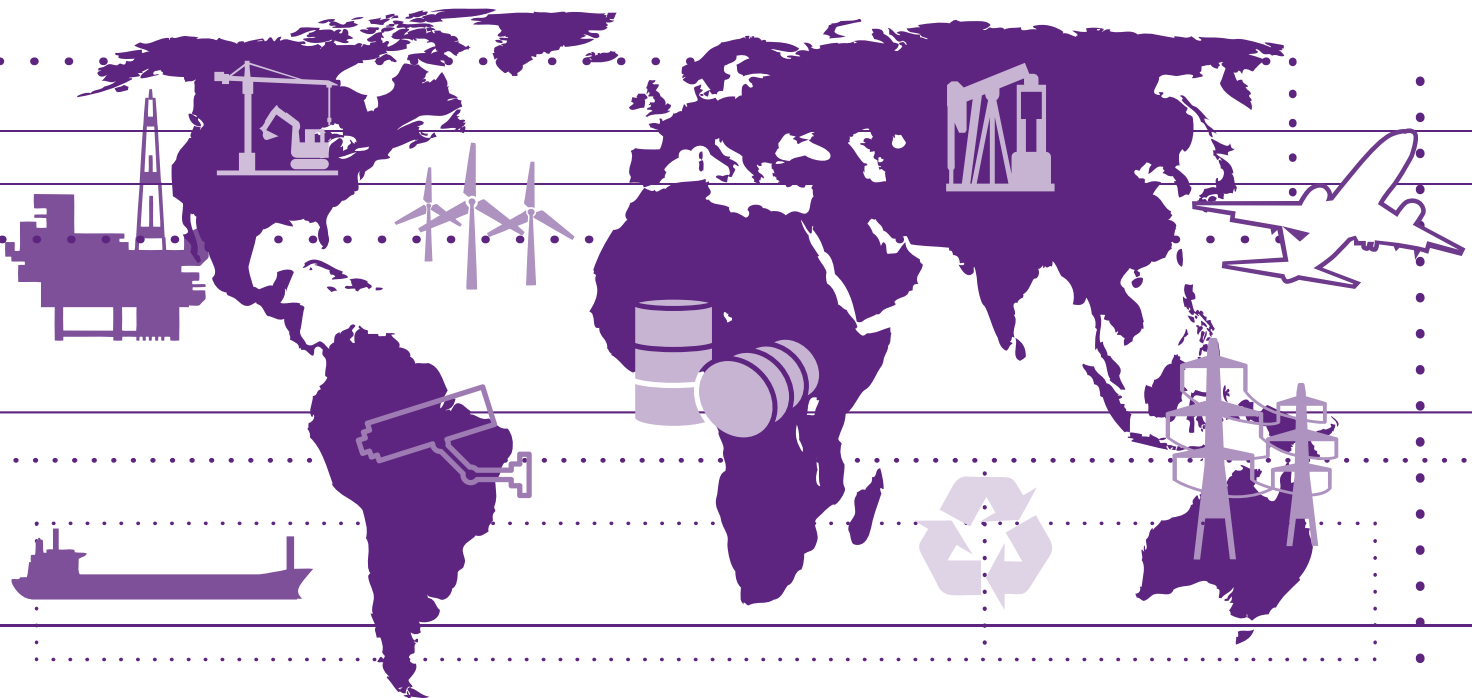




WHITE PAPER

SUSTAINABLE ENERGY SECURITY

Strategic risks and
opportunities for business



CHATHAM HOUSE

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FOREWORD

FROM THE CHIEF EXECUTIVE OFFICER OF LLOYD'S



This report, jointly produced by Lloyd's 360 Risk Insight programme and Chatham House, should cause all risk managers to pause. What it outlines, in stark detail, is that we have entered a period of deep uncertainty in how we will source energy for power, heat and mobility, and how much we will have to pay for it.

Is this any different from the normal volatility of the oil or gas markets? Yes, it is. Today, a number of pressures are combining: constraints on 'easy to access' oil; the environmental and political urgency of reducing carbon dioxide emissions; and a sharp rise in energy demand from the Asian economies, particularly China.

All of this means that the current generation of business leaders – and their successors – are going to have to find a new energy paradigm. As the report makes clear, we can expect dramatic changes: prices are likely to rise, with some commentators suggesting oil may reach \$200 a barrel; regulations on carbon emissions will intensify; and reputations will be won or lost as the public demands that businesses reduce their environmental footprint. The growing demand for energy will require an estimated \$26trn in investment by 2030. Energy companies will face hard choices in deciding how to deploy these funds in an uncertain market with mixed policy messages. The recent Deepwater oil spill shows all too clearly the hazards of moving into ever more unpredictable terrain to extract energy resources. And the rapid deployment of cleaner energy technologies will radically alter the risk landscape.

At this precise point in time we are in a period akin to a phony war. We keep hearing of difficulties to come, but with oil, gas and coal still broadly accessible – and

largely capable of being distributed where they are needed – the bad times have not yet hit. The primary purpose of this report is to remind the reader that all businesses, not just the energy sector, need to consider how they, their suppliers and their customers will be affected by energy supplies which are less reliable and more expensive.

The failure of the Copenhagen Summit has not helped to instil a sense of urgency and it has hampered the ability of businesses – particularly those in the energy sector – to plan ahead and to make critical new investments in energy infrastructure. Like the authors of this report, I call on governments to identify a clear path towards sustainable energy which businesses can follow.

Independently of what happens in UN negotiating rooms, businesses can take action. We can plan our energy needs, we can make every effort to reduce consumption, and we can aim for a mix of different energy sources. The transformation of the energy environment from carbon to clean energy sources creates an extraordinary risk management challenge for businesses. Traditional models that focus on annual profits and, at best, medium term strategies may struggle. Parts of this report talk about what might happen in 2030 or even 2050 and I make no apology for this. Energy security requires a long term view and it is the companies who grasp this who will trade on into the second half of this century.

Dr Richard Ward
Chief Executive Officer
Lloyd's

EXECUTIVE SUMMARY

1. BUSINESSES WHICH PREPARE FOR AND TAKE ADVANTAGE OF THE NEW ENERGY REALITY WILL PROSPER – FAILURE TO DO SO COULD BE CATASTROPHIC

Energy security and climate change concerns are unleashing a wave of policy initiatives and investments around the world that will fundamentally alter the way that we manage and use energy. Companies which are able to plan for and take advantage of this new energy reality will increase both their resilience and competitiveness. Failure to do so could lead to expensive and potentially catastrophic consequences.

2. MARKET DYNAMICS AND ENVIRONMENTAL FACTORS MEAN BUSINESS CAN NO LONGER RELY ON LOW COST TRADITIONAL ENERGY SOURCES

Modern society has been built on the back of access to relatively cheap, combustible, carbon-based energy sources. Three factors render that model outdated: surging energy consumption in emerging economies, multiple constraints on conventional fuel production and international recognition that continuing to release carbon dioxide into the atmosphere will cause climate chaos.

3. CHINA AND GROWING ASIAN ECONOMIES WILL PLAY AN INCREASINGLY IMPORTANT ROLE IN GLOBAL ENERGY SECURITY

China and emerging Asian economies have already demonstrated their weight in the energy markets. Their importance in global energy security will grow. First, their economic development is the engine of demand growth for energy. Second, their production of coal and strategic supplies of oil and gas will be increasingly powerful factors affecting the international market. Third, their energy security policies are driving investment in clean energy technologies on an unprecedented scale. China in particular is also a source country for some of the critical components in these technologies. Fourth, as 'factories of the world', the energy situation in Asian countries will impact on supply chains around the world.

4. WE ARE HEADING TOWARDS A GLOBAL OIL SUPPLY CRUNCH AND PRICE SPIKE

Energy markets will continue to be volatile as traditional mechanisms for balancing supply and price lose their power. International oil prices are likely to rise in the short to mid-term due to the costs of producing additional barrels from difficult environments, such as deep offshore fields and tar sands. An oil supply crunch in the medium term is likely to be due to a combination of insufficient investment in upstream oil and efficiency over the last two decades and rebounding demand following the global recession. This would create a price spike prompting drastic national measures to cut oil dependency.

5. ENERGY INFRASTRUCTURE WILL BECOME INCREASINGLY VULNERABLE AS A RESULT OF CLIMATE CHANGE AND OPERATIONS IN HARSHER ENVIRONMENTS

Much of the world's energy infrastructure lies in areas that will be increasingly subject to severe weather events caused by climate change. On top of this, extraction is increasingly taking place in more severe environments such as the Arctic and ultra-deep water. For energy investors this means long-term planning based on a changing – rather than a stable climate. For energy users, it means greater likelihood of loss of power for industry and fuel supply disruptions.

6. LACK OF GLOBAL REGULATION ON CLIMATE CHANGE IS CREATING AN ENVIRONMENT OF UNCERTAINTY FOR BUSINESS, WHICH IS DAMAGING INVESTMENT PLANS

Without an international agreement on the way forward on climate change mitigation, energy transitions will take place at different rates in different regions. Those who succeed in implementing the most efficient, low-carbon, cost-effective energy systems are likely to influence others and export their skills and technology. However, the lack of binding policy commitments inhibits investor confidence. Governments will play a crucial role in setting policy and incentives that will create the right investment conditions, and businesses can encourage and work with governments to do this.

7. TO MANAGE INCREASING ENERGY COSTS AND CARBON EXPOSURE BUSINESSES MUST REDUCE FOSSIL FUEL CONSUMPTION

The introduction of carbon pricing and cap and trade schemes will make the unit costs of energy more expensive. The most cost-effective mitigation strategy is to reduce fossil fuel energy consumption. The carbon portfolio and exposure of companies and governments will also come under increasing scrutiny. Higher emissions standards are anticipated across many sectors with the potential for widespread carbon labelling. In many cases, an early capacity to calculate and reduce embedded carbon and life-cycle emissions in operations and products will increase competitiveness.

8. BUSINESS MUST ADDRESS ENERGY-RELATED RISKS TO SUPPLY CHAINS AND THE INCREASING VULNERABILITY OF 'JUST-IN-TIME' MODELS

Businesses must address the impact of energy and carbon constraints holistically, and throughout their supply chains. Tight profit margins on food products, for example, will make some current sources unprofitable as the price of fuel rises and local suppliers become more competitive. Retail industries will need to either re-evaluate the 'just-in-time' business model which assumes a ready supply of energy throughout the supply chain or increase the resilience of their logistics against supply disruptions and higher prices. Failure to do so will increase a business's vulnerability to reputational damage and potential profit losses resulting from the inability to deliver products and services in the event of an energy crisis.

9. INVESTMENT IN RENEWABLE ENERGY AND 'INTELLIGENT' INFRASTRUCTURE IS BOOMING. THIS REVOLUTION PRESENTS HUGE OPPORTUNITIES FOR NEW BUSINESS PARTNERSHIPS

The last few years have witnessed unprecedented investment in renewable energy and many countries are planning or piloting 'smart grids'. This revolution presents huge opportunities for new partnerships between energy suppliers, manufacturers and users. New risks will also have to be managed. These include the scarcity of several essential components of clean energy technologies, incompatible infrastructures and the vulnerability of a system that is increasingly dependent on IT.

INTRODUCTION

“In some cases, the surprise element is only a matter of timing: an energy transition, for example is inevitable; the only questions are when and how abruptly or smoothly such a transition occurs. An energy transition from one type of fuel (fossil fuels) to another (alternative) is an event that historically has only happened once a century at most with momentous consequences.”

US National Intelligence Council 2008¹

The first part of this report sets out several trends propelling us towards a carbon-constrained world, these include: the dynamics affecting availability and demand for hydrocarbons; and the international climate change mitigation agenda. It considers the responses from government and industry in terms of renewable energy and carbon legislation, and the new risks emanating from technological change and climate instability. The second part explores the implications and associated risks of these trends for businesses in general, and for the energy sector specifically, in the coming decade.

The report looks at short-term (one to five years) and medium-term (five to ten years) risks to general business. It also considers longer-term (ten years plus) issues, particularly as they impact on technological and investment choices for the energy sector. While energy supply disruption is frequently the result of technical faults and strike action, we do not deal with this here, but concentrate instead on the impacts of constraints on carbon and carbon-based resources.

A new look at energy security

Historically, energy security has been understood as defence against supply disruption and price instability. Within this mindset, protecting the status quo is paramount. Yet dynamic trends, including the sharp rise in demand from newly industrialising economies, carbon-dioxide (CO₂) induced global warming and the growth of alternative energy technologies, mean that protecting traditional energy practices will make us far

less secure, and less competitive, in the future. This is in addition to the threat that climate change poses to energy infrastructure. These are not issues for the energy sector alone. The return to high and volatile oil prices after 2005 reinforced the link between energy prices, profits and economic stability for most businesses.

The looming climate challenge

Climate change creates many risks and uncertainties for society and industry. Anticipated disruption around energy, water and other critical natural resources pose new political, economic and human security challenges.

We know that to keep global warming to 2°C above historical levels requires a step-change in the way energy is produced, transported and used. But international progress has been slow. The Copenhagen Accord of 2009 lists actions that the governments of over 100 developed and developing countries propose to take to achieve this, but there is no binding legal commitment.

Until now, supply concerns and relations with energy exporters have tended to dominate national energy policies, but this is changing. Energy efficiency will be the mantra of governments trying to ensure both national security and CO₂ reductions, and energy users are increasingly central in this vision. Energy efficiency is also vital for economic competitiveness and insulates companies from the worst of the energy price volatility. On the supply side, renewable energy has moved into the mainstream and is now supplying the majority of new electricity in some regions. To increase efficiency and allow the uptake of more renewable energy, radically different infrastructures are being planned around the world. These may include local and transnational ‘smart grids’ that communicate with household and industrial appliances and electric vehicles, and can send power back into the grid to help regulate demand flows.

Why is it important for businesses?

Meeting the dual challenge of maintaining stable energy services in the short term, without jeopardising them in the long term, means reformulating ‘energy security’ as

'securing the transition to a low or no carbon economy'. This cannot be based purely on access to affordable units of energy, be it litres of fuel or kilowatt hour (kwh), but rather one which prepares for a long-term vision of efficient, clean, safe delivery of energy services to meet societal needs.²

At the global level, there is little sign that energy demand will go down, with business as usual forecasts suggesting a 40% increase by 2030. This will require \$26trn of investment - some 1.4% of global GDP.³ Given the global commitment to radically reduce emissions and the finite nature of conventional fossil fuel sources, a rapid movement towards a highly

efficient non-fossil energy future would seem to be the logical investment choice.

For energy businesses, the higher upfront investment costs, technological uncertainties and lack of confidence in the short-term economics (compared with conventional fuels) raise problems and risks. These include the dangers of changes in policy or higher costs associated with being a first mover. Businesses in the wider economy also need to be aware of the changing energy context their operations and supply chains will rely on. Businesses that can adapt their activities to benefit from emerging energy trends and manage the risks will gain an advantage over their competitors.

TRENDS

“Secure and reliable energy supply and infrastructure impacts the feasibility and costs of doing business from perspectives of competitiveness and productivity. Energy security is a vital consideration, not only for day-to-day operations, but also for long-term investment.”

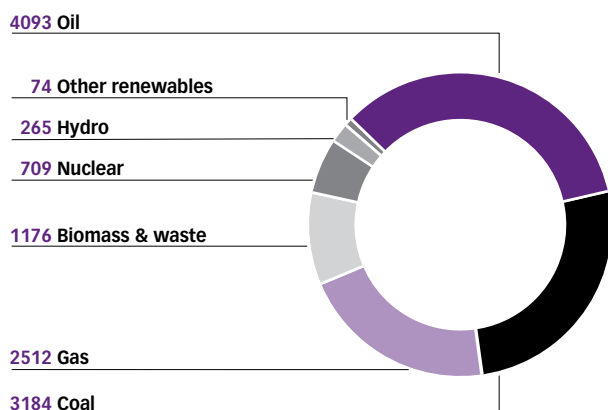
International Chamber of Commerce, 2007⁴

Today, the majority of our heating, power and mobility rely on extractive energy resources. Oil, coal, gas and uranium, account for around 90% of the world’s traded energy. Oil in particular, because it is widely traded on global markets and is the main fuel for transport, has been one of the drivers of global growth over the last century. With world population growth and pressure for higher standards of living in developing countries, demand for energy will reach new heights. But how long can we rely on these ultimately exhaustible and, with the exception of uranium, CO₂ emitting fuels?

The chart below (Figure 1) shows the contributions of different energy sources to global demand. It also highlights the importance of biomass (material from living or recently living organisms, eg wood or dung) and waste, which is often not traded but plays a vital role particularly in developing countries and rural areas.

Figure 1: **Global energy demand in 2007 (million tonnes of oil equivalent – mtoe)**

Source: International Energy Agency 2009



There is now widespread acknowledgement that we are in a ‘transition’ period heading towards less-polluting, more-sustainable forms of energy. Yet there are a variety of views as to what this involves, the duration, and to what extent hydrocarbons should be part of the energy mix. Added to this is the uncertainty around what will replace them. This involves scaling up new technologies and introducing completely different energy delivery systems. These changes will naturally impact jobs, profits, national economies and the environment, just as the dramatic increase in coal use during the industrial revolution and the onset of the ‘oil age’ did in the first part of the 20th century. This means that there will be push and pull factors from stakeholders. This will form the political context for many business transactions and operations over the next 30 years.

This section looks at the trends that will affect this transition in terms of changing energy demand and resource availability; climate change policies and the drive towards renewable energy; a technology revolution; and energy and transport infrastructure in a changing climate. While we cannot forecast exactly when and how this transition will take place, there are several indicators which business should be aware of. These are:

- Global energy demand is putting pressure on fossil fuel markets and increasing price volatility
- Past investment trends coupled with resurging demand suggest that an ‘oil supply crunch’ is imminent. This will lead to harsher national policies to restrain oil consumption
- Increases in policy and regulation to reduce carbon emissions are inevitable and will impact on the economic viability of current investments and operations
- Renewable energy has attracted an unprecedented upsurge in investment and been promoted into the mainstream energy mix in some countries
- The rapid deployment of new technologies brings new risks
- As the climate changes, our existing energy and transport infrastructure are vulnerable to extreme weather events.

1. THE CHANGING DYNAMICS OF ENERGY DEMAND AND RESOURCE AVAILABILITY

Several variables will influence demand for different fuels in the coming years. These include: the pace of economic growth in developing countries; technological development; and policies to augment energy security and reduce greenhouse gas emissions.

This creates risk for energy companies and natural resource owners who must invest large amounts of capital years in advance of expected returns. However, the obvious trends in the short to mid term are a huge surge of demand for all fuels from Asia, particularly China (see Box 1) a declining market for oil and coal in the Atlantic region and the increasing use of gas for electricity generation across the globe.

Energy exporters with comparatively low domestic pricing, such as those in the Middle East, are also increasingly significant as energy consumers. This will have a dramatic effect on where oil will go, where competition for oil resources will take place, and who has the power to balance the oil market in the coming years (see Box 2).

Box 1: China's global energy impact

Growth in China will impact upon the energy trade like no other country in the world. Currently China's energy consumption is dominated by domestic coal. In the electricity sector it provides 80% of the power. While the Chinese government aims to reduce its share in the mix, an additional 450 gigawatts (GW) of new coal-fired generating capacity is planned between now and 2030. In spite of China's massive coal reserves, the pace of growth is leading to significant coal imports. Recent Chinese commercial investments in Australian coal demonstrate this expectation. Domestic oil production in China is expected to peak in 2013, while demand could more than double by 2030. This would account for nearly half of the predicted global increase over the same period. Because of the toll the extra imports would take on China's foreign currency reserves and the volatility of the oil market, the government is keen to encourage alternative transport

fuels at home as well as securing long-term oil supply contracts at stable prices.

China is also becoming a major importer of gas, both through pipelines from Turkmenistan (and later Russia and Burma) and shipped liquid natural gas (LNG). By 2030, around 50% of the country's gas demand is expected to be met by imports. Energy security is resulting in strong policies to improve energy efficiency and develop renewable and nuclear energy. In the longer term, what happens in the areas of policy and new technology to reduce consumption in China, India and other developing countries will shape and catalyse the energy transition in the rest of the world.

Energy is a globalised commodity. Sudden demand pressures for certain fuels in one place, coupled with previous inadequate investment in the necessary resources elsewhere, will push up prices on the international market. As traditional Organisation for Economic Co-operation and Development (OECD) countries decline as oil consumers, so will their power as rule setters in the international oil market. For example, Chinese strategic oil stocks (not yet included in the International Energy Agency's security mechanism) will become vital to balancing global markets.

Before new models of international energy governance are developed, insecurity will encourage strategic investments by the most import-dependent countries. Together with policies to reduce subsidies and increase efficiency, these trends will drive up final consumer prices for transport, fuel, heat and electricity in the short to mid term.

While price rises will vary from country to country (see Box 5), all businesses will be affected through their own exposure to energy costs or that of their suppliers. The more efficient will have an important competitive advantage in times of high and volatile energy prices, especially in energy-intensive sectors or where supply chains are sensitive to energy costs.

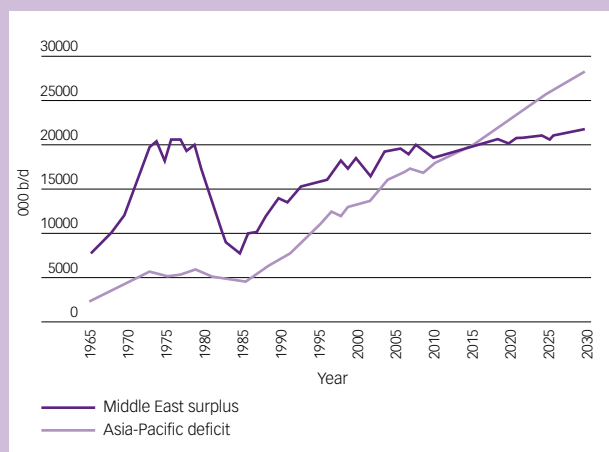
Box 2: A change in the energy market balance between East and West

Advanced economies remain the biggest consumers of primary energy per person but by 2008 non-OECD countries led by China and India had outstripped them in terms of the share of world demand.⁵ This shift began in the 1990s, partly because manufacturing shifted eastwards. Meanwhile, lower population growth, de-industrialisation, greater efficiency, higher fuel prices and a concern for the environment are lowering demand for oil-based fuels and coal in the OECD.

These consumption trajectories mean there is likely to be a tipping point in 2015 when countries in Asia-Pacific need more imported oil in total than the Middle East (including Sudan) can export.

Figure 2: Middle East oil surplus vs Asia-Pacific deficit

Source: John Mitchell, Chatham House 2010



West Africa, Eastern Russia, Central Asia and Northern Iraq are becoming 'pivot zones' which can export to both western and eastern markets. These are already centres for competition and collaboration between western and Asian (usually state-backed) companies.

Box 3: Geopolitics of Energy

Competition among states for access to resources and the impact of energy trade on the international balance

of power are not new, but the changing growth dynamics have introduced new actors and relationships to the game. Key 'hot spots' include:

- African countries, where the industrialised and industrialising world increasingly view resources as ripe for taking. For example China, is reported to have invested up to \$50bn in the past decade on accessing raw materials in Africa, including uranium reserves in Niger, oil interests in Southern Sudan and bauxite concessions in Guinea. Former US Vice President, Dick Cheney said: "Along with Latin America, West Africa is expected to be one of the faster-growing sources of oil and gas for the American market."⁶
- Countries in Central Asia, which have become a key area for competition amongst Russian, Chinese and western oil companies. Turkmenistan in particular will be crucial for the diversification of gas for both China and the EU.
- The Middle East, whose dominance in global oil and gas supply is growing, as other resources deplete – see Box 2.
- Russia, a vital energy supplier, not only to Europe, but also to East Asia. Currently, the EU depends on Russia for 33% of its imported oil and 42% of its gas, with growing dependency in both sectors. Sales of gas and oil to Asia are increasing with the construction of new pipelines, including the 4,700km East Siberia-Pacific Ocean oil pipeline, which reached China in 2009. This diversification of customers gives added security and influence to Russia.

The following sections look at the demand trends for coal, gas, oil and uranium, and how they might be met, with special attention to effects on the price of oil.

1.1 The resurgence of coal

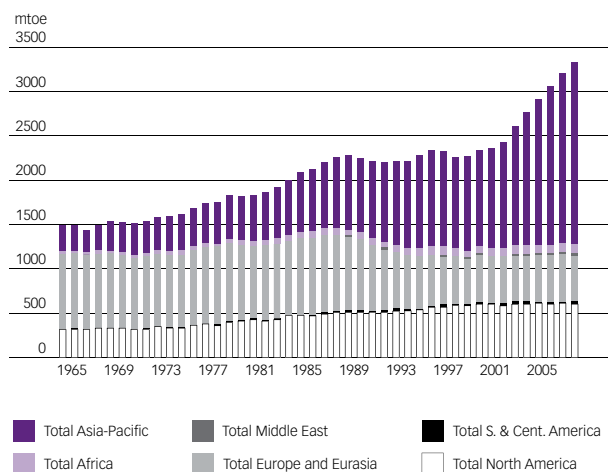
In spite of high CO₂ emissions per unit of energy (two to three times more CO₂ than natural gas when burned in conventional thermal power plants), coal is the

fastest growing fossil fuel. Demand for coal for electricity generation in places with large national and usually cheaper reserves (like China and the US) is rising. This illustrates the clash between policies to keep the cost of energy down and reduce dependence on foreign imports by using cheap domestic resources and policies to mitigate climate change, which may be more expensive in the short term and require resource imports, such as gas or technologies.

Figure 3 shows the extent of the growth that is driven by increases from South East Asia. Between now and 2020, 546 GW of new coal-fired power generation is planned in Asia - more than double that currently deployed in the EU.⁷ China and India lay claim to the world's third and fifth largest coal reserves respectively, yet they are consuming coal faster than they can develop domestic mines. In the last five years, China has gone from being a significant exporter of thermal coal to a net importer.⁸

Figure 3: **Historical coal consumption in major world regions (mtoe)**

Source: BP Statistical Review of World Energy 2009



The supply outlook

While estimates suggest coal reserves are plentiful,⁹ a gap in supply may arise as a result of sharp demand rises in Asia before new extraction projects are completed. There will be strong expectation from Australia and Indonesia who provide around half of global exports, and there are doubts about the ability of these countries to expand exports fast enough.

Prices will rise in response to demand surges, with knock-on effects on electricity prices in other coal-importing countries. For example, wholesale electricity prices in the UK rose by 66% between 2007 and 2008 – due not only to the rising price of gas, but also higher world coal prices affected by China's import demand.

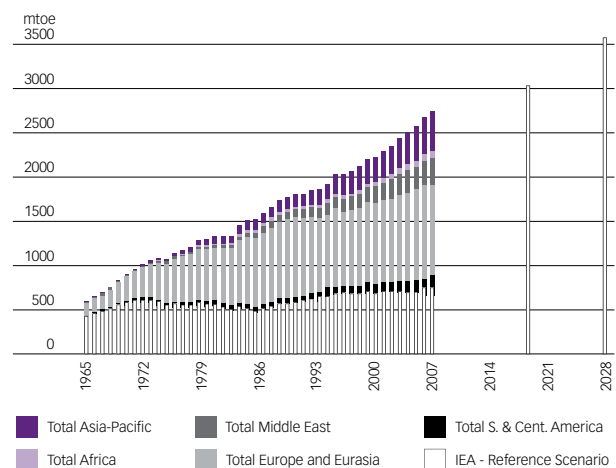
Given transportation difficulties, shortages of coal stocks at power plants are also likely to cause more frequent power disruptions in emerging economies (see also 4.2).

1.2 Gas as the 'transition fuel'

Many countries plan to increase the share of natural gas in their national energy mixes as it has lower emissions than coal and oil and is more versatile (eg it can replace coal as a fuel for electricity generation and oil-based transport fuels in gas-to-liquid and compressed forms).

Figure 4: **Growth in global natural gas consumption and future projections (mtoe)**

Source: BP Statistical Review of World Energy and IEA WEO 2009



Uncertainty surrounds the supply and demand for gas in Asia and, in particular, China over the next decade. The Chinese government projects a tripling of current consumption to 300 billion cubic metres by 2020. Given the lengthy negotiations over routes from Russia's far east gas fields it is hard to tell how much will be politically or economically possible via pipeline, and how much China will rely on the LNG market. The EU is also planning to increase imports of LNG as a diversification strategy.

The supply outlook

Recoverable reserves of natural gas are enough to meet world demand for heat, power and petrochemical uses to at least 2030, according to the IEA. But production equal to that of two Russias would need to come on-stream by then just to make up for the decline in existing fields.¹⁰ Over half of conventional natural gas resources are concentrated in three countries Russia, Iran and Qatar, and there are political, geological and technological obstacles that may restrict international supplies in the short to medium term.

Two developments are counted on to ease gas supply constraints, the greater use of liquefied natural gas and the exploitation of shale gas. Until recently, getting gas from reserves to markets was limited by the direction and feasibility of pipelines. LNG, which can be transported by sea allows a more fluid trade and greater security options for gas-dependent countries.

The recent exploitation of shale gas is adding to global supplies by alleviating the need for imports of gas to the US, and may do the same for other regions (see Box 4). This has led to a gas glut in the global market, discouraging investment in LNG.

Box 4: What can we expect from shale gas?

“A major new factor – unconventional natural gas – is moving to the fore in the US energy scene...it ranks as the most significant energy innovation so far this century. It has the potential, at least, to cause a paradigm shift in the fuelling of North America’s energy future.”

HIS-CERA 2010¹¹

Unanticipated technological developments dramatically increased the availability of non-conventional (mostly shale) gas in the US last year. In 2000, non-conventional gas provided just 1% of total gas supply, but by 2009 it had reached 20%. Forecasts suggest this will reach 50% by 2035. As natural gas prices fell in the US, demand for LNG

fell internationally and volumes destined for US import were redirected to other (mainly Asian) markets. But the full impact is highly uncertain. Production from shale gas wells seems to peak much faster than conventional gas, and data is limited. Assessments of the Barnett wells in the US using horizontal drilling showed that most of the recoverable gas is extracted in the first few years.¹²

Is the US experience set to become a global phenomenon? Some suggest that resources in OECD Europe are large enough to displace 40 years of imports of gas at the current level, assuming recovery rates in line with those in North America.¹³ Exploration is already under way in Europe (including in France, Germany, Poland and the UK) to assess this potential.

1.3 Oil consumption driven by transport and price

Global oil demand will grow in the medium term. But recent demand trends vary regionally. China, India and the Middle East show high rates of oil consumption growth (6% to 10% a year), while consumption in the OECD declines at around 1% a year.

In the developing world, increasing car ownership and subsidised fuel prices will continue to drive up oil demand in the next few years. Whereas fuel efficiency standards, taxed fuel prices and alternatives, including biofuels, reduce demand in the advanced economies. Peak oil demand (the suggestion that reductions in demand as a result of policy, technology and behavioural changes will occur before any geological driven change) is a distinct possibility in the longer term.

Unsustainable consumption trends are forcing many countries, particularly oil exporters, to rethink their energy pricing and subsidy systems to encourage greater efficiency (see Box 5). Strong policy measures here, and the uptake of new vehicle technology in major markets, such as the US and China, could set oil-fuel consumption on a downward trajectory.

Box 5: The impact of government policy on energy pricing

National taxation or subsidisation is a major factor determining the price of fuel at the pump and power at the plug. For example, in Europe the wholesale price of diesel fuel is relatively constant across the EU at about €0.6 per litre, and the final price varies from around €1 to over €1.4, depending on the tax.¹⁴ However, in China the final price would be around €0.75, in India €0.52 and in Saudi Arabia €0.7.

Governments that tax domestic energy become dependent on the revenue, which makes them reluctant to reduce it in the event of higher international prices. Governments that do not tax energy, or that subsidise it, are under pressure to raise prices when the international price is high. This is for various reasons: to encourage greater efficiency; to lower dependency on energy imports; to reduce the subsidy bill; or to free up more energy resources for export. For example, the Chinese government doubled prices for gasoline and diesel between 2004 and 2008, and the Egyptian government recently committed to phasing out energy subsidies for industry by 2011.

The supply outlook

Despite the global importance of oil (the most widely used fossil fuel) there is disagreement on how much will be available to meet future demands. There are basically three positions on this:

- Using advanced technologies will allow us to carry on producing enough oil for generations, particularly from non-conventional sources, such as oil sands and shale.
- Oil production will reach its peak level and go into irrevocable decline sooner than we are prepared for, with catastrophic effects on our societies and economies.
- There may be plenty of oil in the ground but above-ground factors such as cost, willingness to invest and political barriers will constrain its production.

Box 6: Oil research - below ground constraints

“Peak oil presents the world with a risk management problem of tremendous complexity.”

US Department of Energy 2007¹⁵

A vast array of studies have attempted to predict the time at which global oil production will reach a maximum level, from which point it will go into irrevocable decline. Some suggest that this ‘peak’ has already occurred, while others maintain it is either impossible to predict or shows no sign of appearing. Looking further than a decade into the future presents many uncertainties, including: the availability and cost of extraction technologies; substitute technologies; pricing systems in major economies; and carbon legislation.

A comprehensive two-year study by the UK Energy Research Centre completed in August 2009 found that a peak in conventional oil production before 2030 appears likely, and there is a significant risk of a peak before 2020. With average rates of decline from current fields, the report says that just to maintain current production levels would require the equivalent of a new Saudi Arabia coming on-stream every three years. What’s more, giant fields pass peak production levels and there is a shift to smaller, more difficult to produce fields that have faster depletion rates meaning the rate of decline will accelerate.¹⁶

This uncertainty makes it hard for governments and businesses to plan the move away from oil. A report produced for the US Department of Energy highlighted the economic chaos that would result from the onset of declining oil production as global demand continued to rise. It recommended “a mitigation crash program” involving a radical overhaul of the transportation system at least 20 years before peaking. Yet it acknowledged that enacting such policies and paying for it with tax-payers money would be difficult without clear evidence for the peaking date.¹⁷

Even before we reach peak oil, we could witness an oil supply crunch because of increased Asian demand. Major

new investment in energy takes 10-15 years from the initial investment to the first production, and to date we have not seen the amount of new projects that would supply the projected increase in demand.¹⁸

- The IEA projections assume that additional supply from the Organization of the Petroleum Exporting Countries will largely fill the gap between declining non-OPEC production and rising world demand. But this implies the willingness and ability of those countries to invest or attract foreign investment into their oil sectors. The evidence reveals a serious lack of investment relative to demand growth throughout the 1990s, and a subsequent fall in the rate of discoveries. A look at the forecasts and actual outcomes for both OPEC crude capacity and non-OPEC production show that country targets and IEA expectations over the past decade have generally gone unmet.¹
- In the wake of the oil price crash of 2008 and the subsequent global financial crisis, over 20 planned large-scale upstream oil and gas projects were deferred indefinitely or cancelled.¹⁹

Production from Iraq is the wild card. The current target of 12 million barrels a day by 2016 would make Iraq the world's number one producer, potentially increasing global spare capacity and sending the oil price down. However, numerous legal, security and administrative problems hinder this development.

Box 7: Unconventional fossil fuels: prospects and problems

The constraints on access to conventional fossil fuel reserves, namely oil and natural gas, have led to the expansion of the exploitation of the so-called unconventional fossil fuels.

The primary differences between conventional and unconventional petroleum liquids are the density of the

liquid and how easily it flows. Petroleum or conventional oil is found in liquid form and flows naturally or is capable of being pumped without being treated.

Unconventional oil, including very heavy oil, oil sands, and tar sands (bitumen), has a high viscosity. It flows very slowly and requires processing or dilution to be extracted through a well bore. Very heavy oil in Venezuela, oil sands in Canada, and oil shale in the US account for more than 80% of unconventional resources.

While some oil companies have invested large amounts in non-conventional oil, there are a number of limiting factors, including: environmental impacts; capital and operating costs; and the energy balance of the whole operation (how much energy is required to extract, process and transport the fuel compared to the final product).

Unconventional natural gas resources include tight sands, coalbed methane, and gas shales. The primary difference between these and conventional gases is the reservoir in which the gas is located. To extract these gases requires hydraulic fracturing (use of pressurised liquids to crack the rocks) of the host reservoirs.

The costs, environmental impact and security implications of these options differ and are at the centre of fierce debates about the trade-offs between climate and energy security. For example, CO₂ emissions from oil sands are at least 20% higher than for oil currently consumed in the US.²⁰ This is because the energy input (usually in gas) needed to get the oil out is around three times as much as for conventional oil. It also takes three barrels of water to produce each barrel of oil, most of that being too toxic to return to the rivers.²¹ Emissions from shale oil are likely to be higher and those from coal to liquids are at least double the levels of those from conventional oil-based fuel. Gas to liquids would produce emissions some 10% to 15% higher than those from conventional petrol or diesel.²²

¹ For example, plans such as the development of Kuwait's northern oil fields has been delayed for over 15 years due to ongoing parliamentary obstruction to foreign participation.

The May 2010 Deepwater Horizon rig explosion and oil leak in the Gulf of Mexico has highlighted the problems with difficult to reach oil. Operating at depths of 5000 feet below the surface has been technically challenging, which is all too graphically demonstrated by the inability of the companies to stem the vast amounts of oil (with estimates ranging from 5,000 to 60,000 barrels per day) that are gushing out.

The long-term impact on the environment, the companies involved and the sector as a whole is difficult to predict. One commentator likened the accident to Three Mile Island: "The real legacy of Three Mile Island wasn't what happened back in 1979, but rather what happened - or more precisely didn't happen - over the course of the next 40 years in the US. Literally overnight, the near-meltdown of the reactor core changed public acceptance of nuclear power plants. No company in the US has built a new one since."²³ Already President Barack Obama has suspended his recent decision to open new offshore areas for oil development and has declared a moratorium on new drilling.

Supply constraints will drive up the price of oil

"A supply crunch appears likely around 2013...given recent price experience, a spike in excess of \$200 per barrel is not infeasible"

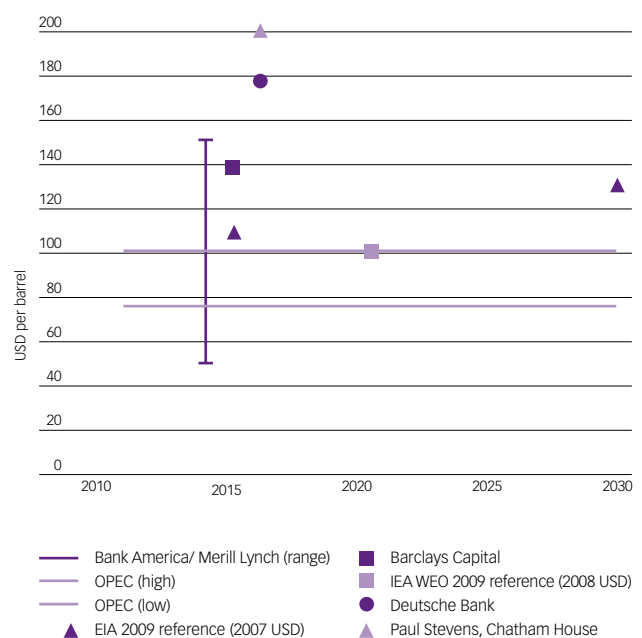
Professor Paul Stevens, Chatham House²⁴

Oil price changes affect the price of other types of energy, particularly natural gas, and many aspects of the economy, for example: mobility; transported goods, including essential foods; importing government tax revenues or subsidy costs; and exporting country investment income. The global impact of higher oil prices on the economy was illustrated by the global recession of 2008-2009.²⁵ Given the expense of extracting unconventional and difficult oils, the cost of oil is likely to rise. The question is when and by how much. Although

there is a huge variety of opinion on how high the oil price will rise, and when it will reach these figures, most commentators agree that the trajectory is upwards (see Figure 5).

Figure 5: **Range of oil price forecasts**

Source: Chatham House, listed sources.



A price spike, inevitable if the supply crunch described above takes place, would prompt government action to make legal and infrastructural changes that would lead to a declining demand for oil.²⁶

1.4 Uranium

To meet energy and climate security objectives, many countries are planning new nuclear power plants. At present, these depend on uranium - also a finite resource. Estimates from the OECD assume that, at current prices, the economically viable reserves for uranium (assuming the same level of nuclear production) will last for around 80 years. If the number of reactors increases as suggested by some, other fuel sources and technologies would need to be added to increase the longevity of nuclear power (see Box 8).

Box 8: The progress of nuclear power

Nuclear power has been in commercial operation for over 50 years and currently provides around 14% of the world's electricity. There are 444 reactors in operation in 30 countries, mainly in the OECD. Over the past two decades the use of nuclear power has not increased significantly and in fact the global peak for reactors in operation was in 1989. This lack of growth is the result of a combination of factors, including: cheaper natural gas; higher investment costs than alternatives; public opposition; slower growth in electricity demand; and the closure of the oldest reactors. However, some regions of the world, particularly Asia, have active and fast growing nuclear power construction programmes.

The current generation of reactors is fuelled by uranium; future designs are likely to diversify as a result of mineral constraints. This may include thorium, while international

programmes are also underway to develop so-called Generation IV reactors, which use plutonium fuels. While the diversification of fuel sources increases supply security, it also brings new technical problems and heightens proliferation concerns.

Fusion is another type of nuclear power being developed. This releases energy by combining atoms, rather than splitting atoms (nuclear fission), which occurs in existing nuclear power plants. A large, international demonstration facility, the International Thermonuclear Experimental Reactor (ITER), is under construction in France and was originally scheduled for completion in 2018. However, it is currently over budget and delayed.

2. CLIMATE CHANGE AND THE DRIVE TOWARDS RENEWABLE ENERGY

The threat of man-made climate change and supply security concerns is challenging the relative competitiveness of fossil fuels in terms of cost, environmental impact, energy output and access. This is driving the rapid deployment of renewable energy technologies, which hold the promise of energy generation free of greenhouse gas emission, with virtually infinite inputs that are often available domestically. As President Obama said in his State of the Union address in February 2010, "We know the country that harnesses the power of clean, renewable energy will lead the 21st Century." Renewable energy solutions can help diversify the energy portfolio of many businesses, bringing added price and supply security in the long-term while adding to a company's sustainability profile.

Box 9: Renewable energy

There are a large variety of sources of renewable energies that are available in different concentrations all over the world. These include:

- Heating and cooling: passive solar architecture; solar thermal collectors; biomass-based combined heat and power; and geothermal energy.
- Electricity: solar photo-voltaic; solar thermal; hydro; solid biomass; biogas; geothermal; on and offshore wind; marine energies like sea current, wave and tidal energies.
- Transport (internal combustion-based): bioethanol; biomethanol; oils from biomass; and biomass-based synthetic fuels.

Until the last decade, the commercial renewable energy field was dominated by hydropower for electricity,

biomass for heating, and solar thermal for hot water. However, the commercial strength of onshore wind has led to unprecedented growth in this area in a number of regions. This trend is likely to continue, as will the development of solar power for electricity production. The use of biofuels as a transport fuel remains controversial, due to the impact on food prices, land use and water consumption. If the use of biofuels is to be expanded, it is likely to require rapid technology innovation and the use of non-food sources for fuel, such as algae.

The most common critique of wind and solar power is that they both rely on intermittent sources. This means that thermal or nuclear capacity is still needed as back-up to compensate for times when the wind doesn't blow or the sun doesn't shine. Solutions are being developed which involve storage and 'super' smart grids and which will enable far greater efficiency and transfer of excess electricity across borders (see also Box 19).

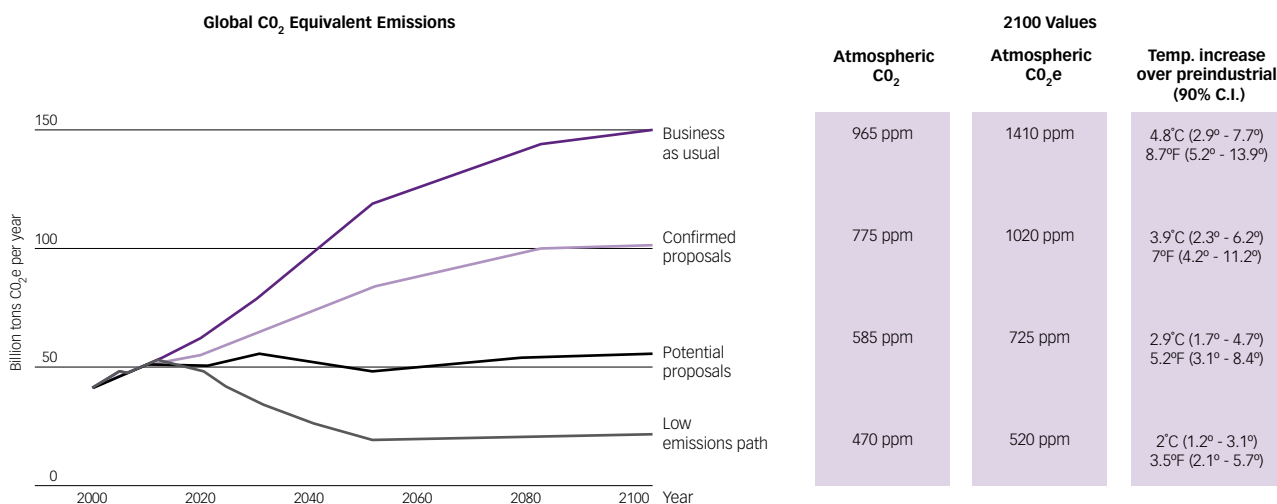
For the majority of the world's scientific community, one of the greatest challenges that the human race faces is how to avoid global temperatures rising by 2°C over pre-industrial levels.¹¹ Developed countries will have to make sharp emissions cuts and move close to a zero-carbon economy by 2050, with major developing countries following suit well before the end of the century.

A 50% global reduction by 2050 implies average global emissions of around two tonnes of CO₂ per person (less than half the present Chinese level, a fifth of the level in Europe and a tenth of that in the US). This implies a transformation in the way we live and the way governments regulate our activities, particularly in relation to industry, transport and buildings.

¹¹ A concentration level of 450 ppm CO₂ equivalent would maintain a 50% chance of staying below 2°C, with a 400 ppm CO₂eq providing a greater than 50% chance. To achieve either of these targets, global emissions would need to be at least 50% below 1990 levels by 2050. This would imply cutting developed country emissions to at least 30–35% below 1990 levels by 2020, while allowing developing economy emissions to grow until 2010 or 2020, but reducing them substantially thereafter.

Figure 6: **Impact of Copenhagen Accord on global emissions**

Source: Climate Scoreboard, 2010 ²⁷



Box 10: The failure of Copenhagen to set a 2°C pathway

Despite great expectations, the Copenhagen Summit in December 2009 did not lead to a binding international treaty on global greenhouse gas emission reductions. The Copenhagen Accord did create a framework in which national low-carbon pledges are monitored, even though these do not yet pave the way for the 2°C scenario. Figure 6 describes the shortfall and points to the potential increase in global emissions that could lead to a rise of 3°C to 4°C by 2100.

The outcome is seen by many in the private sector as a missed opportunity. Without clearer and stronger domestic policies in key markets, it is unclear whether there are sufficient drivers for large-scale renewable investment and deployment. At the same time, the weak outcome from Copenhagen has revitalised discussion around carbon leakage and addressing it through border measures. Unilateral action to impose border tax adjustment outside any global climate agreement is likely to prompt trade-related retaliatory actions, undermining the global trading system.

To achieve the 2°C target (by the IEA’s calculation) countries and markets must stimulate opportunities in low-carbon and energy-efficient investments across the globe and generate \$30trn of investment in the next two decades.²⁸ This requires a massive increase of investment in both efficiency and the renewable and clean energy sector.

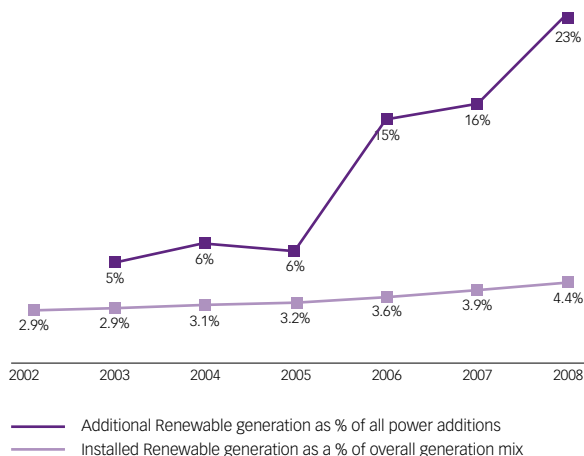
According to Bloomberg New Energy Finance, the extent of global investment in clean energy sources reached \$112bn in 2009, up from just \$18bn in 2004. Only strong policy incentives will promote renewable energy activity under existing market conditions. This is often described as a ‘market failure’ in need of market mechanisms or policies that factor in the environmental cost of higher emitting fuels or subsidise cleaner ones, as a public good.

Lack of confidence in the binding nature of national renewable energy targets or incentive mechanisms has hampered the growth of the sector. But where there is political will, investments are taking place. By 2008, nearly a quarter of all new electricity generation was from renewable sources in Europe. In 2009, wind

power installations accounted for 39% of new power installations, the second year running that more wind power was installed than any other generating technology. Renewable power installations in general accounted for nearly two-thirds of new installations in Europe in 2009.

Figure 7: **Global growth of renewable energy in the power sector (excluding large hydro)**

Source: UNEP et al., "Global Trends in Sustainable Energy Investment 2009", 2009



The success of wind power is not confined to the OECD countries in manufacture or deployment. In 2009, China became the world's second largest installer of wind power and the largest manufacturer. It has now set targets to deploy 100 GW of wind power by 2020. Similarly, India has a strong wind industry, with rapid developments also taking place in Africa and Latin America. This global production will further reduce costs and drive forward technological innovation.

Renewable energy is also making a growing contribution in the transport sector. Given the virtual monopoly of oil in aviation and road transport, there are strong industrial efforts and government mandates for the production and deployment of biofuels. In Western Europe, the EU has set a binding target of least 10% of liquid transport fuels to come from renewable energy sources by 2020 - most of this is expected to come from biofuels. The US has seen a

doubling of production in the last five years. This equates to around 5% of US transport fuel.

Electric vehicles, which could encourage renewable electricity generation through their capacity for storage, are also generating a high level of interest. China is deploying large volumes of electric motorbikes and is seen both as a centre for manufacturing and a market.

Box 11: The Carbon Reduction Commitment and the building trade

As part of the UK government commitment on climate change it launched the legally binding Carbon Reduction Commitment and the Carbon Disclosure Project in 2009. It requires companies that pay more than £500,000 a year for electricity to report on carbon emissions from all energy sources consumed by fixed installations. This affects not only the standards that construction companies work to but also creates a market for them, especially among large companies for whom the only way to reduce the emissions from their operations is to make their buildings more energy efficient. It provides the demand for energy efficient fit out and refurbishment services which many of the bigger construction companies have diversified into: "The CRC is having an impact on many large UK companies because it increases the cost of carbon, increases the risk of fines associated with incorrect reporting, and also introduces a performance league table for publicly rating companies on their carbon reduction," said Liz Collett, Group Environment Manager with Morgan Sindall Fit Out. "Morgan Sindall has to report in the CDP both as a company in its own right and as a supplier to Government departments - so the client pressures for reporting are increasing."

3. THE RISKS ASSOCIATED WITH A NEW TECHNOLOGY REVOLUTION

The transformation of the energy sector has been described as the ‘third industrial revolution’.²⁹ It will challenge all aspects of energy services: from energy sources and storage; to user-technologies, such as lighting, vehicles and electric motors; and infrastructure. Available technologies can deliver a large part of the necessary changes, especially in the field of energy efficiency, but new ones will need to be developed, tested or scaled up to meet this global challenge. Below we set out some emerging material, environmental and security risks that businesses will need to take into account as new energy resources and technologies are developed.

3.1 National and international policy risks

In spite of broad international agreement on the importance of inventing and deploying technologies at scale to meet energy and climate security goals, progress has been too slow. Uncertainties around domestic and international regulations and pricing structures can stall investment, discourage collaborative projects and generally dampen investor confidence. For example, inconsistent policies have entrenched a pattern of boom and bust in the renewable energy and efficiency industries in many parts of the world, including the US.

Enacting policies and freeing up the necessary finance for technological transformation is even harder in the context of the global financial crisis and volatile energy prices. Technology developers worry about recouping their investment in R&D and losing their intellectual property. Naturally, all businesses worry that government subsidies, tax breaks or funds might favour their competitors and disadvantage them. Uneven deployment of technologies across the world is inevitable, with breakthroughs occurring in those countries where there is most encouragement, and consistency, in terms of policy frameworks and market signals.

3.2 New scarcity risks in some raw materials

As demand for certain technologies rises, so will the demand for their raw material components - some of which are rare (see Box 12 on rare earth metals). The availability and price of these materials will determine the prospects for large scale commercialisation. Table 1 gives some examples of new energy technology fields and the materials used in their manufacture.

Table 1: **Material use on new energy sources**

Source: Materials Innovation Institute, November 2009³⁰

	Raw materials (application)
Fuel cells	Platinum Palladium Rare earth metals Cobalt
Hybrid cars	Samarium (permanent magnets) Neodymium (high performance magnets) Silver (advanced electromotor generator) Platinum group metals (catalysts)
Alternative energies	Silicon (solar cells) Gallium (solar cells) Silver (solar cells, energy collection / transmission, high performance mirrors) Gold (high performance mirrors)
Energy storage	Lithium (rechargeable batteries) Zinc (rechargeable batteries) Tantalum (rechargeable batteries) Cobalt (rechargeable batteries)

The demand for these minerals has prompted more research into their availability. This is leading to an increase in reserves in the case of some, but not all, minerals. One study that looked at 57 cases of mineral extraction detected a clear production peak in 11 of these. This included zirconium, the extraction of which is in decline despite demand and rising prices.³¹ Companies pursuing technologies which rely on these and other limited mineral resources will need to consider the ability to re-use or recycle the material or to substitute for alternatives.

Box 12: Rare earth metals

Rare earth metals (REMs) are a group of 17 elements whose unique properties make them indispensable in a wide variety of advanced technologies. They are an important example of material scarcity in the 'third energy revolution', because they are indispensable for so many of the advanced technologies that will allow us to achieve critical national objectives.³² As such, disruption to their global supply is a new energy security concern.

Their production, alongside the metals and magnets that derive from them, is dominated by one country, China. At present, China produces 97% of the world's rare earth metals supply, almost 100% of the associated metal production, and 80% of the rare earth magnets.

REMs such as neodymium are the world's strongest magnets and are key components for more efficient wind turbines, each of which requires about two tonnes. They are also important in enabling the miniaturising of electronic equipment; consequently demand grew between 15% to 25% per year from 2003 to 2008.³³

3.3 Competing resource uses

The production of energy can compete with resources previously destined for other uses. Two well known examples are the production of first-generation biofuels and the development of coal to liquids, both being developed primarily to combat security of supply concerns around oil.

The growth of the current generation of biofuels is expected to slow due to environmental concerns and the impact of such large-scale production on land use and food prices. These concerns have accelerated the development of the next generation of biofuels, which will no longer use potential food sources for the production of ethanol (such as wheat), but farm waste instead. These could become more widespread in the next couple of years.³⁴ Commercially viable third-generation biofuels from specially farmed plant forms, such as algae, are at the research stage.

3.4 New environmental risks

The development of new technologies can bring immediate or longer-term adverse environmental impacts. The industrial landscape is littered with technologies that have been widely used and then abandoned because of their effect on the environment (eg DDT or asbestos).

There are numerous environmental liability concerns relating to major new energy infrastructure, such as nuclear power stations, and carbon capture and storage (CCS) facilities for adapting fossil fuel generation. For example, for CCS to be effective it must contain the CO₂ for at least a few centuries until we develop a way to neutralise its effects on the atmosphere. However, it is likely that the companies engaged in the storage will either cease to exist or will change ownership over this period. The legal mechanisms which will be put in place to ensure adequate accountability in the eventuality of system failure is a crucial issue for the industry.

4. RISKS TO ENERGY AND TRANSPORT INFRASTRUCTURE

Energy generation, extraction, refining, processing and distribution depend on a complex, interlinked, expensive (and sometimes global) infrastructure. Yet much of that infrastructure lies in areas that could be increasingly subject to severe weather events caused by climate change. Energy businesses owning or planning infrastructure now will need to ensure they are resilient to a changing climate, taking account of more frequent unusual weather events and more extreme seasonal fluctuations.

4.1 Power sector risks

Energy infrastructure tends to have a long lifespan. The Hoover Dam in the western US was completed in 1935 and is still an important hydroelectric generator. New sites for refineries, coal power plants and high-voltage transmission lines are likely to be resisted by local communities and therefore replacements are often built on the same locations. This means that sites chosen in the 1980s may still be in operation in 2080 and beyond.

Water flows are fundamental for agriculture, power generation and cooling. Hydropower contributes around 15% of global electricity production, by far the largest of any renewable energy. It relies on the ability to predict the volume of water entering the system. Before construction, care is taken to assess river levels, hydrological cycles and precipitation patterns. Until recently those findings were considered to be constants. However, climate change is expected to cause accelerated changes in the rainfall patterns and what were constants are now becoming variables. This can cause problems for both glacier-dependent and precipitation-dependent power plants.

In Europe, cooling for electrical power generation (including both nuclear and fossil fuel plants) accounts for around one-third of all water used. During Europe's

record-breaking heat wave of 2003, temperatures across the continent reached more than 40° Celsius. As a result, France had to power down 17 nuclear power plants, because of heat and water problems. In 2006, France, Spain and Germany all had to power down nuclear plants for the same reasons. The UK Met Office's Hadley Centre for Climate Change predicts that, by 2040, such heat waves would be 'commonplace'.³⁵

4.2 Changing risk landscape for transport routes

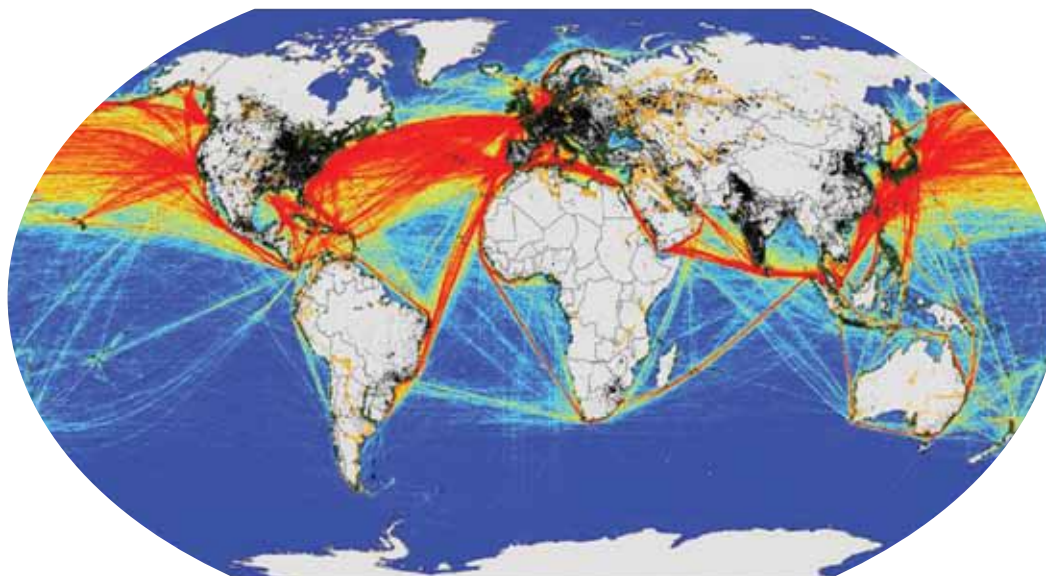
Environmental change (extreme weather events, water shortages, changing sea levels and melting glaciers) will generate great threats to critical infrastructure and to transport routes that underpin traditional energy production and delivery systems. The map below (Figure 8) illustrates the density of a handful of shipping lanes upon which global energy trade depends.

All of the world's largest energy importers are dependent on sea imported oil. The US imports 60% of the oil it consumes (over 95% delivered by tankers) while the growing markets of China and India import 90% by sea. Japan is almost completely dependent on maritime oil imports. The traffic is increasing as countries require greater energy imports further from their markets. For example, both China and India are importing coal from Colombia for the first time in 2010 and bottlenecks at the Australian port of Newcastle in 2007 and 2008 kept coal vessels waiting for weeks restricting supply and contributing to the increasing price of deliveries to thermal power stations.

The development of Arctic resources will create new and riskier shipping routes. Climate change will bring rising tides and more frequent extreme weather events that could increase shipping accidents and damage ports.

Figure 8: **Global shipping routes, pipelines and world ports**

Sources: Hadley Centre (2010), NCEAS (shipping routes1), FAO (ports2), GIS-Lab (pipelines3), NOAA (night-time lights)



Energy Infrastructure



4.3 Oil and gas infrastructure

As accessible oil and gas sites are depleted, more difficult offshore and coastal sites are becoming more significant. Offshore and coastal oil and gas extraction is carried out under a wide range of conditions, from the tropics to the tundra.

Over a quarter of US oil production and close to 15% of US natural gas production comes from the Gulf of Mexico. In the summer of 2005, Hurricane Katrina shut off what amounted to around 19% of US refining capacity, damaged 457 pipelines and destroyed 113 platforms. Oil and gas production dropped by more than half; causing a global spike in oil prices. Much of the infrastructure destroyed in 2005 was rebuilt in the same location, leaving it vulnerable to similar weather events in the future.

The US Geological Survey estimates that the Arctic might contain over a fifth of all undiscovered oil and

gas reserves.³⁶ Siberia could contain as much oil as the Middle East.³⁷ However, dreams of a resource bonanza in the north are premature. The environment is difficult and becoming increasingly unpredictable as a result of the changing climate. The thawing of permafrost in the north is already causing infrastructural damage and reportedly costing Russia around \$1.9bn a year to repair infrastructure and oil and gas pipelines in West Siberia.³⁸

Many of the challenges outlined above can be overcome with sufficient research, planning, engineering and financing. In some cases it may even be possible to integrate change into planning in such a way that energy output increases with changes rather than decreases. For example, hydro installations in regions that are expecting higher rainfall could be designed to eventually take advantage of that excess flow, rather than be overwhelmed by it.

CHALLENGES AND RISKS

FOR GLOBAL BUSINESSES

“Predictable supply of energy is one of the top policy priorities for business and governments in the major global economies.”

Business and Industry Advisory Council to the OECD - 2006³⁹

The constraints on carbon in terms of resource availability, price, policy and the move to a low-carbon economy will have a huge impact and risk implications for businesses, both within and outside the energy sector. This section looks at the implications of the trends outlined above for businesses in general, as well as the energy sector specifically. The last section discusses some opportunities that the shift to a decarbonised energy system presents.

Key challenges that will affect businesses across the board are:

Cost and stability of services: All businesses depend on energy, both directly and indirectly, and projected changes in prices and resource availability will affect their competitiveness and economic viability. Without long-term contracts or hedging mechanisms, the impact of changes in direct costs (such as fuel for transport, heating or electricity) will be immediate, and will result in significantly higher running costs to business. Indirect costs, such as materials or delivery charges affected by higher energy inputs through the supply chain, may be less immediate, but would reduce profit margins on exposed product lines or services. The potential for actual power outages and fuel shortages could also be direct (affecting the area of operations) or indirect (disrupting the supply chain).

Pressure to reduce carbon emissions: The carbon portfolio of companies and governments will also come under increasing scrutiny. Higher emissions standards are anticipated across the major sectors. These will require carefully planned changes in practice and technology in the most energy intensive sectors - energy, heavy industry, construction and transportation. Carbon and efficiency standards in major markets will not only affect national industries, but also those in manufacturing export centres. In the transport sector, we can already see how binding legislation or voluntary standards are affecting the world's major vehicle markets and encouraging competition in efficient technologies.

For energy sector businesses, the dual task of meeting rising energy demand and leading the transition to radically lower carbon emissions presents enormous opportunities. Risks will vary considerably depending on the location of operations and specialisation, as well as technology and practices.

The transformative changes in the energy sector: The use of different resources, technologies and networks will in turn affect the way that we manage energy security. This also presents great business opportunities and new markets. The carbon market and policy mechanisms, such as feed-in-tariffs, are making new investments viable.

In all areas, an assessment of vulnerability to changes in the energy system and markets, and early preparation for these new realities, will give businesses a competitive edge.

IMPLICATIONS AND RISKS FOR BUSINESS IN GENERAL

Three sectors dominate global energy use today: manufacturing, household consumption and transport (see Figure 9). We can gauge the price exposure of a company by looking at its turnover divided by energy costs. The energy costs of heavy industry and transportation are likely to form a larger share of revenue than, say, an IT company or a retailer. But the specific nature of a firm's processes will determine the impact of higher prices or supply insecurity on its bottom line. Can manufacturing processes in a plant stop and restart with little impact? Will it be practical to switch fuels? Firms which have long and complicated supply chains will need to consider the potential exposure of suppliers or logistics operators to energy prices just as carefully. For example, Walmart has 100,000 first-tier suppliers. A 'just-in-time' business model (used by many companies) will mean that disruptions can quickly escalate costs and damage reputation. Therefore, risk managers should investigate whether this model is adequate to cope with emerging energy risks.

Figure 9: **Global final energy consumption (2005)**

Source: IEA 2008⁴⁰

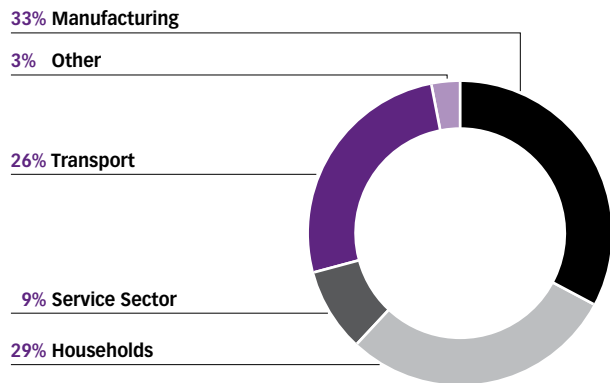
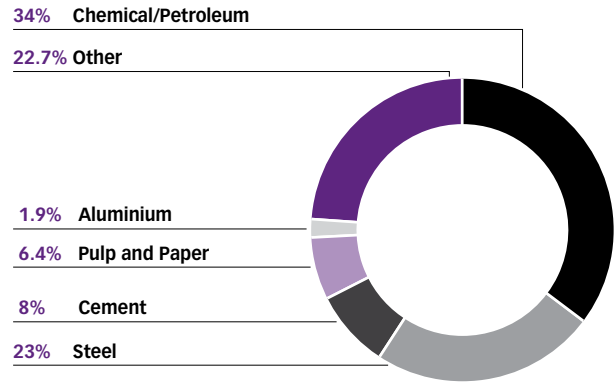


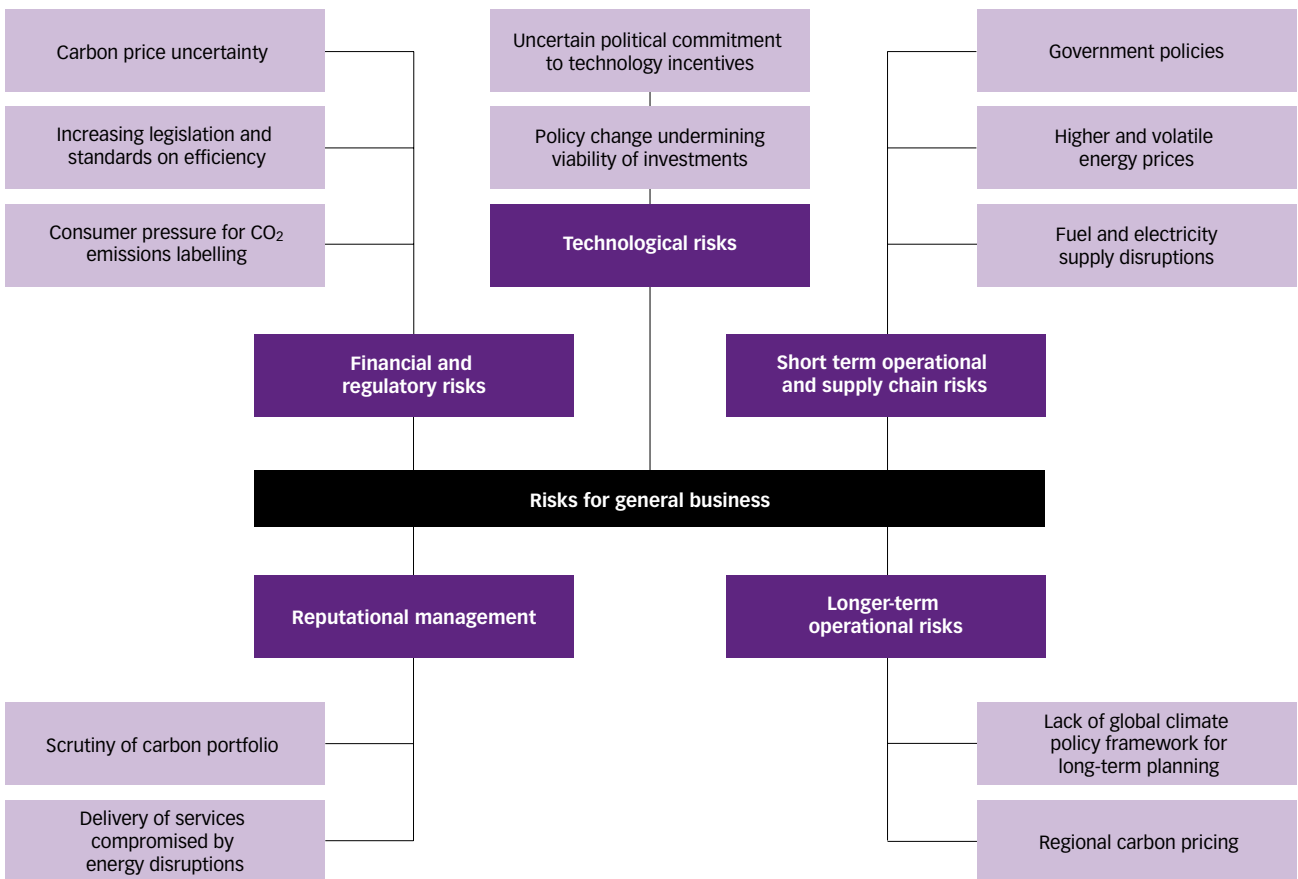
Figure 10: **Major global energy users in manufacturing sector (2005)**

Source: IEA 2008⁴¹



We have grouped the risks for business into broad categories, but these will overlap and be prioritised differently within each company. Some require fairly rapid decisions and contingency measures to prevent either disruption to operations or unsustainable costs. Others deal with events or conditions that should be taken into account in 'strategic' decision-making in order to minimise vulnerability and maximise advantage over a longer time period. Although reputational damage is treated as a separate risk, mismanagement of any of these other dimensions can also contribute to reputational risk.

Figure 11: **Risks for the wider business sector**



Short term operational and supply chain risks: price and supply

Ultimately, governments will determine end-user energy prices - so where a business's operations and supply chains are located is crucial. Its place in the supply chain will also affect vulnerability to price. Energy-intensive sectors, such as chemicals, steel or cement, are by nature more exposed to changes in the price or availability of energy (see Figure 10 for the share of major energy users in the manufacturing sector). For these sectors, even small changes in the prices they pay for energy domestically will affect the economic viability of manufacturing. Costs will be added onto the price of traded goods, affecting their global competitiveness. This has encouraged the shift of energy-intensive sectors to countries where the price of energy is comparatively low and often subsidised.

Profits in the transport sector are especially sensitive to the upward price trend of oil. For the aviation and shipping industries, this exposure is high and largely unavoidable. The movement of goods is also dominated by fossil fuel, in this case diesel, which accounts for 82% of movements. This lack of diversity makes these sectors vulnerable to oil price spikes and tighter markets for diesel. For example, United Airlines decided to ground around a fifth of its fleet when the oil price was at its highest in 2008. In an attempt to reduce fuel costs, research is underway into the use of biofuels, with Lufthansa announcing that by 2012 they would be blending biofuels with traditional fuel. The key risk management strategies for the transport sectors involve long-term strategic and investment decisions to:

- Use energy more efficiently. This may include upgrading buildings, installing 'smart' electricity management systems and planning operations to maximise the productivity of energy.
- Diversify energy supplies and types. This may involve the investment in own back-up generation or large and more permanent domestic generation, such as very small or micro renewables. However, this may also lead to active support of research into and development of alternatives.

Energy supply disruptions will affect businesses differently depending on how reliant their activities are on certain types of energy, where they are located and how their supply chains work. However, the absolute dependence of modern societies on electricity means that even short-term disruption to this electricity may cause multiple operational failures and incur heavy restart costs. Although energy supply disruptions have decreased in most OECD countries in recent decades, significant losses of electricity supply still occur. For example, in California (2000), New York (2003) and Italy (2003) technical failures coupled with inadequate back-up systems and poor electricity management resulted in widespread blackouts. Many larger businesses and infrastructure operators have invested in back-up generators. In 2010 the city of New York purchased stand alone generators for their water treatment plants as a result of the experiences in 2003.

Resilience measures tend only to be justified as 'responses' to crises. A 2006 study found that risk managers in the food industry tended to take uninterrupted power supply for granted and believed the government would step in to ensure fuel provision in the event of a crisis.⁴² However, in terms of essential national servicesⁱⁱⁱ, the food and finance industries are not guaranteed state protection in the event of a fuel supply crisis (see Box 15).

More frequent outages are likely in the developing world where capacity cannot keep pace with demand growth.

Access to reliable electricity is still not guaranteed, even for major industries and cities in developing countries. The lack of fuel for power stations and significant over-demand has led to power rationing and frequent power cuts. Rolling blackouts in South Africa in 2008 (which caused the shut-down of major industries, including gold mines) and brownouts (periods of reduced electrical voltage or scheduled cut offs for selected users) in eastern China in winter 2010 demonstrated the vulnerability of emerging economies to a depletion of coal stocks. As an increasing number of manufacturing and service industries are based in Asia-Pacific countries, this will have a major impact on global supply chains. The case of the textiles industry during the ongoing energy crisis in Pakistan illustrates this well (see Box 13).

Box 13: Electricity and gas cut-offs: the case of the textiles industry in Pakistan

The effect of unscheduled electricity blackouts and gas supply cuts on industry in Pakistan gives a clear example of the problems facing rapidly industrialising nations. As demand for power outstripped supply in Pakistan over the last decade, electricity and gas outages have blighted the textiles industry (which accounts for 60% of exports). This has disadvantaged local companies against competitors in China, India and Bangladesh and they are often unable to meet the requirements of buyers. The larger integrated companies, such as Chenab, which serves Western brands, such as Ralph Lauren and IKEA, have invested in their own gas-fired power plants to keep the looms going. Many of the smaller firms cannot afford these and are forced to shut down for several hours each day. Even Chenab had to shut down production during winter gas shortages and was operating at 70% capacity in 2009.⁴³ Gas cut-offs, which have taken place sporadically during winter, halt the cleaning of raw wool and cotton at mills as the water cannot be heated. According to one report, the profit margins of Rahat Woollen Mills have fallen by about 50% as a result.⁴⁴ In April 2010, the authorities decided to schedule the cut-offs for one day a week - rotating

ⁱⁱⁱ These are the communications, emergency services, energy, finance, food, government, health, transport and water sectors

between industrial zones. Power supply is not guaranteed by the Water and Power Development Authority of Pakistan so the mill and factory owners must absorb the costs. This has led to mass lay-offs. Chenab cut almost a third of its workforce (4,000 people), which is adding to political unrest in the country.

Financial and regulatory considerations: counting the cost of carbon

Assuming a global agreement on climate change is eventually made, all businesses (not just the heavy industrial sector), will be impacted by the price of carbon. Such an increase would noticeably affect energy emissions costs for all businesses. In the EU, through the latest phase of the Emissions Trading Scheme (see Box 14), all emissions will be auctioned in the power sector (as opposed to granted for free as occurred in the earlier phases of the ETS) post 2013. There are some suggestions that this will lead to a 10% to 15% increase in electricity prices.

Box 14: European carbon market

The European Emissions Trading Scheme, which began in January 2005, is the world's largest cap and trade system. The scheme works by reducing the total emissions granted to the affected sectors over time while allowing them to trade emissions permits. Initially the scheme only applied to facilities over 20 MW and mainly impacted power stations and large factories. Therefore it covered only around 50% of the EU's CO₂ emissions. During the first two phases, the emissions permits have been allocated and given for free to companies. However, in phase three (which will take place in 2013), companies will have to buy the majority of the allocations and the number of sectors the ETS applies to will increase, and include the petrochemicals and aluminium sectors.

For most of 2008, the carbon price in the EU-ETS varied within the range of €20 to €27 per tonne of CO₂, but with the worsening financial outlook towards the end of that

year, prices dropped and have remained in the range of €11 to €14 per tonne of CO₂ since. One obvious driver for this price drop has been the reduced production forecasts for manufacturing output and electricity generation as a result of the recession which has led to lower CO₂ emissions forecasts and lower price expectations.

Carbon prices have often been closely correlated with gas prices as higher gas prices lead to the greater use of coal, which in turn results in more CO₂ emissions. Energy prices therefore have a direct impact on carbon prices. In addition, carbon has become a commodity traded by speculators and the prices have followed a similar trend to many other commodities in the recession.

Ultimately, for carbon pricing to work on a global level a single market or intricately linked series of markets is required. This would remove the tensions around different production standards, competitiveness and eventually remove the threat of 'carbon leakage'. As this is some way off, sectoral agreements from particularly affected sectors, such as iron and steel, and a comprehensive agreement on the affects of carbon pricing on global trade, would go a long way in assisting businesses in their risk analysis.

Legislation and standards on energy efficiency, carbon emissions and other environmental impacts will increasingly affect all businesses as they apply to premises, mobility and products. In 2009, for example, the EU adopted legislation which requires all new buildings to comply with tough energy-performance standards and (after 2020) meet a significant proportion of their energy requirements from renewable sources. Stricter requirements were made for public sector buildings, requiring 'nearly zero' energy standards by the end of 2018. While this legislation is vague and the concept of 'nearly zero' is undefined allowing member states to make their own standards, it has set an agenda for the construction industry. Life-cycle analysis of the carbon (and perhaps also greenhouse gases) emissions of buildings will become the norm. More detailed

legislation could follow in the next few years specifying efficiency improvements in existing buildings. This has so far been a voluntary or incentive-based undertaking in most countries. The regulatory environment for these kinds of developments presents a risk in itself given the investments companies are expected to make.

Mounting consumer pressure has also led to several private initiatives to assess the embedded carbon content of specific products with a view to introducing carbon labelling and allowing consumers to make more informed purchasing decisions. In 2007, Tesco announced that it would be seeking “a universally accepted and commonly understood measure of the carbon footprint of every product we sell looking at its complete life cycle from production, through distribution to consumption”, and that they would establish a clear system of labelling for their customers. This is initially being piloted on twenty products and has required the active support of Tesco’s suppliers.⁴⁵ These schemes are voluntary at present, but could well become mandatory - as has occurred with energy use in products, such as fridges.

In moving forward on carbon labelling, as with carbon life-cycle assessments, it is important to caution businesses against over-simplistic processes. Complicated accounting methods could be required, especially for manufactured goods, as hundreds of processes can contribute to the final product.

Longer-term operational and supply chain risks

The lack of a legally binding global climate policy has revitalised appetite for assessing and addressing the issue of carbon leakage. The energy intensive sectors, such as steel and cement, fear that they will be competitively disadvantaged by regional carbon pricing, and that high-emitting industries or companies will relocate to developing countries that do not have a cap on carbon. This is an extremely sensitive political issue for emerging economies, such as China and India, which rely on export-led growth. Managing the potentially explosive dynamics around border carbon mechanisms to address

carbon leakage is critical to energy-intensive industries. Consequently, these sectors are actively engaged in seeking to influence the development of national policies and international agreements.

A number of attempts have been made to develop sector agreements and standards. One example is the Cement Sustainability Initiative, coordinated by the World Business Council for Sustainable Development. Members have set targets for the reduction of their own emissions and shared best practice. Work within the initiative is also progressing on modelling of sectoral targets within the framework of an international climate deal. Unilateral action to impose border tax adjustment outside any global climate agreement could prompt trade-related retaliatory actions, undermining the global trading system.

Reputational management

With increasing reliance on globalised supply chains and IT, stable energy supplies become even more vital to the delivery of services on which reputation is built. For example, some retail industries may need to re-evaluate the ‘just-in-time’ business model (see Box 15) and some global supply chain linkages for potential energy vulnerabilities in order to avoid reputational damage in addition to the economic losses.

The emissions profiles of governments, companies and other institutions are likely to come under increasing scrutiny by the public. Voluntary or mandatory carbon reporting - as required in the European Emissions Trading Scheme or regional initiatives in North America - is increasingly common. A McKinsey Quarterly article suggests that: “Over the next 5 to 15 years the way a company manages its carbon exposure could create or destroy its shareholder value”.⁴⁶

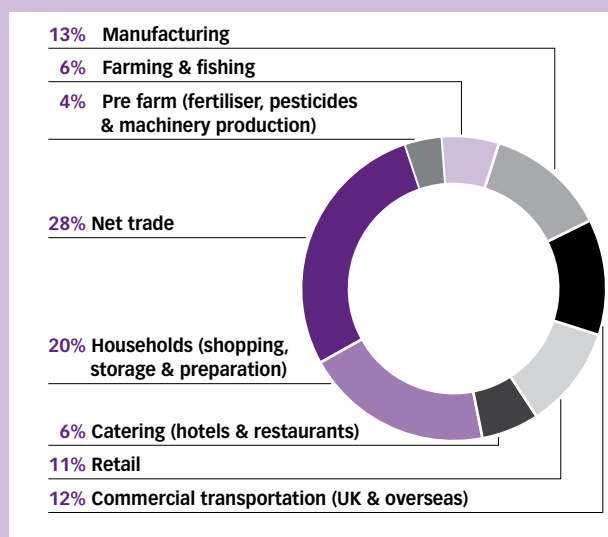
The development of the global low-carbon economy is expected to bring further pressures for harmonisation of reporting and additional verification mechanisms, as has occurred with the expansion of the ETS to cover more and more sectors.

Box 15: How the food industry could be affected by energy disruption

Food production straddles several business sectors and is particularly dependent on fossil fuel energy throughout the supply chain – from fuelling farm equipment to electricity for the supermarket till. Food retail chains are highly dependent on global supply chains. The just-in-time business model and the trend towards strategic outsourcing have reduced the direct control that companies have over contingency planning. A study commissioned by the Department for Food and Rural Affairs in the UK found that the imperative to reduce space used for storage in both retail and manufacturing and the increase in fresh and chilled products had increased the vulnerability of food suppliers to electricity and fuel disruption.⁴⁷ For example, the UK now imports more exotic fruit on a JIT basis and the packaging and the gasses needed for many chilled foods are produced overseas.

Figure 12: **Energy use in the UK food sector**

Source: DEFRA Food Pocket Book 2009



As supermarkets tend to keep only two–three days worth of perishables on their shelves, a transportation fuel disruption lasting just a few days would affect availability. This happened during September 2000 when protests

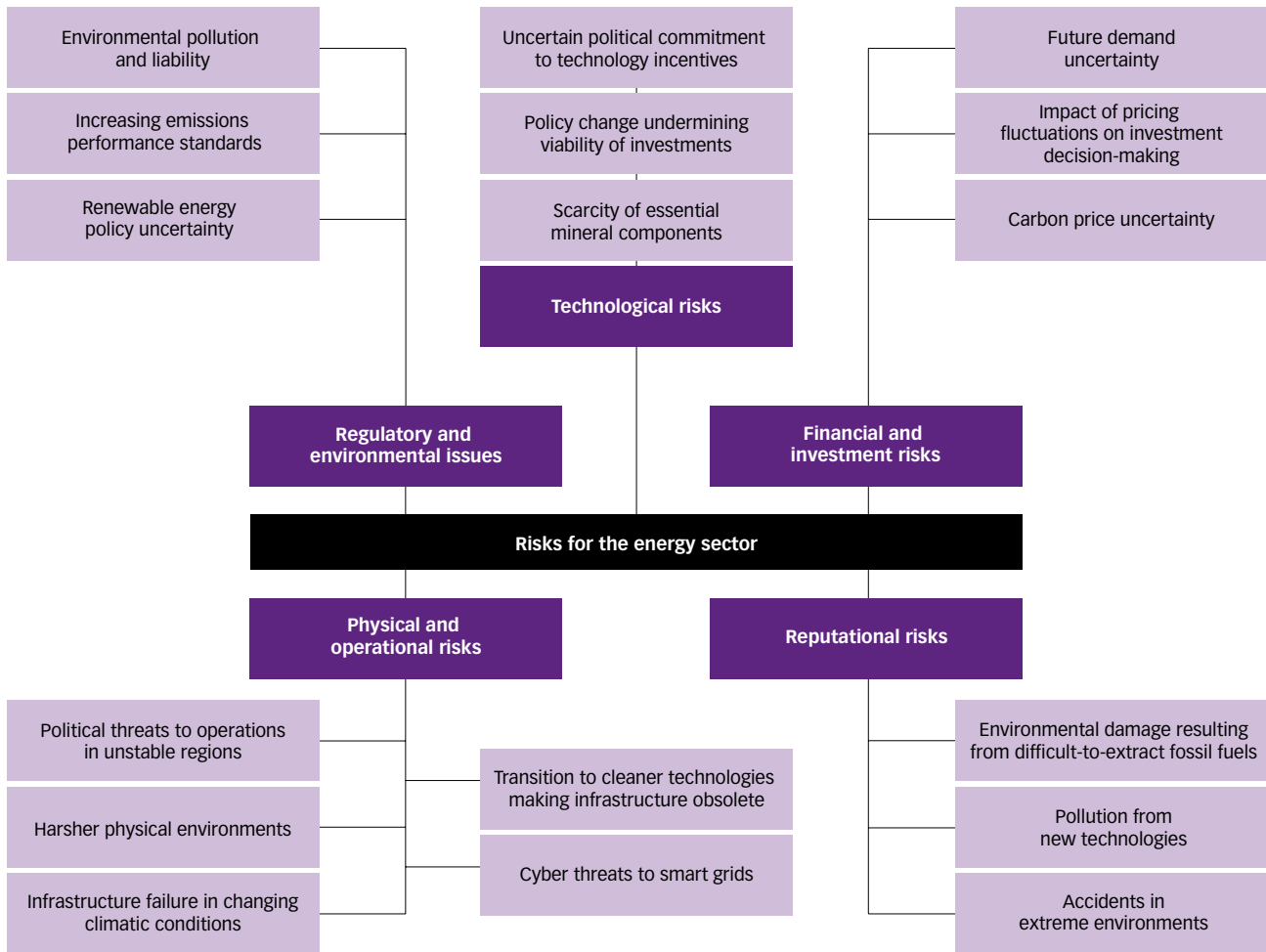
over fuel price rises prevented the distribution of fuel from depots to the rest of the country. Supermarkets were obliged to put the government’s priority user scheme in place at its petrol stations. They also faced ‘panic-buying’ which in some cases ran down stocks before replacements arrived. Several stores decided to implement rationing of basic goods like bread and milk. Companies that prepare and deliver fresh goods to retailers daily were particularly vulnerable. UK food group Geest announced that its deliveries would be unlikely to reach the supermarkets if fuel supplies were not restored in a matter of days.⁴⁸ The chief executive of Sainsbury’s wrote to the Prime Minister to warn that the petrol crisis was threatening Britain’s food stocks and that stores were likely to be out of food in “days rather than weeks”.⁴⁹ Fuel disruptions in other parts of the world also affects transportation of goods to markets, and higher energy prices could push up the price of basic food commodities, such as rice, soya and wheat - as they did in 2008.

A UK food manufacturer interviewed for the DEFRA report commented: “Rolling power cuts would stop operations very quickly.”⁵⁰ The same study also highlighted just how many transactions and logistics depend on IT, and therefore electricity. The 2008 food price rises were partially attributed to both higher oil prices and the spill-over effects of increased biofuel production from corn and rapeseed oil in that year.⁵¹

Food businesses have the potential to improve the resilience of their own transportation system. For example, through long-term investments in more efficient fleets including hybrids and electric vehicles. Other measures food companies can consider could include sourcing fresh produce more locally. One example is the Mid-Counties branch of UK food retailer The Co-operative, which launched ‘Local Harvest’ – a food sourcing scheme designed to support local suppliers and reduce food miles. This has benefited smaller suppliers, providing them with a reliable market.⁵²

IMPLICATIONS AND RISKS FOR THE ENERGY SECTOR

Figure 13: Risks for the energy sector



Energy businesses face important choices over their strategic direction. The coming decades will require the building and rebuilding of global energy infrastructure on an unprecedented scale to meet future demand. Anticipated rises in consumption, outmoded power generation and national energy security imperatives mean governments will welcome and incentivise cost-effective, innovative solutions from the energy sector.

Regulatory and environmental risks

Our existing energy system faces two key challenges: how to adapt to a resource constrained and low-carbon world and how to deliver the non-traditional energy sources that are being encouraged by government policy.

The need to replace depleting energy reserves is leading energy companies to explore harder to get and harder to process reserves. The scale and longevity of the oil leak following the accident at the Deepwater Horizon rig in the Gulf of Mexico highlights the dangers of pollution and the environmental risks of operating in these harsh environments. These risks are increasing with operations in more environmentally sensitive areas, such as the Arctic and the boreal forests of Alberta, Canada. To date, most environmental policies tend to charge polluters for the costs of cleaning up pollution, for the economic cost that pollution causes to other's property, or for the purchase of consents to discharge pollution. However, as the environment is

generally regarded as a 'public good' it is not priced in a conventional market place creating uncertainty around liability limits and how to insure against such hazards (see also reputational risks below).

As governments seek to meet their medium term climate objectives, standards are being introduced to reduce emissions from individual energy sectors. Some regions and countries have introduced or are considering introducing emissions performance standards for the power sector that set a ceiling on the carbon intensity of the electricity, ie how much CO₂ is emitted for every unit of electricity produced (CO₂/kWh). This may lead to the rapid phasing out of certain types of fuel, such as coal, or the requirement to install radical emission reduction technologies, such as carbon capture and storage. This standard setting approach will also potentially be used in the extractive industries and is being considered to discourage the extraction of non-conventional oils, such as tar sands (due to their higher emissions count).⁵³

Globally, over 73 countries have renewable energy policy targets and much of the renewable energy market activity remains predominantly policy driven. While not affected by emission performance standards, the renewable energy sector is exposed to regulatory risks. A lack of confidence in the binding nature and the delivery of renewable energy targets or incentive mechanisms would hamper growth in the sector. This will affect not only the renewable energy sector, but also raises questions for the energy sector as a whole, with uncertainties over the need for traditional energy sources.

Government implementation of 'investment grade' energy policy⁵⁴ will reduce these risks and give investors confidence in the longevity and breadth of the proposed policies. To achieve this it is necessary to establish long term policy targets and incentives that remove ambiguities and ensure that all aspects of energy policy and investment are addressed. This will require action across the whole of the energy sector, including on-demand, planning, connectivity, grids and tariffs. This is something that energy businesses can actively lobby for.

Financial and investment risks

The key question facing the energy sector is how much energy will be needed in the future. Concerns over security of supply and the need for a low-carbon future have created demand uncertainty for energy producers. According to OPEC projections, demand for OPEC crude could be anywhere between 29 million and 37 million barrels per day by 2020. The OPEC Secretary General noted that: "This translates into an uncertainty gap for upstream investments in OPEC Member Countries of over \$250bn. There is therefore the very real possibility of wasting financial resources on unneeded capacity."⁵⁵

The investment dilemma is further complicated by price fluctuations. In the last decade, high energy prices have led to great surges in investment, for instance in unconventional oil and gas extraction in the Atlantic region, in the petrochemical industries in the Middle East and Asia-Pacific, and in renewable energy technologies worldwide. But many projects were stalled, cancelled or became unprofitable when the price fell. Between September 2008 and April 2009, refining capacity of 1.5 million barrels per day were cancelled or deferred in Germany, Italy, Kuwait, Saudi Arabia, South Korea and the US.

Renewable and alternative energy technologies tend to become more competitive if the price of oil is sustained above a certain level. For example, a McKinsey Quarterly report for the Republic of Ireland showed that onshore wind would require a subsidy at \$60 per barrel of oil but be highly profitable at \$120 per barrel.⁵⁶

The uncertainties of price fluctuations are amplified by variations in the carbon price and the uncertainties over which sectors it will affect. Large energy producers in some countries - including the UK - have called for the government to introduce a floor price for carbon, to reduce the risks to business.

The need for accelerated energy investment and financial stimulus packages have increased the level of public-sector expenditure on energy infrastructure projects, particularly for grid extensions and for new power, transport and CCS

demonstration projects. This finance comes with its own risks, such as increased bureaucracy or susceptibility to policy change.

Box 16: Centrica – from energy supplier to energy service provider?

Recognising the new realities of the energy market, some major energy companies are adapting their business strategies. The future business model will not be based on the units of energy that are sold, but on delivering the necessary energy services. One of the largest energy companies in the UK, Centrica (owner of British Gas) states: "The competitive retail market is now driving a transformation in energy services, reflected in the growing role of energy efficiency and small-scale generation in reducing emissions and energy consumption." It is remarkable that a company that has been built on the ethos of selling more energy now states: "A key benefit of a vibrant demand side will be that there may be less of a need for new generation capacity and/or reinforcements to networks".⁵⁷ In February 2010 Centrica's Chief Executive announced four new strategic priorities for the business one of which focuses on shifting the British Gas business model away from energy supply and towards energy services. In April 2010, the company purchased Hillserve, a significant UK insulating firm and stated its objective was to become the leading supplier of domestic insulation. It predicts that the market for home insulation will rise from around £0.6bn a year in 2010 to £1.4bn in 2015.

Technology risks

The widespread use of innovative technologies and practices to provide more energy with less CO₂ emissions is a strategic priority for many companies in the energy sector. New technologies and processes must be developed, piloted and scaled up, yet incentives to drive their innovation and deployment at the scale and necessary pace often lack long-term political commitment. Research by Chatham House and CambridgeIP found that inventions in the clean energy sector have generally taken two to three decades to reach the mass market.⁵⁸

Consequently, many businesses would prefer to adopt a 'wait-and-see' approach rather than be subject to 'stroke-of-the pen' risk (the risk of government policy changing and undermining the viability of investments). The current situation with CCS highlights the risks and dilemmas. The technology brings no additional security of supply benefits, in fact the reverse with an (as yet unknown) energy penalty associated with its use. In a carbon-constrained world, the use of CCS may be the only way in which coal is usable. But without a clear financial incentive or binding requirement for its use, early movers deploying the technology gain little, and therefore the large utilities are reluctant to act.

Box 17: Carbon capture and storage

Commercial scale demonstration projects are planned for the use of carbon capture and storage on coal fired power stations. Coal emits the highest carbon emissions of all conventional fuel sources per unit of energy produced but is the most widely available (and cheapest) fossil fuel. Attempts are being made to develop economically and commercially viable methods of separating and storing the CO₂ produced during coal combustion. The idea is to make coal an acceptable fuel in a low carbon energy system. However, the use of CCS is yet to be proven at scale and there are concerns about the long-term safety and legal issues surrounding the underground storage of CO₂. Its impact on security of supply also raises concerns for developing countries. This is because using CCS is likely to reduce the efficiency of a coal-fired power plant, effectively needing more coal to generate the same amount of electricity produced. The EU target is to have 12 CCS demonstration plants in operation by 2015, although progress to date has been slow. However, funding has been earmarked through the European Economic Recovery Plan and the European Emission Trading Scheme, which may speed things up.

Physical and operational risks

Politics and geology remain major areas of risk for the extraction and supply of energy resources to their markets. The depletion of 'easy to produce' oil and gas

in some areas and political limitations on access to it in others, is leading companies to spend more on exploiting resources in riskier geological and political terrain.

Infrastructure investments generally have long pay-back periods and, in the case of power plants, working lifetimes of up to 50 years. Infrastructure and systems not built to withstand changing environmental conditions will require retrofitting, become increasingly expensive to operate and/or become redundant. For example, power stations that use river water may need to build cooling towers to enable operation in periods of higher temperatures (as higher river temperatures affect the efficiency of the power stations) or droughts.

Energy planners and financiers need to take into account the global transition towards greater sustainability. At the same time, policies to incentivise the deployment of progressively cleaner energy technologies may mean the need to retire some energy infrastructures prematurely. It is therefore critical that investments made today are assessed to meet both medium and long-term energy security and climate change goals.

Some utilities companies are also seeking to change their businesses models, so that they supply energy services, rather than just selling units of energy. This requires new technology and infrastructure such as smart grids (see Box 19) and institutional changes to manage different practices, such as rewarding efficiency and allowing electricity to be easily sold back into the grid. While bringing new opportunities, these innovations also bring new vulnerabilities, such as exposure to cyber attack (see Box 19).

Box 18: Energy and water use - a new flashpoint?

Energy production and sources of drinkable water are intimately linked. Their interdependence, coupled with increasing shortages in some parts of the world, poses a major global dilemma. Energy is essential for

obtaining drinkable water while water is a prerequisite for major sources of energy production. Hydropower, cooling of thermal and nuclear power plants, fossil fuel production and processing, biomass production and hydrogen production are all dependent on a plentiful supply of water. In fact, energy production accounts for approximately 39% of all water withdrawals in the US and 31% in the EU.⁵⁹ Contamination of underground and surface fresh water supplies as a result of energy generation worsens this impact. With energy production forecast to grow by approximately 45% over the next two decades, water consumption for energy production will more than double over the same period.

Another report published by Lloyd's 360° Risk Insight highlights the potential risks for business resulting from growing water scarcity. The report notes that climate change will make rainfall patterns less predictable and that efforts to reduce CO₂ may impose penalties on water practices that are energy/carbon intensive, such as desalination.⁶⁰

Reputational risks

NGO campaigns and the media can have substantial effects on a company's share price and the availability of capital. Recent campaigns against some forms of energy production have raised awareness of their impacts on limited resources such as fresh water and ancient forests. This can harm the reputation of companies operating in or funding the operations. For example, some campaigns have lobbied pension funds that invest in oil companies with operations in the Canadian tar sands⁶¹ and banks that lend to companies carrying out mountain top removal coal mining in the US.⁶²

Green energy companies could also face damaging criticism on health, safety and environmental grounds. For example, a Chinese polysilicon manufacturer was exposed in the Washington Post for dumping its toxic waste products in a nearby village⁶³ and Greenpeace

raised awareness of banks funding palm oil production for biodiesel when this leads to deforestation.⁶⁴ Electronic waste, from solar and other high-tech energy systems, is a growing phenomenon not yet fully legislated for and the industry will have to address increasing pressure for transparency in their practices and supply chains.⁶⁵ These risks and the necessary costs of pollution control and recycling processes will have to be factored into investment decision-making.

Operating in more difficult terrains increases the risk of accidents which have human, environmental and economic consequences. The economic consequences relate to the costs of remediation, compensation and the potential impact of reputational damage on the company's share prices. The pressure to invest in areas with unclear legal frameworks and governance challenges will continue to expose companies to accusations of collusion in human rights abuses or corruption.

Box 19: Smart energy systems bring new opportunities and risks

As energy technologies mature, advances in design, site selection and operation increasingly depend on innovation in information and communication systems. This means that companies and countries with strengths in information communications technology (ICT) are well placed to capitalise on the growth opportunities as these technology systems evolve. Smarter energy systems will also generate opportunities for different kinds of partnerships between energy providers and the manufacturers of user technology. With so much dependence on ICT, security against technical failure, loss of energy supply to the servers and cyber risk will become more important.

A 'smart grid' uses information technology to create an 'intelligent' electricity system which monitors, protects and automatically optimises operation. Smart grids will not only supply but also communicate with industrial

and household users by means of building automation systems, energy storage installations, thermostats and appliances.

Most major economies are planning the introduction of smart grids although with differing timescales. China began building its first pilot smart grid for the Sino-Singapore Eco-City in Tianjin in April 2010. Smart grids will lessen the need for investment in peak load power plants and enable greater deployment of renewable energy. Some renewables, such as wind power, are dependent on the weather on a day-to-day and hour-to-hour basis (this is called intermittent generation). Companies, such as Siemens in Germany, where wind power is a significant part of the electricity mix, are engaged in planning an efficient system that maximises electricity from renewables. If grids are extended widely enough (across all the countries of the EU, for example) non-renewable and renewable energy surpluses could be shifted from country to country. An extensive study by the European Climate Foundation found that given the necessary investment including the rapid development of a European smart grid with interconnection into North Africa, 100% of Europe's electricity could come from renewable energy.⁶⁶

Modernising the ageing grid and deploying smart grid technology is currently thought to have a market of around \$21bn, but this is expected to increase to \$200bn over the next five years, with companies like Cisco, IBM, Motorola, GE and Siemens all vying for a share of the market.⁶⁷

The two-way flow of electricity and information would also enable electric cars to be used as a form of mobile storage. 'Vehicle-to-grid' technology would help balance loads by charging at night when demand is low, selling power back to the grid when demand is high and providing some back-up in the event of outages (see also Box 20).

NEW BUSINESS OPPORTUNITIES

Markets for low-carbon energy products are likely to be worth at least \$500bn per year by 2050, and perhaps much more, according to the Stern Review.⁶⁸ For example, several major insurance markets (including syndicates at Lloyd's) now have units dedicated to insuring the renewable energy market, and construction companies are opening up new lines in low or zero-carbon housing.

“No one should underestimate the sheer scale of the opportunity the transition to a low-carbon economy will offer the construction industry. The requirement for low-carbon construction is probably the biggest change management programme that the industry has faced since Victorian times.”

Paul Morrell, The UK Government's Chief Construction Adviser ⁶⁹

The developing world is also a growth market for products that can combine efficiency and emissions reductions. Several Asian companies are succeeding in this area. For example, Chinese telecoms company Huawei has a 'Green Communications' arm which provides next generation telecommunications network infrastructure featuring 'intelligent management' of electricity and renewable energy options. This claims to cut power consumption by over 60% and is proving especially successful in Africa and South Asia where there are frequent power cuts or areas without grid access. Huawei won a major contract with Reliance Communications in India in 2007 and built Pakistan's first 100% solar-powered base station for Warid Telecom in 2008. More companies are embracing a so-called 'game-changing strategy' - one that allows a company to leapfrog its competitors by creating new markets or reshaping old ones in such a way that they generate or sustain its domination. This strategy often involves collaboration between companies in order to bring about the right conditions to compete in international markets.

Box 20: Competition and collaboration for the low-carbon space - the example of electric vehicles

Electric vehicles (EVs) are an example of how low-carbon innovation is creating new types of industrial partnerships – from research and development all the way to the customers' experience. Collaboration is required because few companies have assets and expertise that cut across batteries, electricity, automobiles and information systems. However, electric vehicles are unlikely to take significant market share until common standards can be agreed for plugging in and charging the vehicles. Finally, new financing models will be needed – the upfront costs of the battery technology are high, even if the running costs are much lower than diesel. In one example, Swedish power company Vattenfall and car manufacturer Volvo have joined forces to create a plug-in hybrid car to be on the road by 2012. The idea is for Volvo to make the car and Vattenfall to develop the charging systems. Meanwhile, battery packs for the vehicles are expected to be supplied by LG-Chem, the leading South Korean firm.

Partnerships between the manufacturer and customer are helping to speed up deployment, such as the deal between Sainsbury's and Smith Edison to produce the supermarket chain's electric vehicle fleet – now the largest in the UK. The calculation is that the fleet will save the company money in the long-run given that they are exempt from the London congestion charge, have around 20% lower running costs and may benefit from lower fleet insurance. Nissan says it will install home charging points (supplied by AeroVironment, best known for advanced military technology) when a customer buys an electric vehicle in the US. This suggests an ongoing relationship with the customer more akin to a mobile phone than a conventional car purchase.

Standardisation of charging and battery technology is a major challenge given that there are still many different options being pursued. A group of Japanese car makers (ChaDeMo), including Toyota and Nissan, have created a

group which by “forming a common ‘language’ for fast-charging electric cars across various brands would save development costs for carmakers and ancillary industries”.⁷⁰

Investing in efficiency offers the most obvious protection against many of the risks noted here as well as increasing competitiveness. Businesses have the tools and incentive to act, especially in the area of energy efficiency, given the rapid payback times for many investments. However, some companies will also face hard choices about how fast to diversify into manufacturing new products or using different technologies.

CONCLUSIONS

We can expect dramatic changes in the energy sector in the coming decades. This report encourages businesses, both in the energy sector and beyond, to look at how this will impact on their firms. The transition towards a low-carbon economy and the interim volatility in traditional fossil fuel markets presents businesses with numerous risks but also opportunities. In order to reduce potential vulnerability and seize opportunities, business should be aware that:

1. Energy security is now inseparable from the transition to a low-carbon economy and businesses plans should prepare for this new reality. Security of supply and emissions reduction objectives should be addressed equally, as prioritising one over the other will increase the risk of stranded investments or requirements for expensive retro-fitting.

2. Traditional fossil fuel resources face serious supply constraints and an oil supply crunch is likely in the short-to-medium term with profound consequences for the way in which business functions today. Businesses would benefit from taking note of the impacts of the oil price spikes and shocks in 2008 and implementing the appropriate mitigation actions. A scenario planning approach may also help assess potential future outcomes and help inform strategic business decisions.

3. A 'third industrial revolution' in the energy sector presents huge opportunities but also brings new risks. Of particular importance for new technologies is the risk of constraints on raw materials such as rare earth metals, as scarcity may drive up costs. The rapid and widespread diffusion of some new technologies may also incur negative environmental implications.

4. Energy infrastructure will be increasingly vulnerable to unanticipated severe weather events caused by changing climate patterns leading to a greater frequency of brownouts and supply disruptions for business. This throws out a critical challenge to energy providers, investors and planners in terms of choosing the location of new infrastructure and fortifying existing plants and networks. Those businesses for which uninterrupted access to energy is of fundamental importance should actively consider investing in alternative energy supply systems.

5. Increasing energy costs as a result of reduced availability, higher global demand and carbon pricing are best tackled in the short term by changes in practices or via the use of technology to reduce energy consumption. The wider use of renewable energy and even self generation, bring added price and supply security benefits.

6. The sooner that businesses reassess global supply chains and just-in-time models, and increase the resilience of their logistics against energy supply disruptions, the better. The current system is increasingly vulnerable to disruption, given the trends outlined in this report.

7. While the vast majority of investment in the energy transition will come from the private sector, governments have an important role in delivering policies and measures that create the necessary investment conditions and incentives. If the global carbon market is to become a reality then government action must be taken to bring additional price stability and transparency. Investing in a secure, low-carbon energy future may have higher upfront costs, but will deliver lower cost energy in the future. Sound renewable energy and demand side measures are crucial elements in delivering the necessary energy services for businesses and the expected return on investments.

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