David Eyton speech to the Chinese Academy of Engineering

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I would like to say Good Morning (Zao Shang Hao) to the esteemed Academicians and Professors gathered here today. I am very honoured to have this opportunity to speak to you.

I am a civil engineer by degree and have spent most of my career in BP's Upstream business, most recently leading multi-billion dollar gas developments in Trinidad and the deep water Gulf of Mexico, which is largely oil, before taking on the role of BP's Head of Technology.

I was kindly invited to talk to you today to provide an international perspective on energy resources and constraints; and the role of technology and engineering in discovering, recovering and conserving more energy.

I will first talk briefly about BP, and BP in China.

BP is one of the world's leading international oil and gas companies. We operate or market our products in more than 80 countries, providing our customers with fuel for transportation, energy for heat and light, retail services and petrochemicals products for everyday items. And we have been doing this for over 100 years. We have also been active in China for almost 40 years.

Our relationships with China extend from scientific research to major operations and partnerships.

On the academic side, it is a privilege for BP to be associated with Tsinghua University, within the Chinese Academy of Engineering, as it has such a respected global reputation for education and innovation. The Tsinghua BP Clean Energy Centre opened nearly 10 years ago and is providing world-class research into more sustainable energy strategy, policy and technology. I will outline later in my talk some of the research on natural resource constraints that we have been conducting with Tsinghua.

In terms of operations:

- BP has been working in China since the early 1970s and we think of ourselves not only as an inward investor but as a local company, with a large workforce of Chinese engineers and well-qualified business teams.
- We have built strong relationships, including those with central and provincial governments and the Chinese oil companies of Sinopec, CNOOC, and CNPC in and outside of China. Outside of China, for example, we work closely with CNPC in Iraq, with Sinopec in Angola and with CNOOC in Argentina.
- Our total investment in energy infrastructure in China by the end of this year will be nearly $5.0bn. We have 26 joint ventures with Chinese companies as well as wholly-owned operations. We employ 1,200 BP staff in China, along with 3,600 joint venture staff and 12,000 contractors.
- Therefore I hope you will agree that BP is well-placed to provide an international perspective on today’s topic. Let me start with the obvious question.

Are energy resources enough to meet growing demand?

The global answer is 'yes'. Geologists have located decades' worth of fossil fuel resources and technology has historically proved equal to the task of discovering and recovering more as the years have gone by.

In round numbers we have something like 1.65 trillion barrels of oil and over 200 trillion cubic metres of gas reserves today with much more than this accessible with adequate price support and ongoing technology development in areas such as extreme enhanced oil recovery (EOR), ultra deepwater (DW), the arctic, High-pressure, high temperature and -- as we have seen in recent times -- in unconventional resources, such as shale gas.

At BP we look at historical trends with the BP Statistical Review of World Energy – documenting annually, for the last 61 years, the way that different sources of energy are produced and consumed.

Over these 61 years, others have regularly made predictions that the world's resources are running out. The most notable came in 1972, when the organisation known as The Club of Rome raised considerable public attention with its 'Limits to Growth' report predicting that economic growth could not continue indefinitely because of the limited availability of natural resources, particularly oil.

While we must acknowledge that the Earth's resources are finite, our data continue to show that proved reserves, and the ratio of these reserves to production, have risen over time, despite the steady increase in consumption. Our Statistical Review states that today's proved reserves of oil, gas and coal are sufficient to meet current production for 54, 64 and over 100 years respectively. Since we began tracking oil and gas reserves in 1980, global reserves have increased every year for gas, and every year but one (1998) for oil. And in the last couple of years, we are witnessing the transformation in the US resource base as a result of the shale gas revolution.

So today the world has a plentiful resource base, but of course we need to also think about the future.

How will supply and demand be balanced over time?

BP also produces a forward-looking study – the BP Energy Outlook 2030 - with our projections of future energy trends and key uncertainties, based on our current understanding of global economy, policy, and technology evolution.

These are projections, but not necessarily the energy world we at BP wish to see. Our Energy Outlook projects that demand will grow by up to 40% over the next two decades in the most likely scenario, with electric power growing the fastest. 96% of direct demand growth is projected to come from the emerging economies - half from China and India alone.

Oil is expected to be the slowest-growing fuel over the next 20 years. However, global liquids demand, which includes oil, biofuels, and other liquids will still likely rise by 16 million b/d, exceeding 103 Mb/d by 2030. This growth in oil demand will come almost exclusively from rapidly-growing non-OECD economies. China's consumption of oil is expected to rise by +8 Mb/d, India's by +3.5 Mb/d and the Middle East by +4 Mb/d). Together these will account for nearly all of the net global increase. Notably OECD demand has likely peaked in 2005, and we expect consumption to decline by 6 Mb/d by 2030.

We believe the supply to meet this expected demand growth should come primarily from OPEC countries, where output is projected to rise by nearly 12 Mb/d.

The largest increments of new OPEC supply will come from Natural Gas Liquids, as well as conventional crude in Iraq and Saudi Arabia.

Non-OPEC supply will continue to rise, growing by 5 Mb/d, due to strong growth in the Americas from the United States (US) and Brazilian biofuels. We also see Canadian oil sands, Brazilian deepwater, and US shale oil, offsetting continued declines in a number of mature provinces.

In contrast to oil, natural gas is projected to be the fastest growing fossil fuel globally, at 2.1% per annum. Non-OECD economies account for 80% of global gas demand growth, averaging 2.9% p.a.

growth to 2030. Demand grows fastest in non-OECD Asia, at 4.6% p.a. and the Middle East 3.7% per year.

We expect that gas consumption will grow rapidly here in China at 7.6% p.a. to a level of gas use in 2030 (46Bcf/d) equal to that of the European Union in 2010. China's growth contributes 23% to the global demand increase. The share of gas in China's primary energy consumption distribution is expected to expand from 4.0% to 9.5%.

On the supply side the main regional contributors to growth are the Middle East, with 26% of global growth and Former Soviet Union at 19%. Significant incremental supply at 11-12% of global growth each is also expected from Australia, the US and here in China, Liquefied natural gas (LNG) will represent a growing share of gas supply. Global LNG supply is projected to grow 4.5% per annum to 2030, more than twice as fast as total global gas production at 2.1% p.a. and faster than inter-regional pipeline trade, with 3.0% p.a.. LNG should contribute 25% of global supply growth from 2010 to 2030, compared to 19% for 1990-2010.

Hence, we expect global energy will remain dominated by fossil fuels, which are forecast still to account for 81% of global energy demand by 2030, down from current levels of 87%. This slow decline in fossil fuels' market share demonstrates the competitiveness of the installed capital base.

Conversely, even with continued policy support, renewables are only expected by us to account for around 6% of energy supply by 2030.

So, given the projected on-going high demand for hydrocarbons, and the physical availability of resources, economics will largely determine supply - that is new reserves will be found and produced if the price is right. I would like to briefly focus on what might be the right price by first looking what is the cost of oil production.

How will oil be priced?

This is a more difficult question to answer.

Oil is produced from a wide range of geological formations (conventional and unconventional), geographies (onshore and offshore), field maturities (with and without EOR), its quality varies and so do the fiscal terms for its production.

The major OPEC oil producing nations also need oil prices at a level that can sustain their own economic growth and investment in new production. Earlier this year the Saudi Arabian Minister of Petroleum and Mineral Resources, Ali Al-Naimi, was quoted as saying Saudi Arabia wants an oil price of around $100/bbl. In an International Monetary Fund report from 2011 on Saudi Arabia, the break-even oil price was estimated to be at least $80/bbl, and likely to rise to $98/bbl by 2016.

What we do see from our own operations is that costs are escalating across the industry, as we develop oil fields in more challenging locations.

BP and other companies use a long term assumption price to justify the case for our investments. These investments have to deliver a minimum rate of return, otherwise the projects and the company itself cannot survive over the long term.

In recent years, the oil market has seen high prices. The price of oil, just like other commodities, is the direct consequence of strong and sustained market demand growth, eating into spare capacity and requiring investment in costlier and more difficult to access sources of supply.

Short term fluctuations in price typically grab the headlines, particularly when they spike to record high prices, in response to disruptions or the fear of disruptions, as we saw last year. It is however the fundamentals of supply and demand that determine price, and not financial speculation.

There are other challenges, of course, some of which I will come onto shortly, and there is uneven distribution of fossil, nuclear and renewable resources and consumption.

So the resources are not necessarily in the right places or the right physical form to supply the relevant markets. However it is our experience and our belief that the global markets can deal with this challenge.

As we seek to manage short-term disruptions and meet long-term demand, we should remember that open markets can be a powerful ally. The US experience with shale gas shows how an open and competitive environment drives technological innovation and unlocks resources. This also means that with plentiful supply, the price is driven down, but if this goes too far then this in turn can discourage future investment.

One of the key things we learned from recent disruptions, chiefly the Arab spring and Fukushima, was that the flexibility of markets – the ability to increase production, to substitute across fuels, and to change trading patterns – has been crucial to the ease with which the system has adapted. For this to work, prices must be allowed their role as signals to guide the reallocation of energy flows.

So, the physical resources are there; global markets function well and can accommodate fluctuations in supply and demand; and economics determine the viability of new production. This all sounds very reassuring, but the truth is that maintaining and increasing production - and maximising conversion and consumption efficiency - will depend more and more on technology.

Predictions about when we will run out of oil and gas tend to underestimate the potential for technology to open up new resources and maximise what we have got.

In 2011, the National Petroleum Council published its report on North America's oil and gas resources, and found that these have greatly expanded due to technology progress in recent years. It says that as recently as 2007, it was thought that the US would have to become increasingly dependent on imported liquefied natural gas, owing to what appeared to be a constrained domestic supply.

We now know that thanks to technological innovation in fracturing and drilling methods, producers can now unlock vast reserves of shale gas and tight gas. The impact of shale gas on the US has been phenomenal, moving the US from a country short of the natural gas that it needs, to one that is currently oversupplied. Shale gas could also potentially be a game changer here in China.

Technology can address a number of major energy challenges. As we know, the world needs more and more energy, but it also wants it to be secure, affordable and sustainable; and rarely do all of these circumstances exist in any nation, which creates major technical and engineering challenges.

The first of these challenges is managing safety and risk. In this business there will always be risks that we have to manage: risk from working with volatile hydrocarbons; risk in the way they are produced and processed; and risk working in the countries and environments where they are found.

After the Gulf of Mexico accident in 2010, BP established a more powerful Safety & Operational Risk function to strengthen our processes and capabilities in safety and risk management. The specialists in that function work alongside our businesses to advise, inspect and if needed intervene. We have hired experts from high hazard industries such as nuclear power, space exploration, chemicals and the military, and with their help we are developing more rigorous standards that in some cases exceed industry norms.

I am aware that here in China, there is also considerable effort going into managing these same risks following last year's leak in Bohai Bay. As a result, we are planning to share our experience with our partner CNOOC later this year.

We continue to deploy technologies that reduce risks. For example, to improve our corrosion monitoring and management capability, BP has worked with Imperial College London to develop wireless integrity monitoring probes, which offer corrosion engineers, inspectors, planners and plant managers previously unavailable insights into the condition and capability of oil and gas assets. We have now deployed several thousands of these probes across all of our refineries and increasingly into our upstream assets. Indeed, BP has very recently helped to facilitate a first demonstration of these probes here in China, with a local refiner.

The key, we believe, is to properly understand the system of risks we face. The risk profile in the upstream is changing - there will always be geological uncertainty, but the challenge of managing engineering risk is becoming more important as the industry tackles harder and more remote reservoirs. Hence, we believe that the oil and gas industry will need to look beyond its traditional supplier base to learn lessons from other industries, for example nuclear, with expertise in operating high reliability systems in hostile environments.

The second major challenge is to find and produce hydrocarbons at the frontiers.

Demand has driven the industry to operate at the frontiers, from the Arctic to DW to heavy oil. Each poses unique challenges, such as temperature, depth, pressure, remoteness, ice, geological formation, and local environment.

From an engineering perspective, the term 'frontier' implies more than simply geographic remoteness - such as we see in the Arctic for example. It can also mean being the first to work in an uncharted natural environment - such as the deep water or complex rock formations. This introduces a unique element of engineering risk. The essence of frontier engineering is the way in which that risk is managed and, in particular, the extent to which it requires the use of newly created technology.

In frontier areas, the industry may find that it does not have appropriate analogues and so has to derive engineering and technology solutions from first principles. We have to design standards using our experience and what we can learn about the new environment before we start operating. Equally, introducing new technology and demonstrating it reliably is difficult, due to the problems of replicating the operating environment at a meaningful scale in a test environment.

As a consequence, sometimes we find we have built in more margin than is needed. At other times we discover something we did not know and we have to create a new and better design.

When BP discovered the Forties field in the North Sea back in 1970, it really was the frontier of the industry. It was located in a water depth of 400 feet and in an area with much more severe weather conditions than the industry had experienced anywhere in the world. The 100-year maximum design wave height exceeded 90 feet, almost twice the design height used previously in offshore engineering. Persistent bad weather throughout most of the year meant that metal fatigue became an over-riding design consideration. With only a brief summer season for offshore construction, a new approach was required for platform and topside installation.

The field was developed using 4 massive steel jackets, that is the steel substructure supporting the platform’s topsides, built in a specially constructed fabrication yard in Scotland. The export pipeline back to the beach also broke all industry records in terms of water depth and size. It was the first offshore pipeline to be constructed using fully automatic welding and the first to be designed to resist propagating buckles.

Over the years, platform design became more sophisticated and the jackets no longer needed to be quite so massive - our better understanding of the risks enabled the transition.

Technology can also open up new resource frontiers such as unconventional oil and gas. The rapid growth of shale gas in the US and also the potential for shale gas here in China has created both excitement and environmental concerns, particularly around water (and I will talk more about water later on).

BP has existing unconventional gas positions in North America, North Africa, the Middle East and Indonesia. BP has a long history of development of unconventional gas, including coal-bed methane and shale gas, and sees the potential for global unconventional gas development to contribute safely and sustainably to global energy security.

Fracturing is used much more widely than in shale gas production alone, with 50% of BP's natural gas production employing this method. Almost all of the BP natural gas production in the US is hydraulically fractured. Hence we are familiar with the long-standing concerns about the potential environmental impacts of unconventional gas development expressed by some stakeholders.

So in our business activities, we seek to apply responsible well design and construction, surface operation and fluid handling practices and engage constructively with government and the rest of the industry to promote sound policies and regulation that in particular protect water resources.

Now we face even greater challenges in exploration and production in the DW. Hydrocarbons are often situated in continental shelves, 35,000 feet below sea- level, through miles of hard rock, thick salt and tightly packed sands.

You may have seen our 'Project 20k' announcement earlier this year. This is all about developing the technology to be able to produce DW fields with reservoir pressures of up to 20,000 pounds per square inch (psi) and temperatures of 350 to 400 degrees Fahrenheit (175 to 205 degrees Centigrade). Over the next decade, we will work with others to develop an integrated system, from the rig to the risers and the subsea, all the way to the well and the ability to intervene.

Making this vision a reality will require unprecedented collaboration across and outside our industry, involving operators, consulting engineers, vendors, contractors, academics and regulators. This will be necessary to define codes and standards for the design, operation and reliability of the new technology.

The third major challenge that technology can help to address is energy efficiency.

This analysis conducted on 2005 data by researchers at the University of Cambridge suggests that only 12% of energy captured at source ends up in useful heat, light and motion.

Not all of these losses can be recovered, even theoretically, but energy efficiency is the single largest opportunity to reduce our energy footprint, and this can be enabled by technology. There is much that can be done to use energy more efficiently from a resources, processing, product and end of life perspective.

Globally BP's Energy Outlook 2030 assumes a 2% pa improvement in energy efficiency globally; this compares with 1% pa over the past 20 years. Without any improvement, demand in 2030 would double from today's demand. This underlines the importance of improving energy efficiency in making the most of our fossil reserves and minimising their impact on the global environment.

Energy efficiency and conservation have never been more important than now globally and for China, with its growing need for energy to support sustained economic growth through the most energy intensive period of industrialization.

The impressive development that China has already achieved in such a short space of time is set to continue for the foreseeable future. It is forecast that over 300 million people will move to the cities and over 300 million vehicles will be on the road by 2030. This creates a challenge but also an opportunity for China. An opportunity, because China is building new infrastructure and can exploit the best available technologies to grow with greater efficiency.

China has already made progress in its effort to enhance energy efficiency. The government has set the ambitious target of lowering energy intensity per unit of Gross Domestic Product by 16% between 2011 and 2015, on top of the difficult target of 20% for the previous five years. This is thanks to the government efforts to shut down energy-inefficient industrial operations and restructure the economy away from energy-intensive activities.

And BP's thriving petrochemicals joint venture in Zhuhai is founded on the principles of energy efficiency, lower emissions, and reduced water usage, whilst still achieving higher productivity at the lowest cost per ton. Industry leading process technologies make the Zhuhai 2 Purified Teraphthalic Acid plant one of the most efficient facilities of its kind, capable of running with around 75% fewer water discharges, 65% fewer greenhouse gas emissions and 40% less solid waste than a similar plant equipped with conventional technologies. These efficiencies also make the plant significantly more economical to operate.

On the demand side, we are working hand in hand with vehicle manufacturers to co-engineer more efficient engines and corresponding fuels and lubricants. Indeed we have opened a new lubricants technology centre in Shanghai, under our lubricant brand name Castrol, to work more closely with Chinese vehicle manufacturers, in developing such co-engineered solutions.

That leads to me the fourth challenge that technology has a role in addressing: climate change and constraints on natural resources.

We think the production of fossil fuels is more likely to be constrained by factors other than availability.

A BP-funded consortium of academics from 13 universities, including Tsinghua, has looked at the challenges of sustaining the world's energy systems. This multi-disciplinary research programme – the Energy Sustainability Challenge (ESC) – concentrates on the nexus of land, water, minerals and energy.

The ESC focuses on scientific evidence, underpinned by peer-reviewed data and analysis. These are essential for sound decision-making and strategic business planning.

This slide shows a global analysis of the natural resource constraints applicable in the energy business other than the availability of the energy reserves themselves - from land, water and minerals to potential limits on atmospheric carbon.

The arrows in this slide are scaled as a proportion of total usage. This suggests that:

- Climate change remains the most significant potential constraint facing the global energy industry, with fossil fuels accounting for around 60% of CO2 equivalent emissions. However, to date the world has not been willing to place a high enough price on carbon to incentivise significant change.
- Fresh water challenges are more immediate, complex and regional. There will be increasingly severe pressures in regional water availability. However, contrary to popular belief, fossil fuel extraction accounts for less than 2% of the total world fresh water use, even with growth in shale gas production, with a further 9% related to cooling of power plants for which there are technology alternatives. In our view the intersection of energy and water can be managed globally
- Modern biofuels are a small part of the agricultural system, currently using less than 2% of cropland, but they sit at the nexus of stresses on land and water and emotional "food vs fuel" debate.
- There appears to be adequate physical supply of the minerals needed for the world's energy systems. However, some rare earth metals and chromium (needed for steel) are produced in few locations and vulnerable to disruption.

It's clear to us that understanding the facts about these constraints, and the way they connect with each other, is vital to sensible policy development, investment and technology decisions.

Of course, understanding global averages is helpful but masks considerable regional variability of natural resource stresses.

For example, water will be a serious constraint for China's energy production.

Research conducted by Tsinghua University and the University of California at San Diego, as part of the ESC, shows that China has low average availability per capita, and serious regional scarcities in the North. The Northwest is actually extremely arid – its per capita water resource looks high simply because the population density is so low.

To address water issues, China has established targets to limit the absolute quantities of water used in industry, which would be expected to otherwise more than double by 2030. A 'business as usual' scenario would fall short of the goals well before 2020, even if energy demand is reduced.

However, Tsinghua's ESC research shows that improved technical approaches, with effective policy leverage, could reduce water use below current levels. Water recycling in coal mining and water-efficient power plant cooling systems are obvious solutions.

ESC research also shows that water used in washing coal improves efficiency of combustion and saves water use at power stations. Improved efficiency of using washed coal is likely to be realized only if policy incentives overcome the increase in operational costs.

In summary…

The world faces challenges in growing supply rapidly enough to sustain growth in energy demand, but at a global level the availability of hydrocarbon resources is not one of them.

However, we need to recognise that it is getting harder and therefore more costly to produce the oil and gas that the world increasingly requires. This brings greater economic and technical risks.

On the economic side, the markets for natural resources, particularly oil and gas, work well to manage supply and demand over the long term and can accommodate short-term disruptions.

On the technical side, BP has decades of experience and expertise in finding and producing oil and gas, even at challenging frontiers, and bringing them to global markets, including China.

We recognize that China is unique in many ways – the biggest energy producer, the biggest energy consumer, the biggest contributor to carbon dioxide emissions. But it is also a country with great potential and commitment to managing its energy footprint.

BP-sponsored academic research shows that energy-related natural resource constraints can be managed, but this will not be easy and will require wise policies and continued improvements in technology.

BP's activities with and within China aim to serve several mutual objectives – meeting demand, increasing sustainability and providing greater economic prosperity for our stakeholders.

And with China at the centre of a massive shift in the global economy and the global energy industry, we are striving for enduring relationships based on mutual benefit, and see partnerships and co-operation between scientists, engineers, policy makers and industry as creating a strong systems-wide alliance to meet energy challenges.

Thank you for your attention. I will now pass over to Prof Li Zheng to help handle any questions you may have.