SECTORAL ENERGY AND EMISSIONS PROJECTIONS IN THE ENERGY WHITE PAPER

Introduction

1.1 Leading up to and alongside the energy white paper, published in February 2003, a good deal of supporting material concerning projections of energy and CO_2 emissions has been made available. This has included:

- IAG Report, Long Term Reductions in Greenhouse Gas Emissions in the UK. Report of an inter-departmental analysts group, February 2002. http://www.dti.gov.uk/energy/greenhousegas/greenhouse.pdf.
- DEFRA supporting material to IAG/PIU, several papers on http://www.cabinet-office.gov.uk/innovation/2001/energy/submissions
- Annex 1 to the energy white paper, Low Carbon Options, http://www.dti.gov.uk/energy/whitepaper/index.shtml.
- Estimates of primary energy demand and electricity generation, DTI note http://www.dti.gov.uk/energy/whitepaper/index.shtml.

1.2 Reviewing the material, published with the white paper, we are conscious that relatively little illustrates the break down of projections by end use sector – households, industry, services and transport[1]. The purpose of this note is to illustrate that breakdown, concentrating on the period to 2020.

1.3 We look first at baseline projections, on the basis of existing Government policy prior to the white paper. Following from that, adjustments are made to give an indication of projections allowing for a further 15-25 MtC savings in emissions by 2020, as targeted in the energy white paper.

1.4 The uncertainties in making projections of this sort are substantial. They should therefore be regarded as illustrative, not as forecasts. The intention is to clarify existing published material. We would welcome comments, to:

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White paper baseline projections

1.5 White Paper baseline carbon dioxide projections to 2050 were derived from the work of the Interdepartmental Analysts Group (IAG) on Long

[1] Though much is contained in the IAG report.

Term Low Carbon Options. This projection utilised the detailed near term projections work of Energy Paper 68 (EP68)[2], based on econometric models, in conjunction with longer –term projections of historic carbon intensity improvements. Full details of the methodology and key assumptions are provided in the IAG report.

1.6 This approach, while drawing on an econometric method to 2010, allowed a more flexible approach beyond that, reflecting the greater uncertainty that is inevitable in the longer term. It provided for more flexibility of assumptions (e.g. on population, household formation, transport and industrial growth) going out from 2010 to 2050. It does mean, however, that the projections beyond 2010 were less detailed in relation to specific fuel use, being constructed more in terms of total energy demand and end user emissions.

1.7 The IAG approach was complemented by the detailed bottom-up technology based MARKAL modelling analysis which explored, on a variety of assumptions relating to costs, how these energy demands could be met by specific technologies and fuels.

<u>The baseline to 2010</u>

1.8 The EP68 projections incorporate government policies considered firm at the time of publication (Nov 2000) e.g. the renewables target of 10% of electricity generation by 2010 and the Climate Change Levy[3], but excluded the full Climate Change Programme (CCP), for which EP68 provided a base. The projections provided a detailed breakdown of the energy used, by specific fuel, by sector and end user emissions.

1.9 For the energy white paper, the EP68 projections to 2010 were adjusted to allow for the full impact of all the measures outlined in the CCP, on the assumption that the CCP targets would be fully met by 2010.

<u>The baseline to 2050</u>

1.10 Taking these projections forward beyond 2010 to 2050 would not have been appropriate on this same econometric basis. Beyond 2010 the energy white paper baseline reflects extrapolation of historic carbon intensity rates of improvement. There is concern, however, that part of our recent success in reducing carbon intensity is non-repeatable. The projection was therefore adjusted to remove the impact of historic fuel switching, dash for gas (dfg) and non- repeatable effects, whilst still allowed to reflect key assumptions of economic growth, population and household growth, service and manufacturing structure and transport growth. Expected closure dates of nuclear plants were also factored into the projections. The projections were based on the UK aggregate

[2] Energy Paper 68 Energy Projections for the UK (EP68 available on http://www.dti.gov.uk/energy/inform/energy_projections)
[3] though not the associated climate change agreements

of four main sectors of domestic, services, industrial and agricultural and transport sectors, plus non- sectoral emissions[4].

1.11 Considerable uncertainty would be expected in any projection over this horizon. This was explored in the use of alternative assumptions and sensitivities in the IAG report. In addition to the baseline projection this included consideration of other “World Markets” and “Global Sustainability” scenarios. More detail of the assumptions underlying each of these three scenarios is given in Table 1.

[4] Emissions arising from land use change and processes emissions e.g. off-shore flaring; cement, aluminium, lime, soda-ash etc production emissions.

Table 1 – Key assumptions used for the White Paper baseline and two of the four alternative scenarios.

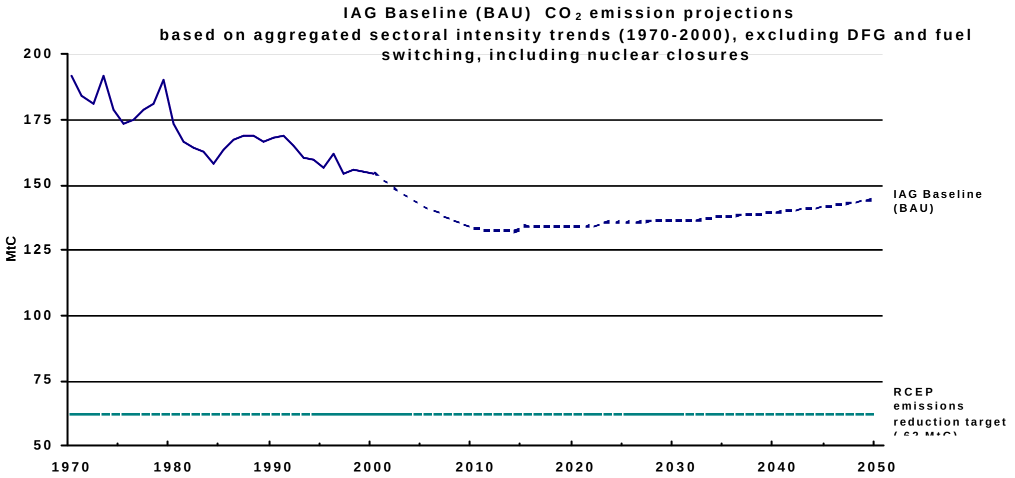
		Baseline	**World Markets**	**Global Sustainability**
UK GDP growth p.a.		2.25%	3.00%	2.25%
Population (million)		65	66	63
Household size		2.17	2.00	2.20
Implied household numbers growth p.a.[1]		0.30%	0.54%	0.18%
Service sector output growth p.a.		2.49%	3.25%	2.36%
Industry sector growth p.a.		1.56%	1.60%	1.80%
Nuclear		Closures continue as planned	Closures continue as planned	Closures continue as planned
Coal usage in electricity generation		Continues as of 2020	Continues as of 2020	Continues as of 2020
Transport[2]	Freight link to economic growth	Ratio = 0.75 in line with historic growth	Ratio = 0.825 higher growth	Ratio = 0.675 slower growth
	“Technology development”[4]	Improvement ratio =1 (in line with historic rates)	Improvement ratio =1.2 (higher rate of development implying lower carbon emissions from vehicles)	Improvement ratio =1.2 (higher rate of development implying lower carbon emissions from vehicles)
	Air travel link to economic growth	Ratio = 1.5 faster than GDP growth	Ratio = 2.0 faster than GDP growth	Ratio = 1 in line with GDP growth
	Car traffic link to household numbers	Ratio = 2.5 faster than HH growth	Ratio = 2.5 faster than HH growth	Ratio = 2.5 faster than HH growth
	Implied transport energy demand growth p.a.[3]	1.51%	2.44%	0.75%
Projected CO_2 emissions in 2050		**145 MtC**	**180 MtC**	**132 MtC**

Notes

[1] Implied growth from 2010 base
[2] 2010 DERV *car* share of 15% assumed
[3] Assumes 2010-2050 growth based on historic energy intensity changes and demand assumptions
[4] “Technology development” represents a vehicle efficiency and pollution index relative to historic rates. The ratio value of 1 indicates a continuation of historic rates of improvement in efficiency and carbon emissions per vehicle. A ratio of greater than 1 indicates an increased rate of improvement in efficiency and emissions per vehicle, which may be by improved efficiency in mpg of fossil fuel or achieved by the introduction of lower carbon fuel technologies e.g. bio fuels.

1.12 The projection considered most appropriate to represent a business as usual baseline projection, suitable for the White Paper Analysis, is referred to as IAG(A) and estimates a total UK carbon emission of 135 MtC in 2020 rising to 145MtC in 2050. The baseline is illustrated in Figure 1.

Figure 1 The IAG baseline based on aggregated sectoral intensity trends



<u>Carbon and energy intensities to meet 60% CO_2 reduction</u>

1.13 The energy white paper accepts the Royal Commission on Environmental Pollution recommendation that the UK should put itself on a path to around a 60% reduction in CO_2 emissions by 2050. Allowing for the impact the CCP is projected to have had on carbon emissions by 2010, the annual required rate of carbon intensity improvement after that date in order to reach the 60% reduction target is 4.3%. None of our baseline projections comes close to this requirement. Reaching such a target - especially allowing for the fact that some factors that have produced emission reductions in the past are not available looking forward (or not available to the same extent) - is a significantly bigger task than anything achieved to date. The rate of carbon intensity improvement required to reach a 60% reduction target by 2050 is:

- significantly greater than the historic trend (3% a year 1970-2000);

- significantly greater than the recent historic trend ignoring the impact of the dash for gas (2% a year 1990-2000);

- greater than the improvement expected over the period 2000-2010 which includes the impact of the CCP (2.8% a year).

Achieving the 60% reduction will therefore be a significant challenge, but the energy white paper provides the framework by which it can be achieved.

CARBON INTENSITY BY SECTOR

1.14 In considering the implications of hitting a 60% reduction target in 2050, it may be useful to examine historic and projected rates of improvement by sector of final demand. Table 2 shows the IAG(A) projections of emissions broken down by sector and energy use (Table 2b).

Table 2a White Paper Baseline Carbon projection to 2050 (MtC), based on assumption of full impact of CCP in 2010.

IAG(A) Baseline MtC

	2000	***2010***	***2020***	***2030***	***2050***
Industry	40.1	32.7	27.3	25.5	19.3
Domestic	39.8	33.6	33.0	32.7	30.4
Services	22.8	19.1	22.3	23.2	26.8
Transport	38.9	38.5	43.6	45.8	59.3
Subtotal	141.5	123.8	126.2	127.3	135.7
Non-sectoral emissions	13.0	9.2	8.9	8.9	8.9
Total emissions	154.5	132.9	135.1	136.1	144.6

Table 2b White Paper Baseline Final Energy[5] Demand equivalent projection to 2050 (Mtoe)

Baseline	**Mtoe**				
	2000	***2010***	***2020***	***2030***	***2050***
Industry	40.4	36.1	32.0	28.1	21.9
Domestic	45.5	41.8	41.9	41.4	40.9
Services	22.8	22.3	24.7	26.8	32.1
Transport	55.0	57.3	64.4	74.5	104.5
Total energy	163.7	157.5	163.0	170.7	199.4

1.15 Table 2a illustrates, on the basis of the assumptions[6], that overall emissions in 2050 will be lower than in 2000, falling initially to 2010 due to the impact of the CCP but rising slowly again to 2050. There is a fall in emissions from two sectors due to a fall in the emissions from the industrial sector, on the basis of an assumed continued shift away from heavy industry, and to a lesser extent a decline in emissions from the domestic sector, due to improved efficiency. These falls, however, are offset by growth in emissions from the other two sectors. The transport sector is likely to be the fastest growing sector in terms of carbon emissions which are assumed to increase some 50% between 2010 and 2050. Emissions from the service sector are projected to grow by some 40% in the same period.

1.16 Overall, as previously estimated, carbon intensity must improve by 4.3% post 2010. Table 3 below compares the rates of improvement observed over the period 1970-2000 with the rate of improvement required post 2010 (assuming the CCP delivers as expected) to meet a 60% cut by 2050 in each sector. In practice, cost effectiveness and other considerations will imply that contributions will differ across sectors. For example, it is commonly understood that emissions reductions from the transport sector will be relatively costly to achieve.

1.17 Significant indicators from this are that, if each sector were to achieve its own 60% reduction target:

(i) the greatest gap between historic performance and that required to reduce CO_2 by 60% is in the transport sector;

(ii) a faster rate of reduction is also required in the domestic and services sectors, but the historic rate in industry is broadly in line with achievement of the 60% reduction.

Carbon gap in 2020

[5] Based on a current carbon equivalent energy mix.
[6] Alternative assumptions are explored in the IAG report.

1.18 The long term target of a 60% reduction from current CO_2 emissions levels by 2050 implies a level of carbon emissions of around 60MtC in 2050. A variety of pathways to such a target would exist. However, to be broadly on a straight-line path to this target suggests a target level of emissions by 2020 of around 110-120 MtC. Such a range is broadly equivalent to a carbon reduction of 25% by 2020.

1.19 On this basis the size of the gap in 2020 between a baseline projection (IAG(A)) and an "on-track 2050" target is approximately 15-25MtC. This assumes that all carbon reductions proposed within the Climate Change Programme measures are fully realised.

Table 3: Historic (1970-2000) carbon/energy intensity improvements and requirements to meet 60% CO_2 reduction in 2050

Domestic sector			
Historic rate of carbon intensity improvement (% pa)	4.3	Rate of carbon intensity improvement post 2010 required to meet 60% reduction in 2050	4.8
of which: energy intensity[7]	*2.6*		
carbon to energy	*1.7*		
Historic rate of carbon intensity improvement excluding dash for gas and major fuel switching	3.0		
of which: energy intensity	*2.6*		
carbon to energy	*0.4*		
Transport sector			
Historic rate of carbon intensity improvement (% pa)	1.2	Rate of carbon intensity improvement post 2010 required to meet 60% reduction in 2050	4.9
of which: energy intensity[8]	*1.1*		
carbon to energy	*0.2*		
Historic rate of Carbon intensity improvement excluding dash for gas and major fuel switching	1.1		
of which: energy intensity	*1.1*		
carbon to energy	*0.1*		
Industry sector			
Historic rate of carbon intensity improvement (% pa)	3.7	Rate of carbon intensity improvement post 2010 required to meet 60% reduction in 2050	3.5
of which: energy intensity[9]	*2.8*		
carbon to energy	*0.9*		
Historic rate of carbon intensity improvement excluding dash for gas and major fuel switching	3.0		
of which: energy intensity	*2.8*		
carbon to energy	*0.2*		
Service sector			
Historic rate of carbon intensity improvement (% pa)	2.7	Rate of carbon intensity improvement post 2010 required to meet 60% reduction in 2050	4.9
of which: energy intensity[10]	*1.6*		
carbon to energy	*1.1*		
Historic rate of carbon intensity improvement excluding dash for gas and major fuel switching	1.8		
of which: energy intensity	*1.6*		
carbon to energy	*0.2*		

Estimated sector impact of white paper measures

1.20 The White Paper identifies potential savings of up to 25MtC to fill this gap, with savings spread across the main sectors of final demand.

[7] Energy per unit GDP per household
[8] Energy per unit GDP per household
[9] Energy per unit GDP
[10] Energy per unit GDP

1.21 The White Paper identified potential for energy efficiency measures to deliver carbon reductions of 4-6MtC in the domestic sector, and another 4-6MtC shared between the industry and service sectors. A further 2-4 MtC saving is identified in the transport sector from a further EU wide Voluntary Agreement on the fuel efficiency of new cars, and from increased use of bio-fuels. The saving in carbon due to increased use of renewables in electricity generation is estimated at between 3 to 5MtC and potential of the order 2-4 MtC from fuel switching in electricity generation resulting from the EU emissions trading scheme (EU ETS).

1.22 Table 4 illustrates the impact of the energy white paper measures by sector on their projected emissions and the estimated contribution by each sector to the overall energy white paper goal of a 15 – 25MtC reduction in emissions from the 2020 business as usual projection of UK emissions. The exact target figure will be determined in the light of international negotiations, and the actual mix of measures needed to reach it will be shaped by economic and technological developments. This analysis assumes that the savings in carbon emissions due to renewables generation is shared 9by the sectors in approximate proportion to their consumption of electricity and that the impact on carbon emissions due to the generators' fuel switching is also shared across sectors (shown below):

Sector	MtC	MtC	Mid-point MtC	Contribution to total proposed savings 15-25MtC
Industry	3.7	6.0	4.8	24%
Domestic	5.7	9.0	7.3	36%
Services	3.7	6.0	4.8	24%
Transport	2.0	4.0	3.0	15%
Total	**15.0**	**25.0**	**20.0**	**100%**

1.23 The results suggest that the domestic sector provides the largest percentage savings in carbon emissions on its baseline projection and makes the largest contribution to the total savings overall.

1.24 Relative to their share of emissions the smallest contribution is being made by the transport sector (see Table 4). This would also be true even excluding the contribution of the generation sector (see below):

Sector	MtC	Mid-point MtC	Sector Contribution to total savings (excluding generation)	Sector effort (excluding generation savings) relative to 2020 sector baseline emissions
Industry	2 - 3	2.5	19%	9%
Domestic	4 - 6	5.0	38%	15%
Services	2 - 3	2.5	19%	11%
Transport	2 - 4	3.0	23%	7%
Total	**10 - 16**	**13**	**100%**	

Table 4 Sector emissions projections (with and without energy white paper measures[11]) and contribution by sector to overall proposed reductions.

Baseline	**(MtC)**	**(MtC)**	**Without WP measures (MtC)**	**With WP measures (MtC)**	**Sector effort (including estimated generation savings) relative to 2020 sector baseline emissions (a)**
	2000	***2010***	***2020***	***2020***	***2020***
Industry	40.1	32.7	27.3	22.4	17.7%
Domestic	39.8	33.6	33.0	25.7	22.2%
Services	22.8	19.1	22.3	17.4	21.7%
Transport	38.9	38.5	43.6	40.6	6.9%
Subtotal	141.5	123.8	126.2	106.2	15.9%
Non-sectoral emissions	13.0	9.2	8.9	8.9	
Total	154.5	132.9	135.1	115.1	14.8%

Note (a): based on mid-point White Paper estimates, pro-rata sectoral share of renewables (assumed carbon free) and fuel switching in generation.

1.25 On the basis of historic rates of carbon intensity it is possible to estimate the energy equivalent of Table 4 and this is presented as Table 5 below.

Table 5 Estimated energy equivalent projections (assuming the full impact of the CCP and mid-point estimates of reductions suggested by the energy white paper)

Baseline	(Mtoe)	(Mtoe)	Without WP measures (Mtoe)	With WP measures (Mtoe)	Sector effort (including estimated generation savings) relative to 2020 sector baseline emissions (b)
	2000	***2010***	***2020***	***2020***	***2020***
Industry	40.4	36.1	32.0	28.1	12.1%
Domestic	45.5	41.8	41.9	34.4	18.0%
Services	22.8	22.3	24.7	20.7	16.4%
Transport	55.0	57.3	64.4	61.8	4.0%
Total	163.7	157.5	163.0	145.0	11.1%

Note (b): based on mid-point White Paper estimates, pro-rata sectoral share of renewables (assumed carbon free) and fuel switching in generation.

[11] The mid-point of 20MtC has been assumed in the analysis.

1.26 Whilst, overall, achievement of the carbon reduction goals to 2020 would put the UK on a path to a 60% cut by 2050, there would remain significant differences by sector. See Table 6 below.

Table 6 Rates of carbon intensity

Sector	Rate of carbon intensity improvement post 2010 that would be required to meet 60% reduction in 2050 (% pa)	Approximate rate of improvement in carbon intensity 2010 to 2020 after allowing for white paper measures (% pa)	
		Including generation	Excluding generation
Domestic	4.8	4.8	3.9
Transport	4.9	1.7	1.7
Industry	3.5	5.8	4.9
Services	4.9	3.1	1.8

1.27 Whilst the projected rate of carbon intensity improvement 2010 to 2020 in the domestic and industry sectors would equal or exceed that for a straight line path to a 60% reduction in those sectors, progress is less fast in services and transport. In transport, in particular, this is consistent with the estimation (see annex 1 to energy white paper) that abatement costs are relatively high. Over the next one or two decades, on current estimates, it is more cost-effective, overall, to achieve carbon savings elsewhere, however where there are cost effective instruments available e.g. Voluntary Agreements the energy white paper is committed to pursue these.

1.28 While Table 6 illustrates the effort required if each sector were to meet its own 60% target by 2050 and provides a comparison with the effort implied by the energy white paper proposals, there remains considerable uncertainty and the actual level of emissions reductions achievable by the individual sectors will be determined by economic considerations, especially cost effectiveness of measures and technological developments.

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