

4. Electricity

4.1 Introduction

- 4.1.1 Both the demand for electricity and the level and nature of capacity that will be available to produce it are subject to a degree of uncertainty over the next decade. In this chapter we look separately at the factors affecting future levels of demand and supply, and then at the relationship between them.
- 4.1.2 The Government's commitment to meeting the UK's share of the EU target of delivering 20% of energy from renewable sources by 2020 means that a much higher proportion of our total generating capacity in future is likely to depend on sources which are subject to intermittency. We consider here the impact on security of supply and some of the technological and commercial means which are, or might become, available to manage it.
- 4.1.3 Where analysis in this chapter draws on data provided by National Grid it refers to electricity supply and demand 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

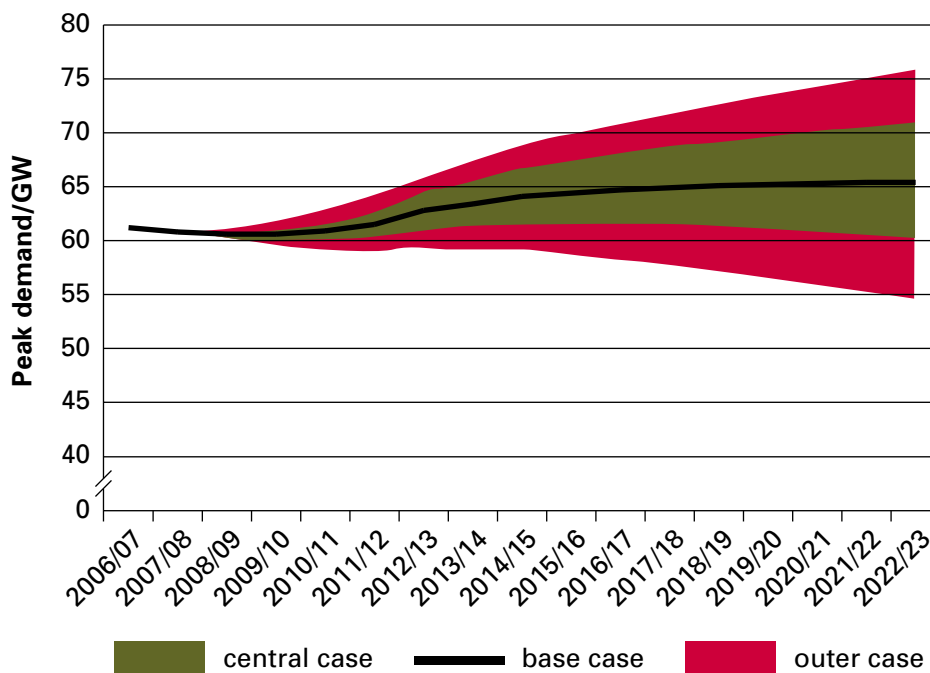
- 4.2.1 Because electricity security of supply depends on generation capacity being able to produce sufficient electricity to meet demand at a particular point in time, the most significant indicator in assessing electricity security is the peak – the highest instantaneous level of demand in any given year.
- 4.2.2 The chart below shows that there is considerable uncertainty about the level of peak electricity demand in the future, particularly over longer time horizons. There are a number of factors that are likely to influence how it develops. 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, and warmer temperatures, particularly in the winter, might be expected to put downward pressure on demand; whereas a combination of increasing summer temperatures and greater penetration

of air-conditioning could eventually lead to the development of higher demand during summer. In the longer term, developments such as an increased reliance on electric-powered storage heating and electric vehicles could begin to reduce the difference between daytime and night-time demand, or possibly increase daily peak demands.

4.2.3 At the moment, demand is largely met by electricity transported across the transmission system from large generators to distribution networks. However, more extensive deployment of distributed energy, such as embedded Combined Heat and Power (CHP) and micro-generation is anticipated to increase the extent to which demand is met by local generation. This could lead to a reduction in demand on the transmission system and thus reduce the demand levels shown in chart 4.1.

4.2.4 The highest levels of demand shown here 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 independent and it is unlikely that they would all combine to push electricity demand in one direction. A narrower central range of more probable demand levels has therefore been highlighted on the chart. Even within this range, however, there are still major variations.

Chart 4.1: Future development of peak demand on the national transmission system

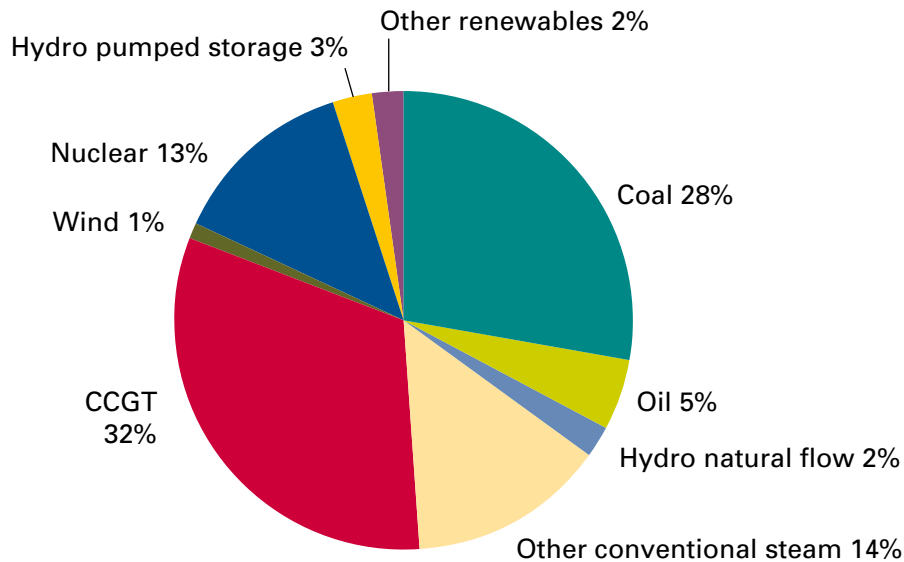


Source: National Grid

4.3 Electricity supply capacity: Present

- 4.3.1 As at the end of 2007, the UK as a whole had a total of 83 GigaWatts (GW) of electricity generating capacity of various kinds. In addition Great Britain had the capacity to import and export a total of 2500 MegaWatts (MW) from and to France and Ireland.
- 4.3.2 The total given above is larger than that in National Grid's Seven Year Statement. This is largely because some 2 GW is located in Northern Ireland. In addition, some generating capacity supplies electricity into local distribution networks rather than into the GB Transmission System, for which National Grid is responsible.¹¹

Chart 4.2: Electricity generating capacity in the United Kingdom, by technology (total 82.591 GW)



Source: Digest of UK Energy Statistics 2008, table 5.7¹²

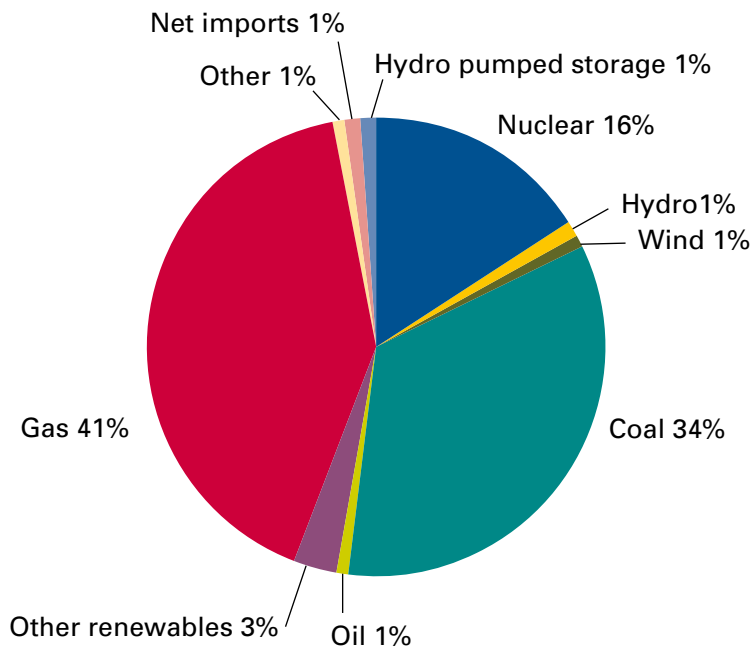
Notes: "Other conventional steam" includes mixed or dual fired thermal capacity and gas fired stations that are Open Cycle Gas Turbines, or have some CCGT capacity but mainly operate as conventional thermal stations.

- 4.3.3 The respective shares of generating technologies in electricity production are different from shares in capacity, since some plant generates more or less continuously (e.g. nuclear), some only at times of extremely high prices and/or demand (e.g. oil) and some depending on the availability of the power source (e.g. wind). Of the 408 TWh of electricity generated in 2007, the breakdown by technology type was as follows:

¹¹ <http://www.nationalgrid.com/uk/Electricity/SYS/>

¹² <http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html>

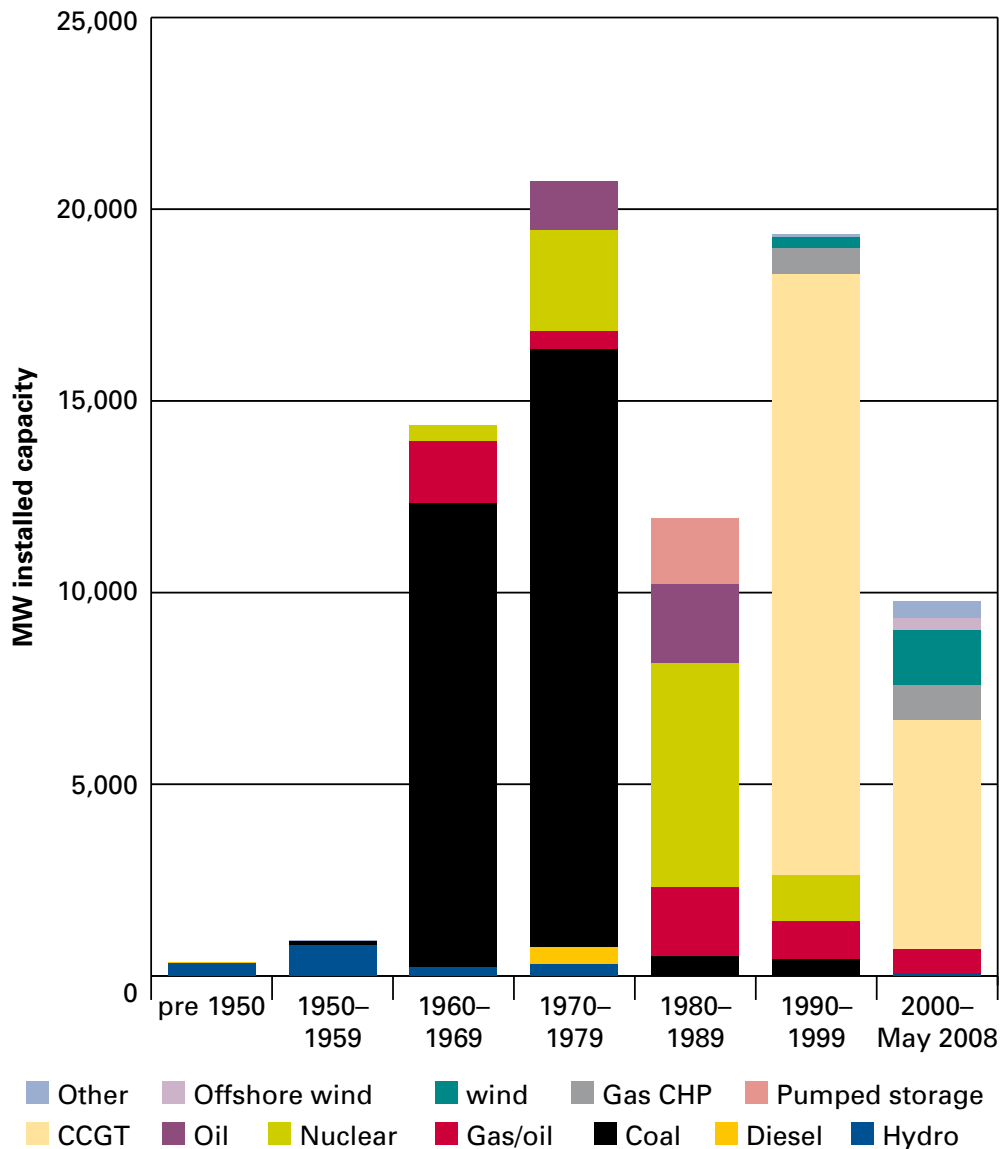
Chart 4.3: UK electricity generated in 2007 (total: 407,671 GWh)



Source: Digest of UK Energy Statistics 2008, table 5.1

4.3.4. The UK's electricity fleet comprises plant of a wide range of ages as well as technology types, including some hydro plants which were first commissioned in the early part of the twentieth century. While about a quarter of our present generating capacity has been commissioned since 1995, over 40% of it was built between 1965 and 1975.

Chart 4.4: Power stations (operational at end May 2008):
Commissioning dates



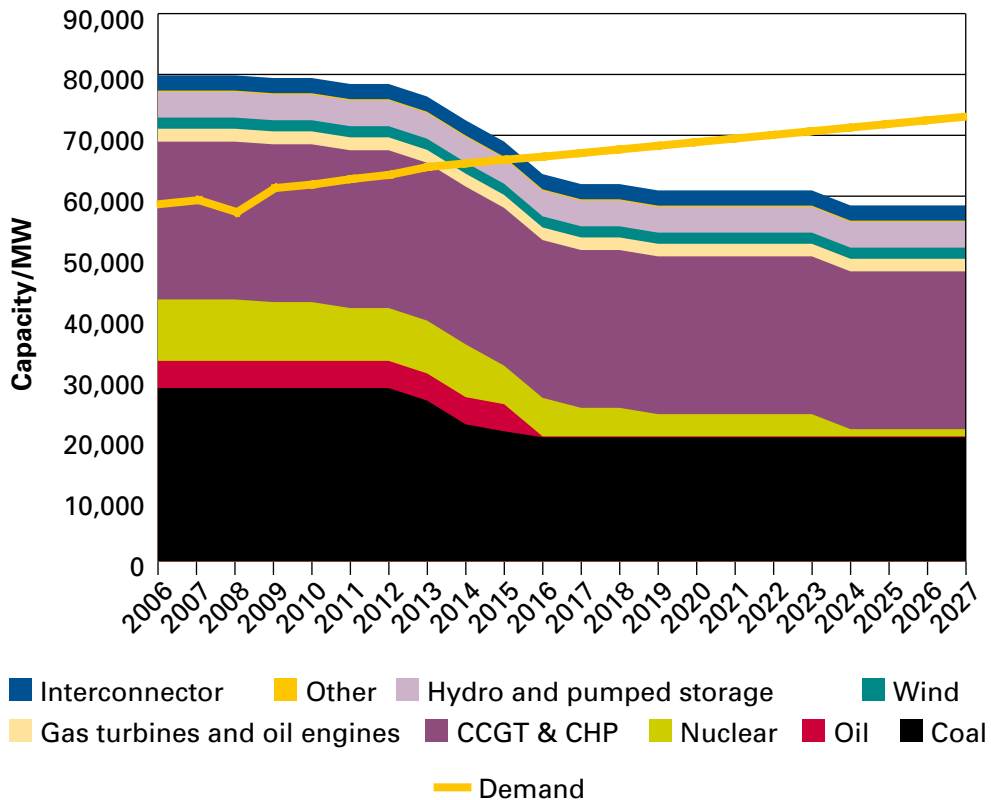
Source: Digest of UK Energy Statistics, table 5.11

4.3.5. 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.

4.4 Plant closures

4.4.1 A substantial proportion of the UK's electricity generating capacity is expected to close over the next few years, which would (if no provision were made to replace the capacity) reduce the UK's total capacity. In addition to the GB closures represented below, some 600 MW of gas-fired capacity at the Ballylumford plant in Northern Ireland will also have to close by the end of 2015.

Chart 4.5: Development of existing GB generating capacity



Source: Digest of UK Energy Statistics/DECC

Plant closures: The Large Combustion Plants Directive

4.4.2 The Large Combustion Plants Directive (LCPD)¹³ requires large electricity generators, and some other industrial facilities, to meet more stringent air quality standards from 1 January 2008. Plant which has “opted out” of this obligation 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” category¹⁴.

4.4.3 The exact timing of these closures is a commercial matter for plant owners, taking 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 with certainty the precise timing of the impact of the LCPD on generation capacity.

¹³ <http://www.defra.gov.uk/environment/airquality/eu-int/eu-directives/lcpd/index.htm>

¹⁴ There is a full list of LCPD opted-out plant on the Energy Markets Outlook website <http://www.berr.gov.uk/whatwedo/energy/energymarketsoutlook/page41839.html>

- 4.4.4 Early experience since the start of LCPD implementation on 1 January 2008 suggests that load factors among the opted-out coal-fired plant have declined, with such plant tending to run only at times of higher electricity prices. However, it would be premature to seek to draw conclusions about the way in which remaining hours of operation will be used.
- 4.4.5 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.

The Industrial Emissions Directive

- 4.4.6 In December 2007, the European Commission published a draft Industrial Emissions Directive (IED). This consolidates seven existing Directives, including the current Integrated Pollution Prevention and Control Directive and the LCPD, in a move towards further tightening of emission limits and regulatory simplification. Negotiations on the new Directive started in summer 2008, with discussions in Council and the European Parliament on the large combustion plant elements taking place over the autumn of 2008. Whilst there is a desire on the part of the Commission and some Member States to reach an agreement by early 2009, failure to do so will result in negotiations running into the European Parliamentary elections and so may postpone any conclusion until late 2009 or 2010. As drafted, the Directive is due to come into force at the beginning of 2016.
- 4.4.7 As presently proposed by the European Commission, the Directive would mean that more UK coal plant owners would face the choice between substantial new investment in technical upgrades to enable them to meet the new standards, or closure by the end of 2015. It would also mean that owners of pre-2002 CCGTs would face the same decision. It is likely that some of these would choose closure, as the investment in plant which is approaching the end of its operating life may not be economic in all cases, so increasing the amount of closures in generating capacity during the next decade. This could have a particular impact on plant that is expected to operate as a back-up as intermittent renewable generation is rolled out to meet the 2020 EU target.

Plant closures: Nuclear

- 4.4.8 The operating lives of nuclear power plant 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. According to current timetables, 7.3 GW of nuclear generation capacity will have closed by 2020 and all but one of the UK's nuclear power stations will have closed by 2025¹⁵.
- 4.4.9 Since publication of the last Energy Markets Outlook, the decision has been taken to extend the lives of Hunterston B and Hinkley Point B to 2016. 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.

4.5 New build: quantity

- 4.5.1 As at September 2008, there is some 10 GW of conventional electricity generating capacity with consent to build, of which 7.5 GW is under construction. In addition there is about 8.3 GW of renewable generating capacity classified as "awaiting construction" while 1.5 GW is under construction¹⁶; and a second electricity interconnector to the Continent with a capacity of 1.3 GW is being built. We are also aware of a further 50 GW which is at earlier stages of the planning and development process¹⁷.
- 4.5.2 New capacity which is now at various stages of the planning, consent and construction process is presented in the following chart. The dates shown are from National Grid's Seven Year Statement¹⁸. Clearly, the further into the future we look, the fewer firm commitments have been made.

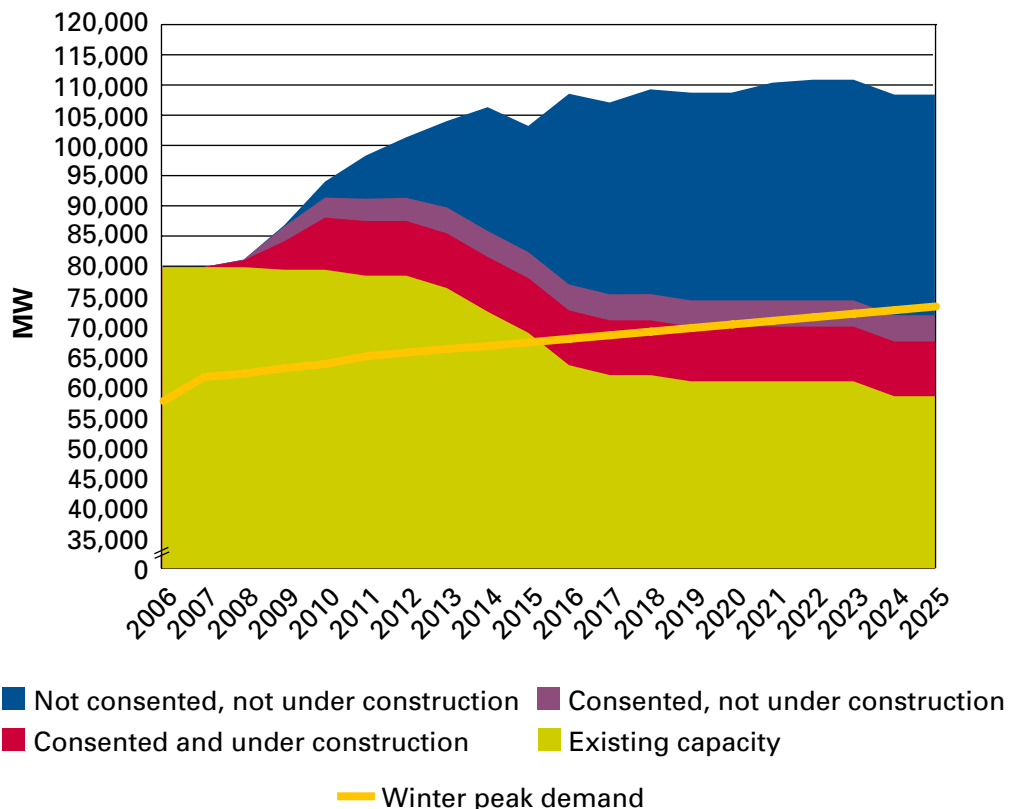
15 There is a full list of the UK's nuclear power plants and their scheduled closure dates on the Energy Markets Outlook website <http://www.berr.gov.uk/whatwedo/energy/energymarketsoutlook/page41839.html>

16 Figures on renewable generating capacity consented and under construction change very rapidly so these figures are likely to be outdated by the time of publication

17 There is a full list of projects on the Energy Markets Outlook website <http://www.berr.gov.uk/whatwedo/energy/energymarketsoutlook/page41839.html>

18 <http://www.nationalgrid.com/uk/Electricity/SYS/>

Chart 4.6: Existing and anticipated GB electricity generating capacity



Source: DECC/National Grid Seven Year Statement¹⁹

4.5.3 In reality, the type and total amount of new build could turn out higher or lower, particularly over the longer term. 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 cost of new plant.

4.5.4 Other factors may constrain the speed and quantity of new deployment. In the context of the Renewable Energy Strategy, BERR commissioned a report²⁰ from consultants Douglas Westwood on supply chain constraints on the deployment of renewable electricity technologies. A separate report by Sinclair Knight Merz²¹ examined constraints on the growth of UK renewable generating capacity. Both reports provide conclusions about constraints on the development of new capacity in the energy industry more generally, as set out below.

19 “Consented and under construction” includes 7.2 GW of CCGT’s under construction and an estimate of renewables under construction, taking account of embedded generation.

20 http://renewableconsultation.berr.gov.uk/related_documents

21 http://renewableconsultation.berr.gov.uk/related_documents

Skills

- 4.5.5 Worldwide competition for human resources arises from expanding energy demand in emerging economies such as China and India, which puts pressure on upstream production capacity to expand, and increases the need for upgrading and replacing energy infrastructure in more developed economies. This is creating cross-sectoral competition for experienced staff, in particular engineers and project managers, although attracting new young people appears to be less of a problem, at least for the renewables sector.
- 4.5.6 The National Skills Academy for Nuclear was launched in January 2008. It has been set up to assess and approve training providers and, in June, entered into its first agreement for apprentice training. The Academy continues, with the Cogent Sector Skills Council, to develop training content and standards. The aim is to start 2500 students on nuclear apprenticeships in the next 5 years.
- 4.5.7 Development of Foundation Degrees with the Universities of Central Lancashire and Portsmouth is well advanced and foundation degree courses on nuclear decommissioning, nuclear related technology, nuclear project leadership and HVAC (heating, ventilation and air-conditioning) energy engineering commenced in October 2008. Over 40 students are enrolled on these programmes. A further foundation degree in nuclear engineering will be launched in January 2009. At least 150 students will enrol on these programmes over the next 3 years.

Planning

- 4.5.8 There are numerous examples where major infrastructure projects, both for generating plant and transmission networks, have been delayed for a number of years in the planning and consenting processes. This causes delay, uncertainty and expense for all parties concerned and acts as a disincentive for investors.
- 4.5.9 The measures set out in the Planning Act²² 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. It is intended that policy will be clearly set out

²² <http://services.parliament.uk/bills/2007-08/planning.html>

by Ministers in National Policy Statements (NPSs); and that 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.

Supply chain components

4.5.10 The Douglas Westwood report identified a number of specific constraints in the supply chain for the construction and operation of renewable electricity generating plants, some of which are also relevant to other energy infrastructure projects. For example, turbines for wind projects include blades, gearboxes, bearings, generators and forged and cast components which also form part of conventional generating turbines. Obtaining vessels and also staff able and willing to work offshore is cited as a particular concern for offshore wind turbines and wave and tidal installations, and this is also likely to be an issue for offshore oil and gas production. Other constraints are more specific to renewable technology, such as silicon for solar panels and feedstock for biomass plants.

Grid access

4.5.11 The forthcoming substantial changes in the electricity generating fleet require large scale investment in and development of the high voltage electricity transmission network. This includes the need to extend and reinforce the transmission infrastructure into areas of the UK where the network has historically been either limited or non-existent. For example, the Highlands and Islands of Scotland have the greatest density of renewable energy resources in the UK; but the existing transmission network was not designed, and is not currently able, to transport significant quantities of electricity from there to the main centres of electricity demand in Scotland's Central Belt and northern England.

4.5.12 Elsewhere in Great Britain there are sites on the transmission network which are less heavily constrained, such as the South-West of England, and which could potentially accommodate additional new generation with minimal reinforcement. The cost-reflective charging mechanism in GB means that charges are locationally based, and provide signals to generators as to which are

the most cost-effective places to site their plant. This means that because there is spare capacity in these areas, generators building in these locations are more likely to get connected faster, and will pay less to use the system as they are essentially preventing it from being reinforced elsewhere, thereby saving costs to consumers. However, as the transmission system in the South-West of England becomes utilised to capacity, these charges will increase to provide incentives for generation to build elsewhere.

- 4.5.13 Building the necessary additional network capacity is itself subject to the same constraints as other large energy infrastructure construction projects, leading to delays in enabling new renewable generating capacity to feed electricity into the transmission network. For example, the original estimated completion date for the Beaulieu-Denny reinforcement, which is intended to transport (mainly renewable) electricity from the north of Scotland to centres of demand further south, was 2008; but it is yet to be started. The planning application is subject to a public inquiry (the inquiry itself ended in December 2007, with the Reporters currently in the process of writing up the findings).
- 4.5.14 The Government and Ofgem jointly published a final report on their Transmission Access Review in June 2008. This sets out a comprehensive set of measures intended to remove or significantly reduce the barriers to all forms of generation gaining access to the transmission network, so speeding up the connection of new generation. For an interim period a "connect and manage" system is being implemented under which generators will be able to use the transmission network when local connection works have been completed, irrespective of whether wider network reinforcements have been made.
- 4.5.15 For the longer term, a more fundamental reform of the way generators gain access to the transmission network is necessary. National Grid and the electricity industry are currently developing proposals for modifications to the existing Grid Codes to deliver this change. These proposals will need to be approved by the Gas and Electricity Markets Authority.
- 4.5.16 In addition, the way in which new grid infrastructure is planned and developed also needs to be accelerated. Ofgem are taking forward, with the transmission companies and the System Operator, development of appropriate

financial incentives to deliver the new network needed to meet the 2020 target. National Grid is leading a significant study to identify the likely scenarios and associated investment to deliver the transmission capacity required for 2020. This work is being overseen by the Electricity Networks Strategy Group, a senior industry group chaired by the Government and Ofgem.

- 4.5.17 DECC and Ofgem are also leading a project to put a new regulatory regime in place to connect up to 33 GW of offshore wind projects currently proposed in UK waters to the GB onshore grid in the most cost effective way. The new regime will ensure that there is an enduring framework in place beyond 2010 for offshore wind and other forms of offshore renewables. It is proposed that the regime should be based on competitive tenders for offshore transmission licences to own and maintain (as well as design, finance and construct where required) the transmission assets for connecting offshore renewable projects. Consultation is ongoing – in early 2009, there will be a final consultation on the full package of proposals for the offshore transmission regulatory regime. The first competitive tenders for eligible existing projects are expected to be run from ‘go-active’ in April 2009 with the regime being fully established at ‘go-live’ in April 2010.

4.6 Nature of new build

- 4.6.1 Numerous different factors influence the choice between different technologies and fuels for new electricity generating capacity. Government policies such as the EU Emissions Trading Scheme and the Renewables Obligation (RO) are intended to encourage investment towards renewable and other low-carbon technologies, but considerations such as likely future fuel availability and prices, fuel efficiency, capital and operating costs and the extent to which the technology is able to respond to demand conditions are also highly relevant, as are local issues such as the availability and cost of land space, access to fuel or other primary energy sources and the local supply-demand balance. We look briefly below at some of the main issues likely to be taken into account in considering investment in the main technology options.

Fossil fuels

- 4.6.2 As at Autumn 2008 we are aware of about 18 GW of new Combined Cycle Gas Turbine generating capacity projects at various stages in the planning and development process. Some 10.5 GW of this has consent to build and about 7.5 GW of this is under construction. We are also aware of about 13.6 GW of coal projects under development, but none of these has consent to build as yet.
- 4.6.3 Coal and gas-fired power stations have the advantage that they can be operated flexibly, regardless of weather conditions, in response to variations in demand from consumers and in supply from other generators. With gas and coal sourced from different parts of the world and coal reserves available from a much wider range of countries than is the case for gas, one provides a useful insurance against the other in case of supply problems and/or price increases. Some gas plant is able to hedge to a certain extent against high gas prices and/or problems with natural gas supply, by switching to distillate fuel. We examine the availability of gas and coal in chapters 5 and 6 respectively.
- 4.6.4 On the other hand, the availability and cost of carbon allowances as well as fuel has to be taken into account. Coal in particular is responsible for significant carbon dioxide (CO₂) emissions. The Government carried out a consultation, *Towards Carbon Capture and Storage*,²³ during 2008 seeking views on further steps that could be taken to prepare for and support the development of Carbon Capture and Storage technologies, currently the only option for delivering significant reductions in fossil fuel power station emissions.

Nuclear

- 4.6.5 As at Autumn 2008 we are aware of up to 11.5 GW of new nuclear generating capacity under consideration²⁴, but none of this has formal consent to build as yet.

²³ <http://www.berr.gov.uk/files/file46810.pdf>

²⁴ Contracted to connect to the National Transmission System. This is a normal part of the overall concept, planning and development process and does not prejudice any decisions as to whether plant will receive the necessary regulatory consent to build and operate.

- 4.6.6 In January 2008 the Government published a White Paper on nuclear power²⁵ setting out the Government's policy on nuclear power development. It stated:

The Government believes new nuclear power stations should have a role to play in this country's future energy mix alongside other low carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to facilitate this.

The White Paper also set out the timetable of facilitative actions necessary to enable energy companies to begin construction of the first new nuclear power station in 2013 – 2014 and start operation in 2017 – 2020.

- 4.6.7 Within the context of EdF's proposed £12.5 billion takeover for British Energy Group announced on 24 September 2008, EdF announced their objective to build four new reactors, each with capacity of about 1.6 GW, at Hinkley Point in Somerset and Sizewell in Suffolk, to come on line from 2017. In addition, the Government has reached an agreement with EdF that the company will sell land to other potential nuclear operators at some specific sites in certain circumstances. This move is expected to accelerate development of new nuclear power stations in the UK by making desirable sites available to at least one further operator.
- 4.6.8 In June 2008 the Government published a White Paper on the management of radioactive waste²⁶ setting out the framework for implementing geological disposal for the UK's higher-activity radioactive waste. Local communities were invited to open, without commitment, discussions with Government on the possibility of hosting a geological disposal facility at some point in the future.

Renewables

- 4.6.9 As at Autumn 2008 we are aware of about 18 GW of renewable projects under development. Of this, about 8.3 GW has received consent to build and about 1.5 GW of this is under construction.

25 <http://www.berr.gov.uk/files/file43006.pdf>

26 <http://www.defra.gov.uk/environment/radioactivity/mrws/index.htm>

4.6.10 In June 2008 the Government also published a consultation document on the UK Renewable Energy Strategy²⁷ seeking views on how to drive up the use of renewable energy in the UK as part of an overall strategy for tackling climate change and to meet the UK's share of the EU target to source 20% of the EU's energy from renewable sources by 2020. It states that because of limitations on the roll-out of renewable heat and transport, approximately half of the UK's share of the target might need to be met in the electricity sector, implying that about a third of the UK's electricity would need to come from renewable sources by 2020.

The impact of increased renewables penetration on security of electricity supply

As explained in chapter 3, there are different aspects to security of energy supply – physical, price and geopolitical. Security of supply may also be considered over different timescales. We explained that security of supply may be influenced by any or all of: the amount of spare supply capacity; the level of diversity of (for example) supply routes and technologies; the reliability of elements of the supply chain, including fuel supplies; and by the responsiveness of the supply-demand balance to price signals and vice versa.

Renewable energy provides clear security advantages over other technologies from some of these perspectives. 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 in these alternatives should ensure cost reductions through economies of scale and technological improvement.

Even in the nearer future, increasing our ability to meet our energy needs from indigenous sources will increase the diversity of our supplies and help to reduce the geopolitical risks which may arise from dependence on external suppliers. For example, the renewables consultation document showed that increased investment in renewables in the UK to meet a 15% renewable energy target in 2020 will reduce annual gas imports in 2020 by 12 – 14%.

27 <http://renewableconsultation.berr.gov.uk/>

However, the intermittent nature of some forms of renewable energy²⁸, in combination with the present lack of an economically viable means of storing electricity, does present new challenges to the maintenance of the short-term reliability of electricity supply in particular. This is because within any electricity system, supply and demand have to be kept in balance on a second-by-second basis. A higher level of penetration by generating capacity whose output is unpredictable (except in the short term) and uncontrollable (except by curtailment) means that the whole electricity system needs to become more flexible. This is not only a challenge for the system operator but also has implications for the efficiency, reliability and economic viability of other electricity generating plant.

Reliable, non-intermittent electricity generating capacity still has to be available to ensure that demand can be met at times of high demand and low wind output. New conventional capacity will, therefore, still be needed to replace the plant which is expected to close over the next decade or so, even if large amounts of renewable capacity are deployed. The extent and timeliness of investment in new capacity will therefore be key to ensuring security of electricity supplies in the medium term.

In the British market, electricity generating capacity does not earn money simply for existing; it earns money only when it generates, or through ancillary service contracts with National Grid requiring capacity to be available to provide standing reserve or fast start capability. This means that wholesale electricity prices are likely to rise to high levels at times when high demand and low wind speeds coincide. This is necessary in order to cover the costs of plant which does not generate very often, and so ensure that generators are incentivised to provide the necessary capacity.

There may, of course, be the reverse issue when wind speeds are high and demand is low, for example during the summer or overnight. The system may not be able to absorb all of the output of both wind and other “must-run” generating plants such as nuclear plant and plant which needs to be kept running in order to enable a reliable and rapid response to demand and wind output variability and unplanned outages. Prices may therefore go very low or even negative at such times.

²⁸ The intermittency and otherwise of different renewable energy sources are considered in chapter 9

It is therefore possible that uncertainty over returns on investment, because of the difficulty of knowing how often plant will get the opportunity to run and the technical challenge of running plants more flexibly than they were designed for, will discourage or delay investment in new conventional capacity – or speed up the closure of existing capacity – and hence increase the risk of occasional capacity shortfalls.

However, Redpoint's modelling²⁹ suggests that, as long as price signals are allowed to operate freely, the market should be able to provide sufficient capacity to maintain a very low probability of interruptions. This is because, despite lower load factors and lower average wholesale electricity prices, conventional capacity that is able to generate flexibly will benefit from substantially higher prices in hours when it does generate.

One challenge for industry will be to understand how the market signals, and hence their business models, will change with a high proportion of wind generation on the system. Investors have indicated that uncertainties over the market and regulatory framework are particularly difficult for them to assess, so companies may decide to wait until such uncertainties are reduced before investing. The publication of the renewables consultation document³⁰ on 26 June 2008 and the Renewable Energy Strategy in 2009 is intended to provide the market with greater certainty over future renewables policy.

Provided there is sufficient back-up capacity available on the system, the technical challenges of maintaining reliable supplies of electricity with high levels of wind generation should be manageable, albeit at higher cost than today. In the longer term, of course, it is possible that other means of improving flexibility in the supply-demand balance, such as improved electricity storage technology and dynamic demand response technologies, will also emerge.

4.6.11 The Government expects the majority of this to come from onshore and offshore wind, with important contributions from biomass, hydro and potentially major tidal range projects in the Severn Estuary and elsewhere. We examine the availability of the natural resources and the potential constraints on the deployment of technologies to exploit them in chapter 9.

29 "Implementation of the EU 2020 renewable target in the UK Electricity Sector: Renewable support schemes" Redpoint et al (2008) available at http://renewableconsultation.berr.gov.uk/related_documents

30 <http://www.berr.gov.uk/energy/sources/renewables/strategy/page43356.html>

Impact on the electricity market

4.6.12 The Renewable Energy Strategy consultation document also examines the issues related to a high level of renewable penetration in terms of day-to-day operation of the system³¹. These issues can be categorised as follows:

- additional reserve and response requirements: the System Operator, National Grid, will need to manage more and larger short term fluctuations in the supply-demand balance;
- additional pressure on other plant: conventional capacity is likely to have to run more flexibly than it has previously done, with possible implications for its efficiency, reliability and economic viability;
- additional capacity requirements: a greater total absolute amount of capacity will be needed to maintain a sufficient surplus of supply over demand when there is a higher proportion of intermittent capacity in the mix.

4.6.13 Greater variations in electricity prices, as a result of the increasing amount of generating capacity with low running costs on the one hand and the increasing running cost of conventional plant on the other, may also bring forward the development of innovative ways of arbitraging between high and low price periods. These might, for example, include new techniques of “dynamic demand management” utilising new technologies such as commercial-scale electricity storage and demand control devices which reduce electricity offtake for non-sensitive appliances such as refrigerators at periods of high demand. The future widespread use of electric vehicles could provide distributed energy storage capacity via batteries and could potentially improve the efficiency of the electricity grid by smoothing power demand between day and night. So too could storage heating.

4.6.14 With the exception of some niche markets, fuel cells are at the pre-commercial stage, with developers striving to make significant improvements in the areas of cost reduction and durability. The Government is assisting this by supporting research, development and demonstration under the Technology Strategy Board and Environmental Transformation Fund Programmes. Considerable interest is being shown in the potential use of fuel cells in distributed generation/combined heat and power, particularly at the

³¹ In sections 3.9 and 10.4

individual household scale. Earlier this year it was announced that two UK utilities had entered into collaboration with separate UK fuel cell developers, which, subject to satisfactory technical progress, could lead to commercial roll out of these technologies from about 2011.

4.6.15 Further to a consultation exercise in 2007, the Government is also moving ahead with the deployment of advanced metering for larger businesses and assessing the case for deployment in smaller businesses and households³². On 28 October, DECC announced, as part of the Energy Bill debate, that smart meters would be rolled out to domestic customers. This technology has the potential to encourage shifts in daily demand use away from peak periods, through the conscious decision of the consumer and also, perhaps, by encouraging installation of demand control devices.

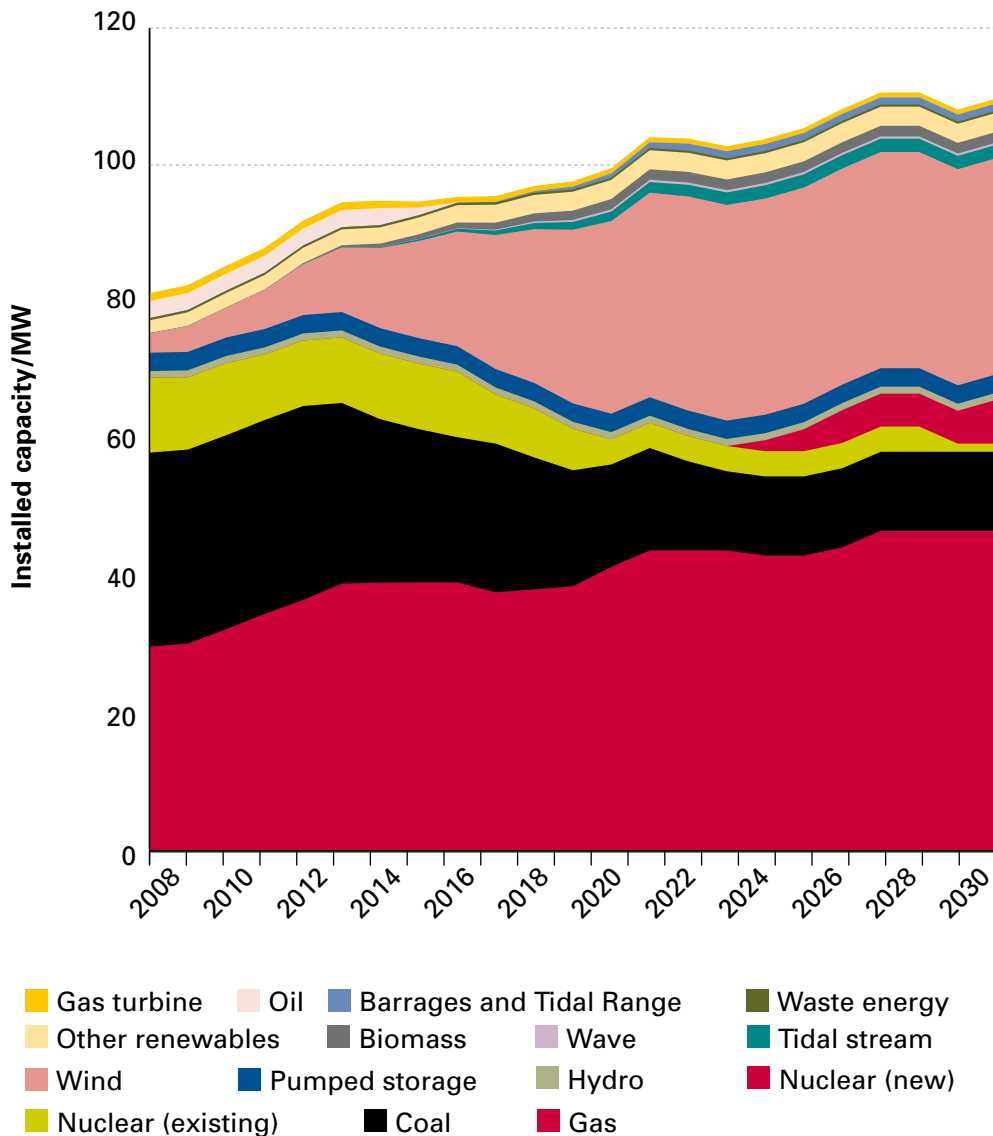
Generating mix

4.6.16 The combination of the target to increase the proportion of energy supplied from renewable sources, and the requirement to close a substantial amount of existing generating capacity, presents a formidable investment challenge. A wide range of possible combinations of closures of existing plant and new build of various technology types is possible in response. Numerous factors, many of which are extremely uncertain, will influence how the total generating mix develops over the medium term; for example high fossil fuel prices might be expected to encourage earlier nuclear build, while the pace and nature of renewables build is likely to be influenced by supply chain issues and the performance of the various technology types.

4.6.17 We show here the modelled development of the capacity mix under one scenario, in which the Government targets a 32% share of electricity demand to be met from renewable sources by 2020 by extending the current Renewables Obligation. The scenario used here is the central case used for illustration in the consultation document. No decision has been taken as to the level of renewable electricity deployment which the Government will aim for, or the means it will use to reach the target level.

³² <http://www.berr.gov.uk/whatwedo/energy/whitepaper/consultations/billing-metering/page40854.html>

Chart 4.7: Development of UK total (including existing) electricity generating capacity, under a policy environment designed to deliver 32% of the UK's electricity from renewable sources by 2020 through extension of the Renewables Obligation



Source: Redpoint³³

4.6.18 This scenario suggests that, in total, the UK will need investment in some 47 GW of new capacity by 2020. This represents about 57% of current total capacity and an average annual deployment rate for new capacity of roughly 4 GW. This has been achieved in individual years³⁴; 5.6 GW of new capacity was commissioned in 1967, 4.7 in 1971 and 4.2³⁵ in 1974 (and these totals do not include any plant which has since closed). However, a sustained period of new build at this rate represents a significant challenge.

33 "Implementation of the EU 2020 renewable target in the UK Electricity Sector: Renewable support schemes" Redpoint et al (2008) available at http://renewableconsultation.berr.gov.uk/related_documents
 34 Digest of UK Energy Statistics 2008 <http://www.berr.gov.uk/whatwedo/energy/statistics/source/electricity/page18527.html>, table 5.11
 35 3870 MW of this is at one coal station, Drax in Yorkshire

- 4.6.19 The modelling shows gas-fired capacity expanding in the next few years, quickly followed by a rapid expansion in renewable capacity. Nuclear capacity reduces at first as scheduled closures take place, and begins to expand in later years. A relatively small amount of new coal capacity is deployed as closures take place.
- 4.6.20 The gas dominance of the non-renewable generation mix increases in the medium term under this scenario. Unless this capacity is also able to switch to alternative fuels, such as distillate gas which can be stored on-site, this dominance would be likely to adversely affect the ability of the electricity generating industry to reduce its demand for gas in response to high gas prices or difficulties in obtaining gas, with consequences for the price both of gas and of electricity.
- 4.6.21 It is possible that supply chain constraints will act as a barrier to the market's ability to deliver this amount of new construction. If this is the case, it may be that other means of matching electricity supply and demand will be further developed. For example, greater energy efficiency and/or more price-responsive demand may be more cost-effective and efficient ways of ensuring that supply and demand meet than would be building additional supply capacity.

4.7 Security of electricity supply: the capacity margin

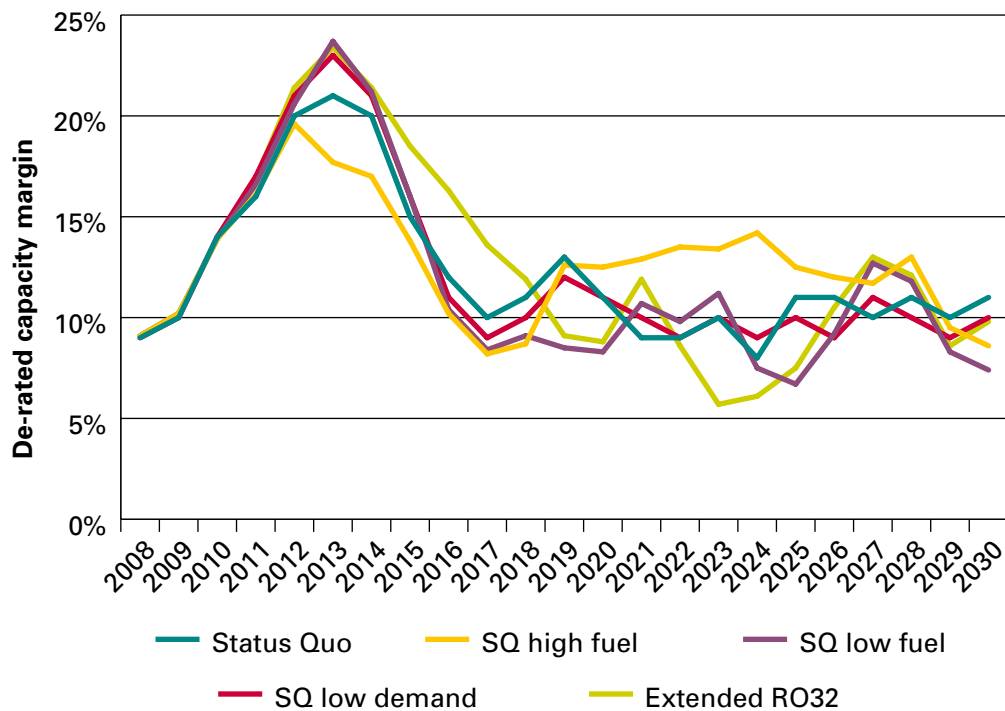
- 4.7.1 The capacity margin is the percentage by which generating capacity exceeds expected peak demand. It is given here on a de-rated basis to reflect the fact that some forms of generating capacity are more reliable, and hence more likely to be available at the time of peak demand, than others. The de-rating factors used here are 70% for existing nuclear capacity and 90% for other non-wind capacity, including new nuclear. These figures reflect historically experienced average forced outage rates during peak demand periods.
- 4.7.2 In the case of wind and other intermittent renewables (wave and tidal), capacity has been de-rated using an appropriate estimate of the capacity credit. This is a measure of the amount of conventional thermal generation that intermittent generation could replace during times of peak load without any increase in the probability of lost load. It is not a static figure; it depends critically on the

level, type and geographic distribution of penetration of intermittent generation on the system³⁶. Therefore, the de-rating factors applied to wind, wave and tidal power evolve over time and vary between scenarios. For example, the de-rating factors applied to wind power in the scenarios set out below vary from 28% in the early years to 18 – 26% towards the end of the period, when penetrations are higher. Different assumptions of availability are possible and these would of course give rise to different results.

- 4.7.3 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 indeed.
- 4.7.4 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 functioning market, are related to each other through price. Market participants respond to the level of expected prices, based on their expectations of supply and demand. If there is excessive supply, prices will tend to decline, which in turn will eventually encourage operators to withdraw production. This will lead in time to the reduction and elimination of the 'over-supply'. Conversely, if the market is expected to be tight, price and profit expectations will rise, thus limiting demand and encouraging new build. This chart shows how the capacity margin might develop under various scenarios.

36 A fuller discussion of the contribution of intermittent generation to security of supply can be found at <http://www.ukerc.ac.uk/Downloads/PDF/06/0604Intermittency/0604IntermittencyReport.pdf>

Chart 4.8: Modelled levels of capacity margin under different scenarios



Source: Redpoint³⁷

Note: The scenarios explored here are: a “Status Quo” under which no Government action is taken other than that already set out in the 2007 Energy White Paper; variations on this changing the assumptions about fuel prices (“high fuel” and “low fuel”) and demand (“low demand”); and a case in which the Government extends the Renewables Obligation to 32% (“RO32”). It should be noted that this does not include any impact from the implementation of the Industrial Emissions Directive (paragraph 4.4.6 refers).

4.7.5 All scenarios suggest an increase in the capacity margin over the next few years, followed by a decline to levels broadly comparable to today’s as plant closures begin to take place. However, uncertainty increases and so does the range of possible outcomes as time goes on.

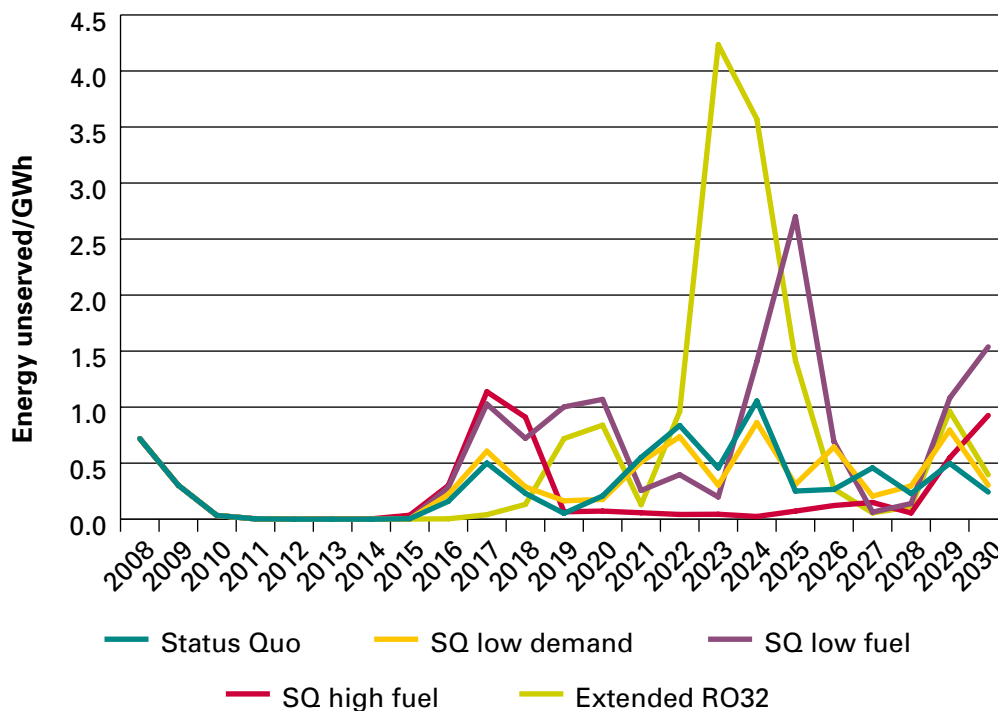
4.7.6 This is a more favourable outlook for the capacity margin than those suggested by the same consultants’ modelling for the 2007 Energy White Paper. Reasons for this include: the fact that construction work has already started on some projects which were not anticipated in the previous model; incorporation into the model of Energy White Paper measures for energy efficiency; and higher fuel price expectations, the latter of which are likely both to reduce

37 “Implementation of the EU 2020 renewable target in the UK Electricity Sector: Renewable support schemes” Redpoint et al (2008) available at http://renewableconsultation.berr.gov.uk/related_documents

demand and to encourage the construction of new electricity generating capacity. This is because high fuel prices increase the cost advantages of more efficient new plant compared to old. Very high fuel costs would also be likely to bring forward the closure of older plant, hence the early downturn under the “Status Quo with high fuel prices” scenario included in the chart above.

4.7.7 The correlation between capacity margin and security of supply is demonstrated by comparison with the chart of “expected energy unserved”, an indicator of probability-weighted average level of energy demand which would not be met under these different scenarios. It shows that where the capacity margin is below what it would be under the Status Quo, for example 2019 – 2021 under the “RO32” case in which the Government targets a renewables penetration level of 32% by extending the Renewables Obligation, security of supply levels are also lower and the amount of energy unserved rises. Conversely, where the capacity margin is higher, for example 2020 – 2029 in the Status Quo high fuel case, security of supply levels are also higher and the amount of energy unserved is lower.

Chart 4.9: Modelled levels of energy unserved under different scenarios



Source: Redpoint³⁸

38 “Implementation of the EU 2020 renewable target in the UK Electricity Sector: Renewable support schemes” Redpoint et al (2008) available at http://renewableconsultation.berr.gov.uk/related_documents

- 4.7.8 By way of context, a loss of 4 GWh in a single year, as is shown for 2024 under the “RO 32” case, compares with some 372 TWh demand modelled for the same year in the same scenario. It thus equates to about 0.001% of annual energy demand.
- 4.7.9 Also worth noting is that the factor which has the most strongly positive influence on the capacity margin over the longer term and on security of supply, is a high fossil fuel price. This encourages reduction in demand and increase in supply as it becomes more worthwhile to build new capacity which is less fuel-hungry than existing plant, either because it is more efficient or because it does not use fossil fuels at all.

4.8 Security of electricity supply: Network reliability

- 4.8.1 Electricity transmission and distribution network owners are subject to price controls set by Ofgem. The price controls are designed to provide the companies with an efficient level of investment, whilst ensuring that customers receive value for money. In addition to the core price controls, the transmission and distribution network operators are subject to incentives which complement these provisions.
- 4.8.2 The three transmission network operators in Great Britain face regulatory incentives that, among other things, create an operating environment designed to minimise energy unsupplied. Historically, the record of the electricity transmission network in Great Britain has been impressive. 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. It compares favourably with other European countries, as the majority of the GB transmission system is built to a higher level of security than its counterparts, at an efficient level of cost.
- 4.8.3 The operators of electricity distribution networks in Great Britain also face incentives to reduce the number and duration of interruptions to supply over their network. Since these “quality of service” incentives were introduced, an average distribution service customer would have

experienced only four interruptions in total over the five years from 2001-2 to 2005-6. The average duration of such interruptions is about 90 minutes.

Distributed electricity and security of supply

The emergence of electricity generating technologies which are less dependent on economies of scale and can more easily be sited near to or in population centres suggests that we are likely to see a growth in generating capacity which feeds into local distribution networks rather than into the national transmission system. This would offer significant economic and efficiency benefits, particularly where heat as well as electricity can be put to commercial use, and reduce pressure for expansion of the national transmission system.

However, this is unlikely to lead to an entirely decentralised system in which all demand is met from local sources via separate, isolated networks. Interconnection at a national or even larger scale via a high voltage transmission system enables the pooling of both generation and demand, which in turn offers a number of economic and other benefits.

An interconnected transmission system provides a more efficient bulk transfer of power from generation to demand centres; and, by linking together all participants across the transmission system, makes it possible to select the cheapest generation available. It enables surplus generation capacity in one area to be used to cover shortfalls elsewhere on the system, resulting in a reduction of the total installed generation capacity required to provide sufficient generation security for the whole system.

Without transmission interconnection, each separate system would need to carry its own back-up capacity to respond instantaneously to meet demand variations, but with interconnection the net response requirement only needs to match the highest of the individual system requirements to cover for the largest potential loss of power (generation) rather than the sum of them all.

While we expect to see an expansion in locally-connected generating capacity, therefore, this is expected to complement rather than replace existing larger-scale infrastructure, which will nevertheless need to adapt and evolve to meet changing demand and supply conditions.

- 4.8.4 It is National Grid's responsibility as System Operator to ensure real-time balancing of the transmission system. National Grid is able to procure services well ahead of real time, as well as a range of ancillary services that it can call upon at short timescales. It can also accept bids and offers in the Balancing Mechanism, and has a range of mandatory service provisions and technical characteristics that generators must be capable of providing if they are to be connected to the transmission system. Not only does National Grid contract with generators, it also contracts with adjustable loads on the demand side, to be prepared to adjust offtake at short notice.
- 4.8.5 The transmission system is also built to accommodate major contingencies including the loss of the largest single source of power on the system, Sizewell B (1320 MW); and National Grid has already dealt with instantaneous demand side fluctuations of up to 2900 MW (the TV pick-up effect). No system can be immune to every contingency, however, as was demonstrated on 27 May 2008 when near-simultaneous outages at two large power stations led to widespread if short-lived interruptions to electricity supply in some parts of Great Britain³⁹. Resilience measures on the grid system operated successfully to stabilise and recover the situation; nevertheless, work is under way to identify any lessons which can be learned from that experience and the subsequent response to it.

Future development of electricity networks

- 4.8.6 Ofgem and its academic partners are looking at a range of future scenarios for electricity networks that could arise as a consequence of market and policy developments and have initiated the long-term electricity network scenarios (LENS) project.
- 4.8.7 The project facilitates the development of a range of future electricity network scenarios for Great Britain for 2050. This provides a framework for discussion between stakeholders on longer term electricity network development issues. Whilst assisting strategic thinking amongst stakeholders in industry and Government within various contexts, the project is not aimed at developing or prescribing particular investment strategies for electricity network companies.

³⁹ National Grid's preliminary report of the incident and the electricity industry's response to it is available at <http://www.nationalgrid.com/NR/rdonlyres/D680C70A-F73D-4484-BA54-95656534B52D/26917/PublicReportIssue1.pdf>

4.8.8 The LENS project has identified three main drivers of change. First, “environmental concern”, or the level to which the environment affects the decision-making of individuals, communities, private companies, public institutions and the Government (on a UK and global basis). Second, “institutional governance”, or the extent to which institutions will intervene in the energy market and the development of the electricity networks. Finally, “consumer participation”, or the level to which all types of consumers (commercial, industrial, domestic and public) are willing to participate actively in the energy/electricity market and to drive greater energy efficiency. Based on a consideration of the plausible evolution of these drivers, the Final Report sets out five scenarios for the future development of GB electricity networks:

- **Big Transmission and Distribution**, in which the transmission system operators (TSOs) are at the centre of networks activity. Network infrastructure development and management continues as expected from today’s patterns, while expanding to meet growing demand and the deployment of renewable generation;
- **Energy Service Companies**, in which energy service companies (ESCOs) are at the centre of developments in networks, doing all of the work at the customer side. Networks contract with such companies to supply network services;
- **Distribution System Operators**, in which distribution system operators (DSOs) take on a central role in managing the electricity system. Compared to today, distribution companies take much more responsibility for system management including generation and demand management, quality and security of supply, and system reliability, with much more distributed generation;
- **Microgrids**, in which customers are at the centre of activity in electricity networks. The self-sufficiency concept has developed very strongly in power and energy supplies. Electricity consumers take much more responsibility for managing their own energy supplies and demands. As a consequence, microgrid system operators (MSOs) emerge to provide the system management capability to enable customers to achieve this with the new technologies;
- **Multi Purpose Networks**, in which network companies at all levels respond to emerging policy and market requirements. TSOs still retain the central role in developing and managing networks but distribution

companies also have a more significant role to play. The network is characterised by diversity in network development and management approaches.

- 4.8.9 These scenarios suggest a range of plausible outcomes for GB electricity networks that is perhaps wider than is often acknowledged in recent debates about energy policy and network investment. They imply that radical change for the electricity sector, including networks, and related sectors (such as transport and heat) is both possible and, depending on how key underlying driving forces play out, conceivable.
- 4.8.10 The breadth of the scenarios suggests that regulatory policy will need to be sufficiently flexible and adaptable to accommodate uncertainty and potentially radical change. For several scenarios, stakeholders may need to develop strategies and act on them in relatively short timeframes. It will be important that Ofgem and other policy makers do not inadvertently close off options for the development of the networks and the wider sector they serve.
- 4.8.11 In addition, National Grid, in conjunction with the two Scottish Transmission owners, is undertaking a study on the various investment options that would help facilitate the UK meeting its renewable and CO₂ targets. The results of this work will be made available in early 2009.

4.9 Conclusions

- 4.9.1 In the near term, there is a relatively large amount of new plant under construction. However, in the medium term as plant start to close, the electricity generating industry faces a substantial challenge in ensuring delivery of the new generating capacity that will be needed if Britain is to maintain security of supply at similar levels to those so far enjoyed. There is considerable uncertainty and hence a wide range of possible out-turns around future levels of electricity demand and new electricity build, as well as the exact timing and sequence of plant closures. In any scenario, improvements in energy efficiency and demand-side responsiveness would help to underpin continued security, as well as limiting the need to invest in new generating capacity. This is an area which the Energy Markets Outlook will continue to monitor closely.
- 4.9.2 In the longer term, of course, uncertainty – for example, as to relative fuel prices, environmental regulation and the

development of global supply chains – becomes far greater; and the possibility of currently unforeseen technological advances in generation, transmission and distribution and demand side management enters into the equation. Government policy will need to evolve to ensure that these uncertainties do not prevent the necessary development of new generating capacity.

- 4.9.3 This is already happening in a range of areas from the Planning Act 2008 to moves to establish a market framework that will bring forward new renewables, new nuclear and clean coal plant. The Energy Act has also updated the legislative framework to reflect the availability of new technologies, such as carbon capture and storage, which would enable coal fired generation to be deployed in a way consistent with the transition to a low carbon economy, and emerging renewable technologies. The Government is also determined to take appropriate action to support the development of CCS technology.
- 4.9.4 The Government is also ensuring there are no unnecessary barriers to the deployment of new nuclear power, and the appropriate regulatory frameworks are in place for nuclear new build. In January 2008 the Government published a White Paper on nuclear power setting out the Government's policy on nuclear power development. The White Paper also set out the timetable of facilitative actions necessary to enable energy companies to begin construction of the first new nuclear power station in 2013 – 2014, to start operation in 2017 – 2020.
- 4.9.5 The Government has set aggressive targets for the deployment of renewables, to implement the EU's target of delivering 20% of energy demand from renewable sources by 2020, and for emissions as set out in the Climate Change Act 2008. Its 2008 consultation sought views on how to achieve the level of deployment of renewable energy in the UK at the speed and scale required. This will help to shape the UK's Renewable Energy Strategy which will be published in first half of 2009.
- 4.9.6 Energy efficiency is an important strand to the Government's approach, offering the possibility of a reduced need for new generation and gas supply infrastructure in the future.

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 Large Combustion Plants Directive. Northern Ireland has current total installed generation capacity of 2,793MW (including renewables). Allowing for availability of generation plant, the current peak demand which can be met is around 2,172 MW with an estimated peak electricity demand expected during 2008/09 of around 1,702 MW. Indigenous renewables currently account for around 5% of electricity output. Forecast estimates of future generation capacity margins in NI can be found in the System Operator for Northern Ireland (SONI) 'Generation 7 year Capacity Statement'⁴⁰. There are currently proposals to construct a new 450 MW CCGT and two 40MW OCGT (Open Cycle Gas Turbine) peaking units.

Around 400MW of wind generation will shortly be connected, and a further 1.2GW is currently in the planning process. Governments in Northern Ireland and the Republic of Ireland recently completed a study into how the electrical grid on the island could accommodate increased levels of renewable generation. The study concluded that it was technically feasible for up to 42% of generation by demand to be from renewable sources, mainly on-shore wind. The study implications, in relation to grid strengthening in particular, are being taken forward in conjunction with the Regulator SONI, and NIE, the electricity grid owner.

Introduction of the all-island Single Electricity Market ("SEM") for trading in wholesale electricity on 1 November 2007 has brought greater competition in generation and substantially increased the potential generation mix available for supplying Northern Ireland customers. The retail electricity supply market in NI was fully opened from the same date.

40 www.soni.ltd.uk/upload/Gen_SYS_2004_Final.pdf

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 some 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.