Chapter 5

Overview of renewable energy scenarios and impacts

1. Scenarios for renewable energy penetration
2. Impacts of renewable energy ambition
3. Next steps in developing renewable energy options
4. Further work of the Committee

Introduction and key messages

In this chapter we do three things:

- We set out renewable energy scenarios based on the scenarios for renewable electricity, heat and transport in Chapters 1-4.
- We summarise energy bill, competitiveness, fiscal and environmental impacts, largely based on more detailed analysis from our advice on carbon budgets[1].
- We highlight next steps in addressing challenges for renewable energy investment.

The key messages in the chapter are:

- Our scenarios for 2020 result in a renewable energy share of around 15% (230 TWh) and are therefore consistent with the UK's target under the EU Renewable Energy Directive. The aim to deliver the target through around 30% (120 TWh) penetration in electricity, around 12% (70 TWh) penetration in heat, and around 8% (30 TWh) penetration in transport, is currently appropriate. However, a flexible approach should be adopted with scope for rebalancing as uncertainties over costs and deliverability of various options are resolved.
- Under the current financing approach, delivering a 15% renewable energy share is likely to increase household energy bills by around 4% in 2020 against what they would have been without renewables ambition. There is scope to more than offset these potential energy bill impacts through energy efficiency improvement.
- Our scenarios for 2030 imply a renewable energy share of up to 45%.
- Tailoring ambition in the 2020s to the cost of renewable technologies would mitigate energy bill impacts through the 2020s.
- Next steps in introducing incentives to support required investment in renewable energy include:
  - **Electricity generation.** Include provisions for technology support in new electricity market arrangements; establish a Green Investment Bank with the flexibility to provide the full range of financial instruments; implement a planning approach consistent with national priorities to build a low-carbon economy and deliver carbon budgets.
  - **Heat.** Confirm RHI tariffs for the residential sector as soon as possible; provide clarity about long-term RHI financing; address non-financial barriers through accreditation of installers, integration of renewable heat and energy efficiency policies (i.e. the RHI and the Green Deal).
  - **Transport.** Introduce safeguards to ensure biofuels deployment is consistent with sustainability objectives; further develop the evidence base on availability and best use of sustainable biofuels; provide support for electric vehicle market development.

[1] CCC (2008) *Building a low-carbon economy - the UK's contribution to tackling climate change;* CCC (2010) *The Fourth Carbon Budget - Reducing emissions through the 2020s.*

1. Scenarios for renewable energy penetration

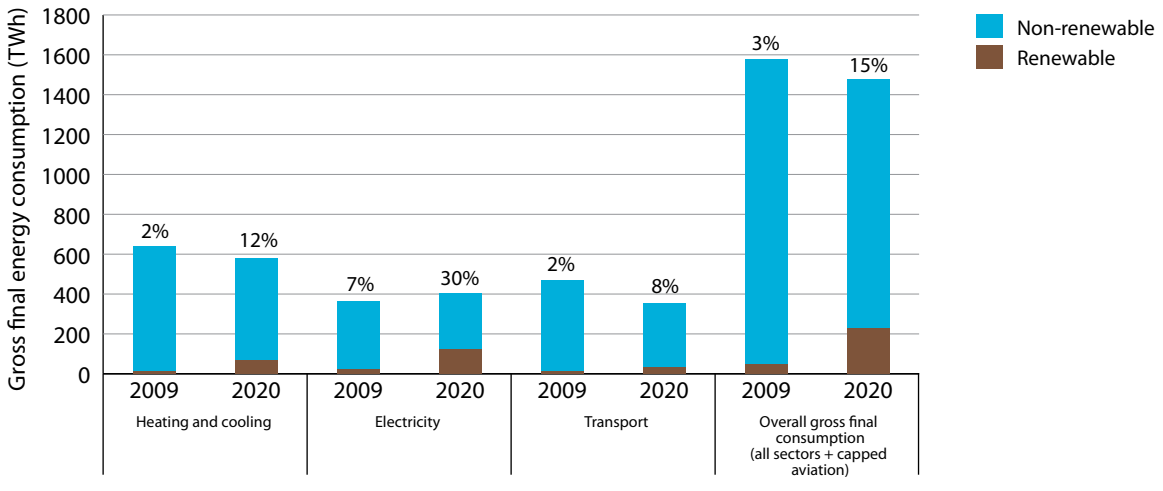
i) Renewable energy penetration in 2020

Our renewable energy scenario to 2020 incorporates the various sectoral scenarios in Chapters 2-4 and reaches penetration of around 15% (230 TWh) by 2020. This is in line with the UK's target under the EU Renewable Energy Directive and current Government plans (Figure 5.1):

- **Renewable electricity.** We assume a renewable electricity share of around 30% (120 TWh) in total electricity consumption in 2020, based on investment predominantly in wind generation, and demand reductions due to energy efficiency improvements in lighting and appliances.
- **Renewable heat.** We assume penetration of around 12% (70 TWh) in 2020 through a range of technologies including electric heat pumps, biogas and biomass, alongside demand reductions due to energy efficiency improvement through buildings fabric measures and boiler replacement.
- **Biofuels.** We assume 8% (30 TWh) penetration, by energy, of sustainable biofuels in 2020 in line with recommendations of the Gallagher Review[2], together with assumptions that demand for travel will increase in the period to 2020, and fuel efficiency of new vehicles will improve from current levels of around 150 gCO_2/km to 95 gCO_2/km in 2020.

Whilst this balance is appropriate now as a planning assumption, we have stressed the need for monitoring and flexibility in the balance of effort between technologies and sectors (e.g. possibly substituting offshore wind effort for onshore wind or renewable heat depending on feasibility and relative cost, or purchasing renewable credits in the European market).

Figure 5.1: Share of renewable energy by sector (2009 and 2020)



Source: DECC (2010) *DUKES;* CCC calculations.

Notes: Overall gross final consumption is calculated on the basis as set out in the EU Directive. Energy consumption shown in the heating sector is taken from the CCC heat model and is calculated on a slightly different basis. Demand assumptions are taken from our fourth budget analysis, based on CCC's bottom-up modelling and energy projections from the DECC energy model using central assumptions for population growth from ONS and GDP growth from the Office of Budget Responsibility.

[2] Renewable Fuels Agency (2008) *The Gallagher Review of the indirect effects of biofuels production.*

ii) Renewable energy scenarios to 2030 and 2050

Scenarios to 2030

Our scenarios to 2030 include renewable energy penetration of up to 45% (680 TWh), reflecting an underlying range for renewable electricity penetration and potentially high levels of renewable energy penetration in transport and heat (Figure 5.2):

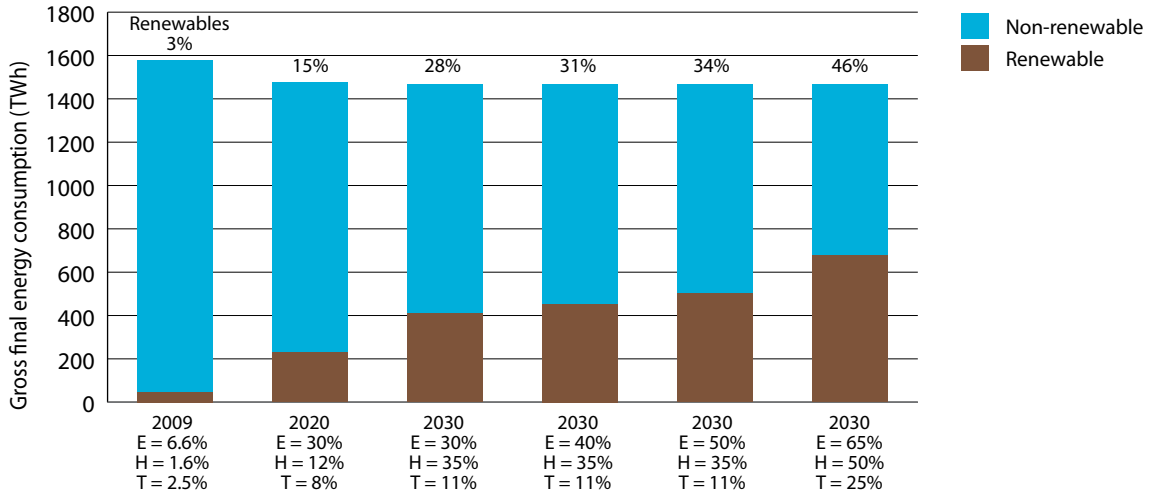
- **Renewable electricity.** Our renewable electricity scenarios range from limited investment beyond 2020, to very high levels of investment depending on relative costs and feasibility constraints for other low-carbon technologies. The range for the share of renewable electricity in 2030 in our scenarios is up to 65% (300 TWh), with 40% (185 TWh) in a central scenario.
- **Renewable heat.** Our renewable heat scenarios are based on significant penetration of heat pumps in residential and non-residential buildings, and the use of bioenergy primarily in industry, with some applications in buildings. Renewable heat shares relative to heat demand are estimated based on an assumption that there is ongoing energy efficiency improvement (e.g. through solid wall insulation in the residential sector). The resulting share of renewable heat in our scenarios in 2030 is up to 50% (280 TWh), with a central scenario of around 35% (210 TWh).
- **Renewable transport.** Our renewable transport scenarios are based on continued penetration at volumes recommended in the Gallagher Review, with a high scenario including a penetration based on the IEA's BLUE Map scenario. In estimating renewable transport shares in total transport energy consumed, we factor in ongoing growth in demand for travel through the 2020s, and ongoing fuel efficiency improvements. The resulting share of renewable energy in transport in 2030 in our central scenario is around 11% (by energy), and in our highest scenario is around 25%.
- **Renewable energy scenarios.** The sum across sectors weighting for energy consumption in 2030 is around 30% (460 TWh) in our central scenario[3]. Higher levels of ambition (e.g. up to 45%, 680 TWh) are technically feasible and might be economically desirable, depending on the evolution of relative costs and the development of supply chains.

The precise level of appropriate ambition will become clear over time. We recommend that the Government keeps ambition for renewable energy under review and revisits this as uncertainties over the economics of different low-carbon technologies are reduced (e.g. in 2017/18 when the first new nuclear plant and CCS demonstration plant are due).

The costs associated with delivering our scenarios are of the order of under 1% of GDP in 2030 compared to a scenario where there are no carbon constraints.

[3] When summing across sectors we also add in renewables in electricity generator own use and biofuels in aviation, and we convert renewable heat to an input basis in line with accounting in the EU Directive. The total is therefore higher than the sum of the individual sectors.

Figure 5.2: Renewable energy and overall gross final consumption in 2009, 2020 and illustrative scenarios for 2030



Source: *DUKES* (2010); CCC calculations.

Note(s): E = Electricity; H = Heat; T = Transport. Overall gross final consumption is calculated on the basis as set out in the EU Directive. Demand assumptions are taken from our fourth budget analysis, based on CCC's bottom-up modelling and energy projections from the DECC energy model using central assumptions for population growth from ONS and GDP growth from the Office of Budget Responsibility.

The path from 2030 to 2050

Beyond 2030 there will be a need for ongoing decarbonisation, with the appropriate contribution from renewable energy currently highly uncertain:

- **Renewable electricity.** Between 2030 and 2050, additional low-carbon capacity will need to be added to the system. This will support the further electrification of the transport and heat sectors, given the increased take-up of electric vehicles and heat pumps (potentially supplemented with hydrogen vehicles and resistive electric heat). Renewables are likely to continue to play a significant part, with the potential to provide the majority of generation, depending on achieved cost reductions and availability of alternatives.
- **Renewable heat.** The path from 2030 to 2050 requires substantial further decarbonisation of heat after 2030, including the further roll-out of heat pumps to suitable residential and non-residential buildings and the use of bioenergy, particularly in the industry sector (possibly combined with CCS). Where limits to heat pumps and bioenergy apply, there is likely to be a role for district heating and/or resistive electric heating, both of which have the potential to be renewable.
- **Renewable transport.** From a situation in 2030 in which the majority of new cars are electric (including plug-in hybrids and hydrogen vehicles), this will need to reach nearly 100% by around 2035 in order for the fleet to turn over fully to electric by 2050. If expected limits on the availability of biofuels do not transpire, then there could be a substantial role for biofuels in 2050 (e.g. a large proportion of cars could be plug-in hybrids). If not, surface transport fuel would be renewable to the extent that the sources of low-carbon electricity and hydrogen production are renewable.

2. Impacts of renewable energy ambition

Impact on energy bills to 2020

Under the current financing approach, the cost of renewable electricity generation will be passed on to consumer bills, and the cost of renewable heat will be funded by the Exchequer (with fiscal implications discussed below).

We estimate that, under central fuel and cost assumptions, achieving the renewable power generation ambition in our 2020 scenario would increase annual energy bills for the average household by around £50-60 in real terms, or 4% (Table 5.1):

- We estimate that the costs of renewable power would add 1.7 p/kWh to the electricity price by 2020, largely due to costs associated with bringing forward investment in offshore wind, which could add around 0.8 p/kWh onto the electricity price under central cost assumptions.
- This would increase the average household electricity bill by £50-60 (10%), relative to what they would otherwise be in 2020.
- Given that electricity accounts for around 40% of household energy bills on average, this translates to a 4% increase in total household energy bills in 2020.

Table 5.1: Average annual household energy bills in 2020 and impact of renewable energy ambition

	2020 (no renewables)	2020 - including cost of renewable energy			2020 - including renewables and energy efficiency		
		Low renewables costs	Central renewables costs	High renewables costs	Low renewables costs	Central renewables costs	High renewables costs
Average unit price, electricity (p/kWh)	15.6	16.7	17.3	17.8	16.7	17.3	17.8
Average household electricity bill	£520	£550	£570	£590	£470	£490	£510
Average household gas bill	£850	£850	£850	£850	£730	£730	£730
Average household energy bill	£1,360	£1,400	£1,420	£1,430	£1,200	£1,220	£1,230

Source: *DECC Quarterly energy prices*; CCC calculations.

Note(s): 2010 prices. Numbers may not sum due to rounding. Range for cost of renewable energy under low, central and high generation cost estimates (see Chapter 1), includes additional system costs due to intermittent renewables e.g. back-up and interconnection, and is inclusive of VAT at 5%. Based on central gas and carbon price projections for 2020 (69 p/therm, £30/tonne).

The costs of renewable generation are additional to the costs of a rising carbon price. The Government's announced carbon price floor of £30/tCO_2 in 2020 will add around 0.6 p/kWh to the electricity price compared to today's levels, adding around £20 to the average household's annual electricity bill. Other rises in electricity bills to 2020 are attributable to expected rises in the price of gas, independent of climate change policy.

Renewable energy in transport is not expected to add to motoring costs as biofuels are expected to be a similar cost to petrol and diesel under central assumptions for the oil price. We have factored the increasing cost of electricity into our analysis of the cost-effectiveness of electric vehicles and electric heat pumps.

Scope for offsetting bill impacts through energy efficiency improvement

It is also important to consider opportunities for reducing energy bills through energy efficiency improvement:

- In the residential sector, we estimate that there is scope for a 14% reduction in heat consumption to 2020 through buildings fabric measures, boiler replacement and behavioural measures.
- Our analysis also suggests that there is scope for a 14% reduction in electricity consumption through the purchase and use of more efficient appliances.

Therefore if the full range of cost-effective measures for improving energy efficiency are implemented, the aggregate bill impacts associated with renewable energy costs can be offset (Table 5.1). This would more than compensate for impacts of renewable electricity investment, and ensure that the share of expenditure on energy relative to income remains roughly flat when allowing for upward pressure on bills from rising gas and carbon prices along with expectations of rising incomes.

There are a range of levers for addressing any ongoing fuel poverty impacts (e.g. social tariffs, income transfers).

Energy bill impacts beyond 2020

The costs associated with delivering this level of ambition are of the order of under 1% of GDP in 2030 compared to a scenario where there are no carbon constraints.

The 2030 energy bill impacts over and above those to 2020 are limited:

- **Electricity.**
  - An increasing proportion of electricity will be paid for under long-term contracts at prices below those of unabated gas with a £30/tCO_2 carbon price in 2020.
  - Whilst unabated fossil-fired generation will become more expensive with an increasing carbon price in the 2020s, this will account for a declining share of total generation (e.g. providing less than 10% of generation in 2030).
  - Whilst there will be some ongoing investment in more expensive offshore wind and marine, this will be limited unless there have been significant cost reductions.
- **Heat.** During the 2020s there is scope for some renewable heat technologies to become cost-competitive and possibly lower cost than conventional heating technologies.

The story in the 2020s is therefore likely to be one of more modest price rises than during the 2010s, and with average energy bills falling relative to income, assuming incomes continue to grow.

Competitiveness impacts

Higher electricity prices could lead to impacts on competitiveness of a small number of energy-intensive UK industries which compete in global markets (e.g. iron and steel, aluminium).

Options for addressing these impacts could include increasing the rebate on the Climate Change Levy, rebating tax as allowed under the European Union Emissions Trading System (EU ETS) Directive, and possibly exempting energy-intensive industries from that part of the electricity price which relates to renewables support (e.g. as in some EU countries).

More generally, competitiveness impacts from renewable energy ambition are likely to be limited to 2020:

- Competitiveness risks are most pronounced as regards possible leakage to other EU countries. These risks are mitigated given ambitious EU-wide renewable energy targets under the Renewable Energy Directive.
- Risks are also mitigated through limited energy bill impacts under the current policy approach to financing of renewable heat investment.

Any increase in UK energy prices through the 2020s due to investment in renewable energy should ideally occur in the context of an EU-wide approach.

To the extent that there are competitiveness risks for this period – inside or outside the EU – there is a range of potential mitigating measures (e.g. as above, plus sectoral agreements, border tariff adjustments).

More generally, developing a full range of renewable and low-carbon options for required economy-wide decarbonisation in the 2020s, and deployment at this time according to least-cost principles, could give the UK a competitive advantage in a carbon-constrained world.

Fiscal impacts

The main fiscal impacts of meeting the renewable energy target are through proposed financing of investment in renewable heat by the Exchequer, rather than via energy bills. It is estimated that this cost will rise from around £100 million in 2011/12 to around £2 billion in 2020, reflecting the additional cost of renewable heat technologies at a penetration of around 12% compared to conventional alternatives.

Environmental impacts

Our scenarios reflect consideration of environmental impacts including impacts on nature, ecosystems and biodiversity, and air quality impacts:

- **Nature.** Our assessments of resource potential for renewable power generation exclude resource where this could impact adversely on national parks, areas of outstanding beauty and nature reserves. Particular concerns relating to a Severn barrage are addressed in Box 1.13.
- **Biodiversity and ecosystems.** Our cautious approach to use of bioenergy reflects a range of considerations including potential impacts on ecosystems and biodiversity associated with changing land use to grow bioenergy feedstocks.
- **Air quality impacts.**
  - Although there is potential for adverse air quality impacts due to burning of biomass in densely populated areas, our scenarios envisage this will primarily be used in industry, away from urban centres.
  - The move away from fossil fuel burning in the transport sector in our scenarios would have positive air quality impacts, given that road transport is currently a key source of air pollution in the UK.

3. Next steps in developing renewable energy options

In our assessment of renewable electricity and heat we have identified key actions to develop options for deployment required to meet carbon budgets in the 2020s, and in the case of renewable transport we have identified the need to improve the evidence base on sustainable biofuels:

- **Renewable electricity.** Key determinants of the investment climate for renewable electricity include Electricity Market Reform, the ROC banding review, mechanisms to increase the availability of finance, the transmission investment regime, and the planning framework:
  - New electricity market arrangements should provide ongoing support for immature renewable generation technologies where UK deployment will be important in driving cost reductions. For example, within the Government's proposed Contracts for Differences for low-carbon generation, a proportion of these could be targeted at supporting less mature renewable technologies. Within this support, the 2020 ambition for offshore wind (12 GW) should not be increased, and could be reduced if other means can be found to meet the EU renewable energy target.
  - Existing arrangements need to be effectively grandfathered and available until new arrangements are clear. This could require extending the RO beyond the date proposed in the Electricity Market Reform consultation.
  - The Green Investment Bank could address potential finance bottlenecks that may otherwise work against delivery of offshore wind ambition through providing a full range of products (i.e. equity, debt and insurance), particularly if is allowed to borrow money from its inception.
  - Approval by Ofgem is required for investments in transmission to ease bottlenecks and support investment in renewable electricity (e.g. onshore and offshore wind).
  - Planning approaches should facilitate investments in transmission that are required to support investments in renewable and other low-carbon generation. In addition, a planning approach which facilitates significant onshore wind investment would reduce the costs of meeting the 2020 renewable energy target, and of achieving power sector decarbonisation through the 2020s.

- **Renewable heat.** Key determinants of the investment climate for renewable heat include detailed design of the Renewable Heat Incentive (RHI).
  - Early clarification is needed about RHI tariffs for the domestic sector to ensure they become available in 2012.
  - Accreditation and possible training of renewable heat installers will be important in easing supply chain constraints and increasing consumer confidence.
  - The RHI and the Green Deal should be integrated. This would provide a number of benefits, including increasing the number of houses suitable for renewable heat technologies, improving confidence and reducing hassle costs, and offering a source of finance for up-front investment costs.
  - Close monitoring of renewable heat deployment will be required, with flexibility to change the financing for specific technologies and review the overall ambition.
  - A decision on financing the RHI after 2014/15 will be required in light of further evidence on fiscal constraints, impacts on consumer bills and potential leakage of energy-intensive industry.
- **Renewable transport.** The key issue here is the level of sustainable biofuels likely to be available given land constraints and alternative uses of bioenergy. These aspects are highly uncertain and further evidence is required. A prudent approach to use of biofuels in surface transport is currently appropriate.

4. Further work of the Committee

There are two key areas where the Committee will provide further evidence and analysis relevant in the context of renewable energy strategy:

- **Bioenergy review.** This will be published before the end of 2011 and consider two key questions:
  - How much sustainable bioenergy is there likely to be available?
  - In which sectors should this best be used given alternatives for decarbonisation (e.g. biofuels in surface transport or aviation, biogas and biomass in heat for buildings and industry, biomass power generation with carbon capture and storage)?
- **Progress reports to Parliament.** We will continue to monitor progress on increasing the level of renewable energy penetration as part of our broader reports to Parliament on progress reducing emissions and meeting carbon budgets. Our next report to Parliament will be published in June 2011.