Towards a sustainable energy future: realities and opportunities

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My purpose in this paper is threefold. First, I would like to examine why the world needs us to produce more energy. Second, I will look at the range of energy sources available for a sustainable future. A number of myths have grown up around the various energy sources and their relative contribution to addressing the global energy challenge: I will seek to dispel some of those. Third, I want to highlight what I see as an urgent need: for more informed decision making and more action in this complex area.

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1. Why does the world need more energy?

Much of the world is deprived of what the West considers normal [1]: a quarter of the people in developing countries still live on less than US $1.25 a day; one billion people do not have access to clean drinking water; 1.6 billion people—a quarter of all the people in the world—lack electricity; three billion people—nearly half the world’s population—lack adequate sanitation.

There is some good news. Over the last couple of decades, a large proportion of the 5 billion people who live in what has been called the ‘Third World’ have seen improvement. Today, about 80 per cent of those people live in countries that are developing—some much more rapidly than others: notably, China, India, Brazil and Russia. But there are still huge gaps in living standards around the world, and there are still a billion people in 50 or so states that are showing little signs of forward motion at all [2].

The present situation is neither stable nor sustainable. As the economist Paul Collier has pointed out in his book The bottom billion [2], the problems of people who live in poor conditions are problems for people everywhere—because of the interconnectedness of the globe, because of the pull on international aid resources, because of the costs of addressing conflict in poverty-stricken regimes, and so forth.

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Economic growth helps to lift people out of poverty. It would not resolve all the issues contributing to underdevelopment. There are also factors of governance, conflict, education and more to take into account. Let us just say that economic growth is a ‘necessary, but not sufficient, condition’ for improving the quality of life for many of the world’s people.

Achieving economic growth and increased prosperity means increasing energy consumption—putting pressure on already tight energy supplies. And this is in a world expected to be home to 3 billion more energy consumers by 2050. Any authority agrees that we could not stand still. More energy is not just a reality; it is a necessity.

This, of course, implies the prospect of more emissions—at a time when the need to ensure that carbon and other emissions are carefully managed and contained is already obvious. As the countries in the developing world grow, it is vitally important that we help them to do that without going through the same learning curve as the West did. This calls for a marriage of aspiration and pragmatism: balancing near-term actual delivery of the possible and good with longer-term efforts to achieve the excellent.

In practice, the focus, therefore, needs to be on delivering near-term improvements in energy conservation and efficiency; more energy from more diverse sources; and cleaner, safer energy; while at the same time constantly scanning the long-term horizon, developing plausible scenarios of life on Earth 30–50 years hence, and thinking about what needs to be done to deliver sustainable responses to those scenarios.

Creating a sustainable energy future for our planet is a massive challenge. And there is no silver bullet to address it. Many factors are involved. Complex decisions need to be made—not least, about where we should be getting our energy from.

### 2. Energy supply sources

As someone who has worked in an oil and gas company for three decades, I imagine you would expect me to have oil and gas embedded at the centre of my radar screen. In fact, the key to maintaining global energy security is diversity.

The global energy mix is already diversifying. This is partly due to government action. Take biofuels, for example. Shell currently spends more than US $3 billion a year buying biofuels for oil product mandates as set out by host governments. We are in the process of signing a US $12 billion joint venture with industry leader Cosan in Brazil; its purpose is the production of ethanol, sugar and power, and the supply, distribution and retail of transportation fuels. We have also been investing for some time in technology to deliver advanced—or ‘next generation’—biofuels. Some of the fruits of that investment were seen in the first Grand Prix of the 2010 Formula 1 season, in Bahrain. Fernando Alonso came first in a Ferrari car running on fuel containing cellulosic ethanol made from non-wheat straw—it was also the first time such fuel had been used in this setting.

A diverse energy mix will also include renewable sources such as wind, solar, geothermal, tide and wave. According to organizations such as the International Energy Agency (IEA), these sources can be expected to grow rapidly in the coming years. However, the challenges of scaling-up renewable energy sources are very substantial. Today, after a couple of decades in development, wind, solar,
geothermal, tide and wave energy together still account for less than 1 per cent of global energy. By 2030, that share is expected to have doubled [3] and—if you include biomass and waste as renewable energy sources—their total share reaches nearly 12 per cent, but there is still an energy gap to be filled to meet the world’s needs. Predictions for renewables in 2050 are higher: the IEA has estimated that 12 per cent of global electricity could come from wind power alone, if the world invests US $3.2 trillion.

In Europe, some countries are taking radical steps towards diversity. Switzerland is working to cut its energy consumption by more than half by 2050, to become a ‘2000 watt society’. Sweden has announced an oil phase-out by 2020. Here in the UK, the government is working towards a zero-energy building standard for all new housing by 2016.

In the meantime, fossil fuel sources will also need to grow in absolute terms to meet the increasing energy demand. By 2030, the IEA estimates that China’s primary oil demand will be more than double 2008 levels, up 8.6 million barrels a day; and the combined oil demand of India and the Middle East will rise by a comparable amount. Primary natural gas demand across the globe is expected to rise 1.5 per cent year on year between 2007 and 2030, from 2.5 to 3.5 billion tonnes of oil equivalent.

So, whatever future you look at—and there are many scenarios out there—hydrocarbons are going to be part of the global energy mix for a long time to come. I argue that oil and gas are as much a part of a sustainable energy future as other sources. Indeed, it is difficult to envision a sustainable energy future without increased natural gas—which is cleaner than other hydrocarbon sources, convenient and cost-effective. Increasingly, with conventional supplies under pressure—for a range of reasons, including geopolitical ones—the important thing is knowing how to access and produce more difficult sources, such as tight gas, and also how to clean up contaminated—or so-called ‘sour’—gas.

3. Promoting good debate: clarifying terms and debunking myths

I know there are many other views on what a sustainable energy future looks like. And I am very much in favour of debate on this vital subject. However, the current debate is perhaps not as constructive as it might be, because it can become emotional rather than factual. I believe we scientists have an important role to play, by putting a technical and scientific perspective on things. To promote good debate, we should insist on much greater clarity and consistency in the way people use certain terms.

A term much in need of clarification is ‘peak oil’. It is popular—if you Google it, you get about 14.5 million results. As you probably know, ‘peak oil’ was originated by a Shell worker, M. King Hubbert, in the 1950s. He used it to describe a theory for what happens to the oil produced in a given well, or a given field, or a given set of fields in a region, over time: output rises, peaks and then falls in a bell-shaped curve.

Nowadays, commentators often note how Hubbert ‘correctly’ predicted that US oil production would peak between 1965 and 1970. However, I would like to highlight two important things about this theory and prediction: one, Hubbert was talking about conventional oil; and two, he was talking about

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onshore oil. Today, thanks to massive investments in technology, we are working successfully well outside these parameters. We are exploring and producing unconventional sources of oil, such as oil shales and oil sands. And we are able to operate far offshore, in deep-water, ultra-deep-water, Arctic and other remote locations. Yet, because the term is not defined clearly and used consistently, the ‘peak oil’ debate—‘Have we reached it? Will we soon?’—continues in a somewhat confusing fashion with several conflicting viewpoints (http://www.iea.org/Papers/2009/Wind_Roadmap.pdf).

Some of these are summarized in the report from the UK Industry Taskforce on Peak Oil and Energy Security [4]. The report’s main authors warn of an ‘oil crunch’ in the UK in the next 5 years. Another contributor expresses the view that global oil production is likely to hit its maximum possible rate within the next decade (and possibly 5 years). Research by Australia’s MacQuarie Bank is quoted [4, p. 31]: ‘We’re not running out, but we won’t have enough.’ Cambridge Energy Research Associates are also quoted: they see no oil peak through to 2030, thanks to technology developments. All in all, the picture is quite confusing.

The world certainly has a finite amount of oil—but the present rate of diversification makes it unlikely that we will use it all up in the short to medium term. The IEA’s most recent World energy outlook [3] estimates global oil production continuing to increase from 83 million barrels a day in 2008 to 103 million barrels a day in 2030. This takes into account not only conventional oil, but also the unconventional and extra-heavy oil sources with which our industry is increasingly engaged.

As I said, clarifying our terms of reference is important to promote a useful debate about the right balance of energy sources. It is also important to help people recognize and reject myths. Here I would like to focus on three:

— myth 1: global gas supply is declining;
— myth 2: oil sands will never be cost-effective; and
— myth 3: the real cost and contribution of renewables.

4. Myth 1: global gas supply is declining

Our first myth forms part of the bigger ‘peak oil and gas’ tale, on which I have already touched. And it is true that 2008–2009 saw a drop in natural gas supply and demand. This was largely due to two factors: the global financial situation and circumstances in Russia, including heavy domestic demand and maturing fields—Russia produces nearly one-fifth of the world’s natural gas, and holds nearly a quarter of the total natural gas resources, so what happens there has an impact globally. However, the outlook for natural gas is growth.

On the demand side, for example [5], China’s gas use in 2008 rose to near 80 billion cubic metres (bcm) from 69.5 bcm the year before. And gas still accounts for less than 4 per cent of China’s total primary energy supply. But this is changing: contracts are in place to import a minimum of 24 bcm of liquefied natural gas (LNG) by 2011; there are also plans to import up to 40 bcm of Turkmen gas by pipeline; and China has its own ambitious targets to double domestic gas production by 2015. In India, demand for natural gas could double if supply were not constrained. Today, barely 5 per cent of the nation’s total

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primary energy supply comes in the form of natural gas. Domestic production is projected to double by 2012; and LNG import capacity is also on a rapid growth path. On the supply side, North American gas production is currently rising faster than expected: the US Energy Intelligence Agency (EIA) recently revised its 2010 forecast of domestic production upward by an average 2 billion cubic feet per day.

Here in the UK, there is a seismic shift under way from a ‘just-in-case’ oil-based economy to a ‘just-in-time’ gas-based economy. By 2020, 35 per cent of UK gas could be in the form of imported LNG, up from 1 per cent today. This has broad implications for the nation, which need to be thought through carefully—not just the economic and possible societal ramifications of building more regasification facilities, but also the need for enhanced shipping security at a time when piracy is rampant in some parts of the world’s oceans through which LNG would typically travel.

Generally speaking, there are issues to be addressed on a national and a global level if natural gas is to play its full part in a sustainable energy future. But the bottom line on this myth of declining supply is: it has no basis. The IEA estimates that there is enough recoverable conventional and unconventional gas to meet global consumption for 250 years at current rates of production.

5. Myth 2: oil sands will never be cost-effective

Let me turn now to my second myth: that oil sands will never be cost-effective. Here again, we can see the impact of not defining terms clearly: what do we mean by cost-effective?

Experience in any industry shows that the market will pay what it has to for what it wants or needs. So the cost-effectiveness of any oil source depends on what people are prepared to pay for oil. Oil prices have been very volatile over the last couple of years. However, there is a general consensus that the days of cheap oil—the US $14 barrel that formed the basis of much planning at the beginning of this century—are well and truly over.

Even with the dramatic drop in oil price from its peak in 2008, existing oil sands operations remain competitive. In Shell’s oil sands portfolio in Canada, for example, unit cash costs are US $32 a barrel, well below both present and IEA-forecast oil prices. The market for labour, material and equipment became heated as a consequence of the rise in oil prices. As that heat dissipates, the economic viability of new oil sands projects is likely to improve.

Oil sands present environmental challenges, in terms of energy use, water use and emissions, and these also have associated costs. So we are developing or acquiring technologies to address those issues—new heat exchangers, new froth treatment technology, new treatment for waste (tailings) and more. We have a ‘reclaim-as-we-go’ approach to help realize our commitment to biodiversity in the area. And we are working with the Alberta government in the Quest project, focused on carbon capture and sequestration or storage, which could have a substantial impact on emissions. The project is currently at the stage of scoping and public consultation. The Alberta government has committed C$745 million to the project, with a further C$120 million from the Government of Canada.
Adding the cost of carbon sequestration to the cost of extraction does increase the cost of oil sands relative to other, less carbon-intense, energy sources such as windmills. But windmills do not provide the continuity of supply that business and consumers need. And wind power will not propel the millions of cars that will hit the road in China over the coming decade. So the future will necessarily include both fossil and renewable fuels, increasing the share of renewable sources steadily but using oil from oil sands for mobility and continuity.

The debate about the cost-effectiveness of oil sands is therefore missing the point. Generally, markets will pay for what markets want. The real issue for any energy source is the energy balance: if producing energy from a given source requires you to put more energy in than you get out, that is when the energy source is patently not viable.

6. Myth 3: the real cost and contribution of renewables

The merits of any energy source need to be seen in the proper context, which brings me to my third and final myth: it is about the real cost and the contribution of renewables in the context of the global energy challenge.

First, the cost of any renewable energy source needs to take account of not only the energy employed to produce that renewable energy, but also the mineral, metal and other resources consumed in building the necessary facilities. After all, energy is not the only scarce resource on the planet. Virtually every low-carbon energy technology actually uses more mineral resources than energy from oil or natural gas. Take wind turbines. They consume double the amount of steel to produce the same amount of electricity as a natural gas-fired power plant. Wind turbines also consume more nickel and chromium than conventional power stations for the same amount of electricity. And a lot of cement is needed for their concrete foundations. In a coal-fired power plant, you can reduce greenhouse gas emissions using carbon capture and sequestration. But you will need double the amount of steel. In a renewable energy system, long-distance electricity transmission at high voltage would have to increase. So more copper would be needed.

Renewable energy systems also tend to be more high-tech. So instead of using oil and gas as raw materials, you are using the often scarce materials typical of high-tech applications, such as lithium and neodymium. Lithium is a crucial component in electric cars; there are only a few places on Earth where it is produced easily in large quantities and current production methods put pressure on the environment. Neodymium is used in the strong magnets you find in wind turbines and car batteries. It is abundant in the Earth’s crust, but not often in large concentrations, and it is hard to produce in an environmentally friendly way. Today, 90 per cent of the world’s neodymium comes from China; mines in the USA and elsewhere closed some years ago, for environmental and economic reasons. And China has indicated it may tighten export controls on neodymium.

As I stressed earlier, we do need a diverse energy mix, using both renewable and fossil fuel sources. So it is vital that people understand more fully the complex issues around the real costs of all sources, including renewable ones; and the need to build responsible use of all the Earth’s resources, not just oil and gas, into the equation.
Financial costs make for interesting comparisons as well. In its *Annual Energy Outlook 2010*, the EIA provides average levelized costs for a variety of ‘new-generation’ power plants entering service in 2016 (www.eia.doe.gov/oiaf/aeo/electricity_generation.html). The categories looked at include: coal, advanced coal and advanced coal with carbon capture and storage (CCS); several types of natural gas-fired plant, with and without CCS; advanced nuclear; wind, both onshore and offshore; solar photovoltaic and solar thermal; geothermal; biomass; and hydro power—altogether, a fairly comprehensive list. The total system levelized cost—i.e. taking into account things like capacity factor, capital cost, operations and maintenance costs, and transmission investment—was remarkably similar across most categories. Coal-fired electricity costs ranged from US $100/MWh$ for conventional to US $129/MWh$ for advanced coal facilities with CCS. The range for natural gas using combined cycle technology was lower, from US $83/MWh$ to US $113/MWh$. Nuclear came in at US $119—the same as hydro. Biomass and geothermal were US $111/MWh$ and US $116/MWh$, respectively. The numbers of wind and solar are somewhat higher: onshore wind came in at US $149/MWh$, offshore wind at US $191/MWh$; solar thermal reached US $257/MWh$ and solar photovoltaic reached US $396/MWh$. These cost estimates from the EIA are further supported by EU data analysed by Shell.

The last aspect of renewables that I would like to mention is the amount of space required to house the facilities. Let us take the UK as an example. Average energy consumption here is 125 kWh per person per day [6]. It has been calculated that, to produce only 20 kWh per person per day, you would need to cover the windiest 10 per cent of the UK’s land with wind farms. The Institution of Electrical Engineers estimated that the total of all renewables’ technical potential is about 27 kWh per day per person. And that is assuming quite radical changes in UK society and industry: for instance, consumers not objecting to wind turbines near the shore or in a field nearby, or biomass plants in their local countryside; mariners being happy that offshore wind turbines would not upset their radar; and so on.

Yes, renewable sources have an increasingly important part to play in the energy mix in the coming years. Getting the balance right—in terms of policy and investment—requires more people to understand the real nature of what we are dealing with, rather than relying on propaganda from any side, however good it may appear from a vote-winning or public relations perspective.

### 7. Impact of technology

At this point, I would like to stress again, briefly, the importance of technology advances in making a sustainable energy future with a large hydrocarbon component no oxymoron. The future can hold many surprises.

My own experience bears this out. When I started work in Shell, more than 30 years ago, we used to regard natural gas as a waste product, a nuisance. Success in harnessing it and making the most of the benefits it offers mean that it is now taking over as the fossil fuel of choice. Natural gas will account for around half of Shell’s upstream output by 2012.
Another technology impact is the increase in recovery factors from oil and gas reservoirs—up a good 10 per cent in my working life. In the next few years, thanks to innovations in areas such as subsea completion and well intervention, we could see recovery increasing from today’s 35–45% to as much as 55–75%.

As with so much else in life and industry, how much you want to push the limits depends on how much you are prepared to pay and what the different options are.

8. Action required

As scientists, we have a responsibility to make sure that influencers and decision-makers, in both industry and government, are fully informed about their options going forward, so that appropriate action is taken, in a timely fashion. Action is needed by many parties to create a sustainable energy future.

Business needs to focus very hard on increasing energy efficiency and reducing its carbon footprint: in every aspect of day-to-day business operations, through focused research and development, in a new product development, and by promoting customer demand for products and services that help them to use less energy and emit less CO₂.

Investment in technology development and innovation is absolutely crucial. Without investment in the oil and gas industry, for instance, we would not be able to work in water 2450m deep, with high-temperature, high-pressure reservoirs, using four-dimensional seismic imaging, remote operations and many more sophisticated technologies. For Shell, this kind of investment is paramount: we currently invest more than any of our peers in research and development, because we know our future success depends on it.

Business has a responsibility to work with government to achieve more effective CO₂ regulation—for example, by advocating ‘cap and trade’ systems, and stressing the need for a carbon price. We also need, from government, clear incentives for CO₂ capture and storage, and simple credible targets for the share of renewable sources in energy supply. It would be very useful to see measures introduced in the transport sector that separately drive vehicle efficiency, more efficient modes of transport and fewer miles travelled, and sustainable fuels that emit less CO₂ on a well-to-wheels basis. Robust energy standards for buildings and appliances, with incentives to retrofit, would also help.

9. Conclusion

The basic realities of a sustainable energy future are stark. The world will need twice as much energy in 2050 as it did in 2000; and there are no silver bullets.

There needs to be better awareness and understanding of the energy options available, including their real impact on emissions, their real costs and the impact of pricing. In pursuing the sustainable energy future, we need to balance near-term achievables with long-term imperatives.

There are major opportunities to help create a sustainable energy future—i.e. one that is environmentally, socially and economically beneficial—through more action on: energy conservation and efficiency, more energy from more diverse sources, and cleaner and safer energy.
The energy industry has made the impossible possible time and again over the last century. We have done that by doing what we are good at, and continual striving to get better. This is Shell’s strategic intent for the future, in our bid to help meet global energy demand in a responsible way, while providing a competitive shareholder return.

References

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