 USD/boe in 2018.

The overcapacity and the low margins in the supply chain have not allowed for reinvestment, or equipment replacement. This combined with a large exit of the people and expertise required to manage projects foretells both equipment and people shortages in the future. Overcapacity in the oilfield service sector may be around for some time to come, and suppress E&D costs for longer. But it won't last forever, and it is unlikely that costs will be reduced much below the current level.

Based on this analysis of long-term and short-term trends, we have created a range of expected required funds to develop and produce the volumes of oil and gas in our primary energy 'pivot to gas' scenario. We use a low-end based on the average observed costs of 2017 and 2018 and apply those to our projection of oil and gas production. In addition, we increase these costs by 50% to reflect a jump back to tighter future service markets, which will increase pricing levels for the services. A 50% increase is then an approximation of another upwards service cycle we expect to, play out between 2020 and 2040.

The cost projection is applied to all oil and gas produced, as there is an ongoing need to replace declines in legacy production. Our approach is based on the average observed spending per boe produced, which includes both new and legacy production.

On this approach, total production costs for the period 2020-40 range from 14 trillion USD to 21 trillion USD, of which 45% is on legacy production. Exploration and development costs are estimated to range from 20 trillion USD to 30 trillion USD. Total required spending is then between 34 trillion USD and 51 trillion USD. These dollars will deliver 233,000 Mtoe, of which 105,000 Mtoe is legacy and 128,000 Mtoe is new oil and gas.

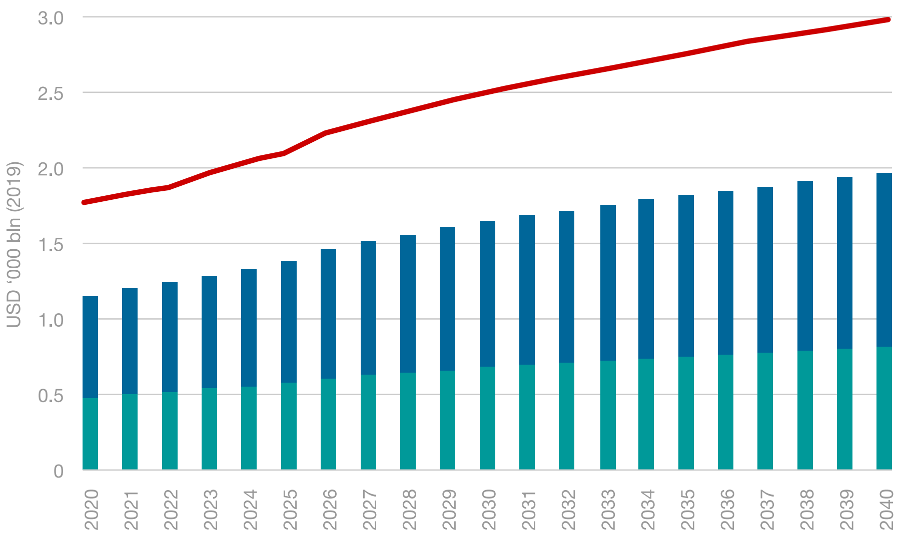

Figure 5

Forecast costs for E&P industry

Annual spending on oil & gas production

Operating cost at current rate
E&D spending at current rate
Total spend at 50% higher rate

4.2 LNG Market

Initially one might think that a large increase in demand for gas would be favourable for LNG. However, this is not necessarily the case once the following factors are considered.

The commerciality of previously 'stranded' gas fields, such as those offshore West Africa improve, thus requiring that either the local infrastructure is upgraded, and gas is consumed locally, or the FLNG option is widely adopted. In the short to medium term we envisage a continued increase in LNG-related spending (for liquefaction, FLNG, import terminals, and vessels). However, the long-term effect on the wider LNG market is less certain as more gas is consumed locally. International gas producers may well prefer to export with LNG based on the credit worthiness of international gas buyers, but as more gas is produced by local companies this pressure will reverse with preference being given to local markets.

A rise in local gas demand (e.g. in sub-Saharan Africa) would mean that less gas will be available for shipping to OECD markets. Also, the take up of renewables will not be evenly spread across the globe. It is likely that OECD countries will consume a relatively larger amount of renewable energy than non-OECD. Countries or regions will tend to disproportionally use the resources they have, i.e. gas in west Africa, wind in UK, solar in north Africa. The US will likely have a wide range of primary energy options available and markets could become localised within the US.

4.3 Carbon Dioxide Emissions

Burning such large amounts of gas will produce significant quantities of CO_2. To achieve anything close to the targets set out in the Paris Agreement, these volumes of gas will ultimately need to be captured and sequestered.

Depleted gas fields will be able to store some of this but there will still be large quantities that need to be stored in greenfield, and saline aquifer sites. It can be expected that over time, specific CO_2 produced per unit of energy from fossil fuels will fall. Cleaner technology will be used for new installations, retrofitting will take place in life extension programs and older facilities will be shut down. That implies that the remaining oil and coal that will be produced, will pollute less on a unit basis. As these policies and market effects take place, coal related unit CO_2 emissions drop 37% from 3.85 ton per ton of coal to 2.40, oil drops 15% from 2.54 to 2.18 and gas 8% from 2.19 to 2.01 by 2040.

Overall CO_2 emissions peak out by 2022 at over 34,000 million tonnes (MT) per year, before dropping slowly to 30,600 MT/year in 2040, or 7% below estimated 2018 emission levels. The average unit emission level including the substantial increase in renewables as well as hydro and nuclear will then have dropped 37% from an estimated 2.3 MT/Mtoe primary energy in 2018 to 1.43 MT/Mtoe in 2040. How much of the CO_2 produced can be sequestered and stored, and how the E&P industry can support that effort, is the subject of a follow up paper by Xodus.

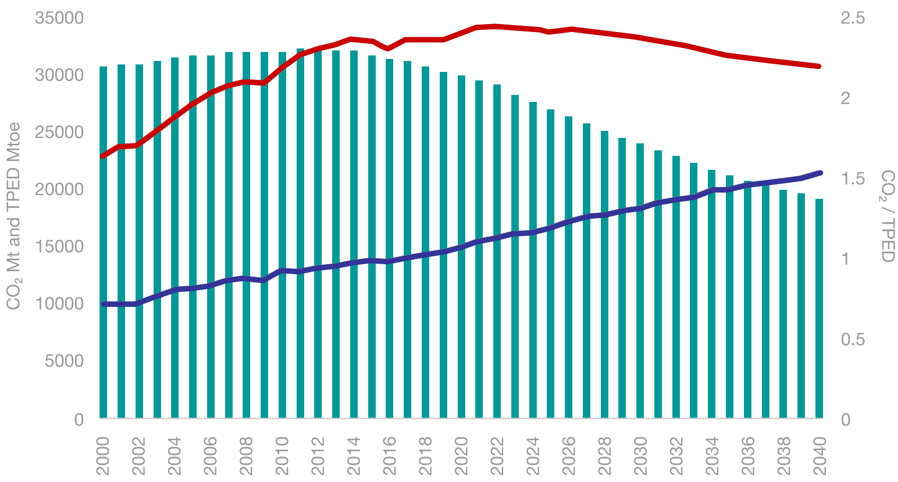

Figure 6

CO_2 emissions 2000-2040, Mt and total primary energy demand, Mtoe

- *CO_2 / Mtoe PED*
- *Total CO_2 emissions*
- *Total primary energy demand*

4.4 Image of Big Oil

The major international oil companies account for approximately 15% of oil production and 15% of global gas production.

They bear the brunt of the social and political pressure with respect to pivoting away from oil. The energy pivot has been a recurring theme for these companies since the 1970s, when nuclear was touted as the next big thing. It did not come to pass. The switch to gas has also been talked about for a long time. While the oil companies have been investing strongly in developing gas, their oil-gas production ratio has not increased since 2011. Of the major oil companies, only ENI has really pivoted, reaching 52% of total production from gas by 2018. Shell has not, despite acquiring BG, a gas-focused company.

While the talk by Big Oil is of a move to gas, the reserves data show that this pivot will require further substantial effort. The overall developed reserves base of the companies we looked at totals 95 billion boe at the end of 2018, according to SEC reporting by the companies. This number has not changed materially since 2002. Of this, gas now makes up 44%, down in both relative and absolute terms. The developed reserves total 63.5 billion boe, or 67%. That share is up from 60% in 2014. Developed gas reserves also stand at 67%. The depletion rate of liquids has dropped somewhat to 13% of developed reserves and 8.5% of total reserves, whereas gas depletion increased from 12 to 12.5% of developed reserves over the past years, and from 6 to 8.5% of total reserves. The recent ramp-up of gas production is therefore coming at the expense of existing reserves. The effort to pivot is underway, but sustained growth requires that resource replenishment will be required soon.

Big Oil is strongly investing in LNG and all of the majors talk about the need to increase their gas production. That need is identified for several reasons. The first is that oil output cannot easily be grown. The past 10-15 years have shown that despite spending large amounts of capital, overall liquids output has not grown at all. Now the tone is about oil portfolio high grading, which really is the same as selling off assets and focusing on the best of the remaining possibilities. The second is that gas allows growth in overall output, since gas demand is projected to grow much more strongly than oil demand, for reasons already discussed. And secondly, gas is presented as a transition fuel by Big Oil on the way to a low carbon society.

As TOTAL says, gas is the fuel that can replace oil, indicating some 10 mmb/d of oil demand to be replaced by gas between 2015 and 2040. And, like TOTAL and Equinor, BP mentions that the switch from coal to gas in power generation allows for halving of CO_2 emissions in that segment alone. Furthermore, gas is seen as the ideal complement to intermittent renewable energy, such as wind and solar, which require back-up capacity.

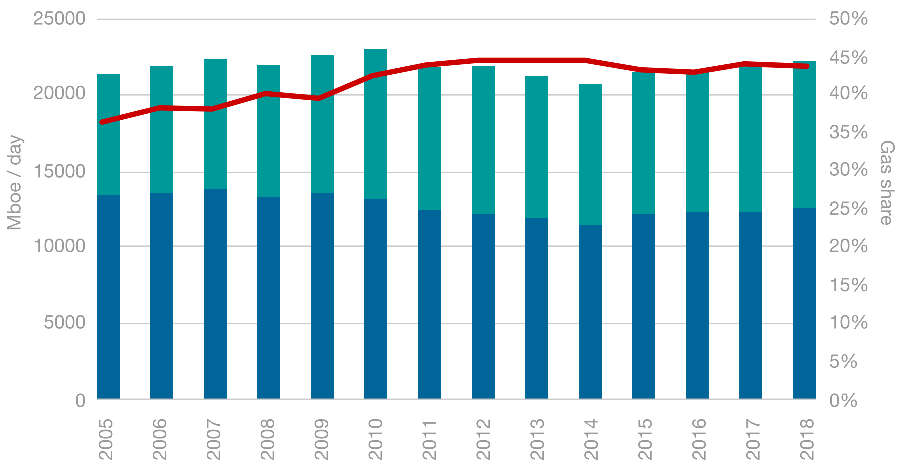

Figure 7

Major oil company oil and gas production, 2005-2018, Mboe/d

- *Liquids*
- *Gas*
- *Gas Share*

Source: Oil company filings (XOM, CVX, COP, RDS, BP, TOT, ENI, EQN)

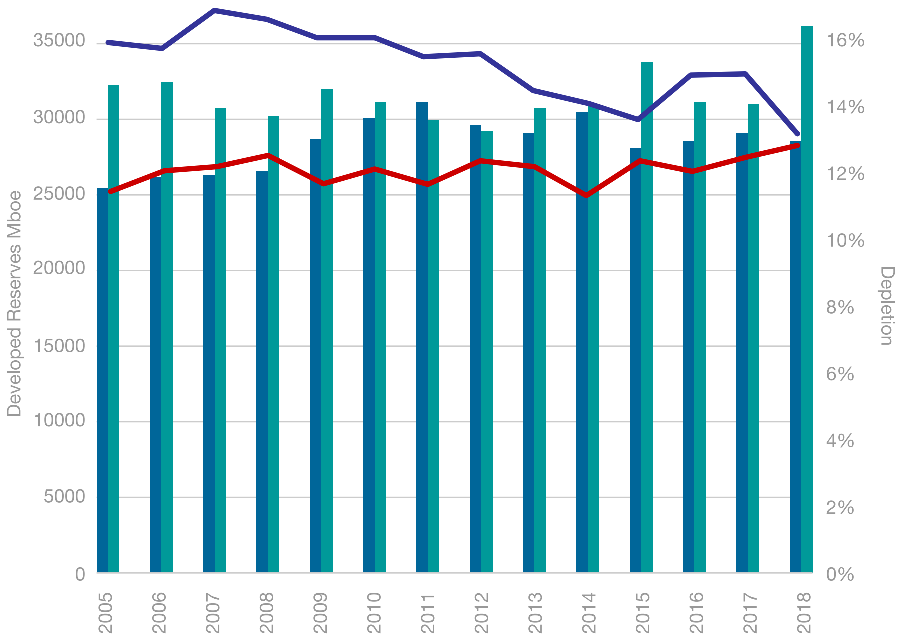

Figure 8

Major oil companies hydrocarbon reserves and depletion, Mboe, 2005-2018

- *Developed Gas Reserves*
- *Developed Liquids Reserves*
- *Gas Depletion*
- *Liquids Depletion*

Source: Oil company filings (XOM, CVX, COP, RDS, BP, TOT, ENI, EQN)

Although it is to the advantage of oil companies if gas becomes the dominant primary energy source, over coal for example, stakeholder pressure is strong. Both large shareholders and NGOs are driving the companies to pay more than lip service to changing demands from society. The companies are demonstrating how they are decarbonising and greening their part of the value chain. Shell and TOTAL indicate that although they only control 15% of the value chain, their target is to be CO_2 neutral by 2030. The plan is to achieve that by making more use of renewables, reducing waste and using carbon sinks, such as CCS.

Big Oil is undertaking substantial investments in renewables and technology, including biofuels, batteries, wind turbines, solar and even nuclear fusion (ENI with MIT). But the interesting element that provides clearer evidence that this time, the pivot is imminent, if not underway, is the fact that the oil companies have included climate change into their risk management. Now, decarbonisation is considered a way to manage company risks. This approach makes the pivot an embedded feature of the business, and natural gas enables the companies to remain at the forefront of energy supply in the future.

CONCLUSION

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Energy demand will increase significantly over the next 20 years, driven by growth in primary energy per capita and population in non-OECD countries.

In order to grow their economies and generate wealth, these countries will need to intensify their development towards energy prosperity that the Western world began over 200 years ago. Renewables will help reduce the fossil fuel intensity of this growth, but the majority will need to come from fossil fuels. Natural gas can provide ideal support for electrification with high energy density, wide availability, affordability and being 'cleaner' than oil or coal. Gas therefore should be the likely energy source to fulfil this increase in demand. Carbon Dioxide emissions produced from burning this natural gas will increase and in order to even get close to some of the Paris Agreement targets, these emissions will need to be stored via CCS (or similar) technologies.

While the mix of primary energy sources in our 'pivot to gas' view is one of many possible scenarios, we believe a large increase in overall primary energy demand forecast is highly likely. To meet this, there will need to be significant growth in the supply of natural gas. Whether this is double or treble current levels is up for debate, but the requirement for the E&P industry to adjust to 'more gas' is not.

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6

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GLOSSARY

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Bcm	Billion cubic metres
BGR	German Federal Institute for Geosciences and Natural Resources
boe	Barrels of oil equivalent
CBM	Coal Bed Methane
CCS	Carbon Capture and Storage
CIS	Commonwealth of Independent States
E&D	Exploration and Development
E&P	Exploration and Production
ET	Evolving Transition
EUR	Expected Ultimate Recovery
FLNG	Floating Liquified Natural Gas
GDP	Gross Domestic Product
IMF	International Monetary Fund
LNG	Liquified Natural Gas
ME	More Energy
MIT	Massachusetts Institute of Technology
MT	Million Tonnes (of CO_2)
Mtoe	Million tonnes of oil equivalent
NGL	Natural Gas Liquids
NGO	Non-Governmental Organisations
OECD	Organisation for Economic Co-operation and Development
Ref	Reform
Ren	Renewal
ROCE	Return on Capital Employed
RT	Rapid Transition
Tcm	Trillion cubic meters
UN	United Nations