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Linking Carbon Markets and Technology Support Mechanisms: Making Sense of the EU Climate Change Package

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The EU is currently at a hectic stage in the development of its internal climate change policies. Having proposed a package of measures in January 2008, the Commission is now in negotiation with parliament and Member States, aiming to finalize a deal by the end of the year. The key elements include proposals to improve and extend the EU emissions trading scheme (Europe's flagship carbon market), an allocation of effort between member states on reducing emissions, and an ambitious Directive to meet 20% of the EU's total energy demand from renewable sources. There is also ongoing debate over the support for the demonstration of carbon capture and storage (CCS) technology. Added into this mix are the international climate change negotiations which are supposed to reach a global deal by the end of 2009. The outcome of these international negotiations has a direct link to the internal EU package because the European Council has proposed that the EU target of a 20% abatement of emissions by 2020 would rise to a significantly more ambitious 30% abatement target if other major countries came on board with comparable commitments.

Because they all tackle emissions from the same key sources, there is significant scope for these wide-ranging and potentially transformative proposals to undermine each other. This paper introduces a novel way of looking at the interaction between carbon markets and technology support mechanisms with the hope that an intuitive picture of the fundamentals will promote a clearer and more productive policy dialogue. Using CCS and renewable energy as an illustration, the paper shows how supporting early stage technology development may reduce the overall cost of meeting an abatement target, whilst supporting large-scale technology deployment through separate policy mechanisms will tend to suppress the carbon price, weaken investment incentives for other low carbon technologies and increase the overall costs of reaching the abatement target.

Proponents of carbon markets claim that they are the most effective way of directing capital to the cheapest sources of emission reductions, thereby meeting emissions reduction targets at least cost. The theory behind this is linked to the familiar representation of a 'marginal abatement curve' which ranks the costs of various options for reducing emissions as shown in Figure 1. Doing the cheapest things first is economically efficient if we expect to be richer in the future and therefore have positive discount rates for future expenditure. In this view of the world, all you need to do is set a target for reduction of emissions, and the market will deliver the most economically efficient outcome.

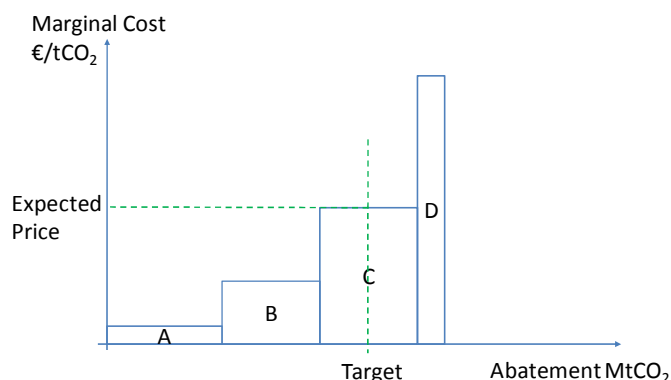


Figure 1. Standard representation of a marginal abatement curve

On the other hand, this classical view does not capture the dynamics of technology development. In particular, technology learning in which costs come down as a result of economies of scale and supply chain development, as well as issues around the costs of new infrastructure tend to be left out of the simple ‘snapshot’ of costs that are included in the ‘marginal abatement curve’ representation. In fact, the technology learning view of the world has precisely the opposite relationship between price and quantity as shown in Figure 2. In this view of the world, you cannot get to the cheap abatement options until you have first been through the more costly stages of research, development and demonstration of the technologies.

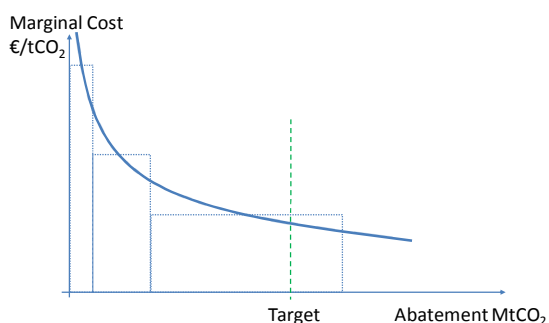


Figure 2. Technology learning curve

The contradiction between these two world views is well known, and it is becoming increasingly recognised that carbon markets on their own will not deliver the structural changes to the energy system needed to meet the energy security and climate security challenges over the coming decades. But without a coherent mental model which can bridge the gap between the above two competing world views, it is easy to get drawn into confused thinking about how to combine different policy mechanisms to best achieve energy policy goals.

In fact, a new description of the problem can be constructed by simply combining the above two pictures into a 'cost + learning' curve (Figure 3). In this hybrid world view, the technologies are still placed in order of ascending cost as in Figure 1, except in cases where the availability of the technology is dependent on a previous more costly development phase. In Figure 3, the first tranche of technology D represents the early deployment version which will be more expensive than subsequent tranches of the same technology D_2 and D_3 . However, D_2 and D_3 are contingent on D_1 having occurred first. A pure carbon price signal would tend to drive investment up through the ranks of successively more expensive technologies. In this situation, the mature version D_3 may get stuck behind the development phase of the technology which would not be incentivized until much higher carbon prices were reached. In this situation, abatement option C gets prioritized over option D_3 despite being more expensive. Deploying technologies in this order may lead to a sub-optimal economic outcome.

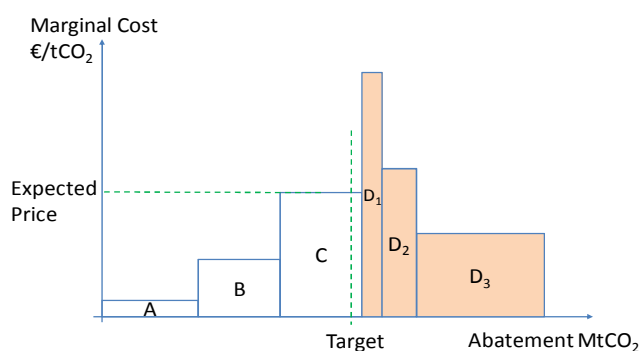


Figure 3. A combined cost + learning curve

The solution is to bring forward the development phases D_1 and D_2 in order to allow the mature technology tranche D_3 to take its natural place in the ranking (as shown in Figure 4). The cheaper technology D_3 is now setting the carbon price at a lower level. In fact, bringing technologies to the front of the curve is what happens any time an abatement option is subsidized over and above the prevailing level of the market price of carbon, as is the case for example with renewable energy support mechanisms. Notice that doing so shifts the rest of the curve to the right, effectively displacing cheaper options A and B, and suppressing the expected carbon price. This only makes economic sense if doing so unlocks the potential to access cheaper emission reductions in the future.

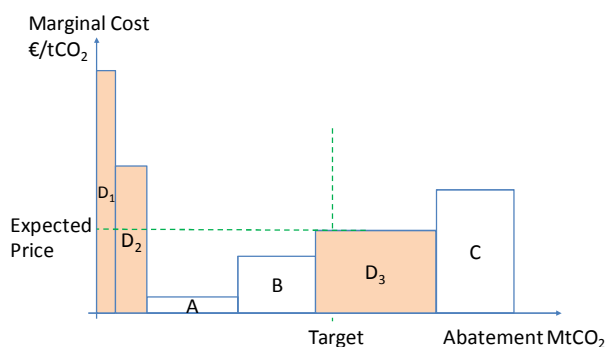


Figure 4. Supporting early technology development allows the mature technology to enter the abatement curve in its natural place

Moving technologies D_1 and D_2 to the front of the curve requires additional financial outlay which will not be covered by the carbon price. Who pays these additional costs is a separate question relating to the classical economic idea of an R&D externality. If the technology development phases D_1 and D_2 are likely to lead to substantial new private-sector intellectual property, allowing companies to recoup these investments through licensing of the technology to other users, for example, then there is a case for expecting this initial upfront investment to be made by private capital. On the other hand, if many companies are likely to benefit from the cost-reduction effects of the initial development phase, then it will be hard for the first-movers to appropriate the benefits of their investments creating a barrier to investment. In this situation there is a case for public financial support for the technology development phase.

Using this approach, a quantitative model has been developed to support climate policy analysis as part of an ongoing research programme being carried out by the author in collaboration with London Business School.¹ The model comprises an economic analysis of 14 key technology options available over different timeframes for reducing emissions in the sectors currently covered by the EU emissions trading scheme EU-ETS (i.e. the power sector plus large industry). The model allows a 'cost + learning' curve to be built up for each 5-year period out to 2030, with the option to bring various technologies to the front of the curve as in the figures above. The model allows for uncertainty in the cost and quantity of abatement that each option will deliver, and uncertainty in the baseline, so that ranges can be calculated for the total cost and marginal price of achieving any particular abatement target. The model has been developed using data from PRIMES

¹ The author would like to thank in particular Prof. Derek Bunn from London Business School for his collaboration in this research.

(the economy-wide energy model used by the EU Commission) together with technology cost data from the IEA and BERR. There are several aspects of climate policy that the model can be used to analyse, including carbon price formation and risk, policy interactions, and economic analysis of technology support mechanisms. The case below looks in particular at the economic rationale for supporting early-stage technology development, using carbon capture and storage as an illustrative example.

To provide a concrete example, we can look at the case for supporting the early stages of carbon capture and storage technology development. The model is set up to include the abatement options available for meeting the proposed targets for the EU emissions trading scheme to 2020 and the subsequent proposed rate of reduction in emissions beyond that to 2030. There has been a proposal by the European Council that 12 full-scale CCS demonstration plants be built in the EU by 2015. However, no agreement has yet been reached on who would fund these. There seems to be a good case for public funding given the difficulty of obtaining any kind of intellectual property rights since the underlying technologies have mostly been proven at smaller scale in other applications.

If CCS support is thought of as bringing the early development phase to the 'front of the curve', allowing access to the mature technology, then we can look at the effects of this on the economics of meeting indicative targets at the 2030 timescale. The mature technology phase of CCS is estimated to require a carbon price in the region of €50/tCO₂ to support commercial development, whereas the initial demonstration phase could be at least three times more costly than this. If this is the case, then the annual cost of the 12 demonstration plants, assuming an average capacity of 300MW for each, would be in the region of €3bn. Escalating this up using a discount rate of 5% to compare it to measures taken in 2030 puts the annual price tag at €5.7bn in 2030 value terms.

If the overall emission reduction target for the EU is set at 20% by 2020 with a continued downward trend to 2030, then the total annual cost in 2030 of meeting the corresponding EU-ETS target without early support of CCS would be approximately €23bn under best-guess estimates for technology costs and availability. Under these best-guess costs, the initial outlay for CCS does not get recouped over the 2030 timescale. Including the first tranche of investment *increases* the central estimate for the total cost of meeting the 2030 target to around €27bn. This is because under the central fuel price scenario in PRIMES, the cost of building new gas-fired generation, also in the region of €50/tCO₂ would be slightly less than the expected mature

technology costs for CCS, so that CCS would not actually need to be deployed in order to meet the abatement target. However, there may be various reasons to want to avoid such an increase in reliance on gas generation, notably because this would raise the proportion of gas in the generation mix and lead to a greater exposure of the electricity system to price variability of gas supplies.

In a more ambitious policy environment where the EU aims to meet a 30% emission reduction target by 2020, and where this rate of reduction is continued to 2030, the case for early CCS demonstration becomes more convincing. If the technology development stage for CCS is not carried out early on, then a range of more expensive options start to be deployed to meet the corresponding EU-ETS target including additional use of biomass and credits from the clean development mechanism (CDM), leading to an overall annual cost of just over €50bn. If CCS demonstration is carried out in time to enable commercial deployment by 2030, these costs could be brought down to a central estimate of €42bn. In fact, this more ambitious scenario for 2030 is probably not ambitious enough to meet the EU's proposed target of halving global emissions by 2050. It corresponds to approximately a 3% year-on-year decarbonization rate which would reduce emissions for the EU-ETS by around 70% by 2050 compared with current levels. Under any reasonable burden sharing of the global 50% target, the EU would need to achieve emission reductions of around 80% or more for the economy as a whole by 2050, and the power sector would probably need to achieve proportionately more (i.e. close to complete decarbonization). In this scenario, the case for early support for new technologies becomes even more convincing.

The ranges on these cost estimates are very large, in the region of \pm €40bn around the central best-guess estimates. In other words, the uncertainty in costs swamps the cost differences introduced by whether or not CCS is supported. A large part of this uncertainty stems from uncertainty around the cost of fuel, as well as uncertainty over 'business-as-usual' emissions levels. In reality, policy targets are likely to adapt to some extent to the facts on the ground as they develop over these timescales, but from an *a priori* perspective there may be good reasons to want to limit this range of costs. Cost containment in the form of caps and floors on prices in the emissions trading scheme have been discussed in various forums, but another way to constrain the range of costs may be to promote a diversity of technologies in the abatement curve. Although all technologies will have uncertainties associated with them, being able to pick the cheapest from a range of

different technologies is likely to lead to a cheaper outcome than being saddled with only a few options.

The case for separate policy mechanisms to support large-scale deployment of mature technologies is less convincing. The above picture can be used to understand the effect of the renewable energy directive on the carbon price. Since the Directive supports renewables through policy mechanisms that are independent of the EU-ETS, it will have the effect of bringing significant amounts of emission reductions to the front of the abatement curve. In order to meet the overall 20% target, the power sector will need to deliver between 30% and 37% renewables by 2020, up from current levels of 15%. This will deliver around a third of the target emission reductions for the EU-ETS, pushing the rest of the abatement curve to the right, suppressing the average carbon and reducing the price signal for other emission reduction investments. Early modelling results indicate that under a scenario of 20% overall emission reduction by 2020, the introduction of the additional renewables reduces the carbon price by about 30%. In addition to reducing the carbon price, the additional support for renewables raises the risk of a carbon price collapse (say to below €10/tCO₂) from close to zero to around a 10% chance. This combination of reduced price expectation and higher price risk undermines the investment signals that the carbon market is intended to create. A coherent policy response to this problem would be to make the greenhouse gas abatement targets more ambitious in line with the ambition of other technology support policies in order to create a robust price expectation in the carbon market.

The other economic consequence of large-scale technology support is to increase the overall costs of meeting the EU-ETS target because the area under the curve becomes greater when more expensive technologies are brought *en masse* to the front of the curve. The central estimate for meeting the EU-ETS share of a 20% abatement target in 2020 rises from around €20bn to €40bn when the additional renewables are brought to the front of the abatement curve. Extrapolating these trends to 2030, the annual cost of abatement rises from €30bn to €90bn with the additional renewables. The cost of meeting the more ambitious 30% overall abatement target increases as a result of the additional renewables, from around €30bn to €50bn in 2020 and from €40bn to €110bn in 2030. Again, the ranges on these figures are substantial, in the order of ±€15bn by 2020 and ±€25bn by 2030. To get a picture of the scale of these cost increases, these figures can be compared with a retail value for the annual electricity supply within the EU in the order of

€300bn; these costs are therefore substantial, but not overwhelming compared to the current costs borne by consumers.

The point of presenting these costs is not to suggest that the investments are not worthwhile. Clearly, these additional costs need to be weighed against the benefits from reducing climate change impacts and addressing other externalities such as energy security. The question is what is the best policy framework for internalising these externalities.

The support packages that will be put in place to meet the EU 20% renewable energy target are mostly not intended to address market failures in delivering sufficient R&D. Much of the target will be met by onshore wind, an already mature technology with little prospect of significant cost reductions. The issue here is not support for R&D, but support for large-scale technology deployment. In principle, a carbon market could provide the necessary financial incentives to support the financing of such technologies, but it is unrealistic to hope that targets for the EU-ETS could be ramped up sufficiently quickly to meet the 2020 targets – proposals for the EU-ETS are nowhere near that ambitious.

For CCS on the other hand, once the initial development phase is over, support for large-scale deployment should be through the carbon market rather than a new policy mechanism. This applies mainly to the period after 2020, so may seem like a long-term problem that doesn't matter now. However, significant investments in new power generation capacity are due to be made over the next few years to replace a wave of retirements by 2015, and expectations over the future of the EU-ETS are vital in supporting these investment decisions now.

The focus should be on creating an expectation that future emission reduction targets will be sufficiently stringent that carbon markets will support CCS and other mature technologies such as wind power. This is not only an economically efficient solution, but also a politically more robust model. The temptation to create separate support mechanisms for each abatement technology should be resisted. The result would be a fragmented and fragile policy approach where the strength of each support mechanism would be dependent upon the lobbying power of different interest groups. This would leave the carbon market to pick up the leftovers, resulting in lower and more volatile prices, weakening incentives to improve energy efficiency, and leaving little choice to be made in meeting targets other than switching to more gas-fired power generation.

William Blyth is an Associate Fellow on the Energy, Environment and Development Programme at Chatham House. He would like to acknowledge the financial support of the Electric Power Research Institute in developing this research.