Royal Irish Academy Climate Change Sciences Committee

Scientific Statement No. 8
REVISED October 2013

Market-based policies for reducing carbon dioxide emissions

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Introduction Natural scientists and engineers are investigating a range of technical measures to reduce greenhouse-gas emissions. While it is vital to promote the efficacy of such carbon-reduction measures in a research setting, it is equally important that we understand the cost and application of these measures in the real world. In addition, we need to be aware of several policy-based approaches developed by economists which, if adopted, can help to promote the uptake of worthwhile technologies for emissions reduction, and encourage their development. In this scientific statement we see a useful way to consider how to choose between reduction technologies. In addition, we see that market-based policies can offer people flexibility as to how reductions are achieved, and, ultimately, achieve carbon reduction at a lower cost to society as a whole. In doing so, we outline the advantages and disadvantages of various market-based approaches, and summarise the most desirable features in order to inform our choice. The perspective is global, using evidence from Ireland and Europe to illustrate the issues.

1. There are many options for reducing CO_2 emissions—some are cheap, some are very expensive

Many current and promising technologies can be used to reduce CO_2 emissions. Take the Irish case—the chart below shows the options available, such as insulation refits for buildings or onshore wind power, but these options cost money.[1] On the vertical axis, the chart gives the costs of reducing, or 'abating', emissions, expressed in euro (€) per tonne (t) of CO_{2e} reduced. The units CO_{2e} in the chart are 'CO_2 equivalent', which includes all greenhouse gases expressed in terms of CO_2. For brevity, in this paper 'carbon' or 'CO_2' are to be read as meaning CO_2 equivalent.

The horizontal axis shows the scope for Irish carbon reductions, or abatement, in million tonnes of carbon by numerous technological options. In this marginal abatement cost (mac) chart, these options are ranked in increasing order of cost from left to right.

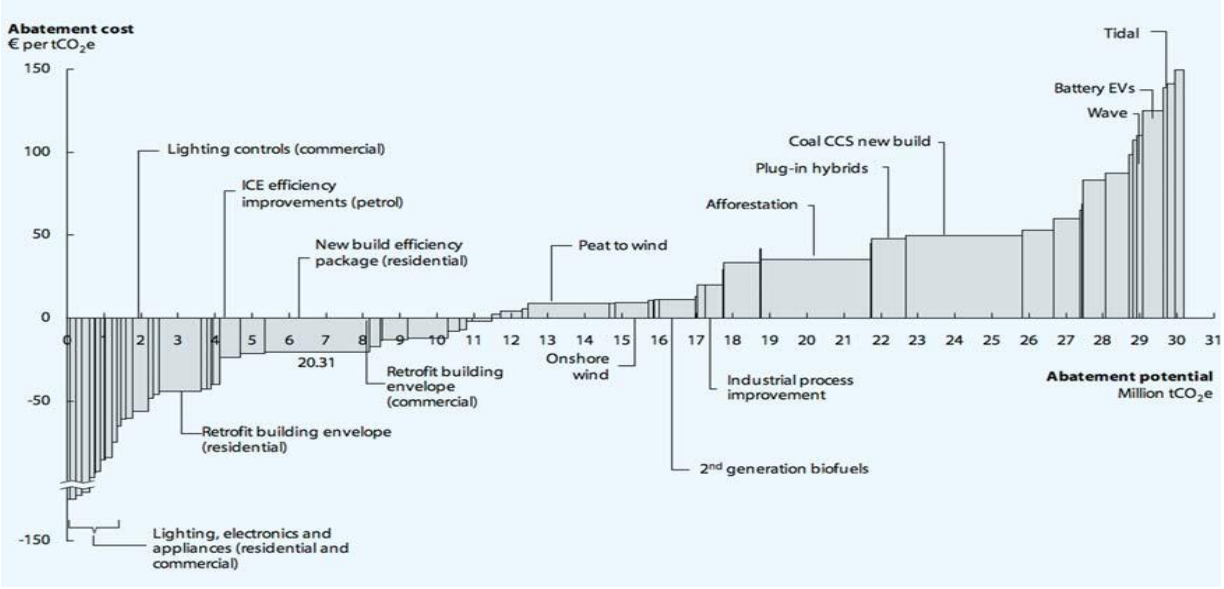

Fig. 1: ***Marginal abatement cost chart, 2030.*** *The vertical axis measures the cost per unit of carbon reduction in Ireland (€ per tonne of CO_{2e}), the horizontal axis measures carbon reduction potentials in the year 2030 by various technologies ranked in increasing order of cost from left to right (million tonnes CO_{2e}). Source: SEAI, 2009, Ireland's low-carbon opportunity.*

The chart suggests there is a broad range of options for enabling the reduction of up to some thirty million tonnes of carbon, and a variety of associated costs ranging from negative costs (i.e. gains) to over €100 per tonne of carbon reduced. The really profitable or cheap options on the left-hand side, such as low-energy light bulbs, are priorities for action. By contrast, some renewable energy options on the right-hand side are expensive and less worthwhile, at least until the technology becomes cheaper. Such charts show that selecting no-cost or low-cost options could spare the nation unnecessary expense. The ideal policy, then, would be one that automatically encourages progressing *up* the options until the national reduction target is met. In that way, Ireland would avoid unnecessary high-cost carbon reductions.

2. … but at the individual level, costs vary hugely and are not known with precision.

Naturally, many assumptions underlie these costs, which vary greatly between individuals, regions and so on. The expensive options could be worthwhile in circumstances that were special, or the hassle involved in good-value retrofits could be serious in other circumstances, representing a genuine extra cost. The chart is a simplification that shows each reduction technology's average cost as a guide to the potential by 2030.

As a result of the economic downturn, Ireland's greenhouse-gas emissions in the medium term are not projected to be as high as previously thought. However, Ireland's target for 2020 is still demanding, requiring an approximate twenty per cent reduction on 2005 emissions, so that exploiting relatively cheap options appropriate to individual situations is highly important. In the absence of perfect knowledge on relative costs at individual level, an ideal policy would be one that encourages individuals and entities to take up the options that are cheapest *for them*, thereby keeping down national costs overall. In many instances, such an approach is likely to be more efficient than one where the carbon-reduction technologies are mandated by government.

3. Carbon price and potential reduction level are linked, as seen in the schedule of options.

The MAC chart has further importance in showing how the cost of reducing a tonne of carbon is linked to the scope for worthwhile reductions. The cost of a target reduction of, say, twenty million tonnes on the horizontal axis is seen on the vertical axis to reach about €25 per tonne reduced. Thus, a carbon-emission price, such as a carbon tax imposed on fossil fuels actually charged at €25 per tonne, would make it worthwhile for emitters to undertake reduction options that cost up to that amount.—that is, they would *want* to reduce emissions by twenty million tonnes of carbon because reduction would be cheaper than paying carbon tax on the fuels. A still higher carbon price would make it worth their while to use more reduction technologies. It is of course noted that most people do not currently exploit existing profitable options, and there are many reasons for this.[2] This could be due to lack of knowledge, perceived risk that the option might not work, or real but hidden costs of taking action, such as the hassle involved in clearing the attic in order to install better loft insulation, or because the property or equipment is rented. For reasons such as these or due to a lack of knowledge required for an energy audit, the chart could be over-optimistic about some options. It might be the case that people are sensibly planning to take action later to reduce emissions more cheaply with other tasks, or perhaps they expect a subsidy.

4. The issue is how to make carbon reductions happen.[3]

The issue, then, is not alone the feasibility of reducing carbon emissions but also how to alter the behaviour of individuals and firms. Many government actions can play a role in nudging people in the right direction. These include information campaigns, emissions-performance labelling for cars, homes and appliances, and building regulations to improve the energy performance of homes and other buildings. A logical approach to finding a solution is to ask how to make our emissions 'unhappen'—what made human beings emit this level in the first place?

5. Free helpings of the atmosphere's (valuable) assimilative capacity are at the root of the problem.

The fate of free common resources that are both valuable and finite is well known—they are over-used. (In a restaurant, it is tempting to indulge if someone else is paying the bill.) The capacity of the atmosphere to absorb carbon is just such a valuable and finite common resource. As with any resource, its value lies in the benefits derived from using it, such as the profits from running machines and the comfort from burning fossil fuels. Every tonne emitted causes damage, and, if left unpriced, capacity is over-used. Informing and helping people to understand the issue leads the conscientious to restrain their emissions, but, alas, they will be exploited by those preferring and able to freeride on their efforts. Furthermore, any amount of regulation cannot supervise the manifold actions that cause emissions, and would not remove the underlying pressures to overuse. The root cause can be tackled by pricing emissions, which would rein in emissions and, vitally, reward and encourage necessary R&D and adoption of new technologies.[4] Two major economic instruments, specifying either quantity or price, can be called upon to do this: (1) emissions trading schemes, which place a quantity limit on permits to emit. Permits can then be traded at a price that, as with milk quotas, is determined in the market and the product's price responds; (2) carbon taxes that add a price on fossil fuels, differentiated by how much carbon each fuel emits.

6. But people seem to prefer government subsidies, unaware of how costly these could be!

Subsidy schemes play a vital role in the introduction of new technologies, and, in the absence of grants, insufficient resources will be given to R&D owing to the common-good aspect of its benefits (a conceptual mirror image of the earth's assimilative capacity discussed above). But the economy would be severely strained by reliance on subsidies to change consumers' energy-using behaviour given the full cost of sourcing funds from taxation[5] and the scale of the task. Worse, if subsidies do not reward emission reductions per se but merely the means to reduction, such as biofuels that displace crops, harmful side effects can emerge, and the resulting cuts in emissions could be lower than expected. Subsidies have to be generous in order to entice applicants. Measures such as the pay-as-you-save scheme for home upgrades in the UK, for example, may require high state support. Subsidies can also reward people who would have invested in any case, and hitches in eligibility and administration and monitoring requirements can be substantial. Governments can make poor choices that inadvertently cause prices of scarce inputs to rise. Rarely do they return to check schemes, such as grants for retrofits, to estimate the total cost per tonne of carbon reduced.[6]

7. Next in popularity are emissions trading schemes (ETS)—these are not ideal[7]

The EU's Emissions Trading Scheme (the EU ETS) is an example. These schemes set a cap on carbon emissions by means of permits allocated to emitters in relation to their past or expected emissions. Permits can also be allocated by auction, which, importantly, yield revenue. Each permit allows an emission of one tonne of carbon, and permits are valuable as long as their overall number is carefully limited. Recipients of permits can trade them, and a market price emerges; another name for this is 'cap and trade'. Recipients can buy permits if they need more, or sell if their emissions are less than their number of permits. Recipients will apply those carbon-reduction options that are cheaper than the permit cost, and thus the target cap is achieved and society as a whole is spared excessive expense. The limit imposed on the number of permits and the cost of reduction at any moment determine their price in the market, along the lines described for the MAC chart above. Three problems with the EU ETS stand out:

(1) The share-out of permits is difficult, subject to political manoeuvring[8] and almost inevitably disadvantages firms that have already taken significant steps to reduce their emissions over those that have taken little or no action. Companies already employing cleaner technology—for instance, in cement manufacture—do not automatically benefit, so why would they bother? Derogations to lobby groups mean that some emissions are not regulated by the scheme, placing a greater burden of reduction on firms with regulated emissions, whose extra reductions are likely to be more costly.

(2) The permits are assets, heretofore mainly given out free because of industry's resistance to paying, such as by auction. Permit holders nevertheless add the value to their industry's product price and profits (e.g. the electricity industry). But in the absence of revenue flowing to government to enable it to help consumers to cope with the energy price rise, the value of the scarce resource (assimilative capacity) is in effect transferred to industry's profits at consumers' expense. Variants of emissions trading schemes such as cap-and-share schemes—which hand out equal numbers of permits to individuals, and likewise yield no revenue to government—also do not help consumers or the vulnerable according to need. The appeal of 'free' permits masks these serious shortcomings.

(3) Thirdly, changing economic conditions and individual circumstances cause variations in emissions and demand for permits such that the permit price will fluctuate. The volatile carbon prices of the EU ETS, as shown in the chart below,[9] are a poor way to encourage investment in carbon reduction and R&D. Carbon prices in the EU ETS could be stabilised by reducing the number of permits or by adopting an internationally agreed floor price whereby a carbon charge kicks in when permit prices are low, and a ceiling or rebate when prices are high. The need for a credible long-term price of carbon might thus be met, similar to the carbon tax alternative illustrated in the chart. Such intervention in the EU ETS is contentious, but when the price falls to the extent that it helps even new coal-burning investments to become worthwhile, concern arises as to whether an emissions trading scheme is the right approach at all. Rather than struggle to make emissions trading schemes behave like carbon taxes, international effort would ideally switch to carbon taxes.

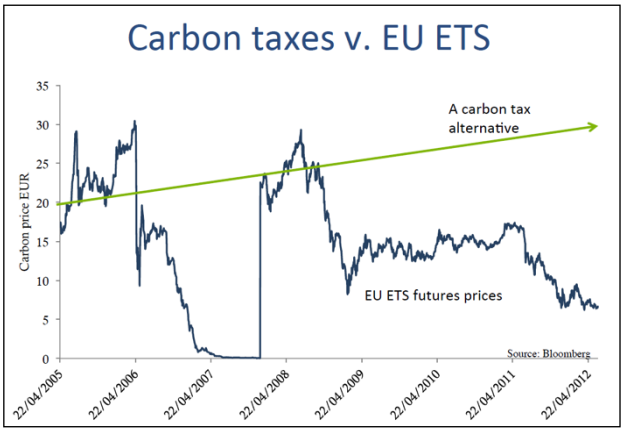

Fig. 2: Carbon prices in the EU. *The carbon futures price in the EU's emissions trading scheme compared with a carbon tax alternative. Source: Bloomberg; D. Helm,* The carbon crunch: How we're getting climate change wrong—and how to fix it *(2012).*

8. Carbon taxes get to the root of the problem and are the fairest approach for reducing CO_2 emissions.

Carbon taxes are applied to fuels according to their carbon emissions. A good approach is for countries to use the resulting revenue to reduce existing income taxes, or, in fiscally constrained times, to avoid having to raise income taxes. Though it may not appear obvious, this can actually help growth. Such tax 'swaps' applied to varying degrees have been widely analysed and already applied in six EU member states with good results, though modest given limited application.[10] Studies indicate that such a tax swap is also good for Ireland,[11] which introduced a limited carbon tax in the 2010 budget at €15 per tonne of CO_2, rising to €20 in the 2012 budget, with an extension to cover solid fuels. The carbon tax applies to carbon not already covered in the emissions trading scheme. Investment in carbon reduction is encouraged, and improvements grow over time,[12] especially if applied EU-wide or beyond. The revenues facilitate economic competitiveness by enabling taxes that affect labour costs to be lower than otherwise, and a part of the revenues can be set aside to protect the vulnerable in society. There is much support in the independent peer-reviewed literature[13] for a global carbon tax, with difficulties foreseen if the fundamental requirements of carbon pricing and the means to help competitiveness and the vulnerable are not in place. As mentioned, other policies are required, such as Building Energy Rating (BER) that helps people make informed choices[14]. Removal of existing subsidies to fossil fuels is also deemed a priority; there are often better ways to give social supports if that is their aim.

A perceived disadvantage of a carbon tax is that, unlike a quota system, it does not guarantee a target level of reductions. But if progress on reducing emissions needs adjusting, it is easier nationally, and probably internationally, to increase or decrease the carbon tax than it is to change the allocation of permits. The problem of vulnerable firms is addressed by offering an alternative, such as negotiated agreements.[15]

The opportunity now exists to apply lessons from recent experience, and to get the fundamentals right for the global effort that will be required.[16] In particular:

- The atmosphere's capacity to assimilate carbon is finite and valuable, and economic research supports the use of an approach where all carbon emissions would be subject to a sure and steadily rising harmonised price.

- Pricing, be it by a carbon tax or by an emissions trading scheme, needs to be established to yield revenue that can be used to alleviate impacts on the vulnerable of raised fossil-fuel prices, to reduce other taxes—especially those affecting labour costs—and to fund R&D.
- It is consumption that ultimately drives emissions. Unpriced or unrestrained carbon emissions embodied in imports that are not already subject to a carbon tax or similarly effective regulation in the exporting country ought also to be subject to pricing in an agreed fair manner.

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[1] SEAI, 2009, http://www.seai.ie/Publications/Low_Carbon_Opportunity_Study/Irelands_Low-Carbon_Opportunity.pdf, reference scenario cost function, 13, see assumptions. Abatement costs are calculated as discounted streams of estimated net-cost changes divided by the emissions changes. Important hidden costs may arise, making the curve optimistic on some options.

[2] Reasons have been extensively researched by, for example, Eoin O'Malley, Susan B. Scott and Steve Sorrell, *Barriers to Energy Efficiency: Evidence from Selected Sectors* (Economic and Social Research Institute, Dublin, 2003).

[3] As in Department of Energy and Climate Change, UK, 2008, Committee on Climate Change, http://www.theccc.org.uk/pdf/TSO-ClimateChange.pdf. Barry, Clinch and Convery, 2002, previously covered this issue in http://www.ria.ie/committees/iccc/pdfs/economics.PDF.

[4] The good record on price instruments in Ireland includes the forty per cent reduction in leakage and water use after pilot metered water-charging in the National Federation of Group Water Schemes, a forty per cent reduction in waste after pay-by-weight was introduced in west Cork (despite low price elasticity of -0.27; see http://www.epa.ie/downloads/pubs/research/econ/ertdi%20report%2054.pdf), and an eighty per cent reduction in plastic bags since the levy. Other policies not covered here, such as education, technical help and research, have a vital part to play, as do regulations applied on foot of sound assessments. These also help deal with barriers.

[5] Owing to distortions due to taxation, it costs €1.5 to raise €1. P. Honohan, *Key issues of cost-benefit methodology for Irish industrial* (Academic Books, Dublin, 1998); Forfás, *The Economic Appraisal System* (Forfás, Dublin, 2001)

[6] OECD, 2013, *Effective Carbon Prices*, OECD Publishing. http://www.oecd.org/env/tools-evaluation/carbon-prices.htm

[7] Due to steeper curvature of the abatement-cost function relative to the benefit function; see M.L. Weitzman, 'Prices vs. Quantities', *Review of Economic Studies*, 41 (4) (Oct. 1974), 41.

[8] Taxes are also susceptible to lobbying, but the outcome is likely to be more transparent.

[9] Chart from Bloomberg and from D. Helm, *The carbon crunch: How we're getting climate change wrong—and how to fix it* (Yale, New Haven, CT, 2012). Use of either instrument has to confront the issue of embodied carbon in imports from regions that do not price their carbon emissions. Their unfair advantage enables them to undercut local suppliers, who may indeed relocate elsewhere, resulting in so-called carbon leakage. Border carbon adjustments on embodied carbon in imports are a way to overcome this, and thus make the taxes focus more correctly on carbon consumption rather than on production. With border taxes in place, exporting countries then have an interest in taxing their emissions themselves. Estimates of embodied or 'virtual' carbon in Irish trade were calculated by Lyons, Mayor and Tol for figure 5.4 of Fitz Gerald et al., 2008, http://www.esri.ie/UserFiles/publications/20080515155545/MTR11.pdf, based on E. Hertwich and G.P. Peters, 'Carbon footprint of nations: A global, trade-linked analysis', *Environmental Science and Technology*, 43 (16) (2009). See also Stiglitz http://www.carbontax.org/issues/border-adjustments/ and D. Helm et al., *Oxford Review of Economic Policy*, 28 (2) (summer 2012), http://oxrep.oxfordjournals.org/content/28/2/368.abstract .

[10] COMETR, http://www2.dmu.dk/cometr/COMETR_Summary_Report.pdf, 36; see also G. Mankiw, 2007, http://scholar.harvard.edu/mankiw/files/one_answer_to_global_warming.pdf; G. Metcalf, 2007, Brookings Discussion Paper, http://www.brookings.edu/~/media/research/files/papers/2007/10/carbontax%20metcalf/10_carbontax_metcalf; W. Nordhaus, 2007, *Review of Environmental Economics and Policy*, http://www.econ.yale.edu/~nordhaus/homepage/nordhaus_carbontax_reep.pdf. Industry and governments rejected the 1992 EU carbon-tax proposal (J. Delbeke), http://aei.pitt.edu/4830/1/4830.pdf and the EU emissions trading scheme was implemented instead.

[11] T. Conefrey, J.D.F. Fitz Gerald, L.M. Valeri and R.S.J. Tol, 'The impact of a carbon tax on economic growth and carbon dioxide emissions in Ireland', *Journal of Environmental Planning and Management*, 56 (7) (2012), http://dx.doi.org/10.1080/09640568.2012.709467. S. Scott, IIEA blog 2013 http://www.iiea.com/blogosphere/maturing-of-the-carbon-tax-debate.

[12] The statistically significant and fairly stable price elasticity of demand for energy, though modest in the short term, is stronger over the long term, viz. S. Scott, *Domestic Electricity Demand,* ESRI GRS 151 (1991); 'Environmental effectiveness' in OECD, *The Political Economy of Environmentally Related Taxes* (OECD, 2006), http://dx.doi.org/10.1787/9789264025530-e5-en.

[13] US Government Accountability Office, *Climate change: Expert opinion on the economics of policy options* (US Government Accountability Office, Washington DC, 2008), 'preferred either a tax on emissions or a hybrid policy that incorporates features of both a tax and a cap-and-trade program', http://www.gao.gov/new.items/d08605.pdf .

[14] Preliminary analysis of BER by M. Hyland, R. Lyons and S. Lyons (ESRI, Dublin, 2012) shows buyers are willing to pay more for increased energy efficiency, http://www.esri.ie/research/research_areas/energy/energy_conference_1510200/Hyland_et_al.pdf.

[15] As in UK, see COMETR, 277, http://www2.dmu.dk/cometr/COMETR_Final_Report.pdf; or for Ireland, see Sustainable Energy Ireland, *Large Industry Energy Network, Annual Report* (2007), http://www.sei.ie/Your_Business/Large_Industry_Energy_Network/LIEN_Annual_Reports/ .

[16] See A.C. Morris, W.J. McKibbin and P.J. Wilcoxen, 'A climate diplomacy proposal: Carbon pricing consultations', Harvard Project on Climate Agreements policy brief, Feb. 2013, http://belfercenter.ksg.harvard.edu/publication/22794/climate_diplomacy_proposal.html.