HM TREASURY

DEPARTMENT OF ENERGY & CLIMATE CHANGE

Energy Market Assessment

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Executive summary

The energy market in Britain has delivered significant benefits for businesses and households over the past 20 years. It is already delivering investment in the new infrastructure necessary to decarbonise and ensure continued security of supply to 2020. But the challenges of the decades ahead are significant and the Government must ensure that the right choices are taken for the long term so that the UK has the clean, secure, affordable electricity supplies it needs to deliver its 2050 climate change objectives.

This work needs to be done now because global changes are challenging the underlying assumptions of the UK's energy markets:

- the Government has committed to a legally binding target to cut greenhouse gas emissions in the UK by 80 per cent by 2050 which requires the electricity sector to have largely decarbonised during the 2030s;
- technological change means it is increasingly clear that electricity markets will play the key role in reducing the carbon emissions of the transport and heat sectors;
- changes in global credit markets and associated re-pricing of risk are affecting assumptions about corporate appetite for financing projects; and
- businesses worldwide now know more about both the challenges with building and operating current low-carbon technologies and the possibilities of future technologies.

In the UK, Ofgem has undertaken substantial further work on the operation of retail electricity markets that can inform policy thinking. The Government's 2050 analysis summarised in Annex A provides a clearer sense of the scale and pace of change needed to achieve our decarbonisation targets. Following publication of the Low Carbon Transition Plan the Government believes it is timely to consider the long-term structure of the electricity market to ensure it is equipped for the challenges beyond 2020.

The 2009 Pre Budget Report therefore announced that the Government would take forward work to ensure the electricity market framework can most effectively deliver secure supplies[1], the low-carbon investment needed in the long-term and a fair deal for the consumer.

The Government has concluded that the investment needs associated with carbon reduction place challenging requirements on four areas of the market framework and make new demands of the strategic state:

- **the economics of low-carbon generation.** Low-carbon generators face high upfront capital requirements and low operational costs. They are therefore more exposed to uncertainty in future electricity prices. Despite policies to support some low-carbon generation, over the medium term investors may lack confidence that they can make a reasonable return on most large-scale low-carbon investment in the current market, making these investments less attractive than gas-fired generation;

[1] Gas supply is also essential to the electricity sector and wider UK economy. The Government will shortly be setting out its analysis of gas market security of supply.

- **the finance requirements of low-carbon generation.** Financing a secure, low-carbon system will require a commitment to unprecedented levels of capital expenditure and construction risk that may exceed the capacity or appetite of existing investors. There are also potentially barriers to entry for new sources of equity;
- **security of supply.** The Government is confident that the current arrangements will continue to deliver secure supplies of electricity over the next decade. However, the system may not give investors the right signals to invest in the extra capacity and other mechanisms needed to provide flexibility during the 2020s, when there is increased intermittent and inflexible generation. On gas, the Government will publish shortly its policy statement on security of supply. This document will confirm that the risks of the gas market being unable to meet demand are very low, even in extreme scenarios and that there are no scenarios where there any involuntary interruptions to supplies; and
- **concerns about efficiency and fairness.** Although the current market arrangements have delivered benefits for consumers since liberalisation, the Government is concerned that the substantial barriers to entry across the industry are restricting the levels of innovation and competition. Furthermore, the changes required to meet the carbon reduction challenge are already placing increased pressure on prices. Prices would be expected to rise even if the UK remained on a path of high-carbon generation.

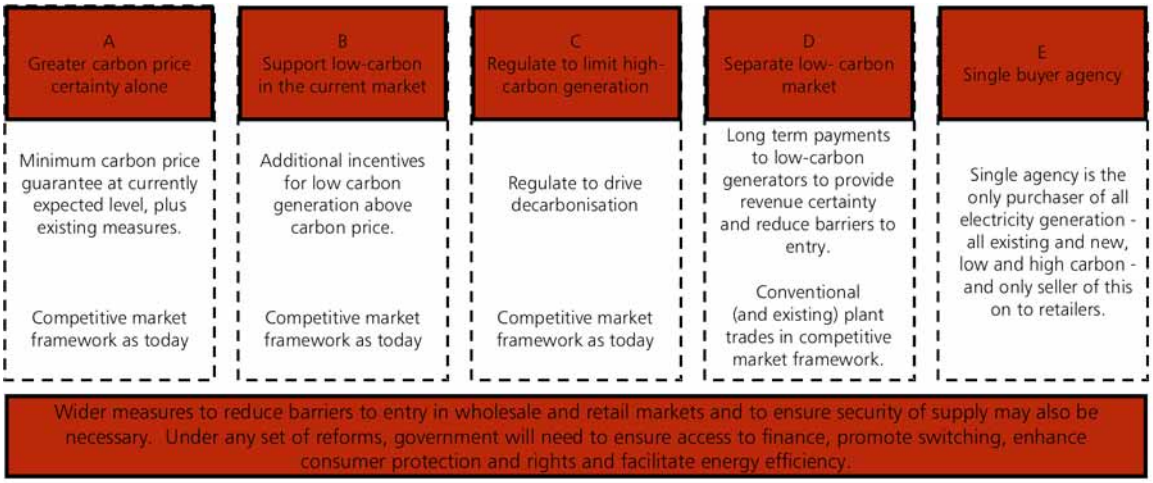
The initial conclusion of the assessment is therefore that the current market framework will need further reform if it is to deliver the necessary investment beyond 2020.

In principle the Government could use a variety of policy levers to seek to influence the outcomes delivered by the electricity market. These include statutory regulation, creating new markets, using price interventions, changing the balance of delivery between the private and public sectors and using the public balance sheet to support the financing of investment.

In practice, the options fall into groups on the basis of whether:

- to **provide an additional payment to low-carbon generators** in addition to the revenue they make from selling their electricity in the current wholesale market, to reflect the risks and costs of such investments;
- to **limit investment in high-carbon generation**, so the electricity price that low-carbon generators receive should then rise to the level required to make such investments attractive; or
- to **provide a fixed revenue to low-carbon generators**, insulating them from the risks in the wholesale market and to reflect the costs of such investments.

Chart A: Overview of groups of options for market reform



The Government has assessed the options this framework provides against its objectives, as set out in Chart A. The Government has concluded that the options at each end of the chart (those that give greater carbon price certainty alone and the single buyer agency) would not meet these objectives. There may be a case for action to provide greater certainty on carbon prices to complement other options for reform. However, this alone is unlikely to be sufficient to deliver all the investment needed over the longer-term. A single buyer agency would lack the disciplines to drive efficiency and therefore be fair for consumers. But the other options illustrated in Chart A could in principle meet the Government's objectives.

The Government has also published a strategy for national infrastructure containing proposals for a Green Investment Bank (GIB). The GIB will co-invest alongside utilities and other infrastructure sponsors and will target major projects in the low-carbon sector where the equity gap will be most critical.

The next phase of work will be to examine the remaining options from Chart A in more detail. In particular the Government will examine the extent to which the different approaches are consistent with three principles:

- **cost-effectiveness.** The energy market framework should deliver its objectives as efficiently as possible. Where markets can function dynamically and effectively they should be allowed to do so, driving down prices for customers and improving quality of service and choice. Reforms should also ensure that barriers to entry are reduced, creating more competition and creating fairer prices for the consumer. Where there is a need for Government intervention, including where there is market failure, it should be sufficient and well designed, maximising effectiveness and minimising costs;
- **affordability.** As well as being effective relative to their cost it is important that any interventions are affordable in absolute terms, especially to the extent that they place demands on taxpayers and customers; and
- **stability and certainty**. Any change needs to provide consistency and certainty for investors by providing long-term stability for investors, but also in the period of transition.

The energy market assessment will consider the three remaining groups of options, including a detailed consideration of a range of specific interventions. This assessment will include:

- a quantitative assessment of the relative efficiency of the different options for reform;
- an assessment of how the full range of interventions could be combined to make complete packages that address the full set of energy policy objectives (including any possible trade-offs);
- an assessment of the risk to the delivery of options for reform including compatibility with UK and EU legal requirements;
- analysis of how interventions can support improved energy efficiency and demand-side response, especially amongst households;
- a consideration of the implications for the institutional design of the energy market including how to ensure the role of independent economic regulation is maintained; and
- an approach to implementation that ensures the confidence of existing and future investors in the electricity market is maintained and that there is a smooth transition from the current market arrangements to any new framework.

The Government will enter into a dialogue with interested parties to make these assessments and will bring forward proposals for consultation this autumn, with a White Paper setting out conclusions by spring 2011. This will enable decisions to be taken in time to give clarity to developers who will be seeking to making investment decisions in the period after 2011.

1 Energy market objectives

1.1 A secure and reliable energy supply is a crucial input into almost every aspect of UK citizens' lives. Energy provides an essential foundation for the UK economy and its future growth prospects. The Government has sought to deliver secure, clean and affordable energy supplies through independently regulated competitive energy markets. Regulation and intervention in the energy market are required because:

- the market may not otherwise provide adequate incentives for the investment and operational decisions needed to provide security of supply;
- electricity generation is one of the primary sources of carbon emissions in the UK. Reducing these emissions requires intervention to ensure the cost of carbon is clearly priced, so that market participants face the full costs of actions when planning investments; and
- there are segments of the energy industry where competition is neither possible nor desirable, such as parts of transmission and distribution, and a strong regulatory framework for the sector is needed in order to protect customers' interests and, in particular, ensure that the most vulnerable members of society are protected from any unfair practices.

1.2 The Government has therefore set out three objectives for energy policy. These are to:

- maintain security of supply;
- reduce carbon emissions; and
- ensure that consumers are treated fairly.

1.3 These objectives are described in full below.

Security of supply

1.4 Maintaining a secure, reliable supply of electricity for homes, businesses and public services is essential in a modern industrialised nation. Continued security of electricity supply is dependent on sufficient capacity to generate enough electricity to meet peak demand, diversity in sources of fuel and electricity production, and a resilient and well maintained transmission network.

Reducing carbon emissions

1.5 Fossil fuels emit carbon dioxide into the atmosphere. Since the beginning of the Industrial Revolution, the concentration of carbon dioxide in the atmosphere has risen by 38 per cent. The evidence that human actions are changing the planet's climate is compelling and the risks of future climate change are considerable. The Stern Review[1] concluded that the benefits of strong, early, co-ordinated action against climate change far outweigh the economic costs of that

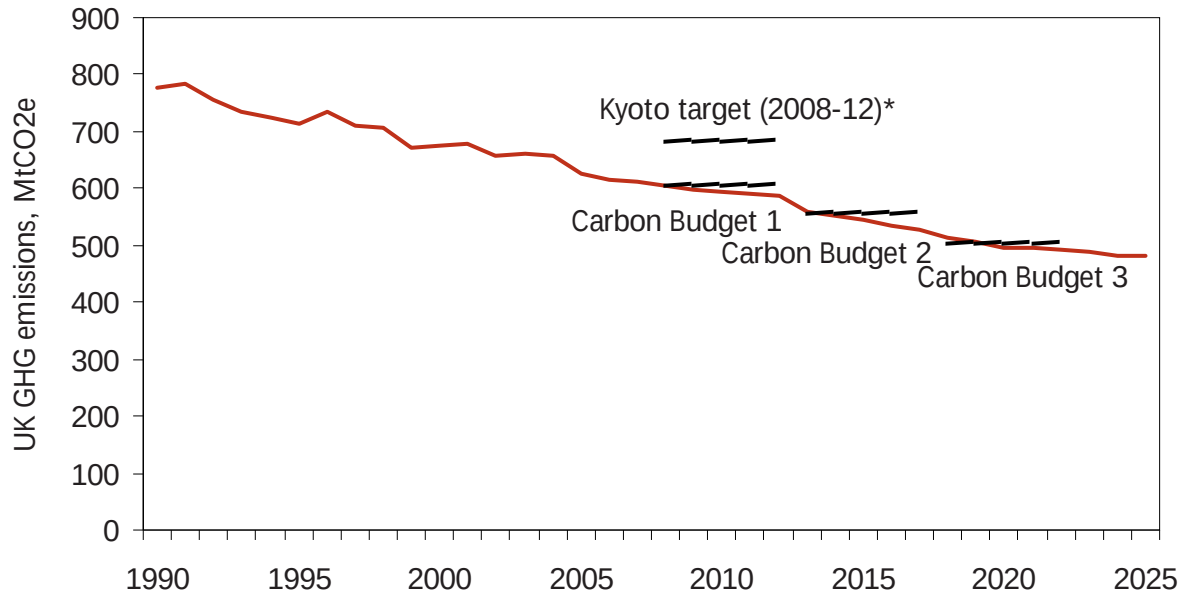
[1] The Stern Review of the Economics of Climate Change, 2006

action. It estimated that the cost of not acting could amount to losing 5-20 per cent of annual global GDP, whereas the costs of taking action can be limited to around one per cent of annual global GDP.

1.6 Government intervention is necessary to ensure that energy markets operate in a way that reflects the environmental externalities caused by carbon emissions. The Government has committed to a legally binding target to cut greenhouse gas emissions in the UK by 80 per cent by 2050.[2] The UK has also committed that 15 per cent of its energy comes from renewable sources by 2020.

1.7 The Government has put in place a comprehensive policy response to deliver its goals to 2020 based on the EU Emissions Trading System (EU ETS), which puts a price on carbon emissions, and the Renewables Obligation, which would require around 30 per cent of electricity to be generated from renewable sources by 2020.

Chart 1.A: UK emissions 1990 - 2025



Source: DECC

1.8 The challenges beyond 2020 are, however, significant. The Government has considered the potential approaches the UK might take to achieving its 2050 climate change objectives. In almost all scenarios that meet the emissions reduction objectives:

- further significant energy efficiency improvements have an important role to play in limiting the costs of reducing carbon emissions;
- electricity production would need to increase markedly as both transport and domestic heat are expected to move away from fossil fuels; and
- the electricity sector would need to be largely decarbonised by some point in the 2030s.

1.9 Over the coming decades significant further investment will therefore be needed in renewables (particularly wind), fossil fuel generation with carbon capture and storage (CCS) and

[2] Compared to 1990 levels

nuclear power to replace ageing existing power stations and to accommodate increasing demand. A summary of the 2050 analysis can be found in Annex A.

Fairness for consumers

1.10 Domestic fuel bills are an important element of household expenditure, therefore it is important that electricity markets operate fairly for all consumers. Appropriate economic regulation of electricity markets helps to ensure that market participants behave fairly and that there is competition in the market, which drives down prices and encourages innovation.

Conclusion

1.11 The characteristics of energy markets create a role for government intervention in order to ensure security of supply, to deliver carbon emissions reduction and to ensure markets work fairly for consumers. The Government's objectives for energy markets reflect this.

1.12 The energy market assessment has considered how well the existing framework is able to deliver these objectives during a period when significant new capacity is needed.

Box 1.A: Economic benefits of the transition to a low-carbon economy

The transition to a low-carbon economy will mean a transformation of the economy, requiring new services, technologies and industries. Such a change will provide an opportunity to invest for growth in these sectors, creating new openings for business, and the development of highly skilled jobs in the UK. The Government wants to make the UK a world leader in the low-carbon and environmental sector, which is worth £3 trillion globally.

By 2015 the sector could be worth £150 billion in the UK alone, and employ around 1.3 million people. The sector includes new forms of energy including wave and tidal power, civil nuclear power and offshore wind; low-carbon business like green venture capital and the development of low-carbon buildings, transport and cutting edge technology such as ultra low-carbon vehicles and renewable chemicals.

In 2009, the Government published the Low Carbon Industrial Strategy, setting out a range of policies designed to build supply chain capacity in the sector, through direct support and improving the UK's skills base in the low carbon sector. Over the course of last year, the Government announced £1.8 billion of targeted support for the sector to implement this Strategy.

2 The electricity market in Great Britain

2.1 This chapter discusses how it has met the Government's objectives of clean, secure and affordable electricity supplies to date. It also explains how the market has continued to evolve to meet the UK's changing energy needs. Chapter 3 considers whether the electricity market can deliver the UK's future needs in a changing global energy context.

Market structure

2.2 The electricity system in Britain has transformed from a state-owned system of regional monopolies to one of the most liberalised in the world, with a well-established regulatory framework.[1]

2.3 Strong, independent economic regulation plays a critical role in this framework in providing stability for investors and protection for consumers. The regulators along with the Government are responsible for protecting the interests of both current and future consumers, promoting effective competition wherever appropriate, and regulating monopolies in transmission and distribution.

2.4 The electricity market is divided into:

- the wholesale market, where generators, suppliers and large customers buy and sell electricity;
- transmission and distribution networks at national and regional levels; and
- the retail market, where suppliers sell to and bill customers.

2.5 Within these markets energy companies are responsible for investing in infrastructure and ensuring generation capacity is available to meet demand. The network monopolies support company investment by ensuring the networks are developed in a timely way that supports reliable transmission and distribution.

2.6 At liberalisation a number of companies entered both the generation and supply markets. Since then both markets have become increasingly concentrated. The retail electricity market is now dominated by six major energy companies,[2] which have a 99 per cent share of domestic supply.[3]

2.7 These six major energy companies are vertically integrated, meaning that they operate in both wholesale and retail markets: they both generate power and sell it to customers. In the wholesale market the same six major suppliers comprise 67 per cent of the market.[4]

[1] The UK's liberalisation approach was used as the basis for European internal market legislation to liberalise electricity and gas markets across Europe.
[2] E.ON, RWE npower, SSE, EDF, Centrica and Scottish Power – the so called "Big Six".
[3] Ofgem Energy Supply Probe, 2008
[4] Liquidity Proposals for the GB wholesale electricity market 2010, Ofgem

Security of supply

2.8 UK electricity supplies are among the most reliable in Europe. Supply outages in the UK are almost always the result of a physical interruption to the transmission and distribution system rather than a shortage of electricity generation.

2.9 Maintaining a high level of security requires continued investment in transmission and distribution networks and sufficient generating capacity to meet peak demand.

2.10 A large proportion of UK electricity is produced in gas-fired power stations, therefore the security of gas supply has an effect on the security of electricity supply. Since the 1990s the UK has moved from being self-sufficient in gas to being increasingly dependent on imports. Over the next decade it will be important to maintain diverse sources of gas supply as well as adequate gas storage infrastructure.[5]

2.11 The Government has worked closely with industry to facilitate substantial investment in the domestic gas infrastructure in order to provide greater resilience. This has enabled:

- an increase in gas storage capacity. Storage capacity has increased over the last decade by around 25 per cent. This enables the UK to store more gas, which can be used to meet peak demand or if there are difficulties bringing in imports; and
- a substantial increase in import capacity. There has been a 500 per cent increase in UK gas import capacity in the last decade, with the majority built since 2005-6. The infrastructure is now capable of importing more than 120 per cent of annual gross demand. This allows the UK to import gas from a wider range of sources and to increase gas flow in response to high demand.

2.12 In winter 2009/10 the market was able to respond to record levels of demand combined with supply problems with Norwegian gas without significant increases in price or any involuntary disruptions to supplies. Longer term risk assessments have tested the ability of the system to respond to even very high impact, very low probability events (such as the loss of the UK's largest source of supply for a whole year combined with a severe winter). These assessments conclude that the risk of the market being unable to meet demand is very small and in all scenarios (including a combined shock disrupting two major sources of supply) there are no involuntary interruptions to customers' supplies. The Government will shortly be publishing a statement on the outlook for gas security of supply, setting out this analysis in further detail

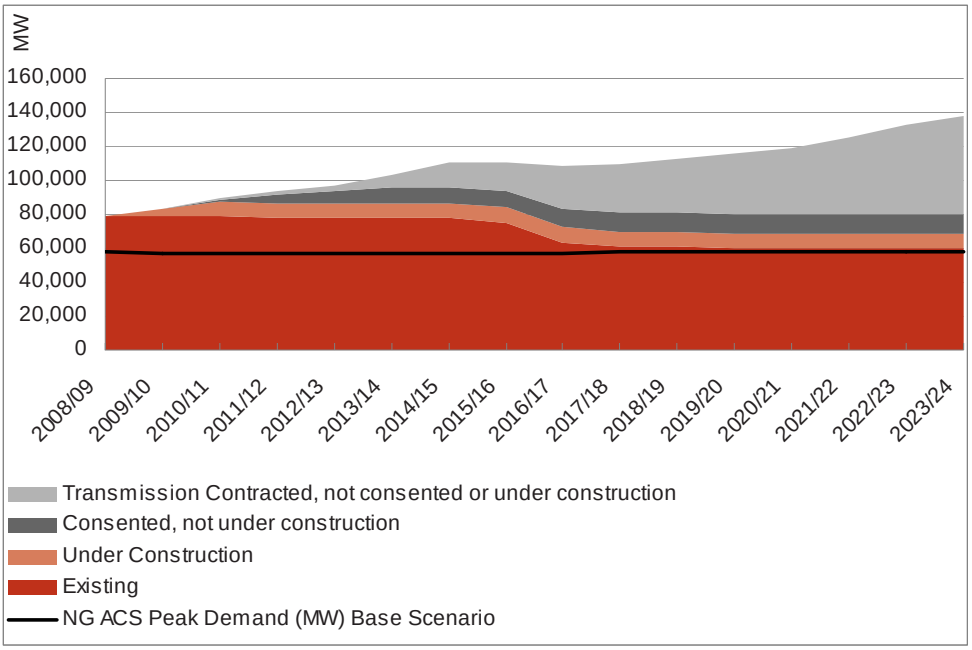
2.13 Security of electricity supply also depends on continued investment in new generation in order to meet the UK's needs. By 2018, 18 Gigawatts (GW) of existing generating plant will close due to a combination of the Large Combustion Plant Directive and the retirement of a number of existing nuclear power stations (illustrated in Chart 2.A below).

2.14 Significant new investment, is however planned in onshore and offshore wind generation and gas generation that will be enough to replace the closing plant. Under current investment plans around 10GW of new gas and renewable generation is under construction and a further 11GW has the necessary planning consents. Many more gigawatts of generation have permission to connect to the electricity network although do not yet have planning consent, as shown in Chart 2.A. This shows that there will be significant capacity above the peak demand line. The Government believes this will ensure that an appropriate level of security of electricity supply will be maintained in the period to 2020. While risks to the capacity margin increase nearer to 2020, UK electricity supplies have delivered robust security of supply since liberalisation and if demand forecasts were to increase Government believes the current market arrangements

[5] The Government will shortly be setting out its analysis of gas market security of supply.

would send the necessary price signals to bring new construction forward. Analysis of all plausible scenarios shows there are very low risks of insufficient capacity leading to supply interruptions in the pre-2020 period.

Chart 2.A: Existing and planned electricity capacity



Source: Energy Markets Outlook December 2009

Reducing carbon emissions

2.15 The Government has intervened in the electricity market to promote energy efficiency and support the development of low-carbon forms of generation in order to reduce carbon emissions and make progress towards its 2050 emissions reduction target.

2.16 The UK is set to achieve its Kyoto emissions reduction target, which requires a reduction in greenhouse gas emissions of 12.5 per cent against 1990 levels by 2008-2012. The UK has also set the world's first legally binding carbon budgets. It is on course to meet the first three budgets.

2.17 A significant proportion of the required carbon savings were and will be secured through new investment in electricity generation. This has been driven both by policy measures (see box 1B) and, during the last two decades, by the switch from coal to less carbon-intensive gas generation. Investment in new power stations since 1990 has led to gas providing over 30 per cent of generation, becoming the single largest source of electricity.

2.18 The Renewables Obligation (RO) provides additional financial support to generators of renewable electricity. The RO is driving significant investment with the result that large utilities and other investors have so far brought 7.6GW of renewable generation into operation, with another 2.9GW currently being constructed, 8.6GW with planning consent awaiting construction, and a further 10.6GW in the planning system.[6]

[6] Department of Energy and Climate Change

Box 2.A: Overview of Government interventions to support carbon emissions reduction

EU Emissions Trading System Carbon Price

The EU Emissions Trading System (EU ETS) is the central pillar of the Government's strategy for delivering reductions in carbon emissions. The EU ETS limits the emissions of heavy industry and power generation to a capped level agreed across the EU. Large emitters are given incentives to reduce their emissions or to buy permits from other emitters who are able to reduce their emissions more cheaply.

Household energy efficiency

Heating and powering homes accounts for more than a quarter of Britain's CO_2 emissions. Existing policies to improve household energy efficiency are already helping to drive down these emissions, whilst at the same time enabling millions of families to save money on their energy bills. The key policies are the Carbon Emission Reduction Target established in 2002 and the Community Energy Saving Programme in 2009. The government has set out its ambitious new policy, "Warm Homes, Greener Homes: a strategy for household energy management", on 2 March 2010. This strategy will cut carbon emissions from homes by 29 per cent by 2020.

Renewable Energy Strategy

The UK has committed to sourcing 15 per cent of its energy from renewable sources by 2020 – an increase in the share of renewables by almost a factor of seven on 2008. This will be delivered through:

- the Renewables Obligation, which provides financial support to generators investing in onshore and offshore wind as well as other renewables;
- Feed-in Tariffs for small scale renewable generation (FITs). Subject to Parliamentary approval the FITs scheme will start from 1 April 2010 and will encourage deployment of additional low-carbon electricity generation by organisations, businesses, communities and individuals, many of which are not traditionally involved in the production of electricity; and
- the Renewable Heat Incentive. Heat accounts for around 49 per cent of UK energy use. Most of it is not covered by the EU ETS. The Government is consulting on the introduction of a Renewable Heat Incentive (RHI) scheme to deliver up to 30 per cent of the overall renewable energy target.

Climate Change Levy

The Climate Change Levy (CCL) is a tax on business and public sector energy consumption. Since its introduction in 2001, CCL has reduced total energy consumption in these sectors by three per cent and now delivers annual emissions reductions of 13.5 mega tonnes of carbon dioxide equivalent. Businesses that implement Climate Change Agreements are entitled to tax relief from CCL of 65 per cent from 1 April 2011.

Carbon Capture and Storage Incentive

The Carbon Capture and Storage Incentive (CCS) is being introduced to support the development of a programme of four carbon capture and storage demonstration projects in the UK. The incentive provides a revenue stream for operators of CCS projects, by levying a charge on electricity suppliers to fund the costs of the CCS demonstration equipment. The demonstration programme is expected to lead to emissions reductions of 6.7 mega tonnes of carbon dioxide equivalent per year by 2020.

Fairness for consumers

2.19 In principle, competitive markets should provide the best outcome for consumers. The liberalisation of Great Britain's market has delivered increased choice in tariffs and services and the ability to switch supplier. The UK's electricity switching rate of 18 per cent per annum is the highest in Europe and the highest of any sizeable competitive energy market in the world.[7] Over the last five years, more energy and gas customers switched supplier than in any other UK consumer services sector of a comparable size, apart from car insurance.

2.20 Retail prices have generally followed wholesale prices, which has protected customers from wholesale market volatility by smoothing their bills over time.[8] Suppliers' net margins on customer bills have generally been low – close to zero in recent years. Evidence to date does not suggest that energy companies have been making excess profits.

2.21 There does appear to be a consistent pattern to the order in which the six major domestic retail suppliers pass wholesale price changes through to consumers, which could suggest that suppliers feel little pressure to take risks in order to maintain or grow their market share. This "price following" behaviour suggests that competitive pressure is not as strong as it could be. There are also a number of other signs that the market is not functioning as dynamically as it could. In a competitive market, new entrants and the threat of new entry provide competitive pressure on incumbents, restraining profit margins and encouraging innovation and cost efficiency. However, in Great Britain's retail electricity market there is a very low level of independent activity. The six largest suppliers now provide 99 per cent of domestic supply and also directly control two thirds of the wholesale market.

2.22 The main reason for the lack of independent activity is likely to be the barriers to entry in both wholesale and retail markets. The primary barrier is low wholesale market liquidity. The lack of liquidity arises from the vertically integrated companies 'self-supplying' their electricity (i.e. their supply arms purchase their electricity requirements from their generating arms) and/or entering into long-term contracts with independent generators, which ultimately means there are low volumes of electricity available to trade on the wholesale market. This makes it hard for new entrants into the retail market to obtain the volume and range of electricity wholesale products at the predictable prices that they need to compete.

2.23 Vertical integration offers several benefits including lower risk from wholesale electricity price volatility, economies of scale and price smoothing. If the lack of wholesale market liquidity can be addressed the potential impact of vertical integration should be mitigated. Ofgem has committed to monitoring whether existing market initiatives, such as this year's launch of a new trading exchange (N2Ex), work in improving liquidity. It has set out broad criteria against which it will measure the effectiveness of these new initiatives. Ofgem proposes four possible interventions in the event that it is not satisfied that the market is delivering improved liquidity, and aims to be in a position to implement an appropriate remedy at the end of the year.

2.24 There are however, other barriers to entry including:

- obtaining finance in a framework where investment returns are extremely uncertain;
- regulatory and compliance requirements;
- the level of technical skills needed to participate in the market; and

[7] Ofgem Energy Supply Probe 2008

[8] Ofgem's Energy Supply Probe 2008 found that between 2004 and 2008, customers had been left neutral compared with a hypothetical case where they paid a tariff that explicitly tracked wholesale costs. The lag in pass through of wholesale prices to retail prices is caused by the vertically integrated Big Six hedging against wholesale price volatility by purchasing their energy in advance, at a set price, via long-term contracts (typically 18 months).

- the costs associated with establishing brand awareness and achieving economies of scale as a new entrant.

2.25 In addition to these structural problems, there are also concerns that the market is not delivering positive outcomes for some groups of consumers. Ofgem's recent Energy Supply Probe found that certain consumer segments, in particular customers who have never switched supplier, and more vulnerable groups, have been unfairly disadvantaged by the pricing policies of the energy companies. Consumers also lack confidence in the effectiveness of the market. A recent Ipsos MORI survey for Consumer Focus saw customers rank the gas and electricity market last out of 45 consumer service markets on key performance indicators relating to confidence and transparency.

2.26 In response to the above issues with market structure and delivery, Ofgem has introduced a broad range of measures to strengthen both competition and consumer protection (see Box 2.B). The Government is also intending to publish a discussion document shortly, which will discuss measures to enhance consumer rights and confidence.

Box 2.B: Recent measures to support competition and protect consumers

Ofgem has acted to:

- require payment method differentials to be cost reflective and ban undue price discrimination (from September 2009);
- require provision of better information on all bills (from July 2010);
- require provision of an annual statement with further information to inform switching (from July 2010);
- require any information used during the sales process, including for doorstep and telesales, to "be complete and accurate, understandable, appropriate and not misleading" (from October 2009);
- require provision of written estimates prior to door-to-door sales (from January 2010);
- allow more customers to switch supplier even if they are in debt by doubling the debt threshold to £200 (from January 2010);
- require the "Big 6" energy companies to publish revenue, costs and profits from their electricity generation and supply businesses and their gas supply businesses (from mid 2010); and
- propose that energy companies be required to notify consumers of price changes more quickly (consultation expected before April 2010).

In addition the Energy Bill:

- extends the time limit for Ofgem to impose financial penalties for breaches of licence conditions from one year to five;
- makes it easier for Ofgem to address exploitation of market power where there are constraints on the amount of electricity that can be transmitted; and
- creates powers for the Secretary of State to address situations where cross subsidies between gas and electricity businesses lead to groups of consumers being disadvantaged.

Conclusion

2.27 The British energy market has delivered benefits for businesses and domestic consumers since liberalisation. Strong independent economic regulation has provided a stable framework for investors. However, the electricity market is not functioning as dynamically and efficiently as it could. This might become more of a problem in future, given the demands placed on the market in the transition to low carbon generation. The Government and Ofgem are working to continue improving competition, so as to ensure that the market works as efficiently as possible, and that consumers are protected.

2.28 Investment has been consistently and effectively channelled into efficient low cost generation. However, Britain's future investment needs to deliver new, more challenging technologies and therefore the Government has created stronger incentives to support renewables and investment in onshore and offshore wind.

2.29 New investment in generation, transmission and distribution and the provision of fuel imports from a wide range of countries mean that the UK has maintained secure supply and is on track to continue to do so through to 2020.

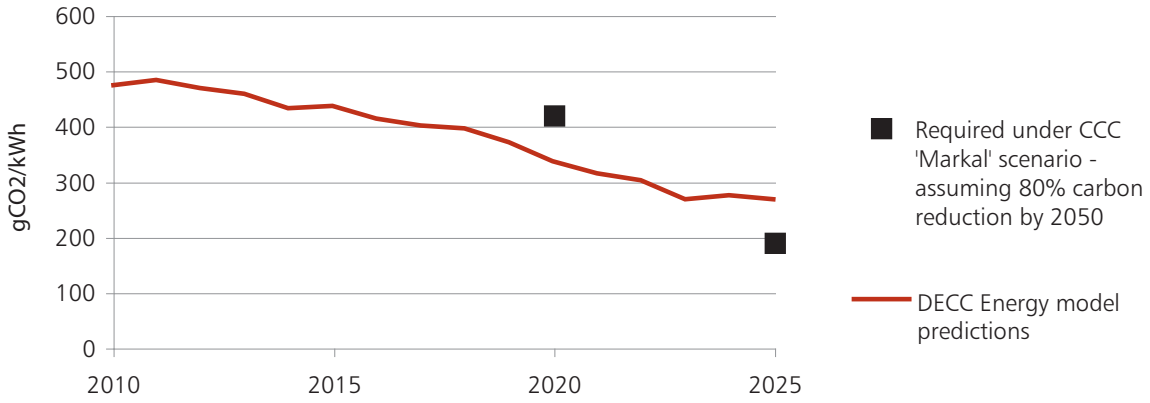
2.30 The competitive electricity framework has delivered choice for consumers as well as acceptable levels of pricing. There are some signs that more recently the market has not been functioning as dynamically as it could. Initial positive steps have been taken by the regulator and Government will continue to work with Ofgem to pursue this agenda.

3 Challenges facing the energy market in Britain

3.1 Chapter 2 set out how the existing electricity market framework has delivered to date against the Government's three energy policy objectives. This chapter now considers how the current market arrangements will deliver over the period beyond 2020. It does so in the context of the Government's legal commitments to reduce the carbon emissions of the economy and its targets for renewable energy.

3.2 Investment in low-carbon generation is the central issue. Chart 3.A shows the Government's latest projections for the carbon intensity of the electricity grid, assuming that the current market arrangements and incentives for low-carbon generation remain unchanged. This trajectory is compared to the emissions output required under a Committee on Climate Change scenario for delivering an 80 per cent reduction in carbon emissions by 2050. This shows that the UK is likely to achieve the lower level of carbon emissions needed in 2020 with current policies.

Chart 3.A: Carbon intensity of the grid – required and predicted



Source: DECC and Redpoint. Produced for the CCC, Decarbonising the GB power sector, October 2009

3.3 However, these projections also suggest that under the current market arrangements and without any other form of Government intervention the UK is unlikely to achieve the required emissions reduction objectives after 2020. The Government has therefore considered the extent to which it is reasonable to expect that the market framework will deliver the additional investment required to bring the UK back onto trajectory while maintaining security of supply and delivering fair outcomes for consumers.

3.4 The Government's assessment is that without further actions to address the new challenges facing the electricity market, Britain is unlikely to achieve its longer-term objectives for the period beyond 2020. There are four factors underlying this:

- **the economics of low-carbon generation.** Low-carbon generators face high upfront capital requirements and low operational costs. They are therefore more exposed to uncertainty in future electricity prices. Despite policies to support some low-carbon generation, over the medium term investors may lack confidence that they can

make a reasonable return on most large-scale low-carbon investment in the current market, making these investments less attractive than gas-fired generation;

- **the finance requirements of low-carbon generation.** Financing a secure, low-carbon system will require a commitment to unprecedented levels of capital expenditure and construction risk that may exceed the capacity or appetite of existing investors. There are also potentially barriers to entry for new sources of equity;
- **security of supply.** The Government is confident that the current arrangements will continue to deliver secure supplies of electricity over the next decade. However, the system may not give investors the right signals to invest in the extra capacity and other mechanisms needed to provide flexibility during the 2020s, when there is increased intermittent and inflexible generation. On gas, the Government will publish shortly its policy statement on security of supply. This document will confirm that the risks of the gas market being unable to meet demand are very low, even in extreme scenarios and that there are no scenarios where there any involuntary interruptions to supplies; and
- **concerns about efficiency and fairness.** Although the current market arrangements have delivered benefits for consumers since liberalisation, the Government is concerned that the substantial barriers to entry across the industry are restricting the levels of innovation and competition. Furthermore, the changes required to meet the carbon reduction challenge are already placing increased pressure on prices. Prices would be expected to rise even if the UK remained on a path of high-carbon generation.

3.5 In addition to the investment required to reduce the carbon intensity of the UK's energy generation, significant investment will be required in the UK's transmission and distribution networks, to adapt to the different locations and production patterns of low-carbon generation, including connecting offshore wind projects to the onshore grid. Further investment will be needed in interconnection, storage, smart grids and smart meters to enable the network to support greater energy flexibility and efficiency.

3.6 Recent estimates by the Electricity Networks Strategy Group suggest that upgrading the onshore grid to meet these challenges could require up to £4.7 billion of new investment over the next decade. In common with other utility sectors, the electricity sector has successfully used the regulated asset base (RAB) approach to deliver appropriate investment in network infrastructure. Ofgem will continue to use this approach alongside competitive tenders to secure investment in the next phase of network infrastructure. Chapter 4 considers whether this RAB approach could be extended beyond the network infrastructure into aspects of low-carbon generation.

The economics of low-carbon generation

3.7 Current low-carbon generation requires additional support to compete with conventional gas-fired generation because it is more expensive than existing high-carbon technologies and is more exposed to electricity price uncertainty.

3.8 Although price comparisons are difficult, recent analysis suggests that, for example, the capital cost of onshore wind is around £1.2 billion per GW and that of offshore wind is around £2.8 billion per GW.[1] This compares to around £0.6 billion per GW for a conventional gas-fired power station. Under existing arrangements this difference in capital costs needs to be recovered through the price received for the electricity produced, during the operating life of the

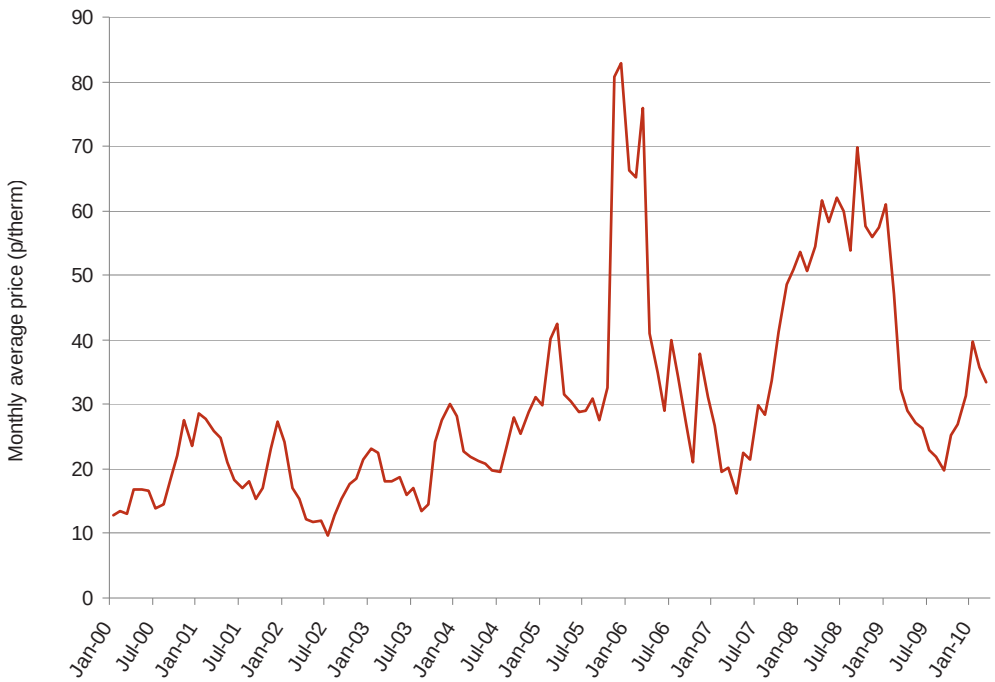
[1] Ofgem, Project Discovery Energy Market Scenarios, October 2009

technology. As wind power only generates intermittently there is greater risk around its ability to achieve a commercial return.

3.9 Most forms of low-carbon generation are not 'price-setting' and are therefore exposed to additional uncertainty over price. The UK market price for electricity is currently set by flexible coal or gas generation. In the 2020s, as existing unabated coal stations are phased out, the electricity price will be increasingly linked to the gas price. The volatility of the gas price means that there could be periods of low gas prices during the life of any low-carbon investment where the electricity generated cannot be sold at a price that covers the costs of investment.

3.10 The European Union Emissions Trading System (EU ETS) goes some way to addressing these issues by reducing the cost differential between low and high-carbon generation through establishing a carbon price. However, at current levels and without further international agreement, it is insufficient to alter fundamentally the relative economics of the different investments. Furthermore, investors consider that the carbon price is unlikely to rise fast enough to compensate for the potential impacts of the price volatility that results from gas setting the price. The cost of gas is a much more significant driver of the electricity price than the cost of carbon, for example DECC analysis suggests that in 2020 a 50 per cent increase in the cost of carbon allowances would be offset by just a 15 per cent reduction in the cost of gas. As chart 3.B illustrates, gas has shown significant price volatility in recent years.

Chart 3.B: Gas price volatility Jan 2000 – March 2010



Source: ICIS Heren

3.11 The Government has intervened by introducing bands in the Renewable Obligation (RO) in order to ensure appropriate levels of return for different technologies. The design of the RO still means there are uncertainties for investors over the future price of RO certificates. Some argue this could lead to a dampening effect on investment. There remains a risk that further evolution in the operation of the RO will either over-reward or under-reward necessary investment.

3.12 Due to its inherent intermittency, increasing deployment of renewable electricity is likely to lead to increased volatility in the price of wholesale electricity and so greater price uncertainty for all generators. Uncertainty about the rate of take-up of renewable generation, particularly in the 2020s, will also lead to investor uncertainty around how often other power stations will run and so returns, in particular for generation with limited flexibility, such as nuclear, are less predictable.

The finance requirements of low-carbon generation

3.13 Low-carbon investment faces two particular financing challenges caused by both the scale of capital investment required in relation to the existing investor base over the next 30 years, and the particularly risky nature of the construction phase of most low-carbon generation. This in particular can create barriers to new investor entry.

3.14 In the period to 2020, utilities and other investors will need to support the development of new gas-fired generation, the renewables required to deliver the Renewable Energy Strategy 2020 target, significant investment in the onshore and offshore grids, and the first new coal CCS and new nuclear stations. Estimates suggest total investment requirements in the electricity sector to 2020 could be around £110 to £120 billion[2]. This is set against a background of unprecedented investment requirements in Europe: Citigroup estimates that the capital expenditure required by all European utilities could be around €1trillion between 2010 and 2020.

3.15 The scale of investment to 2020 is significantly higher than the current rates of investment in the UK electricity sector and beyond 2020 the level of capital expenditure needed is likely to increase still further.

3.16 Achieving the annual rates of investment required to deliver the UK's generation needs post-2020 will be very demanding. The issue is not the overall scale of investment in relation to the capacity of global capital markets. Instead it derives from the characteristics of low-carbon investment. Low-carbon generation tends to have higher capital costs than conventional fossil fuel generation and many low-carbon technologies have longer lifetimes over which they pay back this capital investment; for example, nuclear generation has a typical lifetime of at least 40 years compared to a lifetime of 25 years for gas. Moreover, the development and construction risks around low-carbon technologies are greater than for conventional fossil fuel generation. This reflects that the technologies have potentially longer build times and are typically less well proven than their high-carbon equivalents. Investors have significant experience of building gas-fired generation and investors can price the risk associated with construction accordingly; they have less experience of technologies such as deep-water offshore wind generation and accordingly find pricing the uncertainty more complex.

3.17 This means that in the current market the most likely investors in this sector are the existing large utilities. Many of these firms operate in multiple markets and are constrained in the amount of capital expenditure and project risk they are prepared to take on in respect of any one location or technology type.

3.18 Some of the largest projects may exceed the limits of the investment constraints that the utilities set for themselves. In time, as the market becomes increasingly confident in pricing the risks in financing low-carbon generation, some of these problems may reduce. In the meantime it is likely that achieving the necessary levels of investment will require additional sources of finance to enter the sector.

[2] Undiscounted, 2009 prices: Department of Energy and Climate Change.

3.19 Alongside this document, the Government has also published a strategy for national infrastructure containing proposals for a Green Investment Bank (GIB). The GIB will co-invest alongside utilities and other infrastructure sponsors and will target major projects in the low-carbon sector where the equity gap will be most critical.

Security of supply and intermittency

3.20 As Chapter 2 sets out, analysis of all plausible scenarios shows there are very low risks of insufficient capacity leading to supply interruptions in the pre-2020 period.

3.21 Looking further into the future all decarbonisation scenarios for the UK depend on large amounts of intermittent and / or inflexible generation, including wind generation and other low-carbon technologies. This means that the UK will require sufficient additional capacity to meet its energy needs at times when renewables are not able to deliver a consistent electricity supply.

3.22 This capacity may only be used irregularly and can come from additional domestic generation or from interconnection with neighbouring countries. Better demand-side management and the introduction of technological solutions, such as electricity storage, can also help manage intermittency. Current market arrangements do not necessarily provide sufficient incentives for investment in infrastructure to provide such additional generating capacity for the period after 2020.

Competition, efficiency and minimising costs for consumers

3.23 The scale of the new investment required, alongside expected higher fossil fuel prices, is expected to result in upward pressure on wholesale electricity prices, and so to some extent in higher consumer bills.[3] It is therefore essential that competitive pressures and independent economic regulation continue to drive efficiency throughout the system to minimise costs to the UK economy and protect consumers. In addition, all energy users must be supported in taking up energy efficiency measures to minimise their bills.

3.24 The Government is concerned that although the competitive market has broadly delivered, it is not functioning as effectively as it could. There are currently only very low levels of independent provision in the domestic supply market outside the "Big Six" vertically integrated companies and there are a number of barriers to entry to both the wholesale and retail markets. This situation may become more acute in the future. For the market to operate effectively, new entrants and the threat of new entry are necessary to provide stronger competitive pressure on incumbents. Further action, by industry itself, Ofgem or the Government is likely to be needed to address these challenges.

3.25 The wholesale price is set by the most expensive generation type operating on the system at the time. By 2030, gas could still be setting the price for seventy per cent of the time but only providing ten per cent of the electricity.[4] This would increase the potential for excess profits for low operating cost baseload generators, such as nuclear.

3.26 In addition the higher financing costs, due to the risks associated with low-carbon investment, may lead to higher costs for consumers. Generally, risks should be placed with the party best able to manage them – whether in the private or public sector – but government has a broader role in minimising regulatory uncertainty.

[3] Ofgem, Project Discovery Energy Market Scenarios, October 2009.

[4] Modelling by Redpoint Consultancy for the Committee on Climate Change (CCC).

Box 3.A: International attempts to overcome these challenges

The economics of low-carbon generation present a worldwide challenge. Most markets that already include significant low-carbon generation feature either large amounts of nuclear (e.g. France, Slovakia) and/or hydro (New Zealand, South American nations). However, in all cases this was achieved via considerable state intervention, except where local geography (e.g. in Chile) has made investment in hydro economic in its own right.

Nations that have more in common with the UK in their ambitions for reducing the carbon intensity of generation and driving large increases in non-hydro renewable generation are still in the process of identifying interventions that work most successfully. This includes US markets such as California and Pennsylvania-New Jersey-Maryland, and European examples including Germany, Spain and the Nordpool (Denmark, Norway, Sweden and Finland).

The experience of these and other electricity markets can present useful lessons to the UK Government about how to establish or change its market framework. The energy crises that followed the liberalisation of both the Californian market and the Ontarian market demonstrate the importance of implementing a design that suits the market in question. They also demonstrate that steps must be taken at the right time to ensure investor certainty. Both moving too hastily and delaying decisions can impact negatively on the market's ability to meet the Government's goals in the longer-term.

Deregulation of California's electricity market in 2000 led to a crisis characterised by extremely volatile and high prices and blackouts.[5] The deregulated power industry relied too heavily on short-term markets and a combination of a drought (that reduced hydroelectric power), high gas prices, unexpected nuclear outages and high demand for electricity caused a severe energy crisis. Although it performed well initially, the market failed to deliver sufficient available capacity to sustain a reliable supply or encourage investment.

The situation was resolved by the introduction of a price cap and long-term power purchase agreements. These are still in place and supply is now secure and California is leading the US in terms of investment in renewables.

The Canadian province of Ontario experienced a similar energy crisis in 2002 when the retail and wholesale markets were fully liberalised.[6] Uncertainty around this transition appeared to deter investors and the market failed to deliver enough capacity to cope with high demand over the summer months. This left the province heavily reliant on imports and led to price spikes in the wholesale markets and to higher consumer bills. In response, the government closed down the retail market, introduced price freezes and then created a new agency, the Ontario Power Authority, to oversee all generation and capacity in the longer-term. This model continues today and allows the province to specify contracts to meet its objectives. However, reserving this right places cost burdens on the OPA and ratepayers.[7]

[5] *California's electricity market: A post-crisis progress report,* Carl Pechman, California Economic Policy, vol.3, no.1 January 2007.

[6] Overview of Electricity Regulation in Canada, Blakes, 2008.

[7] For further information on the OPA's negotiations see The Bruce Power Refurbishment Agreement, Officer of the Auditor General of Ontario, 2007.

Conclusion

3.27 The Government's assessment is that the market is well placed to deliver its objectives to 2020. The Renewables Obligation is ensuring that substantial onshore and offshore wind generation is built. Beyond 2020 however there are risks that the current market arrangement will not drive the investment in low-carbon generation that we need to meet our longer term goals for carbon emissions reductions because:

- the economics of low-carbon generation are not yet sufficiently attractive to investors as, without additional support, low-carbon investments are typically more expensive and carry greater risks than investment in conventional gas-fired generation;
- the risks associated with the construction and development of low-carbon generation are very different from those of high-carbon generation;
- the increase in intermittent renewable generation could pose challenges for security of supply if no further action is taken. Into the 2020s, additional intermittency management is likely to be required and it is not clear that the current market provides appropriate signals for this investment to occur; and
- there are currently negligible levels of independent activity in the domestic supply market outside the six large vertically integrated companies and a number of barriers to entry to both the retail and wholesale electricity markets. In a competitive market, new entrants and the threat of new entry are an important competitive influence on incumbents.

4 Options for market reform

4.1 Chapter 3 described the challenges in the current energy market framework that could affect the UK's ability to meet its energy policy objectives over the long term. This chapter sets out options for reforming the framework that the Government is evaluating and assesses each one against the three energy policy objectives set out in Chapter 2: reducing carbon emissions; security of supply; and consumer fairness.

4.2 The analysis in the previous chapters highlighted the challenges that the UK will face in achieving the required pace of reductions in carbon emissions over the coming period. It explained how issues around investment in low-carbon generation were at the heart of this problem and that there were also potentially significant impacts on security of supply and outcomes for consumers. A range of possible approaches could be taken in response. In particular, there are important choices around the extent to, and way in which, government should become involved in the choice between different technologies used to generate electricity.

4.3 In any credible strategy to address the challenge the carbon price must play a key role. Pricing carbon drives reductions in emissions through differentiating the costs of high- versus low-carbon generation and therefore provides an incentive to reduce emissions. It encourages market participants to identify the lowest-cost ways to reduce emissions. This is the principle that underpins the EU ETS. Under any option for reform, the EU ETS will remain central to the UK's strategy to reduce carbon emissions, as set out in the box below.

Box 4.A: European Union Emissions Trading System (EU ETS)

The EU ETS will remain an essential prerequisite to reducing the carbon intensity of the UK power sector. Under any of the options explored here the carbon price will still play a critical role in providing signals for the optimal operation of high-carbon generation (such as the choice between running coal or gas power stations), for the investment in low-carbon generation and the optimal choice of flexible technologies, such as between gas-generation or demand-side response technologies.

In options where new low-carbon investment earns all or part of its revenue from the wholesale market, the carbon price will serve to differentiate between low- and high-carbon technologies. In options with a funding mechanism for low-carbon investment, outside of the wholesale market, the carbon price will be an important benchmark for regulators in setting incentives. A strong and stable carbon price will therefore still be essential for the power sector as well as still being the primary driver for emissions reductions in the other sectors of the EU ETS.

Furthermore, decisions at the European level through the EU ETS will continue to ensure international action is taken to tackle climate change.

4.4 As Chapter 3 explained, there are reasons to believe that although the carbon price is important, it may not in itself be sufficient to drive the pace and scale of change required to secure the transition to a low-carbon economy beyond 2020. In particular, the economics of

low-carbon generation are fundamentally different from those of high-carbon generation. Typically, low-carbon generation requires high levels of up-front investment in technologies that are sometimes unproven or subject to higher levels of risk. In addition, given that gas-fired generation tends to set the electricity price, uncertainty in gas prices will cause uncertainty in electricity prices, making rates of return on low-carbon investment unpredictable and hence the investment less attractive.

4.5 Reflecting these particular characteristics, the Government has already put in place a number of complementary interventions which support particular technologies or types of technologies for which Government has additional targets. The Renewables Obligation and feed-in tariffs for small-scale renewable generation are examples of interventions of this type.

4.6 In principle Government can use a variety of policy levers to seek to influence the outcomes delivered by the electricity market. These include:

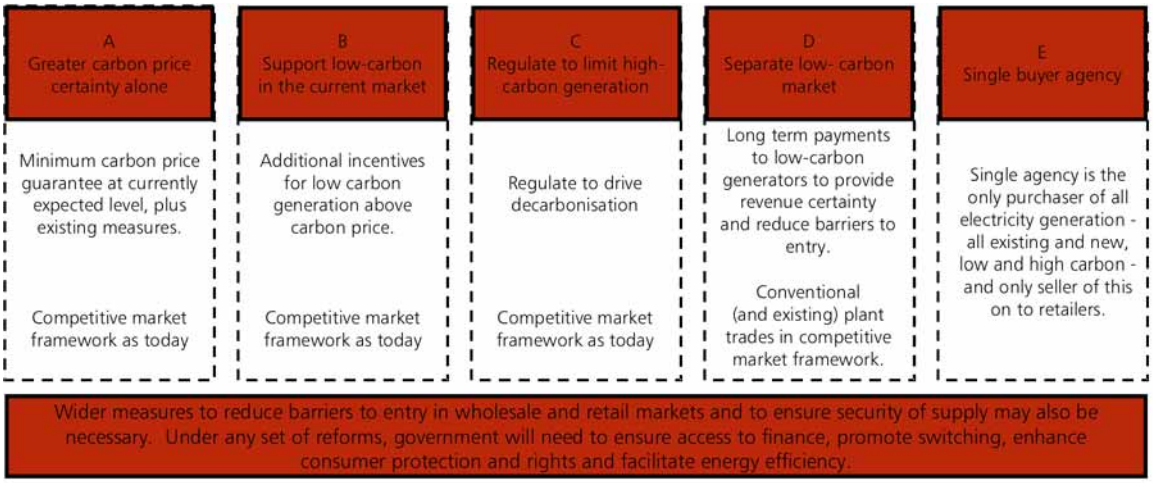
- **statutory regulation**, for example passing legislation to restrict certain types of activity;
- **economic regulation**, for example changing the roles, functions and duties of the electricity market regulator. This would also include allowing the price of or returns to low-carbon electricity generation to be determined through regulatory processes rather than through existing wholesale markets;
- **creating new markets** where there is no market at present, in the same way as the EU ETS does for carbon emissions;
- **using price interventions,** whether through tax or subsidy, to alter the relative prices of different technologies in the market. A current example is the Renewables Obligation;
- **changing the balance of what is delivered by the private and public sectors**, as liberalisation in 1990 did; and
- **using the public balance sheet** to support financing investment in electricity generation.

4.7 In practice, the range of options for reforming the framework to encourage more investment in low-carbon generation considered in the energy market assessment is a subset of this list. The options fall into groups on the basis of whether:

- to **provide an additional payment to low-carbon generators** in addition to the revenue they make from selling their electricity in the current wholesale market, to reflect the risks and costs of such investments;
- to **limit investment in high-carbon generation**, so the electricity price that low-carbon generators receive can then rise to the level required to make such investments attractive; or
- to **provide a fixed revenue to low-carbon generators**, insulating them from the risks in the wholesale market and reflecting the costs of such investments.

4.8 On this basis, it is possible to structure the options into five groups, ranging from the lower levels of intervention towards the left, to the highest on the right, as set out in chart 4.A.

Chart 4.A: Overview of groups of options for market reform



4.9 This chapter considers the potential impacts of the options on all three energy policy objectives, starting with the challenge of supporting additional low-carbon investment. It then examines a range of measures that might be appropriate to address the risks to the UK's energy security as a result of increasing the proportion of low-carbon electricity in the generating mix, and to ensure that consumers pay a fair price for their energy.

a) Greater carbon price certainty alone

4.10 Under this option, the electricity market would remain largely as it is today. Low-carbon generators would continue to sell their electricity in the wholesale market and receive the price determined by the market. The existing support regimes for certain technologies could remain in place. However, the Government would intervene to increase certainty over the future carbon price in the UK electricity sector, in order to encourage more low-carbon investments.

4.11 This could be achieved for example through a contract for difference, where government enters into a contract to give low-carbon generators a top-up payment if the EU ETS price falls below a certain level.

Assessment against objectives

4.12 This option provides greater certainty in the level of the carbon price. As a result, low-carbon forms of generation have more of a competitive advantage compared with fossil-fuel generation.

4.13 However, this option will not address all the challenges for low-carbon generation set out in Chapter 3. The additional certainty about the carbon price element of the electricity price is likely be masked by uncertainties in other factors driving the electricity price, principally the gas price. Therefore, while greater certainty over future carbon prices could be an important part of a complete package of policy interventions, on its own it is unlikely to be sufficient to support the levels of new low-carbon generation demanded by the Government's policy objectives.

4.14 To the extent that this option encourages more low-carbon forms of generation, it will increase the risk of interruptions to supply, arising from an increasingly intermittent and/or inflexible generation mix, as set out in Chapter 3. Therefore, implementing this option would strengthen the argument for action to provide more incentives for developers to bring forward additional flexibility through additional generation capacity, demand-side response and interconnection and storage. Interventions that could achieve this are discussed below.

4.15 This option retains the benefits of a competitive wholesale market in driving cost-effectiveness. Although putting a price on carbon will drive carbon emissions reductions throughout the economy, on its own this option still leaves low-carbon generators facing significant uncertainty. Therefore, it is likely that their cost of capital would remain high, which would feed through to higher prices for consumers. This would offset some of the efficiency benefits of this approach.

b) Support low-carbon in current market

4.16 Under this option, the electricity market arrangements would remain largely as they are now. Low-carbon generators would continue to sell their electricity in the wholesale market and receive the price set by the market. However, government would intervene to increase and make more certain the degree to which low-carbon generators receive additional revenue compared with high-carbon generators. This could be done in a technology-neutral way, combined with additional policies to meet the UK's renewables target and demonstrate CCS, or could be tailored towards specific technologies.

4.17 Examples of the types of intervention that would achieve this include:

- a **Low Carbon Obligation**, which would require suppliers to source a certain percentage of electricity from particular sources of low-carbon generation;
- a system of **"premium" feed-in tariffs** where the generator would receive an additional revenue stream to supplement its revenues from electricity sales; and
- a **contract for difference on the electricity price**, where government and the low-carbon generator would agree a fixed price for electricity sales. If, for example, the average wholesale price in a given time period was below this level, the generator would receive a top-up payment to take their revenue up to the agreed fixed level.

Box 4.B: International examples of support for low-carbon generation within existing market structures

Premium feed-in tariffs (FITs), which offer a premium over and above the wholesale market price, have been used in nations including Denmark, Germany and Spain[1] to encourage investment in renewables. The premium can be calculated:

a) **as a percentage of the market price.** In Denmark and Germany, premium FITs were established in the early 1990s, calculated as a fixed percentage of the market price. The percentage was dependant on project size and technology type. Though successful at stimulating significant development of wind power in both countries, in 2000-01 Germany abandoned premium FITs in favour of fixed price FITs and Denmark moved to a model offering a constant premium above market price. Premium FITs calculated on a percentage basis have the advantage of linking payments for low-carbon generation to market prices, but on the other hand they amplify any volatility in prices, with a corresponding adverse impact on investor security;

b) **as a fixed rate above the market price.** The premium can be calculated to reflect project costs, or to reflect an estimate of the social and environmental value of the technology. An advantage of the fixed premium is that it maintains a link to market prices without the same level of volatility as the percentage-based model. However, as prices fluctuate, payment levels can at times be too low to cover investor costs, or so high as to give investors excess returns, so this model still carries risks for investors and government; or

a) **as a variable rate dependent upon the market price.** In 2007, Spain introduced a variable premium FIT that includes caps and floors. Between a certain range of market prices, a fixed premium is paid on top of the market price. Below the bottom limit of this range, the premium rises, effectively giving a price floor to investors, allowing them greater security. Above the top limit of this range, the premium declines gradually as market price increases, effectively capping the payment received. At a certain price, the premium reduces to zero and above that producers receive the market price. This model is designed to provide investment security but also to minimise excess profits.

Assessment against objectives

4.18 This option recognises that investment in low-carbon generation may need more certain and higher revenues than is provided just by giving greater certainty to the carbon price and hence the electricity price. The additional revenue would improve the attractiveness of investment in low-carbon generation. However, low-carbon generators would still face electricity price uncertainty and would still have to manage the risk of not having a customer to purchase their electricity. The degree to which there would be long-term policy certainty depends on the design of the chosen intervention.

4.19 In encouraging more low-carbon forms of generation, this group of options will increase the risk to security of supply arising from an increasingly intermittent and/or inflexible generation mix. As set out in Chapter 3, under an energy mix that is predominantly based on wind and nuclear, gas-fired power stations would run for increasingly limited amounts of time, making them a riskier investment. Therefore, implementing this option would strengthen the argument for additional action to increase the incentives in the current market to bring forward additional flexibility, through additional generation capacity, demand-side response and interconnection and storage. Interventions that could achieve these are discussed below.

[1] *Analysis of feed-in tariff remuneration models: implications for renewable energy investment", Couture and Gagnon, Energy Policy 39, 2009*

4.20 This option retains the benefits of a competitive wholesale market in driving cost-effectiveness. However, it would require government to form a view on a preferred generating mix and overall capacity in the future. This is not without risk; in particular excessive returns (economic rents) may be paid in a way that would not arise if the market has a greater role.

4.21 Some of the interventions give government a role in assessing the level of reward for specific technologies. This could result in payment levels being set higher than is necessary to bring forward the desired amount and type of generation, or alternatively being set too low to incentivise investment. This would result in a loss in efficiency. Government already faces these risks in deciding the banding levels for the Renewables Obligation.

c) Regulate to limit high-carbon generation

4.22 Under current arrangements, high-carbon investments will often be more attractive to investors than low-carbon investments. Government could introduce regulatory options to seek to limit the amount of high-carbon generation that can be built in the UK and/or to limit its operation. These options need to be considered within the context that the UK will still need the construction of significant new gas-fired capacity in the 2010s to replace the coal and nuclear power stations closing over the period and that, while carbon capture and storage is still at a relatively early stage of development, inflexible regulatory interventions risk stifling innovation in that technology.

4.23 Limits on the construction of new high-carbon generating capacity could be absolute, for example limiting the construction of new unabated fossil-fuel generation directly, or relative, for example a policy where for every gigawatt of installed wind or nuclear capacity, the market can invest in a pre-determined amount of unabated fossil-fuel generation. The latter option allows potential investors to respond more quickly to provide the necessary contingency and flexibility to maintain a secure system. To implement this option the Government could, for example, impose a limit in a future Energy National Policy Statement (although this may impose new consultation requirements or processes to re-designate the Statement).

4.24 Independently, or in combination, limits on operation could be set at the level of an individual plant or on a fleet basis. These could be implemented directly, by limiting running hours, or indirectly, by limiting carbon emissions (an emissions performance standard), either per unit of electricity generated or through an overall cap. To implement this option the Government could, for example, direct the Environment Agency to include limits in environmental permits.

4.25 The Government has previously stated that it believes that an emissions performance standard raises particular risks to investment and that it sees no case for introducing such a policy in the short term.

Assessment against objectives

4.26 If the construction and/or operation of high-carbon generation (which has a lower generating cost) is restricted, the electricity price that low-carbon generators receive should respond by rising to the level required to make low carbon generation attractive.

4.27 However, the economics of low-carbon generation would still be subject to policy and regulatory uncertainty. There is significant risk that investors would not have sufficient confidence that government would maintain the policy and allow prices to rise and remain at a sufficiently high level that makes low-carbon investments attractive. Moreover, this option does not tackle all the underlying difficulties in investing in low-carbon generation outlined in Chapter 3.

4.28 This option presents significant security of supply risks. Faced with the choice between either building low-carbon generation or handling uncertainty over their ability to construct and operate high-carbon plant in Great Britain, or building elsewhere where such restrictions would not exist, developers may choose to invest abroad. In considering this risk, it is important to remember the international nature of the companies investing in the energy market and the range of international investment opportunities. Companies will identify the most attractive international markets in which to invest, and this option could make the energy market unable to compete for international capital.

4.29 Even if sufficient overall capacity were built, through low-carbon investments going ahead, there is a risk that there would not be enough flexibility in the system to maintain security of supply (either through flexible generation or demand-side response), because of the characteristics of these forms of electricity generation. Even combined with the interventions discussed later in this chapter, there could still be some security of supply risks.

4.30 The Government believes that there are significant risks to investment associated with the introduction of an emissions performance standard, which would affect plant operation, and that such a policy should not be pursued in the short term. It is included as an option here because the energy market assessment is examining the framework over a longer time horizon.

4.31 Regulating to limit high-carbon generation shares the same benefits as option A (providing greater carbon price certainty), because it leaves the market with the freedom to identify the lowest-cost way of meeting the UK's low-carbon objectives. Within the regulatory constraint, companies would be allowed to decide what type and how much low-carbon generation to build, reducing the risk of building capacity that is not needed. However, this option is still unlikely to deliver at least cost because the policy uncertainty may result in a high cost of capital.

d) Separate low-carbon market

4.32 In this option, a guaranteed revenue stream is developed for low-carbon generators that is separate from the existing wholesale market. The price could be established in a number of ways through:

- a **competitive tendering** approach for low-carbon generation. In this model, government would set a target amount of low-carbon generation and would run a series of auctions where developers would bid for a fixed payment in return for building the low-carbon capacity. The lowest bid would win in each auction, and successful bidders would then receive the fixed payment in addition to their revenues from electricity sales. Government could choose to run technology neutral or technology-specific auctions;
- being **set by government** (a "fixed" feed-in tariff); or
- **regulation of an appropriate return** (the regulated asset base approach taken for electricity networks).

4.33 Under these options there would need to be a system to guarantee off-take (i.e. an agreement for a party to buy any electricity generated) and sell the electricity to suppliers. Examples include a pool-type system in which a centralised bid-based system is used to distribute electricity from generators to suppliers, an obligation on suppliers to buy the electricity or an agency that would buy and sell on the electricity into the wholesale market.

4.34 Under the regulated asset base and competitive tendering approaches, government would need to decide on how much of the market it wanted to contract for in this manner, and how much should be left to the wholesale market.

Box 4.C: International examples of separate low-carbon generation markets

Fixed feed-in tariffs (FIT) are used in many European nations including France, Germany and Ireland. They feature fixed prices, not linked to wholesale market prices, though they may be adjusted over time for inflation. Some are front-loaded models, whereby higher payments are offered in earlier years to bring cash flow forward (e.g. FITs for wind power in France and Germany).[2]

Provided payment levels are guaranteed for a sufficient period of time, any form of fixed FIT can provide a high level of security for investors. This can result in lower costs of capital and a more cost-effective system than premium FIT models (see Box 4.B above). However, the system does require government to set a price that meets investors' need for adequate returns whilst avoiding granting windfall profits.

Assessment against objectives

4.35 A separate low-carbon mechanism provides low-carbon generators with a guaranteed electricity price and off-take (i.e. an agreement for a party to buy any electricity generated), unlike option B where low-carbon generators still bear the risks of changes in prices set in the wholesale market. This could lead to a relatively lower cost of capital, because developers would be insulated against more risks than under the other possible options discussed in this chapter. This would be expected to reduce the overall costs of generation that are ultimately passed onto consumers through electricity bills.

4.36 The additional support would increase low-carbon generation in the 2020s to a level that, if no additional changes were made, could result in additional challenges in responding to an increase in intermittent and inflexible generation. Therefore, it would strengthen the argument for increasing the incentives in the current market to bring forward additional flexibility. Interventions to achieve these are discussed below.

4.37 This option gives government a role in assessing the levels of reward for specific technologies, which creates certain risks to efficiency (discussed above). Interventions that fix quantities or the technology mix, such as running competitive tenders, as opposed to fixing the price, are likely to be better placed to manage these risks.

4.38 However, competitive tenders require sufficient competition for a tender in order to have downward pressure on prices. The initial analysis (as set out in Chapter 3) suggests the scale and risk of low-carbon investments (as set out in chapter three) means that there may be limited interest in participating in such a process. Across most options, there is also a risk that if the future electricity price subsequently rises higher than expected at the time of setting the payment level, low-carbon generators could earn excessive profits at the expense of the consumer or taxpayer.

4.39 A separate low-carbon mechanism creates an opportunity to increase competition by reducing barriers to entry in the wholesale market for low-carbon generators, who would not face the same difficulties as independent generators face today because there would be a guaranteed price and off-take. New entrants would be able to sell their electricity on the same terms as large vertically integrated companies. The increased competition would in turn benefit consumers by providing greater choice and downward pressure on prices.

[2] *Analysis of feed-in tariff remuneration models: implications for renewable energy investment", Couture and Gagnon, Energy Policy 39, 2009*

4.40 Some of the interventions, i.e. those combined with a pool-type mechanism for selling electricity to retailers, could also improve access for new retailers to the wholesale market. This would help address concerns about the degree of control exercised by the vertically integrated utilities over the retail market. Thus, the changes required to deliver the separate low-carbon mechanism may be sufficient to address competition issues. If not, additional measures to increase competition in the wholesale or retail market could be considered.

4.41 However, by reducing their exposure to the wholesale market (both the price and off-take risks), this option is also likely to reduce generators' incentive to improve efficiency. There are also risks – as with the supporting low-carbon in the current market option – about government taking views on the values of individual technologies, although these are more pronounced here because government decisions will set the generators' entire revenue.

e) Single buyer agency

4.42 This option represents the biggest change to the current arrangements, and puts a central buying agency in control of all the key decisions in the market, controlling the level and type of all generation investment. A central agency, acting as the sole buyer of electricity from generators, and sole seller to retailers, would take a view of the necessary capacity needed to ensure energy security and a generation mix that would deliver the required carbon emissions reductions. The agency would run a series of competitive tenders for long-term generation contracts. This would mean existing generators moving into the new regime, as well as tendering for any new low-carbon, and, certainly in the medium-term, any additional fossil-fuel generating capacity needed.

Assessment against objectives

4.43 Broadly speaking, a single buyer agency would not deliver any additional benefits for supporting low-carbon investment over and above the competitive tendering approach discussed above. Instead, this option is more likely to be attractive as a response to significant concerns about security of supply, and the ability of developers to invest in fossil-fuel generation.

4.44 Theoretically, this option gives the most certainty on future security of supply: the central agency would be responsible for tendering for all electricity and as such could ensure sufficient flexible capacity – or demand-side response – to manage all risks. However, in practice, the central agency would need to take decisions on optimum levels of capacity and generation mix, which may not be straightforward. The agency's decisions are important because it would control all investments through their tendering processes; even if developers saw commercial opportunities in new generating capacity, they would not be able to pursue them. Under the current arrangements, there is scope for developers to exploit these opportunities and make investments in flexible capacity. The reliance on the central agency to make decisions on capacity requirements creates a risk, compared with a market-based approach where the diversity in analysis of different potential investors offers security of supply benefits. For example, if the central agency underestimated the need for generating capacity, say in response to unexpected economic growth, it would potentially expose the UK to issues such as supply interruptions and high and volatile electricity prices.

4.45 Alternatively, the central agency may place a high premium on spare capacity and may tend to over-invest in new generating capacity (as some argue was the case in the past with the Central Electricity Generating Board). It is likely that the costs of meeting the Government's energy objectives will be greater than with a market-based solution. The administrative costs of creating such a new public sector body could also be significant.

4.46 There are some potential opportunities for efficiency in the model: because there would be no alternative to selling to or buying from the single buyer, the single buyer may be better placed to negotiate on price than suppliers. Although this could reduce costs, there is a high risk that the agency may not be as well placed as suppliers in a competitive market to correctly determine the need for generation investment, which may well outweigh any benefits of negotiation power.

Additional interventions to ensure delivery of all energy policy objectives

4.47 Each of the options discussed above will have different implications for security of supply and different impacts on customers:

- on security of supply, the more successful options are at increasing low-carbon generation, the greater the case for action to ensure the right incentives are in place for investments in flexibility (either gas-fired generation or demand-side response); and
- in respect of consumer fairness, those options based on the existing market arrangements are likely to be insufficient to generate increased competition, so may need to be combined with measures to remove barriers to entry in the wholesale and retail market through measures to improve liquidity and measures to facilitate customer switching in the retail market.

4.48 Once decisions have been made on the above options, the Government will consider whether additional interventions are necessary to support its policy objectives. These could include:

- enabling better demand-side response and storage;
- creating more effective price signals in the current market;
- introducing capacity mechanisms;
- improving consumers' interaction with the market; and
- interventions aimed at increasing liquidity in the market and promoting competition.

Security of supply

4.49 The Government has considered three principal additional security of supply interventions that could be included as part of a complete policy package.

4.50 The first intervention, which would be pursued in all scenarios, is to enable better demand-side responses and storage. Demand-side responses can play a role in helping to balance a system with higher levels of inflexible or intermittent generation in a cost-effective way, by enabling levels of demand to be shifted at times of system tightness. While the roll-out of smart meters will be key in enabling this kind of response among domestic consumers, there are also certain technical barriers that need to be addressed, including enabling more sophisticated time-of-use tariffs.

4.51 Electricity storage technologies are at an early stage of development. Measures to increase awareness of their potential benefits and tackle the barriers that discourage market participants from investing in research and development into storage technologies could also help improve the outlook for security of supply in the future. For example, under the current arrangements,

there is uncertainty about the scope of existing supplier and distribution licences and whether they allow licence holders to undertake electricity storage activities.

4.52 The second intervention would introduce more effective price signals in the current market. Ofgem has proposed to expose electricity generators and suppliers to the full costs of the National Grid's actions to keep the electricity system balanced so that supply meets demand.[3] Market participants are not currently exposed to the true costs of balancing the system and therefore the full impacts of their decisions to increase intermittent generation. As a result they may under-invest in flexible generating capacity to balance their portfolios.

4.53 The third intervention that could play a role in ensuring energy security is capacity mechanisms. These mechanisms reward available capacity, instead of developers receiving all their revenues from electricity sales. They have been discussed above in the context of supporting low-carbon investment, but could equally be used to support investment in flexible generation. They could play a particularly important role where there are significant amounts of intermittent and inflexible generation on the system, and a relatively significant intervention in the market. Whilst they are unlikely to be necessary until the end of this decade, it is important to consider these options now alongside other options for reform.

4.54 Capacity mechanisms could include placing obligations on:

- **suppliers**, to demonstrate they are able to meet their expected demand and a pre-determined amount of "spare capacity"; and
- **the system operator**, to maintain a pre-determined capacity margin (the system operator would then run long-term capacity tenders to fulfil its obligation).

4.55 International experience suggests that capacity auctions are likely to be the most cost-effective way to implement a capacity mechanism. Parties offering demand-side response and energy efficiency measures could also bid for capacity contracts. This would create a strong financial incentive for those able to free up capacity on the system. Auctions could potentially be expanded to include storage.[4]

[3] Project Discovery – options for delivering secure and sustainable energy supplies, Ofgem, February 2010

[4] *2009 State of the markets report*, ISO/RTO Council

Box 4.D: International experience of capacity mechanisms

Capacity mechanisms are used in many nations, and have generally been used to reward all generation types, not just low-carbon technologies. Typically they can work through:

- **capacity payments**, which have been used in Spain and several South American nations. In Spain, the system operator collected an amount of money from all suppliers, according to electricity supplied to consumers, and then redistributed that money amongst generators to reward them for making capacity available. Such a system provides an additional revenue stream to help cover investment costs. However, it can be difficult to agree a value for the capacity provided by renewables generation, because of their intermittency;
- **capacity obligations**, as used in parts of the United States. Generators receive a capacity credit, which they can sell to retailers. Retailers are obliged to purchase capacity credits to cover the demand they serve, plus a margin. Credits are tradable between retailers. Such a system provides a market-based mechanism for providing additional revenue to generators. However, it has not always succeeded in providing enough certainty to stimulate additional investment in generation; or
- **capacity auctions**, again used in parts of the United States, for example in the PJM market (the electricity market serving north-eastern USA). In this market, the system operator is under an obligation to maintain a certain amount of spare capacity. It discharges this obligation by forming a view on any gap between their obligation and the anticipated capacity, and then running auctions to procure additional resource as necessary. A particular feature is the participation of the demand side, where demand aggregators participate in capacity auctions alongside developers of new flexible generation.

Fairness for consumers

4.56 In all scenarios the Government will want to ensure that consumers get the best deal and are not put at a disadvantage by the market structure. The Government will shortly publish a discussion document to consider whether further action is needed to build on Ofgem's work on encouraging effective interactions between consumers and the market.

4.57 The Government has identified four key areas that could be targeted in order to improve the operation of the market:

- **minimising costs.** Enabling effective competition wherever possible through effective, efficient policy and system design;
- **improving transparency in the energy market and helping consumers find the best deal from energy suppliers.** This will help consumers to make good switching decisions and reduce the information barrier that hinders switching;
- **strengthening consumer rights.** This will improve the protection in place for the consumer; and
- **improving energy efficiency.** This will help consumers to better manage the impacts of increases in energy prices over the coming decade.

4.58 Beyond that, the Government welcomes Ofgem's recent measures to improve competition and strengthen consumer protection in the supply market, and their proposals to improve market liquidity, in order to reduce the barriers to entry. The Government will be working with

Ofgem to ensure that it is able to take clear decisions shortly and will also encourage them to explore how other barriers to entry could be tackled. Proposals which could be implemented individually or in combination include:

- an **obligation requiring large generators to trade with small/independent suppliers**. Large generators would be required (by a license condition) to offers terms for trade, set out in guidance when approached by small and independent suppliers;
- **market-making arrangements**. Large generators would be required to provide a certain amount of their generation to a central agent that would make the electricity available through a trading platform;
- **mandatory auctions.** An obligation on all large generators to offer volume into the auction, which would be designed to develop a trusted reference price, to help inform participants entering bi-lateral contracts; and
- **self-supply restrictions** on large, vertically integrated utilities. This would limit the extent to which the vertically-integrated players could supply their own retail businesses from their generation businesses, and instead selling the generation through the market.

4.59 A pool-type arrangement while a significant change from the current arrangements (in which a centralised bid-based system is used to distribute electricity from generators to suppliers) could also address liquidity concerns and bring benefits to consumers by tackling the barriers to entry in the electricity market.

4.60 The Government and Ofgem will continue to keep this under review and take whatever steps are necessary to reduce barriers to entry in retail and generation markets, and ensure that consumers benefit from a competitive market.

Tackling the low-carbon generation financing challenge

4.61 While the options discussed in this chapter are designed to reduce revenue uncertainty and so make financing of low-carbon investments easier, availability of finance will continue to be a key consideration. At the 2009 Pre-Budget Report, the Government commissioned Infrastructure UK to consider the commercial and financing aspects of infrastructure investments, to help the Government in making decisions on options to ensure the market framework delivers the necessary investment in infrastructure to meet the Government's energy policy goals. This work is directly relevant to the finance challenge in the electricity sector as set out in Chapter 3.

4.62 Alongside this document, the Government has also published a strategy for national infrastructure containing proposals for a Green Investment Bank (GIB). The GIB will co-invest alongside utilities and other infrastructure sponsors and will target major projects in the low-carbon sector where the equity gap will be most critical.

Narrowing down the options

4.63 On the basis of the preliminary analysis undertaken in the first phase of the energy market assessment the Government's assessment is that beyond 2020 reform of the existing market arrangements is necessary to meet its objectives. As discussed in Chapter 2, the current arrangements have delivered and will continue to deliver secure supplies of energy that are increasingly low-carbon. Beyond 2020, the scale and pace required by the UK's renewable and carbon reduction targets, and the importance of ensuring that the market works more effectively for consumers, constitute a clear case for change. As set out in Chapter 2 there are particular challenges to overcome:

- **the economics of low-carbon generation.** Low-carbon generators face high upfront capital requirements and low operational costs. They are therefore more exposed to

uncertainty in future electricity prices. Despite policies to support some low-carbon generation, over the medium term investors may lack confidence that they can make a reasonable return on most large-scale low-carbon investment in the current market, making these investments less attractive than gas-fired generation;

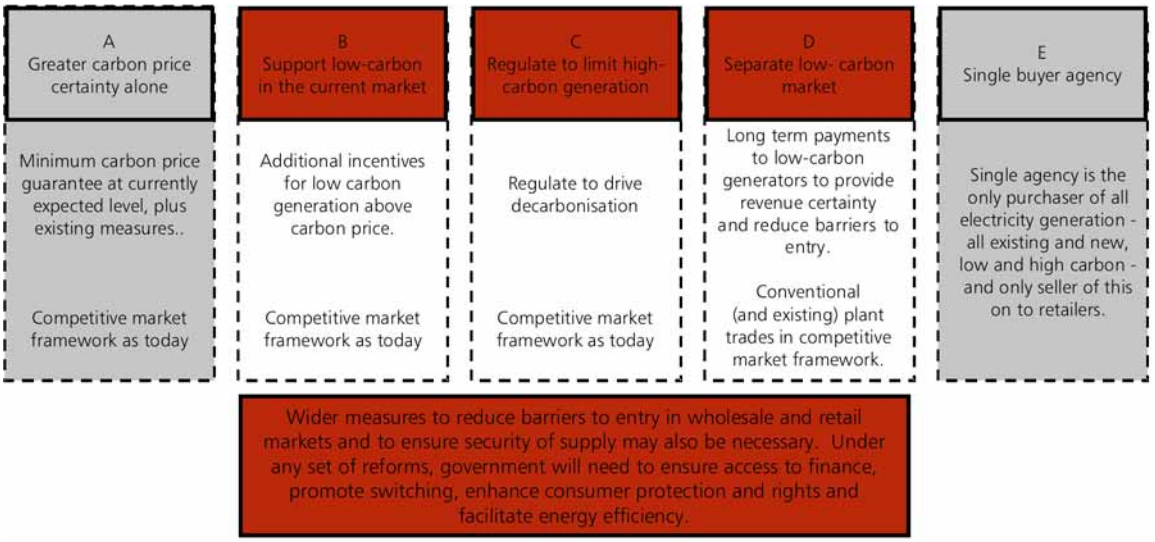
- **the finance requirements of low-carbon generation.** Financing a secure, low-carbon system will require a commitment to unprecedented levels of capital expenditure and construction risk that may exceed the capacity or appetite of existing investors. There are also potentially barriers to entry for new sources of equity;
- **security of supply.** The Government is confident that the current arrangements will continue to deliver secure supplies of electricity over the next decade. However, the system may not give investors the right signals to invest in the extra capacity and other mechanisms needed to provide flexibility during the 2020s, when there is increased intermittent and inflexible generation. On gas, the Government will publish shortly its policy statement on security of supply. This document will confirm that the risks of the gas market being unable to meet demand are very low, even in extreme scenarios and that there are no scenarios where there any involuntary interruptions to supplies; and
- **concerns about efficiency and fairness.** Although the current market arrangements have delivered benefits for consumers since liberalisation, the Government is concerned that the substantial barriers to entry across the industry are restricting the levels of innovation and competition. Furthermore, the changes required to meet the carbon reduction challenge are already placing increased pressure on prices. Prices would be expected to rise even if the UK remained on a path of high-carbon generation.

4.64 The Government has concluded that options A (greater price certainty alone) and E (single buyer agency) do not adequately tackle these challenges and as such would create too great a risk of the UK being unable to achieving one or more of its energy policy objectives.

4.65 The Government does not consider that the option of giving greater carbon price certainty would, on its own, be sufficient to address the challenges outlined in Chapter 3 for the post-2020 period. There may be a case for action to provide greater certainty on carbon prices to complement other options for reform. However, this is unlikely to deliver the investment needed over the longer term without further changes to the market.

4.66 Second, the Government considers that the risks to all energy policy objectives presented by a single buyer agency (as described in option E) would outweigh the benefits. Given the disruption that would be created by wholesale changes to arrangements for remunerating all existing generators, the Government does not see sufficient additional advantages in this option. Furthermore, this option would lose the benefits of a market-based approach to energy policy in terms of driving efficiency, so would be expected to offer a worse deal for consumers.

Chart 4.B: Narrowing down options for market reform



4.67 Accordingly the Government's current assessment is that the choice is likely to be between the remaining options:

- support low-carbon generation in current market;
- regulate to limit investment in higher-carbon forms of generation, although the initial analysis suggests there are particular risks associated with this option, which would require serious consideration; and
- establish a separate low-carbon market.

5 Next steps: detailed option assessment

5.1 This chapter sets out the criteria that the Government will use to assess the relative merits of the remaining groups of options for reform of the electricity market, and the Government's proposed timetable for undertaking further work.

Criteria for assessing options for reform

5.2 As set out in Chapter 1, the Government has three energy market objectives: ensuring secure supplies of energy, reducing carbon emissions, and delivering fairness for consumers. In order to identify the optimal way to deliver all policy objectives, including considering possible trade-offs between them, the Government will consider the remaining options against the following criteria in the next phase of this project:

- **cost-effectiveness.** The energy market framework should deliver its objectives as efficiently as possible. Where markets can function dynamically and effectively they should be allowed to do so, driving down prices for customers and improving quality of service and choice. Reforms should also ensure that barriers to entry are reduced, creating more competition and creating fairer prices for the consumer. Where there is a need for Government intervention, including where there is market failure, it should be sufficient and well designed, maximising effectiveness and minimising costs;
- **affordability.** As well as being effective relative to their cost it is important that any interventions are affordable in absolute terms, especially to the extent that they place demands on taxpayers and customers; and
- **stability and certainty**. Any change needs to provide consistency and certainty for investors by providing long-term stability, but also in the period of transition.

Next steps

5.3 The second phase of the energy market assessment will consider the options set out in Chapter 4. It will develop these options in more detail and test them against the criteria set out above. This assessment will include:

- a quantitative assessment of the relative efficiency of the different options for reform;
- an assessment of how the full range of interventions could be combined to make complete packages that address the full set of energy policy objectives (including any possible trade-offs);
- an assessment of the risk to delivery of options for reform, including compatibility with UK and EU legal requirements;
- analysis of how interventions can support improved energy efficiency and demand-side response, especially among households;

- a consideration of the implications for the institutional design of the energy market including how to ensure the role of independent economic regulation is maintained; and
- an approach to implementation that ensures the confidence of existing and future investors in the electricity market is maintained, and that there is a smooth transition from the current market arrangements to any new framework.

5.4 The Government will enter into a dialogue with interested parties and will bring forward proposals for consultation this autumn, with a White Paper setting out conclusions by spring 2011.This will provide clarity to developers who will be seeking to make investment decisions in the period after 2011.

A Initial findings from the 2050 roadmap analysis

Purpose of the 2050 work

Building on the work carried out as part of the Low Carbon Transition Plan, the Government is developing an analytical model that explores different approaches to decarbonisation as part of the transition to a low-carbon economy by 2050. This analysis aims to identify the decisions necessary to ensure that UK greenhouse gas emissions are cut by at least 80 per cent[1], energy security is maintained, and the UK is able to take up the economic opportunities presented by global decarbonisation.

To tackle dangerous climate change, the Government has set legally binding targets to reduce greenhouse gas emissions by 34 per cent by 2020[2] and by at least 80 per cent by 2050. Carbon budgets have been set down in law to make sure the UK stays on track to achieve these targets, and the Government has already set out a clear path to 2020, as published in the Low Carbon Transition Plan and Renewable Energy Strategy. This work does not replace the plans already in place for this period. Instead it looks further ahead, to the period after 2022, when the shape of the emissions reduction trajectory, relative contribution of different sectors, and the potential for energy imports are more uncertain.

Given this uncertainty, this work does not aim to identify one preferred pathway to 2050; rather it develops an analytical approach which helps to identify and scope some of the key long-term, large-scale choices. Through exploring the different possible ways to achieve an 80 per cent emissions reduction, this work has drawn out the key implications and identified the trade-offs associated with different choices that will be needed to make the crucial shift to a low-carbon economy. Additional analysis will be published later this year.

[1] This is an 80 per cent reduction in greenhouse gas emissions, from 1990 levels. (1990 is the standard international baseline). Emissions cuts within the UK energy system will have to be greater than 80 per cent, owing to emissions from other sectors including agriculture and industrial processes, where equivalent cuts may be harder to achieve.

[2] The Climate Change Act 2008 requires that average annual emissions in the carbon budget period around the year 2020 (i.e. the third period, 2018-2022) are at least 34 per cent below the 1990 baseline. This is referred to as a 34 per cent reduction by 2020 for simplicity.

Box 5.A: The 2050 analytical work

Through extensive engagement with expert stakeholders from across business, academia and the third sector, the ongoing 2050 work is developing an analytical tool covering each sector of the UK economy. For each sector, the analysis develops different emissions and energy trajectories to explore different approaches to decarbonisation where the UK meets its greenhouse gas emissions targets and maintains energy security. There are inevitable uncertainties associated with looking so far ahead and the aim is not to identify a particular pathway to 2050 but to develop an analytical tool that the Government uses to develop strategy going forward. This analysis and underpinning assumptions will continue to be developed. This work will be informed by the Committee on Climate Change, which will be providing ongoing analysis and advice on the carbon budgets that need to be met on the way to 2050, as well as by energy market participants and other stakeholders.

The need for a long-term transition

In the UK, the majority of greenhouse gas emissions (85 per cent) are produced by burning fossil fuels for energy.[3] Reducing emissions will therefore require a fundamental shift in the ways in which energy is produced and consumed.

In addition, world primary energy demand is set to increase by between 17 and 30 per cent by 2030, primarily driven by rapidly developing Asian economies.[4] This will put global supply chains under increasing pressure. Developing sources of low-carbon energy will help to diversify energy supply so as to strengthen the UK's resilience to any geopolitical instability or global price volatility.

Across the world, governments and industries are looking for the technologies that can help them to reduce carbon emissions. There are valuable opportunities for UK businesses to develop and manufacture these products and associated services. Although industry is a major source of emissions, the 2050 analysis demonstrates the possibility of reconciling robust industrial output growth rates in the UK with the Government's ambition to decarbonise the economy.

A number of published estimates indicate that the overall cost of a low-carbon transition is affordable.[5] Cost-effectiveness will be a key factor in guiding choices, along with risk, acceptability, wider welfare effects, and broader environmental impacts. Further detailed analysis and understanding of these implications and trade-offs will be needed as part of this ongoing work.

Planning for a low-carbon transition

Predicting the technologies that might facilitate decarbonisation, the amount of energy the UK will need to produce, the costs involved and the availability of resources both in the UK and abroad is more challenging for more distant time periods.

Despite the difficulties in planning so far ahead, a successful low-carbon transition requires early action and strategic direction. Large building and infrastructure projects require long-term planning, new technology takes time to reach commercial deployment, and behaviours change gradually. Energy infrastructure is long-lasting. Decisions made in the next decade about the

[3] UK Greenhouse Gas Inventory (2007). The other 15 per cent of emissions are produced by agriculture, waste, and industrial processes.
[4] IEA (2009),World Energy Outlook, 2007-2030 growth rates, as set out in "450 Policy" and "Reference" scenarios.
[5] The modelling summarised in the Low Carbon Transition Plan Analytical Annex indicated a possible cost of 0.85 per cent of the UK's GDP in 2050 (compared to baseline) for pathways consistent with an 80 per cent greenhouse gas reduction by 2050. Analytical Annex, The UK Low Carbon Transition Plan, Chapter 7, http://www.decc.gov.uk

replacement of energy infrastructure will have consequences for the next thirty or forty years or more. Analysing today the scale of the challenge will facilitate greater understanding of the possible options and key decisions ahead.

The underpinning analysis covers all sectors that contribute to the UK's greenhouse gas emissions. It takes into account emissions from the supply and use of energy, as well as emissions from agriculture, waste, industrial processes, carbon capture technologies, land-use, land-use change and forestry. All of these sectors can make contributions towards achieving the UK's goals. However, sectors are affected by different drivers and constraints. These include factors such as economic growth, population growth, technical potential, roll-out rates, general acceptability, land availability both in the UK and globally, and ecological sensitivity. The 2050 analysis takes into account the possible constraints in each sector.[6] The analysis confirms that achieving an 80 per cent emissions reduction target while ensuring that energy supply is secure will be challenging but achievable.

Key implications

From the analytical work undertaken so far, these key points emerge.

Ambitious energy demand reduction is needed. Based on the analysis to date, total UK energy demand in 2050 will need to fall significantly (potentially as much as 25 per cent lower relative to 2007 levels). The greater the constraints on supplies of low-carbon energy, the greater ambition on demand reduction through energy saving and efficiency will need to be.

A substantial level of electrification of heating and surface transport is needed. Low-carbon electricity will provide a very large proportion of the UK's future low-carbon energy. It can be used for a wide range of activities, often with high efficiency compared to other fuels, and can, to a large extent, be scaled up to meet demand. It therefore makes sense to switch to electricity where this is practical, despite the major technological and engineering challenges involved. However, other technologies are also likely to be required. For example, in heating, the use of waste heat from power stations, solar thermal technologies and energy from waste may be important and could reduce the burden on the electricity system. In road transport, biofuels and fuel cells may also be long-term contributors, particularly for modes that are hard to electrify. Even so, a significant degree of electrification appears to be necessary.

Electricity supply needs to be decarbonised, and may need to double. The use of electricity for significant parts of industry, heating and transport means that demand for electricity is likely to rise, even as overall energy use declines. The implications of this include:

- the need for substantial, sustained investment in low-carbon electricity generation technologies so that the sector is largely decarbonised during the 2030s;
- the transmission grid would need to become bigger and more sophisticated. It will draw in electricity from a wider range of providers, including offshore wind turbines;
- a growing level of variable renewable generation, in particular wind, will place greater emphasis on the need for supply and demand flexibility, and for storage. The level of need and balance of solutions will be influenced by market arrangements, incentives and technological development, and could include:

[6] In addition to other assumptions, this analysis has taken into account expected growth rates in population, GDP, households and non-domestic buildings.

- higher levels of interconnection with neighbouring countries to allow fluctuations in demand and supply to be smoothed across a number of countries;
- new storage technologies, such as large-scale batteries;
- smart or flexible demand, such as off-peak charging of electric vehicles.

- the distribution network would need to become bigger and smarter to enable a potential doubling of overall electricity demand and to cope with new sources of energy supply and demand.

Sustainable bioenergy is an important, but finite, part of a low-carbon energy system. There are energy demands – such as some industrial heating processes, and the majority of road freight and aviation – where electrification is not likely to be practical. However, it is not feasible to continue just using fossil fuels in all of these sectors and achieve an 80 per cent emissions cut. In these sectors sustainable bioenergy (the use of plant or animal materials of recent origin for combustion (for heat and/or power) or conversion into biofuels/liquids or a renewable gas) currently offers the most plausible option for reducing emissions, although in the longer term hydrogen may also be a valuable low-carbon fuel. Working towards establishing sustainable bioenergy supply chains will be an important activity in the coming years.

Reduction in emissions from agriculture, waste, industrial processes and international transport will be necessary by 2050. In addition to emissions from the energy sector, greenhouse gases are emitted by livestock, waste, soils and industrial processes. If no action were taken to reduce emissions from agriculture, waste, and industrial processes, as well as those from international aviation and shipping, these sectors alone would exceed the maximum level of emissions allowable for the whole economy under an 80 per cent cut.[7] These sectors produce some of the hardest emissions to tackle, so it will be important to understand better the scope for change in these sectors, and plan for solutions for the long term.

Uncertainties and trade-offs

As well as a set of key implications, the interim analysis also identifies some areas of uncertainty, where it is not yet clear what developments will take place, or what the optimal choice would be. These uncertainties include:

The shape of future energy infrastructures. In order to facilitate a low-carbon future there will be important decisions to make in the coming years on creating, extending or upgrading the electricity networks, electricity interconnectors, transport infrastructures, the gas grid, oil and petroleum infrastructures, carbon capture and storage (CCS) pipelines, bioenergy infrastructure and heating infrastructures. In particular:

- upgrades in electricity transmission and distribution networks need to plan to allow for growth in electricity demand. The exact specification required will depend on the scale and nature of demand increases; and
- the long-term role of the gas distribution network under different future scenarios needs to be better understood.

The precise 2050 electricity generation mix. A range of electricity-generating technologies could contribute to the 2050 supply mix. The highest potential contributions come from wind, nuclear and fossil fuel with CCS. Smaller, but potentially important, contributions could be made from

[7] Emissions from international aviation and shipping are not currently included in the 80 per cent target.

other renewable sources. The relative roles of centralised and distributed generation are uncertain.

Availability of sustainable bioenergy. Some bioenergy will be important to achieving the UK's emissions target, but the extent of sustainable bioenergy resources, and the potential for their expansion, are uncertain. There is likely to be competition for bioenergy resources globally and from a number of sectors.[8] The utilisation of both domestically produced and imported bioenergy will require careful monitoring of the associated emissions arising from its cultivation and transportation, and the impacts of direct and indirect land use change, the potential air quality and health impacts of production processes and usage, the effects on local livelihoods and natural ecosystems of large-scale bioenergy cultivation, and impacts on global food prices. Given the current uncertainty associated with future levels of sustainable bioenergy, it is not yet clear how constrained bioenergy resources should be used most effectively and efficiently within the UK energy system. Also, when considering infrastructure that would use sustainable bioenergy, the UK should continue to assess the risk of locking-in a less than optimal use of limited bioenergy resources. Further cross-departmental work is necessary in this area.

International dynamics. The direction that other nations take will affect fuel and resource availability, supply chains for key technologies, and technological development. UK decisions need to respond to shifting global priorities and events, to be resilient to developments and to maximise UK business opportunities. In three fuel sectors international developments are likely to be particularly influential:

- oil: the use of oil will decline substantially in the UK energy mix by 2050, but it is likely to remain an important fuel for some sectors, and as an important feedstock for manufacturing. Given expected declines in UK oil production, the price and availability of the UK's oil will be determined largely by developments in the international oil market. Globally, oil demand is likely to increase significantly at least to 2030 and, given finite oil supplies, this could result in significant price effects;
- gas: this will remain an important fuel for many years to come, but the scale of its long-term role will be influenced by developments such as the viability of CCS at scale. Global reserves of gas are significant, but price and availability will be influenced by a range of factors such as investment in production and pipeline infrastructure, international trading arrangements, and geopolitical developments; and
- sustainable bioenergy: availability and carbon savings potential will depend increasingly on technological and supply chain development, and global sustainability criteria, as well as demand from other countries.

To ensure the security of its energy imports, the UK will need to build on its existing range of policies to promote efficient and transparent international energy markets, production and supply of essential fossil fuels, investment in low-carbon technologies, and increased energy efficiency. The UK will also need to continue working with its partners in Europe to ensure that further progress is made on the functioning and integration of EU energy markets, the diversity of the routes and sources of the EU's energy supplies, and the move to a low-carbon economy.

Technological uncertainties. Technological developments in a range of sectors will be necessary to meet our long-term targets. Many low carbon technologies, such as CCS, have been developed but not yet been demonstrated or deployed at a commercial-scale. Other technologies, such as various uses of hydrogen, or advanced biofuels, require further

[8] There may also be competing demands for bioenergy resources for non-energy uses such as construction and chemical feedstocks.

development. In addition, unforeseeable disruptive technologies may emerge. This emphasises the importance of continuing this analytical work on an ongoing basis.

Next steps

The initial findings of this analytical work have significant implications for the development of future strategy. As part of this ongoing work, the Government will continue to assess the full range of evidence and analysis about the UK's emissions and energy needs, as this becomes available, to inform the steps along the long-term low-carbon transition. Further work will be informed by the Committee on Climate Change, which will provide ongoing analysis and advice on the appropriate carbon budgets that will need to be met on the way to 2050, as well as energy market participants and other stakeholders, both in the UK and internationally. Additional analysis will be published later this year.

This analysis supports the Government's conclusion that the investment needs associated with decarbonisation will provide significant challenges for the energy market framework beyond 2020.

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