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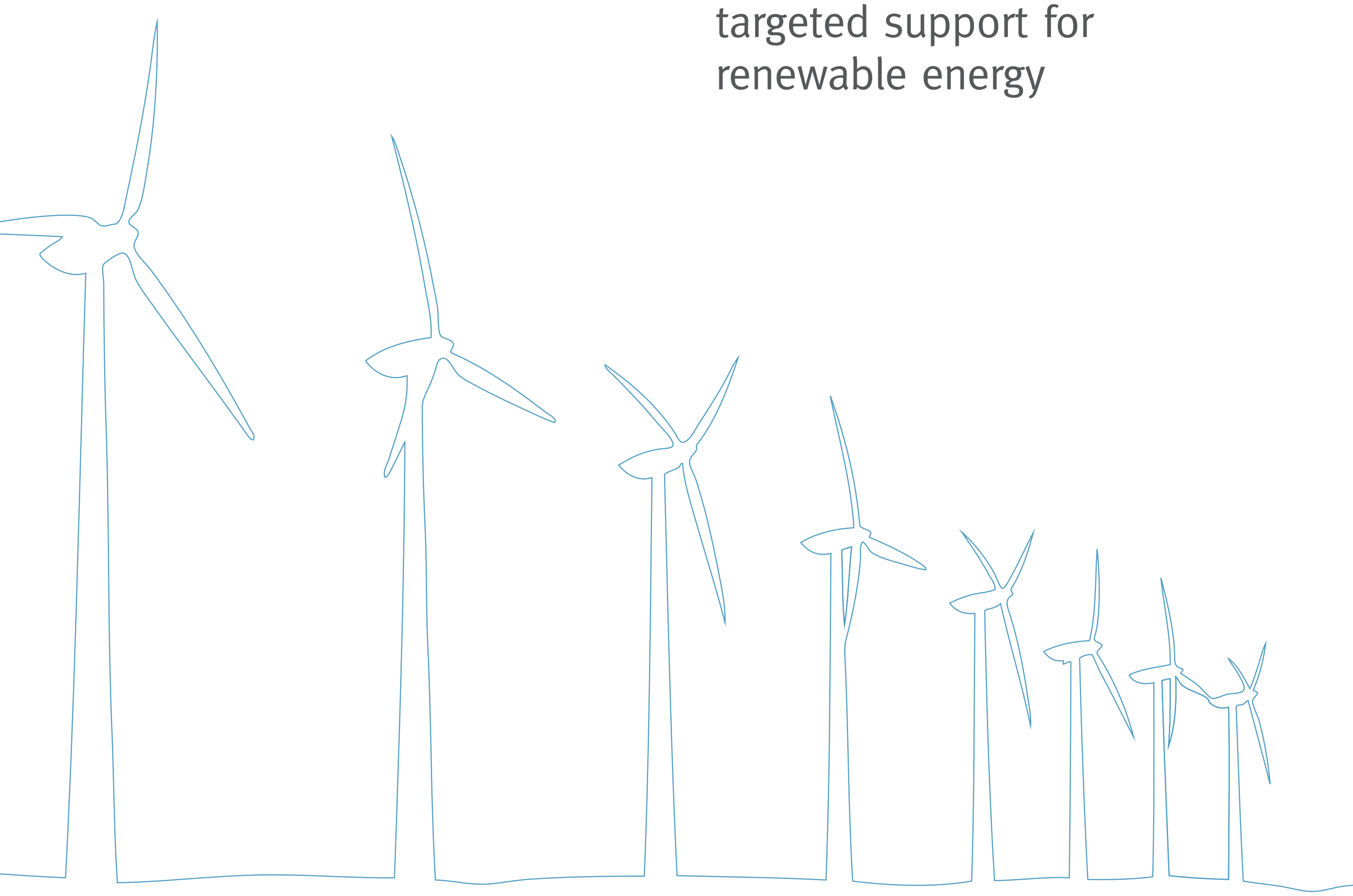
On picking winners:

The need for targeted support for renewable energy



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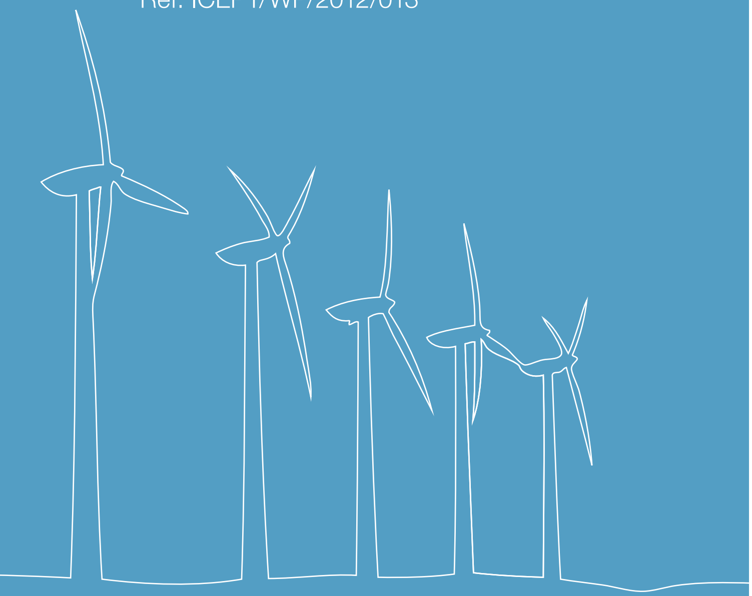

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ON PICKING WINNERS SUPPORTS WWF'S VISION FOR AN ENVIRONMENTALLY SUSTAINABLE POWER SECTOR

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Executive Summary

Introduction and context
Britain's plans to reform the electricity market have placed the relative role of policies that seek to promote renewable energy versus interventions to price carbon at the centre of the policy debate. Many argue for a mix of approaches, stressing the importance of technology specific strategies to promote innovation as a complement to carbon pricing. This is accepted wisdom internationally, and is reflected in country policies around the world. Yet some economists argue that technology specific subsidies distort the functioning of carbon markets, hindering efforts at decarbonising the economy.

It is puzzling to find that around the world many countries currently support renewables directly, and rather few countries have carbon taxes.

The neoclassical economic arguments for carbon pricing as the primary, even sole, form of intervention appear attractive, at least at first glance. In this theoretical world, if policymakers also intervene directly to subsidise renewable energy the effect is to undermine the market and increase the costs of abating carbon emissions. It is therefore surprising that more than sixty countries have support schemes for renewables, and rather few have carbon taxes. Looking ahead, the policy position is less clear. For example, EU level commitment to specific renewable energy policies beyond 2020 is now subject to debate, with some countries favouring a move to technology neutral low carbon policy.

The question arises as to whether, when and under what conditions targeted support should give way to generalised support through a carbon tax, and indeed why policies target technologies at all.

In seeking to address these questions the paper considers:

- The difficulties associated with setting the 'optimal' carbon price
- Why neoclassical economic theory and investment economics part company
- Why carbon pricing is politically difficult, both domestically and internationally
- The case for supporting technology directly to overcome lock-in to fossil fuels and encourage innovation and learning effects in low carbon options

Determining the right carbon price is difficult
The theoretical conditions under which the 'optimal' carbon price can be determined do not apply in reality and carbon prices or caps need to be set pragmatically.

Climate change is undoubtedly a very large problem. However, the impacts of climate change are difficult to properly quantify in financial terms given uncertainty about climate feedbacks, the uneven geographic distribution of impacts and the varying costs (both damage and abatement) across economies. Setting the *optimal* carbon tax (or cap), based upon an analysis of global damage costs, weighed against the benefits of fossil fuels is not a realistic proposition. This is not an argument against pricing carbon, but rather for setting carbon prices or caps pragmatically.

This means both carbon pricing and policies to promote renewable energy need to be judged empirically, in terms of what works, not what is theoretically optimal in an abstract realm.

Short run prices and long term investment in the real world

Investment risks cannot be removed by carbon taxes alone. Stable, targeted policies are required by investors and can reduce risks, lowering finance costs and benefiting consumers.

It might appear that provided a carbon tax is in place that raises the cost of gas generation and makes the generating costs of a wind farm (for example) equal to (or slightly lower than) a gas power station, rational energy firms in a competitive market will stop building gas power stations and start building wind farms.

In the real world it is not so simple. Whilst carbon pricing can create conditions that make investment in wind or other renewables more attractive, there are uncertainties associated with wholesale power prices, carbon permit prices, and future political decisions on carbon tax levels. **These make renewable energy projects more risky, which drives up the cost of capital, and discourages investment.**

These considerations explain why the renewable energy investment community prefers targeted policies such as feed-in tariffs, which fix the price of wind-generated electricity, to less certain interventions such as cap and trade schemes. **The international evidence is clear that well designed policies can reduce the cost of capital (the cost of borrowing money), which in turn reduces the cost to consumers.**

The politics of international carbon taxes

Fossil fuel is more often subsidised than taxed. Political realities mean that a global price on carbon is difficult to achieve and remains a distant prospect.

A carbon price would in principle be sufficient to persuade investors to invest in renewables irrespective of fuel and power price uncertainty, provided they believed that a *high and stable* carbon price would sustain for long enough to deliver an adequate return on capital.

Yet in many parts of the world carbon is subsidised not taxed. The IEA estimate global fossil fuel end-use subsidies at around $409 billion for the year 2010. Recent climate negotiations have demonstrated the complexities and competing interests associated with global action on climate. In the domestic political realm, carbon pricing has the potential to place additional burdens on the least well-off and on energy intensive industry. **In short, carbon pricing is difficult because it can be presented as a regressive tax that damages traditional industries, and benefits some countries more than others.**

Renewable policies can address carbon lock-in and support innovation

Renewable energy support schemes make long run and international carbon prices easier to impose. They foster innovation, and harness powerful economic forces that can promote lower costs and better performance.

Looking forward, targeted support can create early markets for emerging technologies. This is because they have what innovation economists call *dynamic effects:* they foster innovation, yield increasing returns to adoption and help low carbon technologies move along their learning curve. Thus, targeted subsidies bring down the costs of low carbon technologies, creating options which can be deployed cost-effectively in the future. In the meantime the long asset lives of coal and gas plants (and associated institutions, commercial/lobby interests and skill sets) mean that investment decisions made in the short term result in carbon 'lock-in' that lasts for several decades. This leads to two key policy conclusions:

1. Action now to encourage low carbon investment can induce innovation, driving down future costs in emerging technologies. 2. The absence of action now will further lock the energy system into high carbon assets with long lives.

Conclusions: the need for targeted support in a portfolio of policies

Neoclassical concepts of external costs aren't wrong, but they need to be understood in a dynamic and practical sense. Policy also needs to harness innovation through policies that encourage investment in renewable energy.

Renewable energy policy needs to be dynamic, because the technologies are new and improving. Costs are not fixed; over time with the right policies they can be reduced. This requires effort on a number of fronts including investment in science and in research and development. It also requires policymakers to harness innovation through policies that make large scale investment in non-fossil energy possible. Doing so will allow an opportunity for technological development, learning, and cost reduction. Pricing carbon is part of the solution to the climate change problem, but to the extent that it is not the most cost effective means to drive investment it is neither sufficient nor optimal.

Global society is still experimenting with policies, still gathering data on 'what works' in the global struggle to contain greenhouse gases. It is important to ensure that support levels are appropriate and drive down costs over time. There is considerable evidence that targeted subsidies, and particularly feed-in tariffs, *do* work. They are establishing a track record in promoting low carbon investment, driving innovation and promoting lower cost low carbon technologies.

This paper does *not argue against pricing carbon.* Rather, it finds that targeted technology support can make renewable energy investable, help make it cheaper, and assist in delivering long run, international and meaningful levels of carbon pricing. In so doing they can help mankind develop cost-effective low carbon options, cut carbon emissions and reduce the risks of dangerous climate change.

Contents

Introduction

Britain is preparing to reform its electricity market[1], mixing technology specific contracts (so called Contract for Difference Feed-in Tariffs or CfD-FiTs) with a floor price on the European carbon price and an Emissions Performance Standard. This paper discusses the role and importance of policies that seek to promote renewable energy directly alongside policies to price carbon, such as the UK carbon price support scheme. This is a highly contested space. Some analysts argue for a mix of policies, stressing the importance of technology specific policy to promote innovation as a complement to carbon pricing (Stern 2007, Fischer & Newell 2007, Kalkuhl et al. 2012, Grimaud & Lafforgue 2008). Others argue that targeting renewable energy distorts the functioning of carbon markets, ultimately hindering efforts at decarbonising the economy. According to this school of thought, carbon pricing is an alternative to technology specific policies, and to be preferred (Moselle & Moore 2011, Less 2012, Nordhaus 2009).

Governments and international bodies appear to have largely accepted the case for targeted support for renewable energy, with 65 countries having some form of feed-in tariff or related policy to promote the deployment of renewable energy (REN 21 2012)[2]. The case for supporting low carbon energy technology directly has been laid out variously by the IEA, World Energy Council and OECD, as well as by national governments (UNDP 2009, IEA 2008, HM Government 2009)[3].

However it would be a mistake to consider that the international debate over low carbon energy policy is closed. At the time of writing, EU level commitment to renewable energy beyond 2020 appears uncertain, with some (including Britain) favouring a move to technology neutral low carbon policy (Council of the European Union 2012). The question arises as to whether, when and under what conditions targeted support should give way to generalised support through a carbon tax or related policy. This in turn reopens the question as to why policies target technologies at all. This paper addresses this question, using the latest international evidence. It draws upon ongoing research at Imperial College London.

A hidden hand: the Neoclassical solutions to pollution

The neoclassical economic conceptualisation of the problem of climate change is that manmade greenhouse gases are an externality, the costs of which are not borne by polluters themselves. The

[1] At the time of writing the UK plans are at Draft Bill stage, described at http://www.decc.gov.uk/en/content/cms/legislation/energybill2012/energybill2012.aspx

[2] In this paper we often refer to Feed in Tariffs as short hand for targeted premium payment instruments, rather than the full range of policies to provide renewable energy with premium payments. For a discussion of the range of interventions and their issues, see Gross and Heptonstall (2010).

[3] There are lots of reasons governments support renewable energy, including security of supply, reduction of local air pollution and industrial or regional development policies. This paper focuses on the carbon abatement debate, assessing the arguments and evidence on carbon pricing and renewable energy policy in terms of economic efficiency, political realism and attractiveness to investors.

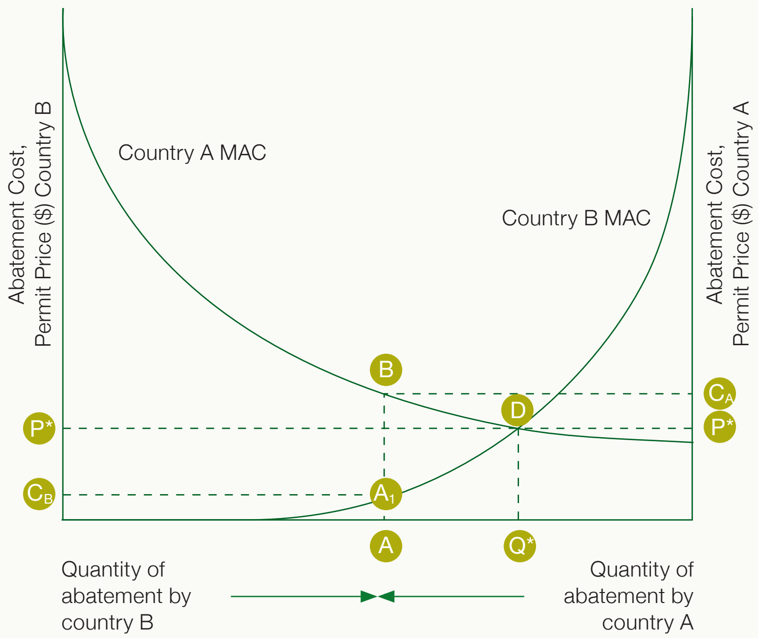
theory of Pigouvian taxation, now nearly a century old (Pigou 1920), suggests that an optimal solution would internalise the externality through a tax set equal to the marginal external cost of greenhouse gas (GHG) emissions.

There is a debate in the climate policy and economics community about whether a carbon tax would be better than a scheme that caps emissions, allowing permit trading to deliver a carbon price. We don't debate their merits in this paper, but the theoretical advantages of one over the other turn upon the relative rates of marginal abatement and damage costs (Hepburn 2006). For now, we note simply that in both cases the idea is that market participants respond to the direct price signal imposed through a tax or the permit price created by a cap and trade scheme. This ensures that the market delivers emissions reductions where they are most cost-effective, thus minimising overall mitigation costs (Newberry 2005, Stern 2007). Market-based solutions are also argued to encourage innovation and reduce implementation costs when compared with traditional 'command and control' regulation of pollution (Jaffe, et al. 2000, Kerr & Newel 2003).

So what happens if policymakers also intervene directly to subsidise renewable energy? In a theoretical world, the effect is to undermine the market based solutions that taxes and/or cap and trade schemes are seeking. The effect can be shown most readily under a trading scheme. Figures 1A and 1B illustrate the effect of a subsidy for low carbon technologies in the hypothetical instance where two countries participate in a cap and trade scheme and one decides to subsidise renewable energy directly[4]. The effect is essentially the transfer of abatement effort to the subsidising country, giving rise to substantial benefit to the 'free riding' country and a deadweight loss to global society overall.

Figures 1A & 1B: Effect of a technology subsidy in one country in the context of a global market for greenhouse gas emissions (author's illustration)

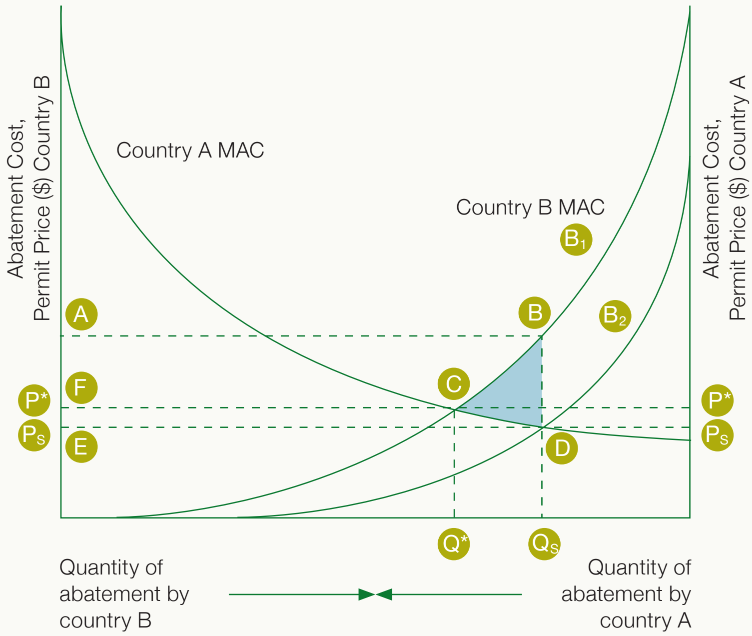
Figure 1A: Efficient allocation of emissions reductions between countries in an ideal carbon market



Abatement is shared between two countries (A & B) such that at all points on the x axis the environmental objective is achieved, but the allocation of abatement between the two countries varies. If emissions allowances were initially allocated equally (point A), the Marginal Abatement Cost (MAC) of the last unit of abatement for country A (C_A) would be considerably higher than for country B (C_B). Therefore both countries would be better off if country B were to carry out additonal abatement up to Q and country A were to buy emissions allowances from country B at price P*, up to the point Q* where it is no longer cheaper to buy allowances and MACs are equalised between countries. The overall saving in costs to the world as a result of the trade is A1BD.*

[4] It is important to note here that the unilateral introduction of a carbon tax in one country could also lead to distributional issues of abatement effort among countries, due to potential competitiveness and carbon leakage impacts. We return to these issues in Part 4.

Figure 1B: Effect of a technology subsidy in one country in the context of an ideal carbon market



As a result of trades in figure 1A, the market has reached equilibrium at Q, P*. A subsidy is introduced in country B as a payment per unit of abatement achieved of AE. This could for example represent a subsidy to renewable generators. It has the effect of shifting down country B's effective MAC curve (the abatement cost faced by firms net of subsidy) from B1 to B2, with the result that the market for carbon emissions will reach a new equilibrium at Qs, Ps, with country B carrying out Qs - Q* further abatement and country A carrying out the same quantity less abatement and purchasing Qs - Q* permits from country B at price Qs.*

The abatement cost saving in country A as a result of country B's subsidy is the area under the MAC curve avoided, CDQsQ, and the extra abatement cost incurred by country A is the area BCQ*Qs. The triangle BCD therefore represents the additional abatement cost to the world or 'deadweight loss' that will be brought about by the introduction of the subsidy.*

The conclusion of this line of thinking is that a global carbon price set at the right level is not only a sufficient, but also a first-best solution to the problem of climate change. This implies that there is no role for any energy subsidies or climate regulations beyond carbon pricing, or at least that such interventions are 'second best' solutions:

'Internalising the cost of certain externalities, for example by instituting more widespread or higher CO_2 prices, may represent a more economically efficient approach [than subsidies], although there are political hurdles to be overcome.' (IEA 2011)

Another line of argument used in favour of technologically neutral carbon pricing is that it avoids the need for governments to make judgements about the costs of individual technologies. Governments are held to be poorly informed about industry costs and prone to make judgements influenced by lobbying from industry (Helm 2010). The result is to over-reward renewable generators and transfer wealth from consumers to the renewables industry (Ibid). Extending this line of thought to technological learning, it is further argued that governments that seek to 'pick winners', deciding which technologies will improve and deserve subsidy, are also prone to making poor judgements (Less 2012). The argument goes that trying to pick winners leads governments to back losers, wasting consumers' money on ineffective technologies.

It is important to note that this line of argument has shifted from economic theory to the empirical or ideological contention that governments are 'worse' at key judgements about technology than the private sector. We return to this issue in Part 5.

Limitations to the neoclassical view: the remainder of this paper

The arguments for market-based solutions and against technologically specific subsidies set out above appear very attractive, at least at first glance. So it is extremely puzzling to find that around the world many countries subsidise renewables directly, rather few countries have carbon taxes, and in Europe the emissions trading scheme co-exists with country level feed-in tariffs, carbon taxes and a variety of other policies (UNEP & WTO 2009, REN21 2012). Europe has also set separate targets for carbon, energy efficiency and renewable energy (European Commission 2010).

Either policy-makers around the world are blind to the logic of economic theory, or there are factors that overwhelm or undermine the theoretical Pigouvian considerations set out above. The rest of this paper discusses the considerations that differentiate real world from theoretical economics, the issues that affect the politics of climate policies, and the dynamic factors that lead abatement costs to change over time. In what follows we consider:

- The theoretical difficulties associated with Pigouvian taxation **(Part 2)**
- Why neoclassical economics and investment economics part company **(Part 3)**
- Why carbon pricing is politically difficult, domestically and internationally **(Part 4)**
- The case for supporting technology directly to overcome lock-in to fossil fuels and encourage innovation and learning effects in low carbon options **(Part 5)**

Part 6 concludes the paper with a discussion on how to combine the long term benefits of carbon pricing with more immediate and dynamic benefits that arise from targeted support for renewable energy. This draws upon a review of the international evidence on 'what works' in terms of portfolios of carbon pricing and technology policy.

Riding spherical horses in a vacuum

The theoretical difficulties with Pigouvian taxation

The neoclassical approach set out in Part 1 relies upon a set of simplifying assumptions about efficient markets, availability of information and behaviour of economic agents. In a recent paper on UK electricity market reform low carbon investment expert Ian Temperton uses the analogy of a physicist who has devised a model to predict the outcome of a horse race – provided the horses are perfect spheres, racing in a vacuum (Temperton 2011). The economist's spherical horse is the 'perfect market', where there are enough participants to prevent any from exercising market power, where market players are perfectly rational profit maximisers, where information about costs and benefits is perfect and costless to acquire and where resources can be allocated swiftly and with no political impediments (Ibid).

Carbon markets don't align very well with the economist's spherical horse, because costs and benefits are not transparent and numerous non-price 'market failures' exist. This is not unique to the climate problem. Indeed the information problems associated with the Pigouvian approach to environmental problems were expressed forty years ago:

'All in all, we are left with little reason for confidence in the applicability of the Pigouvian approach…We do not know how to calculate the required taxes and subsidies and we do not know how to approximate them by trial and error.' (Baumol 1972, p 318).

The extent to which Baumol is correct varies between pollutants. The immediate damage created by local pollution (for example a liquid chemical spill from a factory causing damage to soil and crops in a farmer's field) may be relatively straightforward to cost (Stern 2007, Meade & Hjertonsson 1973). However, the damage costs incurred to society from climate change are extremely difficult and perhaps impossible to properly quantify given the uncertainty in terms of climate feedback impacts, the uneven geographic distribution of impacts and the varying costs (both damage and abatement) across economies. Intergenerational factors complicate matters further, since the worst damage costs associated with climate change occur in the future, perhaps many centuries ahead (Stern 2007, Hansen et al. 2008, CCC 2010). Furthermore, the existence of potential non-linearities in the response of the climate system to temperature rise mean that damage costs do not rise uniformly with emissions. Damage costs may increase slowly at first then rise rapidly as thresholds are breached, with high levels of atmospheric carbon leading to more profound damage and severe impacts on human life (IPCC 2007, CCC 2008).

Moreover, just as damage costs are uncertain and difficult to quantify so are the long run costs of abatement since technological and behavioural changes offer the prospect of reducing (but uncertain) mitigation costs (Anderson et al. 2001). Indeed, as we explain in more detail in Part 5, it is a mistake to think of abatement cost as fixed. Given innovation and various forms of 'learning by doing' which reduce costs as experience increases, abatement cost curves will move over time. As we also argue in Part 5, technology subsidies can help this to happen.

In short, climate change is undoubtedly a very large problem, but neither damage costs nor abatement costs can be quantified accurately enough to support the notion of a cost optimised approach. Setting the optimal carbon tax (or cap), based upon an analysis of global damage costs, weighed against the benefits of fossil fuels is not a realistic proposition. Of course this does not mean that carbon pricing is impossible or should not be attempted. It follows instead that a greenhouse gas target (or price) should be set pragmatically at a level that aims to reduce the probability of severely damaging impacts to low levels (CCC 2008). The optimal solution set out in theoretical discourse, and used in the argument that targeted subsidies are distortionary, is a hypothetical optimum, based upon assumptions and judgements about damage and abatement costs that are in practice very hard to quantify. Whilst in theory subsidies might create a deadweight loss, in practice this will depend on whether the tax or cap was set at an optimum level to start with, and how the targeted subsidy changes each country's ability to abate over time.

We have therefore moved from a world where the 'right' carbon price can be known to one where carbon prices or caps are pragmatic and political judgements. Carbon pricing, technologically specific subsidies and all of the other policies that can be brought to bear upon the carbon problem need to be judged on their real world costs and real world results rather than against abstract notions of economic efficiency. It is therefore important to consider the real world factors that a technology subsidy or carbon price can affect. The first of these is long term investment decisions.

Short run marginal prices and long run capital investments

Why carbon markets pick renewables last

Pricing carbon has the effect of making burning fossil fuels more expensive. This creates an incentive to burn fuel more efficiently, save energy through end use efficiency, use fuels with a lower carbon content, and ultimately to replace energy system assets that run on fossil fuels with devices that do not – like wind farms or nuclear power stations.

Let's consider the characteristics of this last category of response to a carbon price signal; constructing a new non-fossil power station. The first thing to note about wind farms, nuclear power stations, photovoltaic arrays and any form of marine or hydro generation is that without exception they are more expensive to build (measured in cost per unit of power £/MW) than an equivalent gas fired power station (Mott MacDonald 2010, 2011). Of course renewables (with the exception of biomass power) don't require any fuel to operate, so the lifetime costs of building and running a non-fossil power station, known as their levelised costs (price per unit of electricity (£/MWh)), may or may not be higher than those of a gas or coal fired power station. This will depend upon the price of fuel (including any carbon price), other running costs, capital costs, and the cost of capital (i.e. the interest that must be paid on debt or the cost of equity). The evidence suggests that currently the cost of onshore wind power is a little higher on a levelised basis than the cost of gas-fired electricity, and costs of offshore wind and most other renewables significantly higher (Ibid), although the offshore wind industry is striving to reduce costs considerably over the next decade (BVG Associates 2012).

It might appear that provided a carbon tax is in place that raises the cost of gas generation and makes the generating costs of the wind farm (for example) equal to (or slightly lower than) the gas station, rational energy firms in a competitive market will stop building gas power stations and start building wind farms. Unfortunately it is not quite so simple. As we explain in what follows, investors may still prefer to build gas-fired stations even in the presence of a carbon tax that equalises levelised costs.

The principal reason lies in the ability of gas fired power stations to affect wholesale electricity prices and pass variations in gas, and carbon, prices through to consumers. Gas fired power stations have relatively low capital costs. Servicing capital costs amounts to less than 20% of total generation costs, the bulk of the remainder being the cost of fuel (Mott Macdonald 2010). For reasons described elsewhere (Gross et al 2007), higher gas prices usually feed through into higher electricity prices, which creates an inherent 'hedge' against gas price fluctuations. Moreover, with a smaller burden of capital cost to recover gas-fired power stations can remain profitable over a range of operational regimes. They may run a large fraction of the time or only operate during peak periods when power prices are at their highest. They may even be shut down altogether for a while if gas input prices become too high relative to power prices (Gross et al. 2007, 2010).

By contrast, wind farm investors face a range of revenue uncertainties that aren't reduced by the presence of a carbon price. Whilst carbon taxes raise the price of fossil fuel, fossil fuel prices themselves remain uncertain and volatile and this fuel price volatility feeds through into electricity price volatility. Unlike gas power stations, wind farms do not have a direct affect on marginal electricity prices (Gross et al 2007, Chignell & Gross 2012). Carbon taxes are also subject to political uncertainty – future governments may reduce or remove them, as discussed in Part 4. Cap and trade schemes add a further layer of uncertainty, since the carbon permit price can change over time. This uncertainty creates significant risk for investors in wind farms, since their revenues depend on the carbon permit price or tax and on potentially volatile wholesale power prices.

Financing represents a much larger share of energy costs for the wind farm compared to the gas power station, because of the much higher capital costs and absence of fuel costs (Mott MacDonald 2010). Finance, however raised, will typically span an extended period, perhaps 15 or 20 years and servicing it will absorb much of the wind farm's revenue. Throughout this period investors will need to be sure that the electricity/carbon price will stay sufficiently high that the wind farm can sell electricity profitably (Gross et al. 2007, Gross et al 2010, DECC 2012).

Ian Temperton describes the effects above in terms of average costs and marginal prices (Temperton 2011). Capital intensive, zero fuel cost power stations like wind farms, need to cover their long run average costs – mainly the cost of capital. They can neither actively affect/set marginal power prices[5] nor respond to power price changes, except to curtail output which does not save costs (as there is no fuel cost to save), but does lose revenue (Temperton 2011, Gross et al. 2007). However carbon prices only affect the marginal price of fuel and power. We should therefore expect that an emissions trading scheme will encourage fuel switching from coal to gas, and efficiency first and renewable energy (or indeed nuclear) investment last[6]. This is exactly what we have seen in reality.

In short, whilst carbon pricing can create conditions that make investment in wind more attractive, there are uncertainties associated with wholesale power prices, carbon permit prices, and future political decisions on carbon tax levels. These make wind investment more risky, which drives up the cost of capital (investors require higher returns), and discourages investment.

These considerations explain why the renewable energy investment community prefers feed-in tariffs, which fix the price of wind-generated electricity, to less certain interventions such as cap and trade schemes (IEA 2008, DBCCA 2009). They also suggest that all other factors being equal, a targeted subsidy will be more economically efficient than a carbon tax at incentivizing the construction of wind farms or other renewables because it will attract investment with a lower cost of capital (i.e at a lower risk premium) (Redpoint 2010, Gross et al. 2007).

It is obviously important to ensure that the policies used to promote deployment of emerging technologies don't over reward and are as cost effective as possible. The means to ensure this are beyond the scope of this paper but the use of degression, reducing subsidies over time or as deployment expands, is a key mechanism (Gross and Heptonstall 2010). It is also important to ensure that policies offer investors a low risk environment with regards to price risks and also lower the cost of capital, hence total burden on consumers. There is a lively debate with regards to the relative merits of fixed price schemes such as Feed in Tariffs relative to quota based schemed such as the UK Renewables Obligation (Gross et al 2007, Gross and Heptonstall, 2010). How best to target support to renewables is not the focus of this paper. However, the risk of over-rewarding highlighted in Part 1 must be set against the cost of capital issues described above. The next question is whether an international carbon price might emerge that approximates to what the climate science suggests is needed, and hence do more to drive investment in low carbon energy.

[5] The presence of large amounts of wind on a power system can depress average wholesale price, whilst also making prices more volatile, but this is rather different from the relationship between gas and power prices where the former sets the latter. For a discussion of the impact of wind on power prices see https://workspace.imperial.ac.uk/icept/Public/WindsofchangeFinal1.pdf

[6] The exception here is biomass fuel switching, where this is possible in a conventional power station.

Political realities and investment

Uncertainty, distributional issues and fossil fuel subsidy

A sufficiently high and stable carbon price would in principle be sufficient to persuade investors to get out of gas and into wind farms irrespective of fuel and power price uncertainty, provided they believed that the high carbon price would sustain for long enough to deliver an adequate return on investment. This section considers the political issues associated with seeking a long run, stable, and sufficiently high carbon price.

Long term credibility of carbon pricing and effect of incomplete international carbon markets

In 2007 Nicholas Stern anticipated the spread globally of regional carbon pricing regimes over the following decade after a global deal to limit greenhouse gas emissions (Stern 2007). As of 2009, 9 Gt of CO_2 emissions had been incorporated into emissions trading schemes, out of a global total of 48 Gt per year (Kossoy et al. 2010, CCC 2008). To date the only major carbon trading regime in the world is the EU Emissions Trading Scheme (ETS), which is currently only guaranteed to operate until 2020. Real emissions savings thus far have been limited due to the weakness of the emissions cap (Ellerman & Buchner 2008, Sandbag 2011). Following slow progress at the Copenhagen and Durban climate change negotiations (Harvey 2011) it is now unclear how quickly, if indeed at all, the spread of carbon markets will take place.

As we discuss below, with the only significant carbon price signal occurring in the EU, there is a risk of carbon leakage whereby energy intensive industries move to markets elsewhere in the world. This not only would impose economic costs on Europe, but it could lead to increases in global emissions – if the carbon intensity of manufacturing in countries without a carbon price is higher.

Furthermore, in many parts of the world carbon is subsidised not taxed. The IEA estimate global fossil fuel end-use subsidies at around $409 billion for the year 2010 (IEA 2012). These are essentially the inverse of a fossil fuel tax, or in another words a negative carbon price. This translates very crudely to a negative average global price on carbon dioxide emissions of around $13.5 /t$CO_2$. Whilst there are wide variations in the level of this price between regions and technologies the overall effect is that fossil fuel subsidies work directly to undermine global carbon pricing.

With carbon prices weak and fossil fuels widely subsidised the evidence of substantial decarbonisation is not encouraging. In their latest World Energy Outlook, the IEA anticipates strong growth in coal to 2030, in stark contrast to the requirements of its own ‘450’ scenario (IEA 2011). The mainstream view from the IEA, oil companies and others is that that fossil fuels will continue to grow strongly to 2030 (B.P. 2011, Shell 2008).

The presence of fossil fuel subsidies and lack of a long term, universal, credible carbon price signal is primarily an argument for broadening and making stronger that carbon price signal, and rolling back fossil fuel subsidy. Some commentators are calling for the ETS to be strengthened post 2020, to do just this (Moore & Less 2012). Greater international political commitment would undoubtedly help. However it is also important to assess some of the reasons that carbon price signals tend to be weak and international negotiations difficult. We need to understand why the politics of climate pricing are challenging.

Distributional issues and international competition – the politics of carbon pricing in the real world

Within economies, it is estimated that the groups hardest hit by carbon pricing are the fossil fuel industries, intensive energy consumers and the least well-off (Fischer 2008, Kalkuhl et al. 2011). The structure and carbon/energy intensity of economies also differs radically, even within the group of wealthy 'Annex 1' countries. This creates political tensions, for social policy, industrial policy and in international climate negotiations – we explore each issue below.

Energy prices and social impacts

Any energy policies paid for through consumer bills have the potential to be regressive, impacting the least well-off more significantly than the rich. This is because poorer people spend a larger proportion of their income on energy, particularly domestic electricity and heating. In Britain, the scale of the impact of support for renewable energy and the cost of the emissions trading scheme (EU ETS)/carbon price support mechanism (or carbon price floor)[7] are similar in terms of cost per household[8]. One distinction between carbon taxes and a renewables support scheme is the opportunity or lack thereof for bill-payers, particularly in poorer households, to benefit from the scheme. The authors argue elsewhere for example that it is possible for policies such as the UK's feed-in tariff for small scale generation to be designed and implemented so that they offer lower income households direct benefit in the form of lower bills (Saunders et al. 2012). By contrast, carbon taxes are often viewed as yet another tax, extracting revenue from consumers with little immediate benefit. The UK's carbon price floor, introduced by the Treasury in 2011 has been singled out for particular criticism in this regard (Maxwell 2011). Carbon taxes can also create windfall benefits for low carbon generation that consumers have already paid for, for example existing nuclear power stations. Of course it is possible to hypothecate carbon taxes to assist poorer consumers, and renewable energy subsidies do not all offer consumers benefits, neither are they universally popular. Nevertheless, experience in other countries suggests that economic benefits from renewable energy subsidies can and do accrue to the wider public and this tends to engender popular support (DBCCA 2009, Toke et al. 2008).

Energy intensive industry

Policymakers in the EU and other economies are also concerned about a loss of competitiveness amongst energy intensive industries, such as the aluminum, cement, steel and chemical sectors. This may also lead to carbon leakage, where domestic emission reductions resulting from carbon commitments "leak", leading to increased emissions in countries with less stringent policies on limiting emissions (Wooders et al. 2009). Hence, industry bodies argue for example that the EU should not increase carbon or renewable energy targets because of the impact on competitiveness (European Steel Association 2010). The scale of such impacts are controversial and some analysts have argued that there may be benefits as well as costs for the tradable sector, particularly in the long run (Romani et al. 2011). It is also possible to ameliorate such impacts, for example, in Denmark reimbursement was provided for energy intensive industries to offset negative effects on competitiveness of the carbon tax (Danish EPA 2000). Nevertheless the concerns of energy intensive industries can resonate strongly with policy makers and certainly militate against strengthening the carbon price.

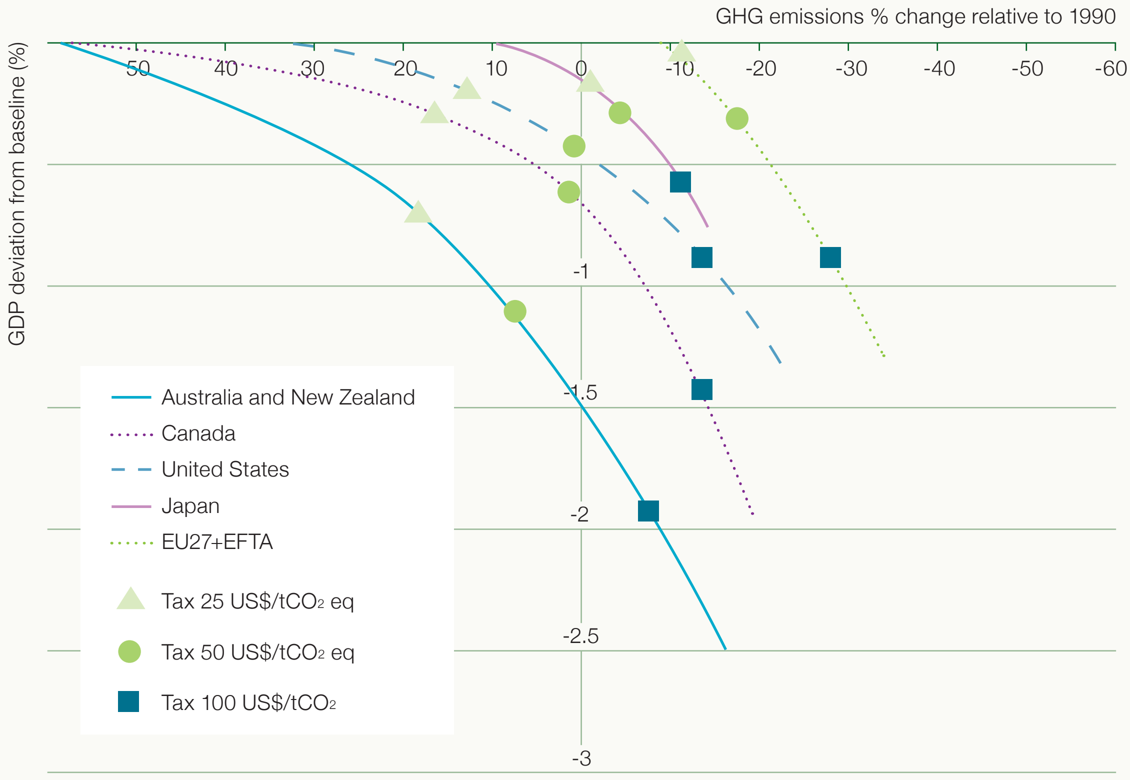
International differences

Variations in the costs of abatement between countries also create political issues for international carbon pricing. Figure 2 shows that among Annex 1 (developed country) signatories to the Kyoto Protocol, relatively modest emissions reductions give rise to large differences in abatement costs as a percentage of gross domestic product (GDP). On the basis of this figure, it could be expected that a carbon-trading scheme among Annex 1 countries would give rise to large flows of cash from Australia, New Zealand and Canada to the EU in order to 'buy' relatively cheaper emissions reductions credits. Such transfers are unlikely to be politically popular in the donor countries. Where developing countries are involved, even more complex ethical issues arise.

[7] The carbon price stabilisation mechanism is a reformed variant of a pre-existing energy tax, the climate change levy. It provides a variable carbon tax on top of the EU ETS. See http://www.hm-treasury.gov.uk/consult_carbon_price_support.htm

[8] See for example DECC's estimate of the cost of policy in 2020 http://www.decc.gov.uk/en/content/cms/infographics/household_bill/household_bill.aspx

Figure 2: Regional costs of a carbon tax at different levels in Annex 1 countries. Author's own, based upon OECD (2009)



As we've already discussed, the main alternative to carbon trading would be a carbon tax, as was proposed for Australia (Business Green 2011). This has the advantage (from an Australian point of view) of avoiding large money flows to Europe but the drawback that the level of tax would need to be considerably higher than the purchase price for allowances from the EU system in order to achieve the same level of abatement. In short, carbon pricing is difficult because it can be presented as a regressive tax that damages traditional industries, and benefits some countries more than others.

It is tempting to exhort governments to 'try harder' in the face of the problems described here. Of course burden sharing and co-operation at an international level is to be desired given the significance of the climate change problem. However the proposition that politicians should just 'do more' appears to rather misunderstand the nature of politics. It is to be expected that leaders stand up for their interests in international negotiations (however narrow), try to help their industries sustain/create jobs and to protect the most vulnerable. Climate change represents a formidable collective action problem.

Rather than ignore the politics of the problem we suggest that policies which both encourage low carbon energy and are politically expedient should be viewed as complements to global carbon pricing. This does not mean that targeted subsidies are merely 'second best' alternatives to be used when carbon prices cannot be implemented fully. Renewable energy subsidies also make long run and international carbon prices easier to impose. This is because they have what economists call dynamic effects: they foster innovation, and harness powerful economic forces that can promote lower costs and better performance, as Part 5 explains.

Increasing returns

Avoiding lock-in to high carbon and using lock-in to benefit low carbon

Lock-in path dependence and increasing returns to adoption

A large body of literature argues that the responsiveness of the energy sector to a carbon price is severely impaired by technological and institutional 'lock-in' to high carbon infrastructure which prevents low carbon technologies with the potential for low long term costs from breaking through (Unruh 2000, David 1985, Arthur 1989, Gross & Heptonstall 2010). A famous case study of lock-in in the general economic literature is the example of the QWERTY keyboard, designed to deliberately reduce typing speed to prevent jamming by mechanical typewriters, which persisted despite the invention of the technically superior Dvorak keyboard (David 1985), and indeed despite the development of word processors that rendered any mechanical constraints on typing obsolete.

Such 'lock-in' occurs due to increasing returns to adoption (Arthur 1989), whereby the more people who learned to type on QWERTY keyboards, the greater the revenues to be made from selling a typewriter (then computer) with a keyboard compatible with already existing trained behaviour. In the energy sector, such 'network externalities' arise for example in the physical structures of large scale high voltage alternating current (AC) power grids (themselves a reminder of early energy planners' desire to locate power stations close to the sources of coal), which now provide a cost advantage to large scale centralised generation over distributed alternatives (Unruh 2000). Lock-in also exists in institutions and regulations, skills and expectations, and in the form of lobby interests (Ibid). Another example would be the lock-in of nuclear reactors powered by uranium over thorium because of the early lead gained by military pressurised water reactors in the 1960s (Cowan 1990). Lock-in occurs for a variety of reasons, including various forms of learning (experience increases and costs fall), so called adaptive expectations, where consumers become accustomed to particular products or systems, as well as the network effects described above (David 1985).

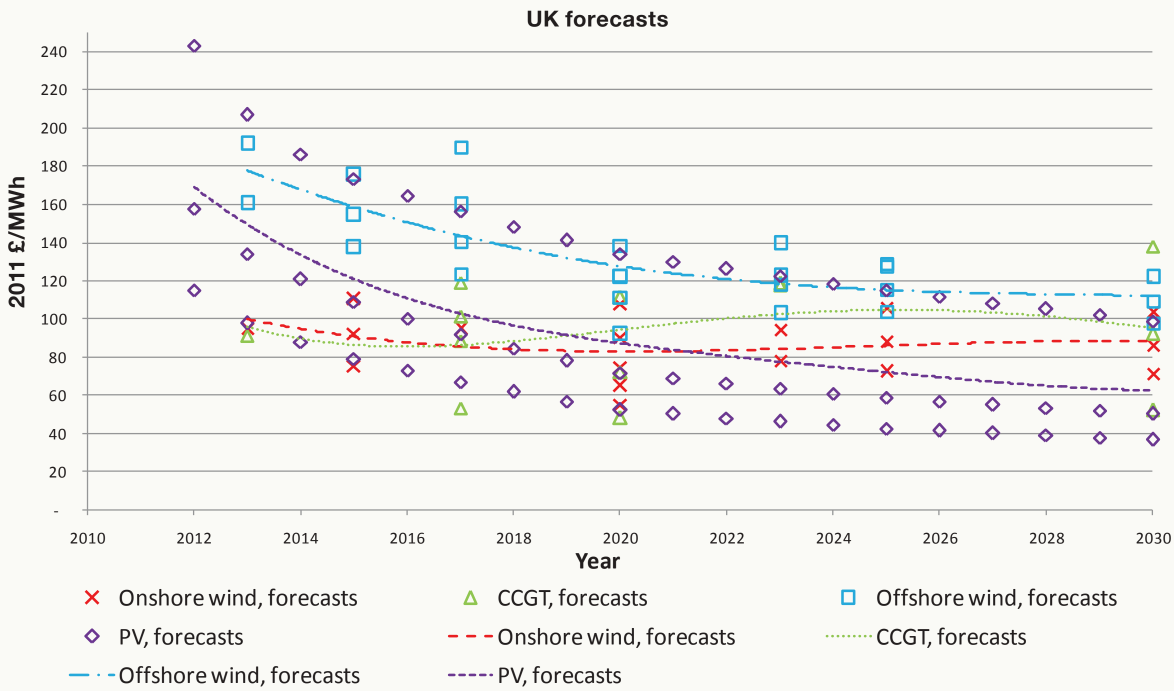
Harnessing increasing returns: lock-in as a positive force

The phenomenon of 'learning by doing', whereby costs for technologies reduce as experience is gained from deployment of the technology creates lock-in. It also creates better, cheaper technologies. The incumbent fossil and nuclear forms of generation have had many decades of technical refinement through experience which have driven their costs down to low levels relative to new, renewable alternatives. In part, this was financed by considerable public subsidy – either direct as in the case of nuclear or as a spill-over from military investment in other, related, technology sectors. This is notable in the case of gas power stations (combined cycle gas turbines, CCGT) - for example, in the USA alone, military spending to improve the turbojet amounted to USD450 million per year between 1976 and 1986 (Williams & Larson 1998).

The very same effects that created lock-in to high carbon systems offer the potential to decrease the costs and improve the commercial/consumer attractiveness of new forms of low carbon energy. Lock-in, properly understood as an economic phenomenon that occurs as the components of technological systems co-evolve through time, is not something that it is possible to avoid. Indeed it is not even desirable to do so because it results in lower costs and an integrated set of technologies and systems that work together. Lock-in to today's energy system emerged because throughout the 19th and 20th centuries, the more the human race used fossil fuels the better we got at extracting and using them. Path dependence has created a cheap, convenient and reliable (but largely fossil fuel based) energy system. Looking to the future, it is to be hoped that the more the human race uses non-fossil technologies the better we will get at deploying and harnessing them too. Learning, co-evolution and path dependence offer the potential, over time, for a cheap, convenient and reliable low carbon system to emerge.

Renewable technologies are at a comparatively early stage in the learning process, but have already shown considerable potential for learning as demonstrated by the solar photovoltaic (PV) industry, where price reductions have averaged 22% per doubling of sales since 1979 (EPIA 2010). Numerous sources show the costs of renewables declining further in future. For example the Committee on Climate Change shows that there is considerable potential for these technologies to reach cost competitiveness in the UK by 2030 (CCC 2010). Recent engineering-based assessment of offshore wind suggests that it offers potential for cost reduction over the coming years (BVG Associates 2012). Forthcoming research by the authors for UKERC (see Figure 3) shows a similar pattern, with costs of renewables falling and gas and renewables lying in an overlapping range in the period from around 2025, depending upon assumptions about gas prices and learning effects.

Figure 3:
Comparative costs of electricity from gas fired CCGT, onshore and offshore wind, and PV[9]



Creating markets and avoiding the valley of death: The need for policy

Learning and other sources of increasing return are usually facilitated through various niche markets (Geels 2002, Kemp et al. 1998, Utterbach 1994). In many sectors, and particularly those which tend to have high levels of innovation, products are differentiated qualitatively and niche markets emerge because consumers (so called early adopters) are willing to pay a premium for the advances associated with a new technology. Put another way, a small market for new, more expensive technologies exists because some consumers want the new product even though it is expensive. Mobile phone devices are an obvious example. There is some evidence that conspicuously 'green' products such as hybrid cars benefit from a consumer led niche market (Ozaki & Sevastyanova 2011). However, in the case of electricity product differentiation is largely zero and consumers are largely passive, so for the most part markets for early stage technologies can only emerge when policies permit. Put simply, in the low carbon electricity sector deployment requires policy, and policy needs to provide the chance for new technologies to establish themselves, for costs to fall and performance to improve. This is the role that feed-in tariffs and policies such as the UK Renewables Obligation can fulfil.

It is important to be clear that support needs to be sustained throughout the deployment and dissemination phase rather than stop with government funded R&D or demonstration projects. Numerous academic analyses of innovation have explained the need for policies that provide both 'demand pull' (a market for low carbon technologies) and 'supply push' (R&D into low carbon technologies) (Grubb 2004). Moreover, effective support for innovation requires that policies are not subject to a 'missing middle' (also referred to as the valley of death) where innovation and development falter when grant funded R&D ends and fully commercial deployment remains a remote prospect (Foxon et al. 2005).

The role of learning and importance of market deployment is not merely an abstract concept of interest to academic innovation economists; it is also an empirically proven phenomenon, subject to real world assessment and offering real world technological and policy lessons. Learning curves, which chart empirically the relationship between market growth and cost reduction, are well documented for a wide range of products, including energy technologies (IEA 2000). The logic of the learning curve suggests that it is possible for policy to 'buy down' costs by stimulating markets. It is important to note here that if a technology is not cost competitive, yet the existence of learning is well established (for example say solar photovoltaics) then we can estimate (approximately) the total cost of the period of buy-down (depending on assumptions regarding deployment rates) (Ibid). Moreover, for technologies that are currently considerably more expensive than conventional alternatives, the total cost of buy down will be much lower if policy targets that specific market than if a more generalised measure is used, such as a carbon tax.

This goes to the heart of the problem with the 'don't pick winners' mantra. As every gambler knows, backing every horse only benefits the bookmakers. Hence recent arguments that policy should avoid 'lavishing huge levels of subsidy in attempt to mass deploy technologies earlier than is efficient, not waiting for technologies to prove themselves nor develop down the cost curve' (McIlveen 2010) fail to attend to the basic point that, in the absence of incentives that create early markets, technologies may struggle to prove themselves and find it much harder to move down the cost curve. Similarly the proposition that 'mass deployment… should be driven by technology neutral carbon pricing…' (Ibid) fails to understand that setting carbon prices high enough to do so is far more economically disruptive and less likely to be effective than targeted support for markets in emerging technologies, using measures which investors can have confidence in.

[9] Based upon ongoing UKERC research, which is undertaking a thorough meta-analysis of estimates of the costs of electricity generation technologies, examining how those estimates are arrived at, and assessing what lessons can be drawn from the accuracy or otherwise of past estimates and projections. The wide range of UK forecasts result from differing assumptions that studies have adopted for key cost drivers such as capital and operating costs, plant load factors, fuel costs (in the case of gas plant), and discount rates. http://www.ukerc.ac.uk/support/tiki-index.php?page=Cost+Methodologiestikhp?page=Cost+Methodologies

The implications of lock-in: conclusions on innovation theory and policy

Looking forward, targeted subsidy can create early markets for emerging technologies, yield increasing returns to adoption and help low carbon technologies move along their learning curve. In the meantime the long asset lives of coal and gas plants (and associated institutions, commercial/lobby interests and skill sets) mean that investment decisions made in the short term result in carbon 'lock-in' that lasts for several decades. This leads to two key policy conclusions:

- Action now to encourage low carbon investment can induce innovation and increasing returns to adoption, driving down future costs in low carbon options
- The absence of action now to prevent new high carbon investment will further lock the energy system into high carbon assets with long lives

In the absence of a global agreement and international carbon price the risk of lock-in to coal and gas suggests that national governments should seek to minimise construction of high carbon assets, for example through an emissions performance standard or direct regulation (e.g. banning new coal without CCS). Alongside this, feed-in tariffs or similar, should allow renewable energy to progress along a learning curve, making a future global carbon agreements or pricing easier to achieve.

Neoclassical concepts of external costs aren't wrong in principle, merely rather simplistic, and inherently static. But the development of low carbon energy is a dynamic proposition; mitigation costs are not fixed, over time with the right policies they can be reduced. Solving climate change requires policymakers to harness increasing returns to adoption through policies that make investment in non-fossil energy possible. Doing so will allow an opportunity for technological development, learning, and cost reduction. Pricing carbon is a partial solution, but to the extent that it is not conducive to low carbon investment it is neither sufficient nor optimal. Neoclassical economics needs to give way to an economics that sees technological change as an evolutionary process, and is rich in understanding of technology and innovation. Hopefully then it will become easier to identify an appropriate mix of policies. The evidence on this is addressed in the final section of the paper.

The best of all worlds?

A portfolio of policies to address climate change

To recap our main arguments:
There are theoretical arguments in favour of carbon pricing as a 'first best' and sufficient policy to promote low carbon. Theoretical arguments also suggest that technology specific subsidies are distortionary and unhelpful. However, the theoretical conditions under which the 'optimal' carbon price can be determined do not apply in the real world and carbon prices or caps need to be set pragmatically.

Whilst in theory subsidies might create a deadweight loss, in practice this will depend on whether the tax or cap was set at an optimum level to start with and how the subsidy changes each country's ability to abate over time. The significance of any notional loss of theoretical economic efficiency needs to be weighed against the benefits of targeted subsidy. Both categories of intervention need to be judged empirically, in terms of what works, not what is theoretically optimal in abstract.

The neoclassical model also fails to address the needs of the investment community for stable and investable policies and doesn't engage with the dynamic effects that drive innovation and reduce costs as deployment increases.

Meanwhile, the difficulties associated with carbon pricing under real world political constraints are considerable, which suggests that long run and stable prices with international reach are unlikely to be realised for some time. Technology specific subsidies offer a complementary approach and the long run potential to promote innovation, reducing costs and facilitating future carbon pricing. Taking into account arguments broadly similar to these, Stern concluded that a portfolio approach is required to address climate change (Stern 2007). Stern's 'three pillars' are a combination of:

- Measures to price carbon;
- Deployment and R&D subsidies to drive innovation and;
- Regulation to address behavioural barriers, particularly in energy efficiency.

Setting an appropriate mix of policies then becomes a legitimate analytical concern, one that might be amenable to numerical analysis. A number of economic modelling exercises explore the balance of Stern's proposed policy mix. Annex 1 summarises some of those reviewed for this report.

Many studies stress complementarities. For example Sinn (2008) shows that without adequate global carbon pricing, switches to low carbon technologies by 'good' countries will lead to lower international fossil fuel prices and as a result greater fossil fuel consumption by 'bad' countries, saving no net carbon emissions. Similarly, Kalkuhl argues that as the use of low carbon technologies expands (through targeted subsidies) demand for fossil fuels falls, hence price falls, which risks a 'rebound effect' (Kalkukl 2012) (rebounds are discussed in detail in Sorrell 2007). However, few studies favour abandoning technology subsidies altogether either. Operating a carbon price or renewable subsidies in isolation was generally found to be more costly, while combining the use of different policies sometimes allowed the price of carbon to be lower than in a carbon price only situation (Fischer & Newell 2008, Grimaud & Lafforgue 2008, Schmidt & Marschinski 2009).

While modelling studies provide some insight into how potential policies may play out in the future, it is also important to be realistic about the difficulties associated with modelling in the face of very great long run uncertainties and in the absence of historical empirical data (for example long term experience with carbon pricing). In many cases model runs go out over several decades, even the entirety of the current century. Over such timescales uncertainties become huge. Framing assumptions have an enormous bearing on outcomes, and judgements about potential future returns to scale, or future learning capacities for specific technologies can make a big difference to the costs or benefits of renewable subsidies (Gerlagh & van der Zwaan 2006).

The insights provided by modelling exercises therefore need to be weighed against the inherent challenges in anticipating long term changes in prices, price responses and technology or societal development, whether in response to specific policy or otherwise.

This suggests that global society is still experimenting with policies, still gathering data on 'what works' in the struggle to contain greenhouse gases. Pragmatically, it appears that there is considerable evidence that targeted subsidies, and particularly feed-in tariffs, are establishing a track record. Viewed in terms of promoting low carbon investment, driving innovation and promoting lower cost low carbon technologies there is considerable evidence that they do work. The evidence thus far on carbon pricing is not so much that it does not work but rather that experience with carbon tax and trading has been limited. What we can say is that widespread and meaningful carbon pricing is extremely difficult to achieve.

Writing in 2001, in a seminal paper on innovation policy (Anderson et al. 2001), the late Professor Dennis Anderson put it thus:

'Because it takes time to develop and implement low pollution alternatives, the short-run elasticities of response to standard policy instruments are small. Thus instruments like environmental taxes raise revenues, and raise hackles, while having limited short-term returns in terms of pollution abatement. This can give rise to political and economic difficulties which hamper policymaking and reduce the pace of change. Of course, in the longer term such policies do send the right signals and engender change. Direct support for innovation and technology development can accelerate the process. Further, by creating options it can facilitate a political and public commitment to a constructive approach - combining short term acceptability with longer term objectives.'

Eleven years later it is clear that Professor Anderson was right. Technology policies work, whilst unfortunately the political and economic difficulties surrounding carbon pricing have proved large. Yet there is still considerable work to do to build a shared political understanding of the need for a portfolio of policies, and the need for policy to do more than just price carbon in the battle to halt climate change. Properly understood, targeted technology subsidies offer the potential to assist in delivering long run, international and meaningful levels of carbon pricing. In so doing they can help mankind develop cost effective low carbon options, cut carbon emissions and reduce the risks of dangerous climate change.

Annex 1

Economic modelling studies on carbon pricing, R&D and deployment subsidies

Author(s)	Type of model	Market failures modelled	Finding(s)
Kalkuhl (2012)	General Equilibrium	Learning effects, R&D spillovers, carbon externality	Technology specific subsidies combined with carbon pricing is welfare optimal. Second best is quota system for learning technologies. Both subsidies outperformed carbon pricing alone
Nordhaus (2009)	Simultaneous equations	Climate externality, R&D spillovers	Optimal solution achieved through carbon tax and R&D tax credit
Fisher (2008)	General equilibrium	Learning effects, carbon externality	Optimal policy combines technology specific subsidies and carbon pricing.
Grimaud & Lafforgue (2008)	General equilibrium	Knowledge spill-overs from R&D, climate change	Optimal policy portfolio entails both emissions pricing and subsidies to R&D on renewables
Gerlagh & van der Zwaan (2006)	General Equilibrium	Carbon externality	Carbon intensity portfolio standard, involving the recycling of carbon taxes to support renewables deployment - most cost-efficient way to address global climate change

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