THE CASE FOR SHALE AND TIGHT GAS

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Malcolm Brinded is Executive Director of the Upstream International business.

He joined Shell after graduating in engineering from Cambridge University and has worked for Shell companies in Brunei, the Netherlands, Oman and the United Kingdom. In 1998 he became Managing Director of Shell UK Exploration and Production and from 1999 until 2002 he was Shell Country Chairman in the UK.

Malcolm has been a member of the Royal Dutch Shell plc Board (and its predecessors) since 2002. Prior to his current role, he was Executive Director in charge of Exploration & Production.

Malcolm is a Fellow of the Institutions of Civil and Mechanical Engineers and of the Royal Academy of Engineering. He is a member of the Nigerian President's Honorary International Investor Council and a Trustee of the Emirates Foundation. He was appointed a Business Ambassador by the UK Prime Minister in October 2010.

He is also the Chairman of the Shell Foundation and in 2010 he joined the Network Rail Board as a Non-executive Director. In 2002 he was appointed CBE for services to the UK oil and gas industry. In July 2011, His Majesty the Sultan of Brunei awarded him the title of Dato Seri Laila Jasa in recognition of his services to the state of Brunei.

Personal

Malcolm, a British national, was born in 1953. He is married to Carola and has three sons.

In this speech, Malcolm Brinded, Executive Director of Upstream International at Royal Dutch Shell, makes the case for the tight and shale gas revolution as a powerful force for good. By displacing coal-fired power, natural gas is the quickest and cheapest way to cut emissions of CO_2 and harmful local pollutants in the power sector. But given mounting public concern about the safety and environmental impact of tight gas, Malcolm also argues that the industry must maintain the very highest operational and environmental standards. And he recommends the implementation of strict and well-targeted regulation governing the production of these gas sources.

Introduction

It's vital that the UK has a well-informed and balanced discussion about tight gas – one based on hard evidence and rigorous analysis, rather than speculation. And there can be no more appropriate place to conduct such a debate than the Foundation for Science and Technology.

This evening, I'll make the case for the tight gas revolution as a powerful force for good.

In some ways, this case is remarkably straightforward. The gas supply revolution is an opportunity to meet surging demand for energy – while safeguarding the environment for future generations.

That's because natural gas offers the fastest and cheapest route to reducing CO2 emissions in the global power sector by addressing the threat of coal-fired power.

So put simply: the larger the world's natural gas supplies, the more quickly and economically we can displace coal-fired power.

Nevertheless, public anxiety about the safety and environmental impact of tight gas continues to mount.

Now, there can be no doubt that these areas of concern merit our fullest and most careful attention, whether as industry representatives, policy-makers or scientists.

But it's also true that the oil and gas industry has been too hesitant to engage with the public about these matters, leaving the field clear for a number of misconceptions to take root; misconceptions that form a major part of the case against tight gas.

So this evening I will argue that the industry should do more to understand local community concerns and where possible ensure that rigorous operational and environmental standards are put in place by <u>all</u> players in the sector. And I will make the case for tough and well-targeted regulation.

But I will also try to set the record straight in a number of areas where the facts have been distorted by misinformation or speculation.

The energy challenge

By way of background, tight gas, shale gas and coal bed methane are all gas deposits trapped in very tight or impermeable rock. Only ten years ago, the industry considered them too difficult and costly to access. But there has been huge progress in drilling and fracturing – or "fracking" - the rock to release this gas, so tapping these resources profitably, as well as safely.

As a result, North America now has more than a century of supplies at current consumption rates, just a few years after it was feared that long-term production decline had set in. Just look at the change in outlook since 2005.

Worldwide recoverable gas resources are now estimated as being equal to 250 years of current production, of which roughly half is tight gas, shale gas and coal bed methane. And many countries outside of the US, including

China, are now moving to produce their tight gas resources. Europe, too, has its share of these gas deposits, but it will be some years before they are produced on any significant commercial scale.

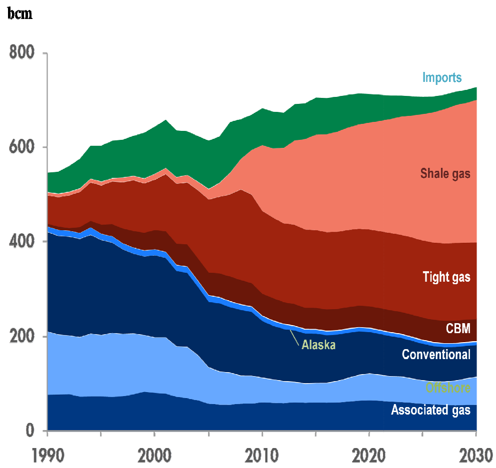

Figure 1 – US tight gas revolution: dramatic impact on US gas production

So why does all this matter?

At Shell, we think that global energy demand is likely to double in the first half of the century, driven by a rising global population and strong growth in the emerging economies.

In these economies, disposable incomes are rising fast, elevating millions of people into the ranks of the consuming or "middle" classes. For example, McKinsey estimates that the Chinese middle class will expand from less than 30% of China's 190 million urban households today to 75% of some 370 million urban households in 2025. In other words, a five-fold increase overall.

With higher living standards comes rising energy use, as people buy their first washing machines, fridges, cars, computers and all the other staples of everyday life we take for granted.

Indeed, the human story of this rising energy use is often forgotten. But it is lifting billions of people out of real energy poverty, in a world where some 1.4 billion people still lack access to electricity.

And we face difficulties closer to home. This summer, the Department for Energy and Climate Change estimated that some 5.5 million households in the UK were fuel poor in 2009, a rise of 1 million compared to 2008.

Supplying the world's rising energy needs will be extremely tough. The world will need to invest heavily in <u>all</u> energy sources from oil, gas and nuclear to wind, biofuels and solar.

In fact, the International Energy Agency estimates that the world will need to invest some $38 trillion to meet projected demand in the period to 2035 ($9.5 trillion in natural gas). That's around $30 billion a week, or $3 million every minute.

Over the same period, the world must tackle its CO_2 emissions. According to the consensus of climate scientists the atmospheric concentration of CO_2 should be limited to 450ppm to avoid the worst consequences of climate change. It's estimated that it has now passed the 390ppm mark, and continues to rise at some 2ppm every year.

The stark reality is that the world will probably overshoot the 450ppm target. So we must limit the extent to which it does so, while preparing for the likely consequences of climate change.

At Shell, we think that by 2050, renewable energy sources could supply as much as 30% of the world's energy – up from 13% today. And that would represent remarkable progress, given the enormous financial and technical scale-up challenges facing new energy sources.

To put this in perspective, in the case of wind the world would need another 1 million turbines covering an area nearly the size of France in order to reach just 10% of global electricity generated by 2030, (or just under 2% of total primary energy). That means expanding the number of turbines manufactured annually from around 22,000 today to 120,000 by 2030.

"…a more sustainable energy system will be one in which cleaner fossil fuels, as well as renewable sources, meet a growing share of demand."

This begins to explain why fossil fuels are still likely to supply more than 60% of global energy in 2050, with nuclear accounting for the remainder.

So a more sustainable energy system will be one in which cleaner fossil fuels, as well as renewable sources, meet a growing share of demand.

The case for natural gas

Against this backdrop, the case for gas is clear.

Displacing coal-fired power with natural gas is the fastest and cheapest route to CO_2 emissions reductions in the global power sector over the next 20-plus years.

Last year, coal was responsible for as much as 44% of energy-related CO_2 emissions, more than any other fuel. And in the run up to 2020, the incremental increase in emissions from coal-fired power in India and China alone is expected to be roughly double the increase from the entire global transport sector.

Natural gas is the fastest way to address these emissions because modern gas plants emit half the CO_2 emissions of new coal plants, and up to 70% less CO_2 than the old steam turbine coal plants, of which there are still hundreds in Asia, Europe and the US.

And gas-fired power is faster and much less costly to install than any other source of electricity. It requires:

- less than half the capital cost of coal per MWH;
- one-fifth the cost of nuclear;
- less than 15% the cost of onshore wind;
- and less than 10% of offshore wind.

As well as CO_2, coal-fired power also releases large quantities of damaging local pollutants. And natural gas brings immediate benefits here, too.

Analysis carried out by various organisations, including the US National Energy Technology Laboratory, confirms that a combined cycle gas plant emits negligible particulates. And compared with a supercritical pulverized coal plant emits:

- Around 20 to 40 times less SO_2
- And almost 10 times less NO_x

Last year, a report published by the US National Academies examined the negative effects of these emissions from 400 coal-fired plants (which represented 95% of the US's coal fired power capacity in 2005). Taking into account their impact on human health, crops and other areas, they estimated that their aggregate societal costs were an enormous $62 billion.

Gas as a transport fuel

The potential of natural gas as a cleaner transport fuel is also coming into sharper focus.

Over the longer-term, gas can provide a cleaner source of electricity than coal for the world's growing fleet of electric vehicles. That would ease many countries' need for imported oil, especially in Asia.

There are also direct applications for gas in transport. One is Liquefied Natural Gas, which can be used to fuel heavy vehicles, such as trucks, ships, barges and trains. It's a smart way to reduce local emissions of sulphur oxides and particulates. And can also help to tackle overall greenhouse emissions, depending on where and how it is used.

For example, we are preparing to make LNG available next year to heavy truck fleet operators along western Canada's busiest truck route, from Calgary to Edmonton. Drawing on local west Canadian natural gas to produce the LNG, we think that fleets could see a reduction in greenhouse gas emissions of up to 19% on a well-to-wheels basis.

And we're optimistic about the potential for LNG as a competitive alternative to diesel in several such

> "…gas-fired power is faster and much less costly to install than any other source of electricity."

applications in North America and elsewhere.

Gas as a 'destination' fuel, not just a 'transition' fuel

Looking ahead, natural gas should play a critical role at the heart of a low-carbon energy system for many decades to come because natural gas power stations can be switched on and off much more swiftly than other power sources. So they are the ideal back-up to the intermittent energy provided by renewable sources such as wind and solar – after all, the wind does not always blow, nor the sun shine.

Another key plus for long-term gas usage is that carbon capture and storage technology has the potential to reduce emissions from gas-fired power close to zero. And CCS is more effective in combination with gas than coal, because it then needs to deal with only half the CO2 emissions.

Natural gas revolution in the US

All these advantages are now being amplified by the tight gas revolution.

You only have to look at how the US is benefitting from its vast, low-cost gas resources. Most important, they are helping to accelerate the displacement of coal-fired power. In the past two years alone, some 4-6% of the country's coal demand has been displaced by gas, with more to come.

The spot price for North American gas, Henry Hub has hovered around $4/MMBtu recently. That's compared with around $9/MMBtu for the UK and $15/MMbtu for Asian LNG.

To see how this translates into lower electricity costs, let's compare the short-run marginal cost of running a typical modern combined cycle plant on gas purchased at these different prices.

A plant fuelled by gas purchased at the North American spot price is 30% cheaper to run than its equivalent in the UK (per MWH). And 50% cheaper than an Asian plant run on gas purchased at the LNG spot price. All of which adds up to a powerful competitive advantage for the US.

That's not all. Think of all those industrial companies who use gas in their blast furnaces or as a chemical feedstock. Several major chemical companies now plan to open or re-open plants in the US, bucking the trend of recent years. A burgeoning gas industry is itself a welcome source of jobs, and will also be a huge driver of renewed US industrial competitiveness.

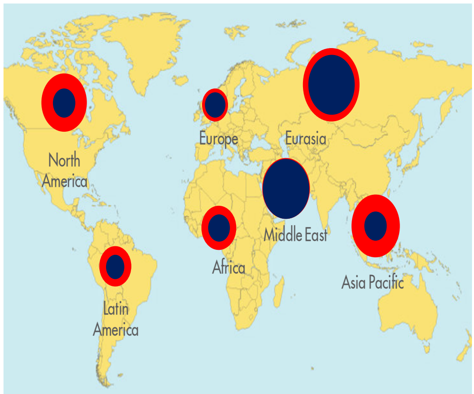

Figure 2 – Global tight gas potential

■ Conventional gas sources
■ Unconventional gas sources

> "The tight gas revolution is poised to become a global phenomenon."

The tight gas revolution is poised to become a global phenomenon. China, Latin America, Australia, Eastern Europe and South Africa all hold significant tight gas deposits. Coupled with the rapid expansion of the global LNG market, this is giving more governments the confidence to back natural gas.

As a result, according to the IEA, between 2008 and 2035 gas demand is expected to grow by:

- 60% globally
- 8x in China
- 5x in India
- And nearly 30% in North America.

Public debate about shale gas

Nevertheless, public concern about the safety and environmental impact of tight gas continues to mount. Several governments have already imposed moratoria on hydraulic fracturing.

As an industry, we must all do much better at listening and responding to the genuine concerns of our neighbours and the public at large. We must be very transparent about our operations. And we must push to achieve the very highest operational and environmental standards.

To this end, at Shell we recently announced our five operating principles for our global tight gas operations. These provide a framework for protecting water, air, wildlife and the communities in which we operate.

These include the clear task of designing, constructing and operating tight gas wells in a safe and responsible way. At Shell, we use what is known as a "safety case" approach based on North Sea regulation. This requires our staff and contractors to assess closely, and mitigate systematically all potential risks before drilling begins.

I emphasize this because a major public concern is that hydraulic fracturing could lead to the contamination of fresh water supplies, either by the fluid used to fracture the rocks, or by the gas itself.

A study published this year by the Massachusetts Institute of Technology found that "there is no evidence" that contamination by fracturing fluids is occurring.

It did however find "evidence of natural gas migration into freshwater zones in some areas, most likely as a result of sub-standard… practices by a few operators" in designing and constructing wells. For perspective here, hydraulic fracturing has been performed more than 1.1 million times in the US alone over the past 60 years.

So the critical message is this: when a well is designed and constructed correctly, groundwater will not be contaminated. And we'd like to see strong regulation and enforcement that requires everyone in the industry to do it properly.

At Shell, we only operate wells that can be safely isolated from potable groundwater. In fact, this is not hard to achieve. First, where we drill through the aquifer we line all of our tight gas wells with multiple steel and concrete barriers to prevent gas or liquids from escaping.

Second, our North American gas formations that require fracturing are typically located a mile (1.6 kilometres) or more below the water table, trapped below many layers of impermeable rock. So it is virtually impossible for gas or liquid to reach drinking water supplies through the localised cracks induced by fracturing the rock, which typically extend no more than 100 metres above the well.

We also support regulation promoting the publication of the chemicals used in hydraulic fracturing fluids in order to ease public concern. For the record, these typically comprise 99% water and sand, and around 1% chemical additives.

Indeed, we would like to see regulations that promote transparency and public engagement by the tight gas industry in relation to <u>all</u> of its activities. That doesn't just mean how we build and design wells or how we protect water sources, but also what we do to prevent excessive lorry traffic on local roads, to avoid disturbing livestock, or to mitigate light pollution at night.

All of which brings me to a second major public concern: that hydraulic fracturing depends on excessive and unsustainable freshwater consumption.

Sound operational practices can keep water consumption to a minimum. For example, at Shell we design our operations with the explicit purpose of reducing the amount of potable water we use. And wherever practicably possible, we use non-potable water, including by recycling and re-using the water from our operations.

It is nevertheless true that it can require double the amount of water to extract

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shale gas than conventional gas. But this is not the whole story.

The extraction phase only accounts for a small fraction of the total amount of water used to generate power. And the water intensity of conventional gas-fired power is far lower than nuclear and all other fossil fuels. So across the entire lifecycle, from production to use, shale-gas fired-power still uses half the volume of fresh water per MWh consumed by coal and nuclear.

Moreover, the water used in the production of shale gas is a tiny proportion of overall water consumption in the main shale gas regions in the US. For example, the water use of the Marcellus shale gas field in the north-east of the country was recently examined in a report prepared for the US Department of Energy.

At peak gas production, the maximum water use represented less than 0.8% of the total used in the area overlying the field in New York, Pennsylvania and West Virginia.

A third area of concern is that greenhouse gas emissions from shale gas far exceed not only those from conventional gas, but even those from coal.

Now, there's no doubt that the question of emissions is a complex one, and that further research is required. But the Cornell University report which sparked this controversy greatly exaggerated the emissions released during the production and distribution of shale gas. For example, it overlooked the steps taken by the industry to contain the amount of methane released during production.

The authors also used a 20 year time frame to study the global warming potential of methane in the atmosphere, instead of the 100 year horizon commonly considered by scientists to be more relevant in assessing the impact of climate change.

Other studies take a more measured view. For example, the International Energy Agency found that on a well-to-burner basis, emissions from shale gas exceed those of conventional gas by as little as 3.5% in the best case scenario and by 12% in the worst.

At Shell we manage our operations to keep emissions to the lower number.

We also measure, catalogue and report emissions to the relevant authorities. And remember: it's in our economic interest to capture as much gas as possible.

In any event, the greenhouse gas emissions from shale gas-fired power would still only be around half of those from coal, across the lifecycle.

Conclusion

And that is the critical point to remember, as public discussion about the gas supply revolution intensifies.

This evening, I've described how tight gas has already brought tangible environmental and economic benefits to North America. And how it now offers the rest of the world the opportunity to cut emissions of CO2 in the power sector, while meeting surging demand for affordable energy.

The sheer scale of this opportunity is what makes it so vital that any discussion about these energy sources is underpinned by hard facts and rigorous analysis.

And the hard facts are these: it's true that there are environmental and operational challenges associated with the production of tight gas. And it's imperative that the industry does its utmost to address them. But it's also true that the industry has the expertise to manage these risks, especially if governed by well-targeted and strictly implemented regulation.

The reality is that this revolution is the best chance for many countries to make immediate and substantial progress towards a much cleaner, lower CO2, more secure and more affordable energy supply. As such, it deserves our full support. *Thank you.*

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