UK ENERGY AND CO₂ EMISSIONS PROJECTIONS July 2006

PART 1

UPDATED PROJECTIONS TO 2020

Introduction

Updated CO₂ Emissions Projections published for consultation in February 2006¹ formed the basis of CO₂ projections underpinning the 2006 Climate Change Programme (CCP2006)² and the consultation on the EU ETS National Allocation Plan³.

There have been a number of developments to the projections since February arising from the Budget announcements in March 2006, developments in UK population statistics, and new CCP measures. We have also considered responses to the February 2006 projections consultation⁴ and updated assumptions for fossil fuel prices going forward.

This paper summarises the revisions to key assumptions in the light of these changes and presents the key results. These projections are, as previously presented, without the impact of the EU ETS, though we consider the response of UK emissions to incorporation of a Carbon price (See Annex J for this analysis including further explanation for the exclusion of the EU ETS from the projections).

For ease of reference, the projections published in February 2006 are denoted UEP21 and the updated projections as UEP26.

In part 2 of this paper, scenario projections of energy demand and emissions to 2050 are presented. These long-term scenario projections are based on the current updated projections (UEP26) and have informed the current Energy Review. The scenario baseline projection updates the Energy White Paper projection and illustrates how recent changes in energy market fundamentals have shifted our view of the longer term.

¹ <u>http://www.dti.gov.uk/files/file26363.pdf</u>

² http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

³ http://www.defra.gov.uk/corporate/consult/euets-phasetwo-nap/index.htm

⁴ A full response to the consultation will be available shortly.

Summary Headline Differences UEP21 v UEP26

Updated (UEP26) headline CO₂ emissions projections to 2020 are shown in Table 1 and compared with previously published projections (UEP21)

Table 1 – Comparison between the current and previously published projections (Central scenario average, MtC)

	1990	2000	2010	2015	2020
UEP26	161.4	148.6	143.4	146.3	146.2
UEP21	161.4	148.6	144.3	148.0	146.6

In summary the impact of the recent revisions, excluding the additional savings, has been to increase the baseline projection by some 3.1 MtC in 2010. Additional savings of 4MtC from new measures announced in the CCP2006 are incorporated, taking the central average projection for 2010 from 144.3MtC (published in February 2006) to 143.4 MtC. This suggests a reduction in CO_2 emissions in 2010, including the impact of EU ETS at -8 MtC, compared to 1990 of 16.2%.

Updated Emissions Projections (UEP26)

Revisions to assumptions

The structure of the projections is the same as previously published and comprises four scenarios based on

- a high fossil fuel price scenario
- a central fossil fuel price scenario, where the assumed prices somewhat favour gas in generation
- a central fossil fuel price scenario, where the assumed prices somewhat favour coal in generation
- a low fossil fuel price scenario.

Fossil fuel price assumptions for the two central scenarios are summarised in Table 2 below. Differences from the February 2006 assumptions in all four scenarios are given in Annex A. Generally, fossil fuel prices in 2010 are assumed to be higher than previously and to rise further beyond 2010 to 2020. In the central scenarios the 2020 oil price assumption has increased from \$35/bbl to \$45/bbl and in the high price scenario from \$50/bbl to \$72/bbl. These revisions reflect recent market signals. Demand for oil appears more robust to high prices than previously assumed. The supply-demand balance is expected to remain relatively tight even after expected increases in supply in the next few years.

	Crude Oil \$/bbl	Natural Gas NBP p/therm		Coal ARA £/tonne
		Fav Gas	Fav Coal	
2005	55.0	41.0	41.0	33.6
2010	40.0	25.8	33.5	27.2
2015	42.5	27.3	35.0	26.1
2020	45.0	28.8	36.5	25.0

Table 2 - Updated fossil fuel price assumptions – central scenarios⁵

Budget announcements in March 2006 kept overall UK GDP projections unchanged, but revised manufacturing slightly down. This had the effect of slightly increasing assumed growth in the non-manufacturing sectors, including the service sector.

The Office for National Statistics published revised projections of UK population and households in March 2006, taking account of further recent analysis of the 2001 census statistics. Compared with the assumptions used in UEP21, the revised ONS forecasts suggest a 2.6% increase in the number of households in 2010 and a 5.7% increase in 2020. Residential energy demand is linked to the number of households. Details of the revisions are provided in Annex B.

Consultation on the EU ETS National Allocation Plan projections concluded in April 2006. Industrial sector growth revisions, based on an assessment of consultation responses, revised manufacturing growth forecasts from the 2006 Budget and work by Oxford Economic Forecasting informed a revision in industrial sector growth assumptions. These revisions are shown in Annex C.

Other revisions include a re-assessment of estimated savings anticipated from the voluntary Climate Change Agreements (CCAs). The CCAs are aimed at improvement in fuel efficiency and are typically based on an agreed level of projected output. Revision of projected output implies revision to estimated savings. Other adjustments to the estimated delivery from CCAs arise from recent information becoming available implying changes to the coverage of agreements within the industry sector.

The Combined Heat and Power (CHP) capacity assumptions within the DTI model are informed by independent consultant analysis. This analysis has recently been revised to suggest lower capacity over the forecast period.

Updated results - Carbon emissions

In summary, revisions to the projections since UEP21 (February 2006) reflect:

- fossil fuel price assumptions (Annex A);

⁵ Oil and coal price assumptions are the same in both central scenarios, only the gas price assumption differs.

- new UK population and household forecasts (Annex B);
- manufacturing growth revisions due to Budget 2006 announcements (Annex C);
- industrial sector growth revisions informed by work by Oxford Economic Forecasting and assessment of consultation responses (Annex C);
- adjustment to the CHP projection (Annex D);
- inclusion of new CCP measures ⁶ (Annex E);
- re-assessment of Climate Change Agreement (CCA) delivery (Annex E).

A detailed breakdown of the contributions of the changes to the differences in 2010 and 2020 based on the average central scenarios is shown in Table 3.

⁶ <u>http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf</u> page 125.

1990	2010	2020
UEP21 published Feb 2006 161.5	144.4	146.6
Contributions outside ESI°:		
Increased number of households	0.54	1.22
Fossil fuel impact in services	0.00	-0.17
Fossil fuel impact in residential sector	-0.04	-0.75
Fossil fuel impact in industry	0.1	-0.1
Higher growth in services	0.27	0
Lower manufacturing growth	-0.45	-0.34
Lower delivery of CCA's	0.51	0.51
Lower own generation CHP	-0.56	-1.7
Interaction impacts	0.26	0.32
Revision to offshore projection	0.37	-0.16
Impact in ESI –power stations	2.1	6.11
Higher residential electricity demand	0.26	1.00
Higher industry demand (incl services, lower CCA delivery)	0.16	0.27
Relative fuel prices/FGD	0.91	2.82
Lower own generation/CHP (higher demand on ESI)	0.67	1.92
Efficiency impact of CHP transfer	0.10	0.10
Updated baseline position before CCP2006 additional	147.40	151.55
measures		
CCP2006 additional measures (excl. EU ETS)	-4.0	-5.36
Current updated position before EU ETS (UEP26)	143.40	146.18

Table 3 – Contributions to changes in emissions in 2010 and 2020, by sector and within the ESI $(MtC)^7$

Updated emissions projections in 2010 for all the four scenarios are shown in Table 4. The table also shows the 2010 projection allowing for the announced 8MtC reduction in allocation of CO₂ allowances under Phase II of the EU ETS⁹. Annex F shows these latest projections and the comparable projections from February 2006 (UEP21).

⁷ Figures are maintained to two decimal places to help differentiate small effects. This does not signify a higher level of accuracy than elsewhere.

⁸ The Electricity Supply Industry (ESI) covers major power producers plus all other renewable generators. All other generators of electricity are included within the industrial or service sector.

⁹ Not all this reduction may be achieved in the UK.

MtC UEP26	Central Favouring Gas	Central Favouring Coal	High	Low			
1990 ¹⁰	161.4	161.4	161.4	161.4			
2010	142.9	143.9	142.5	143.3			
2020	145.8	146.5	146.9	142.9			
2010 Reduction from 1990	-11.4%	-10.8%	-11.7%	-11.2%			
National goal	129MtC	129MtC	129MtC	129MtC			
Carbon gap in 2010	13.8MtC	14.8MtC	13.4MtC	14.2MtC			
Headline emissions after including an 8MtC saving from the EU ETS							
2010	134.9	135.9	134.5	135.3			
2010 Reduction from 1990	-16.4%	-15.8%	-16.6%	-16.2%			

Table 4 – Updated headline emissions projections UEP26, all scenarios

Updated emissions by sector¹¹

Emissions by source in the two central scenarios are shown in Table 5. (High and low price scenarios are given in Annex G). End user emissions for the four scenarios are given in Annex H.

UEP26				Fav Gas			Fav Coal	
	1990	2000	2010	2015	2020	2010	2015	2020
Power Stations	55.7	43.1	42.5	45.4	45.0	44.1	47.6	46.5
Refineries	5.0	4.9	5.7	5.7	5.7	5.7	5.7	5.7
Residential	21.1	23.2	20.3	20.4	20.6	19.8	19.9	20.1
Services	8.3	8.2	5.9	6.1	6.9	5.9	6.1	6.9
Industry	35.3	33.4	32.6	31.7	30.6	32.5	31.4	30.3
Road Transport	30.1	32.0	32.6	33.2	32.5	32.6	33.2	32.5
Off-road	1.6	1.4	1.4	1.4	1.4	1.5	1.4	1.4
Other transport	3.4	2.5	2.3	2.4	2.5	2.3	2.4	2.5
LUC	0.8	-0.1	-0.5	0.1	0.7	-0.5	0.1	0.7
Total	161.4	148.6	142.9	146.4	145.8	143.9	147.8	146.5

Table 5 – UEP26 Central scenario emissions by source by sector (MtC)

 ¹⁰ This figure differs slightly from quoted Defra figures due to a different emissions inventory basis currently used for this UEP.
 ¹¹ Please note, the emissions by sector relate to the year 2010. The EU ETS emissions

projections will be based on an average from 2008-2012.

While higher fossil fuel prices have lowered demand in the longer term in all sectors, the relative price of coal and gas has increased emissions from power stations.

Electricity Generation by fuel type

Table 6 below illustrates the updated generation fuel mix in 2010 and 2020 for the two central scenarios, including comparisons with the UEP21 projections. Revisions to energy price assumptions have tended, on balance, to produce higher coal generation in 2010 compared with UEP21, but particularly so in the favourable to coal scenario, as a result of both the direct competitive effect and also the induced greater capacity of plant modelled to be retrofitted with FGD (Flue Gas Desulphurisation). In all scenarios, a higher amount of FGD capacity has been assumed than in UEP21, reflecting recent market developments. The increase in FGD capacity permits higher levels of coal - fired generation whilst remaining within UK emission limits. In 2020, coal generation is higher than in UEP21, mainly due to the greater stock of coal - fired plants fitted with FGD, without which, closure would have resulted.

The generation mixes for all four scenarios are shown in Annex I.

	UEP21				UEP26				
	Fav	/ gas	Fav Coal		Fav	Fav Gas		Fav Coal	
	2010	2020	2010	2020	2010	2020	2010	2020	
Coal	103	58	108	80	106	82	119	94	
Oil	2	1	2	1	2	1	3	2	
Gas	132	228	122	201	137	235	122	219	
Nuclear	73	26	73	26	73	26	73	26	
Renewables	33	53	33	53	33	53	33	53	
Imports	11	13	10	10	11	11	11	11	
Pumped storage	3	3	3	3	3	3	3	3	
Total	356	381	350	374	365	411	362	407	

Table 6 - Comparison of generation fuel mix 2010 and 2020 for central scenarios, UEP21 v UEP26 (TWh)

The updated projection and progress towards Kyoto Target

The Kyoto target is based on a basket of greenhouse gases (GHG) of which CO_2 emissions represent the largest share.

In our February 2006 paper¹², progress towards the Kyoto target was represented combining the UEP21 CO_2 projection with the Defra estimated projection of non- CO_2 gases. In Figure 1 the non- CO_2 emission projection (unchanged) is combined with the updated UEP26 projection to provide an update of progress towards our greenhouse gas emission target. The UK remains on track to comfortably go beyond its Kyoto commitment of a 12.5% reduction on 1990 levels. Before allowing for the EU ETS, total UK greenhouse gas emissions will be some 20% below the base year level. Allowing for a further 8MtC saving from the EU ETS, the UK is on track for around a 24% reduction¹³.





¹² http://www.dti.gov.uk/files/file26363.pdf

¹³ Historic GHG figures are on the 1990-2003 inventory basis.

PART 2

ENERGY REVIEW SCENARIO PROJECTIONS TO 2050

Introduction

Long term energy and emissions projections to 2050 were first established for the Energy White Paper, 2003¹⁴ and were developed using a combination of econometric analysis and scenario approach. Econometric modelling based on identification of past trends and drivers to project energy in the short to medium term was supplied by the DTI Energy Model, while a scenario approach allowed a more flexible approach to longer-term projections providing a chance to think beyond the continuation of present trends.

The scenario approach provided a range of "expected" carbon emission levels in 2050 on the basis of several key assumptions associated with, for example, GDP, population and sector growth.

This current work has allowed a review of the Energy White Paper analysis to assess to what extent recent changes in energy market fundamentals may have shifted views of the long term.

To capture this, the extrapolation of the 2020 scenarios allows for variation of a wider range of assumptions including fossil fuel prices, UK economic growth and energy intensity.

Methodology establishing the Energy Review 2050 baselines

As in the previous Energy White Paper (EWP) work the development of a range of "business as usual" baselines, and scenario projections of long-term carbon emissions provide an illustration of the absolute level of emissions reached by 2050. The current work, however, incorporates an updated assessment of several key assumptions to reflect

- revision of international fossil fuel prices;
- UK economic growth;
- demographics;
- manufacturing sector growth;
- existing and new policy measures.

¹⁴ The methodology is fully described in Annex 2 of the Energy White Paper Supplementary Annexes (<u>http://www.dti.gov.uk/files/file21214.pdf</u>)

As in the EWP, the baseline approach does not consider the introduction of radical technological changes (although again some limited assumptions are made within the scenario sector assumptions), but looks at what "could happen" if things were to continue according to past trends and two alternative future scenarios defined as high and low growth. The approach is deliberately simple and transparent so that the projections provide a backdrop to the examination of technologies which may be introduced to set the UK on a path to a 60% reduction in emissions by 2050.

Three scenarios represent:

- a business as usual case
- a high growth scenario,
- a lower growth scenario

The first of these scenarios is an extrapolated projection based on the UEP26 projection to 2020¹⁵. The second and third scenarios are defined within the Foresight scenario framework¹⁶ and recently revised as "Perpetual Motion" and "Good Intentions". Both second and third scenarios have, as their 2010 starting point, UEP 26.

The long term scenarios have been developed through the DTI Foresight programme and are developments of earlier scenarios used in the Energy Review. Perpetual motion is described as "strong economic growth and globalisation stimulating rampant consumerism by a society relieved of environmental responsibility". This scenario replaces the previously used World Markets scenario. Good intentions describes a world where consumption of energy is generally restrained and behavioural change limits consumption and replaces the Global Sustainability scenario used in the EWP work.

These scenarios are defined using a limited number of key assumptions, including economic growth, population and number of households, projected energy, carbon intensities and fossil fuel prices to reflect a given storyline. Inclusion of policy measures is based on the recent re-assessment undertaken for the Climate Change Programme Review (CCP2006) of measures. The key parameters describing these three scenarios are given in Table 7.

¹⁵ The long-term scenarios are built on the medium term UEP26 energy and emissions projections out to 2020 and the period 2020 to 2050 based on a scenario projection.
 ¹⁶ <u>http://www.foresight.gov.uk/Intelligent_Infrastructure_Systems/Index.htm</u>

I able 7 – Key parameters describing scenarios to 2

	Baseline	Perpetual motion	Good Intentions
	(central)	(high growth)	(lower growth)
Economic growth GDP 2020-2050 per	2.0%	2.75%	1.25%
annum			
Manufacturing	1.125%	2.125%	1.00%
growth p.a.			
Total UK population in 2050	Around 70 million	74 million	65 million
Total number of UK households in 2050	Around 36 million	38 million	31 million
Environmental effort	Equivalent to current	Equivalent to half the	Equivalent to 150%
to 2020	efforts (CCP)	effort in the baseline	of baseline effort.
Crude Oil price (average 2005-2050)	\$50/bbl	\$75/bbl	\$29/bbl

The approach also takes account of existing policies, saturation effects and limited potential for further fuel switching to provide complimentary baseline energy and carbon projections.

Baseline Projections results

The current baseline projection, which excludes impact of EU ETS, suggests that the gap between the projected emissions in 2050 and the target of a 60% reduction is some 17MtC wider than the EWP estimate. The current projection is 12.6MtC higher than the EWP estimate in 2020 of which some 8MtC is due to higher coal burn in the generating sector, a result of the higher fossil fuel price assumptions which tend to favour coal burn. The higher population assumption accounts for a further 2.2MtC of this difference and an assumption of higher growth in the near term will also have influenced the higher estimate. Including the impact of the EU ETS will reduce the baseline by 8MtC.

Figure 2 illustrates the comparison between the current long-term baseline projection and the Energy White Paper baseline.



Figure 2 – Energy Review v Energy White Paper long-term baseline projection¹⁷

Projecting 50 years ahead demands a scenario approach. Econometric models are valuable in the medium to longer term but projecting beyond 2020 to 2050 becomes difficult as for example, technologies are expected to change, new processes and systems are introduced and the detailed econometric relationships built on past relationships are no longer valid in this time frame.

The baseline and scenario projections include the impact of nuclear closures on emissions with the assumption that capacity is replaced by gas-fired generation. Electricity from renewable sources is maintained at the level achieved by 2020 until 2050.

These scenario approaches, of a baseline high and low growth, provide a measure of the uncertainty out to 2050 and illustrate that even in the low growth scenario the 60% CO₂ reduction target is unlikely to be met without further measures. Figure 3 illustrates the current expected carbon trajectory of the three updated scenarios to 2050.

¹⁷ Differences in historic figures between the current projection and the Energy White Paper are due to revisions to the emissions inventory.

Figure 3 - Current baseline projections to 2050



Sector Emissions and Energy Demand

Projected baseline CO2 emissions by sector

Table 8 below provides emissions projections by sector on an "end user" basis. "End user" emissions are determined on the basis of each sector accepting responsibility for a share of the emissions associated with the generation of the electricity consumed in that sector and similarly the emissions associated with refining the oil consumed (as well as for the emissions from direct consumption of fuels such as coal, gas and oil).

Table 8 - Projected sector end user CO₂ emissions (MtC)

	Residential sector	Transport sector (1)	Industry	Services	Total CO ₂ emissions (including LUC)
1990	40.3	40.0	56.4	23.8	161.4
2000	38.8	41.1	48.9	20.7	143.5
2010	36.7	42.4	45.8	19.5	146.7
2030	41.1	41.5	46.6	21.6	151.4
2050	47.3	40.5	50.3	23.8	162.6

(1) Excludes emissions from international aviation fuel sold in UK.

Baseline final energy demand by sector

	Residential sector	Transport (including aviation)	Transport (excluding international aviation)	Industry	Service sector	Total
1990	40.8	58.0	41.7	38.7	19.2	156.6
2010	43.0	75.3	47.9	33.8	19.5	171.6
2020	45.7	83.5	48.0	36.8	21.0	186.9
2030	46.8	93.0	46.2	37.5	21.6	198.9
2050	49.7	112.2	44.3	38.9	23.0	223.8
Growth 2010- 2050	+16%	+49%	-8%	+15%	+18%	+30.4%

Table 9 - Historic and projected growth of final energy demand by sector (Mtoe)

It is clear that an anticipated increase in aviation fuel demand from continued growth in this sector is sufficient to mask a real fall in other transport fuel demand (8%). The largest reduction is expected to come from road fuel demand as growth in demand for transport moderates, fuel efficiency in transport continues to improve and lower-carbon fuels, especially biofuels, increase their market share.

Baseline energy demand, by fuel

The baseline projection, excluding EU ETS, suggests that total final energy demand¹⁸ (including oil demand from international aviation), will increase from some 171 million tonnes of oil equivalent (Mtoe) in 2010 to 224Mtoe by 2050.

Final energy demand in the baseline, by fuel, is shown in Table 10.

	Electricity	Gas (1)	Oil (2)	Solid fuel	Renewables	Total
1990	23.6	46.0	72.7	13.8	0.45	156.6
2010	29.6	54.0	85.6	1.9	0.43	171.6
2020	33.4	58.3	93.1	1.7	0.49	186.9
2030	36.0	60.9	99.3	2.0	0.66	198.9
2050	40.9	62.9	117.1	2.1	0.78	223.8

Table 10 - Final energy demand in the baseline, by fuel (Mtoe)

(1) Mostly Natural Gas but includes Coke Oven Gas used in the Iron and steel sector.

(2) Includes Aviation fuel supplied in UK and used for international flights.

Demand for aviation fuel has risen sharply in the last 15 years (7.3Mtoe in 1990 to 12.3Mtoe in 2005) and is projected to continue to increase with rising real

¹⁸ Excluding energy used for transformation in the iron and steel sector and including aviation fuel used for international flights but sold in the UK, which is consistent with DUKES energy sector demand definitions.

incomes albeit less sharply than in the past. Aviation fuel demand is projected to be 13.5Mtoe in 2010 and some 35Mtoe by 2050, almost a three-fold increase.

Electricity demand

The baseline projection of electricity demand, assuming no further measures or policies to improve energy efficiency and excluding the impact of EU ETS, is given in Table 11 and illustrates strong growth from the residential, industry and the commercial (service) sectors. Electricity demand in general in all three scenarios is expected to increase well beyond current levels (Figure 4).

Table 11 – Ba	seline electricity	demand growth	by sector	(Mtoe)
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	Residential sector	Industry sector	Service sector	Transport sector	Total Electricity demand
1990	8.1	8.7	6.4	0.46	23.6
2010	10.3	10.0	8.5	0.78	29.7
2020	12.1	11.3	9.2	0.79	33.4
2030	13.0	12.1	9.8	1.16	36.0
2050	15.0	13.2	10.2	2.5	40.9
Growth 2010- 2050	45%	31.4%	20%	223%	+38%





Conclusion

The current analysis shows that, though progress has been made in reducing carbon emissions, the road ahead is particularly challenging. Carbon emissions post-2010 are unlikely to fall further without additional measures and might

instead increase. Electricity demand in particular is expected to increase well beyond current levels.

Table 12 below illustrates the scale of the challenge to meet a total 60% CO₂ reduction in 2050. This compares the carbon intensity improvement required, implied by the EWP scenarios, to the current scenarios. To further illustrate the level of effort required, these are compared with the carbon intensity improvement implied by current policy measures (under the CCP) for the period 2000 to 2010.

For example, the Energy White Paper projections suggested that a carbon intensity reduction of 4.3% per annum was required to meet a 60% reduction by 2050. This is similar in the current projections (4.36% p.a.). To put this level of carbon reduction in perspective, it can be seen that the combined effort of all CCP measures would achieve a rate of carbon intensity improvement of 2.74% per annum (2000-2010).

	Energy White Paper	Energy Review scenario projections 2006	Carbon intensity implied by projections, if all policy measures achieved in full 2000- 2010
Sectors	Post 2010 to 2050(%p.a.)	Post 2010 to 2050 (%p.a.)	
All sectors	4.3	4.36	2.74
Residential	4.8	4.42	3.5
Transport	4.9	4.79	2.85
Industry	3.5	4.08	3.29
Services	4.9	4.21	2.78

Table 12 – Carbon intensity improvement requirements¹⁹

Figure 5 below illustrates the three Energy Review scenarios (baseline, high & low growth) against the 60% target reduction and compared with the Energy White Paper baseline projection, for the years 1970-2050.

¹⁹ Illustrative figures for sectors assuming 60% reductions in each sector.



Figure 5 - Comparison of current baseline projections with Energy White Paper baseline

Energy Strategy Unit DTI – July 2006

Annex A

Fossil Fuel Price Assumptions

The future fossil fuel price assumptions used in this analysis are illustrative scenarios used to reflect uncertainty over the outturn of future prices in the modelling. They are not detailed forecasts or predictions of future prices.

Rationale for the different scenarios:

Central Scenario favourable to coal

In the Central price scenarios, it is assumed that oil prices ease post 2007-2008 as new production capacity comes on-stream and demand growth moderates, leading to a slight increase in spare production capacity. However, as oil is increasingly produced from more expensive sources and spare capacity remains relatively tight, 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 closer to long-run marginal costs.

Central Scenario favourable to gas

The purpose of this scenario is to test the impact different price differentials between coal and gas would have on the generation mix and consequently CO₂ emissions. The Central scenario sensitivity therefore assumes the same oil and coal prices as in the central scenario, but assumes that the gas prices outturn between the central and low scenario (i.e. the gas prices for each year are the midpoint between the gas prices in the central and low scenario for that year).

<u>High Scenario</u>

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 and production costs remain inflated. It is again 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.

Low Scenario

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.

Fossil fuel price assumption revisions for UEP2

	Fav Gas			Fav Coal		
Real 2005 Prices	Crude Oil \$/bbl	Natural Gas Beach Price P/therm	ARA Coal NAR £/tonne	Crude Oil \$/bbl	Natural Gas Beach Price P/therm	ARA Coal NAR £/tonne
2005	55.0	41.0	33.6	55.0	41.0	33.6
2010	40.0	25.8	27.2	40.0	33.5	27.2
2015	42.5	27.3	26.1	42.5	35.0	26.1
2020	45.0	28.8	25.0	45.0	36.5	25.0

	High			Low		
Real 2005 Prices	Crude Oil \$/bbl	Natural Gas Beach Price P/therm	ARA Coal NAR £/tonne	Crude Oil \$/bbl	Natural Gas Beach Price P/therm	ARA Coal NAR £/tonne
2005	55.0	41.0	33.6	55.0	41.0	33.6
2010	67.0	49.9	36.5	20.0	18.0	19.0
2015	69.5	51.4	36.5	20.0	19.5	16.8
2020	72.0	53.0	36.5	20.0	21.0	14.6







Annex B

Millions	Published Projections	Latest Projections	% change
2005	25.7	26.1	1.5%
2010	26.7	27.4	2.6%
2015	27.7	28.8	4.2%
2020	28.5	30.1	5.8%

ONS revision to UK population and household forecasts²⁰

²⁰ Published 14 March 2006

Annex C

	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	104.0	70.6	93.0	111.7	109.5
2008	104.8	61.1	96.4	119.9	114.2
2009	105.7	58.8	97.3	123.2	115.7
2010	106.6	56.5	97.9	127.0	117.0
2011	107.3	54.4	98.6	130.9	118.1
2012	108.1	52.2	99.2	134.8	119.1
2015	110.4	46.4	100.9	147.1	122.9
2020	114.0	37.9	103.7	169.6	128.7
Change in growth at 2010 compared with Feb 06 projection	-0.7%	+1.6%	-2.3%	-0.8%	+2.9%

Projected Industrial Sub Sector Growth Indices²¹

	Non-ferrous metals	Engineering & vehicles	Construction & other industry	Iron + Steel
2000	100.0	100.0	100.0	100.0
2005	118.8	93.1	109.9	87.4
2008	123.8	100.6	116.5	108.7
2009	124.8	101.9	118.3	110.5
2010	125.5	103.2	120.2	110.9
2011	126.3	104.7	121.9	111.2
2012	127.1	106.1	123.6	111.6
2015	129.4	110.5	128.7	112.5
2020	132.9	118.2	137.8	112.9
Change in growth at 2010 compared with Feb 06 projection	+2.5%	-2.1%	-1.3%	-0.7%

²¹ Revised to reflect Budget 2006 announcements, assessment of consultation responses and updated work by Oxford Economic Forecasting

Annex D

Adjustments to the CHP projections

Over the last few years, increases in industrial CHP capacity have been slow with the most significant development being the very large unit at Immingham developed by ConocoPhillips. The success of this unit has opened up the possibility of two tiers of CHP in the UK, a relatively small-scale market with capacities up to around 100MW and extremely large units of around 500-1000MW. Evidence suggests that there are further opportunities for these large units and they are hence expected to make significant additions to capacity over the period to 2015.

Trials of domestic CHP are continuing on a small scale and although their potential is large, they seem unlikely to make a major contribution to the electricity system or carbon reduction before 2010. Whilst market penetration over the period to 2015 seems likely, this is a new technology and it is extremely difficult to project installed capacity. Given the uncertainty in the outcome of trials and the development of the technology, a conservative assumption has been made of zero installed capacity to 2015. This avoids presenting an over optimistic view of emissions reductions.

Projections of overall CHP capacity have been informed by the latest work undertaken by Cambridge Econometrics which shows that, in the absence of the EU ETS, capacities of around 7.5GW and 8.7GW are expected at 2010 and 2015 respectively. Taking account of the sectoral breakdown and size of the individual units, these translate into generation values of 39.8 and 47.8TWh in these years. This generation is netted of the demand that is met by the ESI model used in this work, hence reducing emissions in this sector whilst allocating the emissions from CHP to the industrial sectors in which they operate. The overall treatment of CHP is summarised in the table below:

> Year Capacity Generation MW TWh 26.5 2000 4730 2004 27.4 5606 2010 7470 39.8 2015 8700 47.8

CHP capacity and generation, 2000-2015

Annex E

This annex details all the Climate Change Programme measures included in the baseline projections. Table E.1 details existing measures previously included in UEP 21 and Table E.2 provides details of additional measures outlined in the recent Climate Change Programme Review that have been included in UEP26

Table E.1 provides existing savings from Climate Change Programme measures included in the UEP21.

Table E.1 MtC Saving					
	2010	2015 ²²	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		
Ducinação					
	0.07	0.07	0.07		
	0.27	0.27	0.27		
CCL package	1.10	1.10	1.10		
Building Regulations 2005	0.34	0.30	0.30		
	0.14	0.17	0.17		
CCAS	2.00	2.00	2.00		
Public sector					
Public sector	0.26	0.27	0.27		
		-	-		
<u>Transport</u>					
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		

<u>Other CCP measures included within the UEP 21 baseline</u>. These measures include the Climate Change Levy impact, the impact of the Renewables Obligation and the fuel duty escalator, which has since been discontinued.

²² 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.

Additional measures announced in the Climate Change Programme 2006 now included in UEP26

Table E.2 provides details of estimated savings from measures announced in the Climate Change Programme Review which have been included in UEP26²³.

Table E.2		MtC Saving	
	2010	2015 ²⁴	2020 ⁵²
<u>Residential</u>			
EEC (2008-11)	0.5	0.5	0.5
Energy Performance of Buildings	0.2	0.2	0.2
Directive			
Energy efficiency in buildings	0.1	0.1	0.1
Billing and metering	0.2	0.2	0.2
Products policy	0.2	0.2	0.2
Business			
Subsidy for biomass heat	0.1	0.1	0.1
Energy efficiency in SMEs	0.1	0.1	0.1
Energy saving opportunities in	0.1	0.1	0.1
SMEs			
<u>Agriculture</u>			
Food crop strategy	0.1	0.1	0.1
Public sector			
Local authorities	0.2	0.2	0.2
Revolving loan	0.1	0.1	0.1
Devolved administrations	0.3	0.3	0.3
Other measures	0.1	0.1	0.1
Transport			
RTFO	1.6	1.6	1.6
Future VA	0.1	0.7	1.5
Total (Excluding EU ETS)	4.0	4.6	5.4

The Waste Electrical and Electronic Equipment Directive (WEEE) came into force in January 2003 and will be implemented in the UK from August 2006. This directive is estimated to save some 0.2 MtC in 2010. This saving is not currently in the UEP baseline.

 ²³ http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf
 ²⁴ Estimates of measures beyond 2010 are less certain, and have either been assumed to

²⁴ 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 F

Carbon Gap

All updated scenarios are showing a narrower carbon gap against the national goal of 129MtC in 2010 despite an increase in the underlying baseline due to the most recent revisions. This is because the baseline increase in 2010 (3.1MtC) is lower than the new policy measure carbon savings of 4MtC announced in the CCP2006 and now incorporated in UEP26. This is also the case in 2020 where the increase in the underlying baseline (4.95MtC) is also lower than the 2020 impact of CCP2006 new measures (5.36MtC)²⁵

MtC UEP26	Central Favouring Gas	Central Favouring Coal	High	Low
1990	161.4	161.4	161.4	161.4
2010	142.9	143.9	142.5	143.3
2020	145.8	146.5	146.9	142.9
2010 Reduction from 1990	-11.4%	-10.8%	-11.7%	-11.2%
National goal	129MtC	129MtC	129MtC	129MtC
Carbon gap in 2010	13.8MtC	14.8MtC	13.4MtC	14.2MtC
MtC UEP21	Central Favouring Gas	Central Favouring Coal	High	Low
1990	161.4	161.4	161.4	161.4
2010	144.5	144.1	144.7	145.1
2020	145.2	148.0	148.3	146.9
2010 Reduction from 1990	-10.5%	-10.7%	-10.3%	-10.1%
National goal	129MtC	129MtC	129MtC	129MtC
Carbon gap in 2010	15.4MtC	15.0MtC	15.6MtC	16.0MtC

Updated headline emissions projections UEP26 compared with UEP21.

²⁵ 5.36 MtC is a DTI estimate of the impact of CCP2006 new measures in 2020 and includes a DTI estimate of the impact of a second voluntary agreement by car manufacturers, based on information supplied by DfT.

Annex G

				High			Low	
	1990	2000	2010	2015	2020	2010	2015	2020
Power Stations	55.7	43.1	44.4	48.3	49.5	40.9	41.6	39.9
Refineries	5.0	4.9	5.7	5.7	5.7	5.7	5.7	5.7
Residential	21.1	23.2	19.0	19.0	19.3	21.5	21.5	21.6
Services	8.3	8.2	5.9	6.1	6.9	5.9	6.1	6.9
Industry	35.3	33.4	32.2	30.7	29.5	32.8	31.9	30.7
Road Transport	30.1	32.0	32.1	32.3	31.7	33.1	34.0	33.5
Off-road	1.6	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Other transport	3.4	2.5	2.3	2.3	2.4	2.4	2.5	2.6
LUC	0.8	-0.1	-0.5	0.1	0.7	-0.5	0.1	0.7
Total	161.4	148.6	142.5	145.9	146.9	143.3	145.0	142.9

High and low price scenario sector emissions by source (MtC)

Annex H

			Fav Gas		Fav Coal			
	1990	2000	2010	2015	2020	2010	2015	2020
Business	60.9	51.5	48.5	50.7	52.3	49.2	51.5	52.8
Industrial processes	4.8	4.3	4.1	4.2	4.4	4.1	4.2	4.4
Transport	40.2	42.1	42.7	42.8	41.5	42.7	42.9	41.5
Residential	41.7	39.5	36.4	37.8	37.3	36.5	38.2	37.3
Public	8.7	6.7	5.8	5.6	5.2	5.9	5.7	5.3
Agriculture	1.6	1.2	1.1	1.1	1.0	1.2	1.1	1.0
Land use change (emissions)	0.8	-0.1	-0.5	0.1	0.7	-0.5	0.1	0.7
Waste management	0.6	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Exports	2.1	3.2	4.6	3.8	3.3	4.6	3.8	3.3
Total	161.4	148.6	142.9	146.4	145.8	143.9	147.8	146.5
				High			Low	
	1990	2000	2010	2015	2020	2010	2015	2020
Business	60.9	51.5	49.2	51.4	54.0	47.6	48.6	49.2
Industrial processes	4.8	4.3	4.0	4.1	4.2	4.1	4.4	4.6
Transport	40.2	42.1	42.1	41.8	40.6	43.2	43.8	42.5
Residential	41.7	39.5	35.7	37.5	37.4	37.2	37.8	36.7
Public	8.7	6.7	5.9	5.8	5.5	5.7	5.4	5.0
Agriculture	1.6	1.2	1.2	1.1	1.0	1.1	1.0	0.9
Land use change (emissions)	0.8	-0.1	-0.5	0.1	0.7	-0.5	0.1	0.7
Waste management	0.6	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Exports	2.1	3.2	4.7	3.9	3.4	4.6	3.7	3.2
Total	161.4	148.6	142.5	145.9	146.9	143.3	145.0	142.9

End User Emissions (MtC)

Annex I

			Fav Coal			Fav Gas			
	1990	2000	2010	2015	2020	2010	2015	2020	
Coal	204	112	119	116	94	106	100	82	
Oil	15	2	3	2	2	2	2	1	
Gas	0	127	122	164	219	137	183	235	
Nuclear	59	78	73	34	26	73	34	26	
Renewables	5	10	33	53	53	33	53	53	
Imports	12	14	11	11	11	11	11	11	
Pumped storage	2	3	3	3	3	3	3	3	
Total	298	346	362	383	407	365	386	411	

The generation fuel mix (TWh)

			High			Low		
	1990	2000	2010	2015	2020	2010	2015	2020
Coal	204	112	122	126	136	97	79	54
Oil	15	2	3	2	2	2	2	1
Gas	0	127	116	150	156	143	201	256
Nuclear	59	78	73	34	43	73	34	26
Renewables	5	10	33	53	53	33	53	53
Imports	12	14	11	11	11	11	11	11
Pumped storage	2	3	3	3	3	3	3	3
Total	298	346	360	379	404	362	382	404

Annex J

Estimated UK response to Carbon price

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 c urrent 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.

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; 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 the table below.

Carbon Price	10 euro/tCO ₂	20 euro/tCO ₂	30 euro/tCO ₂	40 euro/tCO ₂
Central (1) favourable to gas	1.0	2.0-3.0	2.5-4.0	3.0-5.0
Central (2) favourable to coal	0.0	0.5-1.0	0.5-1.5	1.5-2.5
Low prices	1.0	3	4-5	≈5
High prices	0.0	0.0	0.0-0.5	0.0-0.5

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

The estimated impacts represent possible reductions in emissions from the baseline levels as a result of fuel switching between fossil fuels.