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UK ENERGY AND CO_2 EMISSIONS PROJECTIONS

Updated Projections to 2020

FEBRUARY 2006

Executive summary

This report presents the latest UK energy and CO_2 emissions projections prepared by the DTI.

Projections were previously published in November 2004.The update provided here includes revisions to assumptions on economic growth, future fossil fuel prices and the most recent evaluation of carbon savings from existing measures.

This latest work, when combined with emissions projections of greenhouse gases other than $CO_{2,}$ indicates that the UK remains on track to comfortably exceed its Kyoto commitment to reduce emissions of a basket of greenhouse gases.

This paper presents updated energy and CO_2 emission projections for the UK. The results suggest that, with existing policies excluding the impacts of EU emissions trading, UK emissions of CO_2 in 2010 will be about 10.6% below the level in 1990, or about 9.4 percentage points away from the domestic goal to reduce CO_2 emissions by 20%. As part of its review of the UK's Climate Change Programme, the Government is considering what additional action is needed to put the UK back on track towards this goal.

The report illustrates the historic and projected trends in final energy demand and carbon intensity and the impact of the current Climate Change Programme measures. The report includes assessment of outputs from the UK 's energy supply industries and of fuel mix within the electricity-generating sector.

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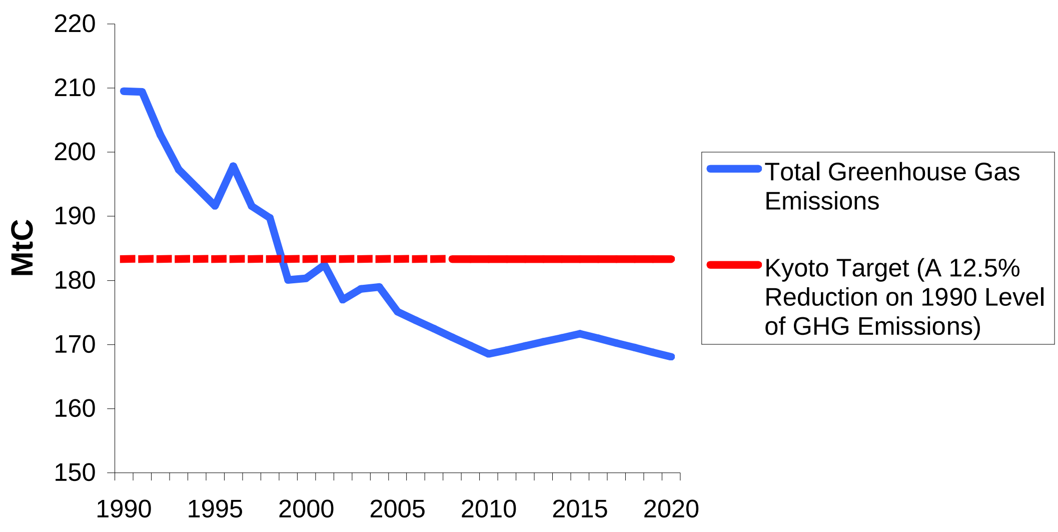
UK UPDATED ENERGY AND EMISSION PROJECTIONS (UEP)

CHAPTER 1 - INTRODUCTION

This paper presents updated energy and CO_2 emission projections for the UK. The results suggest that, with existing policies excluding the impacts of EU emissions trading, UK emissions of CO_2 in 2010 will be about 10.6% below the level in 1990, or about 9.4 percentage points away from the domestic goal to reduce CO_2 emissions by 20%. As part of its review of the UK's Climate Change Programme, the Government is considering what additional action is needed to put the UK back on track towards this goal.

The UK remains on track to comfortably exceed its Kyoto commitment (Figure 1). When combined with emission projections of greenhouse gases other than CO_2, the results presented here suggest that, in 2010, total UK greenhouse gas emissions, even without additional policies or EU emissions trading, will be some 19.6% below the base year level, an achievement well in excess of the Kyoto commitment for an emissions reduction of 12.5% below the base year level on average over the period 2008 to 2012.

Figure 1 - Progress Towards Our Kyoto Target



The most recent set of DTI energy and emission projections were published in November 2004[1]. These were used to inform the finalisation of the UK's National Allocation Plan (NAP) for the first phase of the EU Emissions Trading Scheme (EU ETS). They also informed the consultation document for the Climate Change Programme Review[2] (CCPR) which was published in December 2004.

[1] See: http://www.dti.gov.uk/energy/sepn/uep2004.pdf
[2] UK Climate Change Programme 2006

This paper presents updated projections, taking account of developments since November 2004. This latest work is helping to inform the CCPR and will feed into decision-making on allocations for the second phase of the EU ETS.

The basis of the projections is the DTI UK Energy Model. The Digest of UK Energy Statistics (DUKES)[3] is the principal source of data and provides the basis for sectoral classification. The energy sectors modelled are power stations, offshore sector, refineries and other energy producing industries. The energy demand sectors are residential, services (public and commercial), road and other transport, industry (excluding services) and agriculture[4].

Four scenarios are considered for the baseline projections. These have common assumptions for factors including economic growth and demographics, but vary as to assumed fossil fuel prices. Policy measures considered to be firm and funded are included, on the basis of the most recent evaluation of their carbon saving impact (Annex A). The potential impact of the EU ETS is excluded from the core projections and its potential impact is considered separately.

[3] See http://www.dti.gov.uk/energy/inform/dukes/dukes2004/index.shtml
[4] For the purpose of this paper agriculture is included in services (when not reported separately).

CHAPTER 2 - HEADLINE PROJECTION RESULTS

Scenario Revisions Since the November 2004 Projection

1. The work presented has four variants:

   a. A high fossil fuel price case;
   b. A central fossil fuel price case, but with the assumed prices somewhat favouring gas in generation;
   c. A central fossil fuel price case, but with the assumed prices somewhat favouring coal in generation;
   d. A low fossil fuel price case.

2. Previous UEP projections presented a single central price scenario. The additional scenarios reflect the uncertainty about energy prices going forward, and the potential sensitivity of results to assumptions about this. The sensitivity reflects, in particular, two influences:

   i. When prices are generally higher, energy demand can be expected to be lower. This tends to reduce CO_2 emissions;

   ii. When prices are generally higher, relative fuel prices tend to favour coal over gas. This tends to boost coal use, particularly in generation, leading to higher CO_2 emissions.

3. The basis for the revised fossil fuel price assumptions is considered in Chapter 3.

4. All final scenarios incorporate a number of recent developments. These include:

   a. Economic growth and other announcements in the Pre Budget Report December 2005;

   b. Revisions to industrial sector output growth as advised in work commissioned from Oxford Economic Forecasting (OEF)[5] and consistent with latest overall economic growth prospects;

   c. A life extension for Dungeness B, which was announced in September 2005, and which extends full output from the plant into 2010 and beyond;

   d. Re-modelling of the residential sector incorporating a saturation effect in projected household demand for gas. This revision is consistent with separate modelling by Defra;

[5] This report will be published on the DTI website together with these projections.

e. Re-modelling of the road transport sector. The DTI re-modelling is different in approach to the DfT's own modelling through the National Transport Model (NTM), but indicates a high degree of agreement in overall emission projections[6];

f. Incorporation of revised estimates of savings from current policies and measures. This re-evaluation reflects analytical work undertaken to inform the Climate Change Programme Review (CCPR);

g. Adjustments resulting from revisions to the UK Greenhouse Gas emissions inventory;

h. Reassessment of the offshore sector (details are given in Chapter 5).

Overall CO_2 Projection to 2010

5. Table 1 shows headline results from the four scenarios in 2010. This suggests a relatively narrow range for CO_2 emissions in 2010 from 144 to 145 MtC. This is with no allowance for emissions trading or additional policies introduced as a result of the CCPR. The narrow range reflects only variation due to energy price effects. There are of course many uncertainties associated with a projection of this type and these are considered in Chapter 8.

TABLE 1 – Projected CO_2 emissions, the national goal and the carbon gap (excluding EU ETS) in 2010 (all four scenarios) (MtC)

		Current Projections			
MtC	**November 2004 Projections**	**Central (1) Favouring Gas**	**Central (2) Favouring Coal**	**High**	**Low**
1990	165.1	161.4	161.4	161.4	161.4
2010	141.3	144.5	144.1	144.7	145.1
Reduction from 1990	-14.4%	-10.5%	-10.7%	-10.3%	-10.1%
National goal[7]	132MtC	129MtC	129MtC	129MtC	129MtC
Carbon gap in 2010	**9.3MtC**	**15.4MtC**	**15.0MtC**	**15.6MtC**	**16.0MtC**

[6] The DTI approach is based on econometric analysis of fuel prices, income and GDP whereas the NTM is much more disaggregated by trip type. The agreement between them increases confidence in the projections.

[7] The difference between the current 1990 estimate and that made in November 2004 is mainly that the current estimate takes account of the forest sink as well as emissions from land use change. The forest sink was excluded previously. This change has been applied throughout the time series and will be the basis for assessing progress towards the 20% goal.

6. Focusing on the two central cases, CO_2 emissions in 2010 are projected at 144.1-144.5 MtC. This represents a reduction on 1990 levels of 10.5-10.7%. This suggests a gap, on current policies, against the 2010 target to move towards a 20% reduction of CO_2 below 1990 levels is an estimated 15.0-15.4 MtC.

7. The EU ETS is central to current policy to reduce CO_2 emissions, but is excluded from the baseline projections presented here. This reflects that neither UK nor other member states' allocation levels for Phase II of the scheme, covering 2008-12, have been set. There is considerable uncertainty over the level of carbon price that will emerge from this scheme. The UK's allocation decision for 2008-12 is being considered within the CCPR. This decision will itself be informed, amongst other considerations, by the projected shortfall from the UK's CO_2 reduction target.

8. Clearly, inclusion of the impact of the EU ETS moves UK emissions towards the target. Other than the level of the carbon price[8], uncertainties on the scale of this impact include the level of relativities between fossil fuel prices, availability of credits through Joint Implementation (JI) and Clean Development Mechanism (CDM) and abatement opportunities. At a carbon price of €30/tCO_2, UK emissions are reduced, on our modelling, by a further 1.5 to 3 MtC, on the central scenarios, taking UK emissions to 11.6-12.3% below 1990 levels (Table B3 Annex B).

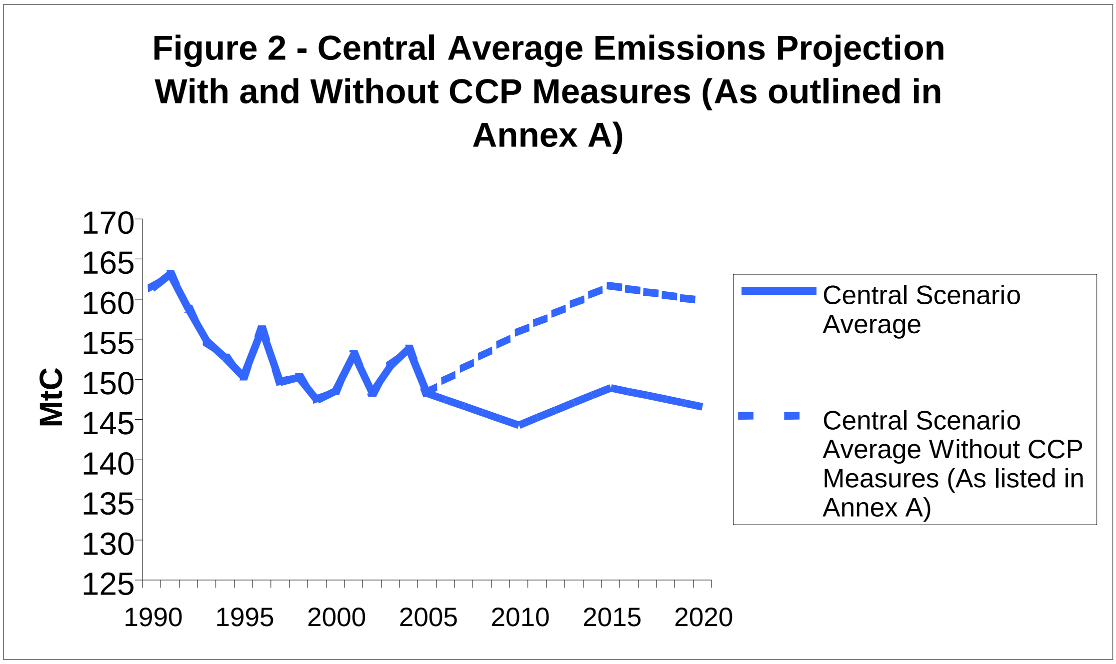
SCENARIO DIFFERENCES

9. Overall, the two central cases show emissions falling in the second half of the decade towards 2010. This reverses the experience of the past few years. It reflects two main factors:

   i. The oil price is assumed to fall, bringing the gas price with it and allowing gas to take a greater share of generation;

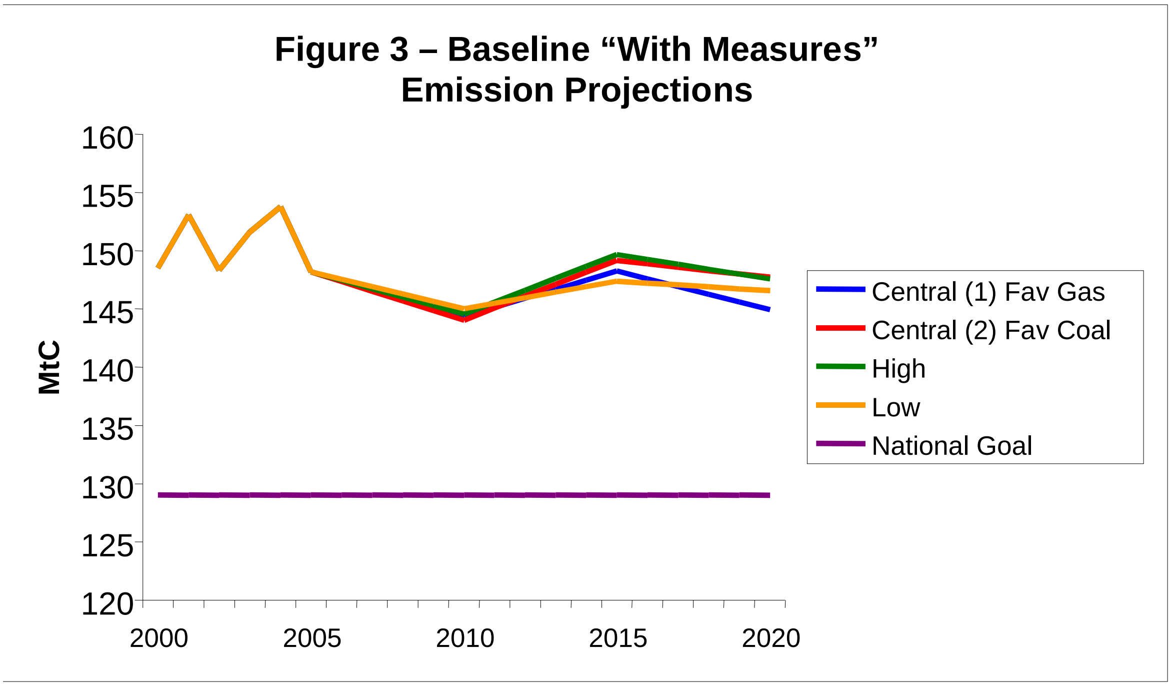
   ii. The impact of the existing Climate Change Programme. Carbon savings from existing measures, based on estimates from inter-departmental work to inform the CCP, are imposed on the projections. In a number of cases this allows for the impact of the measure to be greater in 2010 than now. Projected Carbon savings from existing measures are set out at Annex A. The impact of these savings on our Central average projection is illustrated in Figure 2 below.

[8] Determined EU wide



10. Emissions are projected to increase between 2010 and 2015. Although existing measures are estimated to have slightly greater impact (as, for example, they impact on more of the stock of vehicles or buildings), this is more than outweighed by growing energy use with economic growth and the closure of nuclear generation plant. Further measures will therefore be needed to sustain the fall in emissions. Emissions fall once more after 2015, even without additional measures because it is assumed that a significant number of coal-fired power stations retire from the system post 2015.

11. Figure 3 illustrates all four scenarios from 1990 to 2020. These scenarios include assumed savings from existing policy measures, but do not include either emissions trading or the effect of additional policies introduced as a consequence of the CCPR.



12. The variation across the four scenarios indicates sensitivity to assumed fossil fuel prices, but is small. This reflects a number of countervailing influences. These are illustrated further in Figure 4 below which separates power station and energy demand emissions, and Table 2 which shows the change in emissions from these sectors as fossil fuel price assumptions are varied from the central average.

   a. In the "central case favouring gas" relative fossil fuel prices mean more gas use in generation, relative to coal. But this is outweighed by the greater energy demands attached to this case – emissions are slightly higher overall than in the "central case favouring coal".

   b. In the "high fossil fuel price" scenario, emissions - at 144.7 MtC in 2010 – are higher than in the central cases. Coal is relatively more competitive with gas and consequently more heavily used in generation. This effect outweighs the impact of high energy prices in reducing energy demand, and so the emissions in the high scenario are higher for the whole period 2005-2020.

   c. In the "low fossil fuel price" scenario, emissions in 2010 and 2020 are higher than the central average because the effects from increased energy demand due to lower energy prices outweigh the effects from the fuel switching towards gas in the power-generating sector. The fuel switching effects in the power generating sector dominate the energy demand effects in 2015 in this scenario. As noted in Chapter 6, coal's competitive position in 2015 is relatively weak, leading to lower coal capacity, including upgraded capacity, with consequent significantly lower generation compared with the central cases. In 2020 however, in line with the central favourable to gas case, a core of competitive, upgraded coal fired power stations remains on the system, so that power station emissions differ by relatively little from the central, favourable to gas case.

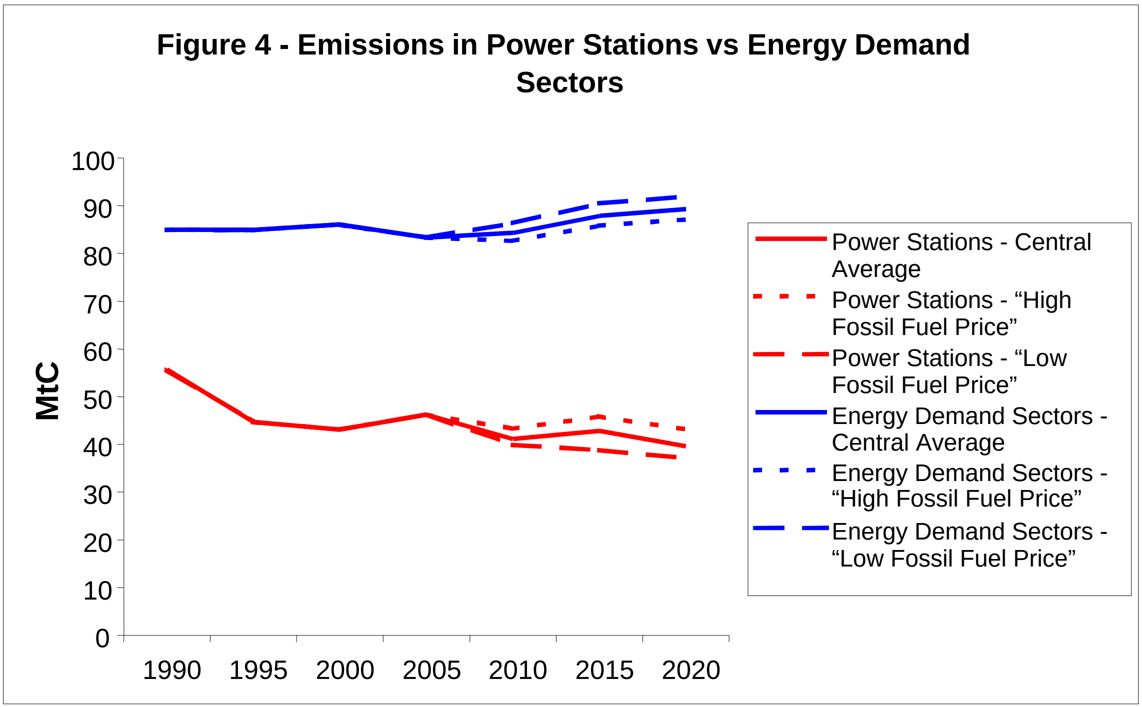


TABLE 2[9] – Emissions Impact on Power Stations and Demand Sectors due to Alternative Price assumptions (MtC)

	Emissions Change with a High Fuel Price Assumption			**Emissions Change with a Low Fuel Price Assumption**		
	2010	**2015**	**2020**	**2010**	**2015**	**2020**
Power Stations	2.1	3.1	3.4	-1.3	-4.0	-2.5
Energy Demand Sectors	-1.7	-2.1	-2.1	2.1	2.6	2.7
Total Deviation from Central Average	**0.4**	**1.0**	**1.3**	**0.8**	**-1.4**	**0.2**

<u>Sector Emissions Projections</u>

13. Sector projections of CO_2 in 2010 for each scenario are shown in Table 3, together with the November 2004 results. The full results by source (2005-2020) are given in Annex D.

[9] Energy Demand Sectors includes emissions from final demand sectors such as Residential, Services, Road Transport, and Industry but excludes the contributions from energy supply industries and industrial processes.

TABLE 3[10] – CO_2 emissions in 2010 by end user and by Scenario Compared with the Previous Published Projections (MtC)

		Latest scenario projections			
	UEP Nov '04	**Fav Gas**	**Fav Coal**	**High**	**Low**
Power Stations	37.4	41.0	41.4	43.3	39.9
Refineries	5.5	5.7	5.7	5.7	5.7
Residential	20.5	20.9	20.5	19.5	21.9
Services (including agriculture)	7.5	6.4	6.4	6.4	6.4
Industry	31.6	32.6	32.3	32.2	32.6
Road Transport	34.5	34.6	34.6	34.3	35.3
Off-road Vehicles (1)	1.5	1.4	1.4	1.4	1.4
Other Transport (2)	2.5	2.3	2.3	2.3	2.4
Afforestation since 1990	-0.65				
Unallocated measures	-1.34				
Land Use Change and forestry (now includes the total forest sink as well as land use change emissions)	2.43	-0.5	-0.5	-0.5	-0.5
UEP "all measures" baseline	**141.3**	**144.5**	**144.1**	**144.7**	**145.1**

(1) Off road includes construction vehicles, agriculture and forestry vehicles, and aircraft support vehicles.
(2) Other Transport includes railways, coastal and naval shipping, fishing vessels, and domestic aircraft.

HISTORIC AND PROJECTED TRENDS IN SECTOR EMISSIONS

14. Figure 5 below illustrates the historic and projected emissions by sector 1990 to 2020. More detail on trends and prospects in the final demand sectors is given in Chapter 4 and in the electricity generation sector and refineries, is given in Chapters 5 and 6.

15. Detailed sector results by source and end user are given in Annexes D and E.

[10] In the November 2004 projections, savings estimates for some measures – labelled "unallocated measures" – were available economy-wide, but not by sector within which they were impacting. That allocation to sector has now been made, and 'Afforestation' incorporated into land use change and forestry. For more detail on the changes between the UEPs, see Annex C.

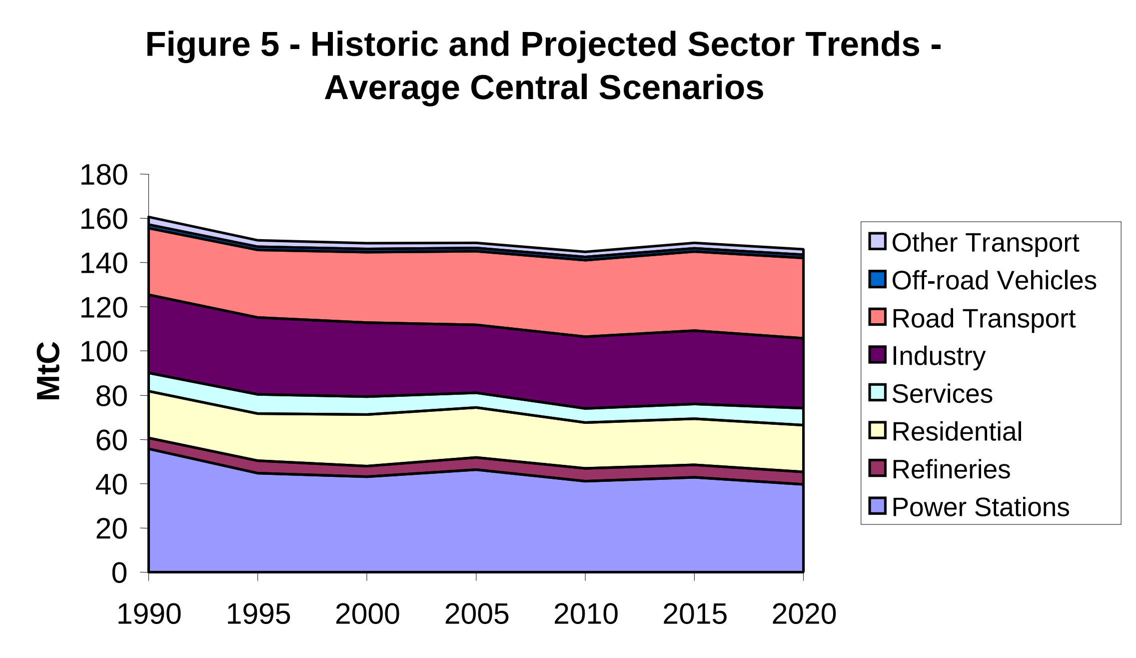


Figure 5 - Historic and Projected Sector Trends -
Average Central Scenarios
MtC
180
160
140
120
100
80
60
40
20
0
1990
1995
2000
2005
2010
2015
2020
Other Transport
Off-road Vehicles
Road Transport
Industry
Services
Residential
Refineries
Power Stations

CHAPTER 3 - KEY MODELLING ASSUMPTIONS

Economic Growth

16. Economic growth assumptions (Table 4) are from the December 2005 Pre Budget Report (up until 2008). Longer-term growth (after 2008) is assumed close to the long-term UK average.

TABLE 4 – Growth Assumptions

	2006	2007	2008	2009-2020
Growth Assumption	2.25%	3%	3%	2.5%

Fossil Fuel Price Assumptions

17. Fossil fuel price assumptions are set out in Tables 5 and 6. In broad terms, the rationale for the assumptions is:

    i. In the Central price scenarios, it is assumed that oil prices ease as new production capacity is built and demand growth moderates. However, as oil is increasingly produced from more expensive sources, prices are assumed to remain higher than the historic average. The gas price in Europe and the US is assumed to remain oil linked and UK gas prices are assumed to be similar to continental prices plus the transport cost differential. Additional investment in coal production capacity, as a result of recent high prices, is assumed to lead to coal prices falling to long-run marginal costs.

    ii. In the High price scenario, global economic growth is assumed to remain strong, and demand elasticity for oil remains low. Spare capacity is assumed to remain scarce. It is assumed that gas prices remain oil-linked. The UK gas supply/demand balance is assumed to remain tight for the next year or so, leading to higher storage prices and so a higher winter spot price. It is also assumed that, despite EU market liberalisation, increased competition in gas markets is limited. Coal demand is assumed to remain strong, especially in developing countries. High gas prices may mean that there is sufficient space for a price rise without coal losing much of its competitiveness relative to gas. New technology in the power generation industries may also boost coal competitiveness.

iii. In the Low price scenario, it is assumed that oil producers invest in new production capacity and technological development minimises the costs of oil production. A slowdown in economic growth and/or substitution away from oil may reduce demand. In the gas market, there could be increased competition due to European liberalisation and significant global liquefied natural gas and pipeline build. As a result, gas prices may be driven down closer to long run marginal costs. Coal demand is assumed to continue to decline due to the competitiveness of gas. Technological advances and increasingly competitive global coal production may drive prices down to marginal costs.

TABLE 5 –The fossil fuel price assumptions[11] – central cases

a. Central (1) Favouring Gas

	Oil ($/bbl)	Gas (p/therm)	Coal ($/GJ)
2005	55	36	2.50
2010	35	23	1.50
2015	35	23	1.43
2020	35	23	1.35

b. Central (2) Favouring Coal

	Oil ($/bbl)	Gas (p/therm)	Coal ($/GJ)
2005	55	36	2.50
2010	35	28	1.50
2015	35	28	1.43
2020	35	28	1.35

TABLE 6 –The fossil fuel price assumptions – high and low price cases

a. High Sensitivity

	Oil ($/bbl)	Gas (p/therm)	Coal ($/GJ)
2005	60	36	2.60
2010	50	38	1.70
2015	50	38	1.70
2020	50	38	1.70

[11] In real 2004 prices

b. Low Sensitivity

	Oil ($/bbl)	Gas (p/therm)	Coal ($/GJ)
2005	50	36	2.40
2010	20	18	1.30
2015	20	18	1.15
2020	20	18	1.00

18. Fossil fuel price assumptions were the subject of public consultation over the summer of 2005, and views of other Government departments were sought. Expectations of prices going forward have generally increased over the past year, and this has been reflected in our assumptions.

19. The current assumptions are illustrated in Figures 6-8 alongside assumptions drawn from work by a range of other forecasters. They reflect considerable uncertainty going forward. The figures also show how forecasters have recently revised their outlook:

    a. In our central cases we assume that the real oil price declines to $35/bbl in 2010, and is then maintained. In the high price case we assume $50/bbl in 2010. The central 2010 assumption is lower than assumed by Cambridge Econometrics, but higher than the previous IEA World Energy Outlook. In the most recent IEA Outlook, published since our assumptions were finalised, the oil price in the IEA reference scenario is $35/bbl[12] in 2010, rising slowly thereafter to $37/bbl in 2020.

    b. Our central case coal price assumption is, in 2010, broadly mid-range in terms of the basket of available comparators;

    c. For the gas price, we have a central case - high variant and central case - low variant. The higher assumption is broadly at the top end of the range of available comparators; the lower assumption is close to the middle of the range.

FIGURES 6-8 - Comparison of forecasts or scenario assumptions of fossil fuel prices

[12] In real 2004 prices

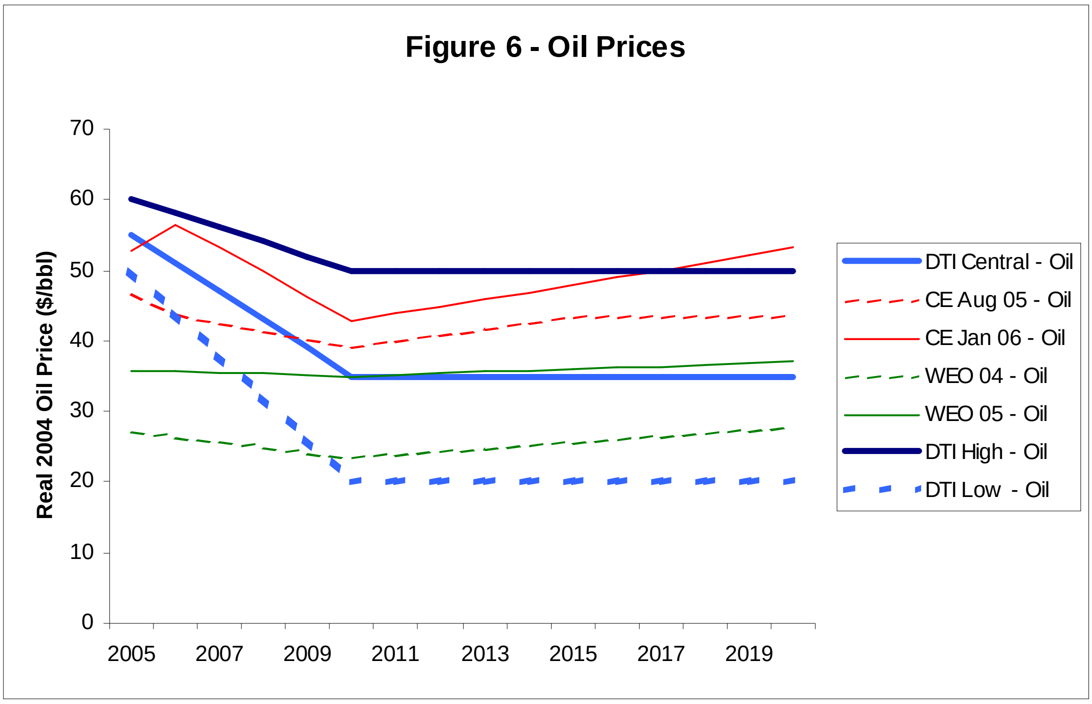


Figure 6 - Oil Prices
Real 2004 Oil Price ($/bbl)
70
60
50
40
30
20
10
0
2005
2007
2009
2011
2013
2015
2017
2019
DTI Central - Oil
CE Aug 05 - Oil
CE Jan 06 - Oil
WEO 04 - Oil
WEO 05 - Oil
DTI High - Oil
DTI Low - Oil

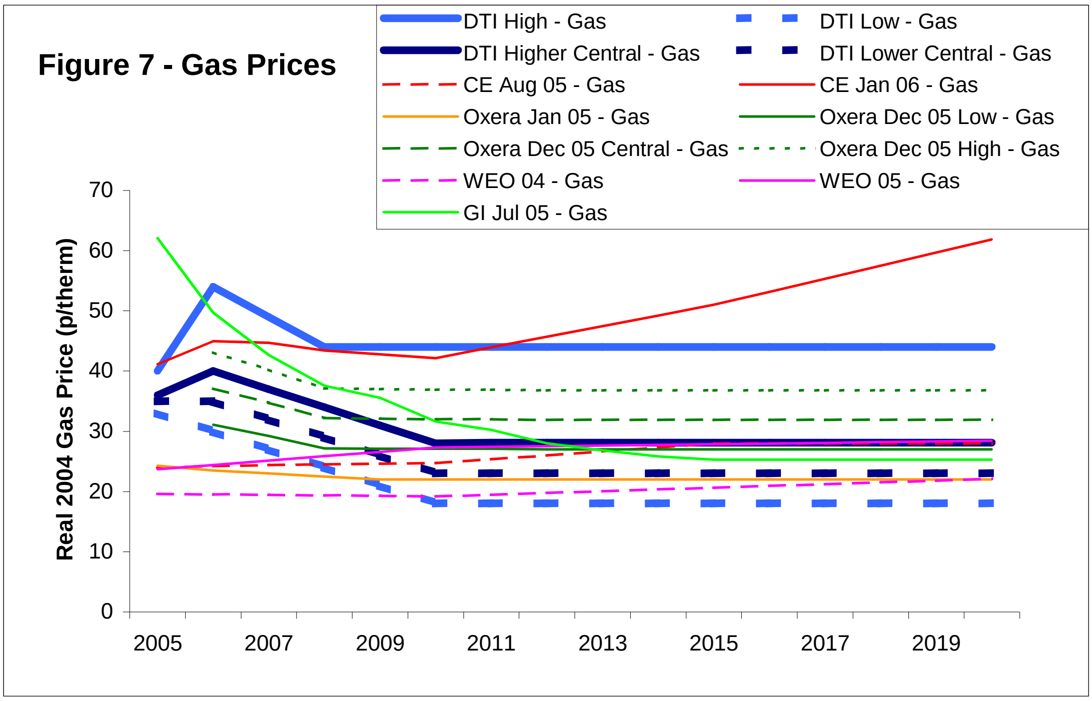
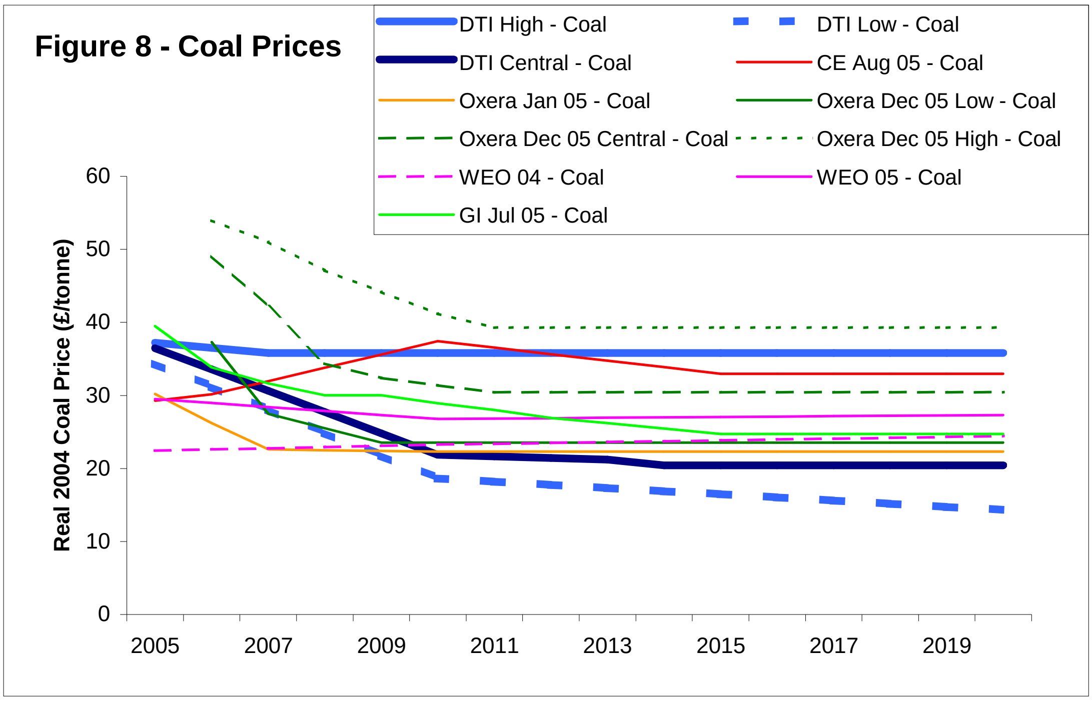


Figure 7 - Gas Prices
Real 2004 Gas Price (p/therm)
70
60
50
40
30
20
10
0
2005
2007
2009
2011
2013
2015
2017
2019
DTI High - Gas
DTI Low - Gas
DTI Higher Central - Gas
DTI Lower Central - Gas
CE Aug 05 - Gas
CE Jan 06 - Gas
Oxera Jan 05 - Gas
Oxera Dec 05 Low - Gas
Oxera Dec 05 Central - Gas
Oxera Dec 05 High - Gas
WEO 04 - Gas
WEO 05 - Gas
GI Jul 05 - Gas



Revised Industry Output Growth Assumptions

20. The overall UK economic growth projection and the structure of growth in the economy are significant drivers of UK energy demand.

21. Output growth to 2010 is from work by Oxford Economic Forecasting[13] (OEF) and is consistent with the Government's economic and manufacturing growth assumptions in the December 2005 Pre Budget Report. Revised growth by industrial sector assumed in these latest projections is compared with November 2004 growth assumptions in 2010 and illustrated in Table 23, further on in the document. Some industrial sectors have higher output than assumed in Nov 2004, others lower. One of the more significant of these - given its Carbon intensity - is the iron and steel sector; where the latest projection of output in 2010 (from OEF) is around 1.5% lower than previously[14], though still considerably up as against output in 2000.

[13] Published on the DTI website
[14] Based on work by CRU

CHAPTER 4 - FINAL ENERGY DEMAND

Historic Trends in Energy Demand and Intensity

22. Total UK energy demand has grown some 9.3 % since 1990. Table 10 indicates how demand has changed since 1990 by sector. Strongest growth has been seen in the residential and transport sectors. This growth reflects the choices made as the economy grows and individuals have more spending power. In a growing economy the demand for transport fuel is growing strongly. Projections of future growth in Transport emissions (see Figure 18 further on in the report) incorporate measures such as Voluntary Agreements, which reduce the level of growth in fuel demand in this sector as the economy continues to grow. Energy demand from industry has continued to decline over this period continuing a trend away from energy intensive manufacturing to less intensive sectors or into services, which now contribute some 75% of total UK GDP. Table 11 shows shares in total energy demand by sector of final demand. Figure 9 illustrates how fuel shares in final demand have moved since 1990 and are projected to change to 2020[15].

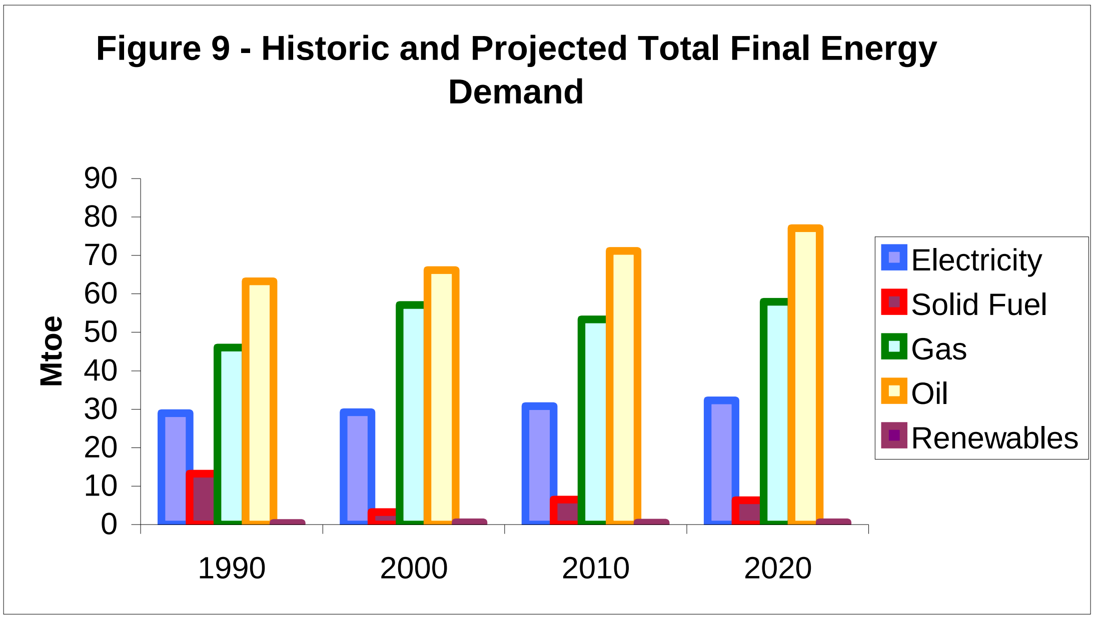
TABLE 10 - Energy Demand By Sector (Mtoe) and Growth in Energy Demand since 1990[16]

	Domestic	Transport	Services	Industry
1990	41	49	19	38
1995	43	50	21	36
2000	47	55	22	33
2004	49	58	21	33
Change from 1990	**19.6%**	**18.1%**	**8.0%**	**-13.9%**

TABLE 11 – Share of total energy demand by sector

	Industry	Transport	Domestic	Services
1990	26%	33%	28%	13%
1995	24%	34%	29%	14%
2000	21%	35%	30%	14%
2004	21%	36%	31%	13%

[15] Projections are based on the Central price scenario, favouring coal.
[16] DUKES 2005. 'Services' in Table 10 and Table 11 correspond to 'Other Final Users' in DUKES.

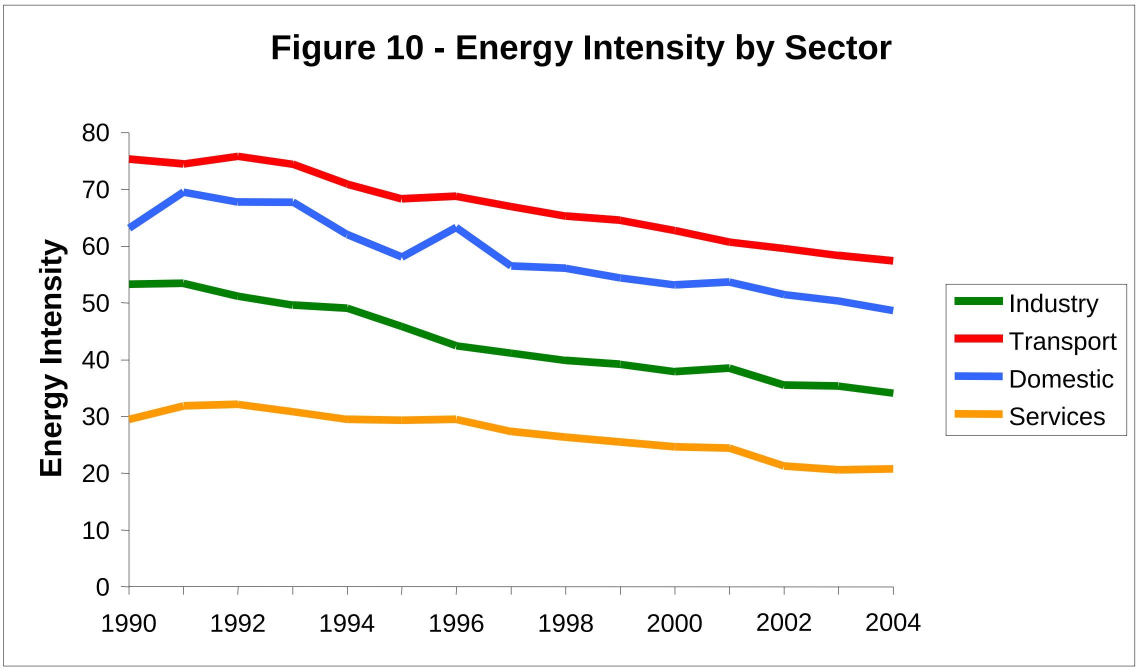


23. While energy demand since 1990 has grown on average 0.7 % per annum, growth in the economy as a whole over this period has been 2.7 % per annum. Overall energy intensity, as measured by the ratio of total final demand to a measure of growth, has generally declined. Industrial energy intensity improvement between 2000-2004 has been slightly lower than previously observed reflecting a recent fall in industrial sector output. With projected improvement in levels of output and the impact of policy measures, energy intensity improvement is expected to higher. Table 12 and Figure 10 illustrate the energy intensity improvement since 1990.

TABLE 12 – Average Per Annum Changes in Energy Intensity by Sector [17]

	Industry	Transport	Residential	Services
1990-1995	-2.8%	-1.9%	-1.6%	-0.1%
1995-2000	-3.5%	-1.6%	-1.7%	-3.2%
2000-2004	-2.5%	-2.1%	-2.1%	-3.9%

[17] Calculated as proportion of energy demand to an index of real GDP (2004=100) for Industry and to an index of real GVA (2004=100) for Services. Calculated as proportion of energy demand to an index of real GDP (2004=100) and an index of households (2004=100) for Transport and Domestic.



24. Climate Change Programme measures will have contributed to the most recent improvements in energy intensity.

Historic Carbon Intensity Change

25. Carbon intensity is measured as the ratio of the total carbon emissions resulting from the burning of fossil fuels to the unit of measured output. Lower carbon intensity could reflect a variety of factors:

   a. Switching from a carbon intensive fuel, for example coal, to a less carbon intensive fuel, such as gas;

   b. Lower energy demand per unit of output represents improvement in energy efficiency;

   c. Structural switching of output away from energy intensive sectors to less energy intensive sectors.

26. Table 13 illustrates historic carbon intensity change by sector 1970-2000 compared with the rate 2000-2020 implied by our central case projection favouring coal[18]. The impact of policy measures at their assumed level of saving is clearly indicated in the residential sector, by improvement between 2005-2010. Projections beyond 2010 do not assume further measures - only further penetration of a measure already existing in 2010, e.g. further improvement of average car stock where new cars purchased beyond 2010 are of the same standard achieved in 2010.

[18] Electricity here is assigned to the final demand sectors.

TABLE 13[19] - Historic and projected rate of carbon intensity improvement (% p.a.)

	Historic rate of improvement	Rate of carbon intensity improvement (% p.a.) implied by central projection			
	1970-2000	**2000-2005**	**2005-2010**	**2010-2015**	**2015-2020**
Residential	4.3 (2.6)	2.8	4.2	2.5	2.5
Transport	1.2 (1.1)	2.1	2.1	1.9	2.1
Industry	3.7 (3.0)	4.0	1.8	1.6	1.6
Services	2.7 (1.8)	4.2	3.2	1.9	2.0

27. Fuel switching in the final demand sectors has generally been to less carbon intensive fuels. In the residential sector, for example, households have switched from fossil fuel such as solid fuel or oil to gas for heating their homes. This can be seen in Table 14, which shows fuel shares in the residential sector since 1970.The absolute levels of fuel use are in Figure 11[20]. Figure 12[21] shows the change in carbon intensity per household in the same period.

TABLE 14 – Residential Sector Fuel Shares Since 1970

	Solid Fuel	Natural Gas	Oil	Electricity	Renewables
1970	48.7%	24.2%	9.1%	18.0%	0.0%
1980	20.9%	53.4%	7.1%	18.6%	0.0%
1990	10.2%	63.4%	6.1%	19.8%	0.5%
2000	4.1%	67.9%	6.9%	20.5%	0.5%
2004	2.7%	69.9%	6.4%	20.4%	0.5%

[19] Figures in parentheses indicate historic rate excluding dash for gas effect.
[20] There are also small contributions from renewables and Heat sold (Heat sold is not listed as a separate element until 1998 in DUKES).
[21] Carbon Intensity calculated as direct carbon emissions (excluding emissions from electricity use) (MtC) to an index of households (2004=100). Emissions from electricity use and heat sold to the domestic sector were excluded from the carbon intensity calculation because the combinations of fuels used in their production are not determined by the domestic sector.

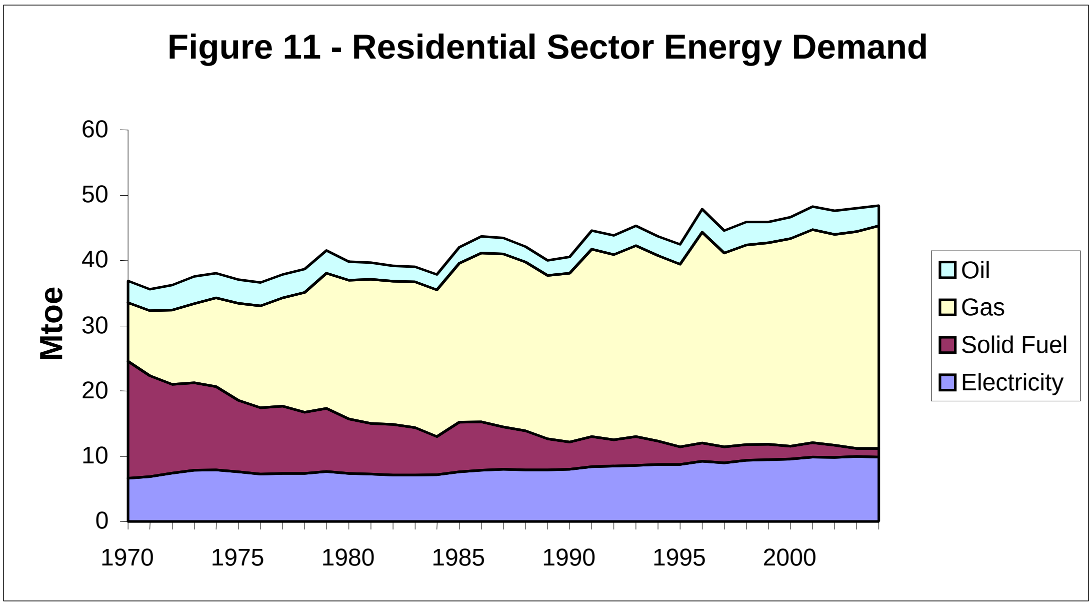


Figure 11 - Residential Sector Energy Demand
Mtoe
60
50
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
Oil
Gas
Solid Fuel
Electricity

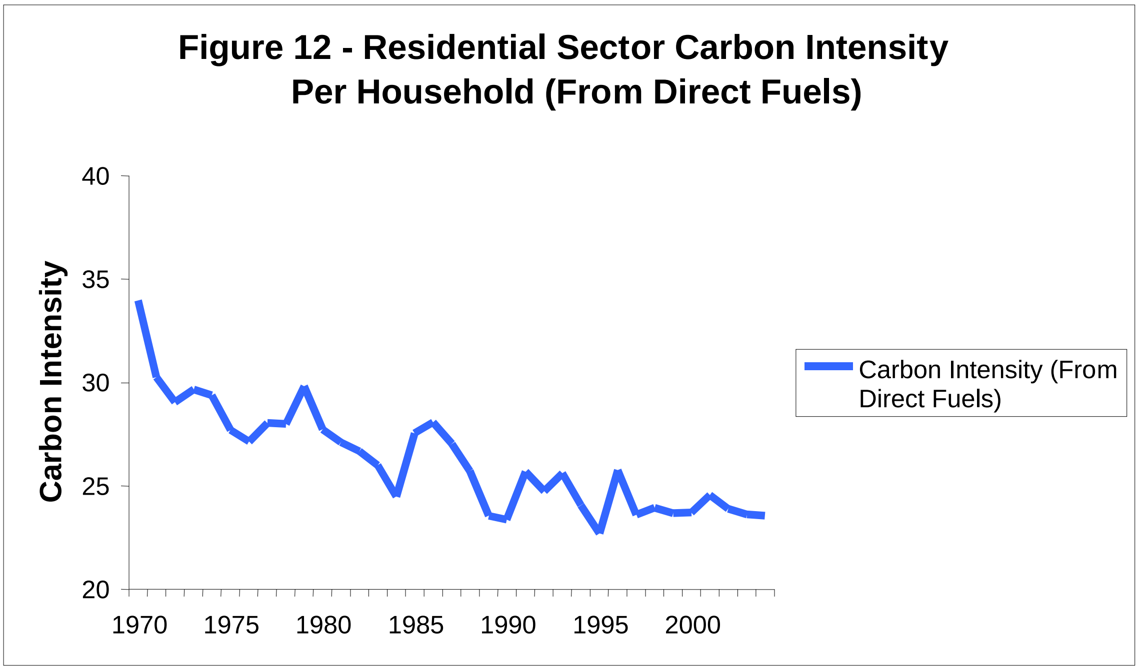


Figure 12 - Residential Sector Carbon Intensity Per Household (From Direct Fuels)
Carbon Intensity
40
35
30
25
20
1970
1975
1980
1985
1990
1995
2000
Carbon Intensity (From Direct Fuels)

28. The quantity of solid fuel and oil consumed in the domestic sector is now relatively low, and this would imply potential for further fossil fuel switching is limited.

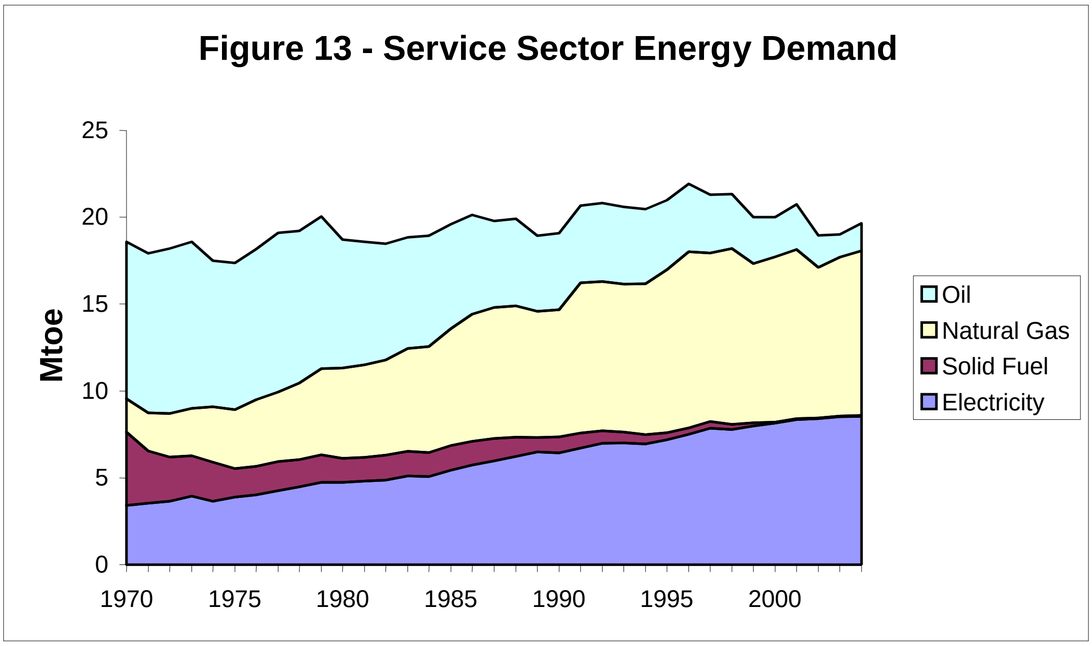
29. Carbon intensity in the industrial sector has also improved since 1970. Some fuel switching has taken place, but this has been largely the result of structural change within the manufacturing sector.

30. Improvement in carbon intensity in the service sector reflects the extent of fuel switching in this sector, carbon intensity change of electricity consumed and the relatively high growth in GDP contribution. The extent of fuel switching can be seen in Figure 13[22] (and Table15[23]) below showing energy demand by fuel since 1970. The service sector includes public administration and the commercial sector. Public Administration includes schools, hospitals etc. The commercial sector energy demand includes energy used in offices, the retail sector, hotels and restaurants. Commercial sector transport fuel demand is included with the transport sector.

TABLE 15 **-** Service Sector Energy Demand (Mtoe)

	Electricity	**Solid Fuel**	**Natural Gas**	**Oil**	**Renewables**
1970	3.4	4.2	1.9	9.0	0.0
1980	4.7	1.4	5.2	7.4	0.0
1990	6.4	0.9	7.3	4.4	0.1
2000	8.2	0.1	9.5	2.3	0.2
2004	8.5	0.1	9.5	1.6	0.2

[22] There are also small contributions from renewables and Heat sold.
[23] DUKES 2005. In this instance, 'Services' corresponds to 'Other Final Users' in DUKES and so also includes Agriculture.



31. Generally gas, oil, solid fuel and some electricity will be used in space and water heating and cooking with electricity providing lighting and power for equipment and appliances. The growth in demand for personal computers since the 1980's has contributed to increased demand for electricity in offices. Overall Service sector output, measured by the sector's contribution to economic growth or gross value added (GVA), has been strong at 4.5 % per annum, indicating a strong improvement in carbon intensity. This improvement has been lower post 1990 than 1970-1990, with scope for further fuel switching reduced. Overall Service sector energy demand has, however, grown on average 0.6% per annum since 1990. Service sector energy intensity improvement since 1990 has been of the order of 1.5% per annum, of which about 1.1 % has been reflected in carbon intensity improvement.

32. The transport sector includes road, air (domestic only) and water transport. Road transport represents 73.5% of energy used within this sector. Within this road transport sector, the DTI modelling methodology is not at the detailed level of miles travelled but at the aggregate fuel demand level, and energy demand reflects only demand for motor spirit and diesel since 1984[24]. Consequently, the approach can indicate relatively little of the detailed factors behind energy and carbon intensity improvement. Table 16 shows transport fuel shares since 1970. Figure 14 depicts absolute levels of use in the same period.

[24] DUKES 2005

Figure 14 - Transport Sector Energy Demand by Fuel

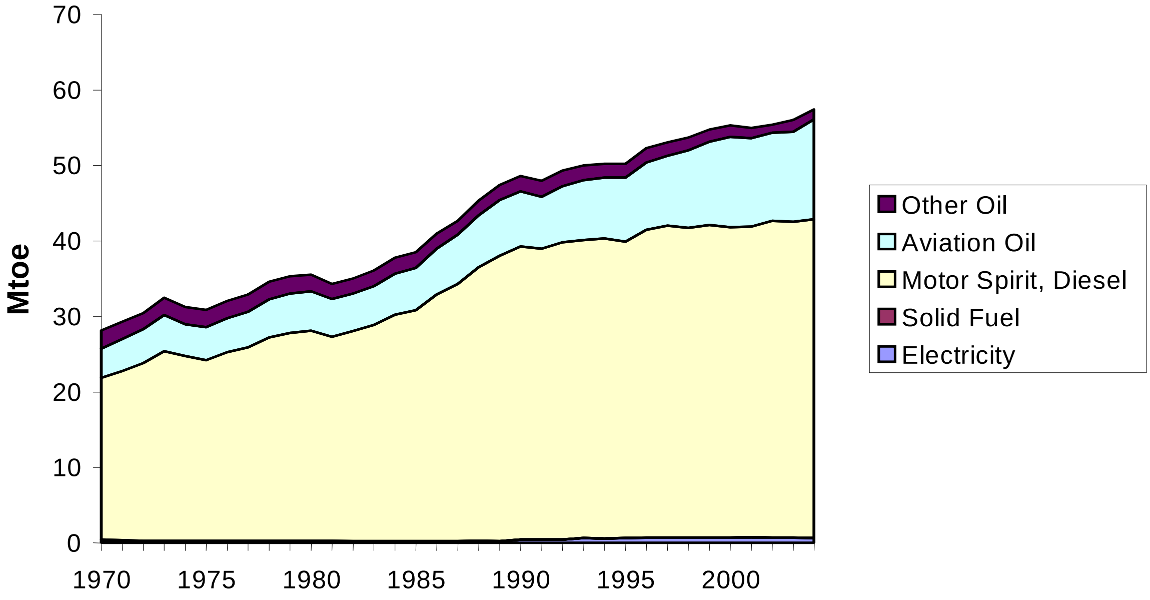
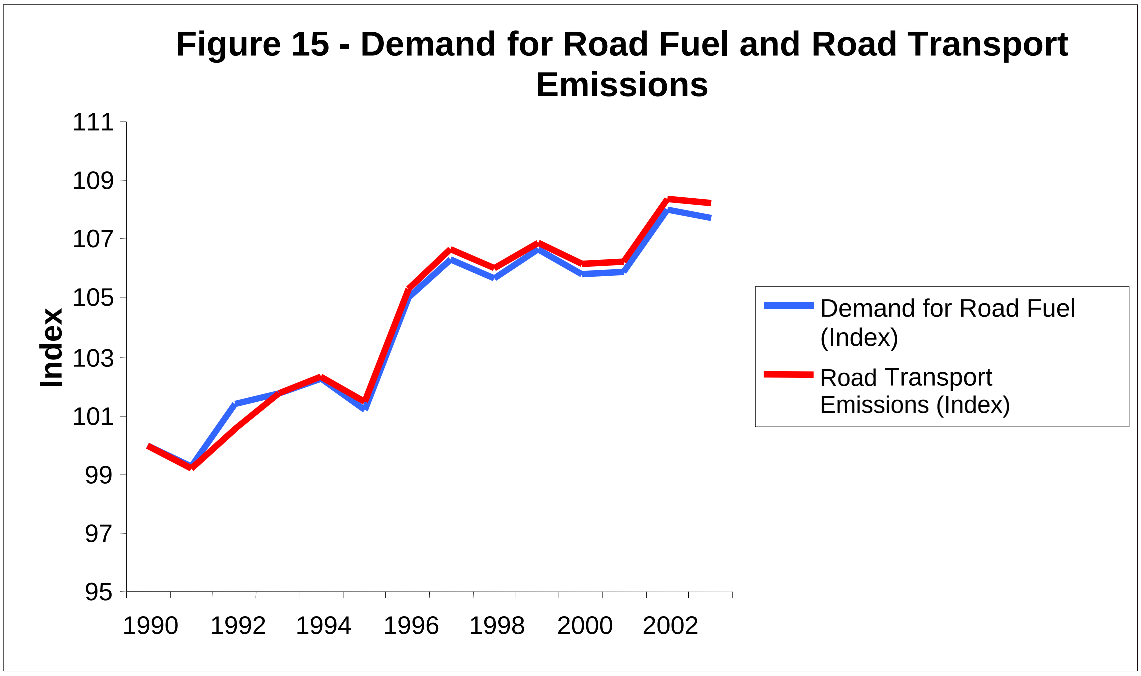


TABLE 16 - Transport Sector Fuel Shares since 1970

	Electricity	Solid Fuel	Motor Spirit and Diesel	Aviation Oil	Other Oil
1970	0.8%	0.8%	76.0%	13.7%	8.7%
1980	0.7%	0.1%	78.3%	14.7%	6.1%
1990	0.9%	0.0%	79.8%	15.1%	4.2%
2000	1.3%	0.0%	74.3%	21.7%	2.7%
2004	1.2%	0.0%	73.5%	22.9%	2.4%

33. Although there has been a significant growth in demand for diesel since 1980 the relative carbon content of diesel and differences in fuel efficiency results in a relatively small change in carbon intensity. Sales of biofuels are currently too low to impact significantly on the carbon intensity of transport. Energy efficiency in road vehicles has improved historically at a rate of approximately 0.6% per annum[25]. However recent moves towards the purchase of larger and heavier vehicles will have offset some of the technical advances that improve efficiency. The current Voluntary Agreement package is expected to provide improvement in carbon intensity in this sector. Figure 15[26] illustrates fuel demand and carbon emission indices since 1990.

[25] Carbon to Hydrogen Road Maps for Passenger Cars: A Study for the Department for Transport from the Department of Trade and Industry (November 2002)
[26] Historic emissions calculated on a 5 yearly basis and so the graph has been interpolated between these years.



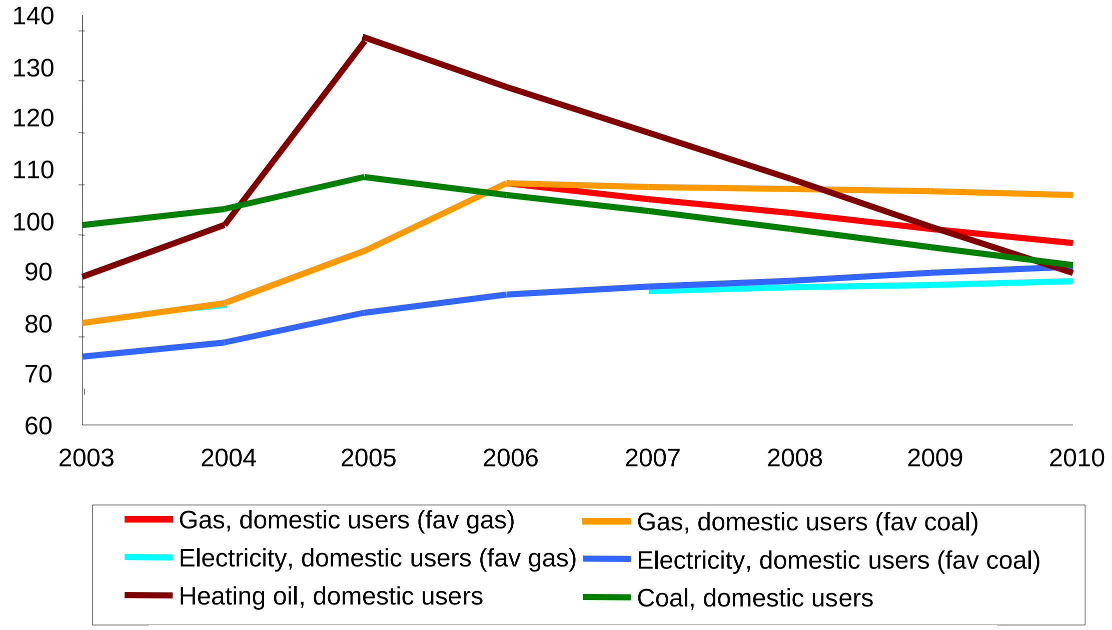
PROJECTED ENERGY DEMAND AND CARBON INTENSITY

34. Energy demand projections are based on each of the four scenarios related to alternative future assumptions of fossil fuel prices and other assumptions as summarised in Chapter 3.

Residential Sector

35. Residential energy demand derives largely from heating and provision of hot water and energy for cooking. Various fuels can provide this energy. Energy is also needed throughout the year to run the various household appliances and entertainment equipment we like to have in the home. This is generally provided through electricity. The number of appliances we have depends on our income and lifestyle. The demand for electricity within the UK is linked to the number of households, the level of disposable income and price of electricity. Figure 16 illustrates the index of growth in domestic fuel prices under the four scenarios.

Figure 16 – Index of Domestic Sector Fuel Prices Under the Four Scenarios (1990=100)



36. The total energy required in the UK to heat homes, provide hot water, and for cooking depends on the total number of households in the UK and the internal temperature. The external temperature - represented by a weighted average of the number of days in the year that the external temperature falls to a level at which the average household would require some form of heating - is known as Heating Degree Days (HDD). The number of HDD per year, the level of warmth we expect within the home and the way in which we choose to heat the home all determine the total energy demand for heating.

37. There is evidence that since 1990 internal temperatures have been increasing. However, 1990 was a particularly warm year. This combination of factors, together with an increase in the number of households in the UK, has led to an increase in residential gas demand[27] since 1990. Measures designed to improve energy efficiency in the homes such as more efficient boilers and tighter building regulations offset some of this. The level of the fuel savings assumed in the projection due to the policy measures is illustrated in Figure 17 as the difference between the solid and the broken lines.

38. Since the November 2004 projections energy demand in the residential sector has been completely re-modelled. The bottom-up methodology, based on appliance ownership data, has been replaced

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[27] Gas is the fuel principally used in heating the home. BRE estimate that in 2000 of the almost 90% of homes with central heating 71% use gas.

by cointegrating techniques which identify both long-term relationships and short-term responses. Household income, temperature and fuel prices are found significant explanatory variables.

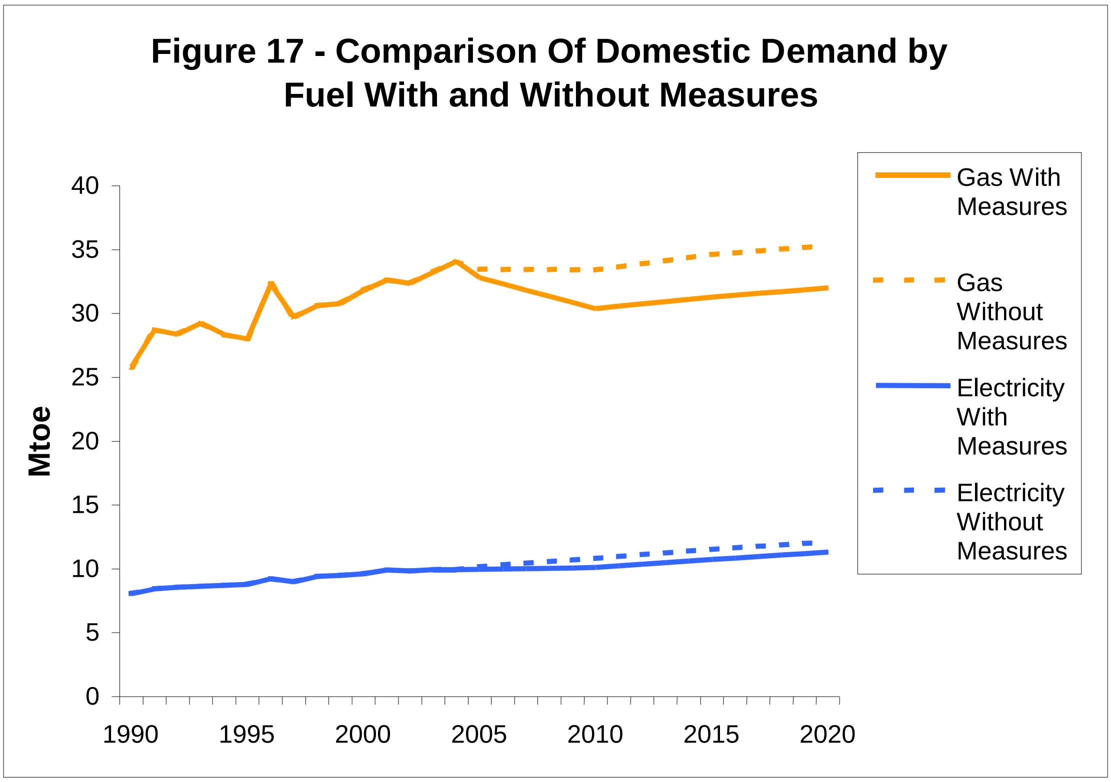
39. Remodelling of residential sector energy demand has allowed for a saturation effect in projected household demand for gas, with – abstracting from the impact of the retail price of gas - household gas demand levelling off rather than continuing to grow at rates seen in the past. This levelling off reflects that demands for gas (principally for central heating) are reaching levels where there is limited scope for further increase. The level of projected demand is broadly consistent with separate modelling of the sector conducted by Defra analysts. The DTI projection assumes that by 2020 97% of homes will have central heating of which 78% will be gas fired.

40. Table 17[28] and Figure 17 below illustrate gas/electricity demand in the residential sector, with and without the impact of current Climate Change Programme measures.

TABLE 17 – Residential Sector Projected Gas and Electricity Demand With and Without Climate Change Programme Measures (Mtoe)

	Gas Demand		**Electricity Demand**	
	With Measures	**Without Measures**	**With Measures**	**Without Measures**
2005	32.8	33.5	10.0	10.2
2010	30.4	33.4	10.1	10.8
2015	31.3	34.6	10.7	11.5
2020	32.0	35.3	11.3	12.1

[28] Projections are taken from the central case favouring coal. A detailed table of all types of energy demand in the residential sector from 1970 to 2020 can be found in Annex G.



Road Transport Sector

41. The transport sector includes energy demand from road, air, water and rail transport. Road transport represents some 73.5 % of total energy demand. For the UEP air transport energy demand includes fuel sold in the UK for domestic flights only.

42. The road transport sector has been extensively re-modelled since the Nov 2004 projections. Current modelling incorporates trends identified by the DfT towards car ownership and vehicle efficiency. Mileage levels constrained by congestion, and demographics implied by DfT modelling are now reflected in the DTI projections.

43. DfT has separately published projections of transport use (CO_2 emissions) in the UK. These projections employ a bottom-up approach, using survey and other detailed data on typical car use, including length and frequency of journey, road use and vehicle type etc. DTI modelling reflects a more top-down approach, using aggregate details such as level of car ownership by household, household income, price of road fuel and a broader approach to vehicle category. It assesses transport demands as one sector within a wider model of overall UK energy demands.

44. Despite the different approaches there is a high degree of agreement between the DfT and DTI emission projections from road transport. In fact, future projections are broadly the same once account is taken of

the fact that DTI modelling only includes firm and funded measures and so, unlike the DfT, does not include the fuel economy improvements expected from a further voluntary agreement or similar policy instrument as one has yet to be finalised.

45. The recent revisions to the DTI road transport modelling are based on two broad vehicle groups of fuel demand. These are termed *cars* (mostly privately owned but including taxis) and *commercial vehicles*. Commercial vehicles include LGVs, HGVs, buses, coaches, and motorcycles. Fuel demand is obtained from DUKES commodity balance data on petroleum products. These data provide total fuel for road vehicles as motor spirit, diesel (and some LPG).

46. Fuel demand data split between private and commercial vehicles are not available in DUKES, however, a NETCEN breakdown of fuel use by category (motor spirit and diesel) was available for the years 1990-2003. Backcasting this data within the constraints of available DUKES and other data sources provides estimated sample series for all categories above. Assumptions on future car ownership levels and the projected split of car stock by fuel type were obtained from DfT based on their own analysis for the National Transport Model. Additional assumptions reflecting efficiency and carbon improvements under the existing Voluntary Agreement package reflect recent analysis and monitoring carried out by the DfT of current and forecast progress towards the agreed levels of emissions for new car manufacture. These assumptions have been incorporated into the DTI modelling approach.

47. Road fuel demand from cars is linked to levels of car ownership, retail prices of petrol and diesel (including duties and taxes) and household disposable income. Price and household income elasticities with respect to fuel demand for this group are estimated at -0.2 and 0.1 respectively. These elasticities are estimated before allowance is made for the current Voluntary Agreement package impact on new vehicle efficiencies.

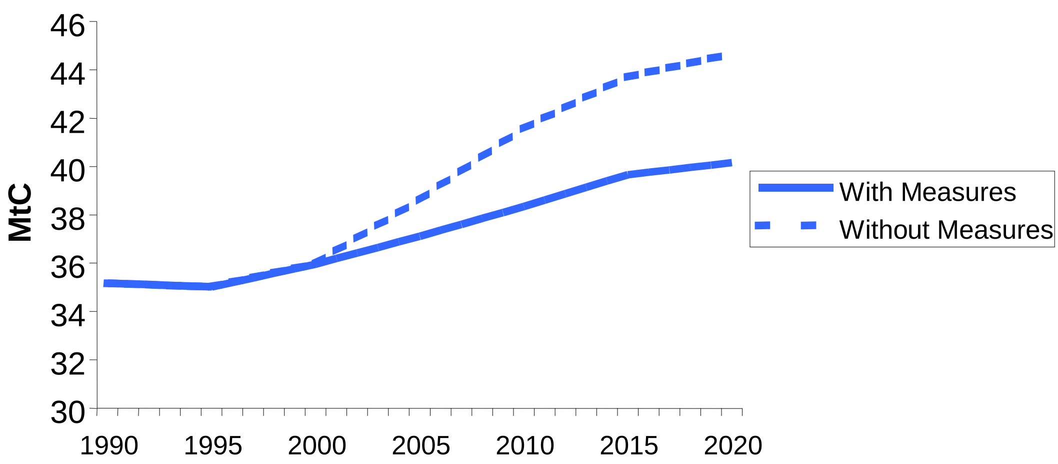
48. Since the DTI baseline projections incorporate only existing policies, a possible further EU Voluntary Agreement package, beyond the life of the existing agreements due to end in 2008/9, has not been assumed. Total commercial fuel demand is driven by economic growth with an elasticity of 0.07.

49. Table 18 below illustrates estimated historic and projected (central scenario) petroleum fuel demand and emissions. Figure 18 provides the historic and projected emissions with and without CCP measures.

TABLE 18 – Estimated Historic and Projected (Central Scenario) Petroleum Fuel Demand and Emissions

	1990	2000	2010	2020
Cars vehicle group				
Fuel demand (Mtoe)	25.1	25.8	28.8	30.0
Motor spirit share (%)	94	88	73	63
Diesel share (%)	6	12	27	37
Commercial vehicle group				
Fuel demand (Mtoe)	13.7	15.2	16.5	17.2
Diesel share (%)	80	90	96	96
Total				
Fuel demand (Mtoe)	38.8	41.1	45.3	47.2
CO_2 emissions (MtC)	30.1	32.0	34.6	36.2
Of which impact of the existing VA package to improve vehicle efficiency (MtC)	0	0	-2.3	-3.1

Figure 18 - Comparison of Transport Sector Emissions With and Without CCP Measures



50. These projections do not include any potential savings from biofuels. The expected Renewable Fuels Obligation will lead to much higher biofuels sales (5% by 2010) and hence will further improve the carbon intensity of transport going forward. Potential transport sector CO_2 savings that might result from this are 1.6MtC.

Service Sector

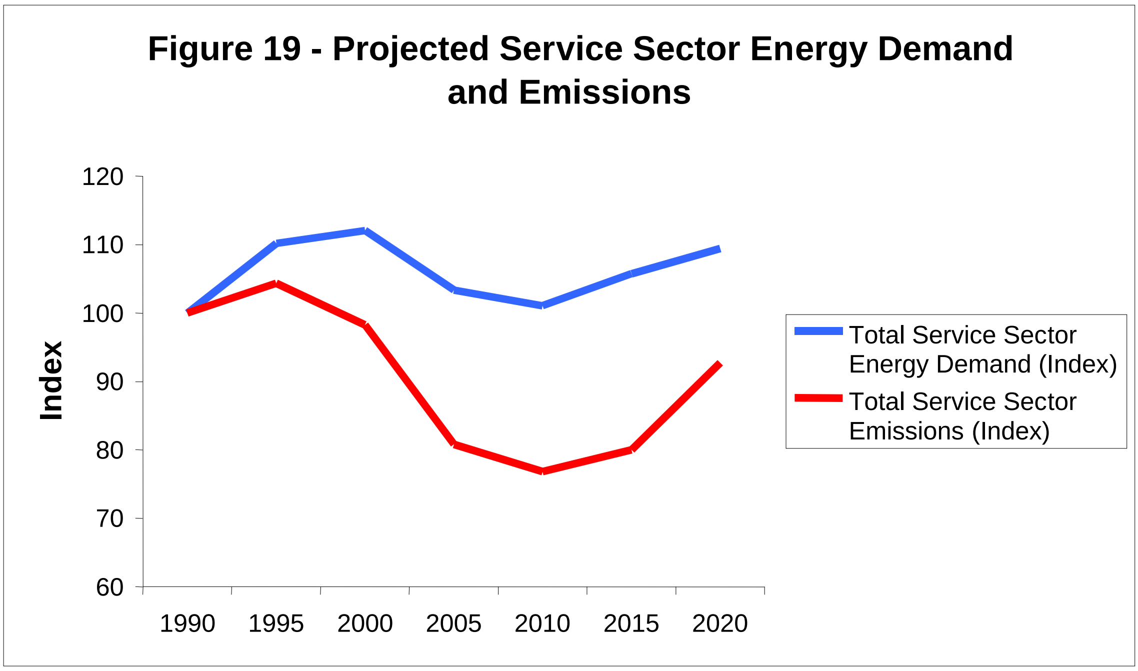
51. Service sector energy demand and emissions are modelled on the DUKES categorisation of the commercial and public sectors. Energy demand growth in the commercial sector is based on economic activity. This is reflected in the commercial sector's contribution to GDP and level of employment. Public administration energy demand is also based on contribution to GDP and the level of public sector employment. Previously modelling has related energy demand in the

service sector to floor space, area of shops, offices etc. This methodology relies heavily on data on floor space collected through surveys. It is more suited to a detailed bottom-up type of analysis, including a much wider testing of explanatory variables. The simplified DTI modelling approach, which was first used in the November 2004 projections, has the advantage that the data is published and available nationally.

52. As shown above the service sector is not as energy intensive as the manufacturing sector. The sector's relative contribution to the UK economy is expected to continue to grow. Underlying energy intensity improvement is expected to continue into the future. The impact of existing CCP measures in the sector is expected to reduce energy intensity still further. Table 19 and Figure 19 illustrate projected energy demand and emissions in the service sector to 2020. Since 1990, the demand for oil within this sector has been decreasing. Until 2000, this demand was replaced by gas. Since 2000, the reduced level of oil demand has resulted in a 1.4MtC reduction in emissions in this sector. This reduction in carbon intensity can be seen in Figure 19.

TABLE 19 – Projected Service Sector Energy Demand and Emissions

	Total Energy Demand (Mtoe)	**Total Emissions (MtC)**
1990	19.2	8.3
1995	21.2	8.7
2000	21.5	8.2
2005	19.9	6.7
2010	19.4	6.4
2015	20.3	6.7
2020	21.0	7.7

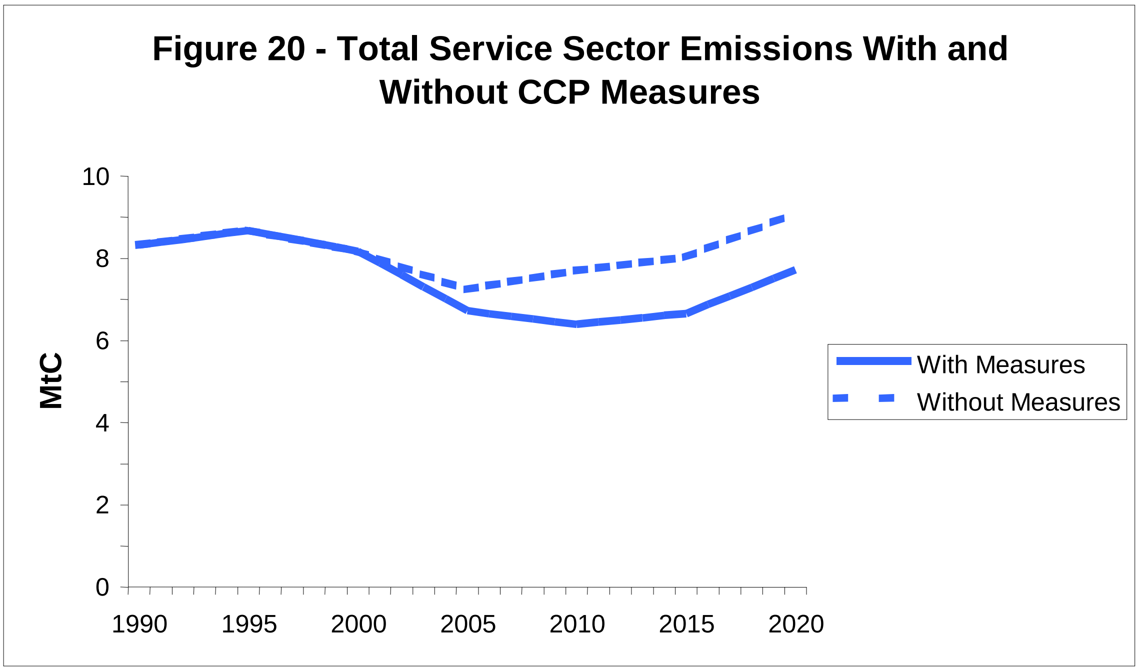


53. The impact of the CCP measures is illustrated in Table 20 and Figure 20[29], which show the expected future level of emissions from the service sector with and without the current Climate Change Programme measures[30].

TABLE 20 – Projected Total Service Sector Emissions With and Without CCP Measures (MtC)

	With Measures	**Without Measures**
1990	8.3	8.3
1995	8.7	8.7
2000	8.2	8.2
2005	6.7	7.2
2010	6.4	7.7
2015	6.7	8.0
2020	7.7	9.1

[29] Linear Interpolation is used between 5-year intervals.
[30] Projections are taken from the central case favouring coal.

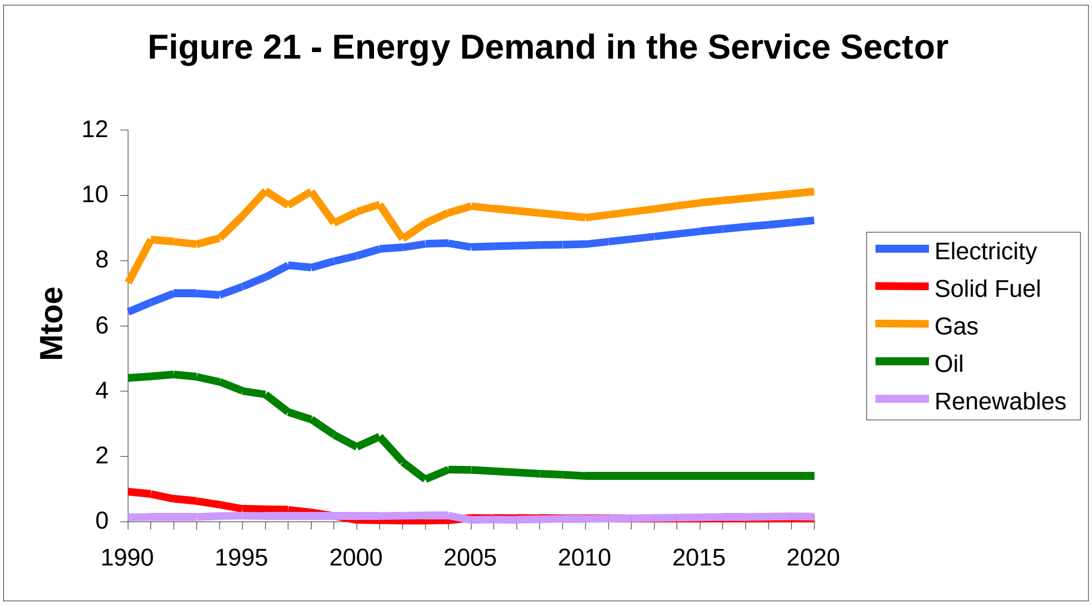


54. Table 21 and Figure 20 illustrate projected service sector energy demand (by fuel)[31].

TABLE 21 - Service Sector Historic and Projected Energy Demand by Fuel (Mtoe)

	Electricity	Solid Fuel	Natural Gas	Oil	Renewables
1990	6.4	0.9	7.3	4.4	0.1
1995	7.2	0.4	9.4	4.0	0.2
2000	8.2	0.1	9.5	2.3	0.2
2005	8.4	0.1	9.7	1.6	0.1
2010	8.5	0.1	9.3	1.4	0.1
2015	8.9	0.1	9.8	1.4	0.1
2020	9.2	0.1	10.1	1.4	0.2

[31] Projections are taken from the central case favouring coal. ‘Services’ here also includes the agriculture sector to correspond with the ‘Other Final Users’ sector in DUKES.



Industry Sector

55. The DTI modelled industry sector is broadly based on the SIC two digit manufacturing sectors and includes a category for construction[32]. The categories are summarised as industry sub-sectors in Table 22:

TABLE 22 – Summary Description of Industry Subsectors

Industrial Subsector	**Sic (03) Classification includes**	**Includes**
Iron and Steel	27, excluding 27.4, 27.53, 27.54	Iron and Steel Production, Casting, Blast Furnaces
Non-Ferrous Metals	27.4, 27.53, 27.54	Non-ferrous metal production, Castings
Mineral Products	14, 26	Mining and quarrying of non-energy producing materials, Glass products, Ceramic goods, Other non-metal products
Chemicals	24	Industrial Gases and chemicals, Pharmaceuticals, Agrichemicals, paints and Varnishes, Toiletries
Engineering and Vehicles	30-35	Metal products, Electrical and optical equipment, Transport equipment, Other Machinery and Equipment

[32] The category construction also includes "other industries" (industries not included elsewhere).

Food, Drink and Tobacco	15, 16	Food, Beverages, Tobacco Products
Textiles, Leather and Clothing	17-19	Textiles, Clothing, Footwear products, Leather goods
Paper, Printing and Publishing	21, 22	Pulp, Paper and paperboard products, Printing and publishing
Construction and Other Industries	13, 20, 25, 36, 37, 41, 45	Construction, Wood and wood products, Rubber and Plastic Products, Water supply, Sports goods and toys, Jewellery

56. Energy demand growth is derived using historic relationships between sub-sector output growth, energy demand and fuel prices. Output growth is measured in terms of physical output, sub-sector contribution to economic growth (GVA) or by Index of production.

57. Assumptions of future UK economic growth are generally made only at the whole economy level or at the level of the split between manufacturing or service sector level. The Treasury Budget or Pre-Budget (PBR) announcements on assumptions of future economic growth are given at this level.

58. Determination of growth by sub-sector, within the overall Treasury umbrella of economic growth, is provided by external consultants Oxford Economic Forecasting (OEF) on the basis of DTI assumptions of fossil fuel prices.

59. Given big differences in energy use across industry, future sub-sector growth is a key assumption in projecting overall industry energy demand and carbon intensity. Table 23 illustrates sub-sector growth determined by OEF and compatible with the most recent growth assumptions made in the December 2005 Pre Budget Report. Change in 2010 output as against assumptions in the November 2004 projections is also shown. These are generally small.

TABLE 23 – Projected Industrial Sub Sector Growth Indices

	Food, drink & tobacco	**Textiles, leather & clothing**	**Pulp, paper, printing & publishing**	**Chemicals & chemical products**	**Non-metallic minerals**
2000	100.0	100.0	100.0	100.0	100.0
2005	104.8	69.5	96.8	111.2	106.5
2008	**105.4**	**60.0**	**100.8**	**120.3**	**110.6**
2009	**106.5**	**57.9**	**102.7**	**124.3**	**112.4**

2010	**107.3**	**55.7**	**104.1**	**128.1**	**113.7**
2011	**108.1**	**53.5**	**105.4**	**132.0**	**115.0**
2012	**108.9**	**51.4**	**106.7**	**135.9**	**116.2**
2015	111.2	45.6	110.7	148.3	119.9
2020	114.7	37.2	117.2	170.9	125.5
Change in growth at 2010 compared with Nov 04 projection	**-3.3%**	**-17.6%**	**-4.5%**	**+0.0%**	**+4.4%**

	Non-ferrous metals	Engineering & vehicles	Construction & other industry	Iron + Steel
2000	100.0	100.0	100.0	100.0
2005	113.4	94.2	110.8	87.6
2008	**119.7**	**102.3**	**118.1**	**111.1**
2009	**121.8**	**104.1**	**120.0**	**112.0**
2010	**122.4**	**105.5**	**121.8**	**112.4**
2011	**123.2**	**106.9**	**123.5**	**112.7**
2012	**124.0**	**108.4**	**125.2**	**113.0**
2015	126.2	112.8	130.4	113.7
2020	129.4	120.7	139.6	114.5
Change in growth at 2010 compared with Nov 04 projection	**+5.4%**	**+0.4%**	**-5.9%**	**-1.5%**

60. Table 24 and Figure 22 show projected total industry energy demand[33].

TABLE 24 – Projected Industry Sector Energy Demand (Mtoe)

	Electricity	Solid Fuel	Natural Gas	Oil	Renewables
2005	9.8	5.1	13.5	6.7	0.2
2010	10.2	5.8	14.3	6.9	0.2
2015	10.8	5.8	15.5	6.8	0.2
2020	11.4	5.8	16.6	6.8	0.2

[33] Energy demand by the Iron and steel sector includes fuel used in transformation and therefore the total industry energy demand is higher than reported in Dukes. A complete table of historic and projected figures, with estimates of transformation added to the data prior to 2005, can be found in Annex G.

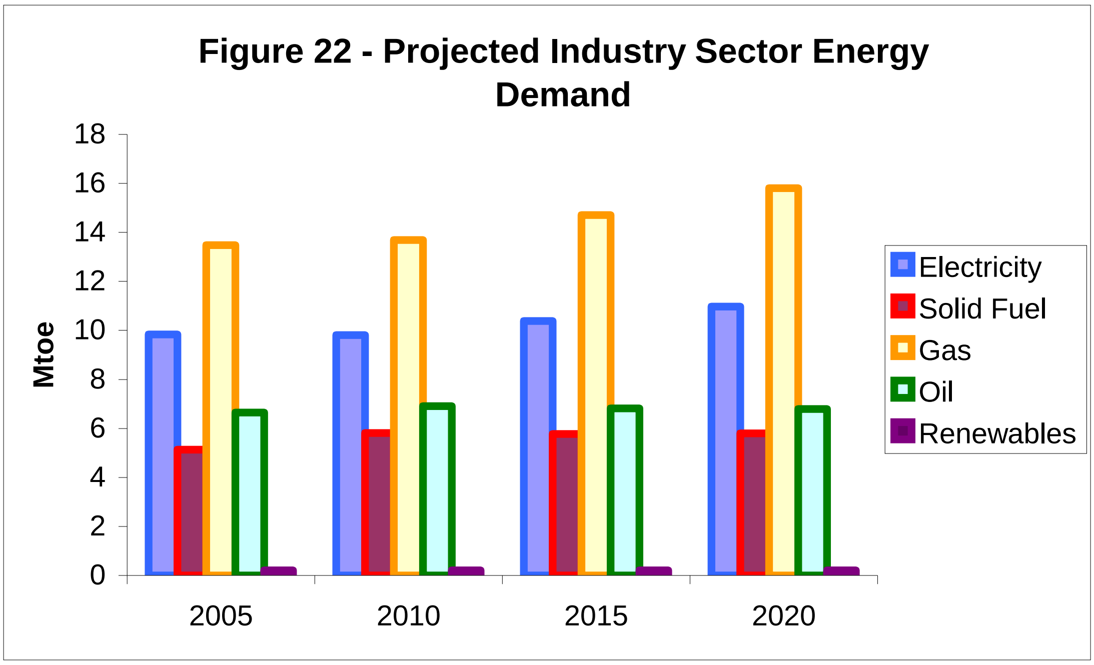


Figure 22 - Projected Industry Sector Energy Demand
Mtoe
0
2
4
6
8
10
12
14
16
18
2005
2010
2015
2020
Electricity
Solid Fuel
Gas
Oil
Renewables

CHAPTER 5 - ENERGY SUPPLY - OFFSHORE AND REFINERIES

Offshore Oil and Gas Extraction

61. Energy use offshore has increased dramatically since the commencement of large-scale oil production in the mid 1970s. However, energy use has not declined with more recent falls in oil production. The measured energy intensity of the sector has therefore risen. One of the main reasons for this is that it requires additional energy use in order to secure additional production from any given field, as, for example, natural reservoir pressure declines and as the water cut[34] increases.

62. The November 2004 projections for offshore emissions in 2005 embodied an assessment of likely emissions arising offshore, including the impact of energy intensity trends. A similar assessment has been made for the current projections exercise for 2010. While there are obvious uncertainties involved, in broad terms the assessment for 2010 is that, while the current offshore infrastructure remains in place, it is unlikely that there will be a significant decline in the level of energy use and, therefore, of emissions before about 2015, for the reasons already given.

63. It is evident from recorded data that flaring associated with oil and gas extraction activities has been in decline over a sustained period. The actual outturn for flaring activity is of course a function of a large number of variables, including the characteristics of fields, the impact of distance from the nearest gas export infrastructure, the impact of consents and also the level of production. Another influence, and one which will perhaps exert more influence from now on, could be the level of gas prices. All other things unchanged, the current and expected level of gas prices should be acting as an incentive to recover more natural gas than would otherwise be the case. This effect will tend to work at the margin for new field developments and it is judged to be extremely unlikely to become economic to retrofit gas export to an existing field. The projection of CO_2 emissions from flaring is for a continuing decline, though slowing a little in absolute terms in later years.

64. Table 25 below shows the key elements of the emissions projection for the offshore sector. The coverage is based on NETCEN's categories of emissions, which is based on energy use data in DUKES. This

[34] The water cut is effectively the share of water in overall fluid production. Water cuts tend to rise as reservoirs become depleted, as oil containing structures are not uniform and some hydrocarbons will be inaccessible to the injected water which is designed to maintain reservoir pressure and to assist in achieving the maximum possible overall recovery of reserves.

coverage includes the activities of the sector as a whole and therefore differs from the coverage of the EU-ETS scheme. The projections also allow for other sources of emission, not reported here. Projections for 2015 and 2020 are particularly uncertain.

TABLE 25 – Projected Emissions from Offshore Combustion and Flaring – UEP Basis

	2010	2015	2020
Offshore combustion, MtC	4.60	3.49	2.33
Flaring, MtC	0.65	0.45	0.30
Total, MtC	5.25	3.94	2.63
Total, $MtCO_2$	19.26	14.45	9.63

Oil Refineries

65. Modelling of refinery emissions has been undertaken on the basis of data supplied by the refineries on their NAP returns and in consultation with the UK Petroleum Industries Association[35]. The data was analysed with regard to direct emissions from fuel combustion, process emission and embedded CHP units and isolated from emissions due to the non-embedded CHP plants at Grangemouth, Immingham, Fawley that supply heat and power to refineries close-by. In the overall modelling for the UK, the Conoco plant at Immingham has been modelled as part of the electricity generation sector whilst the other non-embedded plant is retained as part of the sector.

66. In Table 26 below, 'fuel emissions' are those attributed to fuel use including embedded CHP but excluding the non-embedded plants listed above. 'Other emissions' includes these plants, process emissions and agreed additions which take account of legislative changes regarding the sulphur content of fuels. The large CHP plant at Immingham is excluded whilst the plant at Sullom Voe is included as it is considered to be part of the refinery sector for CHP purposes in government statistics. An annual throughput of 90Mt of crude oil is assumed in 2005 and 2010.

TABLE 26 – Historic and Projected Refinery Emissions

	Fuel emissions	Other emission	Total
2003	4.73	0.93	5.64
2005	4.55	1.03	5.58
2010	4.55	1.13	5.68
2015	4.55	1.13	5.68

[35] There may be some difficulties in coverage between the industry and NETCEN's estimates which could warrant further investigation.

67. These results show a picture of fairly constant emissions over the projection period. This is the overall result of a mixture of slowly increasing throughput following the closure of the Shellhaven and Gulf refineries in the late 1990s, temporary shutdowns of plant, displacement of boiler fuels by new CHP and the additions originating from the sulphur regulations.

68. Moving forward to 2015, no new refineries are expected, but some CHP build that is associated with the refineries is likely. In moving from simple boilers to new embedded CHP, overall efficiency will increase but so will fuel use, as there is now extra fuel necessary for generation. The refineries will benefit by the closure or reduced use of older boilers, thus reducing emissions and power exports to the grid will further reduce emissions in the electricity generation sector. Externally run CHP plant deemed to be in the electricity generation sector will displace old boilers with no extra fuels for generation. These will decrease refinery emissions.

69. Over this timeframe it is reasonable to expect general efficiency increases in the refining sector that can be set against the increased fuel use of CHP. Increased splitting of heavier fuels in order to enhance diesel production, reductions in sulphur content in association with the processing of higher sulphur crudes and the loss of European markets for fuel oil will all put upward pressure on processing requirements and energy use. In the absence of any firm data, however, the projection for 2015 has been left the same as that for 2010.

CHP Assumptions

70. Projections of CHP capacity, excluding the refinery sector, have been based on the analysis of Cambridge Econometrics from 2003. This work used aggregated data from the CHPQA database and projected an installed UK capacity of 8.1GW by 2010. Estimates of emissions from CHP are included in industry emissions quoted in Chapter 2.

CHAPTER 6 – ELECTRICITY GENERATION[36]

RECENT DEVELOPMENTS

Electricity Generation

71. Electricity generation from coal continues at high levels as a result of the large difference between gas and coal prices. Gas prices have increased since the end of 2003 and spot prices have been exceptionally high in the last few months. International coal prices meanwhile have fallen significantly from the levels seen in the last half of 2004, also contributing to coal's competitive position. Further support to coal generation has come from the construction of Flue Gas Desulphurisation (FGD) capacity, which generally enables generators to produce at high levels within plant and company limits on emissions of sulphur dioxide. It is interesting nonetheless that coal generation in the first three quarters of 2005 has remained at broadly the same level compared with the same period in 2004.

72. Gas-fired generation has also remained broadly at 2004 levels. Nuclear generation, while recovering somewhat, has not recovered to the extent previously anticipated. Generation from renewable plants has grown significantly from 2004 levels, partly due to higher output from hydro plants, but generation also seems to have increased from other types of plant. This is in line with the general expectation that new and large-scale wind-based schemes would begin production during the year.

73. Amongst the other key sources of electricity, imports have increased markedly in the last two years and appear to be broadly in line with expectations in the November 2004 projection.

Electricity Demand

74. In underlying terms, total electricity consumption has fallen slightly in the first ten months of 2005 compared with the same period in 2004[37]. If this trend were to continue for 2005 as a whole, it would be the first fall in demand since 1994.

75. As a result of the trend in demand and the likely increase in supply from renewable plants, imports and potentially also nuclear plants, it appears that the overall market for fossil fuels may have fallen a little in 2005.

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[36] The coverage of the industry is major power producers plus all other renewable generators. All other generators of electricity are included within the industrial or commercial sectors.
[37] The reported data shows a small increase, but a change in the statistical reporting periods used in the two years has affected the data.

MAIN ASSUMPTIONS

76. The background energy price assumptions used in this modelling work are set out in Tables 5 and 6 previously. The following explains some of the other key assumptions and thinking behind the projections.

Plant Closures

77. The projections for 2010 are premised on a modest amount of plant closures. Between 2005 and 2010 some 4GW of existing capacity is assumed to close. In round numbers, 1GW of this is nuclear, 2GW is coal and 1GW is other types of plant.

78. It is assumed that coal fired capacity declines a little for a number of reasons. These include the general ageing of the coal fleet and the impact of a more operationally demanding environment since the introduction of the New Electricity Trading Arrangements (NETA). Other reasons include the impact of environmental limits, where, for example, the ability of some generating units to comply with limits may be marginal.

Plant Construction

79. Construction activity in recent years has been relatively modest compared with earlier periods. The main sources of growth in capacity has been the renewables sector, combined with capacity increases in the form of new Combined Cycle Gas Turbine (CCGT) plants whose construction began a number of years previously.

80. Notwithstanding the restrained outlook for demand, there has been continued interest in new CCGT build and it is assumed that some new gas-fired capacity is constructed by 2010. Given likely construction and commissioning timescales, it is unlikely that such plants will be able to build up to their full generation potential during 2010.

81. The Government is committed to ensuring that the contribution from renewables increases over time. Generation[38] from all renewable sources is assumed to reach 33TWh in 2010. This estimate is based on work carried out by consultants to the DTI, supplemented by other estimates of possible generation from waste streams. Renewables capacity is assumed to rise accordingly.

Plant Operations

82. Other than normal operating constraints, plant operations are constrained by environmental limits. In particular, as a broad working assumption, coal plants without FGD are assumed to operate at load

[38] Gross supply.

factors no higher than 27%. Except where FGD equipment is available, a coal plant is assumed to operate on low sulphur coal.

SO2 and FGD Plant

83. Based on existing information regarding proposals to fit FGD, it seems likely that total FGD capacity in 2010 will exceed 13GW. It is possible that further FGD equipment will be added beyond the 13GW, including some projects concluding beyond 2010[39].

NOx

84. It is assumed that nearly all coal stations remaining on the system during the latter half of this decade will have some form of over-fire air system fitted, or will achieve equivalent emission reductions. Indeed, some companies have already announced plans to fit this type of equipment to some generating units. There may be exceptions to this standard, reflecting station-specific conditions. Retrofitting such equipment will add a modest amount to the costs of generating from coal power stations.

Plant Efficiency[40]

85. It is assumed in these projections that there are continued incentives to achieve the highest possible operational efficiency of coal-fired and CCGT power stations and thereby to reduce the underlying level of emissions, both to reduce CO_2 emissions and also reflecting a period of transition from the current acid gas control regime to that pertaining under the Large Combustion Plant Directive (LCPD).

86. Across the range of scenarios examined, the average coal plant efficiency is assumed to be 35% and for existing CCGTs an average of between 46% and 47% is achieved. For new CCGTs constructed by 2010, an efficiency of 53% is assumed.

SCENARIO RESULTS

87. Main influences on the generating sector projection are relative fuel prices – essentially, the difference between gas and coal prices – demand impact of the Climate Change Programme and a projected increase in generation from other sectors.

88. The differential between gas and coal prices in the central energy price cases falls sharply from current levels, although coal remains very

[39] Recent announcements, made after the main work on these projections was completed, suggest that FGD capacity may be higher than expected.
[40] Efficiency is based on the higher heating value and is after deducting own use. Such figures are a little lower than those published in DUKES.

competitive against gas. The Climate Change Programme acts to reduce electricity demand by some 30.5TWh in 2010. Electricity generation from other sources increases between 2005 and 2010.

89. Table 27 shows the projected generation mix in the central, favourable to gas case. Table 28 shows the projected generation mix in the central, favourable to coal case. Figure 23 illustrates the change in the fuel mix in generation over time in this scenario.

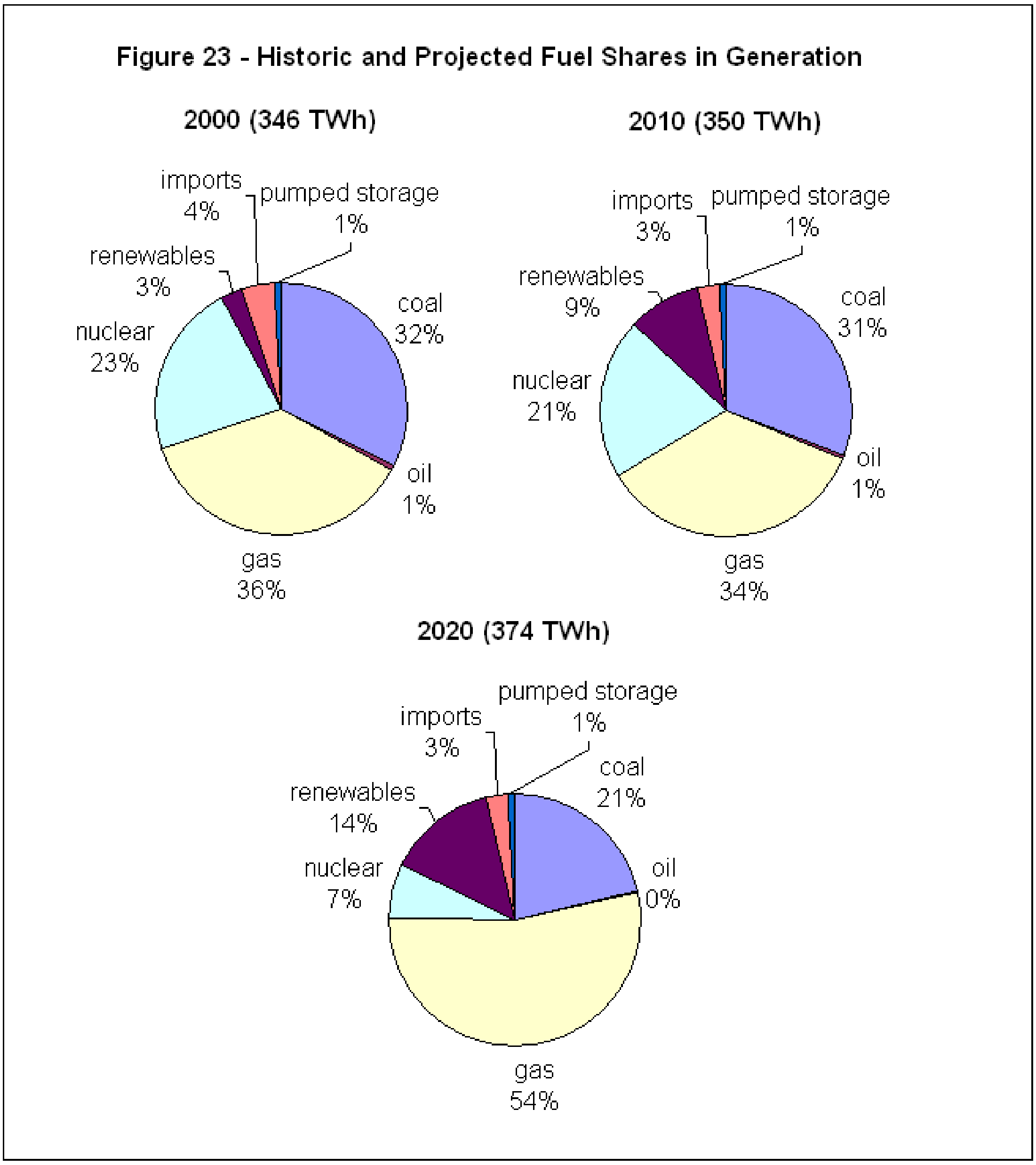
TABLE 27 - Gross Electricity Supply in Central (1) Favourable to Gas Case[41] (TWh)

	2000	2005	2010	2015	2020
Coal	112	123	103	94	58
Oil	2	2	2	2	1
Gas	127	132	132	165	228
Nuclear	78	74	73	34	26
Renewables	10	16	33	53	53
Imports	14	10	11	13	13
Pumped storage	3	3	3	3	3
TOTAL	**346**	**359**	**356**	**362**	**381**

TABLE 28 - Gross Electricity Supply in Central (2) Favourable to Coal Case[41] (TWh)

	2000	2005	2010	2015	2020
Coal	112	123	108	106	80
Oil	2	2	2	2	1
Gas	127	132	122	149	201
Nuclear	78	74	73	34	26
Renewables	10	16	33	53	53
Imports	14	10	10	10	10
Pumped storage	3	3	3	3	3
TOTAL	**346**	**359**	**350**	**355**	**374**

[41] The figures in this table relate to gross supply to the grid, plus imports of electricity. See also footnote 36 relating to the coverage of the sector.



90. This projection suggests a fall to 2010 in coal generation from recent high levels[42] although remaining above 100TWh in both central cases. The reduction in coal generation is brought about by the closure of some coal-fired plants, the increase in gas capacity and by the impact of environmental restrictions.

91. The recent high level of wholesale electricity prices is assumed to continue to lead to high levels of electricity imports, as well as to reduced exports. It is assumed that additional links are constructed, operating mainly in import mode.

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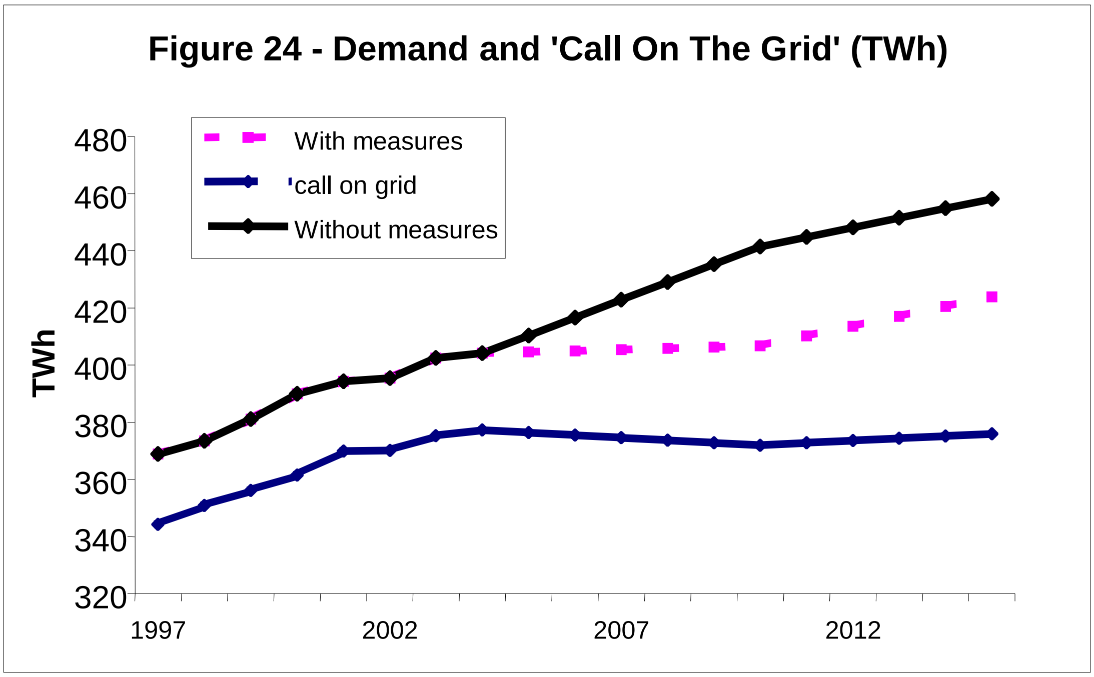
[42] Coal generation in 2004 is estimated to be 122TWh. Generation from gas is estimated to be 138TWh.

92. The ‘call’ on supply from the sector is restrained by demand reductions arising from the Climate Change Programme and by increased supply from other sectors. Figure 24 shows the development of electricity demand, together with the estimated impact of the Climate Change Programme and impact of generation from other sectors.



93. It is important to illustrate the sensitivity of the power station outlook with respect to future energy prices. The effect of alternative energy price assumptions is chiefly to change the split of generation between coal and gas[43]. Table 29 shows projected coal and gas – fired generation in the low and high energy price cases.

TABLE 29 – Coal and Gas Generation in the Low and High Energy Price Cases[44]

	Low Energy Price Case				High Energy Price Case			
	2005	**2010**	**2015**	**2020**	**2005**	**2010**	**2015**	**2020**
Coal	123	98	77	58	123	125	131	101
Gas	132	134	177	222	132	99	118	177

<u>Key Features of the Low and High Cases</u>

[43] The key determinant is the difference between gas and coal prices, rather than the absolute level of prices.
[44] Gross supply after own use

94. In the low energy price case, gas is sufficiently competitive to mean that coal generation falls just below 100TWh in 2010 and declines quite sharply again by 2015. The projected generation from coal in 2015 is influenced by the competitiveness of gas, leading to a lower level of overall coal capacity and upgraded capacity in particular. In broad terms, in comparison with the central, favourable to gas case, coal generation in this case is a little lower in 2010, but significantly lower by 2015.

95. In contrast, the projected generation from coal in 2010 in the high energy price case is comparable with current levels and is projected to increase slightly by 2015 as more upgraded capacity becomes available. Modelling on the high energy price assumptions suggests that not only is it likely that a very significant proportion of existing coal capacity will be upgraded to have FGD and SCR equipment available, but that some new higher efficiency coal plant could be available through retrofits and refurbishment or perhaps through new plant construction. It is also possible that the energy prices assumed in this case could lead to the development and use of improved forms of generation, or adaptations of existing plant, in order to maximise efficiency and profitability. In broad terms, in comparison with the central, favourable to coal case, coal generation in this case is much higher in both 2010 and 2015.

COMPARISONS AND CHANGES SINCE NOVEMBER 2004

96. Table 30 shows a comparison of the November 2004 and average of the current central projections for generation in the years 2005 to 2020.

TABLE 30 - Comparison of November 2004 and Latest Projections of Generation[45]

	November 2004				Latest Projection			
	2005	**2010**	**2015**	**2020**	**2005**	**2010**	**2015**	**2020**
Coal	116	90	81	62	123	106	100	69
Oil	2	2	1	1	2	2	2	1
Gas	135	145	167	221	132	127	157	215
Nuclear	80	65	41	27	74	73	34	26
Renewables	15	40	58	58	16	33	53	53
Imports	10	8	8	8	10	10	11	11
Storage[46]	2	2	2	2	3	3	3	3
TOTAL	**361**	**352**	**359**	**381**	**359**	**353**	**359**	**377**

[45] Gross supply after own use
[46] Gross supply from pumped storage plants

97. Compared with the November 2004 estimates, the key changes in 2005 are that coal generation is rather higher, reflecting improved coal competitiveness, while supply from nuclear stations is lower, which is mainly a reflection of last year’s higher than expected outages.

98. For 2010, supply from coal plants is significantly higher than in the November 2004 projections, and gas lower, by similar amounts. The bulk of this switch will be due to energy price relativities favouring coal. Supply from nuclear stations is now higher than previously expected mainly due to the recent announcement of life extension at Dungeness B. Renewables are now expected to contribute rather less to overall supply even though there is a wide margin of uncertainty on the likely outturn. Legislation relating to waste disposal could increase incentives to utilize waste as an input to electricity generation, with again, significant uncertainty over the exact level of supply that would result.

99. Notable changes in 2015 and 2020 include a downward revision to nuclear output in 2015, based on new information. Coal fired generation is at a higher level than previously expected in these years, as a result of improved competitiveness, including grater longevity of plants even allowing for the impact of the Large Combustion Plant Directive.

CHAPTER 7 – PRIMARY ENERGY DEMAND[47]

100. Primary energy demand has risen slowly since 1996, by around 0.27% per annum. On a temperature-adjusted basis, primary demand has risen by around 0.44% per annum over the same period.

101. Natural gas use has risen considerably since 1990, while coal use has fallen significantly. Nuclear energy use has risen a little, reflecting improved productivity. Renewables have increased to around four times their level in 1990.

Table 31 - Primary Energy Demand[48], Mtoe, Central, Favourable to Gas Case

	1990	1995	2000	2005	2010	2015	2020
Solid Fuel	66.9	48.9	37.9	39.4	34.9	32.4	23.3
Oil	77.2	75.4	75.9	75.3	78.2	81.5	83.8
Gas	51.2	69.2	95.6	94.4	94.2	103.2	112.8
Nuclear	16.3	21.3	19.6	18.2	18.0	8.3	6.4
Renewables	1.1	2.2	2.8	4.4	7.9	10.6	10.7
Imports	1.0	1.4	1.2	0.9	1.0	1.1	1.1
Total	**213.6**	**218.4**	**233.0**	**232.5**	**234.2**	**237.1**	**238.2**

Table 32 - Primary Energy Demand, Mtoe, Central, Favourable to Coal Case

	1990	1995	2000	2005	2010	2015	2020
Solid Fuel	66.9	48.9	37.9	39.4	40.6	41.3	33.1
Oil	77.2	75.4	75.9	75.3	77.5	80.1	82.3
Gas	51.2	69.2	95.6	94.4	84.7	90.6	100.7
Nuclear	16.3	21.3	19.6	18.2	18.0	8.3	6.4
Renewables	1.1	2.2	2.8	4.4	7.9	10.6	10.7
Imports	1.0	1.4	1.2	0.9	0.9	0.9	0.9
Total	**213.6**	**218.4**	**233.0**	**232.5**	**229.7**	**231.8**	**234.0**

[47] For a flowchart illustration of primary demand in the UK, see http://www.dti.gov.uk/energy/inform/flowchart.pdf.
[48] Projections are on a consistent basis with the data presented in table 1.1.1 of the online version of DUKES.

102. In both cases, a small decline in energy use is expected to occur between 2004 and 2005. As a result of a number of influences, including the impact of the Climate Change Programme and also of the growth in renewable energy[49], total primary energy use is projected to decline further to 2010 in both central cases.

103. In the longer term, between 2010 and 2020, there is resumption in the growth of energy use, at a rate of around 0.2% per annum. This is a lower rate of growth than historically observed and is likely to reflect the continued growth in renewable energy, switch from coal to gas use and saturation effects in certain areas of energy use.

Energy Ratio

104. Between 1970 and 2004 on a temperature-adjusted basis, the primary energy ratio declined on average by around 1.9% per annum. This steady decline in energy intensity reflects a range of influences including energy efficiency, structural shifts in the economy and changes in the mix of fuels used.

105. The projected decline in the energy ratio to 2020 is a little more rapid at about 2.4% per annum average decline from 2004 levels[50]. The continued reduction in projected energy intensity results from the impact of the climate change programme, energy saturation effects in some sectors, the increase in the use of renewables, increasing capacity and generation from high efficiency gas fired power stations and the energy demand effects of prolonged high energy prices.

[49] Some renewable energy forms, including wind and hydro, are deemed to be 100% efficient, thus any growth in the use of such types of renewable energy will tend to reduce the overall growth in energy use.
[50] Without temperature adjustment to the 2004 estimated outturn

CHAPTER 8 – UNCERTAINTY, RISKS, SENSITIVITIES AND CCP MEASURES

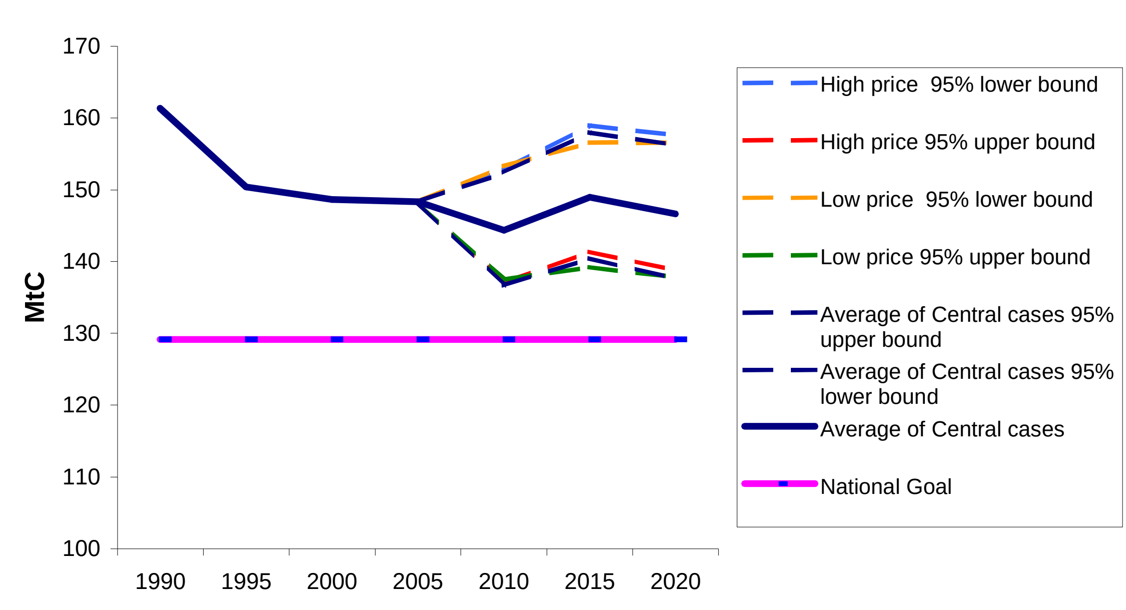
106. As previously noted, considerable uncertainties attach to energy and emission projections of this kind. We allow for some of this by presenting results on a range of scenarios for the level of energy prices. But that does not cater for all the potential sensitivities. In this chapter, therefore, the impact on projected carbon emission levels of uncertainties in the estimation of model parameters and changes in key assumptions is explored.

PARAMETER UNCERTAINTY

107. The complex structure of the DTI energy demand model prevents a detailed analysis of the additional uncertainty introduced into the projections by the uncertainty in the values of parameters fitted to historical data. A first estimate of the potential uncertainties involved has been achieved using an alternative approach. This is based on a simplified model of energy consumption which postulates aggregate energy demand as a function of price, income and temperature. The suggestion is that consideration of the parameter uncertainty in a simplified model may give some indication of the potential uncertainty in the wider model.

108. The simple model - based on aggregate energy demand, with total fuel expenditure, GDP and annual weighted temperature as independent variables - inevitably entails econometric compromises. Nevertheless with only a few parameters to fit the uncertainty associated with the fitting process can be calculated from standard output statistics. This suggests uncertainty bounds related to the projection period 2010 to 2020 of the order ±6% in 2010 rising to ±6.6% in 2020. We assume (without formal justification) that this uncertainty is representative of the uncertainty arising from the parameter fitting process in the main model and leads to an expression of uncertainty in terms of carbon. Figure 25 illustrates the uncertainty associated with the latest scenario projections.

Figure 25 - Parameter Uncertainty (all four scenarios)



KEY ASSUMPTION SENSITIVITY

109. The latest projections are based on a number of assumptions, all of which are themselves uncertain. Chapter 3 outlines the key assumptions of growth and fossil fuel prices providing an indication of the background. In this section we explore the impact of alternative assumptions in these key variables. The impact on the level of projected emissions of making alternative assumptions in some of the other key modelling assumptions is also explored. A summary of these impacts on 2010 emissions is shown in Table 33 below. It is assumed the changes are against the central scenarios unless otherwise indicated. It should be noted that each of these effects is estimated on the basis that other assumptions remain as in the core scenarios. The effects should not be considered in any way cumulative.

Table 33 - Summary of impact on carbon emissions in 2010 of alternative key assumptions

Key Assumptions	**Alternative**	**Emissions in 2010 (MtC)**
Further Voluntary Agreements and other measures		-0.1
Number of households	Higher growth in number of households	+1.2
Car ownership levels	Higher growth in number of households	+1.0
Higher coal generation	5TWh higher	+0.7
Nuclear Output	1TWh higher 1TWh lower	-0.1 +0.1
Different electricity demand	1TWh higher	+0.1
Higher electricity imports	1TWh higher	-0.1
Renewables at various levels of generation	7% of generation 9% of generation	+0.3 -0.3
Temperature	Level Trend	+0.7

Voluntary Agreements to Improve Fuel efficiency

110. Voluntary Agreements (VA) reached between the European Commission and the European Automobile Manufacturers Association (ACEA)[51], requiring car manufacturers to reduce average CO_2 emissions from new passenger cars, are discussed in Chapter 4. The impact of the current VA, underpinned in the UK by other fiscal measures, is incorporated in the baseline projections. Proposed future voluntary agreements would extend the current agreements between the Commission and car manufacturers, which expire in 2008/9. Assuming a “second” VA from 2009 to 2020, which could possibly be underpinned in UK by other supporting measures, suggests that a further reduction in projected emissions from the transport sector may be achieved of around 0.1MtC in 2010 and significant savings by 2020.

Number of Projected Households

111. The current baseline assumption is that the total number of households will have grown by 2.3% from 2005 in 2010 and from 2010, a further 4.6% by 2020. Historically, the number of households has determined energy demand in the residential sector. Assuming an increase in the number of households in 2010 and 2020 of 3.3 and 5.4% respectively, suggests an increase in total emissions of 1.2 and 1.9MtC respectively in the residential sector.

Car Ownership level

112. Energy demand in the road transport sector is associated with the level of car ownership. This is not a one-for-one relationship, as a new car may represent the second, or third car owned by a household and therefore distance travelled and energy consumed would be lower than that associated with a “first” or “only” car. For this reason the estimation of the total emission impact of higher car ownership needs to be related to levels of household car ownership and will be over estimated using current modelling methodology. However, assuming increases in car ownership equivalent to increases in household numbers the resulting increase in emissions is around 1MtC in 2010 and 1.6MtC in 2020.

Higher Coal Generation

113. The prospective mix of generation from coal and gas plants in particular is difficult to gauge with precision. The information provided within Annex D will assist with understanding the broad impact of energy price influences, but not directly answer the question of how

[51] And with the Japanese Automobile Manufacturers Association (JAMA) and Korean Automobile Manufacturers Association (KAMA)

sensitive emissions are to a different mix of generation. It is estimated that if 5TWh of generation were to switch from gas to coal plants, then CO_2 emissions would be around 0.7MtC higher.

Nuclear Output

114. In modelling the generation sector, broad assumptions are made for all plants regarding plant-operating availability. Such assumptions will represent the broad level of performance likely over a run of years. It is clear, however, that performance in any given year is liable to depart somewhat from the assumed levels. Whilst such deviations are likely to be of little importance in themselves for the coal and CCGT fleet, where, due to the large population of plants, the averaging process will help ensure that random deviations are likely to be largely offsetting, the same may not be true where smaller plant populations are involved, including perhaps the nuclear fleet. This sensitivity shows how emissions could vary if nuclear generation were to be different to the assumed level in 2010. The estimated impact of a 1TWh difference is around 0.1MtC, based on gas being the alternative form of generation.

Different Levels of Electricity Demand

115. Electricity demand may differ from projected levels with implications for the associated emissions. If changes in demand were met by gas plant, then the impact of a 1TWh difference would amount to around 0.1MtC.

Imports of Electricity

116. In broad terms, the projections assume a continuation of historic levels of electricity imports. If imports were to be 1TWh different and assuming that gas is the alternative form of generation, emissions would change by 0.1MtC.

Renewables

117. It is assumed that generation from eligible renewables forms around 8% of the total in 2010, though there is a great deal of uncertainty about the likely outcome. If, instead, eligible renewables were to form 7% of the total, emissions would be higher, unless the difference were made up from nuclear generation. If, for example, gas were the alternative form of generation, emissions would be around 0.3MtC higher than in the baseline. Conversely, if eligible renewables were to attain a 9% share, emissions would be around 0.3MtC lower than in the main projections.

External Temperature Effects

118. A significant proportion of energy demand in the residential sector is associated with energy required to heat the home. Modelling in the residential sector requires two variables which measure the effect on recorded energy demand of variations in external temperature. The variables are measured as ‘heating degree days’ and refer to the number of days that the recorded temperature falls 1 degree centigrade below a base level (15.5 ^{o}C). The variables are constructed from detailed Met Office data to provide an overall data set for UK based on regional population distribution. Data from the Met Office suggests an upward trend in weighted annual average temperatures and this is reflected in the heating degree data, which indicates an average temperature in recent years of 0.8^{o}C above the 1961-1990 average. The emissions projections reflect this upward trend in line with Met Office predictions. An alternative assumption is that temperature projection to 2010 and 2020 reflect no upward trend and remains at the recent average. This assumption is estimated to result in an approximate increase in emissions of 0.7MtC in 2010, 0.8MtC in 2015 and 0.9MtC in 2020 from central baseline assumptions.

UNCERTAINTIES AND RISKS

Future Fossil Fuel Prices

119. Projections are based on four scenarios. Each scenario represents a projection of international fossil fuel prices based on a number of considerations. Assessing the future prospect for fossil fuels into the future is uncertain.

Estimates of CCP Impact

120. The emissions projections are based on the assumption that Climate Change Programme measures will reach their estimated savings. Should any existing measure fall short or overachieve estimated level of saving, the overall level of projected emissions will change.

Annex A: Carbon savings from existing CCP measures incorporated in 2010 projection

This table shows what the existing Climate Change Programme measures are expected to deliver by 2010. A synthesis report bringing together the results of an exercise, carried out across government in the first half of 2005, to evaluate policies in the current Climate Change Programme, will be issued at the same time as we publish the updated programme.

Table A

	MtC Saving		
	2010	**2015**[52]	**2020**[52]
Residential			
EEC1	0.36	0.36	0.36
EEC2	1.08	1.24	1.24
HEES/Warm Front 1	0.14	0.14	0.14
Warm Front 2	0.19	0.21	0.21
Building Regulations 2002	0.64	0.70	0.70
Building Regulations 2005	0.70	0.75	0.75
Other, incl Market Transformation Programme	0.15	0.17	0.17
Community Energy	0.04	0.04	0.04
Business			
UK ETS	0.27	0.27	0.27
CCL package	1.10	1.10	1.10
Building Regulations	0.34	0.38	0.38
Building Regulations 2005	0.14	0.17	0.17
CCAs	2.86	2.86	2.86
Public sector			
Public sector	0.26	0.27	0.27
Transport			
Voluntary Agreement Package	2.30	3.13	3.58
10 Year Plan	0.84	0.84	0.84
Sustainable Development	0.10	0.10	0.10
Total	**11.50**	**12.73**	**13.18**

Other CCP measures are included within the baseline. These measures include the Climate Change Levy impact, the impact of the Renewables Obligation and the fuel duty escalator, which has since been discontinued.

[52] Estimates of measures beyond 2010 are less certain, and have either been assumed to continue at the 2010 level or, where penetration of a measure continues beyond 2010 (e.g. more efficient vehicles entering the car stock), the savings have been calculated on this basis.

Annex B: Estimated UK response to Carbon price[53]

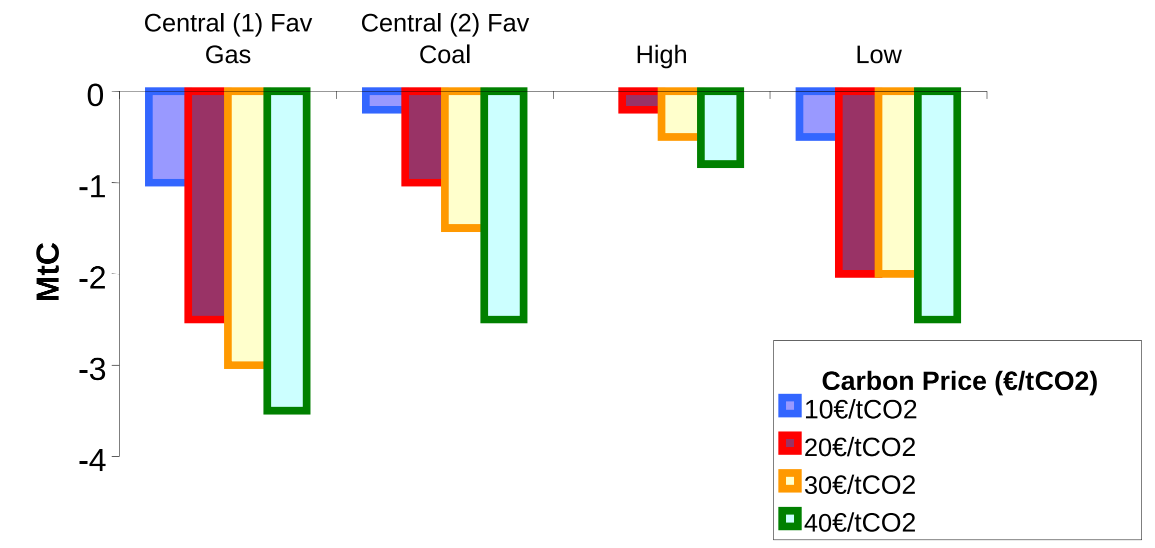
Although it is anticipated that EU trading, which began in Jan 2005, may deliver significant reduction on UK emissions by 2010 the decision to exclude EU ETS from the current baseline projections was based on several considerations.

The most important consideration is the high degree of uncertainty associated with estimation of the impact of EU ETS and the additional layer of uncertainty this would add to the projections. Further, the UK's allocation decision for 2008-12 is being considered within the CCPR. This decision will itself be informed, amongst other considerations, by the projected shortfall from the UK's CO_2 reduction target.

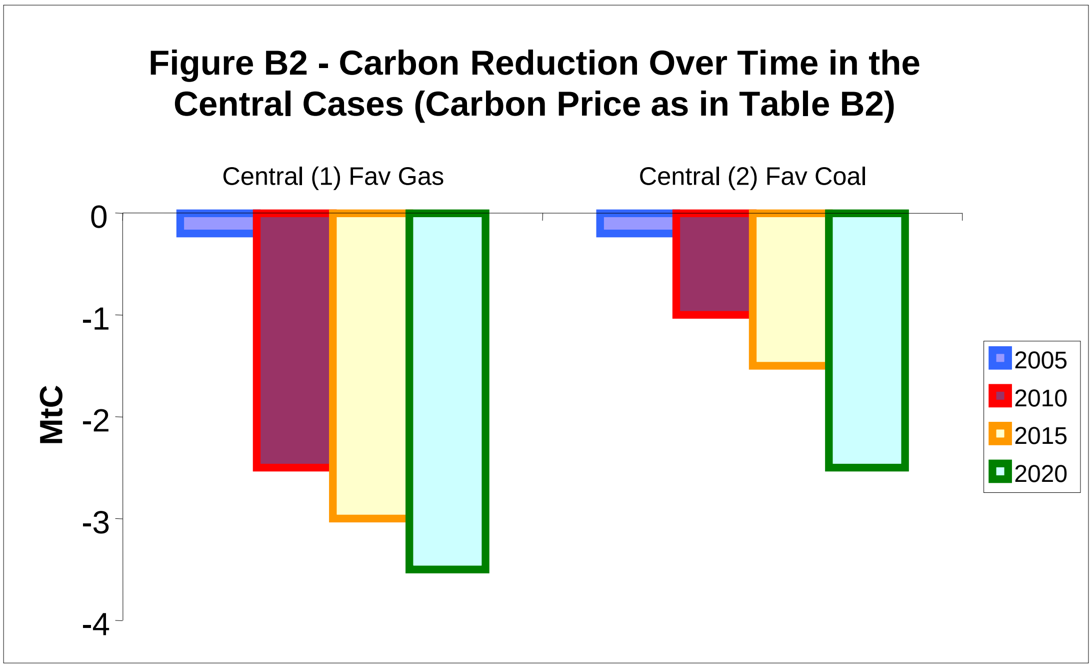
Abatement effort within the UK will reflect the level of the carbon price and the behavioural response to that price. This carbon price will depend on the UK and other member states' allocations for 2008-12 (none of which are yet set); levels and relativities of fossil fuel prices; abatement options; and availability of JI and CDM credits.

Using an adaptation of the DTI energy model to explore the impact of a carbon price for a given level of fossil fuel prices represented in each of the chosen fossil fuel price scenarios indicates the degree of variation in UK carbon savings. This is illustrated in Figure B1 below.

Figure B1 - Carbon Reduction by Scenario in 2010



[53] The estimated impacts are rounded and approximate. The impacts can be very sensitive to the precise assumptions made.



These estimates indicate there is a wide range of implied reductions in emissions across the four scenarios. The estimates are further set out in Tables B1 and B2 below, and are shown graphically in Figures B1 and B2.

TABLE B1[54] – Carbon Reduction by Scenario in 2010 (MtC)

Carbon Price (€/tCO_2)[55]	**10**	**20**	**30**	**40**
Central (1) Fav Gas	1	2.5	3	3.5
Central (2) Fav Coal	0.2	1	1.5	2.5
Low	0.5	2	2	2.5
High	0	0.2	0.5	0.8

Table B2 - Carbon reduction over time (MtC)

	2005 20 euro/tCO_2	**2010 20 euro/tCO_2**	**2015 25 euro/tCO_2**	**2020 25 euro/tCO_2**
Central (1) favourable to gas	0.2	2.5	3	3.5
Central (2) favourable to coal	0.2	1	1.5	2.5

This work suggests that a carbon price of €30/tCO_2 (the current price is around €27) is estimated to result in a 2010 reduction of between 0.5MtC

[54] The estimated impacts are rounded and approximate. The impacts can be very sensitive to the precise assumptions made.
[55] In real 2005 prices

when all fossil fuel prices are high to as much as 3MtC in the central favourable to gas scenario.

The estimated impacts are greatest in the central, favourable to gas case, in which there is likely to be more competition at the margin between gas and coal. In contrast, in the central, favourable to coal case and also in the high case, gas prices are too high to allow much fuel switching at the margin. The estimated impacts in the low case are lower than for the central, favourable to gas case, as the baseline gas generation is already rather higher in the former, thereby reducing the potential for further switching.

Further work will be necessary to explore the potential for switching. In particular, assumptions about the seasonal pattern of gas prices, as well as the annual average level of prices, are likely to be an important determinant of switching potential. For example, it would seem unlikely that gas prices, at times of high gas demand, could be at a level sufficient to make for significant competition between gas and coal. Such effects are likely to be more noticeable in the so-called intermediate periods of the year, namely spring and autumn.

Table B3 shows the impact on the projected carbon gap, against the 20% 2010 goal, assuming that a carbon price of €30/tCO_2 prevails. The gap in the two central cases becomes 12.4MtC to 13.5MtC, and in the two other cases, around 14MtC to 15MtC.

TABLE B3 – Effects on the carbon gap when a €30t/CO_2 carbon Price is included

	Central (1) Favouring Gas	**Central (2) Favouring Coal**
Reduction on 1990	-12.3%	-11.6%
Carbon gap in 2010	-12.4MtC	-13.5MtC
Total 2010 Emissions pre carbon Price	144.5MtC	144.1MtC
Total 2010 Emissions post carbon Price	141.5MtC	142.6MtC

Annex C: Differences and Developments since November 2004

Current projections on the two central cases show CO_2 emissions in 2010 up by between 2.8 and 3.2 MtC (around 2.0 to 2.2%) as against projections published in November 2004. A number of factors contribute to this difference. These are outlined in below.

TABLE C - Changes in 1990 and 2010 between the Nov 2004 projection (CCPR Consultation Document) and the current projection[56]

	1990	2010
UEP (Nov 2004) projection	**165.1**	**141.3**
Factor contributing to change		
Revisions to estimates of LULUCF[57] emissions and Inventory Changes	-3.7	-1.7
Public and other sector energy efficiency		+1.7
Transport – Voluntary Agreement Package (including existing CCP measures)		+1.2
Transport – 10Year Plan		+0.2
Renewables reassessment		+1.0
Changes in relative fuel prices in power stations		+1.7
LCPD Compliance		+0.4
Reduction in assumed power station efficiencies		+0.7
Increased electricity demand		+0.1
Dungeness B life extension, other nuclear changes		-0.7
Other identifiable power station changes		+0.1
Refineries		+0.2
Residential re-modelling, including price changes		+0.7
Services modelling revision and revised growth		-0.8
Revised Industrial growth (OEF)		-2.1
Autogeneration reassessment		+0.2
Offshore reassessment		+1.2
Road transport re-modelled		-1.6
Freeze in road fuel duty		+0.1
Other UEP modelling impacts		+0.4
Latest Current Projection (Central Average)	**161.4**	**144.3**

Revisions to estimates of LULUCF emissions: (-4.6MtC in 1990; -2.2MtC in 2010). Revisions reflect (i) reanalysis of soil carbon densities, (ii) revision of the estimated pattern of land use change to take account of the most recent Countryside Survey. The revised numbers allow full account to be taken of uptake by forests in meeting the 20% target. The inventory is produced by the National Environmental Technology Centre, the Centre

[56] Based on the average of the two central cases.
[57] Land use, land use change and forestry

for Ecology and Hydrology and other organisations under contract to Defra.

Other Inventory Changes (+0.9MtC in 1990; +0.5MtC in 2010): a number of new categories of emissions and amendments have been adopted in inventory methodology. Changes include new categories such as emissions from lube oil in transport and emissions from FGD systems in power stations. The impact on the projection for 2010 is a little less than the impact in 1990.

Evaluations of existing CCP measures. The work programme to inform the Climate Change Programme Review included a series of evaluations of existing measures to check if they were on course to deliver the amounts of Carbon savings previously estimated as part of the Climate Change Programme. The evaluations were led by analysts from within the responsible department. In a number of cases this has led to downward revision of claimed savings. DTI has incorporated the results of these evaluations in the projections, as follows:

Public sector energy efficiency (+0.6MtC), *Other energy efficiency* (+1.1MtC): the CCP claimed savings of 0.6MtC in 2010 from improved public sector energy efficiency. Only around one-third of this is likely to be delivered under current policies. It also claimed savings from other energy efficiency measures, notably 0.9MtC from replacement of community heating systems. The Community Energy Programme will deliver under 0.05MtC (but was not funded to deliver much more than around 0.2MtC). Estimates of savings from EEC and Building Regulations have been reduced, partly as a result of new information from field monitoring – which indicates smaller carbon savings in practice from a given improvement in energy efficiency – and partly from new analysis. Total savings from the household sector are now estimated below 3.5MtC instead of the original 5MtC.

Transport Voluntary Agreement Package (+0.5MtC), *Transport 10 Year Plan* (+0.2MtC): the fuel efficiency of new cars is improving year on year, but at a slower rate than previously hoped.

Renewables Reassessment (+1.0MtC): the proportion of electricity generated through renewables is rising, but not sufficiently to ensure compliance with the 10% target under the Renewables Obligation The projections were revised to incorporate a central case around 8%.

Power Station Changes

Changes in relative fuel prices in power stations (+1.7MtC): fossil fuel price assumptions have been revised, with the effect that coal is more competitive against gas, producing higher emissions. The assumptions used take account of recent experience, forward markets and public consultation. The DTI Energy Markets Unit leads in putting these assumptions together.

Compliance With The LCPD (+0.4MtC):
The November 2004 projections embodied an assumption that the level of generation from and the type of fuels used in coal fired plants would to some extent be changed due to the necessity of meeting the requirements of the Large Combustion Plant Directive be met. This no longer seems to be the case, especially as the amount of FGD capacity on stream in the first LCPD compliance period is now projected to be higher than in the November 2004 projections.

Reduction in assumed power station efficiencies (+0.7MtC):
Recent data on achieved plant efficiencies suggests a downward adjustment is necessary to both coal and gas plant efficiencies. Future coal efficiencies have also taken account of the recent improved outlook for FGD projects.

Increased Electricity Demand (+0.1MtC): estimated impact of higher demand on the major power producers.

Dungeness B Life Extension And Other Nuclear Adjustments (-0.7MtC): plans for a life extension announced and incorporated in the projections. Higher nuclear generation in 2010 displaces fossil fuel generation, which leads to a reduction in projected emissions.

<u>Refineries</u> (+0.2MtC): reassessment of prospects, including higher throughput assumption.

<u>Residential remodelling including price changes (+0.7MtC)</u>

Residential re-modelling (0.9MtC): compared with latest actuals for gas use in the household sector, the Energy Model seemed to under-forecast. We have therefore, making use of this more recent data, re-estimated the forecasting equations for household gas use. Comparisons with recent Defra modelling work suggest high level of agreement.

Adjustment to residential sector prices: based on new information –0.3MtC to -0.1MtC, average impact therefore (-0.2MtC)

<u>Services modelling revision and revised growth</u> (-0.8MtC): revisions to productivity and energy use assumptions, including lower growth resulting from recent adjustments to UK economic growth.

<u>Industry growth revision</u> (-2.1MtC): the projections are consistent with HMT assumptions for GDP and manufacturing growth. Growth rate assumptions for specific industrial sectors were informed, in 2004, by work from consultants (largely Oxford Economic Forecasting - OEF). This work has been updated by OEF, with these latest assumptions incorporated in the projections. Growth in some sectors is projected higher; in some

reduced. But the net effect is a reduction of projected output in the more carbon-intensive sectors.

Autogeneration reassessment (+0.2MtC): a reassessment of emissions from autogenerators, resulting from analysis of more comprehensive data which has become available, particularly that relating to CHP operations.

Offshore reassessment (+1.2MtC): some installations previously assumed to be closed before 2010, or new installations previously assumed to start operating only after 2010, are now assumed to be operating in 2010, with associated emissions. Revised operating dates are linked to the higher oil price, and higher expectations of the oil price.

Road transport re-modelling (-1.6MtC): updated modelling allows for road capacity constraining road transport growth in the longer-term. Current projections to 2010 are close to those of DfT.

Existing CCP measures (0.7MtC): mainly results of further evaluation work from DfT indicating revised savings from the Voluntary Agreement package.

Freeze In Road Fuel Duty (+0.1MtC): road fuel duties have remained unchanged in nominal terms.

Other UEP Modelling Impacts (+0.4MtC): includes miscellaneous changes, the difference between on model and off model estimates[58], plus any unidentified residual.

[58] In Annex C we have attempted to quantify, largely through off – model estimation, the impact of specific revisions. It would not be practical to carry out separate model simulations of each change made. It is inevitable, however, that the on – model changes would to some extent be interactive. There is therefore likely to be a difference between the full model simulation of the full range of impacts and the off – model estimation.

Annex D: Sectoral Emissions Projections (by scenario)

Table D1 - Historic (by source) Sector Carbon Emissions (MtC)

	1990	1995	2000
Power Stations	55.7	44.7	43.1
Refineries	5.0	5.6	4.9
Residential	21.1	21.4	23.2
Services (including agriculture)	8.3	8.7	8.2
Industry	35.3	34.6	33.4
Road Transport	30.1	30.6	32.0
Off-road	1.6	1.5	1.4
Other Transport	3.4	2.9	2.5
LUC	0.8	0.3	-0.1
Total	**161.4**	**150.4**	**148.6**

Tables D2-D3 – Projected (by source) Sector Carbon Emissions (by scenario) (MtC)

	Central (1) scenario -Favouring Gas				Central (2) scenario-Favouring Coal by			
	2005	2010	2015	2020	2005	2010	2015	2020
Power Stations	46.3	41.0	41.9	37.8	46.3	41.4	43.7	41.5
Refineries	5.6	5.7	5.7	5.7	5.6	5.7	5.7	5.7
Residential	22.6	20.9	21.2	21.3	22.6	20.5	20.7	20.9
Services (including agriculture)	6.7	6.4	6.7	7.7	6.7	6.4	6.7	7.7
Industry	30.6	32.6	33.3	31.9	30.6	32.3	32.9	31.4
Road Transport	33.4	34.6	35.8	36.2	33.4	34.6	35.8	36.2
Off-road	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Other Transport	2.3	2.3	2.4	2.5	2.3	2.3	2.4	2.5
LUC	-0.6	-0.5	0.1	0.7	-0.6	-0.5	0.1	0.7
Total	**148.3**	**144.5**	**148.5**	**145.2**	**148.3**	**144.1**	**149.4**	**148.0**

	High price scenario				Low price scenario			
	2005	2010	2015	2020	2005	2010	2015	2020
Power Stations	46.3	43.3	45.9	43.1	46.3	39.9	38.8	37.1
Refineries	5.6	5.7	5.7	5.7	5.6	5.7	5.7	5.7
Residential	22.6	19.5	19.7	19.9	22.6	21.9	22.3	22.5
Services (including agriculture)	6.7	6.4	6.7	7.7	6.7	6.4	6.7	7.7
Industry	30.6	32.2	32.7	31.2	30.6	32.6	33.1	31.7
Road Transport	33.4	34.3	35.3	35.8	33.4	35.3	37.0	37.5
Off-road	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Other Transport	2.3	2.3	2.4	2.4	2.3	2.4	2.5	2.6
LUC	-0.6	-0.5	0.1	0.7	-0.6	-0.5	0.1	0.7
Total	**148.3**	**144.7**	**149.9**	**147.9**	**148.3**	**145.1**	**147.6**	**146.9**

The 2004 greenhouse gas inventory has recently been released which contains updated estimates of CO2 emissions for the period 1990 to 2004. It has not proved to be possible in the time available to reestimate the DTI sectoral data on the basis of the 2004 GHGI. The historic data and projections in this paper are therefore based on the 2003 greenhouse gas inventory, with the sole exception of an adjustment to take account of revised estimates of the impact of land use change in the 2004 greenhouse gas inventory. In terms of total emissions, there is a difference of approximately 0.1MtC between the 2003 and 2004 inventories for the 1990 data.

Annex E: Sectoral (End User) Emissions Projections (by scenario)

Table E1 - Historic Sector (End User) Carbon Emissions (MtC)

	1990	**1995**	**2000**
Business	60.9	53.3	51.5
Industrial processes	4.8	4.3	4.3
Transport	40.2	41.1	42.1
Residential	41.7	38.4	39.5
Public	8.7	8.0	6.7
Agriculture	1.6	1.4	1.2
Land use change (net emissions)	0.8	0.3	-0.1
Waste management	0.6	0.5	0.3
Exports	2.2	3.1	3.2
Total	**161.4**	**150.4**	**148.6**

Tables E2-E3 – Projected Sector (End User) Carbon Emissions (by scenario) (MtC)[59]

	Central (1) scenario -Favouring Gas				**Central (2) scenario-Favouring Coal by**			
	2005	**2010**	**2015**	**2020**	**2005**	**2010**	**2015**	**2020**
Business	49.2	47.9	49.7	49.6	49.2	47.7	50.0	51.0
Industrial processes	3.6	3.9	4.1	4.4	3.6	3.9	4.0	4.3
Transport	43.9	44.8	45.6	45.2	43.9	44.8	45.7	45.4
Residential	39.9	36.6	37.8	35.4	39.9	36.4	38.2	36.5
Public	6.0	5.9	5.9	5.4	6.0	5.9	6.1	5.7
Agriculture	1.2	1.2	1.1	1.0	1.2	1.2	1.2	1.1
Land use change (net emissions)	-0.6	-0.5	0.1	0.7	-0.6	-0.5	0.1	0.7
Waste management	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2
Exports	4.8	4.5	3.9	3.3	4.8	4.5	3.9	3.3
Total	**148.3**	**144.5**	**148.5**	**145.2**	**148.3**	**144.1**	**149.4**	**148.0**

	High price scenario				**Low price scenario**			
	2005	**2010**	**2015**	**2020**	**2005**	**2010**	**2015**	**2020**
Business	49.2	48.4	50.8	51.7	49.2	47.1	47.7	48.7
Industrial processes	3.6	3.8	3.9	4.2	3.6	4.0	4.1	4.4
Transport	43.9	44.5	45.2	44.9	43.9	45.5	46.9	46.8
Residential	39.9	36.3	38.2	36.1	39.9	37.4	37.9	36.6
Public	6.0	6.1	6.3	5.8	6.0	5.8	5.8	5.4
Agriculture	1.2	1.2	1.2	1.1	1.2	1.1	1.1	1.0
Land use change (net emissions)	-0.6	-0.5	0.1	0.7	-0.6	-0.5	0.1	0.7
Waste management	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2
Exports	4.8	4.5	3.9	3.3	4.8	4.4	3.7	3.2
Total	**148.3**	**144.7**	**149.9**	**147.9**	**148.3**	**145.1**	**147.6**	**146.9**

[59] NC/CCPR Basis

Annex F: LULUCF Estimates and Projections (MtC)

Assumed in our projections are the following LUC estimates. This information was provided by the Centre for Ecology and Hydrology under contract to Defra.

Table F

	LULUCF Projections
1990	**0.80**
1991	0.76
1992	0.62
1993	0.30
1994	0.24
1995	**0.28**
1996	0.25
1997	0.15
1998	0.00
1999	-0.06
2000	**-0.12**
2001	-0.16
2002	-0.31
2003	-0.32
2004	-0.53
2005	**-0.56**
2006	-0.64
2007	-0.62
2008	-0.65
2009	-0.60
2010	**-0.46**
2011	-0.32
2012	-0.22
2013	-0.12
2014	-0.03
2015	**0.12**
2016	0.23
2017	0.30
2018	0.36
2019	0.45
2020	**0.65**

Annex G: Historic and Projected Sector Energy Demand (Mtoe)[60]

Table G1 – Residential Sector Historic and Projected Energy Demand

	Electricity	Solid Fuel	Gas	Oil	Renewables
1970	6.6	18.0	8.9	3.4	0.0
1975	7.7	10.9	14.8	3.6	0.0
1980	7.4	8.3	21.3	2.8	0.0
1985	7.6	7.6	24.4	2.5	0.0
1990	8.1	4.2	25.8	2.5	0.2
1995	8.8	2.6	28.0	3.0	0.2
2000	9.6	1.9	31.8	3.2	0.2
2005	10.0	1.1	32.8	3.1	0.1
2010	10.1	0.7	30.4	2.7	0.1
2015	10.7	0.6	31.3	2.4	0.1
2020	11.3	0.5	32.0	2.2	0.1

Table G2 – Industrial Sector Historic and Projected Energy Demand[61]

	Electricity	Solid Fuel	Natural Gas	Oil	Renewables
1995	8.7	7.0	12.7	7.1	0.5
2000	9.8	4.1	15.8	6.3	0.2
2005	9.8	5.1	13.5	6.7	0.2
2010	10.2	5.8	14.3	6.9	0.2
2015	10.8	5.7	15.5	6.8	0.2
2020	11.4	5.8	16.6	6.8	0.2

[60] Projections are taken from the central case favouring coal.
[61] Figures before 2005 are based on estimates of fuel used in transformation for the iron and steel sector.