Contents

Outline of the cost benefit approach adopted by the Energy Review

1. This note is a synthesis of the cost benefit analysis conducted as part of the Energy Review.

2. It supports the analysis of firm proposals presented in the Government's report on the Energy Review: 'The Energy Challenge'. The impact of these firm proposals is described in Chapter 8 of 'The Energy Challenge'. A summary table of the carbon saved by each policy is set out below.

Table 1: Carbon impact of Government measures announced since the 2006 Climate Change Programme Review (except where denoted†)

	MtC abated in 2020
Better Billing	0 - 0.1
Changes to the Renewables Obligation[1]	0.7 – 1.5
EU Emissions Trading Scheme [2]	8
More energy efficient products[3]	2.0
Nuclear new build[4]	0 – 1.1
Renewable Transport Fuels Obligation[5]	0.3 – 1.1
New measure for achieving carbon savings from large non-energy intensive organisations	1.2
Successor to EU voluntary agreements on new car fuel efficiency	1.8 – 2.1
Continued commitment on energy suppliers to 2020[6]	3.0 – 4.0
†Continuation of building regulations 2005[7]	2.5 –3.0
Carbon neutral government[8]	0 – 0.8
Carbon neutral developments[9]	0 – 0.4
Total	**19.5 – 25.3**

1– These carbon savings are additional to those from the existing Renewables Obligation and derive solely from the proposed changes to the Obligation
2 – This value is based on the proposed reduction in carbon allocation in phase 2 of the EU ETS.
3 – Products policy is delivered by a package of measures, including, labeling, minimum standards and voluntary agreements. This 2MtC savings is net of products delivered via EEC or the new measures for achieving carbon savings from large non-energy intensive organisations
4 –The scale of new nuclear capacity and the timing of its commissioning will depend on commercial investment decisions. For illustrative purposes this table assumes that between 0 and 1.6 gigawatts of new capacity are in operation by 2020
5 – These estimates assume that the level of the Renewable Transport Fuels Obligation rises to 10% by 2015. This figure is used merely for illustrative purposes and does not prejudge later UK decision on the appropriate future level of the obligation
6 – Government is committed to maintaining a household obligation on suppliers in some form until at least 2020. The level of ambition from 2011 should at least be equal to that under EEC3, delivering a minimum of 3-4 MtC by 2020
7 – The figures here are for contributions from Building Regulations for 2010-2020 and have not been included in our baseline assumptions. The figures reflect the additional savings from new building, refurbishments and boiler and window replacements between 2011-2020 due to Building Regulations
8 – Policy was announced by Defra in June 2006
9 – Policy was announced by DCLG in May 2006

3. The approach adopted by analysts conducting cost benefit analysis is consistent with that provided in the Green Book[1] and Regulatory Impact Assessment (RIA) guidance. The Climate Change Programme Review

[1] See http://greenbook.treasury.gov.uk

(CCPR) guidance[2], which has been agreed by analysts across government, was also used, particularly with regards to carbon savings arising from options.

4. However, as the Energy Review focused on the possible effects that options could have against all of the Energy White Paper (EWP) goals of carbon abatement, security of supply, competitive markets and fuel poverty, these had to be taken in account when conducting the analysis.

5. This approach aimed to ensure consistency across appraisals of policies by different analysts.

6. The cost benefit and cost-effectiveness analysis carried out was from a UK perspective, which is the appropriate basis for comparing different policies. Costs and benefits were considered relative to 'business as usual' and any core assumptions used were audited to ensure that they were consistent across the analysis as a whole.

Analysis of costs

7. The costs of the policy that were analysed were the real resource costs. This, in general terms, means the materials and manpower used for new investment (and financing costs). It included up-front costs and ongoing running costs, including marketing. This definition also included administrative costs incurred by Government, its agencies and the firms and people affected by the policy.

Analysis of benefits

8. Benefits were counted as welfare-enhancing or harm-reducing activities that were additional to business as usual. Where appropriate, specific attention was given to the four policy goals set out in the Energy White Paper (carbon emission reduction, security of supply, fuel poverty and market competition) as well as any other key direct benefits.

9. The benefits for many policies were, typically, reduced energy consumption, reduced emissions of carbon dioxide, and increases in security of energy supply. For energy efficiency there was also comfort taking e.g. enjoying a warmer house. To the extent possible a monetary value was given to all key benefits. These are partial equilibrium analysis of individual policy options. They do not model explicitly the general equilibrium or macroeconomic effects that implementation of one or more of these options may have.

10. When assessing alternative forms of electricity generation e.g. Carbon Sequestration and Storage; it was assumed that CCGT plant would be displaced. For energy efficiency measures analysis differentiated whether electricity, gas or other fuels were saved. For transport measures, assumptions on the benefits of any reduced fuel use were clearly set out. This gave an indication of any possible carbon savings as well as any impact on security of supply.

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[2] See http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/greengas-policyevaluation.pdf

11. Security of supply was measured in a number of ways. Where appropriate a Value of Lost Load (VoLL) was used to estimate the benefits of more reliable energy supplies. However, for proposals where this was not appropriate the impact of the measure, in terms of reduced gas consumption (or conventional fuel in the case of transport options) was used as a useful metric.

Carbon cost effectiveness

12. Cost effectiveness analysis offered an estimate of the cost (expressed as a positive value) per tonne of carbon saved over the lifetime of the policy or measure and provided a useful metric when comparing policies that involved net costs. When calculating the cost effectiveness of a measure the social cost of carbon (£46-£162/tC, with a central estimate of £84/tC, in 2005 prices), based on analysis conducted by DEFRA[3], was used as a benchmark to show which options give abatement costs above or below the social cost of carbon. It was common practice in the analysis to convert all greenhouse gas abatement into million tonnes of carbon (MtC) based on global warming potentials[4]. However, carbon prices in the analysis refers to £/tonne of carbon dioxide, as traded in the EU Emissions Trading Scheme (EU ETS.)

Discounting

13. All monetary costs and benefits were discounted at the Treasury Green Book rate of 3.5 per cent per year. (N.B. Costs and benefits that occurred more than 30 years in the future were discounted at lower rates.)

14. An appropriate commercial cost of capital was used when calculating the cost of finance for private firms. For example the cost of financing the construction of a power station was annualised over its lifetime using this rate. These costs, alongside the other costs such as fuel, maintenance etc. were then discounted at the Green Book rate, so that costs and benefits that occur at different times could be accurately compared.

Sensitivity analysis

15. Those conducting the cost benefit analysis of options looked at how changes in key assumptions affected the outcomes of their analysis and where appropriate conducted sensitivity analysis.

Energy price scenarios

16. The cost benefit analysis was conducted under three energy price and carbon dioxide emissions scenarios. These were based on DTI forecasts[5] of

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[3] See http://www.hm-treasury.gov.uk/documents/taxation_work_and_welfare/taxation_and_the_environment/tax_env_GESWP140.cfm

[4] Guidance can be found at http://www.defra.gov.uk/environment/envrp/gas/index.htm

[5] More information on the DTI forecasts can be found in 'DTI energy and carbon dioxide emissions projects.' http://www.dti.gov.uk/energy/review

possible future carbon dioxide emissions levels, under a high fossil fuel price scenario, a central fossil fuel price scenario, and a low fossil fuel price scenario. This allowed analysts to determine what the costs and benefits associated with an option were in a range of future environments.

Peer review process

17. All of the cost benefit analysis carried out for the Energy Review was peer reviewed. This review process was conducted by chief economists from DTI, DEFRA, DfT and HMTreasury and also drew on the specialist knowledge of external experts. The peer review group was also supported by an interdepartmental group of analysts who were able to study the cost benefit analysis and feed comments to the main panel. The peer reviewing of analysis ensured that all the cost benefit analysis carried out was fit for purpose. It also ensured that the analysis was based on a consistent set of assumptions and any residual uncertainties were clearly identified. This process meant that analysis looking at a diverse range of options and sectors could be compared and the results used to inform policy decisions.

Other options in the Energy Review

18. We do not present the analysis underpinning the following proposals: EU Emissions Trading Scheme,[6] the continuation of building regulations 2005[7], carbon neutral developments[8], carbon neutral government[9] and a continued commitment on energy suppliers to 2020[10]. These either represent existing policy or have been recently announced so that the information and analysis has been carried out by respective departments rather than directly in the context of the Energy Review. For completeness the analysis is referenced in footnotes below.

[6] Analysis supporting EU ETS will be available as part of a forthcoming RIA on the EU ETS package. This will be published alongside our submission to the European Commission of our Phase II National Allocation Plan.

[7] Analysis supporting the continuation of building regulations can be found at: http://www.communities.gov.uk/pub/95/ProposalsforIntroducingaCodeforSustainableHomesAConsultationPaper441PDFKb_id1162095.pdf

[8] More information on carbon neutral developments can be found at: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/index.htm

[9] http://www.defra.gov.uk/news/2006/060612a.htm

[10] Analysis supporting a continued commitment on energy suppliers to 2020 can be found at: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/index.htm

Cost Benefit Analysis of Improved household electricity and gas billing

Introduction

19. This CBA assesses the impact of providing in-direct feedback on energy bills to households about their own historical energy consumption and how it compares with other households. The premise is that such information would help households have a greater awareness of their energy consumption and enable more efficient use of energy.

Key Assumptions

20. The assumptions used in the CBA are based on an independent evaluation by consultants. Key assumptions are:

- The average unit price of energy (ex VAT) and a forecast out to the end of the evaluation period – 2050 – is in line with DTI updated central scenario energy projections

- The benefits are assumed to last for a period of 20 years from the start of the policy.

- The value of energy saved is based on the average wholesale energy component of the retail tariff drawn from an historical Ofgem study that estimated the various elements of the retail tariff. A sensitivity around this, based on the retail tariff, is also estimated.

- Energy savings of improved billing are assumed to accrue only to credit and not prepayment meters.

- It is assumed that all new connections have a credit meter installed. In addition the number of prepayment meters has been assumed to remain constant over the evaluation period. In practice a proportion of customers each year will be switching between credit and prepayment meters

- The annual cost of improved billing has been assumed to be £0.17 per customer per fuel type which has been annuitised over 5 years at a 10% cost of capital. It is assumed that this level of expenditure will be required to update the bills every five years

- Average CO_2 savings are based on assuming the average generation mix of the electricity system is displaced as a result of reductions in consumption. This assumption will tend to overstate the level of carbon reduction in the longer term where the marginal generation is assumed to be gas fired CCGT. CO_2 emissions saved have been valued at the central Social Cost of Carbon price of £23/tCO_2 in 2005.

- Energy demand is assumed to be constant over the evaluation period. This could increase or decrease results depending on how the energy savings are assumed to apply.

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- Costs such as the loss of VAT to the exchequer or the loss of margin to firms have not been included.

Table 2: General calculation assumptions

Assumption	Elec Credit	Elec PPM	Gas Credit	Gas PPM
Average unit price of energy p/kWh	8.23	8.23	2.17	2.17
Average energy component of retail tariff	35%	35%	50%	50%
Meters installed in GB millions	21.50	3.50	19.00	2.00
Annual growth in installed GB million meters pa	0.15	-	0.15	-
Average electricity consumption kWh	4,290	4,290	20,500	20,500
Carbon emissions factor tC/MWh	0.117	0.117	0.052	0.052

Energy reduction scenarios

21. A literature review of metering, billing and direct displays conducted by Sarah Darby on behalf of Defra[11] was the starting point for forming scenarios of the potential energy savings that could be achieved.

22. Although there are many studies included in this analysis, none is directly applicable to the introduction of better billing in the UK context. The studies often combine a number of other energy efficiency measures implemented at the same time as providing improved billing information and it is therefore difficult to single out the specific impact of these measures. In addition, differences in climates in other countries, and problems of small trial sizes and self-selecting response groups means assumptions about UK response are highly uncertain.

23. Therefore, three sensitivities were used to illustrate the likely costs and benefits if that level of energy reduction could take place. These are given below.

Table 3: Hypothetical sustained energy reduction scenarios

% reduction in energy consumption	**Low**	**Central**	**High**
Improved billing	0%	0.25%	0.5%

[11] Sarah Darby 'The effectiveness of feedback on energy consumption. A review of the literature on metering, billing and direct displays. April 2006. Published on the Defra website at http://www.defra.gov.uk/environment/energy/research/pdf/energyconsump-feedback.pdf

Results

24. The central energy reduction case of 0.25% yields a net present value of £654m from improved billing which falls to -£45m when the additional costs of billing do not generate a response from customers, assuming the wholesale energy cost. The central case increases to £1,264m when 0.5% savings are assumed on the annual energy consumption of customers. The breakdown of the benefits and costs is set out in table 3 below.

25. The table also shows the sensitivity of valuing the energy saved at the full retail tariff. This increases the central case NPV to £1,204m.

Table 4: Improved billing CBA results

NPV £m	**Low £m**	**Central £m**	**High £m**
Consumption savings	0%	0.25%	0.5%
Electricity			
Avoided energy cost	0	171	343
Reduced carbon	0	71	143
Total elec benefits	0	243	485
Gas			
Avoided energy cost	0	277	553
Reduced carbon	0	135	270
Total gas benefits	0	412	823
Total benefits	0	654	1,309
Total costs	45	45	45
NPV (evaluated at avoided wholesale energy cost)	-45	609	1,264
NPV (evaluated at full retail tariff)	-45	1,204	2,453
Reduced carbon MtC 2010	0	0.08	0.16

More Energy Efficient Products. A Negotiated supply side commitment and supporting policies for energy-using products

Description of policy

26. The policies are designed to increase the uptake of more efficient products: we will work at the international, EU and UK levels to stimulate competition in the innovation and supply chain, and will use all suitable policy measures deliver this aim including:

- The ranking of products (e.g. through performance indicators, labels and lists);
- the setting, publication and implementation of efficiency standards;
- Actively influencing the development of EU mandatory labelling and Energy using Products (EuP) measures (Defra/DTI);
- Establish structures for 'quick wins' for Government procurement;
- Establish retailer agreement, pilot Autumn 2006, larger scheme 2007.

Key assumptions

27. The energy savings have been assessed against a reference case projection of the efficiency of energy-using products, using the Market Transformation Programme's bottom-up product model. This model is based on making projections, for each energy-using product, of ownership and sales levels, the usage and efficiency levels to estimate energy consumption.

28. The performance levels assumed as a result of the proposed policy are given in the table 7 at the end of this summary.

29. An 80% compliance rate has been assumed in the modelling. Electricity prices have been included at 8p/kWh.

Results of cost-benefit analysis

30. Significant carbon reductions can be achieved through the introduction of these product-specific policies.

Table 5: Potential annual carbon emissions reduction by efficiency policy through higher efficiency standards by 2010 through to 2020 (MtC)

	2010	**2015**	**2020**
Domestic lighting	0.23	0.55	0.81
Consumer Electronics	0.37	0.69	0.77
ICT	0.39	0.89	1.27
Domestic wet	0.01	0.03	0.06
Domestic cooking	0.01	0.03	0.05
Domestic cold	0.00	0.03	0.12
Motors	0.30	0.86	1.57
Total	**1.31**	**3.08**	**4.65**

31. These carbon reductions will also result in significant benefits from reduced electricity bills. The marginal purchase cost to consumers and manufacturers has not been included.

Table 6: Financial benefits, from reduced running costs, are described below (£m):

	2010	2015	2020
Motors	202	489	752
ICT	260	506	607
Consumer electronics	246	392	369
Domestic cold	1	16	59
Domestic wet	5	17	28
Domestic lighting	156	314	386
Domestic cooking	7	16	25
TOTAL	**877**	**1,751**	**2,227**

Distributional impacts

32. All the policies are designed to improve the efficiency of products at the point of purchase: there is no increase in turnover or early retirement of products assumed. Distributional impacts are assumed to be minimal since the consumer will purchase a new product at the same time as they would have done in the base line case, but the product purchased will now be more energy efficient. The purchase cost should therefore not be significantly higher for the consumer, as has been seen in the case of domestic refrigeration products when minimum energy performance standards were introduced in 1999 which led to a significant improvement in efficiency whilst average purchase prices fell at the same time. In addition, the life cycle cost to the consumer (purchase cost plus running costs) should be lower as a result of purchasing the higher efficiency energy using products.

33. Manufacturers of some energy using products will have to invest in producing higher efficiency products, assuming sufficient lead times this should be done at the time of upgrading production lines so will not impact significantly on costs. Many of the producers of energy-using products are located outside the UK.

34. For the proposed policy on energy-using products there should not be a direct impact on competition.

35. The main costs to the exchequer are those associated with operating these schemes and will be of the order of £10-50m per annum.

Other considerations

36. The above analysis is based largely upon "bottom-up" modelling of purchase decisions and the energy reductions that could be realised from more energy efficiency products. The modelling itself does not explicitly describe in all cases the policy measures that would need to be implemented in order to realise these benefits. In some cases the policy instrument may be less effective than assumed here, may take longer to implement or may involve additional costs to business and/or consumers. These practical considerations mean that the benefit estimates here may represent an upper bound.

Table 7: Levels of product performance assumed

Product	**Delivery Mechanism, Standard to apply and date** **(presume 80% compliance unless indicated)**
Domestic lighting	EEC, ESR, Gov Procurement 2006: Minimum 40 lumens/watt
	Retailer Agreement: 2007: - Fleet Average to be set such that proportion of lamps exceeding 40 lumens per watt (LPW) rising 17.5% in 2010 to 28% in 2015.
	EuP: 2010: Requirements set to phase out most popular GLS lamps (<9LPW) 100W, 60W, 40W) and some halogen bulbs
Information and communication technology (ICT)	EEC, Gov Procurement 2006: decreasing power levels to 2010 values below
	Retailers agreement: 2007: equivalent fleet average + possible minimum standards – decreasing to levels shown below for 2010.
	EuP: 2008: Decreasing to values below by 2010.
	ICT - Domestic values PCs – 2010: sleep=8W, Off=1.4W, on=55W Laptops – 2010: sleep=2W, Off=0.5W, on=15W CRT monitors – 2010: sleep=2.4W, Off=1.4W, on=75.8W LCD monitors – 2010: sleep=1.5W, Off=1W, on=29.2W ICT – non-domestic values PCs – 2010: sleep=3.7W, Off=1.4W, on=60W Laptops – 2010: sleep=2W, Off=0.5W, on=15W CRT monitors – 2010: sleep=2.4W, Off=1.4W, on=75.8W LCD monitors – 2010: sleep=1.4W, Off=1W, on=28.3W
Consumer	EEC, ESR, Gov Procurement

electronics (CE)	2006-2010: decreasing power levels to 2010 below, further decrease in 2015.
	Retailer Agreement: decreasing power levels to 2010 below, further decrease in 2015
	EuP: negotiate as per 2010 below, further reduction by 2105
	Digital terrestrial adapter: 2010 On=8W, standby=2W Satellite/cable adapter: 2010: On=18W, standby=9W External power supplies: 2010: 1W DVD players: 2010: On=9W, standby=2W CRT television 2010: on mode varies with screen size, standby=1.5W LCD television 2010: on mode varies with screen size, standby=1.5W
Domestic cold	EEC, ESR, Gov Procurement 2010: Minimum A-rated 2020: Minimum A++.
	EuP: Now-2010: industry self-commitment for EU fleet average A rated by 2010
Domestic wet	EEC, ESR, Gov Procurement 2010: Washing machines: min A+.; Tumble driers: min C rating + sensor, with A-rated by 2020. Retailers: 2007: min as above and/or equivalent fleet averages EuP: 2008: as above
Domestic cooking	EEC, ESR, Gov Procurement: 2010: Electric ovens: min A-rated Retailers: 2010: 20% of hobs induction; 80% by 2020.
Motors **(including pump/fan- based systems)**	ECA: minimum standard for installed system efficiency as defined Best Practice Installer measure to deliver fleet average 50% take up of sales of pump/fan based systems achieve best practice installations by 2010, these continue through to 2020. EuP: 2010: Motors min Eff1 level, 2015: Premium level, 2020: Super Premium.

New measure for achieving carbon savings from large non-energy intensive organisations.

Introduction

37. The Energy Review has announced that, 'Government proposes to consult later this year on the introduction of a new measure for the large non-energy intensive organisations which lie outside the EU ETS and Climate Change Agreements.' In analysing potential measures to target this sector the costs and benefits of a cap and trade scheme (described as an Energy Performance Commitment) were modelled. This built on the recent work by NERA and Enviros[12]. This analysis is described below but does not prejudge any decisions on measures we will ultimately adopt to target emissions reduction in this sector.

38. A new **UK Energy Performance Commitment** (EPC) would apply mandatory emissions trading to energy use emissions by large non-energy intensive business and public sector organisations outside the EU ETS and CCAs (e.g. supermarkets, BBC, hotel chains, government departments, large local authority buildings). The EPC would not be linked with the existing voluntary UK ETS market, and would focus on energy use at half hourly metered sites, exempting organisations using less than 3000 MW hr / year of electricity. EPC auction revenue would be recycled to participants through direct grant payment or some other means.

39. As energy costs are typically around only 1% of total operating costs for this sector. The current framework just encourages the large non-energy intensive sector to simply pay their energy bills, rather than to also engage in energy efficiency. The EPC would overcome this barrier by placing large organisations in a **quantity based environment**, whereby they have to set themselves **targets**, in the knowledge of the overall scheme cap - and to monitor, report and account for their carbon allowances accordingly.

Results of cost-benefit analysis

40. Analysis conducted by NERA/Enviros concluded that the EPC would save 0.5MtC/year by 2015, rising to 1.2 MtC/year by 2020[13]. This amounts to 18.1 MtC emissions saved over the scheme's lifetime. The analysis also found that the policy resulted in a positive NPV of £965 million. It must be emphasised that figure of £965 million positive NPV ignores benefits to society, focusing purely on private benefits to industry (i.e. it is based on an industry discount rate of 10% rather than a societal 3.5% rate). A summary of the costs and benefits, taking into account benefits to society (as has been done for energy supply options in the Energy Review) is set out in the table below.

Table 8: Cost benefit analysis of EPC proposal – Inclusion criterion 3,000 MWh electricity consumed per year

[12] http://www.defra.gov.uk/environment/climatechange/trading/uk/pdf/nera-enviros-report-060428.pdf.

[13] These figures are quoted as 0.6MtC/yr and 1.3MtC/yr by 2015 and 2020 respectively. This change reflects the new assumed start date of 2009 rather than 2008.

PV investment/expenditure costs *(1)*	299	£million
PV administrative costs[14] *(2)*	308	£million
PV savings on Energy Bills at retail energy prices *(3)*	2,421	£million
PV loss of CCL revenue (transfer) *(4)*	194	£million
PV carbon savings *(5)* low scc	649	£million
central scc	**1,039**	£million
upper scc	1,834	£million
Total NPV without carbon benefits	**1,621**	£million
(3)– (1) – (2) – (4)		
Total NPV with carbon benefits low scc	2,270	£million
(3) + (5) – (1) – (2) – (4) **central scc**	**2,659**	£million
upper scc	3,455	£million
Carbon saved and cost effectiveness indicators		
Carbon saved by 2010	0.098	MtC/yr
Carbon saved by 2015	0.524	MtC/yr
Carbon saved by 2020	1.183	MtC/yr
Lifetime carbon saved	18.1	MtC
Lifetime cost effectiveness (£/tC)	- £ 90/tC net benefit	

Notes:

Discount rate: 3.5%
Values discounted back to base year 2005.
Policy time horizon: 15 years (2009 – 2023)
Time horizon of analysis: 27 years (2005 – 2031)
All values in 2005 prices
Medium induced take-up scenario
Accounts for landlord-tenant split
High admin costs. High energy prices

Distributional Impacts

41. The NERA/Enviros analysis also showed that the EPC would be NPV positive to 26 out of 27 sub-sectors, even when viewed from an industry perspective (10% discount rate). Taking into account benefits to society, all 27 sub-sectors are NPV positive. The analysis of overall costs and benefits (including investment costs and transaction costs) also highlighted that by exempting small energy users, the great majority of the administrative costs could be eliminated whilst preserving most of the emissions coverage and energy efficiency benefits. The overall policy would also be revenue neutral to the Exchequer.

42. There has been no quantitative assessment of effects on security of supply or consumer distribution owing to the EPC's negligible impacts in these areas. However, there would be a positive impact on security of supply as the

[14] The 3.5% discounted PV of admin costs differs from the Nera report figure of £353m because of the Energy Review's analytical convention of 2005 prices and values discounted back to 2005 base year.

energy efficiency measures would reduce overall demand and therefore the need to import energy; and as the policy would only have an impact on firms there would be no fuel poverty implications.

Other considerations

43. Delivering the proposed EPC would require primary legislation (as well as subsequent secondary legislation for the more detailed scheme rules). A competent authority (such as the Environment Agency and SEPA, who act as regulators for the EU ETS) would need to be identified to enforce the EPC.

44. Regulatory impact would be minimized by exempting small energy users, and by making the EPC significantly "lighter touch" administratively than EU ETS. A new EPC would be a significantly "lighter touch" administratively than that experienced by most organisations currently in EU ETS: Group A EU ETS installations (so called "small emitters") are understood to pay £2.70 - £7 / tCO_2 covered per year, whilst larger Group B EU ETS installations pay £0.60 - £0.90 / tCO_2 covered per year. In comparison, analysis indicates the EPC administrative burden would be £0.60 / tCO_2 covered per year.

45. It should be possible to secure EU state aids approval for the revenue recycling mechanism, since this would be offset by EPC auction revenue, and would be consistent with sustainable development principles.

46. The estimates of benefits are based upon detailed cost-benefit modelling of potential energy efficiency improvements. These typically show a positive private return from investments in energy efficiency. Naturally this analysis raises the question of why firms do not introduce these measures without intervention. As noted above, there may be information failures or other constraints on the ability of businesses to take advantage of these measures. However, it is also possible that the analysis does not consider some of the "hidden costs" of investment in energy efficiency (e.g. opportunity cost of scarce management time). These effects are extremely difficult to quantify but suggest that the estimates of benefits might be interpreted as upper bounds.

Reforming the Renewables Obligation Cost Benefit Analysis

Introduction

47. The Renewables Obligation (RO)[15] was introduced in April 2002 to provide a flexible, market based mechanism to support the development of renewable technologies. It places an obligation on electricity producers to supply a specified and increasing proportion of their annual sales from electricity supplied from renewable sources. All qualifying renewables generators receive Renewables Obligation Certificates for each MWh of electricity produced. Electricity suppliers can use these ROCs/SROCs as proof or their compliance with the RO.

48. The Energy Review has proposed a package of changes to the structure of the RO, designed to increase investment, at no additional cost to the consumer. These include:

- Extending the level of the Obligation to 20% on a "headroom basis" (i.e. keeping the level of the Obligation at least 1% point above the level of ROC generation);
- Removing the RPI link from the buy-out price in the Obligation from 2015 onwards (i.e. letting the real terms value of the buy-out price fall gradually from 2015 onwards);
- Introducing a mechanism to ensure that ROC prices do not crash if there is ROC generation in excess of the 20% Obligation level;
- Banding the RO to provide multiples of ROCs for emerging technologies such as tidal power and fractions of ROCs for more economic technologies for example on-shore wind.

49. The following analysis looks at the impact of these changes on the level of renewables generation, and on resource costs and consumer costs.

50. The Energy Review also proposes measures to tackle planning barriers to reduce delays and uncertainties to developers. There will also be funding available for renewable technologies through the Environmental Transformation Fund. These measures have not been included in the cost-benefit analysis below. But initial analysis suggests that these could further increase the level of renewables generation.

Key Assumptions

51. This package of measures was modelled by independent consultants, Oxera, who have a comprehensive model of the RO. The Oxera model estimates the future level of ROC prices, based on the structure of the RO, which determines the level of renewables generation. The impact of the package of changes was compared with a base case scenario of no change to current policy.

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[15] There are three separate obligations covering England and Wales, Scotland and Northern Ireland. ROCs, SROCs and NIROCs are fully tradeable across the UK.

52. The Oxera model incorporates estimates of the potential and cost of renewables energy from research by Enviros (2005)[16]. The model also incorporates assumptions as to the maximum build rates of onshore and offshore wind to reflect potential planning consent time lags; learning curve effects which reflect the anticipated evolution of technology costs over time; a limit to the amount of biomass and co-firing to reflect a possible supply side constraint on the amount of available biomass; and electricity prices.

53. Maximum build rates were based on BWEA[17] assumptions as to the maximum build of wind generation. The model was run using three electricity price scenarios: low, central and high prices, reflecting UEP and Oxera assumptions about future generation costs.

54. In modelling the changes to the RO, a number of assumptions were made about the impact that the changes would have in practice:

- It was assumed that the guarantee of headroom in the obligation up to 20% would reduce the risk for renewables developers, and increase the share of the buyout fund passed through to generators. It was also assumed that the cost and discount rates for onshore and offshore wind would be lower under the headroom option than in the base case.
- Under the de-linking option, we assumed that the link between inflation and the buyout price was broken from 2015/16 onwards.
- The banding option adjusts the number of ROCs per MWh that are given to new projects built in 2009 or later. It assumes that projects built previously retain full ROC rights.

Impact on Renewables Generation

55. Under all electricity price scenarios, the change to the RO has a long term positive impact on the overall level of renewables generation. The profile of extra RO eligible generation over time is shown in Figure 1 below. In particular the change increases the volume of output of offshore wind. Carbon saved over the lifetime of the policies ranges from 13MtC in the low scenario, to 37MtC in the high electricity price scenario measured against a counterfactual of gas CCGT generation.

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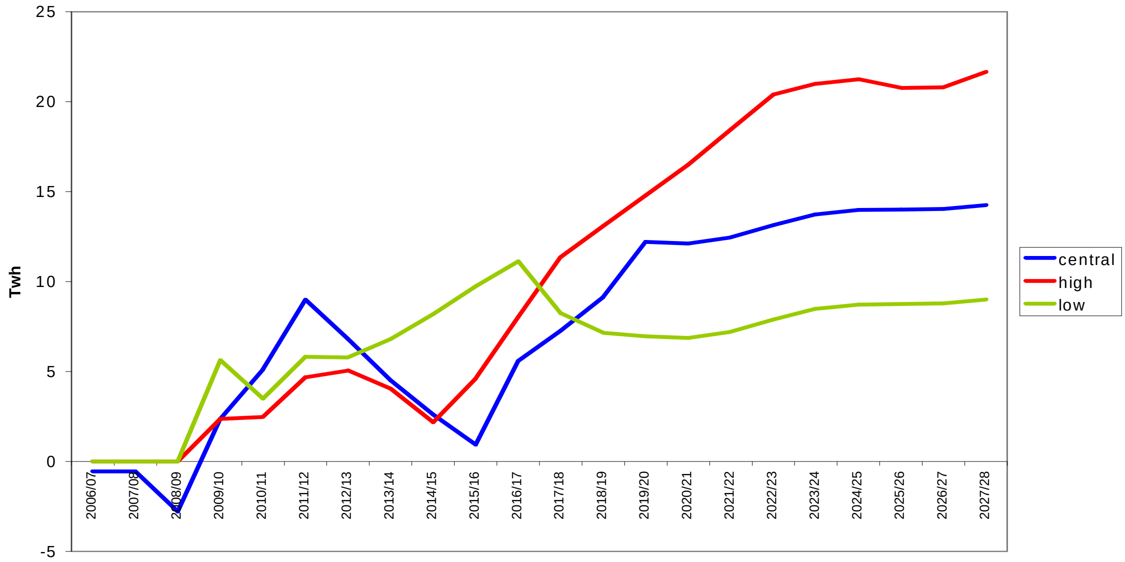
[16] Enviros (2005) 'The Costs of Supplying Renewable Energy'. A copy can be obtained at http://www.dti.gov.uk/renewables/renew2.2.5.htm

[17] http://www.bwea.com/energyreview/AppAOnshore.pdf

Figure 1: Increases in the Level of Renewables Generation, resulting from the proposed change to the RO, under low, central and high electricity price scenarios.



Cost – Benefit Analysis

56. The CBA estimated the impact on a number of cost measures:

- The NPV resource cost. This is the cost to the economy of producing electricity through renewables technologies as opposed to the current mix of generation technologies.
- The cost to firms of the RO. This is defined as the cost to generators plus the benefit to suppliers. Where the cost to generators is the resource cost minus electricity sales plus the ROC purchase cost. Suppliers benefit is the value of ROCs.
- The cost to consumers of the RO. This is defined as the obligation level multiplied by the buyout price. This is the same as the total support given to RO-eligible generators.
- The 'deadweight' element of the RO is the amount of support given to RO-eligible generators in excess of the cost of that generation. This is a measure of transfer from consumers to producers of renewables generation.
- The exchequer impact on CCL revenues. Since renewables generation is exempt from CCL, additional renewables generation would reduce CCL revenue to the exchequer. No other exchequer impacts such as VAT, tax receipts, have been modelled.
- The cost per tonne of carbon. This is the NPV resource cost divided by the amount of carbon saved. This is estimated across all RO-eligible technologies as a whole.

57. The impact of the package of changes on these measures is shown in the table below. All estimates have been discounted according to HMT green book guidance and are given in 2005 prices. The figures represent the change in costs compared to the current cost of the RO under the three electricity price scenarios.

Table 9: Cost Benefit Analysis of Changes to the Renewables Obligation

Electricity Price Assumption	Change in Lifetime NPV £m						Change in Lifetime Carbon Saved MtC	NPV resource cost per tonne of carbon £/tC
	Firms	Cons-umer	Exch-equer	Dead-weight	Resource cost, not including carbon	Resource cost including SCC		
Low	-6,215	1,845	-270	8,060	-6,215	-5,380	13	470
Central	-5,720	-115	-375	5,605	-5,720	-4,465	22	255
High	-4,570	-1875	-580	2695	-4,570	-2,595	37	125

Key Findings

58. The results show that the changes to the RO lead to an increase in resource costs. This is due to the increased incentives for additional renewables generation afforded by the changes compared with the current policy. The increase in resource cost of the package ranges from £4570m to £6215m in present value terms over the lifetime of the technologies.

59. The overall change in the total subsidy given to RO-eligible generators depends on the net effect of the impact of freezing the buyout price, and the introduction of the 20% obligation (on a headroom basis). Under the low electricity price scenario, there is estimated to be a fall in the cost to consumers of £1845m, in the high case consumer costs are estimated to rise by £1875m. Under the central case, the impact of the two measures balances out over the lifetime of the measures. The increase in renewable generation leads to an improvement in the efficiency of the RO under all scenarios, with a reduction in the deadweight element of the RO from £2695m in the high case to £8060m in the low case over the lifetime of the RO. This shows that the package improves the efficiency of the RO by targeting support on technologies that need additional support to bring them onto the market.

60. There is also a small additional exchequer cost, resulting from CCL forgone from increased renewables generation. The cost effectiveness of the RO, as indicated by the cost per tonne of carbon saved, ranges from £125/tC in the high electricity price scenario, to £470/tC in the low price scenario.

61. Costs in table 9 have been modelled over the lifetime of the renewables projects. Costs of renewables projects are annuitised over the lifetime of the projects. Most new build from the change occurs in the period 2015 to 2020, but the costs and benefits are assumed to continue into the future.

Caveats

62. There are a number of assumptions underlying the modelling which will have an impact on the results of the analysis, in particular:

- As demonstrated above, the electricity price assumptions have a significant impact on the effect of the package. Under the high electricity price scenario, the higher level and cost of the change in renewables generation is countered by higher cost of conventional generation, so that the overall resource cost is lower than under the low electricity price scenario. This leads to a lower cost per tonne of carbon saved.
- There is a large degree of uncertainty around the assumptions underlying the impact of introducing headroom. These will bear significantly on the estimated impact of this change.
- The model does not allow for behavioural impacts resulting from the announcement of banding the RO on the timing of investment decisions. This impact could be positive, negative or neutral.

Nuclear Power Generation Cost Benefit Analysis

63. The cost benefit analysis for nuclear power generation assesses the following:

- The full cost of new nuclear generation, including pre development, construction, infrastructure investment, operating and maintenance, fuel, waste recycling and decommissioning.
- The benefits of new nuclear generation as regards carbon emissions reduction, and security of supply.

64. Cost and benefits are compared to a do nothing scenario, where it is likely that investment in new power generation capacity would be based on gas fired technology. The analysis does not attempt to assess the commercial viability of such projects.

65. The central gas price scenario assumes a gas price of 37 pence / therm and a gas fired generation cost of £35 per megawatt hour (MWh). It is assumed that the cost of new nuclear generation is £38 / MWh. (These are "levelised" costs i.e. total capital and other costs are spread equally over the assumed lifetimes of the plant.)

66. The nuclear cost figure is based on various studies together with industry feedback, and construction cost data from the project currently under implementation to add a new nuclear plant in Finland. Waste recycling costs are estimated under the assumption that future waste would be disposed of geologically together with legacy waste. The underlying assumption on decommissioning costs used is higher than estimates provided by vendors.

67. The cost advantage of gas fired plant in the central case is £22 million / GW annually, with NPV of £495 million / GW over 40 years.

68. The cost-benefit analysis includes pessimistic scenarios for nuclear investment: a gas price of 21 pence / therm; a nuclear levelised cost of £44 / MWh. The aggregate annual cost penalty – resulting from a combination of the two pessimistic scenarios - is of the order £3.7 billion / GW. Cost advantages for nuclear in optimistic cases – high gas prices and low nuclear costs – are of the order £2.1 billion / GW.

69. The CO_2 dioxide emission saving from investing in a GW of nuclear plant is approximately 2.5 million tonnes (700,000 tonnes of carbon) / GW compared to investment in gas fired plant. Valuing emissions savings at a CO_2 price of € 36 (£25) / tonne (an upper bound based on projections of future CO_2 prices) gives a present value benefit per GW of nuclear plant of around £1.4 billion / GW over 40 years.

70. Investment in new nuclear capacity would reduce the level of total gas consumption and gas imports. A programme to add 6 GW of new nuclear capacity by 2025 would reduce total forecast gas consumption in 2025 by 7%.

71. In a world where gas fired plant is added to the power system rather than nuclear plant, this increases vulnerability in the event of a gas supply

interruption. Given this vulnerability, the economic option would be to back up gas fired plants with oil distillate switching capability. In the event of a gas supply interruption, gas fired plants would then be able to continue operating for a period up to one winter in duration.

72. If nuclear plant is added rather than gas fired plant, there is no longer the need to maintain back up capability. The benefit of nuclear generation can then be seen as avoided cost of oil distillate back up, estimated to be of the order £100 million / GW.

73. The benefit-cost balance associated with nuclear new build relative to a do nothing scenario where gas fired plant is added to the power system is the sum of environmental and security of supply benefits net of any nuclear cost penalties. Benefit cost balances under alternative scenarios are presented in table 1 below.

74. The table shows that the net benefit of nuclear generation is negative at low gas prices even at the high end of assumed carbon prices, and more so if nuclear costs are high. It is also negative at central gas prices/high nuclear costs for the CO2 price cases below € 10 (£7) / tonne. The benefit-cost balance is positive in the central gas price world depending on the carbon price, and in high gas price / low nuclear cost worlds across the range of carbon prices (including a zero carbon price).

Table 10: Nuclear generation benefit-cost balance under alternative gas price, carbon price and nuclear cost scenarios, NPV over forty years, £ / GW

Carbon price (€ / tCO2)	Low gas price	Central gas, high nuclear	Central gas price	Central gas, low nuclear	High gas price
0	-2100	-1400	-400	900	1400
15	-1500	-900	200	1400	2000
25	-1100	-500	600	1800	2400
36	-700	0	1000	2300	2800

75. The nuclear cost penalty is less than that for the low end of the range for CCS technology on new plant, and comparable to the cost penalty for retrofitting CCS on existing plant. It is less than the cost penalty for other forms of low carbon technology (new CCS, offshore wind, onshore wind). Cost effectiveness of new nuclear generation is around £5 / tonne of CO2 (£18 / tonne of carbon) in the central scenario.

76. Nuclear generation operates as baseload plant and, as such, typically does not determine the price of electricity. To the extent that there might be higher than forecast nuclear costs, these would be borne by investors, under the assumption that any investment is undertaken in the context of the market on a commercial basis. Distributional impacts *vis-à-vis* consumers should therefore be limited.

77. It is unlikely that a new nuclear programme would result in a large increase of nuclear capacity in the generation mix. Even if there were to be limited competition within nuclear power generation, there would be scope for competition between nuclear and other forms of baseload plant (e.g. gas, coal.) Whether there would be competition within nuclear generation is unclear.

Carbon Capture and Storage Cost Benefit Analysis

Introduction

78. The cost benefit analysis for Carbon Capture and Storage (CCS) aims to assess the full economic costs and benefits associated with these technologies relative to the case where new investment would have been in gas fired plant. The analysis does not attempt to assess the commercial viability of such projects.

79. CCS offers an option for continuing the use of fossil fuels while considerably reducing atmospheric emissions of carbon dioxide. There are three distinct processes in the complete CCS system: capture of carbon from fossil fuel combustion; transport to a suitable geological site; and long term storage. There are several different generic processes for CO2 capture, involving post combustion capture, pre-combustion capture and oxy-fuel combustion. These are at different stages of development and deployment.

Modelling Assumptions

80. Whilst there are several large sources of carbon dioxide in the UK, covering power stations and energy-intensive industries such as steel, cement, refineries and chemicals, the analysis presented here is limited to the power sector. Four different types of CCS capture technologies have been assessed:

- New Pulverised Fuel (PF) (advanced super critical) with Fuel Gas Desulphurisation (FGD) and amine scrubbing.
- Retrofit existing PF (ASC) plant with FGD and capture equipment.
- New Integrated Gasification Combined Cycle (IGCC) plant with CCS
- New Combined Cycle Gas Turbine (CCGT) with CCS.

81. Capital and operating costs were compiled on the basis of recent studies by Redpoint and MARKAL, which are outlined in the paper 'Overview of modelling of the relative electricity generating costs of different technologies[18].' A range of costs is presented, largely based on uncertainty around the operational performance of these technologies and, to a lesser degree, the extent of capital costs.

82. It is assumed in this analysis that CO2 is transported by pipeline, which tends to be the most cost-effective option for larger volumes. Storage is assumed to be in a depleted gas reservoir using sub-sea completion system. In the base case the costs for transport, injection and storage are £8/tCO2.

83. The CBA has been undertaken on the following key parameters:

- High and low technology cost assumptions as set out above.
- Central, high and low fuel price assumptions, as set out in the Energy Review document.

[18] http://www.dti.gov.uk/energy/review

- A range of carbon prices of 0, £17/tCO2 and DEFRA's central Social Cost of Carbon (£23/tCO2 in 2005).

84. The CCS plant is assumed to have a capacity of 500MW and to be operational by 2015 in the base case. The cost of capital is assumed to be 10 per cent, and the discount rate applied as in green book guidance. A full range of sensitivities around base case assumptions, including on operational performance, transport and storage costs, interest during construction, operational and construction periods and costs of capital are given in the paper 'Overview of modelling of the relative electricity generating costs of different technologies.'

Results

85. In the central fuel price scenario with no carbon price, gas fired generation has a cost advantage over CCS across all the generation technologies. The levelised cost for CCGT is £34.6/MWh, and the costs for the CCS technologies range from £35.7 to around £60/MWh.

86. The resource cost of CCS relative to CCGT is shown in the table below. Gas fired generation retains a cost advantage over CCS up to a carbon price of £4/tCO2 for the low technology cost range of the most cost-effective CCS technology (Retrofitting existing PF plant) and around £40/tCO2 for the higher cost range for this technology under the central fuel price assumptions.

Table 11: Resource cost-benefit of CCS – low technology costs, central fuel prices

2005 Prices	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	-605	-170	110	14	0.3	50
Retrofit PF with FGD and CCS	-80	240	420	8	0.3	10
New IGCC with CCS	-840	-470	-250	10	0.3	80
New CCGT with CCS	-1,060	-650	-410	11	0.3	90

Table 12: Resource cost-benefit of CCS – high technology costs, central fuel prices

2005 Prices	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	-1,440	-1,020	-740	14	0.3	120
Retrofit PF with FGD and CCS	-750	-425	-250	8	0.3	80
New IGCC with CCS	-1,375	-1,000	-785	10	0.3	130
New CCGT with CCS	-1,960	-1,550	-1,315	11	0.3	170

NPV estimates rounded to nearest £5m. Cost per tonne of carbon estimates rounded to nearest £5, and based on a 40 year plant life assumption. SCC refers to the social cost of carbon, based on DEFRA central assumptions.

- Comparative results for the high and low fuel price assumptions are given at the end of this summary. Levelised costs across all technologies are higher under the higher fuel price assumptions. However, resource costs of the coal-fired CCS technologies are lower in this scenario because fuel costs are a higher proportion of CCGT generation and affect these costs relatively more than CCS generation. The opposite is true under the low fuel price assumptions.

- The carbon savings from investing in CCS are approximately 0.6 million tonnes per GW per year compared with CCGT generation. The cost effectiveness of CCS varies by technology and fuel prices assumed. In the base case (central fuel prices) they vary from £10-£90/tC under the low technology costs, and £80-£170 with higher technology costs. These abatement costs are generally higher than nuclear and lower than renewables on most comparisons.

Ancillary effects

- CCS could contribute to enhanced security of supply because coal is more plentiful than oil or gas, and the world's reserves are more geographically dispersed. No attempt has been made to quantify the potentially lower risk of coal fuel supply interruption relative to gas.

- The impact of CCS generation on electricity prices and fuel poverty is dependant on the number of plants that are build in the future.

- CCS, like other large energy projects, involves technical risk associated with operational performance that could impact on costs. With CCS, the main risk lies in the operation of the system as a whole, since the individual elements of the process have largely been tested in other applications. This risk is reflected in the range of technology costs assumed and in the modelled operational sensitivities. There are also gaps in the environmental assessment of CO2 storage. Some studies have been undertaken but the longer term impact on deep sea populations and ecostructures are difficult to establish.

Conclusions

- Key findings from this analysis are:

87. There is considerable uncertainty over the costs of CCS, resulting in a wide range of generation costs.

88. There is a cost penalty associated with CCS technologies over CCGT generation in most of the technology and fuel price sensitivities modelled. The most cost effective option is retrofitting of existing coal-fired PF plant which could have a cost advantage over CCGT under some scenarios.

89. ith a carbon price reflecting recent EU ETS prices (£17/tCO2), further CCS technologies result in a resource benefit relative to CCGT under the low technology cost assumptions. Much higher carbon prices would be needed to overcome the cost penalty associated with the high CCS technology cost sensitivities.

90. Of the large-scale, low carbon power generation technologies, CCS technologies could provide a cost-effective abatement option.

CCS CBA - Fuel Price Sensitivities

Table 13: Resource cost-benefit of CCS – low technology costs, high fuel prices

2005 Prices	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	15	445	725	14	0.3	-0
Retrofit PF with FGD and CCS	360	685	860	8	0.3	-40
New IGCC with CCS	-300	70	290	10	0.3	30
New CCGT with CCS	-1,175	-765	-525	11	0.3	100

Table 14: Resource cost-benefit of CCS – high technology costs, high fuel prices

2005 Prices	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	-850	-425	-150	14	0.3	70
Retrofit PF with FGD and CCS	-305	15	195	8	0.3	35
New IGCC with CCS	-825	-450	-235	10	0.3	75
New CCGT with CCS	-2,125	-1,715	-1,480	11	0.3	180

Table 15: Resource cost-benefit of CCS – low technology costs, low fuel prices

2005 Prices	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	-1,170	-740	-460	14	0.3	95
Retrofit PF with FGD and CCS	-495	-170	5	8	0.3	55
New IGCC with CCS	-1,340	-965	-750	10	0.3	125
New CCGT with CCS	-920	-510	-275	11	0.3	80

Table 16: Resource cost-benefit of CCS – high technology costs, low fuel prices

	Lifetime NPV resource cost-benefit £m			Lifetime carbon abated MtC	Annual Carbon Saved MtC	Cost per tonne of carbon £/tC
	£0/tCO2	£17/tCO2	SCC			
New PF ASC with FGD and CCS	-1,990	1,565	-1,290	14	0.3	165
Retrofit PF with FGD and CCS	-1,160	-840	-660	8	0.3	125
New IGCC with CCS	-1,885	-1,510	-1,295	10	0.3	175
New CCGT with CCS	-1,775	-1,370	-1,130	11	0.3	150

Renewable Transport Fuels Obligation: moving beyond a 5% Obligation

Description of policy

91. This note provides a summary of analysis looking at the costs and benefits of moving beyond the Renewable Transport Fuels Obligation (RTFO) as it is currently expressed: as a requirement that from 2010-11, 5% of fuels sold must be from a renewable source.

92. There are several options for moving beyond the RTFO as it is currently specified. These could include, for example, moving to a higher volume target, or specifying the Obligation in terms of carbon savings rather than volumes of renewable fuel**. This note provides a summary of purely illustrative analysis of the additional costs and benefits that could arise, were we to set the Obligation at 10%. This analysis is without prejudice to any announcements on future targets. However, there are a number of conditions that would need to be met before this could happen.** These are discussed in more detail in section 5 below.

Key assumptions

93. The costs and benefits of this measure have been assessed against the counterfactual scenario of a 5% (volume) Obligation. Any costs and benefits are therefore *additional* to those accruing from the Obligation as it is currently specified. The key factors influencing the cost of this policy and its impact on carbon emissions are: the cost of the biofuels; the cost of conventional fuels; and the carbon savings from substituting biofuels for conventional fuels.

Cost of biofuels

94. Our best estimates of future resource costs of biofuels are presented in Table 17 below.

Table 17: Resource Costs of Biofuels (£/litre)

	Bioethanol	Biodiesel
2010	0.31	0.43
2020	0.25	0.29

95. These cost estimates include capital and operating costs of biofuel supply, as well as the cost of the inputs. The estimates are based on the assumption that new ‘second generation’ technologies become available by 2020 and the cost of production falls to around two thirds of its 2005 cost.

Cost of conventional fuels

96. Central, low and high oil price forecasts to 2020 were supplied by DTI. These were then converted into petrol and diesel prices using the DfT fuel price forecasting model. The pre-tax petrol and diesel price forecasts under each oil price scenario are given in table 2 below.

Table 18: Resource costs of conventional fuels in 2005 prices (£/litre)

	Low oil price ($20/barrel)		Central oil price ($40-45/barrel)		High oil price ($67-72/barrel)	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
2010	0.14	0.15	0.21	0.24	0.31	0.35
2020	0.13	0.15	0.23	0.26	0.33	0.37

97. *Carbon savings from biofuels*

The use of biofuels in place of conventional fuels is assumed to save 57% of carbon relative to conventional fuels in 2010, increasing linearly to 75% in 2020 for both bioethanol and biodiesel[19]. These assumptions are in line with the resource cost scenarios described above. They assume that new 'second generation' technologies become available by 2020. Estimates of future carbon savings from biofuels are highly uncertain. We therefore carried out sensitivity analysis for lower carbon savings of 50% in 2010, increasing to 65% in 2020.

Other assumptions

- We have assumed that at blends of less than 5% there is no difference in energy content between conventional fuel and blended fuel. A lower energy content has been factored in when biofuel blends exceed 5%.[20]
- Demand forecasts for petrol and diesel are taken from the National Transport Model[21]. Scenarios were run based on the latest oil price forecasts from DTI.
- We have used a price elasticity of -0.25 in our analysis to take account of motorists responding to a fuel price increase by using less fuel.
- It is assumed that biofuels have no effect on NOx emissions from cars, and have a small beneficial effect on emissions of particulate matter (PM10).

Results of cost-benefit analysis

98. It is estimated that moving from a 5% to a 10% volume target by 2015 would generate additional carbon savings of **1MtC** in 2020 at a lifetime cost of **£174** per tonne of carbon saved. The costs of the policy mainly come from the increased resource cost of biofuel over conventional fuel while the benefits arise from fuel savings, reductions in carbon emissions and reductions in particulate matter (air pollution).

[19] In this analysis we have taken account of the lifecycle emissions of biofuels, irrespective of where they are produced. This means that when calculating the biofuels needed to reduce carbon by 5%, we are including carbon emitted during the production of biofuels abroad which are then imported and used in the UK.

[20] The energy held in a litre of bioethanol is around one third less than in a litre of petrol and around one fifth less in biodiesel than in diesel. However, evidence suggests that at blends of less than 5%, the lower energy content is offset by biofuels helping the conventional fuel burn more efficiently.

[21] http://www.dft.gov.uk/stellent/groups/dft_econappr/documents/divisionhomepage/030708.hcsp

Table 19: Results of analysis

		Low oil price scenario	Central oil price scenario	High oil price scenario[22]
Impact on annual carbon in 2020 (MtC)		1.1	1.0	0.3
NPV to 2020 (£m) [1]		-2,080	-1,156	-255
Cost-effectiveness (£/tC) [1]		290	174	86
Impact on security of supply (mill litres saved in 2020)	Petrol	939	928	908
	Diesel	1523	1512	0
	Total	2462	2440	908
Impact on fuel prices		Likely to be a small rise in pump prices (<1p/litre). Under the high oil price scenario there may be a slight fall in pump prices, though this would tend to be offset by the slightly lower energy content of the blended fuel.		
Other ancillary impacts		Positive impact on particulate emissions and positive impact on innovation (not quantified). Possible negative impact on NO_x emissions (not quantified).		

[1]Excluding ancillary impacts

99. The impact on security of supply is ambiguous. An increase in the use of biofuels in place of conventional fuels could save around 6,600 million litres of petrol and 10,200 million litres of diesel over the period 2010-2020. However, it is likely that some of the biofuel which will replace these conventional fuels will need to be imported from abroad.

100. Sensitivity analysis looking at lower expected carbon savings suggests that carbon saved in 2020 could range from 0.2MtC (under a high oil price scenario) to 0.9MtC (under a low oil price scenario).

Distributional impacts

101. Costs to the Exchequer of administering the scheme have not been included in the analysis. The impact of a 10% Obligation on exchequer revenues is dependant on the level of any duty differential on biofuels (set at 20p/litre until 2008-09). The Government expects that the emphasis will move from the duty incentive towards the buy-out price as the principal support mechanism in future years. It is expected that the additional resource cost of biofuels would be passed on to businesses/consumers in the form of higher prices at the pump, though this effect is likely to be very small (less than 1p/litre).

[22] Under the high oil price scenario, the energy-adjusted price of biodiesel becomes cheaper than conventional diesel. We assume that a rational supplier would supply biodiesel in the absence of the RTFO and therefore we do not claim any additional savings (carbon or fuel) as a result of this policy. This also explains why the carbon savings are lower in the high oil price scenario than in the low oil price scenario.

Other considerations

<u>the availability of biofuels</u>

102. In the UK, domestic supply of biofuel is currently dominated by biodiesel, produced from virgin oil and waste oil, though the latter is limited by its supply as a waste product. Beyond the UK, production capacity for biodiesel and bioethanol is rising quickly both in the EU and the rest of the world. Although, there are likely to be limits to the availability of arable land for conversion to biofuels, some feedstocks can be produced in areas not suitable for food production.

<u>assurance of their sustainability</u>

103. Concerns have been expressed about the sustainability of biofuel production especially with rising global demand. To counter this, the UK is developing carbon and environmental assurance schemes. The European Commission is also looking at an EU-wide environmental certification scheme. There are also concerns that there may be negative social consequences of biofuel production especially in developing countries, for example, the use of child labour, poor working conditions and health and safety risks. However, increased used of biofuels can also stimulate new international trade with developing countries, with increased economic productivity of rural areas through production of fuel feedstock, growth and employment through development of local biofuel industries, and reduction in exposure to high international energy prices (petroleum imports) through use of biofuels locally.

<u>the net carbon life-cycle emissions of biofuels</u>

104. The level of carbon savings can vary significantly between different biofuel sources and production techniques. An Obligation expressed solely in volume doesn't take into account the relative carbon life-cycle emissions of different types of biofuels. However, the carbon assurance scheme currently being developed as part of the Obligation will require obligated companies to report on the level of carbon savings achieved.

<u>the proportion of cars able to use higher biofuel mixes</u>

105. Vehicles in the EU are currently warranted to run on blends of up to 5% though it is possible that blends of up to 10% could be used in the future. Much higher biofuel blends are likely to require the use of modified (flex-fuel) vehicles.

<u>developments at EU level</u>

106. It is likely that future EU legislation on biofuels will introduce targets for beyond 2010. The format of these targets will have a big influence on the discretion left to member states to set the format of targets in domestic legislation.

A successor to the current Voluntary Agreements on new car fuel economy

Description of policy

107. This note provides a summary of the appraisal of a successor to the current Voluntary Agreements (VAs) to reduce CO_2 emissions from new cars. The current VAs were agreed between the European Commission and European, Japanese, and Korean car manufacturer associations in the late 1990s and require improvements in average new car fuel efficiency of 25% from 1995 levels. The targets are set at EU level but, in the UK, are projected to result in around a 15% reduction in average CO_2 emissions from new cars over 1995 levels by 2008.

108. In our analysis we have assumed that the current VAs would be succeeded by further EU-wide targets when they expire in 2008/9. In our analysis, we have made no assumptions about the form that this successor instrument might take, simply that it would result in an annual improvement in average UK new car fuel economy of 1.5%. This would mean that by 2020, average new cars would be around 17% more fuel efficient than they would have been in the absence of the new agreement and average new car fuel economy would be 135g of CO_2 per km. This assumption does not prejudge later UK decisions on the appropriate level of any future targets, but is used merely for illustrative purposes.

Key assumptions

109. The model estimates the costs and benefits of the measure for the period 2005 to 2020, and over the lifetime of the policy (i.e. over the lifetime of the cars that enter into the market between 2009 and 2020). It is assumed that a new instrument would lead to new car fuel efficiency improving at a similar rate to that seen under the current VAs (around 1.5% per year) from an average level of 162g CO_2/km in 2008. In the absence of the future VA, it is assumed that average fuel economy would have remained constant at 2008 levels[23].

110. The key factors influencing the cost of this policy and its impact on carbon emissions are:

Numbers of new cars purchased each year

111. Forecasts of annual new car purchases are provided by the National Environmental Technology Centre (Netcen)[24]. These show annual increases in new car purchases of about 1%. It is assumed that a new fuel efficiency target will not affect the numbers of new cars purchased each year – that is, new car numbers are the same in the actual and counterfactual scenarios.

Additional costs of technology to improve fuel economy

[23] While some fuel economic technology would have been adopted by car producers in the absence of the future VA, some of this would have been counteracted by the fuel penalty likely to be associated with future air quality and safety standards. This assumption has been tested using sensitivity analysis.

[24] www.netcen.co.uk

112. Estimates of the cost of fuel saving technology were provided by the consultants Ricardo[25]. These estimates are based on the historical cost of mass produced technology from 1995-2004, and projections of the future cost of technology per percentage improvement in fuel economy. Percentage improvements expected from the policy were input into the Ricardo model, to produce average cost estimates per car. The counterfactual scenario assumes no additional technology costs.

Composition of the fleet

113. It is assumed that 41% of the fleet are diesel in 2009 and 42% thereafter.

114. Cars are split into small, medium and large segments, based on 1995-2004 data provided by the Society of Motor Manufacturers and Traders. The percentage of cars in each size segment is assumed to be the same in the counterfactual as in the actual. This means that any downsizing as a result of the policy occurs *within* the size segments rather than from one segment to another (for example, there could be a move from purchasing cars from the higher end of the large segment, to smaller large cars).

Rebound Effect

115. The rebound effect is the demand response to the increase in fuel efficiency. We assume there are three parts to this effect:

- an increase in mileage due to a fall in the price of driving per km (estimated as having an elasticity of -0.2)
- extra comfort taken when driving - e.g. increasing the use of air-conditioning, heat seaters etc and more aggressive driving (estimated as having an elasticity of -0.05)
- the choice of a bigger car when making a purchase decision (this is taken into account in the new car fuel economy averages).

116. There is no rebound effect in the counterfactual, as fuel economy is assumed to remain constant.

Results of cost-benefit analysis

117. The main results of our analysis are given in table 1 below. It is estimated that the future VA would result in an annual carbon saving of **1.96MtC** in 2020 at a lifetime cost of **£184** per tonne of carbon saved.

118. The costs of the policy mainly come from the cost of new technologies and the costs of congestion from the additional driving miles while the benefits arise from fuel-cost savings and carbon savings.

[25] See: http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_611428.pdf

Table 20: Results of analysis

		Low oil price scenario	Central oil price scenario	High oil price scenario
Impact on annual carbon in 2020 (MtC)		2.05	1.96	1.84
NPV 2009-2020 (£m)[1]		-8,017	-6,983	-5,974
NPV 2009-2032(£m)[1]		-6,282	-4,089	-2,024
Cost-effectiveness (£/tC) [1]		270	184	97
Impact on security of supply (million litres saved in 2020)	Petrol	1,914	1,831	1,725
	Diesel	1,147	1,098	1,034
	Total	**3,061**	**2,929**	**2,759**
Ancillary Impacts	Small but negative impact on air quality (increased mileage), positive impact on innovation (not quantified). Potentially large negative impact on congestion (as a result of the fall in the marginal cost of driving).			

[1] Excluding ancillary impacts

Sensitivity analysis

a) Impact of lower technology costs on cost-benefit results

A report[26] by the Institute for European Environmental Policy (IEEP) on the costs of CO2 emission reduction measures in the automotive industry suggests that the costs of fuel saving technology may be significantly lower (around 25% of the Ricardo cost estimates). Sensitivity analysis suggests the results are highly sensitive to assumptions surrounding costs of fuel saving technology. When we assume technology costs that are more in line with IEEP estimates the lifetime (2009 - 2032) NPV of the policy is estimated at around £4.5 billion with a *benefit* per tonne of carbon abated of £142.

b) Impact of fuel efficiency improvements in the baseline

Work undertaken for DfT by Ricardo on the prospective evolution of low-carbon technology[27] suggested that we would expect to see 0.6% annual improvement in fuel economy even if there was no voluntary agreement in place. Sensitivity analysis which includes a 0.6% annual fuel economy improvement in the baseline estimates a lifetime (2009 - 2032) NPV of -£2,623 million and a cost per tonne of carbon abated of £273.

Distributional impacts

119. The costs of the new targets on three groups in society (firms, consumers and the exchequer) have been estimated. The results of the distributional analysis include secondary effects. They therefore cannot be summed to find the cost to society, as this would entail double counting. The policy results in a net benefit for consumers, but a net cost to firms and the exchequer. The exchequer loses out in tax revenue due to reduced fuel

[26] IEEP (2005) 'Service contract to carry out economic analysis and business impact assessment of CO2 emissions reduction measures in the automotive sector - final report'
[27] Ricardo (2003) 'Carbon to Hydrogen Roadmaps for Passenger Cars - Update'

consumption. Consumers and firms incur the technology costs of achieving the new targets, but save on fuel costs.

Table 21: Distributional Impacts of Voluntary Agreements

Distributional Impacts (2005 prices)		
Lifetime distributional impacts: NPV benefit With ancillary impacts	Exchequer[28]	-£7,669
	Firms	-£5,949
	Consumers [29]	£4,725

120. Costs of monitoring new car CO_2 emissions have not been included in the analysis since the data is already required for the classification of vehicles into graduated vehicle excise duty bands.

Other considerations

121. The analysis makes no assumption about the mechanism by which EU wide targets for new car fuel efficiency will be achieved. The costs and benefits associated with specific implementation options were not included in this analysis. Issues such as the impact on competitiveness and the administrative burden on manufacturers would need to be explored before we can reach a view on a preferred approach for implementation.

[28] Revenues from graduated vehicle excise duty and company car tax would also be affected by an increase in the pace of vehicle fuel efficiency improvements, but these effects are not quantified.

[29] Carbon savings are allocated to consumers in the distributional analysis.