CHAPTER 3 TECHNICAL APPENDIX

The Committee on Climate Change reference emissions projections

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TECHNICAL APPENDIX

The Committee on Climate Change (CCC) have developed, in collaboration with the Department of Energy and Climate Change (DECC) a set of 'reference' projections of energy demand and CO_2 emissions. The projections represent scenarios against which we would need to improve our emissions performance to meet carbon budgets. The difference between reference emissions and our proposed carbon budgets determines the scale of the challenge we face.

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EXECUTIVE SUMMARY

The Committee on Climate Change (CCC) have developed, in collaboration with the Department of Energy and Climate Change (DECC) a set of 'reference' projections of energy demand and CO_2 emissions. They project what emissions would be in a world without new policies. The difference between reference emissions and a given carbon budget indicate the scale of the challenge we face.

Energy and CO_2 emissions projections are subject to considerable uncertainty. Reflecting this, CCC conducted five reference projections varying expected fuel prices, economic/population growth and existing policy impacts. These reference projections are all on the basis of policies in place up to, but not including, the 2007 Energy White Paper (EWP), and exclude the impacts EU Emissions Trading Scheme (EU ETS). A further scenario includes the impact of the EU ETS and assumed increased roll-out of renewables in the electricity generation sector.

Before running the model, CCC and DECC commissioned Oxford Economics to undertake a detailed review of the DECC Energy and Emissions Model, including full documentation of how energy demand is determined by sector and the structure of the behavioural equations within the model.

Emissions are expected to fall or remain at most equal to current emissions, even in the most pessimistic reference projection. The central projection for the middle of the third budget period (2020) is 533MtCO_2, +14MtCO_2 in the 'worst case' projection and -18MtCO_2 in the optimistic (high-high prices) projection. This represents a 10% reduction on 1990 levels in the central projection, or between 8-13% reduction across scenarios (a 1-7% increase on current emissions).

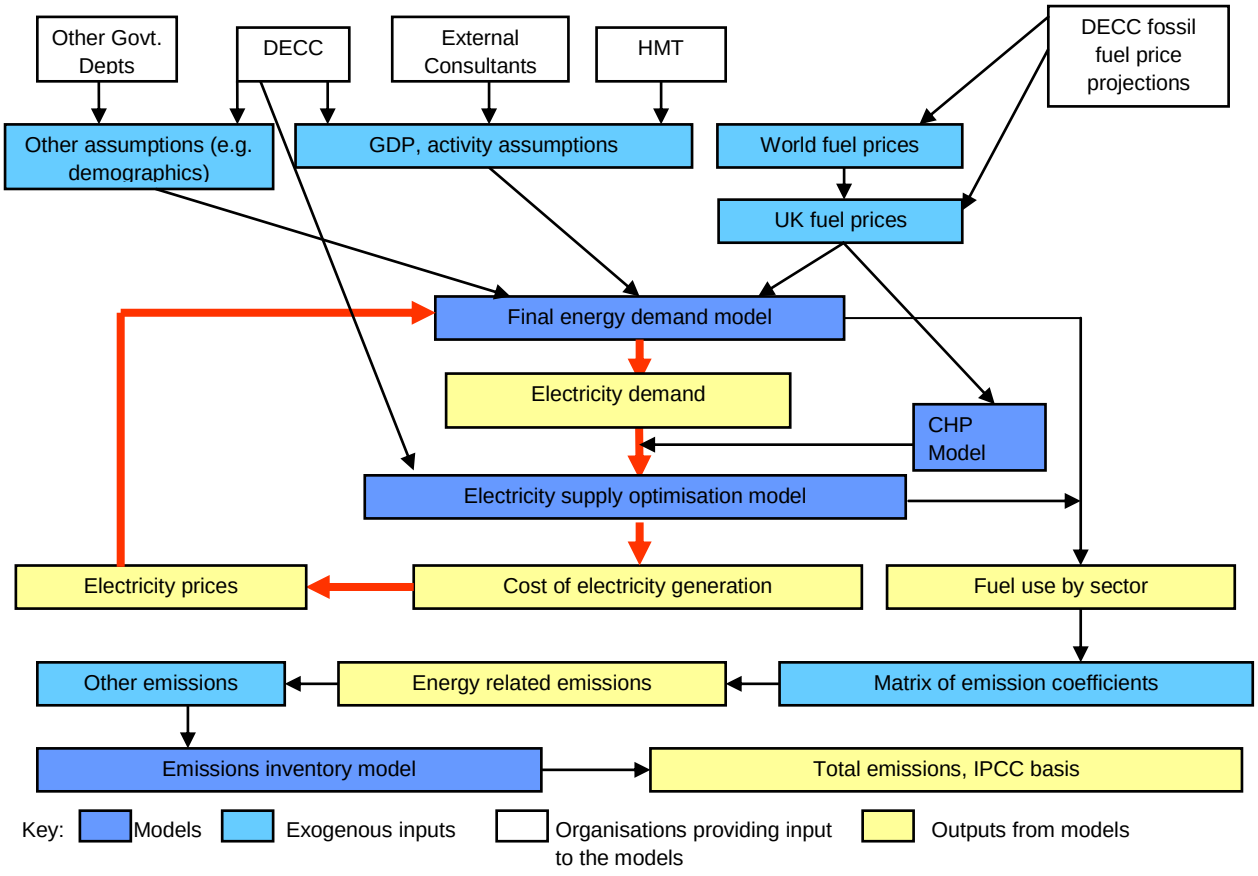
- Power sector emissions are expected to be at most flat despite increasing demand from end-use sectors, with the continued expansion of gas, limited new coal build and moderate growth in renewables.
- In the residential sector, pre-EWP government policy helps to deliver a reduction in overall energy consumption, reducing direct emissions by around 20% on current levels.
- Following a decline from 1996 to 2006, direct emissions in industrial and service sectors are expected to remain flat across the projection period.
- Emissions from road transport are relatively sensitive to fuel prices, with emissions falling by up to 5% on current levels under high fuel prices or increasing by 2% under low fuel prices. Domestic civil aviation emissions are expected to continue to increase but will remain a very small proportion of overall CO_2 emissions (less than 1%).

It is important to note that these are not the Government's projections, the latest of which are available and published on the DECC (BERR) website.[1]

MODEL OVERVIEW

The DECC Energy and Emissions Model is an econometric, partial equilibrium model of the whole UK energy market, balancing electricity supply with demand and projecting energy consumption and CO_2 emissions out to at least 2022. The model covers all CO_2 emissions as listed in the UK inventory (and defined by IPCC), these are mostly from energy use, plus those from land use[2]. Some of the key inputs include assumptions about future economic growth and fossil fuel prices. The model has been used extensively since 2000 to inform Government energy and environmental policy on, for example, the EU ETS Phase 1 and 2, the Climate Change Programme Review (2006), the Energy Review and more recently the Energy White Paper in May 2007. A schematic representation of the model is given below demonstrating how exogenous inputs are fed into various points of the model and what the main assumption groups are.

Figure 1. DECC Energy and Emissions Model simplified interaction



Source: DECC

[1] DECC (November 2008) *Updated Energy and Emissions Projections.* http://www.berr.gov.uk/files/file48514.pdf

[2] Emissions from land use are taken from the Centre for Ecology and Hydrology projections: *Inventory and projections of UK emissions by sources and removals by sinks due to land use, land use change and forestry*. Defra contract GAO1088

As part of their first Report and in line with continuous development undertaken on the DECC model, the CCC commissioned in conjunction with DECC a detailed review of the model, specifically the demand-side comprising of a number of econometric forecast equations[3]. As part of this review, Oxford Economics provide detailed documentation of the inner-workings of the model, and highlight they key strengths of the model as well as areas which may be subject to review in the context of projecting CO_2 emissions and setting CO_2 budgets. Their key conclusions on the strengths of the model are summarised below.

- The econometric foundations of the model mean that the projections are firmly based on observed past relationships between the drivers of energy demand and the resulting use of energy.
- It comprises of both supply and demand components. The electricity supply module calculates the least cost generation mix of technologies to meet a given electricity demand and allows for a detailed assessment of generation by fuel and emissions.
- Additional adjustments are made to take account of the impact of Government policies (such as those designed to encourage energy efficiency). This ensures that the projections take into account past relationships as well as allowing for the impact of future policies, often designed to modify behaviour (See Box 1.1, below).

In terms of areas for development, the equations in the transport, residential and industrial sectors were highlighted. As a result of the Oxford Economics review, DECC and the CCC commissioned further work to re-estimate energy demand forecasts in the industrial sub-sectors and the domestic sector, which are published on the CCC website[4]. CCC have also disaggregated the projections described in this paper to produce emissions projections for Wales, Scotland and Northern Ireland; these projections are presented in another technical paper accompanying CCC's first report.

The projections

Five reference projections were run to capture the range of uncertainty; Table 1 below lists the key aspects of each. There are four variants on fossil fuel prices, in addition to a 'worst – case' type scenario which combines low fossil fuel prices with high economic and population growth, as well as pessimistic assumptions on the saving of energy demand as a result of existing Government policy (see Box 1.1). Note that where this paper refers to pessimistic and optimistic assumptions it is in relation to likely impacts on emissions – so, for example, high economic growth would be a *pessimistic* scenario as it would tend to increase emissions.

[3] Oxford Economics (2008) *Review of the BERR Energy Demand Model*. Published on the CCC website www.theccc.org.uk

[4] Oxford Economics (2008) *Estimation of households demand for gas and electricity,* Oxford Economics (2008) *Re-estimation of the BERR Energy Demand Model,* www.theccc.org.uk

Table 1. CCC reference emissions projections

Name	Activity assumptions (e.g. GDP growth)	Fossil fuel prices	Policy assumptions
central	central	central	As in the baseline to 2007 Energy White Paper. No carbon price
high	central	high	as above
high-high	central	high-high	as above
low	central	low	as above
'worst case'	high	low	as above but with more pessimistic assumptions on final energy savings from policy measures

In addition to using the DECC model, the CCC also collaborated with Cambridge Econometrics (CE) to develop a benchmark set of projections, using the same key inputs. These are explored in more detail a separate technical annex and in the CE Report to the CCC.[5]

KEY INPUTS IN THE CCC DECC ENERGY AND EMISSIONS MODEL PROJECTIONS

DECC energy projections generally draw on assumptions from across Departments for the exogenous inputs. CCC have generally followed that principle in setting assumptions for these projections. The following inputs are key drivers of energy demand and are discussed in turn:

- **Demographics:** Population and households, car ownership;
- **Activity:** UK GDP, Manufacturing GVA and household disposable income;
- **Fossil fuel prices:** wholesale oil, gas and coal prices.

Demographics

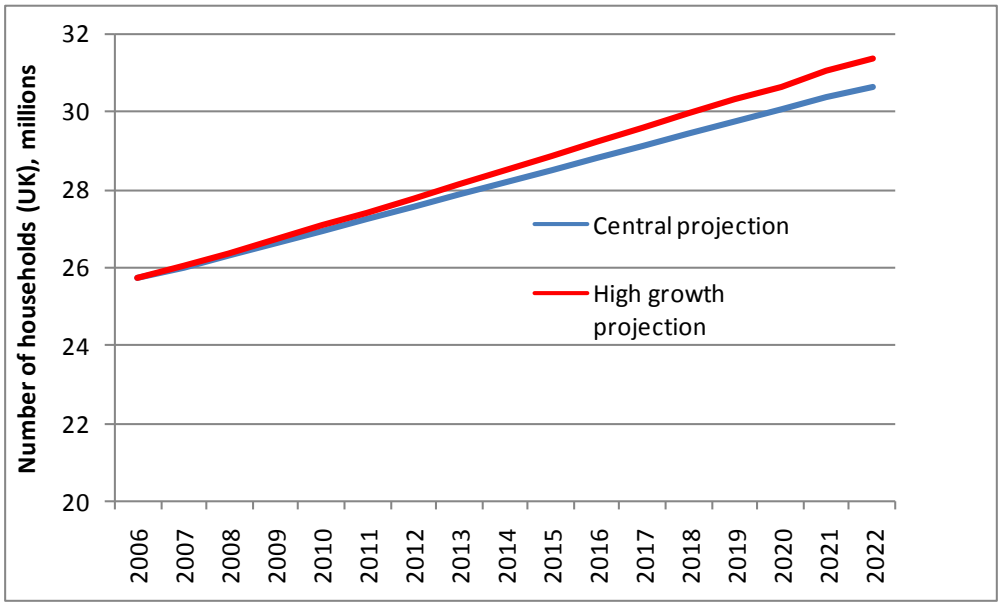
The latest ONS population projections (2006-based) were used in the forecasts of demographic growth. The 'principal' (i.e. central) projection sees UK population around 67 million (compared with around 61 million today). In the 'high' scenario we have used the 'high-combination' variant rising to around 69 million in 2020.[6]

[5] CCC, *Alternative reference projections: DECC Energy and Emissions model and Cambridge Econometrics MDM-E3* (2008); Cambridge Econometrics, *Projections of UK* CO_2 *emissions and assessment of the economic impacts of carbon budgets,* (2008), www.theccc.org.uk

[6] Variant A - combining high range assumptions on fertility, inward migration and life expectancy. The full list of scenario variants is here: http://www.gad.gov.uk/Demography_Data/Population/2006/methodology/varlist.asp

The demographic driver for energy demand in the DECC model (for the residential and road transport sectors) is the number of households (rather than population *per se*).[7] Figure 3 illustrates household growth assumptions used in the central and high growth emissions projections (consistent with the 2006-based population projections) rising to 30 and 31 million respectively by 2020 (average growth 1.0 and 1.2% per annum).

Figure 2. Projected number of households (UK) central and high growth scenarios



Source: DECC/CCC calculations[8]

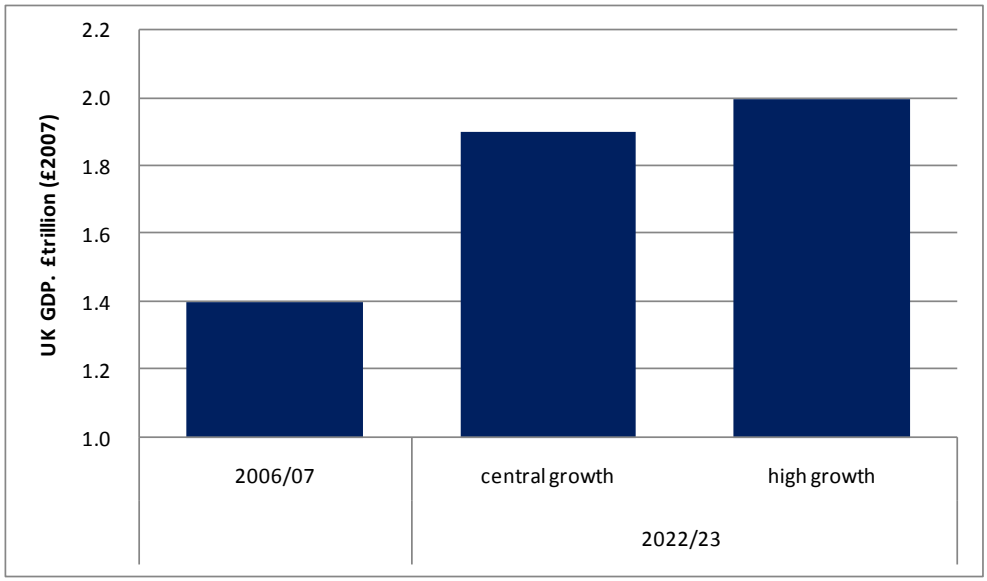
Activity

CCC/DECC liaised with the Treasury (HMT) to come up with detailed growth (GDP and Whole Economy GVA) projections for both a central and high scenario out to 2030. Out to 2012/13, GDP growth assumptions are consistent with those published in the Budget 2008. Beyond 2013, growth forecasts are taken from the HMT long-term growth model, applied to the level from the short-medium term forecast[9].

In the long term, central and high growth scenarios are determined by different assumptions on employment, population and productivity. In the 'high-growth' scenario, employment projections consistent with the 'high combination' population projection (2006-based). The productivity assumption remains 2% for both the central and high growth scenarios.[10] In the central scenario, overall GDP growth is in the order of 2-2.5% and in the high scenario is around ¼ percentage points higher – overall UK GDP in the scenarios is illustrated in Figure 3 reaching £1.9-2 trillion by 2022-23.

[7] Household growth is also used in DfT's car ownership model; the outputs of which is one of the drivers for energy demand in the DECC Road Transport fuel demand equations. The DfT model uses projections consistent with the 2004-based population projections reaching around 65m in 2020 (2m lower than 2006-based).
[8] Note these are from calculations based on latest population projections and are not official government projections, which have not yet been updated.
[9] These are reported in the Long-term Public Finance Report, published alongside Budget 2008.
[10] 2% is the average long term productivity growth rate for the UK since the 1950s.

Figure 3. UK GDP in central and high growth scenarios, 2007 and 2022-23*



Source: HMT Budget 2008, DECC/CCC calculations. Rounded to the nearest £100m.

Table 2. UK GDP and GVA Manufacturing annual growth – central and high projections

	Overall GDP		Manufacturing GVA	
	central	high	central	high
2008	2.25%	2.25%	1.00%	1.50%
2010	2.75%	3.00%	2.00%	2.25%
2015	2.25%	2.50%	1.75%	1.75%
2020	2.25%	2.25%	1.50%	1.75%

Source: HMT Budget 2008, DECC/CCC calculations. Rounded to nearest quarter percentage point.

Linked to economic growth is real household disposable income, a key driver for energy demand in both the transport and residential equations. In the short to medium term we use the range consistent with the Budget 2008; beyond that, we assume that it grows in line with real GDP. Table 3 sets our assumptions on average household disposable income.

Table 3. Average disposable income per household – central and high projections

	£ per household	
	central	high
2006	33,800	
2010	35,000	35,200
2015	37,700	38,400
2020	40,500	41,400
2022	41,600	42,500

Source: HMT Budget 2008, DECC/CCC calculations. £2007 prices rounded to nearest £100.

High and central range manufacturing GVA up to 2012-13 is consistent with the Budget 2008 forecast. Beyond 2012-13, it is assumed that the relationship between manufacturing growth

and GDP growth is consistent with the relationship that the medium term forecasts tends towards. [11]

Sub-sectoral forecasts were provided by Oxford Economics based on these growth forecasts. These are summarised in Table 4, below.

It is worth noting that the inputs to the CCC reference projections were finalised before events in the financial markets in mid-2008 which have led to significant revisions to the growth forecasts for all developed countries, including the UK. The 2008 Pre-Budget Report now forecasts the UK economy to contract by -1¾ to -¾ in 2009 (compared with 2¾ - 3% growth in our emissions projections) before returning to 2¾ to 3¾ growth by 2011. Other things being equal this will reduce energy demand and emissions relative to that presented in this paper.

Table 4. Industrial sub-sectoral growth indices in the central and high growth projections (2005 = 100)

2005=100	Manufacturing	Iron & Steel	Non-ferrous metals	Minerals	Chemicals	Engineering & Vehicles	Food, Drink and Tobacco	Textiles, Leather & Clothing	Paper, Printing & Publishing	Construction
2005	100	100	100	100	100	100	100	100	100	100
2010	107	110	106	111	111	111	103	92	101	109
2015	118	116	112	123	134	124	112	79	108	121
2020	128	120	117	134	160	135	121	68	113	129
2022	132	122	119	138	171	140	124	64	115	132
2022 - high growth scenario	135	125	122	142	175	143	127	65	118	134

Source: DECC Energy and Emissions Model, Oxford Economics

Fossil fuel prices

Future fossil fuel prices are inherently uncertain. Fuel prices are crucial drivers not only for the demand for fuel at 'end use' (e.g. gas for heating) but also in determining which fuels are most intensively used to generate electricity – the relative price of gas and coal can have a significant impact on emissions (as coal plants can emit more than double that of a gas plant, per kWh of electricity generated). To capture the range of uncertainty, in consultation with DECC the CCC used all four scenarios published by DECC: low, central, high and high-high[12].

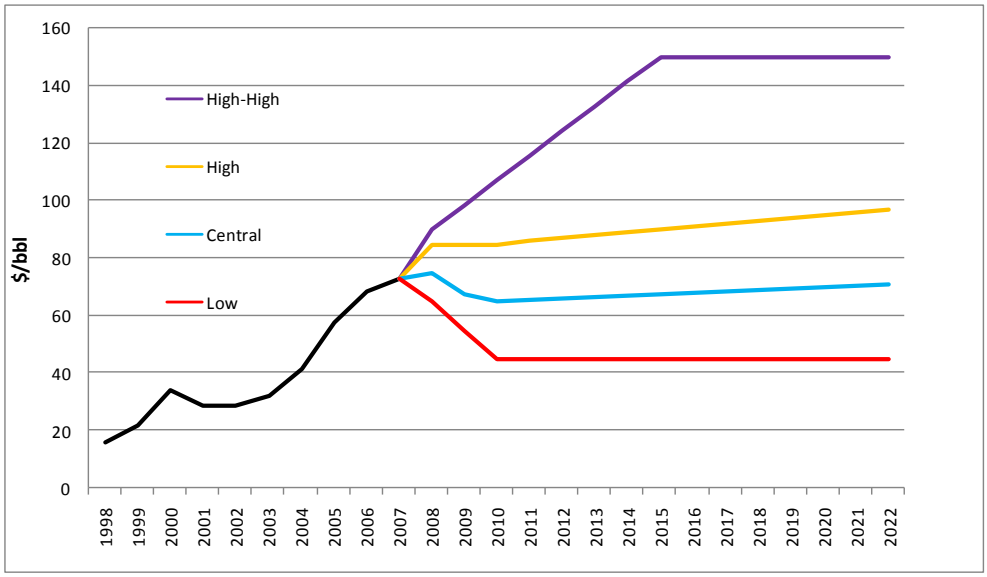
Oil prices, along with other fossil fuels, have remained volatile throughout 2008, peaking at $140 in July 2008, from around $90/bbl at the beginning of the year when the projections (illustrated in Figure 4) were compiled. Prices have since fallen (and averaged just over $70/bbl in October). In the central scenario prices remain higher than the historical average ($70/bbl in 2020) reflecting growth in global demand and tightening of supply. The high and high-high scenarios reflect strong growth in global demand, with a particular lack of spare

[11] In other words, assuming trend GDP growth of 2.75% and Manufacturing GVA growth of 2%, post GDP growth is scaled by this factor to give Manufacturing GVA.

[12] These projections were put out to consultation by DECC (then Energy group within BERR) in January 2008 and published in May: *Update to present the latest fossil fuel price assumptions following the January 2008 Call for Evidence* (BERR, 2008).

capacity driving up prices to $150/bbl by 2020 in the latter scenario (real 2007 prices). The low scenario reflects prices returning to something like the historical average (last decade) (this is generally true for other fuels, discussed below).

Figure 4. Historic and projected oil prices (annual averages), 1998-2022

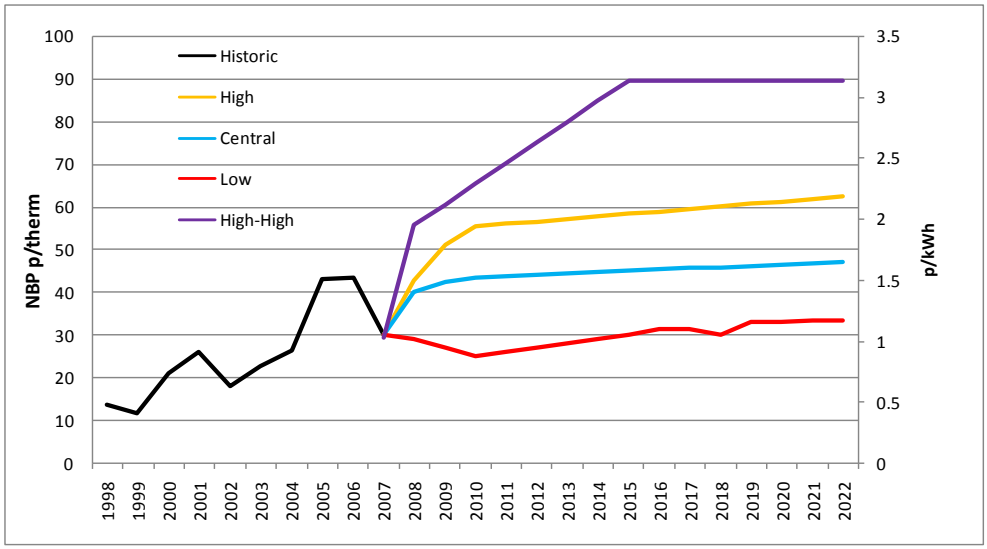


Source: US EIA, DECC (BERR). Note: Real prices (£2007), day-ahead.

Like oil, gas prices rose considerably above historical averages in 2008 and reached record highs for a summer period (around 2p/kWh compared with 0.7p/kWh the same period a year earlier). In the projections, it is assumed limited liberalisation of global gas markets mean that gas prices remain oil-linked and therefore follow the same trend.[13] Prices are seasonal, and here we present the annual average - in the central scenario, gas rises to just over 1.6p/kWh (just over 60p/therm) in 2020, and up to 3p/kWh (90p/therm) in the high-high scenario.

[13] Initially, gas was frequently co-produced with oil, and prices have historically been linked to oil and remain so. A significant liberalisation of global gas markets would help to break this link.

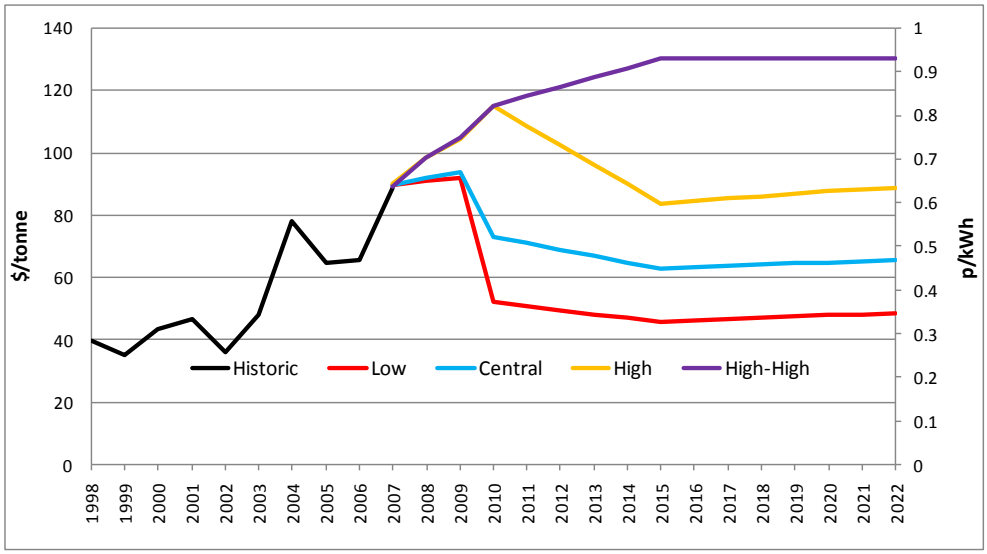
Figure 5. Historic and projected gas prices (annual averages), 1998-2022



Source: DECC (BERR) and CCC calculations. Note: Real prices (£2007), National Balancing Point (NBP) day-ahead.

Historically, month-on-month coal prices are less volatile than equivalent gas and coal prices. Freight bottlenecks and unexpected disruptions in exporting countries have forced 2008 prices to record levels in the summer (up to $200/tonne, or around 1.5p/kWh, compared with average price of $88/t in 2007). To an extent these disruptions are anticipated in the projections (with prices in all scenarios rising up to 2009) but after a short while are expected to ease in the low and central scenarios to $47-62/tonne in 2020 (around 0.3-0.5p/kWh).[14] Coupled with growing global demand, the high and high-high scenarios see further market tightening to at least 2011 and, in the high-high scenario, given corresponding high-high gas prices there is sufficient leverage for coal to remain high without losing its competitiveness (at $130/t or just under 1p/kWh).

Figure 6. Historic and projected coal prices (annual averages), 1998-2022



Source: DECC (BERR) and CCC calculations. Note: Real prices (£2007), Amsterdam – Rotterdam – Antwerp (ARA) 90-day forward price

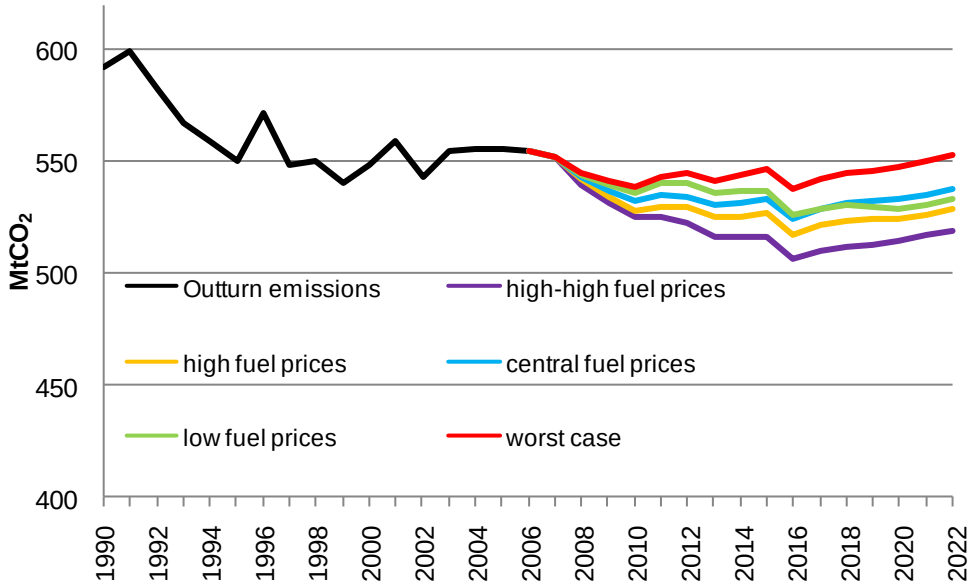
[14] Assuming calorific value of 25.12 GJ per tonne of coal and an exchange rate of $2:£1.

Given the relative price of coal and gas more gas generation and new build is expected in the low fuel price scenario (in the absence of a carbon price) where it is most competitive (with an average ratio of around 2.8 to coal, compared with over 3 in the central and high scenarios). We therefore expect to see more coal in electricity generation in the central and high cases.

HEADLINE RESULTS – CO_2 EMISSIONS

Headline results for UK domestic CO_2 emissions (in accordance with the National Atmospheric Emissions Inventory)[15] are set out in Figure 7 and Table 5 below.

Figure 7. Historic and projected UK CO_2 emissions in reference projections – Total UK



Source: National Atmospheric Emissions Inventory (NAEI) 2008, DECC Energy and Emissions Model. Note: Excludes international aviation and shipping, Overseas Territories.

[15] That is, excluding international aviation and shipping, which are reported as memo items in the Greenhouse Gas Inventory. The DECC model also excludes emissions from Overseas Territories (OTs) – (e.g. Monserrat and Cayman Islands), but includes emissions from Crown Dependencies (Isle of Man, Gibraltar). Emissions from OTs in 2006 were 1.3 $MtCO_2$ (0.2% of total emissions).

Table 5. Historic and projected UK CO_2 emissions, reference projections

	1990	2006	2010	2015	2020	2020 change on 1990	2020 change on 2006
central fuel prices	592	555	532	533	533	-10%	-4%
high fuel prices	592	555	528	526	524	-11%	-5%
high-high fuel prices	592	555	525	517	515	-13%	-7%
low fuel prices	592	555	536	537	529	-11%	-5%
worst case	592	555	538	547	547	-8%	-1%

Source: National Atmospheric Emissions Inventory (NAEI) 2008, DECC Energy and Emissions Model. Note: Excludes international aviation and shipping, Overseas Territories.

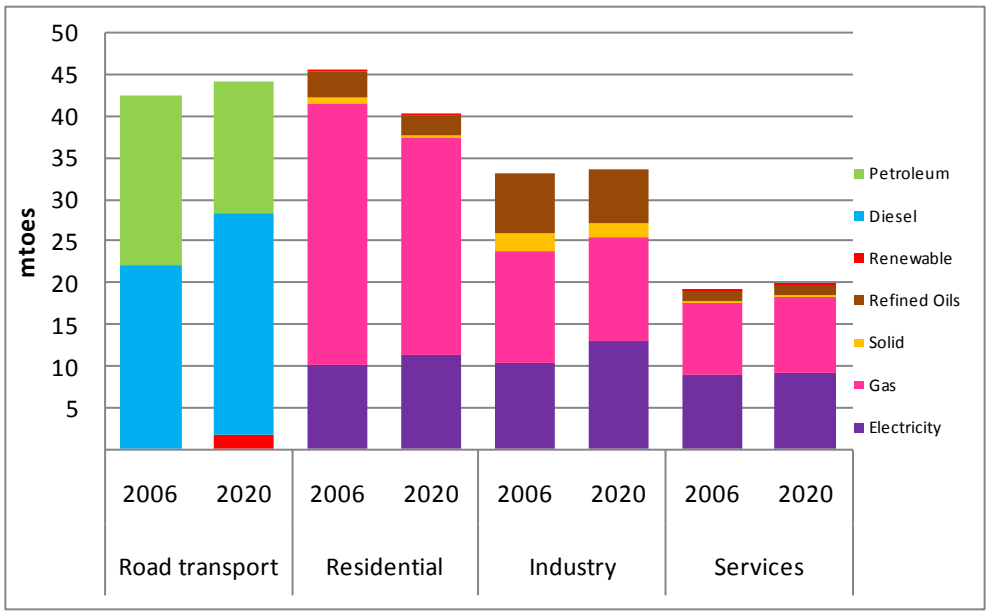
- In 2006 (the latest year for which verified detailed data is available) emissions stood at 555MtCO_2 or just over 6% lower than 1990 levels. The fall in emissions since 1990 has been primarily due to the switch from coal to gas fired generation in the power sector;

- However, since 2000 these gains have slightly reversed (see Figure 11, below); and overall emissions have remained broadly constant since 2002 (with the increase in power emissions offset by reductions in direct emissions from industrial sectors).

- Emissions growth is benign even in the most pessimistic of cases. Energy demand is sufficiently curtailed under high-high fuel prices to keep emissions falling to 2016. Thereafter we see some moderate growth, primarily driven by new conventional coal build in the power sector in the absence of a carbon price.

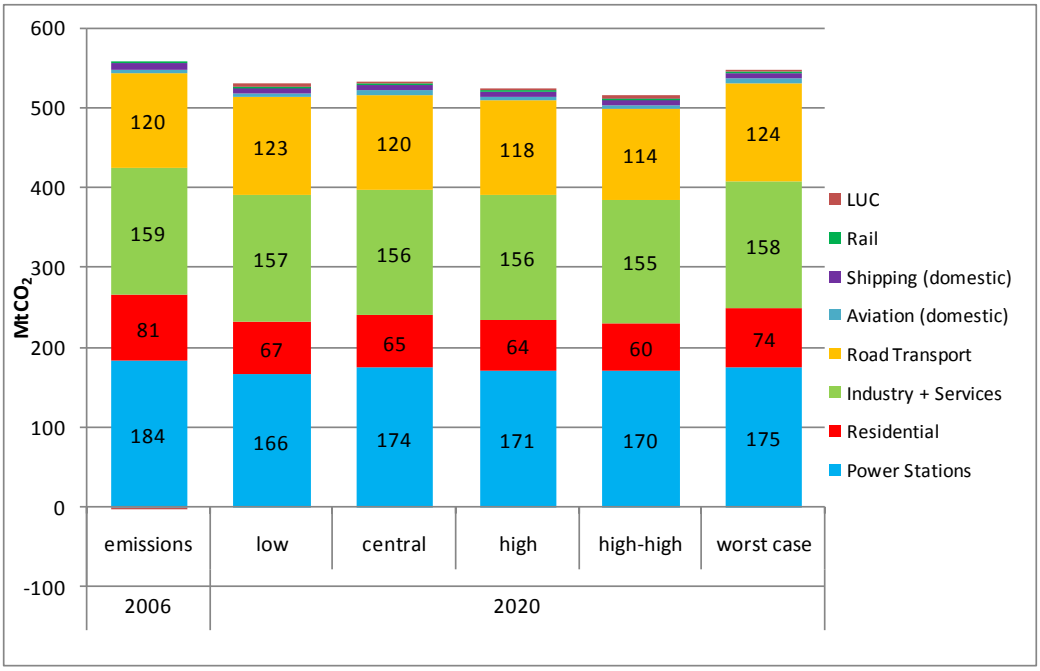
- The central projection for the middle of the third budget period (2020) is 533MtCO_2, +14MtCO_2 in the worst case scenario and -18MtCO_2 in the optimistic (high-high prices) scenario.

Figure 8. Final energy demand by major end-use sector, 2006 and 2020 – reference projection (central fuel prices)



Source: DUKES 2008, DECC Energy and Emissions Model based on CCC assumptions

Figure 9. Emissions by DECC source sector in 2006 and projected in 2020 – reference projection (central fuel prices)



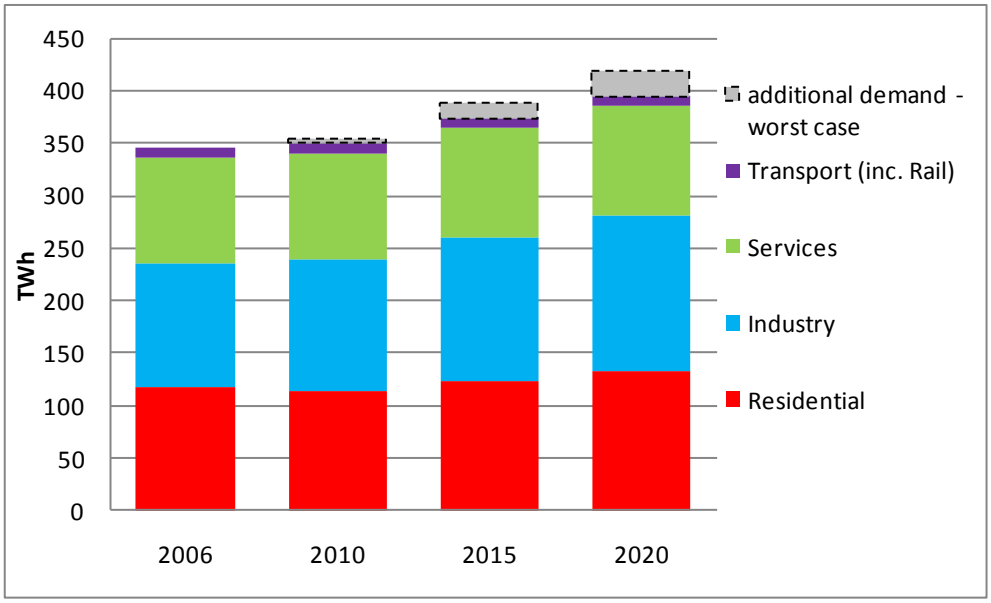
Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

ELECTRICITY GENERATION

Emissions in the power sector are driven by two factors – demand for electricity in end-use sectors determining overall generation; and the mix of fuel used to generate. The latter 'supply' effect usually outweighs the former 'demand' effect given the wide variation of CO_2 intensity of fuels meaning even a small change in the fuel share can have a significant effect

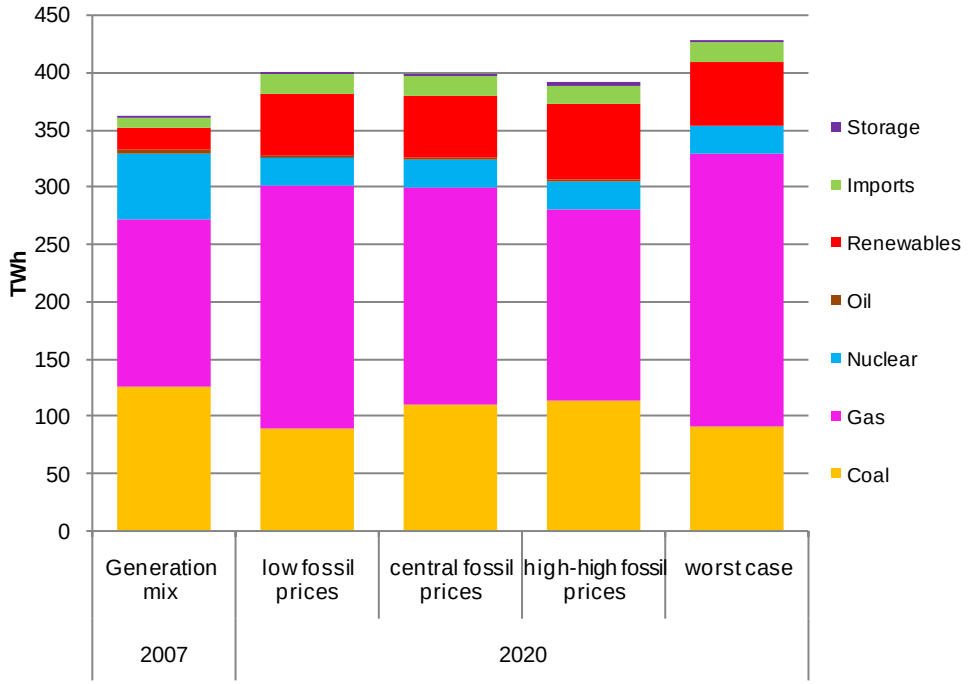
– an existing coal plant emits around 930 gCO_2/kWh of generation supplied, and a gas plant around 410 gCO_2/kWh. Nuclear and renewables emit no carbon in the generation process.[16]

Figure 10. Electricity demand by final user, central fossil fuel prices 2006 – 2020 (high growth scenario, 2020)



Source: DECC Energy and Emissions Model based on CCC assumptions

Figure 11. Generation mix in 2007 and projected in 2020

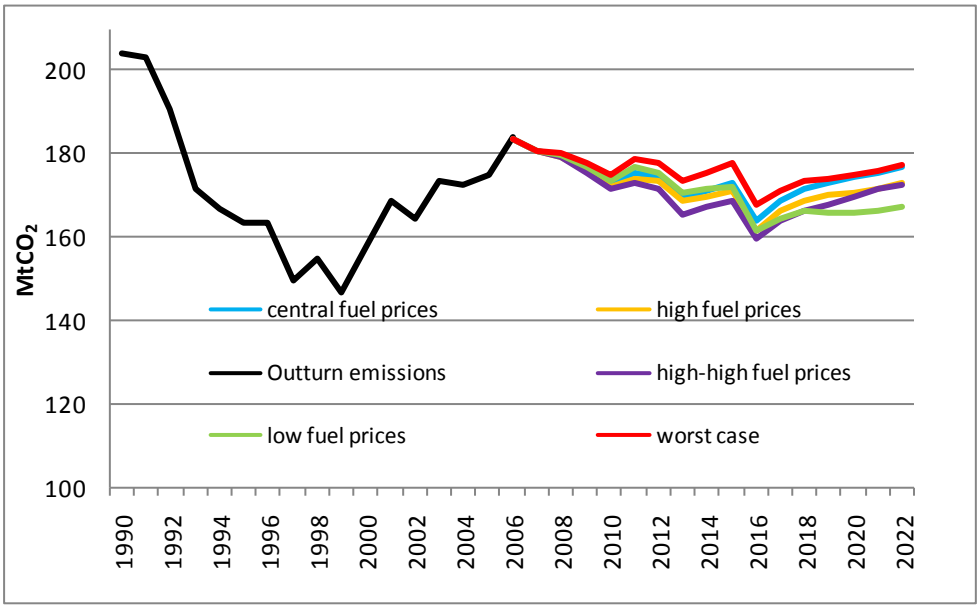


Source: DUKES 2008, DECC Energy and Emissions Model based on CCC assumptions

[16] DUKES 2008, Table 5C. Adjusted for own use, not adjusted for losses. Emissions intensity varies each year depending on a number of factors, including the calorific value of fuels and the efficiency of fuel plants (new plants will be more efficient therefore somewhat less intensive).

- Electricity demand increases under all fuel prices in the reference projections – in the central scenario, demand in 2020 is 395TWh, or 14% higher than 2006 levels.
- In the 'worst case' projection overall demand this increases to 419TWh. Under high-high fossil fuel prices it is constrained to 388TWh. (Figure 10).
- The fuel mix is particularly sensitive to fuel prices as Figure 9 illustrates. Under central and high-high prices we see up to 27% (+24TWh) more coal than under low prices, by 2020The combination of supply and demand effects is not completely straightforward, with important implications for emissions (Figure 12). Under high-high prices lower overall demand helps to keep down emissions in the short-term, relative to that under central and low fuel prices.
- In the longer-term, however, despite higher share of renewables (17% of generation) the increased coal burn outweighs the 'demand' effect'. As gas is more competitive under low prices this helps bring emissions down -10% on 2006 levels, by 2020 (compared with -5% and -8% in the central and high scenario). Note that in the 'worst case' scenario demand growth is sufficient to outweigh the supply effect.

Figure 12. Historic and projected CO_2 emissions from the power sector, 1990-2020



Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

- These projections do not incorporate the impact of a carbon price. This would increase the cost of all fossil generation and particularly coal as it is more carbon intensive, giving emissions reductions from both the demand and supply sides.
- This would help bring down emissions and constitute progress against the EU ETS cap. Ultimately, the EU ETS caps determine emissions on a 'net carbon account' for the traded sector (and this includes all emissions from major power generators).

These projections without a carbon price therefore illustrate the amount of 'effort' required to meet the caps by demonstrating emissions in an 'unconstrained' world.[17]

RESIDENTIAL SECTOR

The Residential sector in the DECC model covers all UK households and the final consumption of fuels such as electricity, gas, solid fuels (e.g. coal) and refined oils (e.g. burning oil). In 2006 this sector accounted for 27% of final energy demand and 15% of (direct) emissions (27% emissions on an end-use basis).

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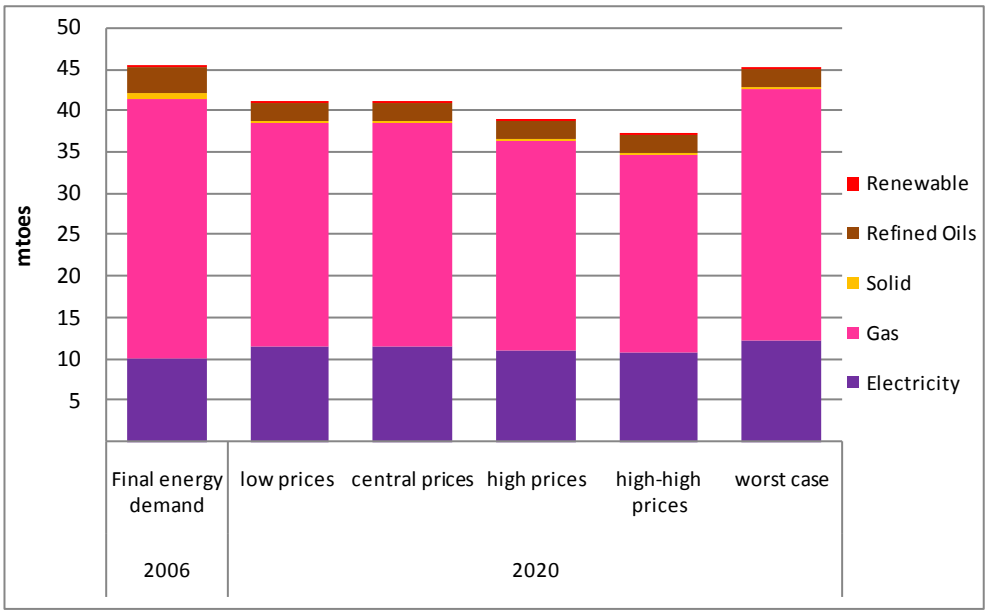
Figure 13. Residential final energy demand by fuel, 2006 and projected in 2020



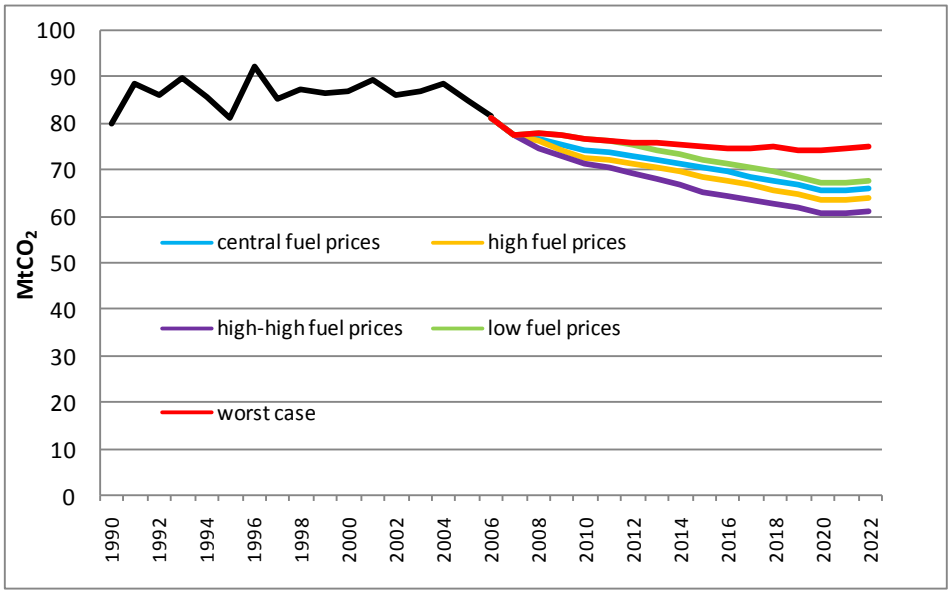
Source: DUKES 2008. DECC Energy and Emissions Model based on CCC assumptions

- Figure 12 shows the range of projections for residential final energy demand in 2020 relative to that in 2006. It shows that, under high-high prices demand could fall by up to 18% on 2006 levels, with the majority of savings coming from gas (-20% or -7.5 mtoes). Solid (i.e. coal) consumption falls by nearly two-thirds, by 2020 (-0.4 mtoe).

- The expected impact of policies such as future phases of EEC help to reduce demand overall – see Box 1.1 on how policy savings are captured in the reference projections. In the 'worst case' projection overall demand is largely unchanged on 2006 levels (some expansion of electricity at the expense of solid fuel and oil) – this is mainly due to more pessimistic assumptions over policy savings (Box 1.1).

[17] Note that Phase 2 (2008-2012) cap for the power sector is around 107MtCO_2. These projections suggest that the power sector would undertake around 66MtCO_2 of 'effort' in the central fossil fuel reference projection in the middle of the first budget period (2010).

Figure 14. Historic and projected direct emissions in the Residential sector – 1990 - 2022



Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

- Direct emissions[18] (Figure 14) have remained fairly stable since 1990, with falling CO_2 intensity of fuels (shift from solid to gas heating) helping to offset overall increase in energy demand. Looking forward emissions are expected to fall in all reference scenarios, under high-high prices up to -25% on 1990 levels, and -7% under low prices & high growth (-18% in central).

[18] Direct emissions are those from energy consumption of all fuels other than electricity. Emissions allocated by end use, accounting for electricity consumption, are illustrated in section 8.

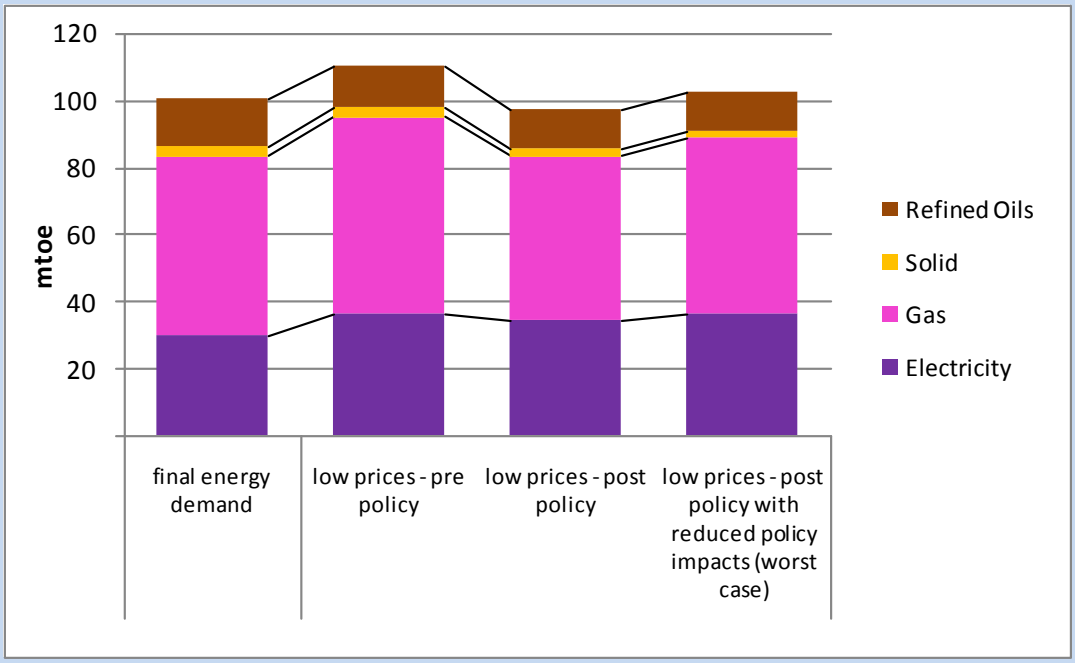
Box 1.1. Policy savings in the reference projections

The DECC model is an econometric model, which makes it difficult to capture trends which represent a break with the past. However, government policy is often designed to do just that, such as encouraging the more efficient use of energy by improving appliance product standards. Therefore to take into account the impact of government policies, the expected level of energy saving as a result of policy is subtracted from the projected level of 'pre-policy' demand given by the demand equations to give the 'post policy' demand projection. The impact of policies are quantified as part of the policy appraisal process conducted by Departments.

The CCC reference projections include the impact of the policies in the baseline to the Energy White Paper 2007 projections. This includes the policies in the Climate Change Programme 2006, such as the first 2 phases of EEC and CERT. These policies save approximately 13 mtoe of energy in 2020, the majority of which is gas saved in the residential sector (around 7.5 mtoe lower). The reference projection also includes the impact of the Road Transport Fuel Obligation at 5% (by volume) by 2010.

In order to capture the risk associated with policy delivery, we combined high economic and population growth assumptions with more pessimistic assumptions about energy savings from policy for the' worst case' projection. Figure 14 shows that, in 2020 without policy savings, final energy demand would be over 110 mtoe, an almost 10% increase on 2006 levels. Including policy impacts, however, demand falls by around 3% on current levels to around 97 mtoe. With more pessimistic assumptions as shown in the final column, policies save just 9 mtoe so demand actually slightly increases over the period to 102 mtoe.

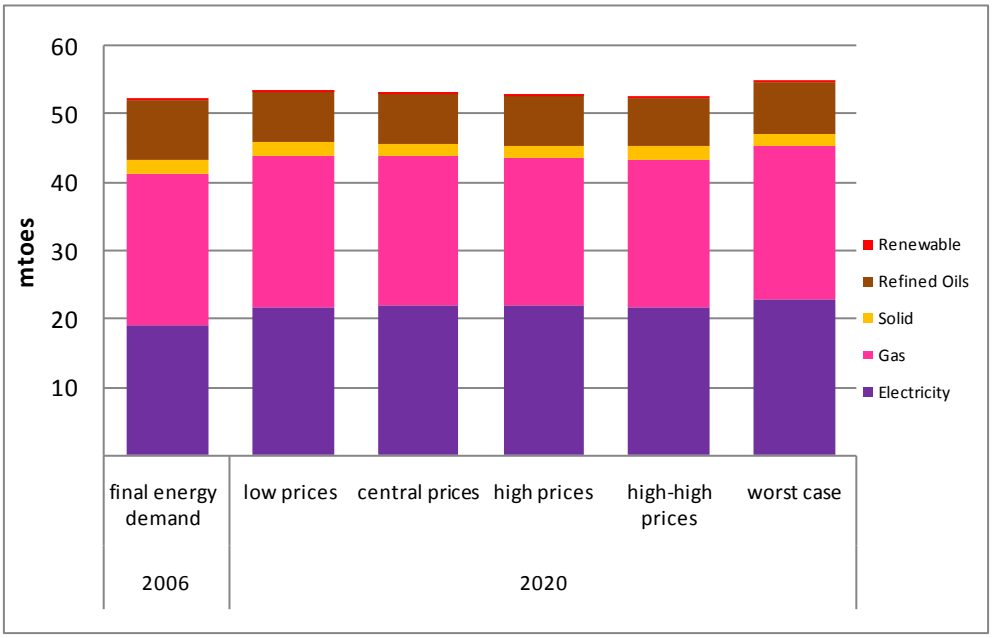
Figure 15. Final energy demand by fuel with and without policy adjustments and in the high growth, low price projection



INDUSTRY AND SERVICES

Together the industrial and service sectors (including agriculture) accounted for 28% of CO_2 emissions in 2006. In the DECC model the Industrial sector is actually made up of nine industrial subsectors, listed in Table 2, above. Final energy demand for these sectors is illustrated in Figure 15, below, as well as demand in the public and commercial sector. Total industrial and Service sector emissions are included in Figure 16. [19]

Figure 16. Industrial and Service sector final energy demand by fuel, 2006 and projected in 2020



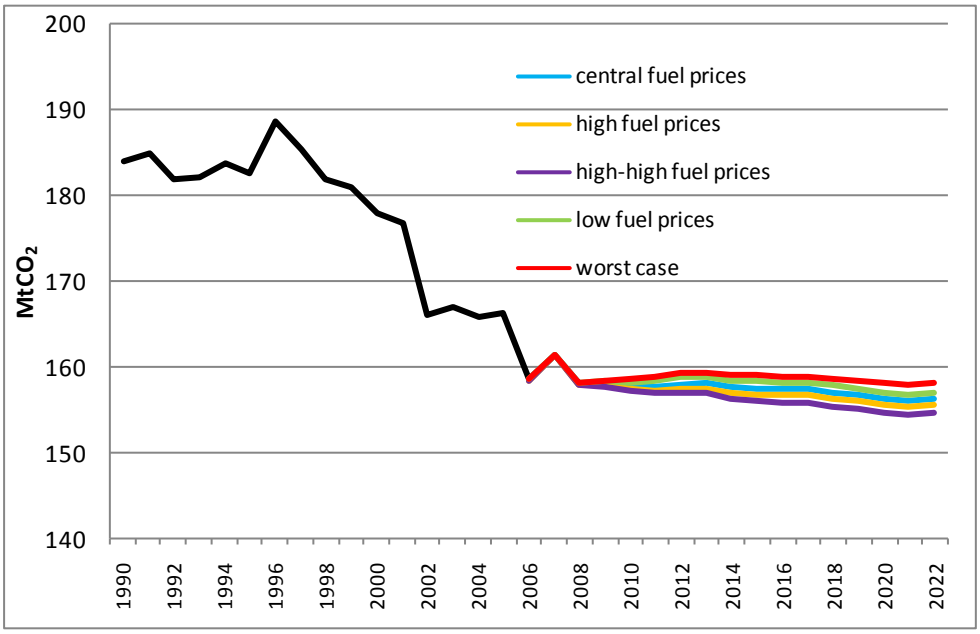
Source: DUKES 2008. DECC Energy and Emissions Model based on CCC assumptions. Final energy demand for industrial sectors, public and commercial services, and agriculture.

- In the central reference projection, final energy demand is expected to increase by just 2% on 2006 levels by 2020 (or just under 1 mtoe). Given the either very low or zero fuel price elasticities in the industrial and service sector equations, there is little variation in the level of demand under different fuel prices.

- Output is the driver for the majority of these sectors, therefore by 2020 we see demand rise by 5% on 2006 levels in the high growth/low price scenario. The majority of this increase is in electricity (21% higher than 2006).

[19] Figure 12 is final energy consumption, but within emissions we have also included emissions from the fuel industries such Refineries and autogeneration within industry. We have also included emissions from the 'Off-Road' category within the DECC model outputs. Off-Road emissions include emissions from agricultural and industrial mobile machinery and where around 12.6 MtCOX in 2006 (2% of total emissions).

Figure 17. Historic and projected CO_2 emissions from Industrial and Service sectors 1990-2022



Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions. Includes Refineries and emissions from autogeneration within the industrial sector.

- Despite the marked downward trend in emissions for these sectors since the mid 1990s, direct emissions are expected to remain around flat in the pessimistic scenario , or falling slightly, by up to an average of -0.2% p.a.
- This is due to the relative sub-sectoral growths, with those higher emitting sectors (like iron and steel) becoming a larger proportion of total industry GVA going forward.
- Again, given the relative inelasticity of demand for these sectors, the range is small, with the central projection for 2020 156 $MtCO_2$ +2.0/-1.5 $MtCO_2$.

TRANSPORT

Transport within the DECC Model covers 3 key areas:

- Road Transport, which is the largest source of transport emissions (22% of UK CO_2 emissions)
- Domestic aviation and shipping, which are counted on a 'bunker fuels' basis and contribute a relatively small amount to CO_2 emissions (2%);
- Rail, measured on a source basis (consumption of gas oil) (0.4% of emissions).

We consider each of these in turn.

Road Transport

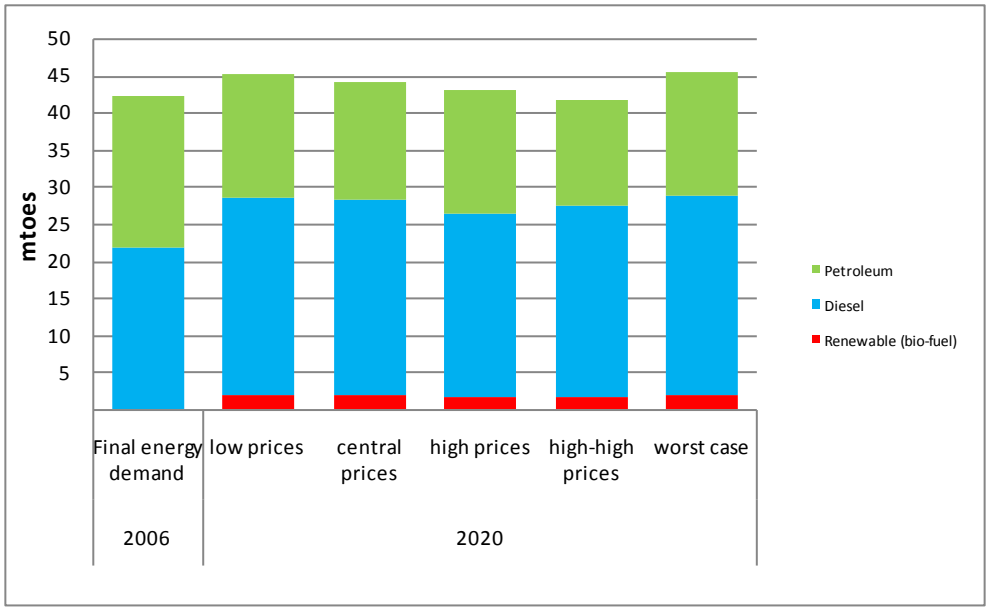
In 2006 this sector consumed 42.5 mtoes of petrol and diesel (accounting for around a quarter of final energy demand) and contributed 22% of CO_2 emissions.

- Fuel demand in 2006 and projected in 2020 under different fuel prices is given in Figure 15 below. The central scenarios sees a 4% increase in fuel demand relative to 2006 levels. Transport is relatively elastic to fuel prices (0.4) and high-high prices are sufficient to reduce demand by 1% on 2006 levels by the middle of the third budget period.

- Under low prices, demand increases by 6% on 2006, and up to 7% when combining with higher demographic change (worst case).[20] In the short term, emissions are expected to fall due to Road Transport Fuel Obligation (RTFO) as biofuels makes up an increasing proportion of the fuel mix. However, this proportion remains constant after 2010 (5% by volume).

- By 2020, emissions (Figure 16) in the central scenario are 122 $MtCO_2$ (+10% above 1990 levels),with a range of +4 $MtCO_2$/-6.5 $MtCO_2$ (13-4% higher than 1990). This represents a -5% to +2% change on current levels.

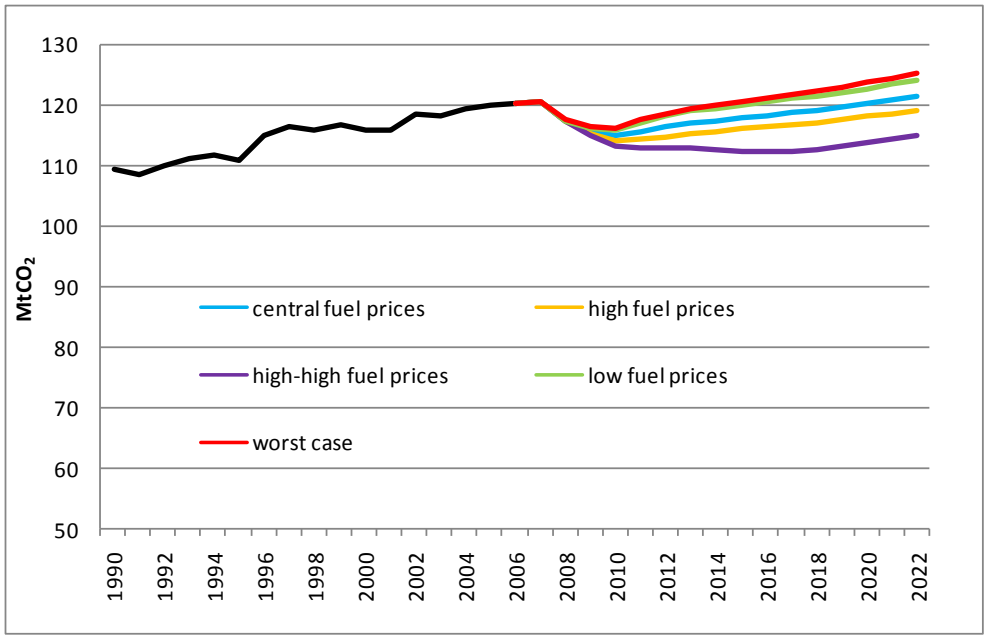
Figure 18. Road Transport final energy demand by fuel, 2006 and projected in 2020



Source: DUKES 2008. DECC Energy and Emissions Model based on CCC assumptions

[20] Car ownership is the demographic driver in the equations. Average number of cars per household is assumed to be approximately 1.18 (from the DfT car ownership model). This is then multiplied by the number of households to derive total ownership – in the central scenario this is 35.3 million in 2020 (compared with around 28.6m today). In the high scenario ownership is 36 million in 2020.

Figure 19. Historic and projected CO_2 emissions from Road Transport 1990-2022

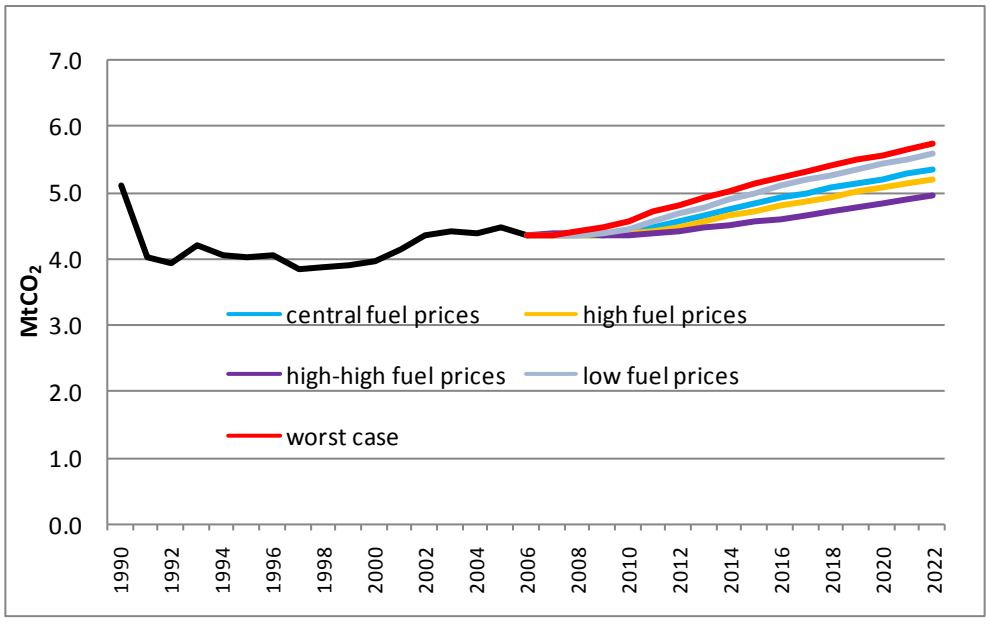


Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

Domestic aviation and shipping

The estimate for fuel and emissions from domestic aviation is derived by the proportion of bunker fuel sold in the UK used for domestic flights only. Together with domestic shipping it makes up just 2% of total UK CO_2 emissions.

Figure 20. Historic and projected CO_2 emissions from domestic aviation 1990-2022



Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

- Figure 20 illustrates emissions from domestic aviation under different fuel prices.[21] Even under high-high fuel prices emission are expected to rise – by 11% on current

[21] Domestic aviation is made up of civil and military aviation and in 2006 emissions were 2.3 $MtCO_2$ and 2.0 $MtCO_2$ for these sectors respectively. The increase in emissions from civil aviation since 1990

(2006) levels, rising to 20% in the central and 28% in the low prices & high growth scenario. It is worth noting that emissions from this sector remain very small as a proportion of overall emissions (less than 1%).

- Given the relatively small size (6.2 $MtCO_2$ in 2006), a rather simple methodology is used to project domestic shipping emissions, which are assumed to rise in the short term and are held flat thereafter at 6.7 $MtCO_2$ across the budget periods.

Rail

In 2006 this sector used 0.7mtoe of gas oil, coupled with around 2.9TWh of electricity for traction purposes.

- On a source basis (i.e. excluding electricity) this sector accounted for less than 0.5% of emissions in 2006. Looking forward, gas oil consumption is expected to fall slightly to 0.5mtoe then remain constant throughout the projection period, with emissions remaining steady at 1.6 $MtCO_2$.

PROJECTIONS INCLUDING A CARBON PRICE AND FURTHER TARGET FOR RENEWABLES IN GENERATION

In addition to the reference projection we also ran scenarios including a carbon price and a quantitative target for renewable electricity, reflecting the likely UK contribution to the EU target of 20% renewable energy, by 2020. As set out in the draft Renewable Energy Strategy (RES) this is approximately 120 TWh of electricity from renewable sources by 2020, compared with around 20 TWh today. We ran 2 scenarios on central and high fuel prices, with the CO_2 price of 28 euros rising to 50 euros per tCO_2, by 2020 in the central and 36 euro rising to 66 euros per tCO_2 under high fuel prices[22].

- Emissions fall through a combination of supply and demand effects, with the carbon price increasing the cost of all fossil fuel generation, but more specifically the price of coal relative to gas.

- It is assumed that 100% of the carbon price is passed onto the consumer in the form of higher electricity prices, therefore reducing demand. For example, the residential electricity price increases 25% to around 14.5p/kWh in 2020, compared with around 11.5p/kWh in the reference projection (see Fig 23,below).[23] And at 385 TWh overall demand for electricity in 2020 in the end-use sectors is 10 TWh or 3% lower than the reference projection.

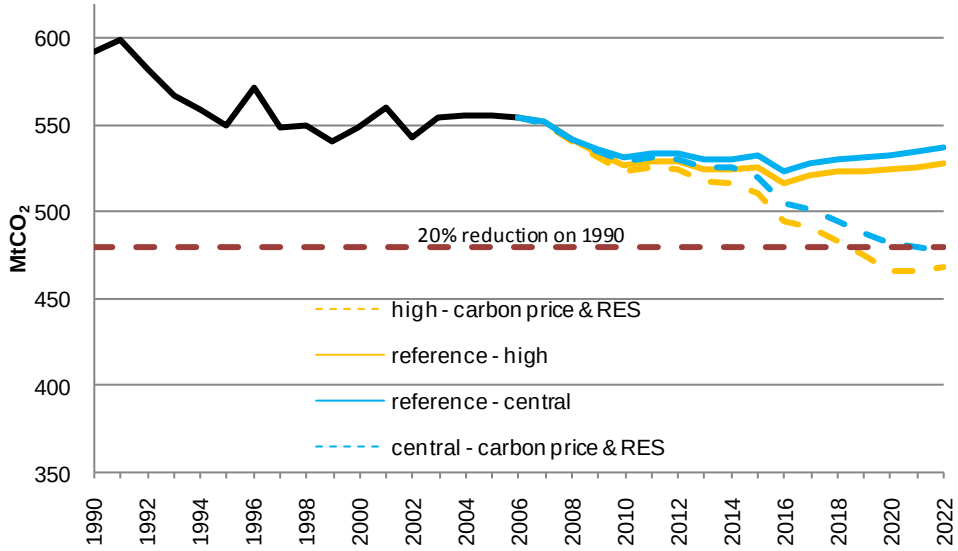
(it is around double that in 1990) has largely been offset by reductions in military aviation, so that overall aviation emissions have remained fairly flat since 1991. In the projections military aviation emissions remains flat at 2.0 $MtCO_2$

[22] These carbon price projections are detailed in full in a technical paper accompanying the CCC's first report, also available on the CCC website.

[23] Note the rise then fall in 2010/2011 is due to the financial impact of CERT (less than 0.5p/kWh) which is assumed to finish in 2011. A continuation of the CERT policy may continue to have financial impacts (in terms of consumer bills) however here we have assumed no further costs after 2011.

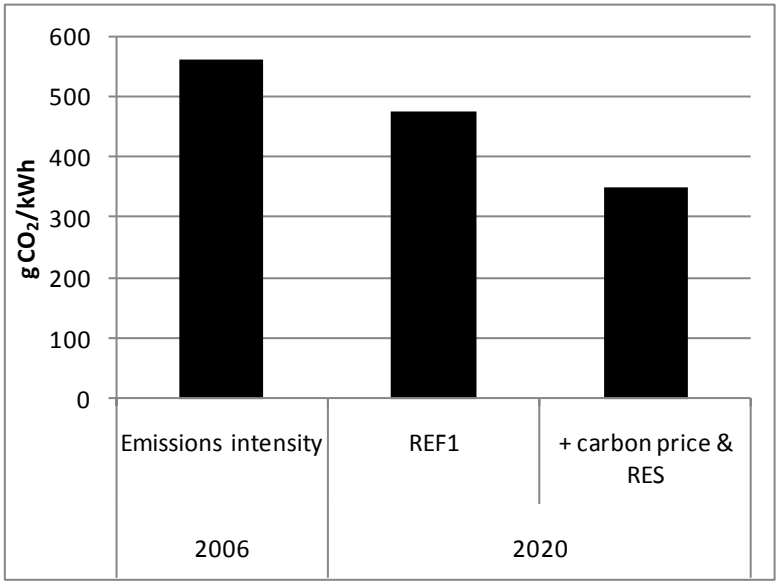
- Emissions are illustrated in Figure 21, below, falling to 20% below 1990 in the central scenario or 21% with high prices. Emissions intensity for both scenarios is illustrated in Fig 22 – potentially falling up to

Figure 21. Historic and projected CO_2 emissions – Total UK



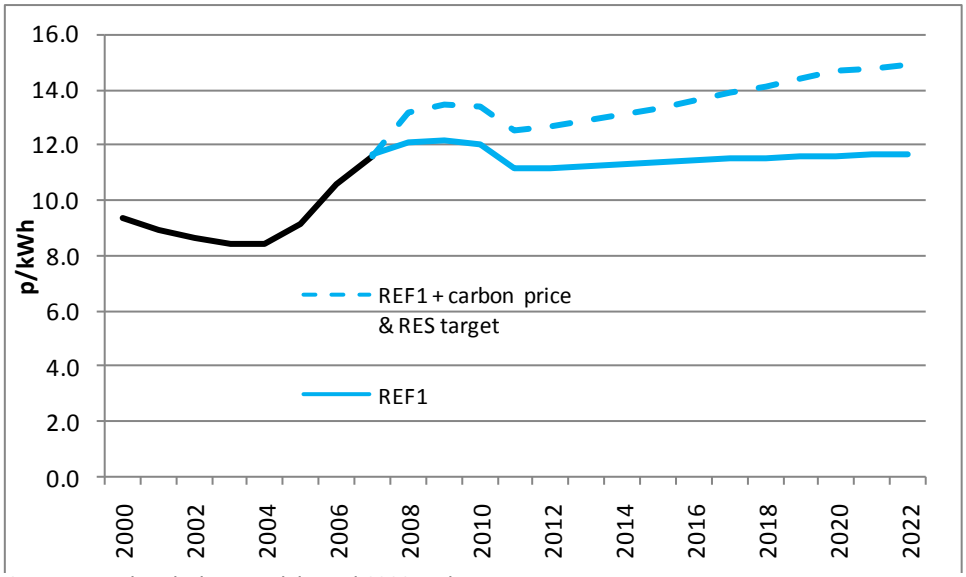
Source: NAEI 2008, DECC Energy and Emissions Model based on CCC assumptions

Figure 22. Emissions intensity in 2006 and 2020 in the reference projection and including impact of RES and CO_2 price



Source: DECC Energy and Emissions Model. Note: Adjusted for electricity generators' own use and losses in transmission and distribution.

Figure 23. Historic and projected retail electricity prices for residential sector (annual average)

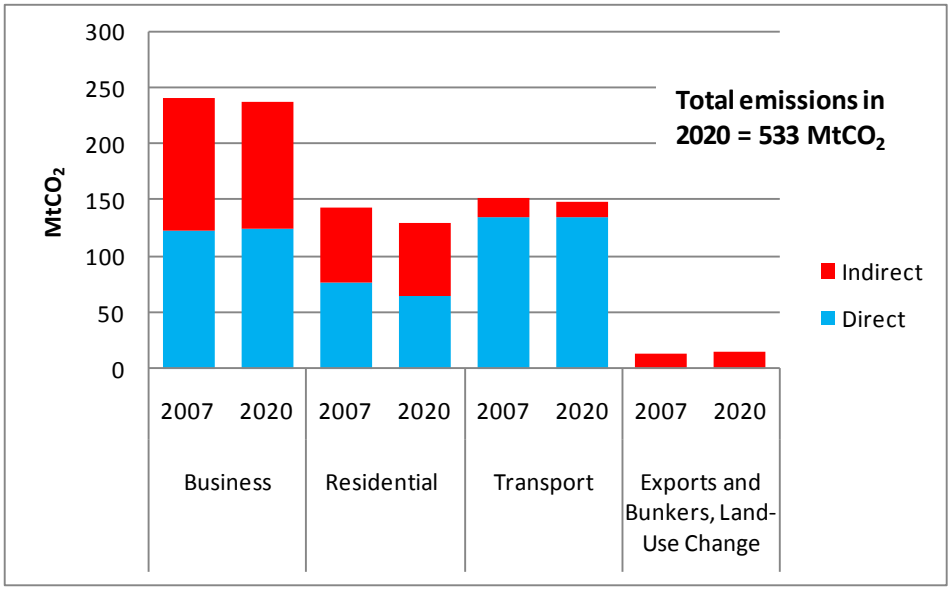


Source: DECC Energy and Emissions Model. Real £2007 prices.

EMISSIONS BY END USE

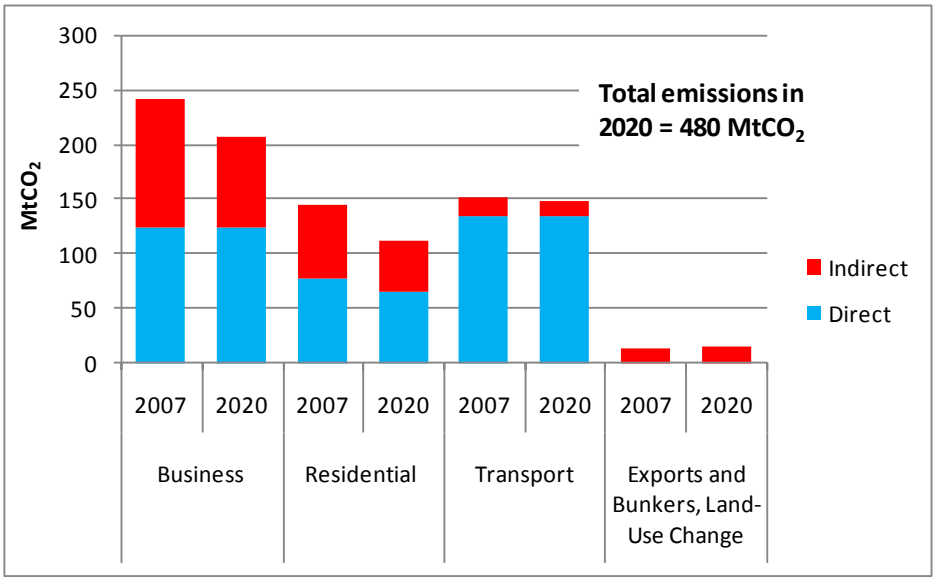
Emissions on and end use basis in the central projection are given in Figure 24 and 25, below, split by direct and indirect emissions – the latter capturing emissions from energy supply sector reallocated to the end-use sector based on their consumption of that energy. The savings from the demand and supply effects in the power sector are shown clearly in A2 as indirect emissions are squeezed and direct remain broadly unchanged.

Figure 24. Projected emissions in 2007 and 2020, split by direct and indirect (central reference projection)



Source: DECC Energy and Emissions Model based on CCC assumptions. Note: Business includes industry, commercial services, public sector, agriculture and waste management.

Figure 25. Projected emissions in 2007 and 2020, split by direct and indirect (central scenario with carbon price and RES target for generation)



Source: DECC Energy and Emissions Model based on CCC assumptions. Note: Business includes industry, commercial services, public sector, agriculture and waste management.

SUMMARY

- We have used the DECC model to produce a number of scenarios based on input assumptions drawn from current government projections
- In the central reference scenario overall UK CO_2 emissions fall from 555 $MtCO_2$ in 2006 to 533 $MtCO_2$ in 2020, which is 10% below 1990 emissions
- Applying our forecast carbon price to this projection and assuming renewables increase to provide 120TWh of generation in 2020, emissions fall to around 480 $MtCO_2$, or 20% below 1990 levels
- This sets the challenge for meeting carbon budgets, which require CO_2 emissions to be reduced by 2020 to about 40% below 1990 levels in our Intended budget, or 29% below in the Interim budget.