ENERGY MARKETS OUTLOOK

OCTOBER 2007
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td><strong>Renewable and low carbon energy</strong></td>
<td>97</td>
</tr>
<tr>
<td>9.1</td>
<td>Introduction</td>
<td>97</td>
</tr>
<tr>
<td>9.2</td>
<td>Supply variability</td>
<td>97</td>
</tr>
<tr>
<td>9.3</td>
<td>Contribution to security of electricity supply</td>
<td>100</td>
</tr>
<tr>
<td>9.4</td>
<td>Capacity</td>
<td>100</td>
</tr>
<tr>
<td>9.5</td>
<td>Production</td>
<td>102</td>
</tr>
<tr>
<td>9.6</td>
<td>Physical resource</td>
<td>104</td>
</tr>
<tr>
<td>9.7</td>
<td>Renewable heat</td>
<td>105</td>
</tr>
<tr>
<td>9.8</td>
<td>Renewables in transport</td>
<td>107</td>
</tr>
<tr>
<td>9.9</td>
<td>Conclusions</td>
<td>108</td>
</tr>
<tr>
<td>10.</td>
<td><strong>Carbon</strong></td>
<td>109</td>
</tr>
<tr>
<td>10.1</td>
<td>Introduction</td>
<td>109</td>
</tr>
<tr>
<td>10.2</td>
<td>How it works</td>
<td>109</td>
</tr>
<tr>
<td>10.3</td>
<td>Impact on security of supply</td>
<td>110</td>
</tr>
<tr>
<td>10.4</td>
<td>Experience in practice</td>
<td>111</td>
</tr>
<tr>
<td>10.5</td>
<td>Future directions</td>
<td>113</td>
</tr>
<tr>
<td>10.6</td>
<td>Conclusions</td>
<td>114</td>
</tr>
<tr>
<td>11.</td>
<td><strong>Afterword</strong></td>
<td>115</td>
</tr>
</tbody>
</table>

**Glossary of Acronyms**

**Glossary of Technical terms**
In the 2007 White Paper *Meeting the Energy Challenge*, we acknowledged that we face two long-term energy challenges: tackling climate change, by reducing greenhouse gas emissions both within the UK and abroad; and ensuring secure, clean and affordable energy as we become increasingly reliant on imported fuel.

The White Paper set out the ways in which Government seeks to ensure the best possible environment, both internationally and at home, to encourage and enable the wide spectrum of energy market participants to play their part in delivering those objectives. Their role is crucial.

Energy supply companies need to anticipate future demands, so that they can take appropriate action; such as investing in new infrastructure to maintain energy supplies (while reducing carbon emissions), or negotiating appropriate supply contracts with overseas producers.

Customers – particularly large industrial consumers – need to understand the risks of periods where supply may be tight and prices may be relatively high, so that they can decide what action may be necessary; such as contracting ahead with suppliers, investing in energy saving technologies and establishing contingency arrangements.

Timely and credible information about the outlook for supply and demand is key to the decisions which need to be taken by energy suppliers and customers. This first Energy Markets Outlook seeks to take forward the process of improving our and stakeholders’ shared understanding of the security of supply outlook and the main risks, helping both consumers and suppliers of energy to take timely and well-informed decisions about how to manage those risks. But this is only the start of a dialogue.

---

I am grateful for the part that Ofgem, National Grid and the Department for Enterprise, Trade and Investment (Northern Ireland) have already played in developing the analysis set out here. I look forward to broad participation and wide-ranging discussion in the dialogue to follow.

Malcolm Wicks MP
Minister of State for Energy
1. Introduction

1.1 The publication of the Energy Markets Outlook is the first stage in delivery of the Government’s undertaking, in the 2007 Energy White Paper, to introduce a new information service providing forward-looking energy market information relating to security of supply.

1.2 We are simultaneously launching a website containing additional detail. This web-based resource provides underlying data, background analysis and links to other sources for readers with an interest in a more in-depth examination of topics which are summarised in the report. It also enables us to provide up-to-date information on an ongoing basis in a way which is not possible in an annual report.

1.3 This work builds on that previously undertaken by the Joint Energy Security of Supply working group. The Energy Markets Outlook looks over a longer time horizon and covers other important energy sources as well as gas and electricity. It also looks at supply chain issues such as the availability of skilled staff, materials and labour for the construction and operation of new infrastructure, although this first report does not present a systematic assessment of this aspect of supply.

1.4 We have already been able to draw on expertise from a range of sources in assembling the information presented in this report. A range of forecasts has been used, reflecting the suitability of particular projections to particular areas, including the level of detail required in order to examine particular issues. We are particularly grateful for the part that National Grid, Ofgem and the Department for Enterprise, Trade and Investment (Northern Ireland) have played in developing the analysis set out in the chapters describing the prospects for electricity and gas.

1.5 We are keen to extend the range of contributions which inform the debate about the Energy Markets Outlook. We plan to engage with a broad range of stakeholders to seek feedback on the content of this first report, so that we can develop it in subsequent years. We hope to do this through a series of meetings and events over the next few months.

---

Footnote 2: http://www.berr.gov.uk/energy/energymarketsoutlook/page41839.html
and to reflect the findings and feedback from that exercise both on the website and in future reports. Details on these stakeholder events will be provided in due course.

1.6 In the meantime, we would welcome any comments or suggestions about the scope, content and analysis contained in this report and on the accompanying website. These should be addressed to:

Nicola Kirkup  
Energy Markets Outlook  
Department for Business, Enterprise and Regulatory Reform  
1 Victoria Street  
London SW1H 0ET  
020 7215 6566  
nicola.kirkup@berr.gsi.gov.uk
The energy policy framework combines competitive energy markets and effective, independent regulation

2.1 The Energy White Paper set out the Government’s continuing commitment to competitive energy markets and effective, independent regulation as the most effective way of delivering secure and reliable energy supplies to domestic and industrial energy customers.

2.2 Under this policy framework, market participants can respond to price signals and the supply/demand outlook in a number of ways. On the supply-side, companies can invest in new infrastructure to deliver more or alternative energy supplies. On the demand side, customers can invest in energy saving technologies or seek to reduce their energy use during periods of peak energy demand. The lead times associated with the different types of response and different technologies vary.

2.3 Recent experience from the gas market in Great Britain has shown that markets can deliver significant investment in new supplies which help to maintain security of supply. It also highlighted that when investments are delayed or shocks lead to supplies being very tight relative to demand, prices rise and customers respond by reducing their consumption, thereby helping to prevent blackouts or shortages. But this response comes at a cost to customers, particularly industrial customers who compete in international markets.

2.4 No amount of investment will ever be enough to deliver an absolute guarantee that energy supplies will be sufficient to meet any level of demand. Therefore, security of supply is not a simple question of “will the lights stay on?”, but a matter of assessing the risks to supplies. In other words, “how likely is it that some level of demand will not be met in the future?” Chapter 3 presents a further discussion on security of supply in a competitive energy market.
The focus of attention should be on the medium term

2.5 The key aim for the Energy Markets Outlook is to try to identify risks, whilst recognising that the further we look into the future, the more uncertain future forecasts of demand and supply become. One of the reasons for this is that the further we look into the future, the greater the flexibility for investment, both on the supply-side and the demand-side, to respond to security of supply risks.

2.6 In the longer term, there is a wide range of options open to market participants, including significant capital investment. This means that the critical focus is on ensuring an adequate supply of primary sources of energy, while doing all we can to incentivise energy saving.

2.7 In the medium term, the focus is on the availability of infrastructure, the planning process and supply chain issues such as the availability, both within the UK and internationally, of raw materials, machine components and project management and engineering skills.

There are significant opportunities for the construction of new generation capacity

2.8 Great Britain currently benefits from a diverse mix of electricity generating capacity. However, the implementation of the Large Combustion Plant Directive and scheduled closures of nuclear plant will progressively erode some of this capacity. In addition, generators will need to respond to the incentives being created by the EU Emissions Trading Scheme and UK policies such as the Renewables Obligation to reduce carbon dioxide emissions.

2.9 In the medium term, there appear to be significant opportunities for the construction of new generation capacity in order to meet current expected levels of demand. This is consistent with the conclusion set out in the Energy White Paper that around 20–25 GW of new generation will be required by 2020. Companies are now responding to these opportunities and have already announced over 14 GW of new generation. See Chapter 4
Price signals will play an important role in balancing gas supply and demand

2.10 The forecast decline in indigenous gas supplies means that the UK will be increasingly reliant on gas imports, the price of which will be linked to prices in European and global gas markets. Price signals and the ability of markets to anticipate and respond to them in a timely way will have an important role in ensuring that gas supply and demand remain in balance. Ongoing and planned investment in gas storage and supply infrastructure would put the UK gas market in a stronger position to deal with present and future risks. In particular, accessing the global liquefied natural gas market would allow for greater flexibility to respond to shocks which may affect demand or supplies from any source.

2.11 In terms of capacity, on the assumption that facilities currently under construction are completed to target, new import capacity should more than offset declining indigenous production until around 2015. Gas supplies to the UK will therefore not be constrained by physical capacity until this time (although prices may need to rise to attract supplies to the UK.) Further investment will be needed to avoid physical capacity constraints from around 2015.

2.12 It should be noted that as gas and, in particular, liquefied natural gas is traded internationally, import infrastructure will be used to deliver gas supplies only if UK prices are attractive relative to other countries. Although this allows for considerable flexibility to respond to shocks affecting one or more supply source or route, it does increase the complexity of assessing the future security of supply; and means that price signals may have an increasingly important role in balancing gas supply and demand in the short term. See Chapter 5

The future use of coal, oil and nuclear fuels is unlikely to be limited by resource availability

2.13 There is a range of scenarios concerning demand for coal in the UK over the next decades, driven by assumptions about levels of coal-fired power generation. The extent to which this demand can be met by the indigenous production of coal will be affected by issues such as planning consents for
surface mines and rail infrastructure. In all reasonable scenarios, there is a significant reliance on imports.

2.14 Given the abundance of proven global reserves of coal, future use of coal is unlikely to be limited by the availability of resources. However, there are a number of international issues and risks that could affect prices. These include the economic growth of rapidly developing nations and increasing levels of consumption by countries which are currently coal exporters. The global market is assessed to be sufficiently flexible and robust to respond, but higher prices and short term price spikes may be experienced. See Chapter 6

2.15 Our analysis of the oil market shows that forecast demand is unlikely to be met by indigenous production and, therefore, that there will be a significant reliance on imports. We conclude that global resources are sufficiently abundant to meet demand for the foreseeable future, but a number of constraints have the potential to threaten the ease with which these resources can be turned into production. These include labour, equipment and service sector constraints and geopolitical risks (such as resource nationalism and the risk of disruptions as supply routes become longer and have to cross more borders). See Chapter 7

2.16 Uranium supply is unlikely to limit nuclear power for at least the lifetime of a new generation of nuclear reactors, were there to be one. Increased stocks of uranium could be maintained by the generators, without difficulty, if necessary. This means that short-term supply interruptions are easier to manage than they are in commodity markets depending on just-in-time delivery. An increase in civil nuclear new build that aimed radically to increase nuclear power’s share of electricity generation might, in the period to 2025, face some personnel and supply chain tightness but uranium resources are not seen as a significant constraint. See Chapter 8

The UK is well supplied with primary renewable resources

2.17 Fossil fuels are finite resources. This fact, along with the contribution made by fossil fuel combustion to global greenhouse gas emissions, reinforces the potential benefits of improved energy efficiency and step changes in the rate at which we develop and deploy new low carbon technologies. In the coming decades, such technologies have the potential
to replace fossil fuels in our transport and electricity generation systems.

2.18 The UK is well supplied with primary renewable resources. Greater deployment of renewables will have an important role to play in helping to cut carbon emissions. Our modelling work suggests that maintaining security of supply with the wider use of renewable energy sources is achievable, although it will involve some additional costs both in terms of the maintenance and provision of back-up capacity and of transmission system balancing in the absence of significantly greater demand-side flexibility. See Chapter 9

**Increases in the price of carbon should encourage investment in low carbon generation capacity**

2.19 The future structure of the EU Emissions Trading Scheme is not yet clear, but developments in the EU and the UK indicate continuing and significant political commitment to reducing carbon emissions.

2.20 In the long term, increases in the price of carbon should encourage investment in new, low carbon generating capacity. In the short term, however, uncertainty about the future of the carbon market may cause delays in investment in new generating capacity. This underlines the importance of an early and successful conclusion to discussions on Phase III of the EU Emissions Trading Scheme, which is due to start in 2013.

**First steps in a process**

2.21 This report is intended to start a process of developing an improved understanding of the likely and possible sources of future risk and opportunity which will help stakeholders to form their own assessment as to how best to prepare for and respond to future developments.

3.1 Introduction

3.1.1 Continuity of energy supply is fundamental to the functioning of the modern economy. The objective of ensuring security of supply is an explicit element of the Government’s energy policy. It also has a high profile in the energy policies of other states and international institutions.

3.1.2 The Government looks to the market to deliver the necessary energy infrastructure and competitive sources of energy. The Government seeks to encourage this through the establishment of an appropriate regulatory framework, which is then administered by (in Great Britain) Ofgem and (in Northern Ireland) the Northern Ireland Authority for Utility Regulation (NIAUR), the independent energy Regulators. Under this policy framework, energy companies invest to maintain secure and reliable supplies in response to price signals emerging from energy markets, to their own projections for future supply/demand balance and to the contracts they strike with their customers. However, neither the Government nor the regulators are well-placed to second guess individual companies’ investment plans, either in the UK or overseas, as explained below.

3.1.3 This chapter explores three aspects of security of supply:

- How customers value security of supply
- Assessing security of supply over different timeframes: the way in which the focus of attention changes depending on the timescale under consideration
- Indicators of security of supply

3.2 How customers value security of supply

3.2.1 Different groups of customers will place a different value on security of supply. Within the market framework, suppliers are better placed than Government or the Regulator to

3 http://www.ofgem.gov.uk/About%20us/Pages/AboutUsPage.aspx
http://www.niaur.gov.uk/
understand and respond to the value that their different customers place on security of supply.

3.2.2 Some larger business customers enter into interruptible supply contracts, where they allow the supplier to instruct them to reduce part or all of their demand in return for a discount.

3.2.3 Customer surveys carried out by Ofgem⁴, as part of its work on network price control incentives, indicate that domestic customers do place a value on increased security of supply. However, there is a limit to what they are willing to pay to avoid interruptions to their supplies. Moreover, the recent experience of difficult winters and correspondingly high prices suggests that even domestic demand can reduce quite significantly in response to high prices.

3.3 The relationship between timescale and security of supply

3.3.1 Market participants can respond to price signals and the supply/demand outlook in a number of ways. On the supply side, companies can invest in new infrastructure to deliver more or alternative energy supplies. On the demand side, customers can invest in energy saving technologies or seek to reduce their energy use during periods of peak energy demand. The lead times associated with the different types of response and different technologies vary.

3.3.2 While this report attempts to look further into the future than previous reports have done, it is important to recognise that uncertainty about the outlook increases as we do so. Uncertainties about future levels of energy demand are driven by the potential impact of the cumulative effects of efforts to combat climate change and increasing price responsiveness of demand. Likewise, uncertainties about energy supply need to be understood in the context of the fact that different types of investment require different lead times.

3.3.3 As a consequence, the scope of feasible investment decisions widens as the time horizon is extended beyond the required lead times. Moreover, the lead times may themselves shorten as a result of technical innovation. For example, the use of regassification facilities on board

---

⁴ Consumer Expectation of DNOs and WTP for Improvements in Service Report (June 2004) 
specially designed tankers enabled the GasPort LNG importation facility at Teesside to be commissioned less than two years after it was first proposed; this was much faster than would be possible for a conventional LNG import terminal.

3.3.4 As a consequence, while this report is designed to help in the debate about the risks and drivers for energy supply and demand, conclusions about security in the longer term should be drawn only with extreme caution.

3.3.5 In the short term, the main concern is the extent to which we can be confident that energy can be delivered when and where it is needed, i.e. the reliability of the mechanisms (both technological and commercial) which convert primary energy sources for use by the final consumer.

3.3.6 In the medium term, the focus is on the availability of infrastructure, the planning process and supply chain issues such as the availability, both within the UK and internationally, of raw materials, machine components and project management and engineering skills.

3.3.7 In the longer term, there is a wider range of options open to market participants, including significant capital investment and the development of new technology. Given this, the key concern in this time-frame is likely to be the availability of primary sources of energy.

3.4 **Indicators of security of supply**

3.4.1 For the purposes of this Energy Markets Outlook, we have focused on measures of the physical security of supply, rather than on price. However, because occasions when energy supplies become tight would normally be associated with higher prices, this analysis can also be used to indicate times when there is likely to be a risk of higher prices.

3.4.2 Simply looking at out-turns (for example, whether the lights stayed on or not) tells us little about whether supplies have been, are or are likely in future to remain secure. Measuring security of supply is primarily about measuring the risk (rather than the actual outturn) of involuntary interruptions to supply. This risk may be influenced by a number of factors:
• **Capacity**: the safety margin between likely demand and the physical ability to supply enough energy to meet that demand.

• **Reliability**: the probability that the capacity on the system is actually available to deliver supplies when required. This may be affected, for example, by technical or engineering problems or the availability of fuel, sunshine, wind etc. in the case of electricity generating capacity. In the case of imported commodities, reliability could also be affected by wider geopolitical factors, such as the rise of resource nationalism in some countries, as well as infrastructure investment and the ability of key producers to meet supply commitments.

• **Diversity** of energy sources, which has an impact on the probability of large amounts of supply being unavailable at the same time. This is particularly important where supply reliability is subject to a high level of uncertainty. Diversity may, for example, be geographic (not importing all fuels from the same country) or technological (not relying on a single type of generating capacity).

• **Effective price signals**, to ensure that market participants have appropriate incentives to react in a timely way to any mismatch between supply and demand.

Our analysis suggests that the most important influence on security of supply is the overall balance – the margin – between demand and physical supply capacity. In this report we therefore take that indicator as our main proxy for security of supply; adding qualitative commentary where appropriate on other factors such as production and/or distribution reliability, diversity and the functionality or otherwise of the relevant markets.

3.4.3 One way in which the analysis contained in this report could be further developed would be to use the concept of “expected energy unserved”. This combines possible levels of shortfall between supply and demand with their probabilities to give a probability-weighted amount of unserved demand\(^5\), thus quantifying the risk itself rather than the factors which contribute to the risk. An example of this type of analysis can be seen in Box 5.1 at the end of chapter 5. The use of this type of analysis is one of the issues that we would particularly like to discuss with stakeholders as we seek to further develop the Energy Markets Outlook process.

---

3.5 What is the right level of security?

3.5.1 In the next chapters we look at some of the physical indicators and what they tell us about the extent to which the market framework is ensuring supply security. We do not, however, attempt to draw conclusions about whether the level being delivered is “adequate” or “optimal”.

3.5.2 We can show whether the total level of security for any given fuel is rising or falling, but this does not in itself indicate whether any given level is “better” than another. A higher level of security of supply can actually be less beneficial than a lower level if the cost of achieving it is disproportionately greater than the cost of accepting a small risk of supply interruption. In other words, the “right” level of security depends on the balance between the costs and the benefits of increasing security.\footnote{http://www.oxera.com/cmsDocuments/Agenda_nov%2005/Margin%20for%20error.pdf}

3.5.3 In order to make a quantifiable assessment of this trade-off we would need to calculate the cost of a decrease in security of supply. This could then be compared with the cost of anticipated savings from, for example, building less additional capacity.

3.5.4 However, carrying out a comparison of this type is far from straightforward in practice. The costs of interruptions to supply differ, depending on various factors including their frequency, duration and timing; whether and how much advance warning can be given; which customer groups are affected; and the extent of contingency preparedness on the part of energy users. We showed in paragraphs 3.2.1-3.2.3 above that different customers place different value on security and that this may change over time.

3.6 Conclusion

3.6.1 It is neither appropriate nor possible for Government or a regulator to determine the “right” level of security. Under the UK framework, this is left to the market as suppliers are better placed than Government or the Regulator to understand the value that their different customers place on security of supply and strike appropriate contracts with customers and energy producers to meet their customers’ demands. This already happens in the industrial and commercial market and with technological development it may also become possible for suppliers to offer domestic...
consumers different levels of security of supply at different prices.

3.6.2 Government’s role is to provide a stable regulatory framework. Ofgem oversees the market rules to make sure that energy suppliers face the full economic costs of any failure to match their energy supplies to their customers’ demands. This enables them to make trade-offs between the costs and benefits of additional investments to reduce the risk of imbalances.
4. Electricity

4.1 Introduction

4.1.1 Both the demand for electricity and the level of capacity that will be available to produce it are subject to a very wide range of uncertainty over the next decade. On the supply side, for example, there is uncertainty both around the timing of forthcoming closures of existing coal-fired and nuclear capacity and around the timing and amount of new build. We look separately at the factors affecting supply and demand, and then at the relationship between them as a proxy for security of supply.

4.1.2 The analysis in this chapter relies mainly on data provided by National Grid, who are responsible for electricity transmission in Great Britain. The electricity market in Northern Ireland is described in a separate box at the end of the chapter.

4.2 Electricity demand

4.2.1 Electricity cannot currently be economically stored in meaningful quantities. This means that it is not possible to generate large amounts of electricity at times of low demand and put it aside for use later at times of high demand. Consequently, electricity has to be generated at the same time as it is consumed. To ensure that demand can be met at all times, therefore, it is necessary to have available enough generating capacity to meet the highest expected level of demand (“peak demand”).

4.2.2 There is considerable uncertainty about the level of peak demand in the future, particularly over longer time horizons. There are a number of factors that are likely to influence the level of peak demand. For example, higher economic growth and lower electricity prices would be expected to lead to increased levels of peak demand. In contrast, increased energy efficiency, perhaps as a result of environmental policy, or milder winters, might be expected to depress peak demand. However, a combination of increasing peak summer temperatures and greater use of

air-conditioning could eventually lead to the development of a summer peak. Overall demand might also be constrained by persistent high prices.

4.2.3 At the moment, demand is largely met by electricity transported across the transmission system from large generators to distribution networks. However, developments in distributed energy, such as embedded Combined Heat and Power and micro-generation, could increase the extent to which demand is met by local generation. This could lead to a reduction in peak demand on the transmission system.

Chart 4.1: Possible future levels of electricity demand on the transmission system in Great Britain

There is a wide range of possible future electricity demand levels, depending on the interplay of several variables.

4.2.4 The highest levels of demand shown in the figure above would be reached only if the relevant factors were all stimulating demand growth and no factors were acting to reduce demand. In practice, these variables are not mutually exclusive and it is unlikely that they would all combine to push electricity demand in one direction. For example, it is possible that weaker fuel prices and weaker economic growth could coincide, thus cancelling each other out in
terms of their effect on electricity demand. A narrower central range of more probable demand levels has therefore been highlighted on the chart above.

4.3 **Electricity supply capacity**

4.3.1 As at winter 2007-08, Great Britain as a whole has a total of 75 GW of electricity generating capacity of various kinds. Coal-fired capacity presently represents the largest share of transmission-connected capacity.

*Chart 4.2: GB Electricity generating capacity at the end of 2007*

- **Coal** 38%
- **CCGT & CHP** 34%
- **Nuclear** 16%
- **Hydro** 5%
- **Wind & Biomass** 1%
- **Oil & OCGT** 6%
- **Wind & Biomass** 1%

*Source: National Grid*

*In addition there is an electricity interconnector with France which is capable of importing (or exporting) about 2 GW.*

4.3.2 Future levels of generating capacity will depend on how much of this existing plant is retired from service and how much new plant is built. There is a range of factors that influence plant owners’ decisions on plant closure and the timing, volume and type of new build. These include expected profitability, environmental and safety legislation and station reliability. These factors are discussed in more detail below.
4.4 Plant closures: Fossil fuel

4.4.1 The Large Combustion Plants Directive (LCPD)\(^8\) requires large electricity generators, and some other industrial facilities, to meet stringent air quality standards from 1 January 2008. If they opt out of this obligation, this plant will have to close by the end of 2015 or after 20,000 hours of operation from 1 January 2008, whichever is the sooner. Some 12 GW of coal and oil-fired generating plant falls into this opted-out category:

<table>
<thead>
<tr>
<th>Plant name</th>
<th>Owner</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilbury (coal)</td>
<td>RWE npower</td>
<td>1.1</td>
</tr>
<tr>
<td>Cockenzie (coal)</td>
<td>ScottishPower</td>
<td>1.2</td>
</tr>
<tr>
<td>Didcot (coal)</td>
<td>RWE npower</td>
<td>2.1</td>
</tr>
<tr>
<td>Ferrybridge (stack 2) (coal)</td>
<td>SSE</td>
<td>1.0</td>
</tr>
<tr>
<td>Ironbridge (coal)</td>
<td>E.ON</td>
<td>1.0</td>
</tr>
<tr>
<td>Kingsnorth (coal/oil)</td>
<td>E.ON</td>
<td>2.0</td>
</tr>
<tr>
<td>Littlebrook (oil)</td>
<td>RWE npower</td>
<td>1.2</td>
</tr>
<tr>
<td>Fawley (oil)</td>
<td>RWE npower</td>
<td>1.0</td>
</tr>
<tr>
<td>Grain (oil)</td>
<td>E.ON</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Total capacity</strong></td>
<td></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

*Source: BERR*

All of this plant, some 15\% of Great Britain’s present total capacity, will have to close by the end of 2015.

4.4.2 The timing of these closures within these constraints is a commercial matter for the plant owners, who would be expected to take into account factors such as other environmental restrictions and the state of repair of the plant. For example, if a facility suffers serious technical difficulties and would otherwise only have a limited life in any case, then it may not be economic to invest in repair and maintenance. Hence, it is impossible to predict the precise timing of the impact of the LCPD on generation capacity.

4.4.3 One approach to estimating the impact, however, is to extrapolate from recent experience. Based on the average number of hours that the coal-fired power stations have

---

\(^8\) [http://www.defra.gov.uk/environment/airquality/eu-int/eu-directives/lcpd/index.htm](http://www.defra.gov.uk/environment/airquality/eu-int/eu-directives/lcpd/index.htm)
been used between 2000 and 2006, it is estimated that all will have used their 20,000 hours allowance before 31 December 2015 and that available capacity will fall as shown in the table below:

<table>
<thead>
<tr>
<th>Date</th>
<th>Available capacity of coal plant that has opted out of the LCPD (based on current operating patterns) (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 January 2008</td>
<td>8.2</td>
</tr>
<tr>
<td>Mid 2012</td>
<td>6.2</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>4.2</td>
</tr>
<tr>
<td>Autumn 2013</td>
<td>2.2</td>
</tr>
<tr>
<td>1 January 2016</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Source: BERR*

Based on historical operating patterns, some of these plants could have used up their allowance of hours by early 2012.

The LCPD is likely to affect oil-fired plant in a different way since, as peaking plant, the oil-fired power stations tend to run for fewer hours over the year as a whole, producing electricity only at times of very high demand. They are therefore less likely to run out of hours before the end of the period.

4.4.4 During the next few years while the opted-out plants are working out their remaining lives, the 20,000 hour limit may have an impact on plant owners’ operating decisions as to whether and when to run them. To obtain maximum value out of the allowance, the owners of a power station may wish to ensure either that the whole station or none of it is working at any one time, rather than adjusting the level of output to meet the level of demand. This possible reduction in supply-side flexibility from this part of the total generating fleet is likely to present additional challenges to National Grid in their task of balancing aggregate electricity supply and demand, requiring additional flexibility from the rest of the generating fleet and perhaps leading to greater price volatility.
4.5  Plant closures: Nuclear

4.5.1  The operating lives of nuclear power plants can be extended, but only with the approval of the Health and Safety Executive’s Nuclear Installations Inspectorate (NII). The decision whether to apply to the NII for an extension of the operating lives of nuclear power stations beyond their scheduled closure dates is a commercial decision for the operators. At present, the operating lives of Great Britain’s nuclear power plants are scheduled to end at these dates:

Table 4.3: Estimated closure dates of nuclear power plants in Great Britain if operating lives are not extended

<table>
<thead>
<tr>
<th>Nuclear Power Plant</th>
<th>Estimated Closure Date</th>
<th>Type of Reactor</th>
<th>Installed Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oldbury</td>
<td>2008</td>
<td>Magnox</td>
<td>0.47</td>
</tr>
<tr>
<td>Wylfa</td>
<td>2010</td>
<td>Magnox</td>
<td>0.98</td>
</tr>
<tr>
<td>Hinkley Point B</td>
<td>2011</td>
<td>AGR</td>
<td>1.26</td>
</tr>
<tr>
<td>Hunterston B</td>
<td>2011</td>
<td>AGR</td>
<td>1.21</td>
</tr>
<tr>
<td>Hartlepool</td>
<td>2014</td>
<td>AGR</td>
<td>1.21</td>
</tr>
<tr>
<td>Heysham 1</td>
<td>2014</td>
<td>AGR</td>
<td>1.20</td>
</tr>
<tr>
<td>Dungeness B</td>
<td>2018</td>
<td>AGR</td>
<td>1.08</td>
</tr>
<tr>
<td>Heysham 2</td>
<td>2023</td>
<td>AGR</td>
<td>1.20</td>
</tr>
<tr>
<td>Torness</td>
<td>2023</td>
<td>AGR</td>
<td>1.20</td>
</tr>
<tr>
<td>Sizewell B</td>
<td>2035</td>
<td>PWR</td>
<td>1.19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>2 Magnox</strong></td>
<td><strong>11.00</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>7 AGRs</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1 PWR</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: BERR

According to current timetables, 7.4 GW of nuclear generation capacity will have closed by 2020.

4.5.2  There are no proposals at present to extend the lives of either of the remaining Magnox nuclear power stations. We understand that British Energy expects to make a decision on whether to apply for life extensions for its Hunterston B and Hinkley Point B stations by the end of the 2007-08 financial year. Decisions as to the extension or otherwise of the operating lives of other stations are expected to be taken nearer the time and will take into account such factors as plant safety and operating cost, as
well as supply, demand and price expectations in the electricity market as a whole.

4.6 New build

4.6.1 We show here a list of all the conventional electricity generating plants which we understand to be at various stages in the development process.

**Table 4.4: New conventional electricity generation projects**

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Owner</th>
<th>Capacity (MW)</th>
<th>Type</th>
<th>Section 36 Status</th>
<th>Construction Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langage</td>
<td>Centrica</td>
<td>890</td>
<td>CCGT</td>
<td>Approved</td>
<td>Commercial operations expected by winter 2008-09.</td>
</tr>
<tr>
<td>Immingham</td>
<td>ConocoPhillips</td>
<td>450 (expansion from 730 MW to 1180 MW)</td>
<td>CHP</td>
<td>Approved</td>
<td>Commercial operations expected by summer 2009</td>
</tr>
<tr>
<td>Marchwood</td>
<td>SSE and ESB International</td>
<td>840</td>
<td>CCGT</td>
<td>Approved</td>
<td>Production expected to start in 2009</td>
</tr>
<tr>
<td>Staythorpe</td>
<td>RWE npower</td>
<td>1650</td>
<td>CCGT</td>
<td>Approved</td>
<td>Construction expected to start late 2008 (some ground works already complete) with commissioning due 2010</td>
</tr>
<tr>
<td>Location</td>
<td>Company</td>
<td>Capacity</td>
<td>Fuel</td>
<td>Status</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td>----------</td>
<td>------</td>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Uskmouth</td>
<td>Severn Power</td>
<td>800</td>
<td>CCGT</td>
<td>Approved</td>
<td>Site works started. Commercial operations expected by 2010 after 4 months commissioning.</td>
</tr>
<tr>
<td>Pembroke</td>
<td>RWE npower</td>
<td>2000</td>
<td>CCGT</td>
<td>Applied</td>
<td>Building contractor appointed pending section 36 consent, with the intention of starting construction in 2008</td>
</tr>
<tr>
<td>Drakelow</td>
<td>E.ON</td>
<td>1220</td>
<td>CCGT</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td>West Burton</td>
<td>EDF</td>
<td>1270</td>
<td>CCGT</td>
<td>Applied</td>
<td></td>
</tr>
<tr>
<td>Sutton Bridge</td>
<td>EDF</td>
<td>1260</td>
<td>CCGT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partington</td>
<td>Bridestones</td>
<td>380</td>
<td>CCGT</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td>Barking</td>
<td>Barking Power</td>
<td>470</td>
<td>CCGT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kingsnorth</td>
<td>E.On</td>
<td>1600</td>
<td>Coal</td>
<td>Applied</td>
<td>Two super-critical generating units proposed</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>14105</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Of the total 14 GW listed here, nearly 4.5 GW of conventional capacity is presently under or close to construction.

4.6.2 The construction of an additional 2 GW of capacity, in the form of the BritNed interconnector and a number of wind farms (further information is in chapter 9), is also under way.

4.6.3 In reality, the type and total amount of new build could out-turn higher or lower. Generators’ investment decisions fundamentally depend on expected future profitability, which is largely informed by investors’ views of such factors as likely future developments in the supply-demand balance, Government and regulatory policy, relative movements in fossil fuel and CO₂ prices, and the capital costs of new plant.
4.7 Other potential sources of new generating capacity

4.7.1 The forecasts set out above are based only on those technologies currently deployed on a large scale. In this report, we do not speculate about potential new technologies or designs that may come into commercial operation over the next decades beyond noting that their widespread deployment could have a major impact on energy supply. Examples of these technologies might be:

- medium-scale fuel cell combined heat and power (CHP) plants
- new designs of nuclear reactors
- wave and tidal energy
- improved energy efficiency and/or demand-side flexibility
- electricity storage technologies
- carbon capture and storage (CCS) technologies
- microgeneration

4.7.2 It is also possible that the UK will develop greater interconnection with other European countries in the future and even, through Europe, to electricity markets further afield. Although there are costs from building more interconnection capacity (especially to islands such as Britain), a trans-national electricity system brings security benefits.

4.7.3 These benefits arise from the fact that interconnection allows relatively small national markets to access a greater volume and diversity of generation. This can reduce the need to invest in more expensive domestic sources that would otherwise be required to meet periods of high demand. The fact that periods of national peak demand in different European regions do not tend to coincide also means that capacity can be utilised more efficiently. Such developments may all contribute to future security of supply.

9  http://www.berr.gov.uk/energy/sources/sustainable/index.html
4.8 Potential influences and constraints on the level and nature of new build

Skills

4.8.1 The 2007 Energy White Paper tasked the Sector Skills Councils with reporting on the skills situation and actions being taken to ensure an adequate supply of skilled workers for the future. It is anticipated that this will be completed in the first half of 2008.

4.8.2 Recent work by the Sector Skills Council, Energy & Utility Skills, has shed more light on the ageing workforce in the power sector. While recruitment and natural wastage have been balanced over recent years, retirement will have an increasing impact from 2010, earlier than anticipated from previous research. Without a marked increase in recruitment and training, a significant shortage of skills could develop as early as 2013. Apprentice recruitment attracts a healthy level of applicants but the graduate market is more competitive. Moreover, current training capacity is short of what is needed. The industry is developing plans to increase recruitment and training, but the next decade is likely to be challenging, not least because competition for skills from the rest of the economy and from the power sector internationally will be strong.

4.8.3 The nuclear sector carried out a major study of the skills needed for operations and decommissioning in the early 2000s. Since then, significant parts of the sector have achieved a more balanced age profile, although some areas still face retirement issues in the 2010s. The sector faces significant skills gaps, as workers are re-deployed from operations to decommissioning. With a strong lead from the Nuclear Decommissioning Authority, employers and the Sector Skills Council, Cogent are developing a nuclear skills strategy. A key role will be played by the National Skills Academy for Nuclear, which should be formally launched early in the New Year. The Academy has firm plans to deliver 800 apprenticeships, 150 foundation degrees and re-skill 4000 workers in its first three years. Higher education is responding with eleven university institutions now offering Masters level courses.

10 http://www.euskills.co.uk/index.php
4.8.4 Building significant numbers of new power stations and new transmission and distribution network infrastructure would require a strengthening of the science, engineering, project management and on-site trade/technician skills base. We anticipate increased competition for construction resources, in particular, if planned capital projects in the UK all go ahead. Specialist science and engineering skills, for example in reactor engineering, would be needed in the short term for design and licensing; these are in short supply and face a demand overlap with the submarine reactor programme. This would need careful resource management until the universities and graduate training programmes can deliver more people.

4.8.5 The longer lead times for nuclear power would allow time for the industry to plan ahead for the skills needed to build and operate the stations and to manage supply chain constraints through such measures as placing contracts well in advance to secure slots in manufacturers’ order books.

Planning

4.8.6 Another risk to construction programme delivery is delays in the planning and consents regime. There are numerous examples where major infrastructure projects, both of generating plant and transmission networks, have been delayed for a number of years in the planning and consenting processes. At the current time, arguments about the need for major infrastructure can be re-rehearsed every time a planning application for a nationally significant project is received. Invariably this causes delay, uncertainty and expense for all parties concerned and acts as a disincentive for investors.

4.8.7 The proposed reforms in the Government’s White Paper Planning a Sustainable Future aim to make the planning and consents regime, including for major energy infrastructure projects, more streamlined and certain whilst ensuring that the rights of interested parties are safeguarded. Policy will be clearly set out by Ministers in National Policy Statements (NPSs); consents will be granted by a newly established Infrastructure Planning Commission (IPC) that will have to ensure decisions are in line with national policy as defined in the appropriate NPS.

13 http://www.communities.gov.uk/publications/planningandbuilding/planningsustainablefuture
4.8.8 By producing NPSs for energy, the Government intends to address the question of need – including the importance of the market providing additional new infrastructure to address security of supply challenges and to meet climate change targets – so that the issue will not have to be re-visited during the planning application process. NPS, will be subject to public consultation and parliamentary scrutiny to ensure they are both robust and fit for purpose.

4.8.9 These reforms will be delivered through the Planning Reform Bill which is scheduled to be introduced in the 2007/2008 Parliamentary session. The Bill will set out a new planning regime for major infrastructure projects in water, transport and waste as well as energy; it will also set out reforms to the Town and Country Planning Act which will have an impact on smaller energy (<50 MW) projects, with particular emphasis on renewable energy. It is envisaged that the IPC will be operational in 2009.

Lead times

4.8.10 Broadly, the whole process from decision to invest through to start up takes about five years for a CCGT power station – two for design, planning consent, project planning and permitting, two for construction and six months for commissioning. A coal-fired power station might take around seven years, of which four to five years would be needed for construction. A new nuclear power station might take around five years for construction but has an extended licensing period that would extend the overall programme towards ten years.

4.8.11 While there may be scope for some time savings in the front end, especially for a fleet of identical stations, growing demand for new power stations from around the world is likely to lead to longer order books at the key manufacturers. Moreover, we expect the UK’s construction resource to be under pressure by demand from other sectors. It is therefore possible that these factors will lead to a lengthening of the current lead times.
4.9 Security of supply: Supply capacity margin

4.9.1 We showed in Chapter 3 that the margin between demand and supply capacity correlates well with security of supply, which is why we concentrate mainly on this indicator for the rest of this chapter. It must be emphasised, however, that no amount of spare capacity can ever guarantee that demand can be met under every circumstance. There will always be some level of risk that cannot be eliminated.

4.9.2 It is also important to bear in mind that security of supply can be improved from the demand side as well as from the supply side. For example, greater energy efficiency, increased microgeneration and/or more price-responsive demand can improve security by reducing the electricity market’s reliance on supply-side adjustments to ensure that supply and demand meet.

4.9.3 The traditional definition of capacity or plant margin measures the proportion by which installed electricity generating capacity exceeds peak electricity demand on an annual basis. By this calculation, the capacity margin in Great Britain over recent years has been about 20%. However, it is important to recognise that it is impossible to assess, either ex ante or ex post, whether this is the optimal level.

4.9.4 This methodology implicitly assumes 100% availability of all input sources, which is not true of any electricity source and may be especially problematic for an intermittent and rapidly growing generation source such as wind power. Our modelling has shown that security of supply correlates more closely with a capacity margin which is adjusted to take account of availability using a “de-rating factor“.

This factor, which is specific to each type of generating technology, reflects the probable proportion of a source of electricity which is likely to be technically available to generate, even though a company may choose not to utilise this capacity for commercial reasons.

4.9.5 This chapter uses the following constant availability factors, which are based on National Grid’s Consultation for Winter 2007-2008\(^{14}\). These de-rating figures reflect assumed availability of generating capacity on the twenty highest demand days during winter.

---

Table 4.4: Installed capacity and indicative availability factors for different electricity generating technologies at peak demand in Great Britain in 2006 – 2007

<table>
<thead>
<tr>
<th>Source</th>
<th>Installed capacity¹⁵ (GW)</th>
<th>Assumed availability (%)</th>
<th>Effective capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>28.78</td>
<td>85</td>
<td>24.46</td>
</tr>
<tr>
<td>CCGT &amp; CHP</td>
<td>25.59</td>
<td>90</td>
<td>23.04</td>
</tr>
<tr>
<td>Nuclear</td>
<td>11.88</td>
<td>80</td>
<td>9.50</td>
</tr>
<tr>
<td>Oil &amp; OCGT</td>
<td>4.08</td>
<td>95</td>
<td>3.88</td>
</tr>
<tr>
<td>Wind &amp; Biomass</td>
<td>0.97</td>
<td>35</td>
<td>0.34</td>
</tr>
<tr>
<td>Hydro</td>
<td>3.54</td>
<td>60</td>
<td>2.12</td>
</tr>
<tr>
<td>French interconnector¹⁶</td>
<td>1.99</td>
<td>100</td>
<td>1.99</td>
</tr>
<tr>
<td>TOTAL</td>
<td>76.83</td>
<td>–</td>
<td>65.33</td>
</tr>
</tbody>
</table>

Source: National Grid; BERR

4.9.6 For the current generating mix and using these availability assumptions, effective capacity is some 17% lower than installed capacity. A higher proportion of low-availability generating capacity in the mix would increase this differential.

4.9.7 Different assumptions of availability are possible and these would of course give rise to different results. There is no single correct availability factor for any specific generator class and availability factors can fluctuate over time, for example between winter and summer or as technology develops.

4.9.8 The effective capacity margin, then, depends on demand on the one hand, and on the quantity and nature of generating capacity on the other. As explained above, all are subject to a wide range of uncertainty. This means that the theoretical range of possible future effective capacity margins is very wide.

4.9.9 In reality, however, we are unlikely to see such a wide range in the effective capacity margin because the supply of and demand for electricity, as with any commodity in a

¹⁵ Only the Anglo-French interconnector is included in the table as an electricity source because it typically exports to Britain at times of peak demand. In contrast, the Moyle interconnector to Northern Ireland usually imports electricity from mainland Britain, so it is captured in “peak demand”.

¹⁶ Installed capacity figures are Transmission Entry Capacity (TEC) values published by National Grid.
functioning market, are related to each other through price. If there is excessive supply, prices will tend to decline, which in turn will eventually increase demand and encourage operators to withdraw production; this will lead in time to the reduction and elimination of the ‘over-supply’. Conversely, if the market is tight, prices and profits will rise, thus limiting demand and encouraging new build\textsuperscript{17}. In a similar fashion, market participants will also respond to the level of expected prices, based on their expectations of supply and demand.

### 4.10 Future trends in the effective capacity margin

4.10.1 It is likely that additional new build, over and above what is already planned for, will be needed in due course - the exact amount and timing depending on demand levels, the rate of plant closures and how much of the capacity currently in development is actually delivered. We identify below three broad scenarios to show the possible different levels of opportunity for additional new build, given differing assumptions about these factors but not assuming any investor response. At the end of this chapter, in Box 4.1, we go on to present further scenarios, based on work commissioned from Redpoint for the Energy White Paper, which do additionally include assumptions about future investment in response to the market signals and expectations which would emerge as the supply-demand balance changes.

4.10.2 The “tough carbon” scenario starts from the assumption of a strong regulatory approach to carbon reduction, delivering a high price of carbon (which in turn raises the wholesale price of electricity) and helping consumers to become more environmentally aware and technically enabled. This leads to electricity demand being at the lower boundary of the inner fan in Chart 4.1, as a result of more energy-efficient consumption, increased microgeneration and demand-side response to price signals.

4.10.3 This scenario also assumes that lower demand leads to only half the proposed new gas-fired capacity being built and the LCPD opted-out power stations running less intensively, thus prolonging their lives to the end of 2015. The high carbon price encourages a higher level of new renewables

\textsuperscript{17} \url{http://www.ukerc.ac.uk/ResearchProgrammes/EnergyInfrastructureandSupply/EnergyInfrastructureAndSupply.aspx}
build and also encourages nuclear power station owners to apply for life extension for all of the nuclear AGR plants by five years beyond the scheduled closure date; we assume here that this is allowed by the Nuclear Installations Inspectorate. This scenario would tend also to lead to lower growth in annual gas demand.

4.10.4 In contrast, the “easy carbon” scenario supposes a low carbon price and a limited impact of carbon reduction policies. Electricity demand is at the high end of the inner fan in Chart 4.1. This encourages the LCPD opt-out power stations to run harder and consequently close earlier, either because they run out of hours or because they wear out. All of the proposed new CCGTs are built and some new coal-fired generating capacity is also delivered under this scenario because it is relatively cheap to emit carbon. The carbon price is assumed to be too low to encourage either a high level of renewables build or nuclear life extensions. This scenario would tend to raise the growth rate of gas demand.

4.10.5 The central scenario uses the demand base case shown in Chart 4.1. We assume that LCPD closures take place as described in Table 4.2 above. No nuclear life extensions are included. Delivery of new CCGTs (above what is already under construction) is delayed by two years and only half of the proposed new renewable capacity (above what is already under construction) is built.

4.10.6 These scenarios do not assume any additional plant closures after 2015. It is possible, however, that some coal-fired power station owners will choose not to invest in the installation of equipment such as selective catalytic reduction that would be necessary to meet the further tightening of emissions standards which will be introduced under the Large Combustion Plants Directive from 2016 onwards. These stations would also have to close or reduce their level of operation, opening up a requirement for additional new capacity over and above that which will be needed to fill the gap left by the expected first-stage LCPD and nuclear closures. Looking still further ahead, the first generation of gas-fired power stations in Britain will start to reach the end of their normal operating lives (in the absence of refurbishment) during the 2020s.
All three scenarios show an increase in effective capacity margins in the short term as plant currently under construction comes onstream, followed by a decline after about 2012 as a result of the expected plant closures, and in the absence of any new investment being factored in.

4.10.7 Chart 4.3 shows what happens to the effective capacity margin under these scenarios in the absence of any investor response.

4.10.8 It is worth noting that while, in the absence of new investment, the “tough carbon” scenario delivers the highest level of security, as measured by the effective capacity margin, the amount of new generating capacity delivered is lowest in absolute terms in this scenario. This emphasises the importance of demand as well as supply capacity in determining security of supply in the electricity market.

4.11 Transmission Networks

4.11.1 Generally, the record of the electricity transmission network in Great Britain has been good. For instance, for the seven years commencing 2000, the National Grid transmission

---

network in England and Wales experienced an average loss of unsupplied energy of only 533MWh p.a. This equates to a transmission reliability of approximately 99.99983% over the period, measured in terms of the index of unsupplied energy to energy actually delivered.

4.11.2 The operators of electricity distribution networks in Great Britain face price control incentives to reduce the number and duration of interruptions to supply over their network. Since these incentives were introduced, an average distribution service customer would have experienced only four interruptions in total over the last five years (2001-02 to 2005-06). The average duration of such interruptions is about 90 minutes.

4.11.3 Current and future customer connection requirements may result in the need to extend and reinforce the transmission infrastructure into geographic areas of the UK that have historically not required any. The forthcoming substantial changes in the electricity generating fleet are likely also to require large scale investment in and development of the high voltage electricity transmission network. The amount, nature and timing of investment in the development and maintenance of the national transmission and distribution networks is the subject of regulation by Ofgem and NIAUR in discussion with the network owners19.

4.11.4 Transmission investment requirements are likely to be affected by the type of generation that is being built. Some types of renewable generation will typically be associated with greater transmission investment requirements. For example, wind generation often needs to be sited at the extremities of the network in order to capitalise on optimum weather conditions. In contrast, fossil fuel and nuclear plant can often be located closer to demand and are more likely to be commissioned in areas where there is spare network capacity. In part, this would be in response to Britain’s locational transmission charging regime, which has been designed to reflect long-run network costs. These costs are lower for generators in areas which have spare transmission capacity and/or which are near the main centres of electricity demand.

---

19 [http://www.ofgem.gov.uk/Networks/Trans/Pages/Trans.aspx](http://www.ofgem.gov.uk/Networks/Trans/Pages/Trans.aspx) [http://ofreg.nics.gov.uk/Electricity%20Register.htm](http://ofreg.nics.gov.uk/Electricity%20Register.htm)
4.12 Conclusions

4.12.1 In the near term, the security of supply outlook in the electricity sector looks robust, with a relatively large amount of new plant under construction. However, in the medium term the electricity generating industry faces a substantial challenge in ensuring delivery of the new generating capacity that will be needed if demand continues to rise. There are uncertainties around future levels of electricity demand and new electricity build as well as the exact timing and sequence of plant closures. In any case, improvements in energy efficiency and demand-side responsiveness would also help to underpin continued security, as well as limiting the need to invest in new generating capacity.

4.12.2 There are indications that firms are already considering these challenges and no reason to conclude at this stage that the response will not be adequate. However, this is an area on which the Energy Markets Outlook will continue to focus.
Box 4.1: Modelling the market

An independent study commissioned for the 2007 Energy White Paper\textsuperscript{20} examined the different security of supply outcomes that might prevail under a “well functioning” and an “imperfect” generation market environment, against a background of two possible states of the world (“base case” and “challenging case”).

In short, the well functioning market environment is an ideal that was modelled to incorporate the following features: far-sighted developers; a liquid forward market for electricity; limited barriers to entry; certainty around the future existence of the EU ETS; absence of supply chain constraints; and a supportive planning regime.

An imperfect market environment contained the opposite features, involving a mixture of government and market failures in addition to developers being unable or unwilling to look far ahead, due in part to uncertainty around the future existence of an explicit carbon price.\textsuperscript{21}

Results from the modelling suggest that, even in the worst years of the challenging case, effective capacity margins do not fall below about 3-4\%\textsuperscript{22}. This assessment is obviously dependent on various assumptions about how prices and price expectations are set in the market, what level fossil fuel and CO\textsubscript{2} prices are expected to be and the costs of new capacity. However, the modelling indicates that de-rated capacity margins are unlikely to remain at such low levels for any sustained periods of time as higher prices drive investment in new capacity.

As illustrated below, the annual probability of inadequate generation is more stable in the well functioning market environment than under the imperfect market environment. In the former case, this is because the self-correcting forces that push the generation market back towards a long-run equilibrium are sufficiently timely and responsive to prevent big swings in the effective capacity margin as new projects (including those not yet proposed) emerge in future, as shown below.

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{20} http://www.berr.gov.uk/files/file38972.pdf
\item \textsuperscript{21} The ways in which the Government seeks to address these imperfections and bring the market closer to the well-functioning ideal are set out in the Energy White Paper.
\item \textsuperscript{22} It should be noted that Redpoint were using different availability factors in their calculation of the effective capacity margin from those used in the scenarios set out in section 4.9. Their results are not therefore precisely comparable.
\end{itemize}
\end{footnotesize}
In the imperfect market environment, market participants tend to have a constrained time horizon. This means that they react to scarcity of capacity rather than to expectations of such scarcity, leading to a more cyclical investment pattern and times of market tightness.
Box 4.2: Electricity supply and demand in Northern Ireland

There are three power stations in Northern Ireland (NI), two of which are gas fired and one which is coal/oil fired and which has ‘opted in’ to the LCPD. NI has current total installed generation capacity of about 2,756 MW (including renewables). Allowing for availability of generation plant, the current peak demand which can be met is c 2,079 MW with an estimated peak electricity demand expected during 2007-08 of about 1,760 MW. Indigenous renewables account for just under 4% of electricity output. Forecast estimates of future generation capacity margins in NI can be found in the System Operator for Northern Ireland (SONI) ‘Generation Seven Year Capacity Statement’, the most recent of which covers the period 2005/06 – 2011/12.23

There are currently proposals to construct a new 450 MW CCGT to commence operation in NI by end 2010. There is also 250 MW of additional wind generation with planning permission which could be expected to come on stream by around the same time, and around a further 1,000 MW of wind generation in the planning system.

The introduction of the all-island Single Electricity Market (SEM) from 1 November 2007 will introduce greater competition in generation and substantially increase the potential generation mix available for supplying NI customers.

Interconnection

The Moyle interconnector links NI with Scotland and has a capacity of 450 MW. The North-South interconnector linking the NI and Republic of Ireland (RoI) networks has a capacity of 600MW. However, net transfer capacity is limited to 300 MW, North to South, mainly because of transmission constraints in RoI.

It is planned to build a second North-South interconnector by late 2012 which will more than double North-South trading capacity. The second interconnector will provide benefits to Northern Ireland, including:

- improved security of supply through network stability and access to additional power supplies;

---

• greater grid support to allow for additional wind power generation;
• scope for improved competition in the SEM with the opportunity for cost savings to NI and RoI consumers; and
• access for NI generators to a larger market for export opportunities.

Following the installation of the second North-South interconnector, it is proposed to replace the separate generation adequacy standards in Northern Ireland and the Republic of Ireland with a combined all-island generation security standard.
5. Gas

5.1 Introduction

5.1.1 In this chapter we show that the gas market in Great Britain has responded to declining gas production from the UK Continental Shelf with substantial investment in new import and storage infrastructure. This leaves Great Britain with a broad range of supply options, potentially reducing the extent to which any one shock can impact overall security.

5.1.2 In terms of capacity, on the assumption that facilities currently under construction are completed to target, new import capacity should more than offset declining indigenous production until around 2015. Gas supplies to the UK will therefore not be constrained by physical capacity until this time (although prices may need to rise to attract supplies to the UK.) Further investment will be needed to avoid physical capacity constraints from around 2015.

5.1.3 The analysis in this chapter draws mainly on data supplied by National Grid, who are responsible for gas transmission in Great Britain. The gas market in Northern Ireland is described in a separate box at the end of this chapter.

5.2 Background

5.2.1 There are three general sources of supply that can be used to meet peak daily gas demand. These are indigenous supplies (from the UK Continental Shelf), imports (either through pipelines or LNG tankers) and withdrawals from storage facilities. However, as storage facilities simply allow the transfer of gas from periods of low demand to periods of high (or peak) demand, such facilities cannot be relied upon to provide supplies to meet demand over a longer time period, such as a year. This means that we need to consider the balance between supply and demand on both a peak (including storage) and an annual (excluding storage) basis.

5.3 Gas demand

5.3.1 Natural gas is used in our homes for cooking and heating, and is used to generate well over a third of the electricity used in the UK. It is also used industrially, for example in the manufacture of steel, chemicals, glass, paper and construction materials; and in the food industry and the services sector.

5.3.2 Gas demand may be influenced by a wide range of factors. Gas-fired electricity generating stations in particular are a significant source of gas demand. The expected growth in CCGT capacity will therefore have a large impact on future levels of gas demand. If the construction or use of CCGTs were to be curtailed for some reason, for example as a result of high gas prices, that would substantially reduce the rate of growth in overall gas demand in the future. In addition, the operating pattern of CCGTs will determine the relative magnitude of the impact they have on peak and annual gas demand.

5.3.3 Other factors which influence gas demand include the gas price, the impact of energy conservation measures, general economic growth and in particular the weather, which is the main determinant of short term variations in gas demand. It is worth noting that higher average temperatures, such as would be associated with global climate change, do not necessarily lead to less extreme cold days. Indeed, it is possible that higher average annual temperatures may be associated with no reduction in the incidence of extremely cold days. This would mean that higher temperatures may not reduce peak gas demand to the same extent as it would do for annual gas demand.

5.3.4 As with the factors influencing electricity demand, these variables act together. In some cases they may tend to balance each other out rather than to act cumulatively to push demand towards the extremes shown in the chart below.
A wide range of demand levels is possible.

5.4 Gas supply capacity: Indigenous production

5.4.1 Although gas production from the UK Continental Shelf (UKCS) is now in decline, indigenous production still supplies the majority of GB gas demand and there are of the order of a trillion cubic metres of gas reserves remaining. The rate of decline could be slowed if a high level of investment is maintained, and the Government is working with industry to encourage and facilitate this. Nevertheless it is clear that there will be a large and growing import requirement in the years ahead.
Gas production from the UK Continental Shelf is no longer able to meet UK demand on an annual basis.

5.5 Gas supply capacity: Imports

5.5.1 Great Britain is now a net importer of gas on an annual basis and has the capacity to import direct from Norway and from Continental Europe by pipeline, and from the global market by liquefied natural gas (LNG) tanker.

5.5.2 The following chart shows that if all the proposed import infrastructure projects are delivered, Great Britain will have more than enough physical capacity to meet its annual demand. Given the diversity of gas supply infrastructure, any annual shortage of gas is unlikely to result from, or persist due to, technical failure of any individual piece of infrastructure, since alternative routes are readily available while repairs take place.

Source: BERR
Import capacity in relation to annual gas demand will stay above recent margins for the foreseeable future. This is the case even when only existing capacity and capacity under construction are taken into account.

5.6 Gas supply capacity: Daily total

5.6.1 It is important to note, however, that daily demand levels vary widely during each year so that the annual supply-demand balance does not tell us anything about capacity to meet demand on the coldest (highest demand) days of the year. As the capability of the North Sea to increase or reduce production to meet changes in demand declines, there will be a need for greater flexibility of imports and/or an expansion in our storage capability (in terms of capacity and deliverability).}\(^28\).

---

\(^28\) [Link to source](http://www.berr.gov.uk/files/file28954.pdf)
5.6.2 In addition to enabling management of seasonal variations in demand, close-to-market storage enables a timely response to short-term changes in gas demand. Physical proximity is important because gas (unlike electricity) travels along the supply system relatively slowly and so sources of gas which are physically distant from the market may not be able to respond rapidly to increases in demand.

5.6.3 Different forms of gas storage play different roles in meeting this need. Salt cavity storage can pump out gas more quickly relative to the size of the facility over a shorter time than depleted gas fields. Currently around 75% (around 3,300 mcm) of our gas storage capacity is in the form of long range storage (i.e. depleted fields).

5.6.4 Investment in additional storage capacity has been made in recent years and more is planned and proposed, mainly in the form of salt cavity storage. Capacity could therefore increase substantially from its current level of around 4,300 mcm.

5.6.5 As with major electricity infrastructure projects, the time taken to obtain planning consent for large gas storage and supply infrastructure has to be taken into account in considering when new infrastructure might be deliverable. We set out the Government’s proposals for streamlining the planning and consents process in paragraphs 4.8.6-4.8.9 above.
Peak gas demand in the UK is met from a range of supply sources. If all planned capacity is delivered, there should be surplus capacity to enable peak demand to be met.

5.6.6 Chart 5.4 illustrates the diversity of gas supply sources. This chart also shows how gas demand could be met on days of peak demand under a Base Case scenario described in more detail in Section 5.11. The map below contains details of the location and size of current and planned import pipelines, interconnectors, LNG terminals and storage facilities. Those described as “planned” are at various stages in the development and planning process and there is no guarantee that they will all be delivered with the capacity, and to the timescales, indicated.

29 2007 TBE ‘Development of NTS Investment Scenarios’ (broadly based on Fig. 7)
Readers will wish to note that a planning decision on the Preesall gas storage project was announced recently. The future of this project is uncertain, pending announcements by the developers how they will proceed against the background of this decision.
5.7 Gas delivery

5.7.1 In order to assess the security of future gas supply, we need to look not only at gas supply capacity but also at the extent to which it is likely to be used in practice to supply gas into the UK market. It is also important to understand how resilient the outlook is to a shortfall in supply from one or more individual sources.

5.7.2 Import reliance, although neither new to the UK nor uncommon around the world, can bring additional risks of disruption to supply sources. These risks may include, for example, lack of access to pipeline infrastructure outside UK borders or low market liquidity or competitiveness. Liquid, competitive markets can facilitate the transportation of gas to where it is valued most and investment in interconnection, import facilities and source development.\(^{30}\)

5.7.3 While the UK gas market is one of the most liquid markets in the world and the most liquid in Europe, there is a relative lack of liquidity and competitiveness in some of the markets from which we import gas supplies. This needs to be borne in mind when we consider the likely responsiveness of the international marketplace to price signals from the UK.\(^{31}\)

Chart 5.5: Main Net Inter-Regional Natural Gas Trade Flows (bcm) in the Reference Scenario, 2004 and 2030

Source: IEA

Most international trade flows are expected to increase in the next two decades.

---

5.7.4 Nevertheless, the UK market enjoys a wide diversity of supply sources and supply routes and this increases our resilience to interruptions to, or reductions in, flows from individual supply sources, whether domestic or external. We look briefly below at the likely future availability of gas from the various possible sources of supply into the UK market.

5.8 Norway

5.8.1 Gas from Norway can currently flow to either the Continental mainland (five pipelines) or to Great Britain (Vesterled, Langeled and Tampen Link pipelines). Much of the gas to the Continent is believed to be contracted under long term arrangements. Chart 5.4 shows that in 2016/17 UK import capacity from Norway could represent some 16% of peak supply capacity.

5.8.2 The Norwegian Government estimates that about 35% of the expected total gas resources on the Norwegian continental shelf have been produced. The Norwegian Government expects gas production to increase from its current level of nearly 90 bcm per year, to 125 – 140 bcm per year from 2013. In the longer term, the number and size of future discoveries, as well as Norwegian Government policy, will be a critical factor for production levels. Norwegian Government forecasts indicate that investment activity in the industry will remain high over the long term.

5.8.3 The Norwegian Government is currently considering proposals to expand gas production from the Troll field on the Norwegian Continental Shelf, for delivery by pipeline to the EU. This pipeline could land first in the UK, or in the Netherlands, or in Belgium. Wherever the pipeline lands, this additional supply would improve security for the EU as a whole, including the UK, to the extent that the EU operates as a single gas market.

5.9 Continental Europe

5.9.1 The UK can receive gas by pipeline from the Continent through the Interconnector (IUK) from Belgium and through

33 Norwegian Petroleum Directorate http://www.npd.no/English/Produkter-og-tjenester/Publikasjoner/Faktaherfet/Faktaherfet-2007/coverpage.htm
the BBL line from the Netherlands. This gas may be originally sourced from within the EU or from outside it, for example from Russia or Algeria by pipeline, or from further afield by LNG. Thus while Chart 5.4 shows that import capacity from the Continent could represent some 14% of peak supply capacity, the range of supplies sitting behind these imports means that the UK is not significantly dependent on any single country supplying to the EU market.

5.9.2 The International Energy Agency (IEA) projects that demand in Europe will be some 45% higher in 2030 than in 2004\(^{35}\). This will in part be driven by rising gas fired power generation. Import dependency is expected to rise in Europe (from 40% to over 60% by 2030) as indigenous production falls. Hence new supplies will need to be attracted in, and investment made to enable them to be physically brought in, whether by ship or pipeline.

5.9.3 Expected investment in Europe in LNG import facilities may lead to a trebling of capacity by 2015\(^{36}\). Greater interconnection would be expected to encourage such new supplies to arrive in Continental Europe. Increased EU liberalisation, market opening and competition may lead to a greater use of improved demand management. This will also be important for security of supply for the UK.

5.10 Liquefied Natural Gas (LNG)

5.10.1 There are currently two LNG import terminals in Great Britain – at the Isle of Grain and at Teesside. Two further terminals (Dragon and South Hook) at Milford Haven in South Wales are expected to be commissioned by next summer. The expected increase in the capacity to import LNG will give the UK increased access to the growing global gas market. Chart 5.4 shows that in 2016/17 LNG import capacity in the UK could represent some 23% of peak supply capacity.

5.10.2 We understand that there are long-term contracts in place for the supply of LNG through both Grain and Milford Haven\(^{37}\), although the proportion of likely LNG demand which is not presently contracted for is expected to increase further into the future.

\(^{35}\) IEA World Energy Outlook http://www.worldenergyoutlook.org/


\(^{37}\) GI report (abc7) section 4.2/exhibit 68; http://www.oilandgasuk.co.uk/issues/gas/poyryreport07.pdf
5.10.3 In March 2007 BERR employed Global Insight to look at various scenarios for the global LNG market out to 2025\textsuperscript{38}. Global Insight forecast that, assuming the continuation of current trends, the scale of the global LNG trade will treble between 2005 and 2025 from 200 to 600 bcm/yr. They expect that the market will change from one consisting primarily of bi-lateral trades to a much more flexible one with an increasing proportion of the gas not being the subject of a long-term contract. This will increase the responsiveness of supplies to relative prices in different markets.

5.11 Security of supply

5.11.1 No energy system is invulnerable to the possibility of an interruption to one or more supply sources, or to fluctuations in demand levels. Whether such shocks to the supply-demand balance lead to actual shortfalls in gas supply, will depend on the interaction between the prevailing market situation (is the market already tight? is it well supplied?) and the nature of the shock. A number of different dimensions define the nature of shocks, including:

- when does it occur – winter or summer?
- the size of the shock?
- where does it occur?
- how much warning was given?
- how long does it last?
- how quickly can the market replace the lost supply, for example by increasing delivery from storage or by diverting LNG cargoes from other destinations?
- how quickly and how far can the demand side adjust in response to price signals?

An otherwise very well supplied market could still experience a shortfall if a very large shock were to occur, while a tight market would require only a smaller shock for supply to be unable to meet demand. The difference between supply capacity and demand thus provides one indicator of the resilience of a system to a shock. The probability and implications of these two types of supply shocks are obviously different.

\textsuperscript{38} http://www.berr.gov.uk/files/file41844.pdf
5.11.2 As discussed above, our analysis has found that the difference between supply capacity and demand provides one indicator of the resilience of a system to a shock. We look at three National Grid scenarios\textsuperscript{39} for future peak supply capacity, summarised in the charts below, to assess how the resilience of the system is likely to develop. The cases differ in their assumptions as to:

- the rate of decline of UKCS production,
- the rate of delivery of new capacity which is already under construction,
- the amount and type of new capacity that is delivered, and
- the degree to which capacity is utilised.

These factors are not independent; for example, decisions about investment in new capacity are likely to be influenced by the rate of UKCS decline and expectations as to how existing capacity will be used. In addition, the volume, type and utilisation of new build will be influenced by its expected revenue stream. This in turn depends on investors’ future expectations of prices.

5.11.3 In each case the total supply capacity is compared with the National Grid base case for expected demand on the coldest day of a 1-in-20 winter. While we would expect prices under such extreme demand conditions to be high, encouraging gas into the market from every source, it is always possible that some capacity will not deliver as much gas as it theoretically could do. For example, gas may be technically unavailable due to engineering failure, or it may be attracted to other markets where prices are higher such as the US or Continental Europe, or it may be constrained by contractual commitments elsewhere. If supply, including that from storage, were not able to meet demand as a result of one or more of these factors, then a demand-side response would be needed to make up the shortfall.

5.11.4 It is, of course, also possible that shortfalls in delivery will be so great that annual demand cannot be met – storage facilities cannot be filled in the summer so are unable to compensate for shortfalls in imports during the winter. This would require a circumstance or combination of circumstance far more extreme and extended (and unlikely) than would be required to affect peak supply capability, so is not further considered here.

\textsuperscript{39} The assumptions behind these scenarios are set out in full in National Grid’s report \textit{Development of Investment Scenarios}, available from http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE
Base case

*Chart 5.6: Peak gas supply margin under the base case scenario*

The only new, additional storage facilities are those that already have planning consent or are under construction. The Norwegian Troll pipeline does not come to the UK.

*Source: National Grid*  

40 2007 TBE ‘Development of NTS Investment Scenarios’ (broadly based on Figs. 7, 8, 9 & 10)
Destination UK

Chart 5.7: Peak gas supply margin under the “Destination UK” scenario

In this scenario the Norwegian Troll pipeline does come to the UK and gas from the global LNG market is readily available to the UK, for example as a result of reduced demand on the EU mainland as suppliers there are over-contracted. As a result, there is lower investment in storage capacity and UKCS production slows down because there is less perceived need for it.

Source: National Grid 41

41 2007 TBE ‘Development of NTS Investment Scenarios’ (broadly based on Figs. 7, 8, 9 & 10)
Spot LNG

Chart 5.8 Peak gas supply margin under the “Spot LNG” scenario

In this scenario the Norwegian Troll pipeline does not come to the UK and gas from the global LNG market is not readily available to the UK, for example as a result of higher prices on the EU mainland and elsewhere in the global market. This stimulates greater investment in storage capacity and UKCS production.

5.11.5 Under all scenarios the UK would need to make full use of most of the supply capacity which already exists or is already under construction, to meet demand under the extreme conditions illustrated here. The extent of the safety margin (the area above the line) is heavily dependent in all cases on how much of the additional new capacity is actually delivered.

5.11.6 Once we move beyond the lead time for capacity construction and expansion (typically around seven years), the supply-demand balance (excluding new build) tightens considerably (as can be seen happening after 2014-2015 in all three scenarios above). This reflects a typical feature of scenario building – that the supply-demand balance typically has the appearance of worsening as we look further out into the medium to long term. This is driven

Source: National Grid 42

42 2007 TBE ‘Development of NTS Investment Scenarios’ (broadly based on Figs. 7, 8, 9 & 10)
by the assumption that although demand continually grows and UKCS supplies are forecast to decline, it is harder to project forward plans for new build of capacity not currently under construction.

5.11.7 Beyond 2016, the spare capacity margin, without the contribution from planned ‘new build’, would become negative, thus highlighting the significance of new build to ensure against contingencies, both on the demand side (a very cold spell) or the supply side (the loss of any source of supply); although the diversity of supply sources in the future will reduce the vulnerability of the system overall to interruption from any one source.

5.11.8 Therefore any delay in the planning or deployment of any new project would reduce the margin further for any given year, reducing the flexibility to respond to an unexpected shock which coincides with such demand levels.

5.12 Conclusions

5.12.1 No system can ever provide perfect security against every conceivable circumstance or combination of circumstances. In the short term, however, the UK’s gas supply capacity appears robust against most credible scenarios and events. For the medium to long term, investments over the next five years are critical; if they come forward as expected, the capacity margin will be large enough to provide a buffer against most large single interruptions. Nevertheless, supply will be forthcoming only if the UK price is attractive relative to alternative destinations. Price signals and the ability of the market to respond to them in a timely way will play an important role in balancing demand and supply.

5.12.2 However, any delays in investment could create a situation in which margins are smaller. In this situation flexibility from the various sources (i.e. the capacity to access quickly the full capacity) and perhaps in demand as well would be needed to handle a shock. Of critical importance are the investments in LNG terminals and storage capacity.
Box 5.1: An alternative approach

We set out below a qualitative explanation of an alternative approach to presenting the security of gas supply, under different possible circumstances or combinations of circumstances. A full quantitative explanation is given on the EMO website43, but it is important to emphasise that this methodology is at a relatively early stage of development.

Chart 5.9: Risk of a shortfall in the overall gas supply-demand balance under different combinations of market tightness and supply-demand shocks

Source: BERR

Security of supply reduces (towards the top right) as a result of a tighter market, a worse shock or a combination of both.

The bottom axis gives a measure of market tightness; broadly, the UK is moving leftwards along this axis as more gas supply infrastructure is constructed and supply sources become more diverse. The left-hand axis shows supply shocks (for example, loss of a piece of infrastructure) which could occur at any time, increasing in volume from the bottom to the top. We are evaluating different means of quantifying these factors.

The coloured bands then show different levels of security of supply in terms of expected energy unserved. These get higher – security gets worse – from the bottom left to the top right. Prices would also be expected to increase in the same direction, but we have not yet attempted to model this.

In this particular version of this chart, depending on the supply assumptions used, the position of the UK gas market at the beginning of the winter of 2005 – 2006 is roughly at point A; and the worsening of the security of supply situation as a result of the Rough fire on 16 February 2006 is shown by a shift upwards to point B.

Once we are confident that the correct indicators are used on each axis and the calibration is right, this approach would enable us to show how security of supply in this and future years compares to that historic precedent. For example, we might expect to start the winter of some future year at about point C on the chart. We could then read upwards from that point until we reached points D and E, respectively in the same coloured bands as points A and B. The left hand axis would then tell us how large a shock to the market would be necessary to render the security of gas supply in the UK this winter similar to what it was in the winter of 2005 – 2006.
Box 5.2: Gas in Northern Ireland

The natural gas market in Northern Ireland is concentrated in the Greater Belfast area where gas is supplied to almost 110,000 consumers principally by Phoenix Natural Gas. Firmus Energy is engaged in ongoing work to develop the gas market in ten towns outside Belfast. Natural gas is provided to Northern Ireland via the Scotland to Northern Ireland gas interconnector, hence Northern Ireland also benefits from additional import and storage provision in Great Britain. In addition, the South-North gas transmission pipeline, completed in October 2006 between Dublin and Antrim, provides additional security of supply to Northern Ireland by providing access to gas from the Republic of Ireland.

Gas Demand

The Northern Ireland Authority for Utility Regulation (the energy regulator) prepares an annual report entitled the NI Gas Pressure Report which details current and future gas demand for power generation, business, and domestic users.44

Gas Delivery

Northern Ireland has no indigenous sources of natural gas, and is therefore reliant on gas supplies from Great Britain. While there is gas interconnection with the Republic of Ireland, which has some indigenous sources of natural gas, it too receives the bulk of its gas from Great Britain. Governments in Northern Ireland and the Republic of Ireland are co-operating in completion of a study into the need and potential for gas storage and liquefied natural gas on an all-island basis, with the objective of enhancing security of gas supply on the island.

44 http://ofreg.nics.gov.uk/Docs%202007/26%20March%202007G.htm
6. Coal

6.1 Introduction

6.1.1. In this chapter we report scenarios that have been developed for future demand for coal in the UK, including the potential impact of technologies such as carbon capture and storage. Indigenous production is unlikely to be able to meet this demand so we also examine the prospects for the global coal market.

6.1.2. We draw on the Government’s Updated Emissions Estimates\(^\text{45}\) and work by MDS Transmodal set out in its UK Port Demand Forecasts to 2030 provided for the Department for Transport\(^\text{46}\).

6.1.3 We also present estimates of future coal demand taken from the work of the Coal Forum. The Coal Forum is an independent, non-departmental grouping which brings together the coal producers, generators, unions and equipment manufacturers. A number of government bodies, including the Department, are also represented.

6.1.4. As part of its work, the Coal Forum considered security of supply and energy diversity issues, and developed a number of scenarios for future coal demand in the UK\(^\text{47}\).

6.2. UK Demand

6.2.1. A significant proportion of demand for coal in Great Britain (around 85% in 2006) comes from the electricity sector and so is closely linked to the level of generation by coal-fired power stations. Of the remaining 15%, the majority (10% of total demand for coal) is from the Iron and Steel sector and is met mainly by imported coking coal from Australia, Canada and the USA. This chapter concentrates mainly on steam coal for power generation.

---

47 A report giving an overview of the work of the Coal Forum is published at http://www.berr.gov.uk/energy/sources/coal/forum/page37276.html
6.2.2. The level of electricity generation by coal-fired power stations would be expected in future to depend on the relative price of gas, coal and carbon allowances as well as the environmental and regulatory considerations affecting power station owners’ decisions about closure and new build. The level of investment in new coal-fired power stations may also be affected by the development and deployment of carbon capture and storage technology.

6.2.3. The introduction and successful deployment of carbon capture and storage (CCS) would expand the range of generating technologies available in a carbon-constrained world, by enabling coal to be used as a low-carbon technology. The Government has announced a competition to build the UK’s first commercial scale CCS power plant. Demonstration is intended to enable the electricity generating industry to test CCS technology and understand and reduce the costs, thus facilitating wide scale deployment. 48

6.2.4. In addition, there is potential for further long term improvements in cleaner coal technology. There is also potential for improvements in the thermal efficiency of coal power stations through development of advanced “supercritical” boilers and improved turbines and gasifiers. This could reduce the carbon intensity of coal-fired generation.

6.2.5 Chart 6.1 shows a scenario of coal demand using the BERR policy delivery case, where the CCS demonstration project is assumed delivering no carbon savings in the forecast years until 2020 and then 0.3 MtC. This shows declining demand for coal as the production of electricity from coal combustion declines.

Chart 6.1: Demand for coal for power generation in the UK, 2000 to 2030


6.2.6 The Coal Forum has also developed a series of scenarios for future coal demand. These are based on scenarios for 0, 5, 10 and 15 GW of new or replacement coal plant, which are translated into scenarios for coal demand. The new coal plants are assumed to include a small number of plants with CCS and all the rest (coal) are assumed to be “capture-ready”, i.e., suitable for CCS to be added later. The model then assumes all these capture-ready plants are progressively fitted with CCS starting around 2016 and completed by 2025. These are shown in Chart 6.2, which also includes, as a point of reference, actual coal fired power station demand in 2006.
Chart 6.2: Coal Forum scenarios for future UK demand for and production of coal

Source: Coal Forum; DUKES

6.3 UK Supply: Production

6.3.1 Forecast UK coal production, taken from the McCloskey Group UK Coal Production Outlook: 2004-2016 indicates a broad decline in indigenous production over the forecast period. NB It should be noted that in terms of the longer term projections, MDS Transmodal has modelled production from deep mines only.
6.3.2. Evidence provided by the Coal Authority and producers demonstrated that known UK coal resources could be accessed to maintain production at the current tonnage (taken as 20 Mt pa) or more, to 2030 and beyond. However, this would depend on circumstances, including investment in existing deep mines and a sufficient flow of planning consents for new surface mines.

6.3.3. Currently most coal from both surface and deep mines in the UK is produced and delivered to the rail networks at costs that are competitive with imports. If UK producers can obtain world market equivalent prices, profits can be generated for investment in existing deep mines and in new surface mines. Prices would have to rise considerably, however, for development of new deep mines to be economic in the UK, given the current investment climate in the industry. Planning policy would therefore be expected to have a significant influence on the future of coal production in the UK.
6.4. UK Supply: Imports

6.4.1 The chart below shows the calculation of coal requirements for electricity generation carried out by MDS Transmodal based on the UEP demand scenario (central forecast). This scenario of demand and indigenous production suggests a continuing, though fluctuating, import requirement. Under the higher demand scenarios developed by the Coal Forum, there would be a need for increased indigenous production and/or imports compared with the above case. There would be a market for indigenous coal, at the current output at least, provided that it remained competitive on price. Significant coal imports would be expected to continue. MDS Transmodal, in their UK Port Demand Forecasts to 2030 provided to the Department for Transport, have developed a more detailed forecast of coal traffic through UK ports.

Chart 6.4: UK steam coal indigenous production, demand and imports, 2005 to 2030

Source: MDS Transmodal; UEP

6.5. UK Supply: Stocks

6.5.1. Generators collectively held stocks of 15 million tonnes of coal at the end of 2006. Assuming that the average production rate is 2.55 GWh per kilo-tonne of coal burn, then this amount is equivalent to 38.3TWh of electricity generation – or approx 10% of total electricity supplied in 2006. Based on National Grid data, there is 29 GW of (transmission-connected) coal-fired generating capacity in Great Britain, so it follows that the fleet could run on stocks alone for about 56 days continuously. This is for illustrative purposes only; in reality coal-fired power stations would be very unlikely to operate non-stop for this length of time.

6.6 Global supply and demand

6.6.1 We concentrate in the rest of this chapter on the availability of imported coal (both steam and coking coal, together termed “hard coal”). This is a globally traded commodity so that availability will depend on global supply and demand conditions.

6.6.2 Coal is the most abundant fossil fuel in terms of reserves. Proven global reserves at the end of 2005 amounted to around 909 billion tonnes, equivalent to some 164 years of production at current rates. Whilst a number of recent reports have questioned the validity of some reserves estimates, it seems very unlikely that the world will run short of coal in the twenty-first century. However, accessing new reserves could be associated with higher mining and/or infrastructure costs in the medium term.

51 http://www.worldenergypoutlook.org/
Chart 6.7: Global energy reserves, 2005


Around half of the world’s coal reserves are located in the US, Russia and China.

6.7 Future supply and demand estimates

6.7.1 Most of the world’s coal demand continues to be met by indigenous production with around 15% of production being traded internationally.
**Chart 6.8: International hard coal trade 2005**

**Source:** IEA Coal Information 2006

**Coal prices in the Atlantic and Pacific markets are linked by the ability of South Africa in particular to respond to price differentials between the two.**
Exports from Australia, Russia and South Africa are expected to increase.
6.8 Factors that may affect international availability

6.8.1 A number of factors could increase demand or reduce availability of coal for export:

- Economic growth rates of rapidly developing nations have been consistently under-estimated. This applies particularly to China, but is also relevant to India, Russia, Brazil and other parts of south-east Asia.
- Whilst China is expected to remain broadly self-sufficient in coal, small proportionate changes in the supply/demand balance can have a major impact on international trade.
- India is considered less likely to meet its own demands, and could become a major importer, competing with Europe for South African supplies.
- Russia is expected to increase generation from coal, which may reduce quantities available for export.

6.8.2 The UK’s reliance on supplies from Russia increased last year – exceeding indigenous supply. This increased reliance has arisen from a combination of circumstances:

- Demand for low sulphur coal has been particularly high with much of the new flue gas desulphurisation (FGD) plant still under construction.
- High overall demand has stretched the infrastructure leading to greater use of smaller ports which are suited to Russian supply.

6.8.3 The main Russian coalfields are a long way from port and supply interruptions have been caused over the past year as a result of congestion and shortage of rail cars. These are risk factors which could affect supply or cause upward pressure on prices.

6.8.4 In the longer term, with more FGD capacity in the UK and the possibility of new power station build (both enabling the combustion of higher sulphur coal) as opted-out plant are closed, the specific demand for low sulphur coal will reduce.

6.8.5 In the meantime, in a circumstance where Russian coal availability was constrained, the market should be capable of re-adjusting in a number of ways:
Alternative low-sulphur supplies are available from Indonesia (albeit with high freight rates) and are increasingly being trialled and used by UK power stations.

The disposition of imported supplies between ports is determined by the market at any point in time taking into account available capacity, freight rates for different sized vessels and rail rates to end customers from different ports. If it were necessary to deliver in smaller vessels rather than, for example, increasing utilisation of deeper-berth ports further from the power stations, it would be possible (albeit more expensive) to do so other than from Russia.

6.8.6 The view of buyers and international market analysts on the Coal Forum Sub-Group is that the current supply pattern represents a market solution and that the international market is sufficiently flexible and robust to respond to changes in supply.

6.8.7 On the other hand, factors which could depress coal demand and prices include more robust and effective climate change policies (unless carbon capture and storage can be deployed cost effectively at scale) – such as considered in the IEA Alternative Policy Scenario52. A major fuel-switch to gas or other alternative forms of electricity generation would be likely to depress international prices.

6.8.8 When the UK Coal Forum looked into this issue, they considered that the international reserve base is adequate, and the international market sufficiently flexible and robust, to cope with such issues, but a combination of these could lead prices to trend high and could also lead to short-term price spikes.

6.9 Supply chain issues

6.9.1 Over the last few years the sea freight element of the delivered price to north-west Europe has been high and volatile by historical standards, largely as a result of the appetite for bulk commodities in east Asia, and with periodic major congestion issues at Newcastle (Australia) tying up a significant proportion of the shipping fleet.

52 [http://www.worldenergyoutlook.org/worldpol.asp](http://www.worldenergyoutlook.org/worldpol.asp)
6.9.2 Whilst these factors are capable of causing temporary price spikes, the view of the UK Coal Forum which examined this issue in some detail, is that the international shipping market generally responds relatively well to price signals – over a period of about three years.

6.10 Conclusion

6.10.1 A range of scenarios can be postulated for demand for coal in the UK over the next decades. These are driven by assumptions about levels of coal fired power generation. These demand scenarios provide an opportunity for indigenous production of coal, although issues such as planning consents in particular for surface mines and rail infrastructure would also need to be considered. In all reasonable scenarios, however, there is a significant reliance on imports. Given the abundance of proven reserves of coal globally, the future use of coal is unlikely to be limited by resource availability, but there are a number of international issues and risks that could affect future prices.
7. Oil

7.1 Introduction

7.1.1 This chapter shows that the UK is already heavily involved in the global oil market as both importer and exporter, with the balance expected to move towards increasing import dependency over the medium and long term. We therefore focus mainly on global supply and demand conditions as these will be the main determinants of availability and prices.

7.2 UK oil demand

7.2.1 The majority (67% in 2006) of UK oil demand is derived from the demand for road or air travel, with the remainder for energy or industrial use (21%) and non-energy use (12%) for lubricants and petro-chemical feedstocks.

Chart 7.1: UK oil demand 2006

Source: BERR: UK Energy in Brief

7.2.2 Transport is expected to remain the main use for oil products with a projected increase in demand over the forecast period. In contrast, the use of oil by industry and the domestic sector are projected to decline.
Chart 7.2: Forecast UK oil demand by type of use

Source: BERR forecast model

7.3 UK supply: Indigenous production

7.3.1 The UK’s indigenous oil production peaked in 1999 and has been declining subsequently\(^\text{53}\). PILOT, the successor to the Oil and Gas Industry Task Force, has aspirational production targets to optimise production on the UK Continental Shelf\(^\text{54}\).

\(^{53}\) [http://www.og.herr.gov.uk/information/bb_updates/chapters/Section4_17.htm]
\(^{54}\) [http://www.pilottaskforce.co.uk]. Also see [http://www.og.dti.gov.uk/information/bb_updates/chapters/Section4_17.htm]
After a small upturn this year and next a continuing decline is expected.

7.4 UK supply: Oil stocks

7.4.1 The IEA and the EU both oblige their members to hold stocks of oil for use in the event of disruption of global supplies. IEA obligations are based on net imports and EU obligations on consumption. The same stocks can be used to meet both obligations. Member States are free to decide how to meet these obligations; the UK does so by directing companies to hold stocks.
Chart 7.4: UK oil stocks compared to the EU obligation

Source: BERR Energy Trends Chart 3.5

The UK is meeting the EU requirement, which is presently higher than the IEA requirement.

7.4.2 As a net exporter, the UK has not so far had to hold stocks as an IEA member, but will have to with effect from 2007, as we become a net importer.
While our obligation to hold oil stocks is presently higher under the EU system than it is under the IEA’s, our growing import reliance means that our IEA obligation is now increasing.

7.4.3 Between about 2016 and 2018 the IEA obligation is expected to overtake the EU obligation. Thereafter, the UK obligation will begin to increase steeply from its current level of 67.5 days’ consumption to an eventual total of 99 days’ consumption. At the same time, the total UK obligation is likely to exceed the UK storage available to hold these stocks. The Government is changing the basis on which companies are directed to hold stocks, from the current sales-based system to a system based on production and imports.

7.5 UK supply: Imports

7.5.1 Overall, the UK currently produces about the same amount of oil as it consumes, such that the net import-export balance, while now shifting towards imports, is quite small.

---

Source: BERR

Further information is available on the BERR website at http://www.berr.gov.uk/energy/policy-strategy/international/oil-stocking/page28385.html
7.5.2 However, this small net balance conceals substantial two-way flows, since the UK exports some of what it produces and imports some of what it consumes. This is because refineries are primarily interested in the type of oil and its cost rather than its source. Typically, a refinery will buy and blend a mix of crudes to get the most efficient use of the plant and to meet market demand, e.g. for gasoline vs diesel. The UK’s light oils must be blended with heavier stock from elsewhere.
7.6 UK supply: Refining and distribution

7.6.1 In January 2007, BERR commissioned a report by consultants to look at refining and distribution in the UK. The review was undertaken by Wood Mackenzie and was published alongside the Energy White Paper.

7.6.2 The review identified key challenges affecting the dynamics and competitiveness of the UK refining industry:

- evolving trends in UK demand for oil products. The industry faces the challenge of responding to rising demand for diesel and jet fuel and falling demand for petrol both here and in export markets;

- declining availability of North Sea crude oils. As local crude oil supplies decrease, refiners face increased costs from either importing similar quality crude oils from further away or investing in capital equipment to process lower quality crude oils; and

- evolving qualities of oil products, including the introduction of biofuels.

7.6.3 The report concluded that, subject to present facilities being maintained as fit for purpose, the current UK primary distribution infrastructure is broadly fit for current and

---

future needs. The one area that could potentially benefit from additional facilities is the South East, in the wake of the loss of storage and distribution facilities at Buncefield and the high rate of growth in the region, especially the demand for jet fuel at the main London airports.

7.6.4 BERR is working with the industry and other Government departments to agree actions needed to anticipate and respond to the changing patterns of supply and demand identified. An Aviation Fuel Task Force with the Department of Transport and the oil and aviation industries is looking at medium and long term jet fuel demand, supply and infrastructure.

7.7 The global oil market

7.7.1 We have shown that the UK acts as both buyer and seller in a global market where prices and availability are determined by global supply and demand conditions. We focus in the rest of this chapter on the global fundamentals of supply and demand.

7.8 Global oil consumption

7.8.1 Global oil consumption has more than doubled over the past forty years, driven by global population growth and economic development. While the industrially developed countries still account for the majority (58%) of global oil consumption, the share of developing countries (outside the Former Soviet Union (FSU)) has increased from 20% in 1980 to 37% in 2006, with China alone accounting for around one-third of this growth.

7.8.2 Looking forward, the International Energy Agency’s (IEA) “Reference Scenario”58 projects an increase in global oil demand of nearly 40% between 2005 and 2030 (an average annual growth rate of 1.3%).

---

58 The IEA’s World Energy Outlook 2006 “Reference Scenario” takes account of those government policies and measures that were enacted or adopted by mid-2006. [http://www.worldenergyoutlook.org/](http://www.worldenergyoutlook.org/)
Most of the projected increase in oil demand comes from developing countries, where economic growth is highest.

7.8.3 China and the rest of developing Asia account for 46% of the forecast increase in oil use between 2005 and 2030. Globally, the transport sector absorbs 63% of the forecast increase in global oil demand. In the OECD, forecast oil use in other sectors hardly increases at all, declining in power generation and in the residential and services sectors, and growing in industry. Transport is also the biggest contributor to forecast growth in non-OECD countries, but other sectors, particularly industry, are also expected to see significant growth.

7.8.4 The IEA’s World Energy Outlook 2006 also considered an “Alternative Policy Scenario” which analyses how the global energy market could evolve if countries were to adopt all of the policies they were considering in mid-2006 related to energy security and energy-related CO₂ emissions. These policies include efforts to improve energy efficiency, and to develop non-fossil fuels. As a result, global oil consumption would grow by only 0.9% per year to 2030, by which time consumption would be 11% lower than in the Reference Scenario.
Chart 7.9: Global oil demand under IEA reference and alternative policy scenarios

Data source: IEA World Energy Outlook 2006

Global oil consumption could be substantially less than under the Reference Scenario, by 2030.

7.9 Global oil resources and reserves

7.9.1 According to the BP Statistical Review of World Energy\(^59\), the world’s proven reserves\(^60\) of oil amounted to 191 billion tonnes (or 1372 billion barrels)\(^61\) at the end of 2006. The Middle East accounts for 53% of the world total, with Saudi Arabia alone accounting for 19%. The UK ranks 29th globally in terms of its proven oil reserves.

\(^{59}\) [BP Statistical Review of World Energy 2006](http://www.bp.com/productlanding.do?categoryId=6848&contentId=7033471)

\(^{60}\) Proved Reserves of oil are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

\(^{61}\) Includes established remaining reserves of Canadian oil sands not under active development.
Chart 7.10: Top twenty countries’ proven oil reserves, 2006

<table>
<thead>
<tr>
<th>Country</th>
<th>Reserves (Billion Tonnes)</th>
<th>Reserves (Billion Barrels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>36.3 (264)</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>28.9 (181)</td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>18.9 (138)</td>
<td></td>
</tr>
<tr>
<td>Iraq</td>
<td>15.5 (115)</td>
<td></td>
</tr>
<tr>
<td>Kuwait</td>
<td>14.0 (102)</td>
<td></td>
</tr>
<tr>
<td>UAE</td>
<td>13.0 (98)</td>
<td></td>
</tr>
<tr>
<td>Venezuela</td>
<td>11.5 (80)</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>10.9 (80)</td>
<td></td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>5.5 (40)</td>
<td></td>
</tr>
<tr>
<td>Libya</td>
<td>5.4 (42)</td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td>4.9 (36)</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>3.7 (30)</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>2.2 (16)</td>
<td></td>
</tr>
<tr>
<td>Qatar</td>
<td>2.0 (15)</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>1.7 (13)</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>1.7 (12)</td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>1.5 (12)</td>
<td></td>
</tr>
<tr>
<td>Angola</td>
<td>1.2 (9)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>1.1 (9)</td>
<td></td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>1.0 (7)</td>
<td></td>
</tr>
<tr>
<td>UK (29th)</td>
<td>0.5 (4)</td>
<td></td>
</tr>
</tbody>
</table>

(Figures in brackets show reserves in billion barrels)\(^{62}\)

**Source:** *BP Statistical Review of World Energy 2007*

**The Middle East accounts for over half of the world total.**

7.9.2 There are wide ranging views on when and why a peak in global oil production will occur. The International Energy Agency notes that proven reserves are already larger than the cumulative production needed to meet rising demand until at least 2030. However, in order for the actual flow of oil supplies to keep pace with rising demand, more oil will need to be added to the proven category of reserves if global oil production is not to peak before then. In this respect, currently undiscovered resources, reserve growth from existing fields and technological developments will all help to increase the amount of oil that is ultimately recoverable. For example, the UK’s potentially recoverable oil resources are estimated to be between 1.0 and 3.3 billion tonnes, compared to current proven reserves of 0.5 billion tonnes\(^{63}\). Global proven reserves (including Canadian oil sands) have more than doubled since 1980 despite production in the interim.

---

\(^{62}\) Conversion factors take account of oil density.

\(^{63}\) [http://www.og.berr.gov.uk/information/bb_updates/chapters/Table4_7_07.htm](http://www.og.berr.gov.uk/information/bb_updates/chapters/Table4_7_07.htm)
7.10 Global oil production

7.10.1 In order to meet demand, reserves have actually to be developed and produced. OECD oil production has remained relatively flat since the early 1980s, while production from the Former Soviet Union (FSU) fell between the late 1980s and mid-1990s. As a result, rising oil consumption was met by increased production from the Organisation of Petroleum Exporting Countries (OPEC)\(^6\) and from developing countries outside OPEC, notably Latin America, China and West Africa. In more recent years FSU production has also contributed to meeting rising consumption.

7.10.2 In 2006, the top ten oil producing countries accounted for 62% of global production, with the UK ranked as the 18th largest producer. This compares to the situation 10 years ago when the top ten producers accounted for 65%, and 20 years ago when they accounted for 70%.

7.10.3 Looking forward, OECD production is expected to fall slightly to 2015 and to remain relatively flat thereafter, as declining North Sea production is offset by rising supplies from oil sands in Canada. OPEC is projected to contribute just over half the growth in global oil production between 2005 and 2015, and over two-thirds of the growth to 2030, boosting OPEC’s share of world supply from 40% in 2006 to over 50% by 2030. Outside OPEC and the OECD, significant production growth is expected from Latin America (mainly Brazil) and the FSU (Russia, Kazakhstan and Azerbaijan). All these projections assume that there will be adequate levels of investment in producing countries.

---

\(^6\) Algeria, Iran, Iraq, Indonesia, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE, Venezuela. From January 2007 Angola also became a member.
Most of the future growth in oil production is expected to come from OPEC countries.

7.11 Global issues and risks

7.11.1 A key determinant of developments in the global oil market, and the reliability and price of future supplies is the level of investment across the sector, both upstream and downstream. While the IEA’s 2007 Medium-Term Oil Market Report forecasts an increase in global spare oil production capacity over the next few years, it raises concerns that a lack of investment will lead to a tightening market early next decade, undermining the reliability of future supplies. There are a number of factors which are already restricting, or have the potential to restrict, the level of investment in the oil sector:

- labour, equipment and service sector constraints have increased costs and led to project delays, although there are some signs that cost inflation is moderating;
- in some cases, future oil price assumptions for testing upstream investments may be too conservative;
• resource nationalism is increasing, with a greater degree of state intervention restricting or discriminating against equal access to resources;
• geopolitical risk can hamper investment and increase the costs of production;
• regulatory uncertainty, for example in relation to climate policies, can also undermine confidence amongst investors.

7.11.2 As trade in oil increases and supply routes become longer and cross more borders, the risk of disruptions – whether caused by international disputes, accidents, natural disasters or terrorism – is also likely to increase. Ageing infrastructure also poses a risk to the reliability of global supplies, particularly in the refining sector.

7.11.3 On the demand side, the evolution of governments’ energy and climate policies will be important in determining the rate of global oil demand growth, particularly in the longer-term. The IEA’s “Alternative Policy Scenario” demonstrates the impact that policies currently under consideration could have on future oil demand growth. Pricing policies will also be important. In a number of developing countries, domestic price subsidies on petroleum products have helped insulate consumers from price rises and therefore prevented demand from responding effectively to market price signals. Whether these policies prevail or not is even more important given the growing share of transport demand, which is price-inelastic, in global oil demand.

7.12 Conclusions

7.12.1 Although the UK only quite recently became a net oil importer, we have long been active on the global oil market and therefore already have in place much of the infrastructure, contractual arrangements and commercial relationships needed to acquire our oil needs from external sources. If the oil is available on the global market, then, the UK is as well placed as any market to obtain it and has a well-developed refinery sector to process it. However, there are significant uncertainties surrounding the extent to which global supply will continue to be able to meet global demand, particularly in the absence of the necessary investment in upstream and downstream supply capability.
8. Nuclear fuel

8.1 Introduction

8.1.1 Over the next three decades, in the absence of any lifetime extensions, the current fleet of nuclear power stations operating in the UK will close – Sizewell B power station is scheduled to close in 2035. In the absence of a new build programme, there will be a steady decline in the amounts of uranium fuel required to supply the UK’s nuclear generation capacity.

8.1.2 Uranium supply is unlikely to limit nuclear power for at least the lifetime of a new generation of reactors. Moreover, uranium (as yellowcake) is also easy to stockpile.

8.1.3 A global expansion is new civil nuclear build that aimed radically to increase the nuclear share of generation in the period to 2025, might face some constraints – for example, the supply of a skilled workforce and manufacturing capacity – but the availability of fuel is not seen as a significant constraint in the foreseeable future.

8.2 Demand for nuclear fuel in the UK

8.2.1 The UK currently has nineteen operating reactors at ten power stations, which supplied 75.45 TWh, some 18% of the UK’s electricity, in 2006.

8.2.2 As stated in 8.1.1 above, if no new stations are built, the demand for nuclear fuel in the UK is projected to decline down to zero in 2035. The Government is presently consulting on the future of nuclear power in the UK. At this time no predictions can be made as to the Government’s decision following this public consultation. Should the Government decide that energy companies should be given the option of investing in new nuclear, there is no certainty that they will do so, or what type of reactor system might be built or how many. It is therefore inappropriate to speculate on new nuclear at the time of publication.

8.3 Uranium supply in the UK

8.3.1 The UK is not a uranium producer, but uranium ore may be stockpiled. The stockpiling of fuel in the UK is the responsibility of the utilities concerned and the actual stock levels are commercially confidential.

8.4 Import requirement

8.4.1 The UK nuclear industry currently sources most of its uranium from Australia under the auspices of the Euratom Supply Agency (ESA), which was established in order to implement one of the principal requirements of the European Atomic Energy Community (Euratom) Treaty, to ensure that all users of nuclear power in the Community receive regular and equitable supplies of ores and nuclear fuels:

“...it [the ESA] shall have a right of option on ores, source materials and special fissile materials produced in the territories of Member States and an exclusive right to conclude contracts relating to the supply of ores, source materials and special fissile materials coming from inside the Community or from outside. The Agency may not discriminate in any way between users on grounds of the use which they intend to make of the supplies requested unless such use is unlawful or is found to be contrary to the conditions imposed by suppliers outside the Community on the consignment in question.”

8.4.2 ESA monitors the market, in particular the supply of natural and enriched uranium to the EU, ensuring that EU utilities have diversified sources of supply and do not become over-dependent on any single source.

---

**8.5 Global demand**

8.5.1 There are 438 reactors operating around the world today with another 31 under construction. As at May 2007 there were 74 reactors planned (approvals and funding in place, or construction well advanced but suspended indefinitely) and 182 reactors proposed (clear intention but still without funding and/or approvals). Against this, the world’s reactor fleet is ageing. Thus a proportion of any “new” build would actually be replacement capacity, adding no net increase in demand for uranium.

8.5.2 Nevertheless, forecasts of installed capacity from the Organisation for Economic Co-operation and Development, the Nuclear Energy Agency and the International Atomic Energy Authority generally point to future growth. Installed nuclear capacity is projected to grow from about 369 GWe net at the beginning of 2005 to about 449 GWe net (low case) or 533 GWe net (high case) by the year 2025. The low case represents growth of almost 22% from current capacity, while the high case represents a net increase of about 44%. To put these figures in perspective, world electricity generation is forecast to grow from 16,424 TWh in

---

2004 to 30,364 TWh in 2030\textsuperscript{71} an increase of almost double (approximately 85%), so even the high case above represents a decline in the nuclear share of generation.

8.5.3 Given the above, world reactor-related uranium requirements by the year 2025 are projected to increase to between 82,275 tU in the low case and 100,760 tU in the high case, representing about 22% and 50% increases respectively, compared to 2004 requirements.

*Chart 8.2: projected annual reactor-related uranium requirements to 2025*

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{chart8.2.png}
\caption{Projected annual reactor-related uranium requirements to 2025.}
\end{figure}

\textit{Source: OECD/IAEA Red Book}

8.5.4 The OECD/IAEA have indicated that primary uranium production capability will need to further increase to meet demand, either by expanding existing production centres, opening new production centres or through a combination of the two.

8.6 \textbf{Global supply}

8.6.1 Nuclear energy benefits from having a diverse supply of fuel in insuring against potential interruptions. In this sense, uranium is less vulnerable than other fuels. Deposits of uranium are widely dispersed across a number of countries. The potential sources include countries that we do not

currently rely on for fossil fuels. There are also considerable reserves available in OECD countries.

**Chart 8.3 Identified global uranium resources.**

[Map showing countries with uranium reserves: Canada 9%, USA 7%, Russia 4%, Kazakhstan 17%, Uzbekistan 2%, China 1.3%, India 1.4%, Brazil 6%, Namibia 6%, Australia 24%, Others 17.3%]

*Source: OECD*  

**Known uranium reserves are spread amongst different geographical areas to the world’s fossil fuel resources**

8.6.2 It is difficult to make exact predictions on how long uranium deposits will last in any given country because it is dependent on a number of variables, for example:

- new mines coming on stream and possible expansion of current mining operations;
- price of uranium ore – increased prices allows marginal ores to be processed, bringing larger reserves into production;
- very high prices could make it feasible to produce very low grade ores, which contain large extra reserves of uranium;
- new nuclear reactor technology may use less uranium thereby extending the lifetime of available uranium deposits;
- more nuclear reactors may be built thereby increasing the demand on available uranium deposits;
- the rate at which current operational reactors will come out of service;

72 OECD presentation given in 2006.
increased use of reprocessing to recycle used fuel and create MOX (Mixed Oxide) fuel (a mix of uranium and plutonium).

8.6.3 The difficulty in making exact predictions of uranium reserves is reflected in the range of assessments of the future prospects for uranium supplies. However, every two years the International Atomic Energy Authority and OECD/NEA undertakes a comprehensive assessment of the availability of uranium taking into account expected production and demand levels. Their most recent report estimates the identified amount of conventional uranium resources that can be mined for <US$130/kg to be about 4.7 million tonnes. Based on the 2004 nuclear electricity generation rate (so not taking into account any future expansion in nuclear generation) this amount is sufficient for approximately 85 years, using currently employed fuel cycles.

8.6.4 Over the period 1990 to 2002, almost half of the world’s civil reactor fuel was provided by re-cycling material from weapons programmes, released through the peace dividend. This has now diminished and demand on the mines has increased. The resulting price adjustment has provided the economic signal for the mining companies to increase output and exploration. It should be noted that at the time of publication the spot price of uranium (U₃O₈) has fallen from a high of around $136 per lb in June 2007 to $90 per lb, as of 10 September 2007.

---

8.6.5 The Euratom Supply Agency\textsuperscript{75} reports that

“Global uranium exploration activity has been rising for several years now and continued to increase in 2006. There are literally hundreds of uranium exploration companies active worldwide, most of them headquartered in Canada or Australia. While most of them operate in North America, Australia or Africa, many EU countries are also targeted for exploration: Finland, Hungary, Portugal, Slovakia, Spain and Sweden. Some of these may have relatively good prospects for future production, but actual production is still several years away, and is likely to be small scale in the global context. However, any domestic production would be a useful addition to Europe’s security of supply.”

Table 8.1: Global expenditure on uranium exploration

<table>
<thead>
<tr>
<th>Year</th>
<th>US $ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>89</td>
</tr>
<tr>
<td>2002</td>
<td>95.1</td>
</tr>
<tr>
<td>2003</td>
<td>92.4</td>
</tr>
<tr>
<td>2004</td>
<td>133.3</td>
</tr>
<tr>
<td>2005</td>
<td>195.9 (expected)</td>
</tr>
</tbody>
</table>

Source: IAEA

\textsuperscript{74} Values taken at May each year from TradeTech. http://www.uranium.info/prices/longterm.html

More than double the amount committed in 2001 was forecast to be spent in 2005.

8.7 Conclusion

8.7.1 We cannot predict whether there will be a substantial global increase in nuclear generation. However, the evidence is that sufficient uranium resources exist to satisfy fuel demand for current or increased nuclear generation capacity. The House of Commons Trade and Industry Committee, in its report\(^76\) of July 2006 which examined the issues around new nuclear build in the UK, stated:

“As regards fuel availability, demand for uranium is set to increase markedly in the future, with greater global energy consumption, particularly in East Asia. In the short-term we have concerns about the availability of fuel supplies as secondary sources, such as commercial inventories, are used up. However, in the long-run we believe increased prices and global demand will help maintain reliable uranium supplies, thus not representing a constraint on any new nuclear build in the UK. This provides some reassurance about fuel availability, as it currently seems unlikely that new nuclear power stations would be in a position to use fuel reprocessing to recycle their nuclear waste back into re-usable uranium.”

9. Renewable and low carbon energy

9.1 Introduction

9.1.1 Political commitment to increasing the proportion of energy supplied from renewable and low-carbon technologies has focused mainly on the potential for reducing carbon emissions. This chapter, however, focuses on the security of supply implications of greater use of such sources in electricity generation, heat and transport.

9.1.2 The intermittency of some sources of renewable energy may present challenges to security of electricity supply, particularly in a relatively isolated electricity system such as Great Britain’s. These challenges can be managed, although the cost of this is not well established at present above certain levels of penetration. Recent research suggests that security of supply can be maintained with a higher proportion of energy from intermittent renewable sources in the mix.

9.1.3 Against that, renewable energy increases the diversity of our primary fuel sources and reduces our fossil fuel import dependency, both of which increase the overall resilience of our energy system.

9.1.4 In addition to its target that 10% of UK electricity supply should come from renewable sources by 2010 (with an aspiration to double this by 2020), the Government is committed to the UK playing its part in implementing the European Union’s target that 20% of Europe’s energy demand should be met from renewable sources by 2020. The implications for renewable energy production in the UK of the European target will depend upon its implementation. The European Commission is due to table draft proposals on this in late 2007, and this will then need to be agreed by Member States. This chapter therefore does not reflect any future measures which may be necessary to ensure the fulfilment of our European commitments.
9.2 Supply variability

9.2.1 We explained in Chapter 4 that electricity cannot be cost-effectively stored with today’s technology and therefore has to be produced at the same time as it is consumed. In the very short term, therefore, security of electricity supply depends on the extent to which we can be confident that sufficient generating capacity will be able to meet demand at any given time.

9.2.2 Renewable generation technologies fall into three categories with respect to the reliability of their generation:

- intermittent and relatively unpredictable – wind and wave\textsuperscript{77} power. Predictability increases closer to real time so that these technologies are sufficiently predictable in the timescales required for system operation;
- intermittent and predictable – tidal power;
- controllable/constant – co-firing of biomass in coal-fired plants, landfill gas, geothermal, microgeneration, hydro.

9.2.3 Wind availability in Great Britain on individual days has been observed to vary between less than 5% and over 70% of installed capacity. As the proportion of wind on the system grows, there should be some smoothing of this effect, as different wind-farms in different parts of the country are unlikely to experience very low or very high windspeeds at exactly the same time.

9.2.4 On the other hand, a large proportion of intermittent generation can increase the overall size and/or frequency of short-term fluctuations in total generation that must be managed by the System Operator in, or close to, real-time, in the same way that large fluctuations in electricity demand have to be managed, to ensure a continuing supply-demand balance.

9.2.5 Research\textsuperscript{78} has shown that the balancing task can be managed for wind penetration of up to about 20-25% at little more expense (less than 1% of electricity retail prices) than is presently necessary. Ways in which the cost and difficulty of the task can be mitigated include:

- improving the accuracy of weather forecasts, thus further improving the predictability of wind output;

\textsuperscript{77} Wave strength is strongly influenced by wind speeds
\textsuperscript{78} http://www.ukerc.ac.uk/ResearchProgrammes/EnergyInfrastructureandSupply/EnergyInfrastructureAndSupply.aspx
• encouraging a wide geographical dispersion of windfarms, thus reducing the risk that all wind farms will be out of action at the same time;

• greater interlinkage into the Continental electricity network, enabling fluctuations to be smoothed out over a larger area; and/or

• increasing demand-side flexibility in response to wholesale electricity price fluctuations, for example through the use of appliances which can adjust in responses to changes in frequency indicating fluctuations in supply\(^79\).

In the longer term, new power storage technologies may also come to play a role in smoothing out such fluctuations\(^80\).

9.2.6 To maintain security of supply, for every MW of non-controllable generating capacity, some controllable generating capacity needs to be kept on standby. However, research has shown that it is highly unlikely that all wind farms across Great Britain will be becalmed (or shut down because of high winds) at the same time, so that there is no need for one-for-one marking of wind farms by conventional plant if wind generation is sufficiently geographically widespread. Research is ongoing\(^81\) as to the precise extent to which conventional back-up capacity would need to be maintained, or provided, to ensure an adequate level of security when intermittent supply has a much higher share of the total generating mix than at present.

9.2.7 This in turn will enable consideration of whether our existing market framework provides enough economic incentives to keep open, or invest in new, conventional plant which is likely to generate (and make money) only when there is a lack of wind. As more renewable intermittent generation is added, wholesale price volatility is likely to increase. This will tend to favour the construction or maintenance of more flexible conventional generation plant and may also induce more flexible demand-side response. These developments together should, in turn, allow the market to balance according to price signals despite greater fluctuations in generation output from the intermittent proportion of the generation fleet.

---


\(^80\) [http://www.berr.gov.uk/innovation/technologystrategyboard/index.html](http://www.berr.gov.uk/innovation/technologystrategyboard/index.html)

\(^81\) [http://www.sedq.ac.uk](http://www.sedq.ac.uk)
9.2.8 Increasing the proportion of renewable generation from its current level towards 20% by 2020 will also require varying amounts of reinforcement and expansion of the electricity transmission network, depending on the composition and location of the additional renewable generating capacity. However, in a world where there is significantly more generation connected to the grid than the grid can accommodate at any one time, there is a clear case for “sharing” grid capacity. Work is ongoing to ensure that the technical standards underpinning investment in transmission capacity fully take account of the particular characteristics of intermittent generating technologies.

9.3 Contribution to security of electricity supply

9.3.1 Over a longer time period, generation by renewable and low-carbon technologies reduces the requirement for the import of other fuels\(^{82}\) as well as to reducing overall carbon emissions. It should be acknowledged, however, that a MWh of wind generation saves marginally less than a MWh of fossil fuel because conventional plant cannot always respond rapidly enough to compensate for fluctuations in renewable output. Improvements in conventional plant flexibility may in time enable more efficient management of such issues.

9.3.2 Future levels of production from renewable sources, and hence displacement of the use of other resources, will depend both on the amount of renewable capacity installed and how much it is used. We look below at the outlook for both.

9.4 Capacity

9.4.1 Using scenarios from the 2007 Energy White Paper’s supporting Updated Energy Projections, which take into account current policies and proposed changes to the Renewables Obligation, the generating capacity of renewables, which has grown from 2.8% of UK capacity in 1996 to 4.7% in 2006, is shown (see Chart 9.1) to grow to 12.5% (high fossil fuel price case) by 2020 – providing 10 GW of capacity is achieved (corresponding data for generation, as opposed to capacity, is provided in Chart 9.2 below). For the lower price case 8 GW is predicted, equivalent to 10.3% of total capacity.

\(^{82}\) In the longer term, of course, supply of fossil fuels will adjust to lower demand levels so this effect reduces over time.
Renewable electricity generating capacity is expected to increase, but the precise extent will be heavily influenced by fossil fuel and carbon prices.

9.4.2 Tables showing the total number of renewable energy projects, by technology, that are operational, have permission granted but not yet operational, and those that are under consideration, for each of England, Wales, Scotland and Northern Ireland are available on the EMO website83 and are summarised below.

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Under Consideration Projects</th>
<th>Permission granted but not yet operational Projects</th>
<th>Operational Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW</td>
<td>MW</td>
<td>MW</td>
</tr>
<tr>
<td>England</td>
<td>82</td>
<td>158</td>
<td>378</td>
</tr>
<tr>
<td>Scotland</td>
<td>95</td>
<td>73</td>
<td>123</td>
</tr>
<tr>
<td>Wales</td>
<td>16</td>
<td>21</td>
<td>51</td>
</tr>
<tr>
<td>N. Ireland</td>
<td>54</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>UK Total</td>
<td>247</td>
<td>270</td>
<td>582</td>
</tr>
</tbody>
</table>

*Source: 2010 Planning Database*

The table includes all technologies which qualify as ‘renewable’ under the Renewables Obligation (RO), with the exception of co-fired biomass projects, where there are inherent difficulties in quantifying the capacity value of the biomass component. Under the terms of the RO, only hydro schemes commissioned after 2002 or under 20 MW are included in the database. A number of hydro plants, particularly in Scotland, are therefore excluded.

9.4.3 The construction of new renewable electricity generating capacity faces similar pressures to those confronting conventional generating capacity, with lengthening order books at the wind turbine manufacturers and increasing competition for switchgear, transformers etc. However, the main delay in the deployment of renewable generating capacity to date has been in obtaining planning permission. This is addressed in paragraphs 4.8.6-4.8.9 above, while the availability of the physical resource to feed the capacity is considered below.

9.5 Production

9.5.1 In general, the extent to which electricity generating capacity actually supplies electricity depends on commercial as well as technical factors. In a properly functioning market, when demand levels are low, those generating technologies with the lowest short-run marginal costs – wind and nuclear – tend to operate in preference to those with higher marginal costs (typically determined by the price of fuel and carbon allowances).
9.5.2 It can therefore be assumed that wind-powered generation will supply as much electricity as it is technically able to, unlike (for example) a coal-fired power station which may sometimes be technically able to generate but is nevertheless not called upon to do so since all demand is already being met by other (cheaper) technologies.

9.5.3 Since the introduction of the Renewables Obligation in 2002 the proportion of UK electricity supply generated from eligible renewable sources has risen from 1.8% to 4.6% in 2006.

9.5.4 Using the projections from the 2007 Energy White Paper’s supporting Updated Energy and Carbon Emissions Projections, May 2007, the paths up to 2020 under High, Low, and Central carbon savings and under current policies are shown in chart 9.2 below. For the Central case, if there is no further growth in hydro’s contribution, wind, wave, solar and biofuels will be required to grow at the rate shown in the graph below.

*Percentage of UK generation*

**Chart 9.2: Projected growth in proportion of electricity generation from renewable sources 1990 – 2020 under existing policies**

Source: BERR

9.5.5 The “high carbon saving” case given here represents not only a reduction of 10% in total carbon emissions from electricity generation between 2006 and 2020 but also a
saving of 7.6 million tonnes of oil equivalent, around 8.4 bcm of gas or 12.2 million tonnes of coal, depending on which is substituted for by renewable generation.

9.6 Physical resource

9.6.1 The total amount of physical resource available for renewable electricity generation in the UK is high, particularly for offshore wind and wave and tidal stream. It is also notable that wind speeds are broadly correlated with electricity demand over the year – i.e., wind power availability tends to be at its highest during seasonal and daily peak demand periods. As previously noted, however, factors such as supply chain constraints, the planning process and the need to expand and/or reinforce the electricity transmission and distribution networks are likely to restrict the scope for utilising the resource in the shorter term.

9.6.2 The figures in the table below are in TWh/year and compare with total annual demand in Great Britain, presently about 350 TWh.

Table 9.2: Estimates of the resource available for renewable electricity generation.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Enviros Estimate</th>
<th>Green-X model estimate</th>
<th>Constraints on available resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill</td>
<td>10-12 TWh</td>
<td>4.7 TWh</td>
<td>Constraints on number of landfill sites. Only a certain proportion covered by EU directive – others – older sites and smaller sites more costly.</td>
</tr>
<tr>
<td>Sewage</td>
<td>0.3 TWh</td>
<td>1 TWh</td>
<td>Limit on the amount of gas available.</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>1,400 MW (3TWh)</td>
<td>1.6 TWh</td>
<td>Constraints from the amount of available biomass.</td>
</tr>
<tr>
<td>Co-firing</td>
<td>1,580 MW (about 3.5 TWh)</td>
<td></td>
<td>Maximum proportion biomass (by heat input) that can be co-fired without impacting generating capacity is 5%</td>
</tr>
</tbody>
</table>

---

84 [http://www.eci.ox.ac.uk/publications/downloads/sinden06-windresource.pdf](http://www.eci.ox.ac.uk/publications/downloads/sinden06-windresource.pdf)


<table>
<thead>
<tr>
<th>Onshore wind</th>
<th>40TWh available at reasonably low cost sites with &gt; 5m/s</th>
<th>Around 40TWh</th>
<th>Number of sufficiently windy sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore wind</td>
<td>Enviros estimate that 327,000 MW capacity is available at a depth of between 5 and 30 meters – around 1,000TWh</td>
<td>67 TWh</td>
<td>Available sites that are practical – depth of water a limiting factor</td>
</tr>
<tr>
<td>Wave</td>
<td>50 TWh</td>
<td>Wave and tidal stream 59TWh</td>
<td>Wave power practically accessible</td>
</tr>
<tr>
<td>Tidal</td>
<td>36TWh – based on BERR research of the 10 most promising tidal streams. BERR estimate – tidal barrages could make 18TWh pa</td>
<td>59TWh</td>
<td>Site specific</td>
</tr>
</tbody>
</table>

Source: BERR synthesis of work by Enviros and the Green-X model

Under Enviros’ assumptions, the UK has enough physical resource to meet all its electricity needs from renewable sources, while the Green-X model suggests the physical resource to achieve 45% from renewable sources.

### 9.7 Renewable heat

9.7.1 Less than 1% of UK heat demand is presently supplied from renewable sources, but there is potential to increase this proportion to between 5% and 12% (see Ernst & Young report on BERR website) through biomass heating, solar thermal and ground source heat pumps, and biogas from the energy from waste sector.

9.7.2 Ernst & Young were jointly commissioned by BERR (formerly DTI) and Defra to produce a report which considered the business case for the development of renewable heat, which was published in September 2007. The terms of reference in producing this report were to assemble, examine and develop the evidence base; consider

---

86 [http://www.green-x.at/](http://www.green-x.at/)
the market potential/barriers and cost-effectiveness of existing technologies (financial and in terms of carbon abatement potential); and to use financial and economic modelling to enable future BERR/Defra work on the topic. The work carried out by Ernst & Young is feeding into the Office of Climate Change Heat Project, which is scheduled to report to Government by the end of 2007.

9.7.3 Of the potential technologies, biomass – woodfuel, waste wood and energy crops, straw, biodegradable and agricultural waste – has the highest market and technical potential, with the potential to deliver up to 96.2 TWh per annum, 10% of total current heat use (see UK Biomass Strategy on BERR website81). This is more likely to replace oil and solid fuels used for heating than gas.

9.7.4 The technology for converting biomass into heat compares in its flexibility and reliability to the combustion of fossil fuels for electricity generation, and so would make a similar contribution to overall security of supply per unit of capacity installed. It also faces similar constraints on growth in capacity as do other forms of generation.

9.7.5 The market for feedstock is characterised by a diversity of suppliers and sources and so should be flexible and responsive to changes in supply and demand conditions. Further, biomass can be easily stored, for example through short rotation forestry. However, a number of factors are likely to constrain the future availability of biomass for heat production:

- competition for biomass use in other sectors eg. transport
- availability of agricultural land
- legislation on waste and agricultural policy
- variations in supply due to climatic conditions and seasonal cycles
- measures such as the Woodfuel Strategy for England are in place or in progress to address both domestic production and imported supply constraints88, but this industry is still at an early stage of development and it is difficult at this stage to assess the extent to which biomass heating is likely to fulfil its potential.

9.8 Renewables in transport

9.8.1 The relevance of renewable transport (chiefly biofuel use) to security of supply rests on its contribution to reducing demand for fossil fuels for this sector. We showed in the oil chapter (section 7.2) that the transport sector accounts for the large majority of oil consumption in the UK.

9.8.2 EU Biofuels Directive 2003/30/EC\textsuperscript{89} requires Member States to set targets for biofuels sales. The main objective of the Directive is stated as being to reduce life-cycle emissions of CO\textsubscript{2} from transport across Europe, and to reduce the EU’s future reliance on external energy sources. The means by which the Government intends to comply with this Directive, the Renewable Transport Fuel Obligation\textsuperscript{90}, is due to be introduced in April 2008 together with existing duty reductions for biofuels. The RTFO will require road transport fuel suppliers to ensure that a proportion of the fuel they supply in the UK comes from renewable sources.

9.8.3 Total sales in recent years were:

- 21 million litres in 2004 (0.05\% of total fuel sales)
- 118 million litres in 2005 (0.25\%)
- 264 million litres in 2006 (0.5\%)
- 230 million litres in the first six months of 2007 (approximately 1\%)

This compares with the levels of the obligation, which are 2.5\% in 2008/9, 3.75\% in 2009/10 and 5\%, equating to about 2.5 billion litres, in 2010/11.

9.8.4 The UK has also signed up to a EU target of 10\% biofuels by 2020 – provided these can be supplied sustainably, and that second generation biofuels using alternative feedstocks and new technologies become available as part of the proposed target of 20\% of all energy to come from renewable sources within the EU by 2020.

9.8.5 It is expected that in order to meet a 5\% target the UK will need a mixture of domestic and imported feedstocks. Bioethanol requires feedstocks such as wheat and sugar cane, although sugar beet can also be used in the UK. Biodiesel requires vegetable oils – such as palm oil and rapeseed – as a feedstock.

\textsuperscript{89} http://ec.europa.eu/energy/res/legislation/biofuels_en.htm
\textsuperscript{90} http://www.dft.gov.uk/roads/rtfo
9.8.6 The Government does not hold precise data on the country of origin of biofuels sold in the UK, with biofuels being both produced in the UK and imported. Once the RTFO comes into effect we should have much better data on the provenance and sustainability of all biofuels sold in the UK, because suppliers will be required to provide information, on, among other things, the country of origin of the feedstock.

9.8.7 A number of biofuel plants started production in 2006 and others are currently in the planning phase in the UK. As more and more biofuel is domestically produced, this should lead to cheaper production processes.

9.9 Conclusions

9.9.1 The deployment of intermittent electricity generation does present challenges to the real-time management of the overall electricity supply-demand balance, but the means are available to manage this at the levels of penetration currently envisaged. Other forms of renewable generation and renewables used in heat and transport are less intermittent and/or more predictable in their output.

9.9.2 In the very long term, of course, the fuel inputs to renewable energy are much more plentiful than those forms of energy production which depend on the irreversible use of finite geological resources, i.e. fossil fuels and uranium. As these geological resources become scarcer and the easily accessible reserves are depleted, the commodity price can be expected to rise, encouraging both demand reduction and the development of previously unexploited supply sources as well as increasing the competitiveness of alternative energy sources. Investment and experience should ensure cost reductions through economies of scale and technological improvement.

9.9.3 These market forces, along with the incorporation of an explicit carbon price into the cost of fossil fuel based generation, should help to bring forward the point when renewable and low carbon technologies overtake increasingly scarce and expensive fossil fuels as the most competitive form of fuel for electricity generation, heat production and transport.
10. Carbon

10.1 Introduction

10.1.1 This chapter summarises the current position on the EU Emissions Trading Scheme, considers the impact on security of supply of the introduction of a carbon price and sets out some pointers as to likely future directions in the emerging carbon market.

10.2 How it works91

10.2.1 The electricity generation sector in the UK and EU, along with other carbon-intensive industries such as steel, glass and paper production, now faces a price for emitting carbon dioxide under the EU Emissions Trading Scheme92. This covers the emissions from all generation plant above 20 MW in the EU, and requires the owners of such plant to monitor and report their emissions of carbon dioxide on an annual basis. Plant owners must also ensure that at the end of each year they surrender to the regulators one EU ETS allowance (EUA) for each tonne of carbon dioxide emitted in that year.

10.2.2 Each installation (including large electricity generation plant) is allocated allowances for each phase. The number allocated is set down in National Allocation Plans, which each member state produces.

10.2.3 EUAs can be traded between participants in the scheme throughout the EU. Because EUAs are the same in every EU country, and can be freely traded between them, there is a single EU carbon price93. If the cost of reducing carbon emissions is less than the cost of allowances, it is economically rational for a participant to reduce carbon emissions and either sell allowances or avoid the necessity of having to buy them. The idea is that emitting carbon costs money, and reducing carbon emissions saves or makes it.

92 The Directive is available in several languages from http://ec.europa.eu/environment/climat/emission/implementation_en.htm
93 Current prices can be found on a number of websites, including http://www.pointcarbon.com/ and http://www.nordpool.com/marketinfo/co2-allowances/allowances.cgi
10.2.4 As well as using EUAs, companies can also make some use\(^{94}\) of carbon credits from the Clean Development Mechanism\(^{95}\) and Joint Implementation\(^{96}\) processes set up under the Kyoto protocol. These credits come from emission reduction projects outside the EU, or in the case of Joint Implementation, outside the UK. The idea is that buying carbon credits under these processes funds carbon reductions outside the EU.

10.3 Impact on security of supply

10.3.1 The introduction of an explicit commercial price for emitting carbon is intended to influence decisions as to what kind of electricity generating capacity to invest in and deploy; carbon-intensive forms of generation, such as coal-burning generators, become relatively less competitive with lower-carbon technologies, such as renewable or nuclear. To the extent that the cost of carbon is passed through to the final consumer, the existence of a carbon price should also have an impact on demand for electricity (as well as other products of carbon-intensive industrial processes).

10.3.2 While not its primary objective, the introduction of a carbon price should also encourage investment in new, low carbon and more efficient electricity generating capacity. This is because the carbon price increases the difference between the cost of running efficient new plant and the cost of running less efficient, and therefore more carbon-intensive, older plant. In a competitive generation market, the wholesale price of electricity at any one time is set by the short-run marginal costs of the most expensive generator which is running at that particular time.

10.3.3 The difference between that cost and the cost of less expensive plant represents profit for the less expensive plant. Increasing this profit therefore enables quicker recovery of the capital costs of investment and therefore increases the attractiveness of building new plant. It may also bring forward the closure of less efficient older plant. This would be beneficial in terms of the Government’s climate change objectives, but the net impact on security of supply is less clear-cut.

\(^{94}\) In the UK, up to 7%
\(^{95}\) http://cdm.unfccc.int/index/html
\(^{96}\) http://ji.unfccc.int/
10.3.4 The Government recognises that uncertainty as to the future of carbon policy makes it more difficult for investors to assess the long-term costs and likely returns from investment in different forms of generating capacity. If this uncertainty leads to delay in the construction of new plant while investors wait for a clearer picture to emerge, this could lead to supply-demand tightness as demand rises and supply does not; and consequent higher prices and greater risk of inadequate generating capacity.

10.4 Experience in practice

10.4.1 The EU ETS started on 1 January 2005. The first phase runs from 2005-2007 and the second phase will run from 2008-2012 to coincide with the first Kyoto Commitment Period. The UK’s plan for 2008-2012\(^{97}\) includes 107 million allowances per year for the electricity generating industry, which equates to some 70% of this industry’s projected carbon dioxide emissions over the same period.

10.4.2 The graph below shows how the 2005-07 and 2008-2012 forward prices have moved over time. EUAs from 2005-07 expire at the end of 2007, so there are separate prices for EUAs for the two phases. EUAs from 2008-2012 can be banked for future phases.

---

\(^{97}\) The full UK allocation plan is available from http://www.defra.gov.uk/environment/climatechange/trading/eu/phase2/phase2nap.htm
While the price of carbon in Phase I has dropped as it became clear that there was an excess of supply over demand, the price for Phase II has held up, reflecting a more stringent approach by Member States to the allocation of allowances. A more active trading market appears to be establishing itself.

10.4.3 The main factors affecting the carbon price are:

- the total number of EUAs issued in any year (the supply). This is a result of decisions by the Governments of each participating EU Member State\(^{98}\), including decisions as to how many allowances from outside the EU are allowable;
- the cost of emissions reduction, which will drive how much EU ETS participants are willing to pay for carbon allowances (the demand);
- the cost of emissions reduction is in turn partly influenced by relative fossil fuels prices, since one means of emissions reduction is to switch electricity production away from coal-fired power stations and towards less CO\(_2\)-intensive technologies;
- electricity demand. There is less scope for choice as to which generating capacity to use, if electricity demand is

---

\(^{98}\) Plans for all MS for 2008-2012 are linked to from the European Commission’s website here: [http://ec.europa.eu/environment/climat/2nd_phase_ep.htm](http://ec.europa.eu/environment/climat/2nd_phase_ep.htm)
high. As shown in chapter 4, this is driven by variables such as the weather, general economic growth levels and energy efficiency.

### 10.5 Future directions

10.5.1 The EU has the following targets:

- 8% reduction in greenhouse gas emissions by 2008-2012 compared to 1990 levels (from the Kyoto protocol\(^99\));
- at least a 20% reduction of greenhouse gas emissions by 2020 compared to 1990, and the objective of a 30% reduction by 2020 compared to 1990 as its contribution to a global and comprehensive post-2012 agreement\(^100\).

This is separate from the target, mentioned in chapter 9, for 20% of the EU’s energy to be from renewable sources by 2020.

10.5.2 The UK has the following targets:

- 12.5% reduction in greenhouse gas emissions by 2008-2012 compared to 1990 levels (from the Kyoto protocol);
- a 20% reduction in carbon dioxide emissions by 2010, compared to 1990 levels.

Again, this is separate from the target, mentioned in chapter 9, for 10% of electricity to be supplied from renewable sources by 2010.

10.5.3 The Climate Change Bill\(^101\) currently before the UK Parliament would commit the UK to achieving reductions of 26-32% in carbon dioxide emissions by 2020, compared to 1990 levels. This corresponds to a reduction in greenhouse gas emissions of around 32-37% by the same date.

10.5.4 All of these factors tend in the same direction, indicating significant downward pressure on carbon emissions in the EU.

10.5.5 The UK Government has signalled its commitment to carbon trading as a critical mechanism for delivering that

---

99 [http://unfccc.int/resource/docs/convkp/kpeng.html](http://unfccc.int/resource/docs/convkp/kpeng.html)
100 Provided that other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries contribute adequately according to their responsibilities and respective capabilities.
pressure, en route to a low carbon economy. For example, the UK’s vision\textsuperscript{102} for the future of the EU ETS (i.e. the structure from 2013 onwards) was set out in October 2006, following the publication of the Stern Review\textsuperscript{103}. It emphasised a more harmonised, transparent scheme with a move towards greater predictability and more auctioning of allowances. UK industry, working with Government and NGOs, has also produced a manifesto with its view on the future of the scheme\textsuperscript{104}.

10.5.6 Commitment to carbon trading at the European level is also clear. At the June 2007 Environment Council, the Conclusions on the Review of the ETS underlined the importance of the EU ETS in achieving significant emissions reductions as an essential part of an integrated climate and energy policy.

10.5.7 The UK Government is actively engaged in the European Commission’s current review of the EU ETS. We expect publication of the European Commission’s legislative proposal for amending the EU ETS in December 2007, and negotiations are likely to begin quickly. The UK will carry out a public consultation on the Commission’s proposals early in 2008. The Government sees the review as an excellent opportunity to map out a long term policy framework and provide a clear signal towards a low-carbon economy.

10.5.8 The future structure of EU ETS will become clearer in 2008 once the new draft Directive is published. Other countries are also starting to consider introducing emission trading schemes, and the EU is keen to explore the possibility of linking to those schemes. This would clearly have implications for the price of carbon in the EU.

10.6 Conclusions

10.6.1 The reform of EU ETS and business confidence in there continuing to be a meaningful carbon price are key to future investment decisions. UK proposals for reform are intended to achieve this.

\textsuperscript{102}http://www.hm-treasury.gov.uk/media/1/2/environment_emissionstrading301006.pdf
\textsuperscript{103}http://www.hm-treasury.gov.uk/Independent_Reviews/stern_review_economics_climate_change/sternreview_index.cfm
\textsuperscript{104}http://www.defra.gov.uk/environment/climatechange/trading/eu/pdf/manifesto-uk.pdf
11. Afterword

11.1 There is only limited scope for the Government to assess and report on, far less to direct, the appropriateness, adequacy and timeliness of decisions by commercial companies, either in the UK or overseas, which affect the security of energy supply.

11.2 No amount of investment will ever be “adequate” to deliver an absolute guarantee that supply will always be sufficient to meet any level of demand. The optimal level therefore depends upon the balance of the costs (including in environmental terms) and benefits (including in social terms) of providing more supply (or less demand). As different stakeholders may have different views as to where the balance lies, central direction by Government has historically proved ineffective and/or inefficient in getting this balance right.

11.3 We have not therefore attempted to identify the optimal level of security of supply. Neither do we claim that the market has delivered an optimal balance in the past, or promise to ensure that it will do so in the future. This report is intended rather to start a process of developing an improved understanding of the likely and possible sources of future risk and opportunity which will help stakeholders to form their own assessment as to how best to prepare for and respond to future developments.

BERR
OFGEM
October 2007
**Glossary of Acronyms**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBL</td>
<td>Balgzand-Bacton Line- Gas import pipeline</td>
</tr>
<tr>
<td>bcm</td>
<td>billion cubic metres</td>
</tr>
<tr>
<td>BERR</td>
<td>Department for Business, Enterprise and Regulatory Reform which assumed the Energy Policy responsibilities of the former Department of Trade and Industry on 27 June 2007</td>
</tr>
<tr>
<td>BNFL</td>
<td>British Nuclear Fuels Plc.</td>
</tr>
<tr>
<td>CCGT</td>
<td>Combined Cycle Gas Turbine</td>
</tr>
<tr>
<td>CCS</td>
<td>Carbon Capture and Storage.</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined Heat and Power.</td>
</tr>
<tr>
<td>EEU</td>
<td>European Economic Union</td>
</tr>
<tr>
<td>EMO</td>
<td>Energy Markets Outlook. This report and the analytical and monitoring work which supports it.</td>
</tr>
<tr>
<td>EWP</td>
<td>Energy White Paper 2007</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>IUK</td>
<td>Gas interconnector linking the UK and Belgium</td>
</tr>
<tr>
<td>mcm/d</td>
<td>million cubic metres per day</td>
</tr>
<tr>
<td>NEA</td>
<td>Nuclear Energy Agency.</td>
</tr>
<tr>
<td>NGO</td>
<td>Non Government Organisations</td>
</tr>
<tr>
<td>NIAUR</td>
<td>Northern Ireland Authority for Utility Regulation</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OPEC</td>
<td>Organisation of Petroleum Exporting Countries</td>
</tr>
<tr>
<td>RO</td>
<td>Renewable Obligation.</td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Form</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>RTFO:</td>
<td>Renewable Transport Fuel Obligation.</td>
</tr>
<tr>
<td>SEM:</td>
<td>the Irish Single Electricity Market</td>
</tr>
<tr>
<td>SUEK:</td>
<td>Siberian Coal Energy Company- Russia’s largest coal business.</td>
</tr>
<tr>
<td>TBE:</td>
<td>Transporting Britain’s Energy.</td>
</tr>
<tr>
<td>UKCS:</td>
<td>United Kingdom Continental Shelf: runs from the outer edge of territorial sea to a median line agreed between the UK and neighbouring countries.</td>
</tr>
<tr>
<td>UKERC:</td>
<td>United Kingdom Energy Research Centre.</td>
</tr>
</tbody>
</table>
**Glossary of Technical terms**

**De-rated capacity margin:** the proportion by which electricity generating capacity, multiplied by a de-rating factor that reflects the different availabilities of each type of generating technology, exceeds annual peak electricity demand.

**European Union Emissions Trading Scheme EU-ETS:** A policy introduced across Europe to tackle emissions of Carbon Dioxide and other greenhouse gases.

**Expected Energy Unserved:** The expected volume of inadequate electricity generation or gas supply during a given period.

**Large Combustion Plants Directive (LCPD):** Imposes restrictions on the emissions of substances including Sulphur Dioxide.

**Loss of energy expectation (LOEE):** A measure that takes into account both the size of the shortfall and the period that it takes place.

**Loss-of-load probability (LOLP):** The probability that supply will be insufficient to meet demand at some point over some specific time frame.

**Loss-of-load expectation (LOLE):** The expected number of days in the year when the daily peak demand exceeds the available supply.

**Restats:** The Renewable Energy STATisticS database containing information about relevant renewable energy sources and information about planned renewables projects in the United Kingdom maintained for BERR by AEA Energy and Environment.