The cost effective limit to UK carbon dioxide mitigation in 2010 and 2020

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1. SYNOPSIS

The paper assesses the limit to cost-effective mitigation of CO_2 in the UK for 2010 and 2020, and the role of ESCOs in implementing reductions.

2. ABSTRACT

This paper explores scenarios for CO_2 reduction to meet current targets in 2010 and for tougher targets, post-Kyoto in 2020. The paper presents and then builds upon a set of cost curves of CO_2 reduction measures in each sector of the UK. A Business As Usual scenario (based on current policy initiatives), and an alternative scenario (based on practical limits to the maximum rate of penetration of measures) are used to identify the broad segments in which major market opportunities may lie. The range of business opportunities created for energy service companies through policy responses to CO_2 reduction targets in the UK, and barriers facing them are examined.

The paper shows that the limit of cost-effective reductions of anthropogenic emissions of Carbon Dioxide in the UK under the developed scenario and with current technologies, are 20 Million tonnes Carbon (MTC) in 2010 and 32 MTC in 2020 (73.2 $MTCO_2$ and 117.1 $MTCO_2$ respectively). Given present projections of demand growth, these reductions equate to reductions in CO_2 in the UK from 1990 levels of 19% in 2010 and 21% in 2020. Therefore it seems the Government's target of a 20% reduction in CO_2 levels from the 1990 baseline, by 2010 can be achieved in a cost neutral manner. However, beyond 2010 a reduction in nuclear generation and a continuing rise in energy use under the Business as Usual (BaU) scenario largely offsets additional cost effective measures. If the pressures to reduce CO_2 emissions continue to grow, then a reduction of 30% in CO_2 emissions by 2020 from 1990 levels could be required, necessitating 56 MTC of reductions.

3. METHODOLOGY

Scenario construction

The paper shows a scenario to determine the limit of cost effective, practicable CO_2 reduction, for the UK in 2010 and 2020, estimates the cost of moving beyond these limits and examines the roles for Energy Service Companies, based on work reported in Johnson, 2000. The following steps were taken to derive the desired information:

- Energy use, both historical and predicted under the Business as Usual (BaU) scenario are detailed, as this shows the magnitude of energy usage and the predicted trends against which techniques for energy and CO_2 emissions reduction can be compared.

- Identification of technologies, techniques and polices to reduce CO_2 emissions and the associated cost effectiveness. This allows estimation of the Maximum Technical Potential (MTP) through application of a simple stock-turnover model to represent the normal replacement cycle for equipment and buildings and the resulting stock appropriate for CO_2 reduction measures. The Technical potential is that possible by adopting all techniques either currently available, or thought to be available in the year for which the forecast is being made. In practice nearly all the techniques and technologies used in the analysis are currently available, or are a visible progression from currently available techniques. Highly innovative, unproven or radically new technologies which might change the cost of mitigation of CO_2 and/or increase the reductions possible have not been included in the assessment. Previous research results have been used extensively to provide reduction possibilities and their cost effectiveness, and have been updated or extended to reflect more recent developments.

- The scenario case is then developed by multiplying the MTP in each year by a reduction factor. For any given year, this factor represents the maximum practicable limit of penetration thought possible under the most proactive and progressive of policies, together with a high level of awareness in all areas of society, and is intended to reflect numerous constraints, such as the capacity of industry to manufacture efficient equipment. This is clearly a subjective process, but has been done transparently and is a necessary step to move beyond estimates of technological possibilities.

- The scenario cost curve is produced from the cost effectiveness of each measure, in pounds per tonne of carbon mitigated, and the cumulative quantity of carbon reduced, sorted by cost effectiveness. "Cost" here includes capital and operating expenditures and fuel cost savings arising from more efficient delivery of the same energy service. The figures adopted reflect the average cost effectiveness for a measure across a variety of operating conditions, and are drawn from studies such as Wade and Leach (1998) which include a finer disaggregation.

Carbon Price

For many techniques there is no direct cost effectiveness figure in pounds per tonne carbon (£ per TC) available. Additionally, a calculation of the cost effectiveness including the savings from reduced fuel use can over estimate the benefits of reduction as the organisation making the investment is often different from the person who receives the benefits of the reduced fuel bills. In these cases, a value is assigned to the carbon reductions generated using notional values for a carbon credit. A notional carbon credit value of £30 (EUR 48.9)per tonne Carbon (TC) is taken from the UK Emissions Trading Group (ETG), with the value of £100 per TC used to test if the measures would generate significant value under a higher carbon price scenario (ETG, 2000). This approach reflects the reality faced by some decision makers who do not see the energy costs associated with their actions, and hence reflects the likely uptake of measures - for example, house builders who might claim a carbon credit for building higher efficiency buildings, but will not benefit directly from energy savings. However, this approach provides a conservative view of the benefits to society of a measure, as the avoided costs of electricity or fuel avoided are likely to be higher than £100 per TC.

Energy Service Companies

For the vast majority of companies and organisations, energy costs are only a small percentage of total costs: management of this area is not seen as core business and there is often insufficient expertise to realise cost effective energy savings. With liberalisation of markets, different forms of 'energy contracting' have emerged in which third party companies assist an organisation to realise energy and/or energy cost savings, usually by taking responsibility for investments which reduce energy costs through higher efficiency, with some form of shared-savings contract. The concept of an Energy Service Company (ESCO) is in practice very similar, but with a philosophical shift in focus to the delivery of the fundamental services demanded by end-users rather than the energy commodities themselves. This change in approach helps to de-link the uses of energy from particular fuel types, and liberates innovation in the efficiency and cleanliness with which service needs are met.

The development of a thriving energy service market is seen by many as an important step towards a lower carbon future. However, progress in the UK (and elsewhere) has been relatively slow, hampered for example by the complexity and inertia of existing institutional structures. The realistic opportunities for third party companies to help deliver the emission reduction options identified are discussed briefly for each sector.

4. CO_2 EMISSIONS

UK emissions: 1990 – 2010

The Business as Usual (BaU) emissions from which reductions in the paper are quoted, are shown in Table 1.

Table 1: UK CO_2 Emissions 1990 – 2020 (Million Tonnes Carbon)

	1990 Baseline	2000	2010	2020
Carbon dioxide:				
Projected emissions (MTC)	168.0	152.2	156.3	164.9
Current target			134 (-20% of 1990)	

Source: Energy Projections for the UK, Working Paper (DTI, 2000a)

The significant reduction in CO_2 seen between 1990 and 2000 is in large part due to fuel switching from coal to gas for electricity generation and increased output from nuclear generation. Post 2005, a number of nuclear stations reach the end of their (present) technical lives) and there is no new nuclear capacity planned or likely as unless gas prices dramatically change then nuclear is both economically uncompetitive and currently publicly unacceptable and politically untenable.

UK emissions: 2010 – 2020

There is the potential for three factors to combine to make any post-Kyoto target difficult to achieve. Firstly, the UK GHG emissions after 2010 are projected to rise under the base case scenario caused by a continuing rise in transportation demand that includes the high growth rates in air transportation and the decline in nuclear capacity. Secondly many of the "no-regrets" low cost or economically advantageous technologies and techniques will have been adopted in meeting Kyoto targets, and finally emissions from electricity generation will rise, due to the barriers facing replacement nuclear capacity and facing a dramatic increase in renewable generation.

Technological progress - both incremental improvements and more radical innovations - are not included in the present assessment, but will clearly assist in reaching any post Kyoto commitments. However, significant further reductions will require paradigm shifts and associate policy support. This new paradigm could for example be a shift to 30% renewable electricity generation but this will need to compete against CCGT in replacing the retiring nuclear capacity and further decline in coal capacity.

The following sections describe for each sector the CO_2 reduction scenarios developed, and the estimated range of abatement costs. The market of business opportunities, and scope for involvement of ESCOs, is discussed for the appropriate sectors.

Residential

Residential Energy Usage

The residential sector accounted for 36 MTC of emissions and accounts for 27% of total UK energy demand in 1999, including allocated losses from electricity generation (DUKES, 2000). The DTI projections are that residential demand will increase by between 6.6 and 3.4% between 2000 and 2010 (DTI, 2000a). Energy demand in the residential sector is important as despite programmes to reduce demand; consumption is projected to grow due to increasing electrical demand and an increase in the number of dwellings. The sector has a large unrealised potential to reduce energy use and therefore emissions, but many barriers are present that prevent the uptake of apparently cost effective energy saving measures.

Carbon Savings from the Residential Sector

The study described in Wade and Leach (1998) looked at all the major measures than can reduce energy use in residential buildings and this has been used as the primary data source for the cost curve The Environmental Change Institute (ECI), Lower Carbon Futures report, has been used to provide additional and more detailed data on the savings possible from efficient appliances (Fawcett, *et al*. 2000). The work by Wade and Leach produced a MTP (Maximum Technical Potential) scenario by estimating the total dwelling stock technically appropriate for a measure together with a maximum uptake or penetration rate. Under the MTP scenario most of the technologies reach approximately 82% penetration by 2010 and 100% by 2020.

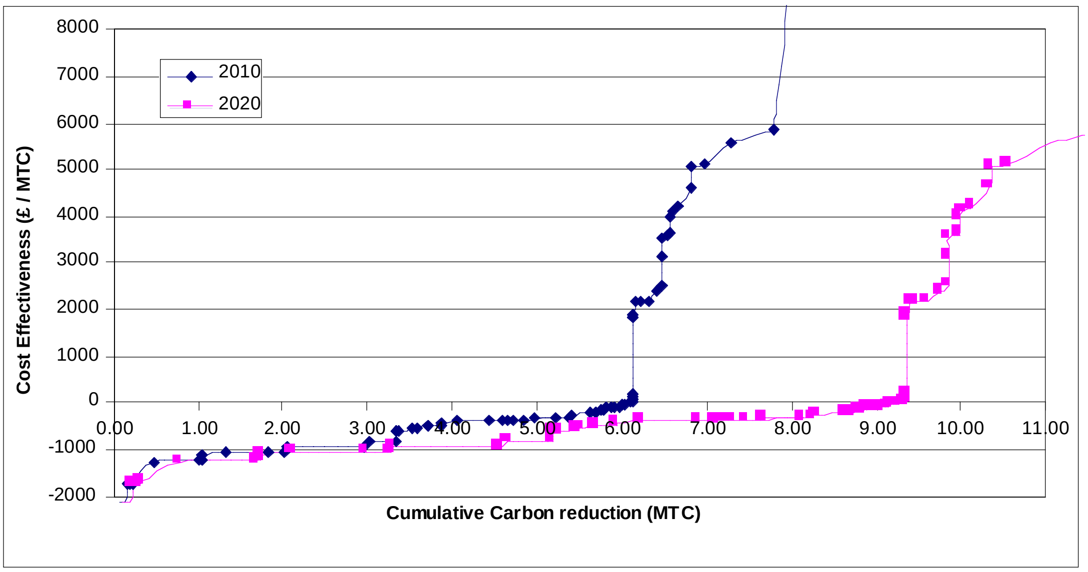
The additional carbon savings between the BaU and MTP have been calculated for each of the technologies to produce the curve for 2010. The 2020 curve has been produced by assuming the 2020 savings will be 22% greater than the savings in 2010, which for most technologies equals 100% penetration. Take-up will never reach the MTP (Maximum Technical Potential) even with the most vigorous of campaigns and financial incentives such as free installation. To produce the Scenario case, a scaling factor of 71% in 2010 and 88% against the MTP has been used to produce an estimate of maximum practicable, cost-effective savings. The scaling factors of 71% and 88% are taken from the ECI, Kyoto+ scenario in Lower Carbon Futures (Fawcett*, et al.* 2000). The Scenario case gives cost effective savings of 6.0 MTC in 2010 and 9.1 MTC in 2020 and is considered cost effective if the cost per tonne is less than zero (Cost < £0 / TC). The total cost curve for the Residential sector under the Scenario case is given in Figure 1.

Residential sector ESCO opportunities

The Residential sector has a large potential to reduce energy use and therefore create potential carbon credits, but it is difficult accessing this potential to produce a business opportunities for an Energy Service type company. Government-supported schemes have provided funds for all the major mechanisms for fuel saving in domestic homes, such as loft insulation grants and subsidies for efficient appliances. However, at a commercial level the benefits are either small or difficult to access, as energy savings will accrue to the householder and current regulations prevent residential customers being tied-in to a supplier, making shared-savings schemes difficult. The likely-hood is that a tie-in fuel purchase agreement, even at a preferential rate, would be seen as negative rather than a positive selling point.

Few independent market opportunities in the domestic sector are therefore seen, unless a scheme is devised in conjunction with the government, with the possibility of claiming carbon credits. The long running, and recently strengthened, requirement for energy suppliers to increase the energy efficiency of their customers' properties and the 'Affordable Warmth' programme to tackle fuel poverty will dominate in improving home energy efficiency for owner-occupiers, and as such it is difficult to see further market potential within the next 5 years.

Figure 1: Residential Sector Cost Curve for Carbon Reductions



Commercial and Public Sector

The commercial and public sectors account for 19.4 MTC of emissions (public sector share, 2.6 MTC) and account for 13% of total UK energy demand (33 Mtoe), including allocated losses from electricity generation. Energy demand in the commercial and public sectors is important, as there is both significant potential for reduction to be made, but currently demand growth dominates. The barriers to implementing energy saving and energy efficiency measurers in the commercial sector are particularly high, principally as energy costs are normally a small proportion of business costs, and often not seen as variable costs.

For the commercial and public sectors in the UK there is limited information available on the potential to reduce energy consumption or increase efficiency. The main resource is the Buildings Research Establishment, through contracts with the Government, who are refining a model termed the Non-Domestic Buildings Energy and Emissions Model (N-DEEM). This model includes data about the number, type and energy consumption of the UK's non-domestic buildings (Moss, 1996). The Sheffield Hallam University Resources Research Unit is the primary source of research into the extent and cost effectiveness of measures to reduce energy consumption form non-domestic buildings (Mortimer *et al*. 1998).

Carbon savings from the Commercial and Public Sector

Public Sector**:** The current emissions from the public sector are 2.6 MTC with maximum cost effective and achievable Public Sector emissions reduction assumed to be 30% from the 2000 level. In a consultation with government, the local authorities estimated they could save between 10 and 30% of current energy usage (DETR, 1999b). The higher figure of 30% has therefore been used as the maximum level achievable by 2020 (0.78 MTC of reductions) and 20% by 2010 (0.52 MTC of reductions).

Commercial Sector**:** Current research (Wade and Leach, 2000 and Mortimer *et al*, 1998) estimates the maximum cost effective potential to reduce emissions from the commercial sector at between 1.28 and 1.7 MTC in 2010. The adoption of a total approach for commercial buildings can lead to dramatic additional and cumulative benefits totalling 50-90% of energy use (RMI, 2000), but the current research has not calculated these benefits. The scenario case assumes that a 50% reduction in energy demand from the commercial sector by 2020 is technically achievable and 40% by 2010. Reductions as great as 90% have been shown for actual buildings such as the ING headquarters in Amsterdam, in addition to other benefits such as a 15% drop in absenteeism. The estimated reductions, 50% in 2020 and 40% in 2010, used to calculate the MTP are in addition to any BaU reduction such as those arising from proposed new building regulations. The proposal for the new building regulations are contained in the Consultation Paper "Proposals for Amending the Energy Efficiency Provisions (Part L), Building Act 1984" issued in June 2000 (DETR, 2000d). These would give the following percentage reduction of space heating requirements (the figures in brackets are % of total commercial energy demand):

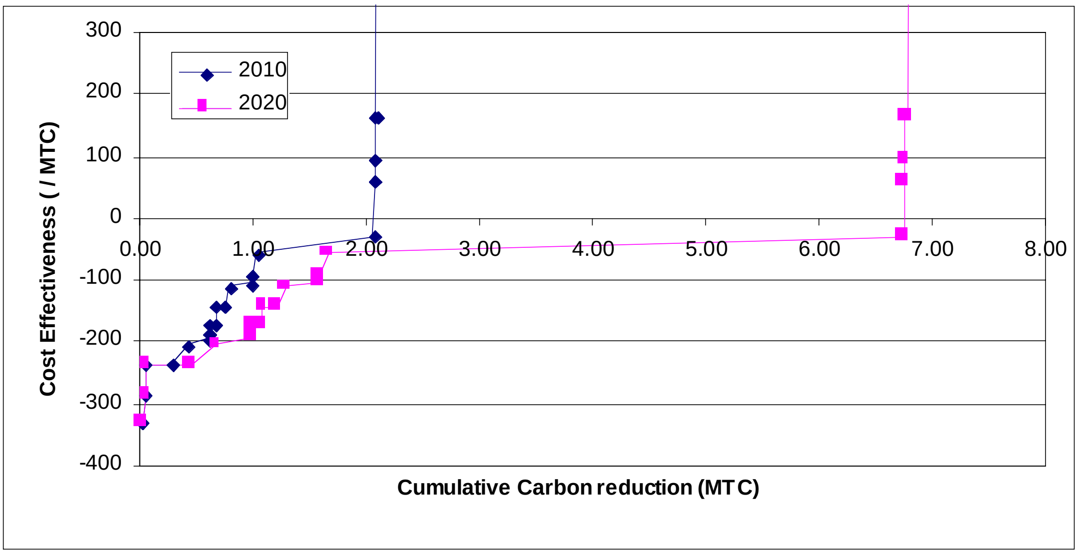
- New naturally ventilated non-domestic buildings: 19% (11%)
- New Air Conditioned & Mechanically Ventilated buildings: 25-30% (15-19%)

The MTP is influenced by the rate at which new buildings are constructed and the maximum theoretical refurbishment / modification rate. The scenario estimates that 50% of buildings could be modified by 2010 and 100% by 2020. This could be achieved for example by; a 2% stock turnover of commercial buildings (twice the rate of residential buildings), a 1% major refurbishment rate and a 2% modification rate between 2000 and 2020. This gives an MTP for the commercial sector of 3.44 MTC in 2010 and 8.45 MTC in 2020, with the reductions above those estimated by the Wade and Leach scenario of 1.73 MTC in 2010 and 6.4 MTC in 2020.

The scenario case is derived from the MTP multiplied by a scaling factor. The maximum take up of the technologies will be less than the MTP, even under the most proactive and progressive policies and awareness. The maximum practicable uptake of highly energy efficient building design and refurbishment is thought to be less than for residential retrofits and appliances. For example, minimum standards for appliances could be more easily introduced under a highly proactive government than a wholesale revision of the building regulations. The UK building industry has always shown reluctance to accept far-reaching changes to the energy efficiency part of the building regulations (Johnson, 2000). The scenario has therefore assumed the maximum practical adoption levels of 60% in 2010 and 70% in 2020. This gives total carbon reductions for the Scenario of 2.1 MTC in 2010 and 6.9 MTC in 2020. The case studies by RMI and in the books "Cool-Companies" (Romm, 1999) and "Factor Four: Doubling Wealth – Halving Resource Use" (von Weizsäcker, *et al,* 1998), show that cost effective reductions of at least 50% in commercial building energy use can be made. For the purposes of building the cost curve, the additional savings of the scenario are therefore assigned an assumed average cost effectiveness of minus £30 per tonne carbon, reflecting a modest net benefit.

The total cost curve for the Commercial sector under the scenario is given in Figure 2.

Figure 2: CO_2 Reduction Cost Curve for the Commercial Sector



Commercial sector ESCO opportunities

There is a large business potential in the commercial sector for energy service companies and this is the traditional sector in which they have worked.

The value of electricity and gas used by the commercial sector in 1999 was approximately £3,300 million and £790 million respectively, and the reduction scenario described here would represent a business opportunity of reducing commercial electrically and gas bills by £500 million in 2010 and £1450 million in 2020. The scope for shared-savings contracts is therefore large, with many fewer contractual obstacles than in the residential sector.

Industrial sector

The industrial sector accounts for 40 MTC of emissions and accounts for 23 % of total UK energy demand (53 Mtoe), including allocated losses from electricity generation. Energy demand in the industrial sector is important, as significant decreases seen between 1990 and 1995 have now halted but it is estimated that emissions could cost effectively be reduced from 1995 levels by a further 19% to 29 MTC, by 2010 (ETSU, 1999b). Agriculture and construction are added to industrial classification, accounting for 0.4 & 0.6% of UK direct energy use.

Carbon savings from the Industrial Sector

Overall or individual sub-sector cost curves for reducing emissions from the industrial sector are not publicly available, due to sensitivity related to negotiated agreements under the new Climate Change Levy (CCL) instrument, which taxes fossil-based energy consumption. Government approved, negotiated agreements will allow the industry sector to claim 80% relief from the CCL in return for commitments to energy efficiency improvement (or CO_2 emission reduction). The information publicly available is the quantity of reductions under scenarios such as "All Cost Effective" (ACE) and "All Technically Possible" (ATP) scenarios produced for the Government's Climate Change programme, but without associated cost estimates.

The Scenario case of a 5.3 MTC reduction in 2010 gives an estimate of the highest practicable reductions under a highly proactive government policy and high priority within industry. This can be compared against the governments Climate Change programme estimate of 3.5 – 5.0 MTC shown below, where some less cost-effective measures will be taken or forced upon some sectors to balance those cost-effective measures not adopted by other industry sectors.

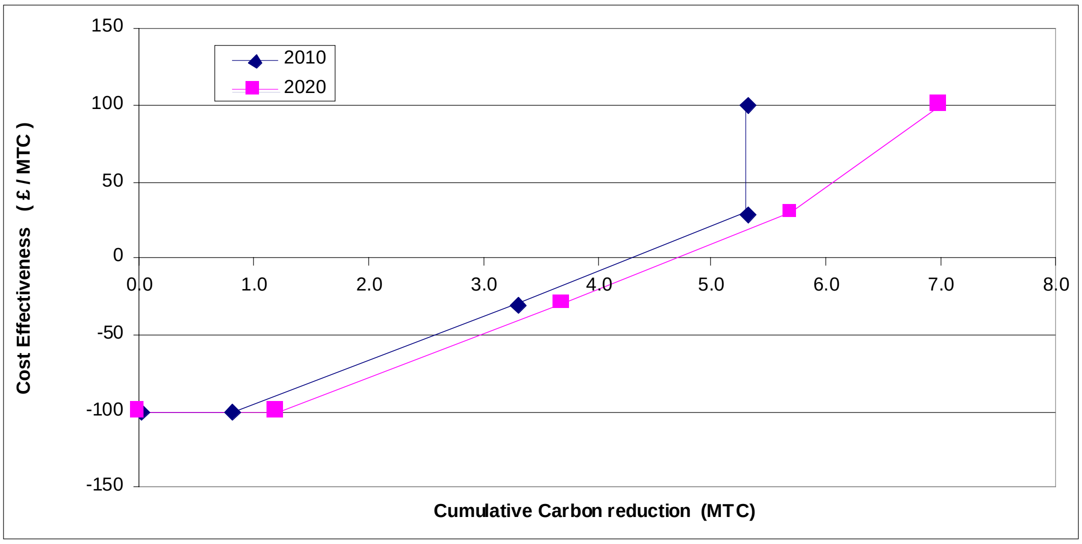
Table 2: Cost Effectiveness of Reductions for the Industrial Sector

	Government Estimated reduction [1] (MTC)	Scenario Case 2010 (MTC)	Assumed Cost Effectiveness (£ / TC)	Scenario Case 2020 MTC)	Assumed Cost Effectiveness (£ / TC)
Negotiated Agreements / IPPC requirements	2.5	2.5	-30	2.5	-30
Energy efficiency measures	0.5	0.8	-100	1.2	-100
Emissions trading scheme	0.5 – 2.0	2.0	+30	2.0	+30
Emissions trading scheme				1.3	+100
TOTAL (above BaU)	**3.5 – 5.0**	**5.3**		**7.0**	

1) Source: DETR, Draft Climate Change Programme 9th March 2000 (DETR, 2000a)

The total cost curve for the Industrial sector under the scenario is given in Figure 3.

Figure 3: Cost Curve for the Industrial Sector



Industrial sector ESCO opportunities

The greatest opportunity for ESCOs is to assist companies in achieving their commitments under negotiated agreements, or by enabling projects which produce carbon savings that can then be traded. The total reductions from trading under the Thesis scenario are 2.0 MTC in 2010, which at the notional carbon price of £30 per tonne of Carbon, represents a value of £60 million or using a higher estimate of £100 TC would give a net traded value of £200 million.

For the energy intensive sectors limited business opportunities are therefore envisaged outside the framework of CCL with negotiated agreements and trading until after 2010. The non-intensive energy sectors have a great potential to reduce energy usage but the barriers to emissions reductions or energy savings are similar to barriers within the commercial sector, where energy costs are normally a small proportion of total business costs and often not regarded as a variable cost to be managed actively. Additionally the total energy used by the non-intensive sector is by definition small for each user and in total a small proportion of the total industry energy use. The market potential therefore not only has barriers to entry but is small in absolute size.

ESI (Electricity Supply Industry)

The ESI used 80 Mtoe or 35% of all UK primary energy usage in 1999, of which 48 Mtoe was lost in transformation and 2.4 Mtoe in network losses, giving 30 Mtoe or 350 TWh delivered to customers. The potential for CO_2 reduction in this sector is therefore very large, either through the reduction in transformation losses or switching to less carbon intensive fuels such as coal to gas, or even zero carbon sources such as renewables. CO_2 emissions can also be reduced by reducing, or limiting the growth in, demand, which is covered by the other sections of this paper.

Carbon savings from the ESI

A scenario for less carbon intensive electrical generation has been developed, with the carbon reductions shown in Table 3. The remaining coal generation capacity is assumed to be displaced in the short to medium term by 10% bio-fuel and 90% gas. In the medium to long term, lower carbon options are then assumed to displace existing CCGT capacity, whether this is for additional renewables, nuclear capacity or for residential cogeneration. These are relatively crude assumptions, but reflect likely timescales for the major fuel switches.

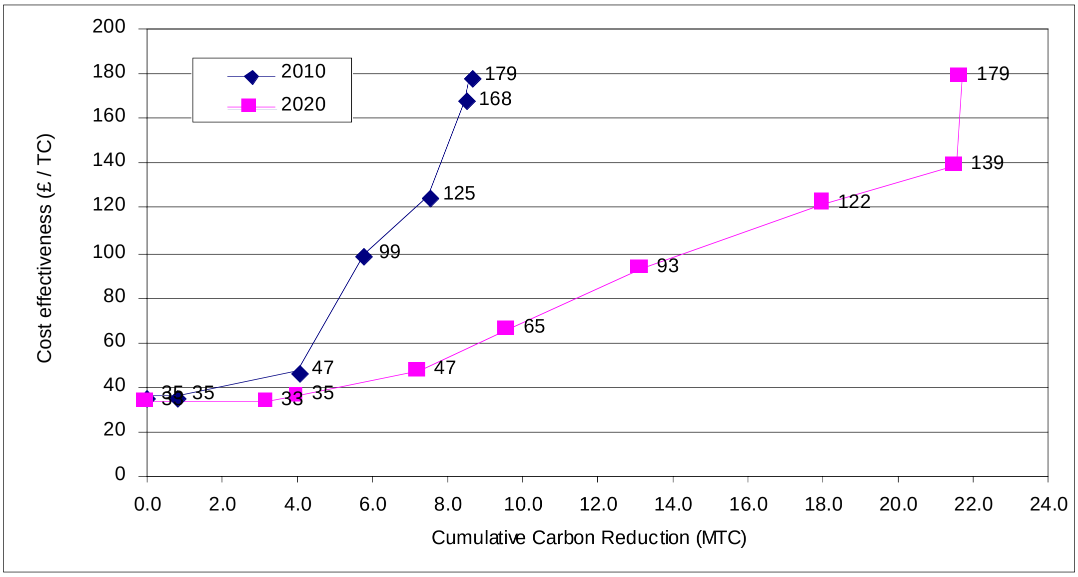
Table 3: Carbon Dioxide Reduction Techniques in the ESI (ranked by cost-effectiveness)

Cumulative Carbon Reduction Measures, for 2010	MTC	Cumulative Carbon Reduction Measures, for 2020	MTC	Displa-cing	Cost £/ TC	Electr-icity TWh	Carbon Reduction MTC
		4 x 1.2 GWe Nuclear life Extension	3.2	CCGT	33	33.6	3.2
Co-Firing 10% of Coal Output	0.8	Co-Firing 10% of Coal Output	4.0	Coal	35	3.6	0.8
90% Coal Stations to Gas Firing	4.1	90% Coal Stations to Gas Firing	7.3	Coal	47	32.4	3.2
		Residential CHP 2 GWe	9.6	CCGT	65	15.8	2.4
		10% -20% Renewables 4.2 GW DNC	13.2	CCGT	93	37.0	3.5
10% -15% Renewables 2.05 GW declared net capacity (DNC)	5.8			CCGT	99	18	1.7
		6 x 1.2 GWe New Nuclear	18.0	CCGT	122	50.5	4.8
15% -20% Renewables 2.05 GW DNC	7.5			CCGT	125	18	1.7
		20% - 30% Renewables 4.2 GW DNC	21.6	CCGT	139	37.0	3.5
Residential CHP 2 GWe	8.5			CCGT	168	15.3	1
Dual Firing to CCGT 35% efficiency	8.6	Dual Firing to CCGT	21.7	Gas	179	4.7	0.1

Source and assumptions: Johnson (2000)

The cost curve of carbon reduction potentials for the UK ESI is shown in Figure 4.

Figure 4: ESI Carbon Dioxide Reduction Cost Curve



Transportation sector

CO_2 mitigation in the transportation sector via increased efficiency by using new technology has been pursued since the first oil crisis of 1973. It has a particular focus in the EU due to high fuel prices and recently the EU attempting to meet its Kyoto commitments. The EU has concluded a voluntary agreement with the European Automobile Manufacturers Association (ACEA) to reduce the CO_2 emissions from passenger cars by 25% in 2008 from the 1995 levels. This agreement will encompass all the advances made in the uptake of new vehicles and has been used by the UK government in their Climate Change Programme.

There are many highly complex issues relating to CO_2 mitigation in the transportation sector, but in the road sector these efforts have been summarised into assumptions for the UK's Climate Change Programme. The technology and the potential for reductions from vehicles is driven by the existing big players with the additional cost of CO_2 reduction measures taken up in new vehicle costs. The cost of reduction used is therefore a very broad and unsophisticated estimate. The UK Climate Change Programme projections for CO_2 emissions from the transport sector have been adopted here, in the absence of information to assemble a cost reduction curve for the transportation sector. The reductions are represented within the total UK cost curve shown below.

Table 4: CO_2 Reductions from the Transportation Sector

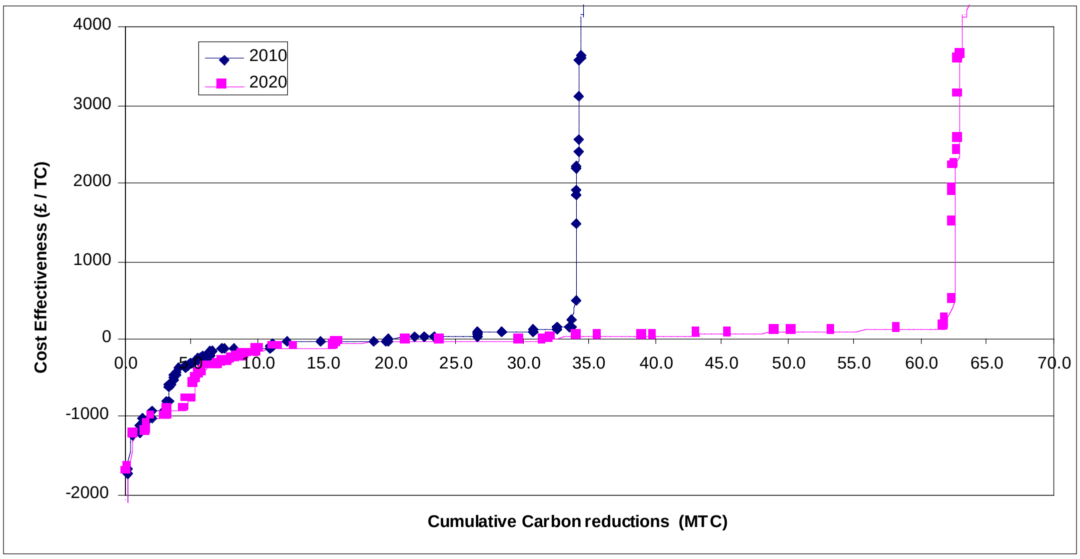
MEASURE	Carbon saved (MTC /yr) 2010 1)	Carbon saved (MTC /yr) 2020 2)	£/TC saved life
Transport Agreement with Motor Manufacturers	4.0	6.0	-30.0
Transport White Paper (Low Intensity)	0.6	1.6	30.0
Transport White Paper (High Intensity)	2.4	3.0	100.0
Transport White Paper (Rail investment)	0.3	0.5	500.0

1) Predicted Savings from Draft Climate Change Programme (DETR, 2000a)
2) Extrapolations from Draft Climate Change Programme Prediction

Total UK CO_2 cost curve

The cost curves from each of the sectors are combined to produce the total CO_2 mitigation cost curve for the UK under the scenario case, shown below. The curve shows there is considerable scope for CO_2 mitigation in the UK, both up to a cost neutral level, £0 per TC, and at a cost of up to £200 per TC. In 2010 the cost-effective potential is sufficient to fulfil the UK government's target of a 20% reduction in CO_2 emissions from 1990 levels.

Figure 5: Cost Curve for Total UK CO_2 Mitigation in 2010 and 2020



There are a large number of measures that are highly cost effective in reducing CO_2 emissions. At the level of minus £100 per TC (i.e. the fuel savings are greater then the cost of implementing the measure), 7.1 MTC in 2010 and 11.2 MTC in 2020 reductions are feasible. Although these measures are financially rational, they have currently not been carried out due to the many barriers to uptake and implementation. At the cost neutral level of £0 per TC, the cost effective potential under the Scenario case is 20 MTC in 2010 and 32 MTC in 2020.

The curve shows a large inflexion at about £200 per TC, with the potential for CO_2 reduction being 34 MTC in 2010 and 62 MTC in 2020 up to this point. Beyond £200 per TC, the mitigation costs sharply rise to between £2000 and £70,000 per TC. This is thought to be caused by two factors: firstly some measurer are implemented primarily for benefits other than fuel savings but the total cost has been included in the cost effectiveness calculation. An example is double-glazing which is installed primarily for comfort and noise reasons, with fuel savings an additional benefit. Secondly the original cost curves used to generate the Scenario cost curves have concentrated on those measures which are, or are nearly, cost effective with just a selection of well-known measures usually implemented for other reasons (such as double glazing), included. The curves may therefore not include all technically possible measures that would require a carbon price between £200 and £70,000 per TC and hence would smooth the curve.

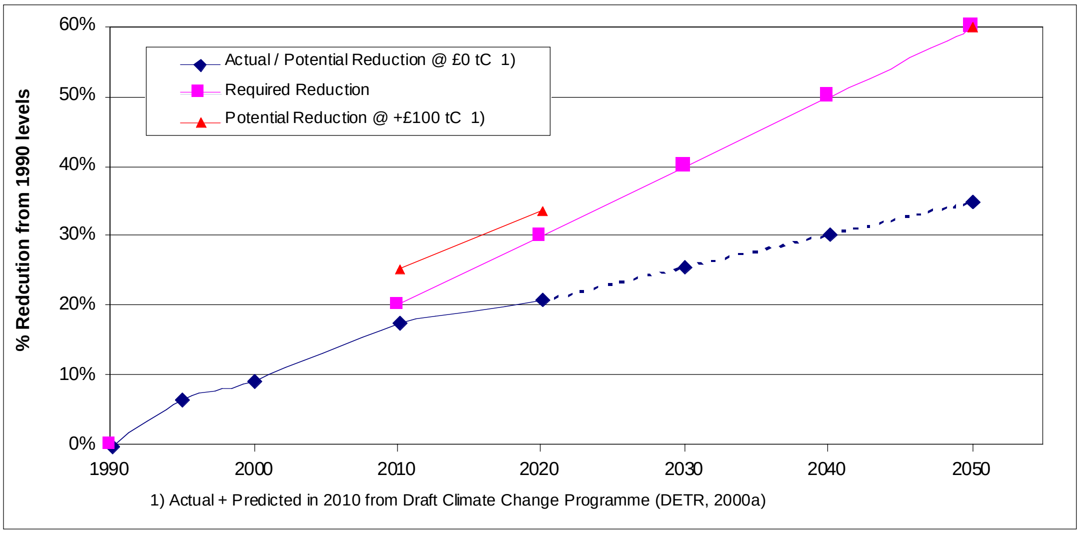
5. ANALYSIS OF UK CO_2 MITIGATION COST CURVES

The cost curves for all sectors have an economically positive region, often termed "no regrets" measures - although in practice there may be economic or other barriers which are difficult to quantify which explain why such measures have not been adopted already. There are many studies focussing on each of the energy sectors, but often with little reference or comparison between the sectors. An analysis of the planned actions for each sector and examination of the cost curves for different sectors shows pressure for action will shift between them. The industrial sector curve and analysis shows the cost effective potential in 2010 is in line with the government projections and expectation of reductions from this sector, whilst the predicted reductions from the transportation sector in particular have been criticised as being too optimistic (ENDS, 2000). Pressure for further reductions should therefore shift to the residential and commercial sectors. In order to achieve the 20% reduction target by 2010 in the most cost effective manner, concerted efforts will therefore be required to remove the barriers preventing the achievement of the scenario case that predicts the required level of CO_2 reduction can be achieve in a cost neutral manner. The Scenario case has included 2.0 MTC of reductions from trading in 2010 at the indicative cost of £30 per TC (ETG, 2000).

The UK government's target of a 20% reduction of CO_2 emissions from 1990 levels by 2010 will require a strong programme to be adopted and followed through, but is probably achievable using "no regrets" policies and actions. The cost curve for 2020 shows significant further potential to reduce UK carbon emissions, although to realise these savings long term actions and polices must be put in place by midway through this decade.

Figure 6 gives a plot of the emission reductions predicted under the Scenario case at, zero £ per TC and £100 per TC for 2010 and 2020. These projections are plotted together with actual and projected emission reductions from the Climate Change Programme, and a line showing the reductions required to meet a long-term CO_2 stabilisation target of a 60% reduction by 2050.

Figure 6: Forecast UK Carbon Reductions 2000 to 2050 vs.1990 Base Year



UK CO_2 Emissions 2000 to 2010

Under the DTI Business as Usual (BaU) scenario the UK CO_2 emissions are projected to fall to 152 MTC in 2000, a 9% fall from 1990 levels, but increase again to 156 MTC in 2020, a reduction of 7% against 1990 levels. The 20% reduction could be achieved via a vigorous implementation of the Climate Change Programme with reductions in the industrial, commercial and residential sectors offsetting further increases the transportation sector.

The UK final expenditure on energy was £61 billion in 1999 of which petroleum products constituted 60% of all expenditure, with duty and taxes accounting for 50% of this expenditure principally from road fuels duty and taxation (DUKES, 2000). The 20% reduction required in 2010 can be achieved with cost neutral measures, although measures with an associated cost will be adopted. Examples are carbon emissions trading which in the Scenario case is predicted to save 2.0 MTC per year and would cost £60 million per year, using the notional level of £30 per TC. The 10% renewables target in 2010 will cost £360 - 540 million per year, assuming a green certificate value of £10 - £20 per MWh, with this cost passed through to electricity customers.

UK CO_2 Emissions 2010 to 2020

The 20% goal by 2010 can be achieved at a near zero net cost, but a target of a 30% reduction by 2020, to be on course to meet 60% reductions by 2050, appears to require all measures to be implemented that are near £100 per TC. Assuming 35 MTC is achieved at or below zero cost and the BaU case in 2020 is 3.1 MTC below 1990 levels, an additional 12 MTC of reductions is required to meet the 30% reduction target in 2020. If an average cost of £50 per TC for these additional reductions is assumed, this would cost an additional £600 million per year.

The ESI is a key area that could produce substantial reduction in CO_2 emissions. The techniques to reduce CO_2 are either from fuel switching to lower carbon intensive alternatives such as gas or from near zero carbon technologies such as nuclear or renewables. The techniques identified for the ESI give a reduction of 8.6 MTC in 2010 and 21.7 MTC in 2020 (Johnson, 2000). This large reduction in emissions can only be achieved at a cost above CCGT, which is currently the lowest cost of electricity generation and a source of relatively low cost carbon abatement. In 2020 the predicted cost of all measures to reduce emissions from the ESI is £1.9 billion per year, for a reduction of 21.7 MTC per year. Whilst this is a considerable sum, it is only 12% of the £16 billion paid for electricity in 1999, which for the residential sector would be equivalent to an increase in the rate of VAT from the current 5% to the standard rate for most products of 17.5%.

A challenge for policy is to find ways to stimulate not just those investments with a simple financial advantage but also to liberate the uptake of measures which are not immediately cost-effective, resulting in a total 'package' which meets necessary reduction targets with acceptable cost to society as a whole.

UK CO_2 Emissions Beyond 2020

If the trend of reductions only at zero £ per TC is followed, emissions in 2050 will only be 35% below 1990 levels whilst if the reduction are made up to the level of £100 per TC the trend is on track to meet the 60% goal in 2050. This paper has only examined measures between 2000 and 2020, the extrapolation of the data beyond 2020 gives no information about the cost of the measures required to achieve the reductions beyond 2020. The cost of carbon after 2020 is highly speculative as international carbon trading, new technologies and the uncertainly in predictions all make the estimation of a carbon price in the long term most uncertain.

6. CONCLUSIONS

The cost effective limit to UK carbon dioxide reductions

Under the scenario developed in this paper, the cost-effective limit to reductions of anthropogenic Carbon Dioxide emissions in the UK, is 20 MTC in 2010 and 32 MTC in 2020. When the reductions from the scenario are combined with the changes from the BaU scenario, this results in a reduction from 1990 levels of 19% in 2010 and 21% in 2020. It is therefore concluded that under the scenario, the government’s target of a 20% reduction in CO_2 levels from the 1990 baseline, by 2010 can be achieved in a cost neutral manner. The scenario assumes that the maximum practicable limit of penetration is achieved for techniques that reduce CO_2 emissions. This would require the most proactive and progressive policies, together with a high level of awareness in all areas of society.

The emissions under the BaU scenario in 2020 are projected to be only 2% lower than in 1990 due to a reduction in nuclear generation, a general increase in energy demand and a particular continuing rise in emissions from transportation. The cost effective CO_2 reductions under the scenario case, together with the BaU changes is only 21% below 1990 levels. It is likely that if the pressures to reduce CO_2 emissions continue to grow, then reductions beyond the 20% target in 2010 will be required. The scenario shows that at a cost level of £100 per TC reduction, 56 MTC of reductions beyond BaU could be achieved. Total reductions would then be 34% below 1990 levels. A simple, undiscounted calculation shows that the net financial saving to reach 32MTC reduction in 2020 is £8 billion (EUR 13 billion). The cost of going beyond the ‘zero cost’ point to savings of 56MTC is £1.5 billion, and thus 56MTC could be achieved with net savings of £6.5 billion. 64MTC could be achieved at a cost of approximately £8 billion, at which point net costs and savings are in balance. This should be compared against the total UK spend on energy of £61 billion per year including £30 billion of duty and tax, or £9 and £25 billion spent on gas and electricity in 1999.

Table 5: Potential for UK CO_2 Reduction in 2010 and 2020 (Million Tonnes Carbon)

	1990	2010				2020			
£ / TC	Baseline	BaU 1)	Scenario Case	Total	Red. vs. Baseline	BaU 1)	Scenario Case	Total	Red. vs. Baseline
£0	168	11.7	19.8	31.5	19%	3.1	32.1	35.2	21%
£100	-	11.7	30.7	42.4	25%	3.1	53.4	56.5	34%
£200	-	11.7	33.6	45.3	27%	3.1	61.9	65.0	39%

1) BaU Business as Usual Changes as Predicted by DTI working Paper for EP68 (DTI, 2000a)

Any attempt to estimate either demand levels or technological responses more than a few years ahead is certain to prove inaccurate, as economic and social conditions are changing constantly. The value of this paper's scenarios are not intended to be the quantitative forecasts of the future, and the results are not intended as prescriptions for action. However, there is value in continually reviewing trends, and the path upon which a country is proceeding, together with (currently observable) opportunities to shift that path.

Business opportunities and the role of ESCOs

Given existing policies and identified trends, the role for ESCOs (and contract energy management in general) seems very variable across the sectors. There are clearly large business opportunities in the larger end of the commercial sector, and in some areas of industry. There are well established as well many new companies working in this field, and more innovative offerings are to be expected as the liberalised markets mature. The residential and small commercial sectors offer bigger a challenge, with large carbon reductions available in aggregate, but with individual projects often too small to be viable. This is the focus of much attention at present, looking, for example, for effective ways to aggregate customers together to achieve bulk efficiencies in project delivery.

The impact of policy on the ESCO business

The previous analysis is based on a snapshot view of the current situation and makes projections based on present beliefs about the cost-effectiveness and potentials for various technologies. Both of these are in practice dynamic, and affecting strongly by policy.

In the domestic sector, the Energy Saving Trust is promoting the use of energy efficiency services and the development of ESCOs through a government-financed programme. Furthermore, the Energy Efficiency Commitments (EEC) of the competitive electricity and gas suppliers in the UK (a development of the earlier Standards of Performance scheme operating for electricity only) could provide a stimulus for realisation of the savings targets through energy efficiency services and the development of ESCOs.

In the commercial sector and less energy-intensive sectors of industry, the new climate change levy (CCL) will certainly enhance the cost-effectiveness of any investments in energy efficiency. This provides an additional incentive for ESCO activity, as well as a new stimulus for end-users to look for energy performance contracts based on shared savings. Even beyond the financial motivation provided by the CCL (which adds approximately 10% to gas and electricity bills), the existence of and discussion about the new instrument may spark some additional activity.

In contrast to this, most energy-intensive industry sectors have avoided paying 80% of the CCL by making voluntary agreements with the Government to increase energy efficiency or reduce carbon emissions. Whilst this should realise some of the potential emission reductions envisaged under this paper's scenarios, there is widespread uncertainty over the depth of the savings that will be achieved. The details of the agreements remain confidential, and the basis upon which reductions are calculated is unclear. Further uncertainty will be introduced if a domestic carbon trading system comes into operation as expected within the next one to two years. The signals that this will send for increased energy efficiency and hence the chances for ESCOs are unclear, and will remain so until the fine details of the scheme are finalised.

A final uncertainty in the UK is due to ongoing institutional changes, as a new 'Carbon Trust' takes on responsibility for both short term promotion of, and long term RD&D for, energy efficiency in the large commercial and industrial sectors. The Trust is at present not fully staffed and its strategy is not likely to become clear until well into the Summer of 2001.

A Sustainable Future?

The IPCC scenario where atmospheric levels of CO_2 are stabilised at 550 parts per million by volume (ppmv) could imply that UK emissions would need to fall by 60% in 2050 and even 80% by 2100 from 1990 levels (RECP, 2000). Emissions reductions of 30% by 2020 from 1990 levels would place the UK on target to meet a 50% reduction by 2050. The study suggests that the 30% target could be achieved at a cost of £600 million per year. In reality, implementation costs are likely to be higher, given real transaction costs that have not been estimated in this study. However, technological progress will bring costs down and increase efficiencies for existing measures, and innovation will open up new reduction options. If actions were taken to achieve the CO_2 emission reductions identified under the scenario developed in this paper, the UK would be firmly on target towards a more sustainable future.

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