Carbon Pricing for Central Government Cost Benefit Analysis in Ireland

Comhar SDC[1]

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Executive Summary

Combatting climate change represents an increasingly difficult challenge for Ireland. It is necessary for Irish greenhouse gas emissions to be reduced significantly to meet our international commitments. As a result, it is key that carbon emissions are factored into all proposed central government project appraisals in the future.

Cost Benefit Analysis (CBA) is widely used as a decision-making tool in capital project appraisal. Factoring the cost of carbon into CBA is an issue with very wide scope. It is Comhar SDC's objective here to propose a **basis** for a price of carbon emissions to include in the CBA process used in Central Government capital project appraisal in Ireland.[2]

Three pricing options – the EU Emissions Trading Scheme (EU ETS) price, marginal abatement costs (MAC), and the social cost of carbon (SCC) - have been considered in this work as a basis for the inclusion of a carbon price in central government project appraisal in terms of their respective credibility and reliability, objectivity and transparency and simplicity. All three pricing options have the capacity to be simple, if a single price rather than a range of prices is used in the CBA process.

On the basis of the research carried out, it was found that the SCC is not credible or reliable, objective or transparent. In contrast, the EU ETS price and the MAC both pass these tests.

While the EU ETS price and the MAC are both considered to be administratively and politically feasible, it is expected that the long-term application of the EU ETS price to non-ETS sectors will result in inadequate emissions abatement, as a result of which the EU ETS price fails the environmental effectiveness test.

On this basis it is recommended that, purely as an interim measure the EU ETS futures pricing should be used as a carbon pricing basis for the period 2008 to 2012. Dec-2013 and Dec-2014 futures prices should be used for 2013 and 2014. All market-based pricing should be based on calendar year averages, to avoid structural break related price distortions. For the post-2014 period, a fixed price of €39t/CO_2 is recommended since the European Commission assumed an average carbon price of €39/tCO_2 in its Impact Assessment of the January 2008 Proposed Climate Change and Renewable Energy Measures from 2012 to 2020 (Curtin, 2008). As this price at least reflects medium term EU policy at present, it is considered to be the most appropriate estimate for medium to long term carbon pricing here, in the absence of a reasonable alternative.

As a matter of urgency, Marginal Abatement Cost Curves should be carried out for all sectors in Ireland. These sectoral MAC curves should be used to inform national climate change policy going forward. As simplicity is one of the key criteria in the carbon price setting process, the application of sectoral MAC-based prices in a public CBA context would be overly complex and could lead to serious errors or inaccuracies. Consequently, there is strong preference for the usage of a single aggregate MAC based carbon price in public CBA for capital project appraisal in the long term.

[2] This research was carried out in part-fulfilment of an MSc in Sustainable Development at Dublin Institute of Technology, Bolton Street, Dublin 1. A copy of the full dissertation will be available in early 2009.

Introduction

1.1. Context and Objective

The Programme for Government agreed and published in July 2007 set out ambitious environmental objectives and makes combating climate change one of the main priorities. The key objective in this context is stated as follows -

"…Government will set a target for this administration of a reduction of 3 per cent per year on average in our greenhouse gas emissions" (ibid:21).

In early 2008, Ireland was challenged with a tightening of long term emissions limits. Per the Department of the Environment, Heritage and Local Government's ('DoEHLG') National Climate Change Strategy (2007), under the Kyoto Protocol, based on 1990 emissions levels plus 13% for the years 2008-2012, Ireland's limit equates to approximately 63 Mt CO_2e per annum. In 2006, almost 70 Mt CO_2e were emitted in Ireland, equating to an increase of almost 26% since 1990 (McGettigan et al, 2008). Ireland's new 2020 EU limit, based on 2005 emissions levels less 20% (Curtin, 2008), translates into only 56 Mt CO_2e per annum.

According to the DoEHLG's National Climate Change Strategy (2007), much of the gap between our Kyoto target and our actual emissions will be dealt with by way of flexible mechanisms, at a budgeted cost of €270m. As a result of the increasing ethical, financial and practical significance of the climate change issue, it is key that carbon emissions are factored into all proposed central government project appraisals in the future.

Cost Benefit Analysis (CBA) is widely used as a decision-making tool in capital project appraisal and is considered to be "the most important technique for project appraisal in the public sector" (Mulreany, 1999:177). CBA is defined in this context as a

"…conceptual framework applied to any systematic, quantitative appraisal of a public or private project to determine whether, or to what extent, that project is worthwhile from a public or social perspective. Cost-benefit analysis differs from a straightforward financial appraisal in that it considers all gains (benefits) and losses (costs) regardless of to whom they accrue" (European Commission, 2002:125).

Unlike traditional discounted cash flow project appraisal employed in the commercial world, CBA in this context takes account of the social costs and benefits of a proposal i.e. the proposal is "evaluated with regard to the economy as a whole" (Hanley et al, 2001:74). CBA in the public sector takes a more social approach than private sector CBA, as it attempts to capture externalities from a societal perspective (Mulreany, 1999).

Factoring the cost of carbon into CBA is an issue with very wide scope and there are numerous aspects which could be considered here including CBA methodology, CBA's relationship with Impact Assessment and other appraisal techniques, choice of discount rate, appraisal period, global warming potential conversion factors, emissions quantification etc.

Comhar SDC's objective here is to propose a **basis** for a price of carbon emissions to include in the CBA process used in Central Government capital project appraisal in Ireland.[3] There is ongoing work in the Department of Finance examining this issue and it is hoped that Comhar SDC's work will contribute to this process.

1.2. Methodology

Desktop research was carried out to examine current practice and to review the academic literature on this issue. A number of interviews in Ireland and abroad were undertaken. The researcher attended a number of relevant conferences in recent months also.

In addition, Comhar SDC hosted a workshop in Dublin on 19th June 2008 (see Appendix A for a list of workshop attendees), with the following objectives -

- to identify research (currently underway/completed) and best practice internationally on this issue; and
- to tease out issues which require further consideration and/or research, against the backdrop of current practice in the UK and in other countries.

Comhar SDC would like to thank all who attended this workshop and made themselves available for interview for their very valuable contribution.

The remainder of this paper is structured in the following manner: Section 2 describes three carbon pricing options, Section 3 examines current practice abroad, Section 4 describes the Irish case, Section 5 presents criteria for selection of the carbon price, Section 6 evaluates the three pricing options, and finally Section 7 outlines our recommendations.

2. Carbon[4] Pricing Options

Carbon emissions represent a negative environmental externality and in many cases the value of carbon emissions is not easily monetised, since there is no market value currently for carbon emissions across all sectors of the economy. However, there are several methods discussed in the literature to estimate the value of carbon emissions that may be arising from a capital project.

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[3] This research was carried out in part-fulfilment of an MSc in Sustainable Development at Dublin Institute of Technology, Bolton Street, Dublin 1. A copy of the full dissertation will be available in early 2009.

[4] Please note that throughout this paper, unless otherwise stated, references to 'carbon' are shorthand for 'carbon dioxide, or an equivalent quantity of other greenhouse gases, with that equivalence defined in terms of global warming potential'.

The following three carbon pricing options were identified during the course of the research –

- EU Emissions Trading Scheme (ETS) Futures Price
- Marginal Abatement Cost of Carbon (MAC) or Avoidance Cost, and
- Social Cost of Carbon (SCC) or Damage Cost

Each of these is discussed in more detail in the next subsections.

A number of the publications referred to below do not unfortunately quote a reference year for aggregate data. It is regrettable that as a result, it has not been possible to normalise data throughout this paper in Euro and in today's terms. Where a reference year has been quoted by a publication's author/(s), this is stated below.

It is noted that Watkiss et al (2005) recommend the development of a price of carbon combining both the SCC and the MAC. This approach is regarded by some as "the most current and comprehensive exercise providing consistent values for CO_2 emissions for application in project appraisal" (Bickel et al, 2006:25). This pricing basis has unfortunately been given comparatively little attention in the literature since its recommendation in 2005 as a result of which it cannot be given full consideration here. Similarly, a full and detailed account of the "Precaution and Pragmatism Approach" referred to at a Friends of the Earth (FoE) hosted seminar in the UK in July 2008 is unavailable at present as a result of which further consideration of that pricing option here is also not possible (FoE, 2008).

The reader's attention is drawn to the fact that since the UK's carbon pricing regime is widely documented and readily available, much of the reference material referred to below relates to this jurisdiction. It is useful also to refer here to the evolution of the SCC and the Shadow Price of Carbon (SPC) in the UK as a way of further elaborating on the carbon pricing debate.

2.1. EU Emissions Trading Scheme (ETS) Futures Price

The EU ETS is considered to be "a product of two failures" (Convery et al, 2008:94), the European Commission's failure to introduce an EU-wide carbon energy tax in the 1990's and the Commission's failure in its opposition to the introduction of trading as a flexible instrument in the Kyoto Protocol in 1997 (ibid).

The EU ETS currently covers approximately 41% of total EU CO_2 emissions (Curtin, 2008) and is estimated to account for 45% of total EU CO_2 emissions and 30% of total EU greenhouse gas emissions by 2010 (World Bank, 2008).

The EU ETS involves installations from the following sectors –

- Electricity Production
- Other Combustion
- Refineries
- Iron and Steel

- Cement
- Glass
- Ceramics
- Pulp and Paper, and
- Aluminium (Convery et al, 2008).

The transport, housing, agriculture and waste sectors are excluded from the EU ETS (World Bank, 2008).

Convery and Redmond (2007) provide a thorough description of the EU ETS, including an outline of its institutional and legal framework, its general characteristics and its performance to date.

The EU ETS is administered in units of EU Allowances (EUA's) (ibid). A single EUA permits its holder to emit one tonne of CO_2 within a given year (Redmond, 2006).

Per Abadie and Chamorro (Publication Pending), a futures market in allowances developed in early 2004, in anticipation of the establishment of the EU ETS. According to Ellerman and Joskow, at present, "the main trading instruments in the EUA market are forward and futures contracts for delivery in December of the specified year" (Ellerman and Joskow, 2008:18), a convention conforming with the calendar year reconciliation procedures of the scheme (ibid) (details of which are outlined below).

Indeed, Capoor and Ambrosi (2008) estimate that, in 2007, options represented only a 2%-3% share of activity (both volumes and values) and spot trade was almost non-existent, comprising of only 2% of volumes transacted and less than 1% of values transacted. The balance of 2007 trading (in excess of 95% of both volumes and values) related to futures contracts (ibid).

By January 2005, a total of seven brokers were involved in the EU ETS market and these were joined by five exchanges by August 2006 (Abadie and Chamorro, Publication Pending).

In 2007, the total volume traded on the EU ETS, excluding bilateral company-to-company trades, was 1,443m EUA's (Point Carbon, 2008). Approximately 70% of the total volume was traded on the brokered over-the-counter (OTC) market and the balance was traded on the exchanges (ibid). The European Climate Exchange (ECX) is the dominant exchange, accounting for almost 87% of exchange-traded transactions in 2007 (Point Carbon, 2008).

Data is readily available on spot and futures prices from the exchanges and companies specialising in analysis of the power, gas and carbon emissions markets such as Point Carbon (see www.pointcarbon.com). EUA pricing quoted on the Point Carbon and ECX websites do not always tally 100%. As Point Carbon's coverage of the EU ETS is far wider than that of the ECX, it is more appropriate to use Point Carbon as a data reference point. In terms of the administration of the EU ETS, the key annual dates outlined in Table 1 below are of significance.

Table 1
Key EU ETS Administration Dates

Key Date	Administrative Significance
28th February	All EU ETS participants must be issued their allowance allocations for each calendar year by 28th February of that calendar year
31st March	All installations participating in the EU ETS must report their actual CO_2 emissions for the calendar year to their respective national authorities by 31st March of the following year
30th April	Installations must ensure that they have sufficient allowances in their national registry accounts to cover their verified CO_2 emissions for the previous calendar year
15th May	Emissions data and surrendered allowance information is published on 15th May annually
30th June	All surrendered allowances must be cancelled by 30th June every year

Source – Convery and Redmond, 2007

It is important to note that each of the above administration dates (referred to as "structural breaks" by Alberola et al (2008)) has the capacity to impact on the EU ETS EUA Market Price.

EU ETS Prices Phases I (2005-2007)

By way of example, the first phase of the ETS market (referred to as Phase I, from January 2005 to December 2007) can be split into the following key stages –

- The launch period (January 2005-April 2006)
- The information shock (April 2006-May 2006), and
- Total disconnection between the first and the second period prices (since November 2006), as illustrated in Figure 1 below.

Figure 1 - EU ETS OTC and Futures Price Volatility

1. High volatility: price shock in April-May 2006 (compliance data release).
2. First period allowance price converges towards zero: surplus of allowances and no banking between periods.
3. Higher prices for second period allowances due to expected scarcity with stricter NAPII decisions and European Council commitments.

Source – Convery et al, 2008:31

It is clear from Figure 1 above that both spot and futures EUA prices have been relatively volatile over the first Phase of the EU ETS and that the release of information at certain structural breaks has had a significant impact on the EUA market price. Therefore if a CBA carbon price is based in some way on the EU ETS, it must be based on calendar year averages, to ensure that any structural break price distortions are averaged out.

One of the key reasons for the near-zero price of carbon in the final stages of Phase I was the inability to bank (i.e. carry forward EUA surpluses from one year to the next) between Phase I and Phase II (2008-2012) (Carbon Markets Association, No Date). Others assert that, combined with an inability to bank, an over-allocation of EUA's via each Member State's National Allocation Plan created the almost zero EUA price in 2007 (Convery et al, 2008).

In addition to the administrative features of the EU ETS, energy prices and unanticipated weather events and weather trends also influence EUA prices to date (Alberola et al, 2008).

EU ETS Prices Phases II and III (2008-2020)

Significant modifications to design elements of the scheme have been made since its inception, in an effort to stabilise the market, to heighten its effectiveness and to minimise the potential for future EUA price distortions. As a result, there are strong indications that the 2008-2012 Phase of the EU ETS "will be robust and effective" and result in a smoother EUA market price (Carbon Markets Association, No Date:2).

Features of Phase II include "tighter emission targets, stronger flexibility provisions for compliance... more attention to internal EU harmonization and, most importantly, longer-term visibility for action to reduce emissions until 2020" (World Bank, 2008:2). Particularly, the European Commission has made efforts "to ensure that Phase II is short [of EUA's] (unlike Phase I)..." (ibid:8), by cutting National Allocation Plans by 10.4% below the EUA caps originally proposed by individual Member States (ibid).

It is asserted that "[T]the fundamental balance of... Phase II is now merged with that of Phase III (2013-2020)... because EUA's can [now] be banked without limits from one year to the next" (Point Carbon, 2008:29). As a result, the European Commission has effectively merged Phases II and III of the Scheme (ibid).

Proposed changes for Phase III include the likely replacement of the current allocations system with centralised allocation, permit auctioning and a widening of the scope of the scheme to include other greenhouse gases such as nitrous oxide and perfluorocarbons (Curtin, 2008).

While Dec-2013 and Dec-2014 EUA's have been offered on the ECX since 8th April 2008 (World Bank, 2008:66), there is still some spread of opinion regarding EUA pricing post Phase II.

According to the World Bank (2008), analysts predict that the EUA will rise to €30/tCO_2 - €35/tCO_2 by the end of Phase II and will trade at €40/tCO_2 by the beginning of Phase III. Others predict that the price will range from €35/tCO_2 - €41/tCO_2 when fully operational in Phase III (Convery, 2008).

Point Carbon's survey of future EUA price predictions, carried out between January 2007 and February 2008 and published in March 2008, yielded the results detailed in Table 2 below.

Table 2
Expectations for EUA prices 2010 and 2020 (€/tCO_2)

	2010	**2020**
2007 Survey (N=1893)	€18	€25
2008 Survey (N=3262)	€24	€35

Source – Point Carbon, 2008:31

In arriving at the cost of carbon to be applied in development agency CBA's, Tol and Lyons (2008) recommended that the post-2012 carbon price be interpolated between the futures prices in 2012 and the model-based IPCC price in 2030 (\$50/tCO_2) for a 550 ppm scenario (regarded as approximating to the long-term EU target) (ibid and in conversation with Sean Lyons, ESRI, 2008).

The European Commission assumed an average carbon price of €39/tCO_2 in its Impact Assessment of the January 2008 Proposed Climate Change and Renewable Energy Measures from 2012 to 2020 (Curtin, 2008). As this price at least reflects medium term EU policy at present, it is considered to be the most appropriate estimate for medium to long term carbon pricing here, in the absence of a reasonable alternative.

Aside from deciding on the most appropriate EU ETS based price for use as a carbon price in capital project CBA, there are other issues that should be considered. There is an asymmetry between Ireland's overall emissions reduction target and the EUA allocations to the trading sector under the EU ETS in Phases I and II (Convery, 2007). By way of example, Ireland's Phase II cap is less than 1% below that of Phase I (ibid). Meanwhile, it is estimated that Ireland's actual emissions for the period 2008-2012 will be 7-10% over the target under the Kyoto Protocol (EPA 2008).

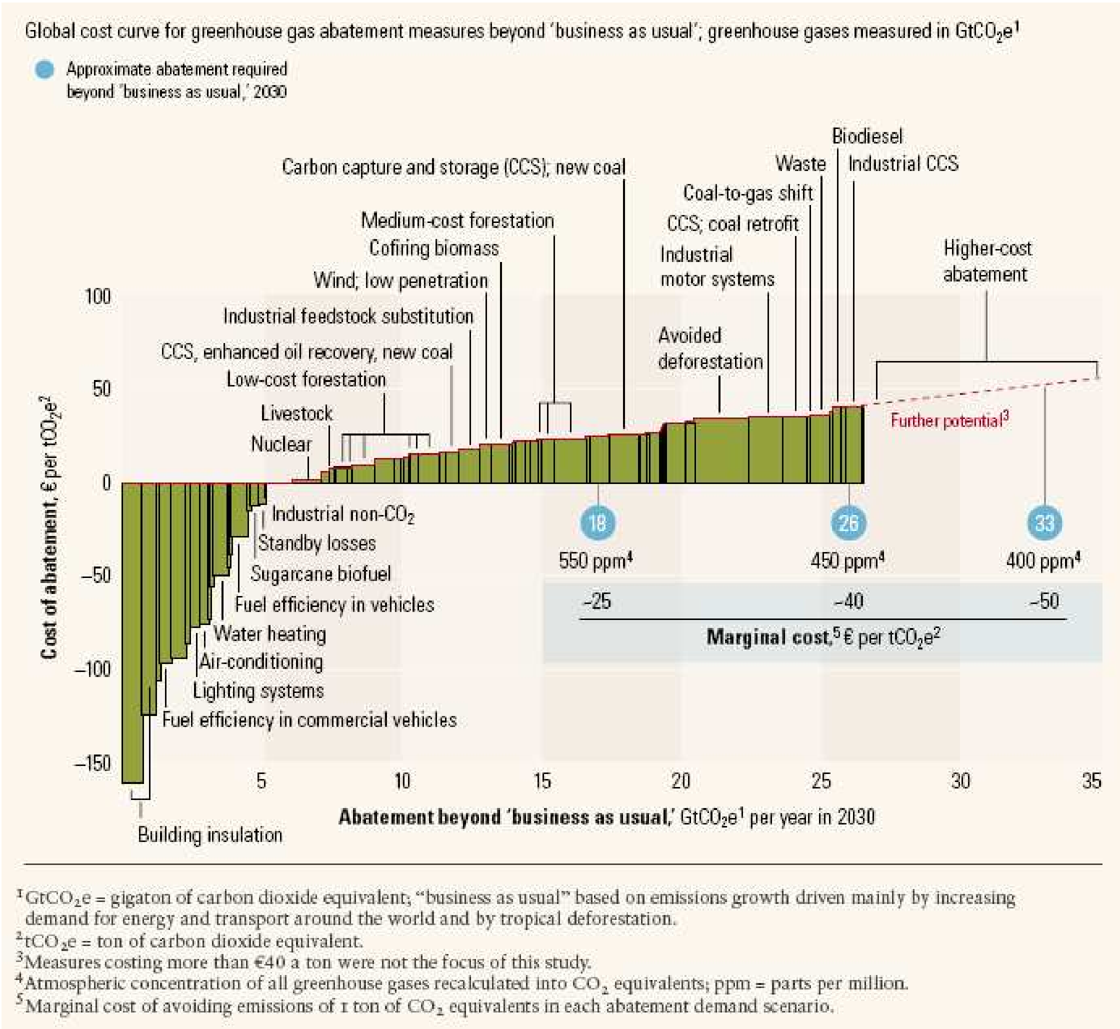
The EU ETS price is a function of the abatement costs in the sectors covered by the scheme. As stated above, the EU ETS covers mainly the power generating sectors and large industry plants. Due to the nature of the non-ETS sectors – agriculture, transport, residential and services – it is acknowledged that the abatement costs in these sectors will be higher than those in the ETS to achieve the same targets (Ryan et al, 2008). Meanwhile, it is proposed that Ireland reduce non-ETS sectoral emissions by 20% based on 2005 levels between now and 2020 (Curtin, 2008). Applying the ETS price to non-ETS sectors will result in less emissions abatement than needed. Using the same carbon price on the other hand across all sectors of the economy would be perceived as fair by business.

2.2. Marginal Abatement Cost of Carbon (MAC) or Avoidance Cost

The Marginal Abatement Cost of Carbon (MAC or Avoidance Cost) is "a measure of effort" (Downing et al, 2005:343) and equates to the cost per unit emissions reduction at a given emissions level (Department of Environment, Food and Rural Affairs (DEFRA), 2007). Stern defines the MAC as "the cost of reducing emissions by one unit" (Stern, 2007:241), or a "measure of effort" (ibid:341).

In a global study published by McKinsey in 2007, assuming scenarios of both 550ppm and 450ppm by 2030 and that mitigation measures are implemented in order of increasing cost on a global scale, it was estimated that the MAC per t/CO_2e would be no more than €25 and €40 respectively (Enkvist et al, 2007). The global MAC cost curve arising from this study is illustrated in Figure 2 below. It was assumed that a stabilisation trajectory of 450ppm by 2030 would be appropriate and that abatement in the region of 26 gigatons would suffice to achieve this (ibid). Further key assumptions were made regarding the cost of carbon capture and storage and other future costs as well as technology deployment rates (ibid).

Figure 2 – Global MAC Cost Curve



Source – Enkvist et al, 2007:38

In the IMPACT study, a study of external transport cost estimates commissioned by the European Commission, Maibach et al (2007) state that –

"...CO_2 reduction targets vary from country to country and that also the translation of national targets to targets per sector may be different between countries. Furthermore also CO_2 avoidance costs may differ from country to country. As such external costs defined on the basis of avoidance costs could be made country specific. The values presented… should be seen as a guideline at the European level for external costs associated with climate change" (Maibach et al, 2007:267).

The point that MAC curves differ between countries and emissions stabilisation targets is reinforced when comparing the work carried out to date by McKinsey regarding the UK and Germany. McKinsey's UK MAC curves (2007b) draw from a number of government and public sources and estimate the MAC's of 120 different carbon abatement measures for 2020 and 2030. McKinsey (2007b) predicted that, to achieve an emissions reduction in the UK of 26% based on 1990's levels by 2020, using 2002 as the reference year, the MAC will be as high as €90/tCO_2e.

Achieving a reduction of 38% based on 1990's levels by 2030, an MAC drop to €40/tCO_2e is predicted, as newer technologies become commercially viable and a greater number of carbon abatement options come on stream (ibid). It is estimated that a total of 60% of all initiatives will involve energy efficiencies while 49% of the 120 abatement measures considered will result in a net financial benefit (ibid).

While a drop in MAC between 2020 and 2030 is predicted in a UK context, the opposite is the case for MAC predictions in Germany (McKinsey, 2007a). Conducted on behalf of "BDI initiativ – Business for Climate", with contributions from over 40 companies and associations as well as participation by 30 companies and independent experts, this study assessed the abatement potential of over 300 abatement measures (referred to as 'technical levers') in Germany up to 2030 (ibid).

It is estimated that a total of 127MtCO_2e per annum could be abated by 2020 by activating abatement measures with costs which would "pay back within the amortization period of the respective decision maker" (ibid:5), with a further 14MtCO_2e to be abated in 2020 with abatement costs of up to €20/tCO_2e (ibid). This would result in reductions of 26% based on 1990's emissions levels (ibid). Substantially greater abatement levels per annum are possible by 2030, but at far greater cost (ibid).

Germany's MAC curves are broken down into sectors, in an effort to inform those involved in the "BDI initiativ – Business for Climate" of where the key future business opportunities lie (ibid). Carrying out a similar exercise in an Irish context is critical to inform future climate change policy.

It is not possible, on the basis of readily available information to formally and accurately compare and contrast the UK and German MAC's to establish why the differences in MAC trend predictions arise. It is also outside of the scope of this work.

In a 2008 meta-analysis by the Economic and Social Research Institute (ESRI), examining MAC estimates' sensitivity to underlying modelling specifications and assumptions, it is concluded that MAC estimates are sensitive to factors such as stabilisation target level, emissions baseline and future technological assumptions, and, to some degree, the scientific "forum" from which the study originated (Kuik et al, 2008).

The ESRI's meta-analysis is based on 26 different models presented in three different modelling fora in 2006, presenting a total of 62 MAC observations for the years 2025 and 2050, each of which was then normalised into 2005 Euro per tonne of CO_2 (€2005/tCO_2) (ibid). Due to incomplete information, of the 62 MAC observations in the database, only 47 (49) observations were included in full in the meta-analysis for 2025 (2050) (ibid).

It is noted that the majority of the studies included in the meta-analysis referred to stabilisation targets between 440-570ppm CO_2 (ibid), and that one study using a stabilisation target of 350-400ppm CO_2 was added "to increase the range" (ibid:6).

A summary of the meta-analysis' key statistical findings is tabulated in Table 3 below.

Table 3
Summary Statistics of MAC of 26 models (€2005/tCO_2)

	2025		2050	
	Full database	Restricted database	Full database	Restricted database
Mean	23.8	23.8	63.0	55.8
Median	16.2	16.2	34.6	32.2
Maximum	119.9	119.9	449.3	209.4
Minimum	0.0	0.4	1.4	1.4
St.dev.	26.7	27.9	72.5	52.9
N	62	47	62	49

Source – Kuik et al, 2008:5

It is significant that when the MAC values of the ESRI's recent meta-analysis are compared with MAC's related to live policy proposals both in the UK and at EU level, the meta-analysis' central estimates are found to be of the same order of magnitude (Kuik et al, 2008).

2.3. Social Cost of Carbon (SCC) or Damage Cost

Stern defines the Social Cost of Carbon (SCC or Damage Cost) as a measure of "the total damage from now into the indefinite future of emitting an extra unit of GHG's now" (Stern, 2007:28). The SCC can be used to represent the price to be paid globally for each tonne of carbon emitted, if no mitigatory action is taken (ibid). The SCC is also defined as "the net present value of climate change impacts over the next 100 years (or longer) of one additional tonne of carbon emitted to the atmosphere today" (Watkiss et al, 2005:ii). It generally refers to "the marginal cost of climate change impacts" (Downing et al, 2005:8).

In a 2005 assessment of 28 published studies in which a total of 103 SCC estimates were calculated, Tol concluded that there is "enormous uncertainty" (Tol, 2005:2071).

A total of eight of the 103 estimates (almost 8%) included in this analysis are based on what Tol regards as unrealistic climate scenarios (ibid). Applying various weightings, Tol calculates standard deviations ranging from \$87/tCO_2 to \$23/tCO_2 and a mean of \$25/tCO_2 and \$14/tCO_2 for all estimates and peer reviewed estimates respectively (ibid).

Tol (2008) is an update of Tol's 2005 meta-analysis of the SCC, updated to take account of the recent doubling of published SCC estimates, the Stern Review's publication in 2007, the IPCC's Fourth Assessment Report in 2007 and Weitzman's assertions regarding the fatness of the probability distribution tails in climate change economics in 2007. The 211 estimates of the SCC considered in this meta-analysis have been gathered from a total of 47 studies (ibid). Tol lists a number of omissions in the total cost estimate calculations and remarks that there has been little progress in recent years in dealing with these omissions as a result of resource issues, with no-one working on a full-time basis in this field (ibid).

The majority of the SCC estimates analysed in this paper are along a Business-As-Usual greenhouse gas emissions trajectory (ibid). 18 of the 211 estimates included in the analysis are based on what is again referred to as unrealistic climate change scenarios (ibid), almost exactly equal to the proportion of estimates regarded as such in Tol's 2005 analysis. Tol specifically excludes two of Stern's SCC estimates, "because they are along a path of arbitrary emission reduction" (ibid:2). Through his analysis, Tol concludes that "the uncertainty in the sample is right-skewed and fat tailed" (ibid:4). Furthermore, it is stated that the SCC uncertainty is so large that the fatness of the tails of the distribution may dominate the debate (ibid).

Tol reasserts many of the conclusions of his 2005 study, stating that SCC estimates are driven by discount rate and equity weighting choices and that "the more pessimistic estimates have not been subject to peer review" (ibid:9).

Applying a number of weightings, estimation methods and methodological approaches, Tol calculates standard deviations ranging from \$96/tCO_2 to \$66/tCO_2 for all estimates and standard deviations ranging from \$51/tCO_2 to \$27/tCO_2 for peer-reviewed estimates (ibid:3). Tol also calculates a mean of \$28/tCO_2 and \$15/tCO_2 for all estimates and peer reviewed estimates respectively (ibid), both higher than the \$25/tCO_2 and \$14/tCO_2 results presented in his 2005 work.

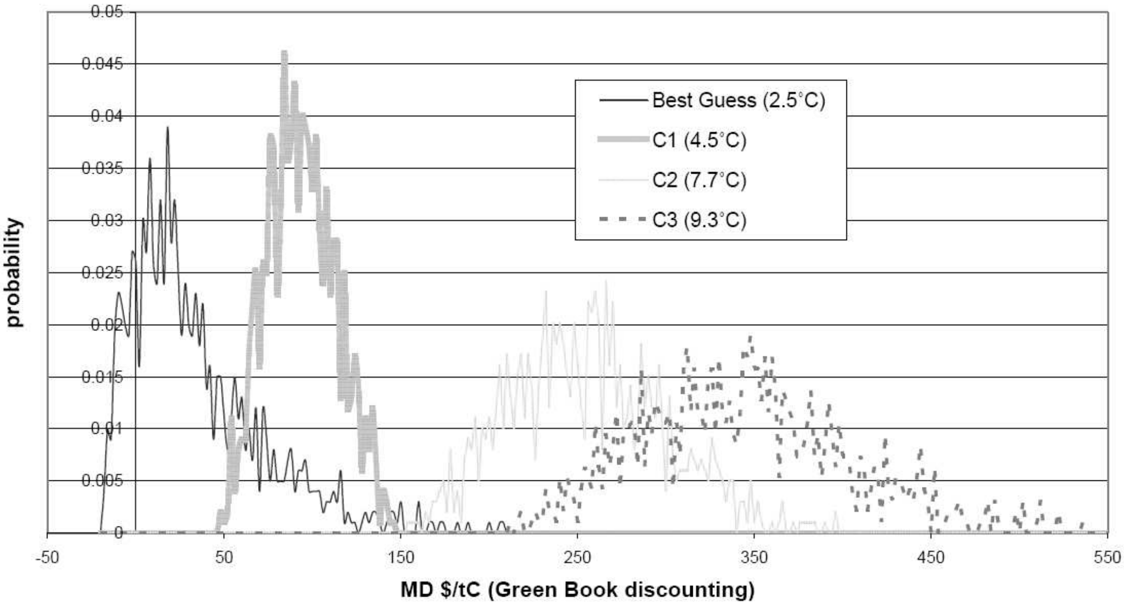
Tol concludes that, contrary to the assertions of the IPCC's 2007 Fourth Assessment Report, there has been a downward trend in SCC estimates (ibid). Yet, Tol's 2008 mean SCC's are higher than those of his 2005 report, primarily "due to the different treatment of uncertainty" (ibid:5). Because of the summary nature of both reports and a lack of detail regarding how uncertainty is dealt with in each, it is difficult to compare their results with any level of accuracy.

Maibach et al (2007) assert that a trend towards higher damage cost values has been observed in the carrying out of the IMPACT study, contrary to Tol's assertions but in line with the numerics of Tol's analysis above. It is unfortunate that detailed numerical analysis of this point is lacking in the published IMPACT report (ibid), to facilitate any meaningful comparison with Tol's work. A total of 16 studies are listed in Annex F (ibid:240-241), compared with Tol's 28 in 2005 and 47 in 2008. Maibach et al (2007) express reservation regarding the validity of Tol's statistical approach to his 2005 study, in part since Tol makes no comment on the likelihood of the SCC increasing over time or otherwise.

Downing et al (2005) assert that a lower SCC benchmark of £35/tC or £10/tCO_2 (2000 reference year) is reasonable "for a global decision context" (Downing et al, 2005:iii), that the actual SCC is likely to exceed this estimate and that the setting of an upper SCC benchmark is far more difficult, as a result of which no upper benchmark is presented (ibid). Due to the extent of underlying uncertainties, no SCC best estimate is presented in this report (ibid).

Downing et al (2005) also highlight the issues of climate sensitivity and climate uncertainty in SCC estimation. Assessments have been carried out by the IPCC and others regarding climate change itself and models have been developed to test the SCC for various temperature change scenarios, as illustrated in Figure 3 below (2000 reference year) (ibid).

Figure 3
Distribution of the SCC with four climate sensitivities



Source – Downing et al, 2005:30

It is noted that while the current global warming 'best guess' is 2.5°C, the SCC at 4.5°C is 5 to 6 times higher than at the best guess level (ibid). In this study, it was concluded that in 2005, no SCC model was known to explicitly capture the interrelationship between policy, impacts and emissions (ibid).

In recent years, the SCC was adopted as a CBA input in the UK and more recently, in 2007, the Shadow Price of Carbon (SPC) was introduced, to fully replace the SCC (DEFRA, 2007). The SPC is based on the SCC but takes policy development and technological advancement into account (ibid). This is described in more detail in the next section.

3. Current Practice Abroad

Tol and Lyons accurately summarise the current position regarding the definition and measurement of "best practice" in this context saying –
"Analysing investment options using environmentally-adjusted cost-benefit analysis is undertaken in many ways by financing institutions worldwide, but as yet there is no clear 'best-practice'" (Tol and Lyons, 2008:22).

Current carbon pricing practice abroad is extremely varied. In a 2005 transport costing and project assessment study of the EU-25 member states and Switzerland, only nine of the 26 countries surveyed were reported to include the cost of carbon in a monetised form in CBA's, per Table 4 below (Odgaard et al, 2005).

Table 4 – Climate Change Coverage

Approach	No. of countries	Countries
Included in CBA	9	*North/West:* Austria, Denmark, Finland, Germany, Netherlands, Sweden, Switzerland *East:* Czech Republic *South:* Italy
Not included in CBA, but covered by MCA, QM and/or QA	8	*North/West:* Belgium, Ireland, UK *East:* Czech Republic, Slovak Republic *South:* Greece, Portugal, Spain
Not covered/No information	9	*North/West:* France *East:* Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia *South:* Cyprus, Malta

Source – Odgaard et al, 2005:61

While the situation might have changed since 2005, at that time eight countries were reported to include reference to climate change in other forms of evaluation, including Multi-Criteria Analysis, Quantitative Measurement and Qualitative Assessment (ibid). Of the nine countries reported as including carbon in a monetised form in CBA, three were using the SCC, four were using the MAC and two countries were reported to be using some other form of carbon pricing (ibid). The monetisation methods employed by each country are summarised in Table 5 below.

Table 5 - Monetisation Methods Employed in CBA

Monetisation method used	No. of countries	Countries
Damage cost approach	3	*North/West:* Finland, Netherlands *South:* Italy
Avoidance costs (costs of avoiding emission)	4	*North/West:* Austria, Germany, Sweden, Switzerland
Avoidance costs (costs of avoiding damage)	0	
Other	2	*North/West:* Austria, Denmark

Source – Odgaard et al, 2005:62

While the 2005 study does not elaborate on the other forms of carbon pricing used by Austria and Denmark, it is expected that neither country used the EU ETS price at that time, since Phase I of EU ETS only began in 2005 This situation may be different now.

Though Odgaard et al reported that in 2005, the UK did not include the impacts of climate change in a monetised form in CBA, it is understood that "[I]in 2002, the UK Government Economic Service (GES) recommended an illustrative estimate for the SCC of £70/tonne of carbon (tC), within a range of £35 to £140/tC, for use in policy appraisal across Government" (Watkiss et al, 2005:ii). It is unclear if this carbon pricing recommendation was fully translated into firm government policy post-2002 since it is referred to simply as a working paper in the Green Book, the UK's Evaluation and Appraisal Guidelines, and the language used was quite casual in terms of how the recommended carbon pricing was to be applied (HM Treasury, 2005).

Paul Watkiss referred the UK's 2002 carbon pricing recommendations in his presentation at Comhar SDC's workshop in June 2008, stating that while the pricing recommended in 2002 was based on a range of specific SCC prices, these recommendations were inconsistently applied across a number of government departments, with many departments doing very different things.

Since Odgaard et al's 2005 report, as mentioned above, the SCC was adopted as a CBA input in the UK and more recently, in 2007, the Shadow Price of Carbon (SPC) was introduced by DEFRA in the UK, to fully replace the SCC (DEFRA, 2007).

While the SCC is purely a measure of the damage caused by carbon and the manner in which this is valued, the SPC is regarded by DEFRA as a more versatile concept which can be adjusted over time to take account of policy development and technological advancement (DEFRA, 2007). Based on a GHG stabilisation trajectory of 550ppm CO_2e, the Stern Review estimates an SCC of £19/tCO_2e in 2000 (ibid). Using this carbon price as a base figure, applying a 2% increase per annum for inflation and a further 2% per annum to take account of incremental damage costs (DEFRA, No Date), DEFRA recommend an SPC of £25/tCO_2e for 2007 (DEFRA, 2007).
In a classical economics context, shadow prices are "estimates of marginal social costs/benefits when market prices are distorted in some way, either through externalities... or due to government intervention in the market" (Hanley et al, 2001:74). However, DEFRA's SPC is "not a shadow price in the classic sense of this term. Instead, the SPC is determined entirely by the SCC, the social cost of carbon, at an assumed stabilization trajectory. Marginal abatement costs are then, in very general terms, compared to the SPC to assess its accuracy. The SPC is determined by an assumed emissions level, while a true shadow price is determined by the intersection of marginal damages and marginal abatement costs" (Stanton and Ackerman, 2008:5).

With regard to the choice of stabilisation trajectory for price setting purposes, Stern (2007) asserts that, on the basis of current evidence, aiming for a carbon stabilisation between 450-550 ppm CO_2e is preferable, taking both risk factors and adjustment cost considerations into account.

Stern (2007) asserts that the difference between the SCC on the Business-As-Usual trajectory and on the various stabilisation trajectories illustrates the point that a tonne of carbon emitted is more harmful and more costly, the higher concentration levels are allowed to go. In his calculation of the SCC, Stern seems to disregard the link between carbon price setting and carbon abatement action (ibid), almost suggesting that policy will be delivered independent of the carbon price setting decision.

In Dietz's review of DEFRA's 2007 SPC proposals, it was noted that, according to the Stern Review, the SCC is strongly path-dependent, with the SCC on a Business-As-Usual trajectory substantially higher than the SCC on an emissions reduction trajectory, as illustrated in Table 6 below (Dietz, 2007).

Table 6
Stern Review estimates of the SCC on different emissions paths, using PAGE 2002 Modelling

Scenario	SCC (year 2000 $/tC)
Business-as-usual (baseline climate)	309.50
650ppm CO_2e stabilisation	143.65
550ppm CO_2e stabilisation	115.70
450ppm CO_2e stabilisation	89.20

Source - Dietz, 2007:6

Stanton and Ackerman (2008) regard the decision to set the carbon price at an assumed stabilisation level, rather than the actual current emissions trajectory as the most significant determining factor in DEFRA's carbon price setting (ibid). It is clear from this review that there is strong justification for the revision of the SCC/SPC price, that it be based instead on a Business-As-Usual emissions trajectory (ibid).

Maibach states that a general trend is recognised "…towards the use of marginal abatement cost estimates as external costs of carbon emissions in project and policy appraisal, rather than a marginal damage cost estimate represented by the SCC. The UK government appears unique in its widespread adoption and implementation of a SCC estimate in policy assessment" (Maibach et al, 2007:249).

DEFRA invited comment in 2007 from a number of widely-respected peer economists on their updated guidance on the SPC (including Dietz, 2007, Ekins, 2007 and Watkiss, 2007).

Interestingly, in response to the collective peer reviewers' comments on their SPC proposals, DEFRA stated that they would consider revising guidance, moving towards an MAC-based approach, in 2008 (Price et al, 2008).

DEFRA commented that -
"…initial investigation into the McKinsey global MAC curve would suggest that the new SPC is roughly in line with the price required to reach (globally) a 450ppm stabilisation scenario. However, this relies upon comprehensive international action and perfect exploitation of abatement potential globally… it should also be noted that the McKinsey UK MAC curve suggests a higher price would be required to reach UK 2020 targets" (Price, Thornton and Nelson, 2008:5).

It is understood that work on this issue is currently ongoing within DEFRA, that MAC curves are being developed on a sectoral basis with a view to factoring the results of this analysis into the UK's Carbon Budget for 2009 and thereafter (Source Withheld).

4. Current Practice in Ireland

It is understood that currently, with regard to public capital project appraisal in Ireland, the Department of Finance (DoF) requires that particular project appraisal techniques be applied depending on the level of capital expenditure involved (DoF, 2005 and 2006). The various scales of appraisal are illustrated in Table 7 below.

Table 7 - Capital Investment Levels & Appraisal Techniques

Capital Investment	Scale of Appraisal
< €0.5m	Simple Assessment
€0.5m - €5m	Single Appraisal (with elements of preliminary and detailed appraisal)
€5m - €30m	Multi-Criteria Analysis
> €30m	Full CBA
Innovative Projects > €5m, involving complex issues/untried technology/considered a pilot project	Full CBA

Source – DoF, 2005 and 2006

Government departments currently refer to the Proposed Working Rules for CBA, issued by the CSF Evaluation Unit in 1999. In the context of externalities, this document states that –

- Shadow prices should be used in situations where market prices, as a result of market failure, do not reasonably reflect opportunity cost

- Only externalities representing a significant project outcome should be included in the CBA; and

- Significant externalities, the impact of which cannot be monetised, should be excluded from the numeric CBA but included in the Cost Benefit Report in a manner to ensure their consideration in the evaluation process.

While Forfás (using a derivative of the predicted EU ETS Futures Price as advised by Tol and Lyons, 2008) and the Department of Transport (attributing a cost of €61 per t/CO_2 according to the Guidelines on a Common Appraisal Framework for Transport Projects and Programmes published in May 2007) have both taken steps to include carbon in their CBA, it is understood that no consistent monetary provision is made for carbon when carrying out CBA's within Central Government in Ireland at present.

Some analysis work on the costs of greenhouse gas emissions abatement in Ireland has been carried out in recent years, the most recent of which had a specific focus on the energy sector and how demand side management can play a large part in dealing with Ireland's likely electricity generation shortfalls in the coming years (KEMA, 2007). Marginal abatement costs were used by KEMA to estimate the potential total energy savings using demand-side management measures (ibid).

In addition, ICF Consulting and Byrne Ó Cléirigh (2004 and 2006) and Indecon International Economic Consultants (2004 and 2006) have carried out MAC analyses for Ireland's EU ETS sectors, at the request of the Environmental Protection Agency. Such analyses must be updated and carried out across all sectors in Ireland as a matter of urgency to identify where the least-cost abatement options lie, primarily to inform policy and secondly, to facilitate carbon price setting for CBA.

5. Criteria for Consideration in the Carbon Pricing Choice

Ozdemiroglu and Bullock (2002) classify criticisms of general CBA and monetisation of environmental impacts into two categories, issues of philosophy and content and secondly, issues related to process.

In terms of philosophy and content, the precision of and level of confidence in a CBA's net benefits and the credibility of a CBA's underlying assumptions are regarded as critical issues (ibid). In the context of morality, it is suggested that some project objectives are absolute, as a result of which budgetary constraints and the application of CBA should be disregarded in the decision-making process (ibid). Additionally, it is argued that a CBA's focus on economic efficiency is not reflective of the multi-objective nature of Central Government (ibid).

Regarding process, Ozdemiroglu and Bullock (2002) assert that CBA is often seen as compromising decision-making flexibility and discretion and is sometimes criticised for its non-participatory nature (ibid).

Taking the above and many other negative issues into account, a substantial majority of the literature dealing with the appropriateness of CBA in the context of environmental issues is in its favour. In spite of its numerous disadvantages, CBA remains "the most developed and soundly based means of evaluating the efficiency of public sector programmes" (Mulreany, 1999:203).

In the context of public sector decision-making, Boyle asserts that the results of an evaluation are more likely to be given credence if they are considered to be "high quality, rigorously sound and analytically thorough" (Boyle, 1999:46). To pass these tests, the evaluation process should be valid, reliable, consistent, accurate and objective (ibid). As a corollary, it is reasonable to suggest that the underlying inputs of such an evaluation (e.g. the price of carbon) should have these characteristics.

While Stern appreciates that carbon pricing is only one element of climate change strategy, he emphasises that "credibility, flexibility and predictability are vital to effective policy design" (Stern, 2007:368).

Tol and Lyons (2008), in their recent paper on carbon emissions costing for development agency project appraisal, emphasise the importance of credibility, robustness and transparency as key attributes in the pricing decision.

A workshop with policymakers and stakeholders was held in Comhar SDC in June 2008 to consult with experts on the subject of including carbon pricing in cost benefit analysis (see Appendix A for a list of participants). The following key points were raised by the participants -

- In terms of carbon pricing, the relevance of criteria such as ease of replicability, practicability, robustness and credibility was stressed. The importance of pricing simplicity and the minimisation of complexity were also highlighted, as well as ease of application and strength of recommendation.
- The strategic benefits of developing Sectoral Marginal Abatement Cost Curves for Ireland were stressed.
- Some expressed strong preference for the application of the EU ETS Futures Price as the carbon price in CBA. It is understood that extensive modelling has been carried out well into the future in this field, with comparatively high levels of certainty and narrow price ranges. Much of this analysis is readily available and is found to reflect "a version of reality".
- While a price based on some form of the EU ETS would be relatively easy to implement, it could lead to problems with "lock-in" and a periodic review of the price could be challenging. Theoretically, but not practically, the SCC is acceptable. It was recommended that MAC curves be considered in greater detail.
- Concern was expressed that setting a carbon price equal to the EU ETS Futures Price would result in too low a price to reach the emissions reduction targets which Ireland is faced with at present.
- In terms of the abatement measures referred to as "free lunches" (i.e. those which could be carried out at less than or equal to zero cost), an assessment of the policy failure which is preventing their implementation should also be carried out.
- Political feasibility is a major issue and in the current political climate the carbon price set is likely to be too low to achieve the required targets.

Significant reservation has been noted among government officials across the EU regarding the monetisation of impacts generally in the EU-wide Evaluating Impact Assessment (EVIA) Study (Jacob et al, 2008). The EVIA report concluded that "…limited quantification is not just due to a lack of expertise and resources, but [is] also linked to reservations of government officials about quantification and monetisation" (ibid:8). It is noted that, in the main, officers are hesitant to use elaborate methods and tools to capture externalities (ibid).

Ryan and Turton (2007) list the following as common criteria for economic instrument evaluation in an environmental context (listed below in order of importance in the context of this issue) –

- Administrative and Political Feasibility – is the proposal likely to gain adequate support from the relevant organisations and people within them?

- Environmental Effectiveness – are the environmental objectives attained?
- Static Economic Efficiency – is the environmental objective achieved at minimum cost?
- Distributional Effectiveness – is the proposal "fair" in its protection of the well-being of those most vulnerable and are the interests of those who are in a position of greatest influence protected to ensure that they are at least unlikely to block it?
- Dynamic Efficiency – is a continuing incentive created for improvement over time and place?

While the above criteria are of relevance here, it is evident from the primary research gathered and literature reviewed that, in this context, their relevance is considered to be somewhat ancillary to the following paramount considerations –

- Credibility/Reliability – a function of the precision of and level of confidence in the carbon pricing choice i.e. how certain or uncertain is the carbon price and what is the origin of and nature of that price's uncertainty?
- Objectivity/Transparency – how strong is the carbon pricing recommendation, how robust is the basis for its calculation and how independent is that calculation process?
- Simplicity – how easily can the carbon price be applied in practice?

Each of these considerations is elaborated upon further in the context of the three carbon pricing options listed below.

During a number of interviews (see Appendix A for interviewee details), the concept of applying a serial evaluation process was introduced and developed. It was suggested that where one or a set of criteria is regarded as determinative or extremely important and a price doesn't initially meet that criteria or set of criteria, it should be disregarded immediately. A matrix has been developed (see Section 6.4 below) to that effect, applying this approach.

6. Carbon Pricing Options Assessment

6.1. EU ETS Futures Price

Tol and Lyons (2008), in their recent paper on carbon costing for development agency project appraisal, recommend the use of the EU ETS Futures price up to 2012. The use of market based information is in this instance regarded as the "more attractive option" (ibid:8). The futures market price is favoured for its ability to capture future expectations, its simplicity and its transparency (ibid).

Attendees of the FoE-hosted July 2008 seminar in the UK concluded that one of the main advantages of using an EU ETS derived price is that it is real, credible and unlikely to attract opposition from those in financial or business spheres (FoE, 2008). Additionally, such a price is a function of pre-set targets (ibid). It is crucial to recognise however that EU ETS derived price, if based on an EU ETS cap which is regarded as too high, will be very low (ibid). Also, compatibility between long term policy targets and pre-agreed EU ETS caps is lacking (ibid).

The fact that the EU ETS excludes a number of sectors is also a key issue (ibid). As a result, the EU ETS mainly reflects the costs of abatement in the power generation sector and in large industries covered by the scheme and it does not reflect costs of abatement across the wider economy.

In summary, the key advantages of the EU ETS price as the carbon price in project appraisal are -

- It is simple and transparent and currently has the capacity to capture market expectations up to 2014.
- It is real and credible and is unlikely to attract opposition from those in political or business spheres.
- It is economically efficient to apply the same carbon price across all sectors in the economy.
- It is a function of pre-set targets.

The key disadvantages of using the EU ETS price are –

- The EU ETS price captures a sub-set only of carbon emitting sectors and greenhouse gases.
- In the next phase of the scheme it will be based on an EU ETS cap which does not sufficiently reflect the Irish greenhouse gas emissions targets.
- The main challenge for Ireland will be meeting the 2020 greenhouse gas emissions targets in the non-ETS sectors. The ETS prices, if applied to carbon pricing of the non-ETS sectors, will not be high enough to reduce emissions in those sectors.

6.2. Marginal Abatement Cost of Carbon (MAC) or Avoidance Cost

The MAC is based on cost-effectiveness analysis, by identifying the least-cost options for achieving emissions reduction and attributing costs to each mitigation measure (Maibach et al, 2007) and assuming that mitigation measures are implemented in order of increasing cost (Enkvist et al, 2007).

Avoidance cost inaccuracies can arise as a result of aggregation/disaggregation (e.g. carrying out an analysis on a sectoral or non-sectoral basis, at national or regional level), choice of time horizon and assumptions regarding target emissions levels, technical and non-technical abatement potential and associated costs (Maibach et al, 2007).

During the course of this research, it was asserted by a number of interviewees and workshop participants that much of the MAC modelling to date is “strong on engineering but weak on behaviour” i.e. MAC modelling assumes the rational consumer. If it is assumed that certain kinds of engineering changes can be made at less than or equal to zero cost and if something is cheap, you can make people do it for free, then the MAC curves are conceptually correct.

This point is further developed by the Office of Climate Change (OOC) in the UK, in the context of the energy sector, in their recent Analytical Audit (OOC, 2007). It is stated that there are numerous market failures or barriers as a result of which cost effective emissions savings opportunities have not been taken up (e.g. transactions costs, liquidity constraints and habitual behavioural issues) (ibid). Conventional MAC curves do not take these market failures or barriers into account at present.

In any case, the MAC or Avoidance Cost approach is regarded as more transparent than the SCC or Damage Cost approach since it refers to climate change policy (Maibach et al, 2007). This is considered to be its main advantage (FoE, 2008). As a result, the MAC is often regarded as more feasible than the SCC (Maibach et al, 2007).

There is a smaller spread of results from MAC studies when compared with those of SCC studies and it is asserted that the use of the MAC is most appropriate when long term emissions reduction targets have been set (ibid).

However, MAC estimation still involves a number of challenges including –

- Uncertainty regarding future innovation and inaccurate policy assumptions, and
- Uncertainty regarding disaggregation decisions, e.g. should MAC estimates be carried out at a global/regional/national/sectoral level (FoE, 2008).

Watkiss et al (2005) concluded, from a review of a wide range of long-term MAC estimates that they can differ by over an order of magnitude, while some studies differ in MAC sign (ibid).

In summary, the main strengths of the MAC are –

- It is based on real abatement cost analysis.
- It is regarded as more feasible and transparent than the SCC or Damage Cost approach since it refers to climate change policy.
- There is a smaller spread of results from MAC studies when compared with those of SCC studies i.e. there is greater confidence in the certainty and accuracy of currently available MAC estimates. Indeed, the extent of MAC estimation uncertainty is in the region of two orders of magnitude less than that of the SCC.

The main weaknesses of the MAC include -

- Inaccuracies can arise as a result of aggregation/disaggregation, choice of time horizon and other assumptions.
- As a concept, the MAC is “strong on engineering but weak on behaviour”.
- Conventional MAC curves fail to take market failures or barriers into account.

6.3. Social Cost of Carbon (SCC) or Damage Cost

Tol notes that a number of SCC studies fail to take account of key inputs such as –

- Extreme weather events
- The possible collapse of the West-Antarctic ice sheet
- The costs of transition and learning

- Low probability/high consequence scenarios, and
- The true compound cost of multiple stresses (Tol, 2005).

Furthermore, Tol highlights the knowledge gap that exists regarding developing countries' climate change vulnerability, while acknowledging that information regarding climate change market impacts in developed countries is at least improving (ibid). Additionally, the challenge associated with capturing adaptation in an impact assessment is recognised (ibid). Tol notes that those studies with better methods and those that are peer-reviewed report smaller uncertainties and lower SCC estimates (ibid).

The IMPACT study summarises the challenges involved in monetising the damage cost of climate change (Maibach et al, 2007). Problems arise due to lack of information regarding the physical impacts of climate change as well as theoretical valuation issues associated with equity, uncertainty and irreversibility (ibid). Further uncertainty stems from future global economic and technological development forecasts and decisions regarding the evaluation time horizon (ibid). Damage cost study results continue to display a large spread, indicating that there are is still a high level of uncertainty associated with the application of this approach (ibid).

At the recent FoE-hosted seminar in the UK, it was concluded that the main advantage of the SCC is that it is "an attempt to measure actual costs" (FoE, 2008:6) associated with a particular greenhouse gas concentration level (ibid).

However, the SCC has a number of disadvantages including –

- SCC estimation is rife with great uncertainty, at a number of levels, including environmental valuation, catastrophic event probability and damage estimation, intergenerational preference assumptions, the resolution of which is uncertain and requires ethical judgment,
- Current SCC models, as a result of their failure to capture these uncertainties and their aged scientific basis, tend to present underestimated SCC's, and
- The estimation of SCC requires a value-judgement regarding future emissions levels, whereby an optimistic view of emissions levels (with significant emissions reduction) would ironically result in a lower SCC value now, clearly a self-defeating process (ibid).

It is important to recognise that the nature of the uncertainty inherent in SCC estimation is not resolvable any time soon (ibid).

Dietz (2007), while referring to Downing et al's 2005 work, draws attention to the origins of SCC estimation uncertainty, including uncertainty regarding future climatic change and its socio-economic impacts and critical climatic modelling omissions (ibid). Dietz acknowledges that the extent of MAC estimation uncertainty is in the region of two orders of magnitude less than that of the SCC (ibid).

It is again noted that few studies take account of non-market damage or extreme weather risk in their estimation of SCC (Watkiss et al, 2005). Watkiss et al reassert that the SCC estimates featured in the literature are only a portion of the total SCC (ibid). In contrast with Watkiss et al's assertions regarding MAC estimates, it was concluded that

SCC estimates can differ by over three orders of magnitude, from zero to in excess of £1,000/tC (ibid).

In summary, the main advantage of the SCC is that it is an attempt to measure actual costs of the damage of climate change in the future.

The key weaknesses of the SCC include -

- SCC estimation is rife with great uncertainty, of a nature which is considered not to be resolvable any time soon.
- Damage cost study results continue to display a very large spread, indicative of the extremely high level of inherent uncertainty involved in its estimation.
- The extent of SCC estimation uncertainty is in the region of two orders of magnitude greater than that of the MAC, based on current estimates.

6.4. Evaluation of Carbon Pricing Options

Each of the three carbon pricing options are evaluated in Table 8 below, firstly in terms of what are regarded as "Determinative Criteria" in this context and secondly, in terms of "Ancillary Criteria", each of which has been defined earlier.

Table 8 - Evaluation of Carbon Pricing Options

Determinative Criteria	**EU ETS Futures Price**	**MAC**	**SCC**
Credible & Reliable?	Y	Y	N
Objective & Transparent?	Y	Y	N
Simple?[5]	Y	Y	Y

Ancillary Criteria[6]	**EU ETS Futures Price**	**MAC**	**SCC[7]**
Administrative & Political Feasibility	Y	Y	N/A
Environmental Effectiveness	N[8]	Y	N/A
Static Economic Efficiency	Y[9]	Y	N/A
Distributional Effectiveness[10]	N/A	N/A	N/A

[5] Each of the three pricing options has the potential to be simple, if a single price, rather than a range of prices is used.
[6] Listed in order of importance in this context.
[7] Since the SCC does not pass all three of the determinative tests, it is given no further consideration.
[8] It is expected that setting a price based on the EU ETS Futures Price will result in inadequate emissions abatement relative to Irish greenhouse gas emissions targets.
[9] It is expected that setting a price based on the EU ETS Futures Price (or any price) will result in abatement at least cost at that price.
[10] The Distributional Effectiveness of the EU ETS Futures Price and MAC is not considered here.

Dynamic Efficiency[11]	Y	Y	N/A

Each of the three pricing options has been considered above in terms of their respective credibility and reliability, objectivity and transparency and simplicity. All three pricing options have the capacity to be simple, if a single price rather than a range of prices is used in the CBA process.

On the basis of the research carried out, the SCC is not credible or reliable, objective or transparent. In contrast, the EU ETS price and the MAC both pass these tests.

While the EU ETS price and the MAC are both considered to be administratively and politically feasible, it is expected that the long-term application of the EU ETS price to non-ETS sectors will result in inadequate emissions abatement, as a result of which the EU ETS price fails the environmental effectiveness test.

It is expected that setting a price based on the EU ETS Futures Price will result in abatement at least cost. An assessment of the distributional effectiveness of the pricing options is regarded as outside of the scope of this work. A carbon price will encourage the search for continual improvement in abatement options at least cost.

7. Recommendations

On the basis of the above assessment, it is recommended that, purely as an interim measure –

- The EU ETS futures pricing should be used as a carbon pricing basis for the period 2008 to 2012.
- As the ECX has been transacting in Dec-2013 and Dec-2014 EUA's since April 2008, these prices should be used for 2013 and 2014.
- All market-based pricing should be based on calendar year averages, to avoid structural break related price distortions.
- For the post-2014 period, a fixed price of €39t/CO_2 is recommended since the European Commission assumed an average carbon price of €39/tCO_2 in its Impact Assessment of the January 2008 Proposed Climate Change and Renewable Energy Measures from 2012 to 2020 (Curtin, 2008). As this price at least reflects medium term EU policy at present, it is considered to be the most appropriate estimate for medium to long term carbon pricing here, in the absence of a reasonable alternative.

It is recognised that there is an asymmetry between Ireland's emissions reduction targets and Ireland's EUA allocation under the EU ETS for the period 2008-2012. Post-2012, the ETS price will most likely not reflect the cost of abatement in the non-ETS sectors. As a result, the long-term usage of an EU ETS based price of carbon for public CBA in Ireland is regarded as inappropriate.

[11] A carbon price will encourage the search for continual improvement in abatement options at least cost.

As a matter of urgency, Marginal Abatement Cost Curves should be carried out for all sectors in Ireland, building on the work carried out to date by KEMA Consultants, ICF Consulting and Byrne Ó Cléirigh and Indecon International Economic Consultants. These sectoral MAC curves should be used to inform national climate change policy going forward.

As simplicity is one of the key criteria in the carbon price setting process, the application of sectoral MAC-based prices in a public CBA context would be overly complex and could lead to serious errors or inaccuracies. Consequently, there is strong preference for the usage of a single aggregate MAC based carbon price in public CBA for capital project appraisal in the long term.

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Appendix A

Workshop Attendees and Interviewees

Name	Organisation
Gordon Conroy	Department of Agriculture, Fisheries and Food
Una Nic Giolla Choille	Department of Communications, Energy and Natural Resources
Mark Winkelmann	Department of Environment, Heritage and Local Government
Georgina Hughes-Elders	Department of Finance
Pat Finnegan	Grian
Brian Motherway	SEI
Ken Macken	EPA
Gemma O'Reilly	EPA
Laura Burke	EPA
Peter Clinch	Department of the Taoiseach
Finbarr Brereton	UCD
Lisa Ryan	Comhar SDC
Stephen Flood	Comhar SDC
Frank Convery*	Comhar SDC
Declan Wylde	RPA
Sean Lyons*	ESRI
Nicola Commins	ESRI
David Anthoff	ESRI
David Korowicz	FEASTA
Luke Redmond*	UCD
Jonathan Healy	Forfas
Laura Watts	RPA
Alan Quirke	Forfas
Paul Watkiss	Paul Watkiss & Associates and Stockholm Environment Institute
Shirley Kilcullen	DIT and Comhar SDC

* Interviewed Post-Workshop

Appendix B - GLOSSARY OF TERMS

Business As Usual (BAU) Scenario – "A business as usual scenario is a policy neutral reference case of future emissions, i.e. projections of future emission levels in the absence of changes in current policies, economics and technology" (Point Carbon, 2008:57).

Cost Benefit Analysis (CBA) – "A conceptual framework applied to any systematic, quantitative appraisal of a public or private project to determine whether, or to what extent, that project is worthwhile from a public or social perspective. It differs from a straightforward financial appraisal in that it considers all gains (benefits) and losses (costs) regardless of to whom they accrue" (European Commission, 2002:125).

Cost Effectiveness Analysis - "an appraisal and monitoring technique used when benefits cannot be reasonably measured in money terms. It is usually carried out by calculating the cost per unit of benefit and requires that means exist for quantifying benefits but not necessarily for attaching a monetary price or economic value to the benefits" (European Commission, 2002:126).

Expected CBA – "…the assumed decision maker is uncertain about future developments. She attaches probabilities to each possible future, evaluates the costs and benefits, and optimises the probability-weighted cost-benefit balance" (Tol, 2003:286).

Externalities - An externality exists "...when a person does not bear all the costs or receive all the benefits of his or her action... when the market price or cost of production excludes its social impact, cost, or benefit" (Hanley et al, 2001:17). Unlike traditional discounted cash flow project appraisal as employed in the commercial world, CBA takes account of the social costs and benefits of a proposal i.e. the proposal is "evaluated with regard to the economy as a whole" (ibid:74), while traditional financial appraisal techniques omit external costs (and external benefits) (Clinch and Convery, 1999). In elaborating on this concept, Clinch and Convery (1999) set out the following equation: Social Cost = Private Cost + External Cost (i.e. the external cost is the difference between the cost of an activity to society (the social cost) and the cost to the individual undertaking that activity).

Global Warming Potential (GWP) Conversion Factors – conversion factors used to convert greenhouse gases (GHG's) other than CO_2 into tonnes of CO_2 equivalent (Maibach et al, 2007).

Impact Assessment (IA) - the formal analysis of the likely effects of a proposed policy, initiated or coordinated by government administrations prior to its adoption, is widely regarded as a key mechanism to improve regulation quality and to integrate different policy objectives (Jacob et al, 2008).

Marginal Abatement Cost (MAC) – "the cost of reducing emissions by one unit (Stern, 2007:241), or a "measure of effort" (ibid:341).

Multi-Criteria Analysis (MCA) - "an evaluation methodology that considers many objectives by the attribution of a weight to each measurable objective" (European Commission, 2002:126).

Net Present Value (NPV) - "the sum that results when the discounted value of the expected costs of an investment are deducted from the discounted value of the expected benefits" (European Commission, 2002:124).

Scenario-Based CBA – "...the assumed decision maker knows the future. Given this single future, she assesses costs and benefits, and optimises their balance" (Tol, 2003:286).

Shadow Price of Carbon (SPC) – A DEFRA (Department of Environment, Food and Rural Affairs, UK) concept, which is "not a shadow price in the classic sense of this term. Instead, the SPC is determined entirely by the SCC, the social cost of carbon, at an assumed stabilization trajectory. Marginal abatement costs are then, in very general terms, compared to the SPC to assess its accuracy. The SPC is determined by an assumed emissions level, while a true shadow price is determined by the intersection of marginal damages and marginal abatement costs" (Stanton and Ackerman, 2008:5).

Shadow Prices – in a classical economics context, shadow prices are "estimates of marginal social costs/benefits when market prices are distorted in some way, either through externalities... or due to government intervention in the market" (Hanley et al, 2001:74).

Social Cost of Carbon (SCC) - "the net present value of climate change impacts over the next 100 years (or longer) of one additional tonne of carbon emitted to the atmosphere today" (Watkiss et al, 2005:ii). It generally refers to "the marginal cost of climate change impacts" (Downing et al, 2005:8).

NB – **1tC = 3.664t CO_2 (e.g. €100/tC = €27/tCO_2)**