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DRIVING CO_2 CAPTURE AND STORAGE IN THE EU: NEW POLICIES, NEW PERSPECTIVES

BEST

Executive Summary and Policy Recommendations

The current suite of EU-level policies provides effective, targeted support to wind, solar, biomass, cogeneration and energy efficiency abatement opportunities – but not CCS. This makes CCS especially dependent on the EU Emissions Trading System (ETS) and the related NER300 scheme to drive its deployment.

However, because the CO2 price in the EU has been much lower than anticipated, the current EU policy framework is not simply trying to pick winners but effectively picking CCS as a loser. Until a structural reform of the ETS can be realized, targeted support for CCS will be necessary.

CCS is unique as a climate abatement tool because it is the sole technology able to decarbonise certain emissions-intensive industrial processes, such as cement and steel production. Its development will thus be crucial in any ambitious future emission reduction scenarios, irrelevant of energy sourcing. Additionally, when combined with biomass, CCS provides the only large scale route for net negative emissions.

The cost of tackling climate change is moving up the political agenda. At this stage in the long-term transition to low-carbon energy, CCS may be able to cost-effectively deliver large amounts of CO2 abatement. Without timely and bold action, however, the EU will lag behind other regions in the world in the deployment of CCS, needlessly increasing the cost of decarbonisation to EU taxpayers and consumers.

In light of the above, Bellona recommends a core EU CCS policy framework comprised of:

1. An overarching EU-wide CCS target; and

2. Complementary market incentive schemes at the national-level.

Every EU CCS projects so far has relied upon a tailor-made blend of several funding mechanisms, suggesting that the policy measures will almost inevitably be deployed in overlap with each other. The proposed EU policy framework pays special attention this fact, as well as to the politico-economic context within the Union, where parallel layers of government can complicate the design and administration of energy policies. Different kinds of policies are best implemented by different levels of government.

An EU CCS Target

At the EU-level, Bellona recommends that the Union adopt a CCS milestone analogous to its '20% by 2020' renewable energy target. A legally binding EU requirement for Member States to capture an agreed percentage of their total CO2 emissions by 2030 would be a politically salient and mobilizing goal, driving CCS deployment in both the power and non-power sectors. It would reassure investors of the political commitment to CCS, but still be flexible enough to complement other policy initiatives at the EU- or national-levels. It would also accommodate Member State differences in ability and willingness to deploy CCS.

Should a CCS milestone prove too difficult to agree, however, a constructive fall-back option would be the adjustment of the current EU renewables target to allow it to be met through CCS in the future. For example, instead of a 2030 renewable energy target, a low-carbon energy target would grant Member States increased freedom to choose a decarbonisation trajectory that best matched their strengths. It would permit CCS to compete on a level playing field in the EU, allowing it to find a suitable niche in the energy mix.

National market incentive schemes

This overarching EU-wide target should then be coupled with a complementary blend of CCS market incentive schemes at the national level. These would better cater to the significant differences between Member States in terms of: 1) the structure of their electricity markets; 2) public opinion on energy sources and use; 3) ideological preferences on the modalities of government intervention; and 4) the fiscal capacity to fund policies. Additionally, because most incentive schemes require the direct management of funds with market actors, they are most suitably realized through national authorities.

There have been many positive examples of the use of financial incentives to shape energy markets in EU Member States: Grant schemes, loan guarantees, green certificates, capacity auctions, purchase contracts and feebates have all been successfully employed. Each has their merits and a place in the policy maker's toolbox.

Amongst the policies examined, however, feed-in tariffs arguably offer investors the greatest security of income. This is because well-designed feed-in tariffs provide financial support to power plants in a form that best ensures them of access to the electricity grid, reducing both revenue risk and price risk for investors. For this reason, they have been very successful in driving the deployment of other forms of low-carbon technology in the EU.

An EU CCS certificate system

Alternatively, the EU could put in place a CCS market incentive scheme itself. Most promisingly, an EU-wide CCS certificate scheme could see the EU issue tradable certificates to CCS power plants for the electricity they produce. Utilities would then be obliged to acquire a certain number of certificates for the CO2 they emit, giving the certificates a monetary value that would provide a supplementary income to CCS producers. There would be no need for EU institutions to directly manage revenues – the Union would simply control the scarcity of certificates, indirectly giving them value to their bearers.

The advantage of a pan-European CCS market incentive scheme is that it is more compatible with the EU's single-market ambitions. The larger market for tradable certificates would also put greater downward pressure on CCS costs.

A note of caution, however: Whilst an EU-wide market based instruments for CCS is theoretically attractive, great care will have to be taken to ensure that it neither fall prey to the shortcomings of the EU ETS, nor undermine its operation. The challenges faced by the ETS suggest that the successful implementation of an EU CCS certificate scheme will be conditional upon a substantial resolve on the part of Member States to broaden the EU's mandate and build the competences necessary to effectively and flexibly administer such a scheme on a large scale.

Other EU recommendations

Around this core policy framework, there are several other stand-alone actions that would greatly facilitate the deployment of CCS in the EU.

First, future EU CCS grant schemes – including a possible continuation of the NER model – should be administered by an inter-service panel drawn from DG CLIMA, DG ENER and DG ENTR.

Secondly, EU legislation should be put in place to ensure sufficient grid access for CCS electricity generation in the same way that priority grid access for renewable energy and cogeneration facilities is mandated by EU law.

And finally, the EU should strongly consider how limited border carbon adjustment measures could help specific industrial sectors address the dangers of carbon leakage should they deploy CCS. Whilst significant practical questions remain about such schemes, competitiveness is a key barrier to CCS deployment in industry and the EU has an exclusive competence in the field of international trade.

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The Bellona Foundation

The Bellona Foundation is a multidisciplinary international environmental NGO based in Oslo, Norway. Founded in 1986 as a direct-action protest group, it has since blossomed into one of the world's most recognized technology and solution-oriented environmental champions with offices on two continents. There are altogether some 40 ecologists, nuclear physicists, engineers, economists, lawyers, advisors and journalists working at Bellona.

The Bellona Foundation is financed by industry, business and individuals as well as through project-orientated grants from philanthropic organizations and the Norwegian government.

Throughout our offices, located in Brussels, Murmansk, Oslo, St. Petersburg and Washington DC, Bellona works with relevant governments, experts and other NGOs in achieving sustainable solutions to the world's most pressing environmental problems. These include fighting global warming, the clean-up after the Cold War legacy in Russia and the safety of the oil and the gas industry in Europe. The work is carried out through information dissemination, lobbying and campaigns directed at local and governmental levels. Bellona publishes its findings on the Bellona web site in order to inform and educate the public about the environment in which it lives.

Bellona is a solution-oriented organization, focusing on making constructive contributions to resolve environmental issues. As an example, we put the first electrical and hydrogen-powered vehicles on the road in Norway.

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1 Introduction

Despite the urgent need to reduce CO_2 emissions, global fossil fuel use is on the increase and fossil fuels are forecast to continue to meet most of the world's energy needs to 2035. CO_2 Capture and Storage (CCS) can abate 90% of emissions from fossil fuel use and complement the large-scale deployment of intermittent renewable energy with low-carbon baseload power generation and, possibly, balancing capacity. Moreover, CO_2 emissions result from many industrial process, making CCS vital to achieving the European Union (EU) 2050 roadmap goals of reducing industrial emissions by the necessary 83%-87% compared to 1990 levels by 2050. In short, it is clear that without immediate large-scale demonstration of CCS, society runs the risk of either failing to effectively combat climate change or doing so at a much increased economic and social cost.

Notwithstanding its critical role, CCS has now reached a tipping point in the EU. CCS is the only established abatement technology that does not benefit from targeted support in the current suite of EU-level policies. It is therefore particularly dependent on the EU Emissions Trading System (ETS) to drive its deployment. With Emission Unit Allowances trading at near record low prices, the steady attrition of projects from the EU's original 12-plant CCS demonstration programme, and the recent failure of CCS projects to win any funds at all in the first round of the EU's NER 300 scheme, urgent policy action is needed to put CCS back on track in the EU – and with it the bloc's energy, climate and industrialization objectives.

With CO_2 prices as low as they are, CCS will require billions of Euros of annual support in the EU. It makes little eventual difference whether these funds come from taxpayers or energy consumers – because energy use is pervasive, these are usually the same people. By failing to commit the necessary funds for effective decarbonisation, the EU has in effect been living beyond its means.

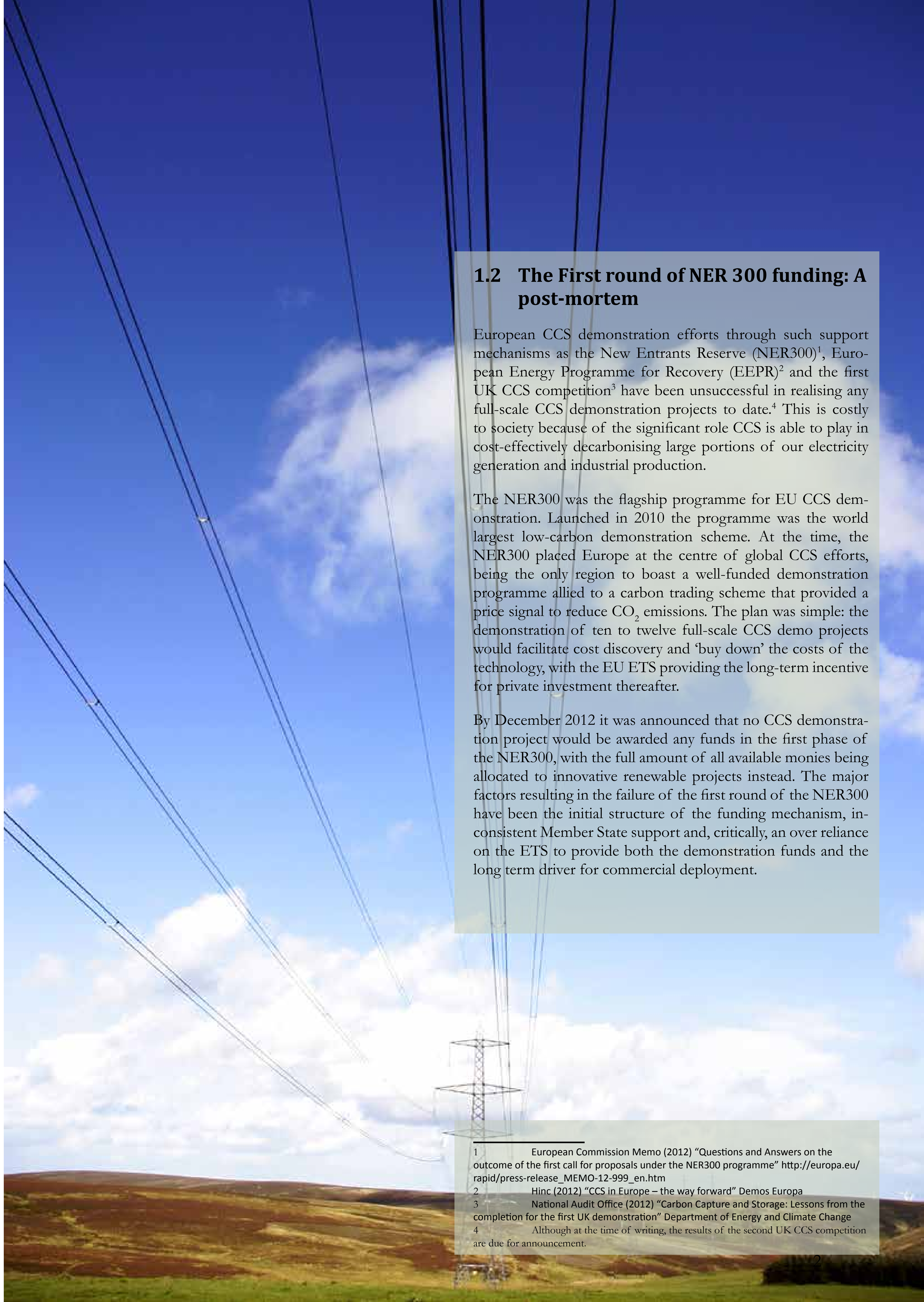
1.1 Scope

This policy paper looks at ways of effectively incentivizing CCS demonstration and deployment in the EU. It presents and evaluates over a dozen policy options in terms of how well they cater to the needs of society and industry, as well as how they have been deployed in the energy sector to date. As well as examining ways of reducing technology costs, this report also looks at how policy design could facilitate industry investment decisions with as little extra cost to society as possible.

It pays special attention to the politico-economic context within the EU, where parallel layers of governance can sometimes complicate the design and administration of energy policies, and blur institutional lines of responsibility. Its final objective is to provide clear and practical recommendations to decision makers operating at both the EU and Member State levels for the necessary reform of the current CCS policy framework within the Union.

CCS is the only established abatement technology that does not benefit from targeted support in the current suite of EU-level policies

Parallel layers of government in the EU can complicate the design and administration of energy policies



1.2 The First round of NER 300 funding: A post-mortem

European CCS demonstration efforts through such support mechanisms as the New Entrants Reserve (NER300)[1], European Energy Programme for Recovery (EEPR)[2] and the first UK CCS competition[3] have been unsuccessful in realising any full-scale CCS demonstration projects to date.[4] This is costly to society because of the significant role CCS is able to play in cost-effectively decarbonising large portions of our electricity generation and industrial production.

The NER300 was the flagship programme for EU CCS demonstration. Launched in 2010 the programme was the world largest low-carbon demonstration scheme. At the time, the NER300 placed Europe at the centre of global CCS efforts, being the only region to boast a well-funded demonstration programme allied to a carbon trading scheme that provided a price signal to reduce CO_2 emissions. The plan was simple: the demonstration of ten to twelve full-scale CCS demo projects would facilitate cost discovery and 'buy down' the costs of the technology, with the EU ETS providing the long-term incentive for private investment thereafter.

By December 2012 it was announced that no CCS demonstration project would be awarded any funds in the first phase of the NER300, with the full amount of all available monies being allocated to innovative renewable projects instead. The major factors resulting in the failure of the first round of the NER300 have been the initial structure of the funding mechanism, inconsistent Member State support and, critically, an over reliance on the ETS to provide both the demonstration funds and the long term driver for commercial deployment.

1 European Commission Memo (2012) "Questions and Answers on the outcome of the first call for proposals under the NER300 programme" http://europa.eu/rapid/press-release_MEMO-12-999_en.htm
2 Hinc (2012) "CCS in Europe – the way forward" Demos Europa
3 National Audit Office (2012) "Carbon Capture and Storage: Lessons from the completion for the first UK demonstration" Department of Energy and Climate Change
4 Although at the time of writing, the results of the second UK CCS competition are due for announcement.

1.2.1 The ETS & NER300

Introduced in 2005, the EU ETS is the bloc's flagship policy to address climate change and the largest carbon market in operation worldwide. Because CCS has not been the beneficiary of significant targeted support schemes to date – feed-in-tariffs or portfolio requirements, for example – its fate is especially dependent on the ETS CO_2 price. As illustrated greater detail in Section 1.4, a high CO_2 price would have ensured that the marginal cost of unabated generation would increase, making CCS generation competitive and driving its deployment in the EU.

Unfortunately, the price of CO_2 has not been as robust as originally forecast (see Figure 1). At the time of writing, an allowance to emit one tonne of CO_2 – an Emissions Unit Allowance (EUA) – is trading at around €4.30/tCO_2. This compared with forecast prices of around €30/t from mid-2008.[5] Moreover, the low price of 10-year CO_2 futures indicates that the market currently does not see the price of EUAs increasing dramatically in this time window. The failure of the ETS to provide as robust a CO_2 price as originally forecast has eroded the business case for CCS in the EU in two important ways.

First, the faltering EUA price has failed to provide the long-term price signal for CO_2 emitters to pursue the development of CCS technology. In particular, the incentive to develop capital intensive decarbonisation technologies such as CCS has declined along with the EUA market. As forecast CO_2 prices remain weak due to difficulties in reforming the scheme significantly before 2020,[6] so too will European commercial interest in CCS technology. The degree of operational support the ETS would have offered demonstration plant has also declined, with demonstration operators in most Member States left with significant commercial risks to sunk investments. These include reduced reliability of plant, higher operating cost and reduced competitiveness in the electricity market.

And secondly, the lower price of EUAs auctioned for the NER300 scheme (€8.10)[7] greatly reduced the funds available to immediately support demonstration projects: At CO_2 prices of €30/tonne, total support could have been as high as €9 billion, however the eventual figure is likely to be around €2 billion. The shrinkage of the pot of funds meant that projects successful in the competition would receive less support than initially anticipated, placing an additional burden on co-funders such as host states and sponsor companies. It also resulted in a rationalisation of the scheme, with fewer full-scale plants able to be supported. Since this diminished the chances of success for individual candidates, it also reduced their incentive to devote significant resources to taking part in the process.

The failure of the ETS to provide a sufficient CO2 price has eroded the business case for CCS in the EU

CCS is able to cost-effectively deliver large amounts of CO2 abatement

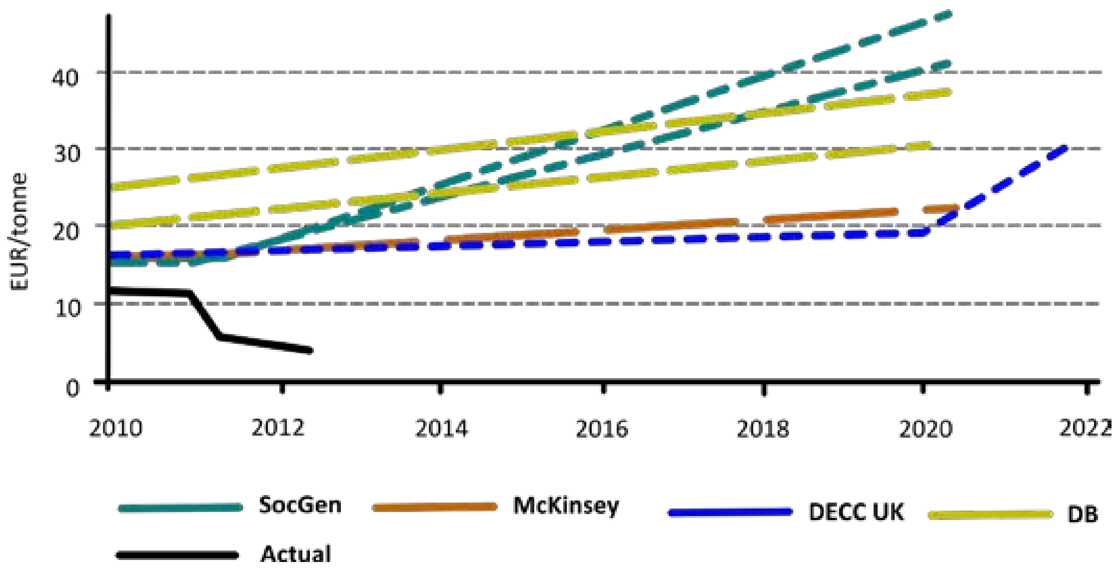


Figure 1: Projected EUA price forecasts from Member State and the financial sector from 2008 – 2010 and the Actual EUA price. Sources: UK Department of Energy & Climate Change, Barclays Bank, Deutsche Bank, Société Générale and McKinsey & Company.

5 Energy and Climate Change Committee (2012) "the EU Emissions Trading System: government Response to the Committee's Tenth report of Session 2010-2012

6 Tilford (2012) "Weak Carbon Prices Threaten the EU's Environmental Leadership" tgae.

7 EIB – NER300 Monetisation Monthly Report http://www.eib.org/products/ner-300/reports.htm

1.2.2 Initial structure of the NER300 funding mechanism & inconsistent Member State support

The metric by which prospective demonstration projects were rated in the NER300 resulted in a distorted awarding process. Directive 2009/29/EC states that the award of NER300 funds shall be dependent upon the verified avoidance of CO_2 emissions.[8] However, projects were reviewed primarily on the cost per tonne of CO_2 stored (€/CO_2 stored).[9] This did not take account of the cost of electricity output, and may have resulted in poor value for money for co-financing Member States that would have been obliged to fill any resulting funding gap.

Figure 2 aptly illustrates the lost opportunity of the NER300 and the continued need for CCS development. It shows that the realization of any single CCS project in the NER300 competition would have generated more low-carbon electricity than all the innovative renewable generation projects awarded funds combined – and with less use of NER300 monies. Although renewable energy will form the backbone of the future energy mix, this very clearly illustrates how CCS is able to cost-effectively deliver large amounts of CO_2 abatement in the transition away from fossil fuels. With the cost of tackling climate change causing jitters in EU capitals,[10] the first round of the NER300 thus represents a grave lost opportunity.

The awarding of a CCS demonstration project would have resulted in significant obligations on the part of the host Member State. In some cases, host states would have to underwrite the entire demonstration project, while being repaid from the NER300 only on a CO_2 stored basis. Failure to store CO_2 in full contracted volumes would require the host state to reimburse the EC the difference. And in all cases, Member States had to 'confirm' the value and structure of the total public funding contribution, with legal consequences for errors in this. Many Member States may have regarded these terms as overly onerous, particularly as demonstration projects are risky and the experience of a successful demonstration would benefit all Member States (more information in Section 2.1).

Compounding the issues mentioned, Member State support for CCS demonstrations continues to be inconsistent,[11] with few Member States having a national strategy for CCS development and fewer still with policies to assist commercial CCS deployment. The absence of supplementary Member State support structures to bolster the beleaguered ETS CO_2 price made commercial operation of CCS demonstrations in these countries problematic.[12]

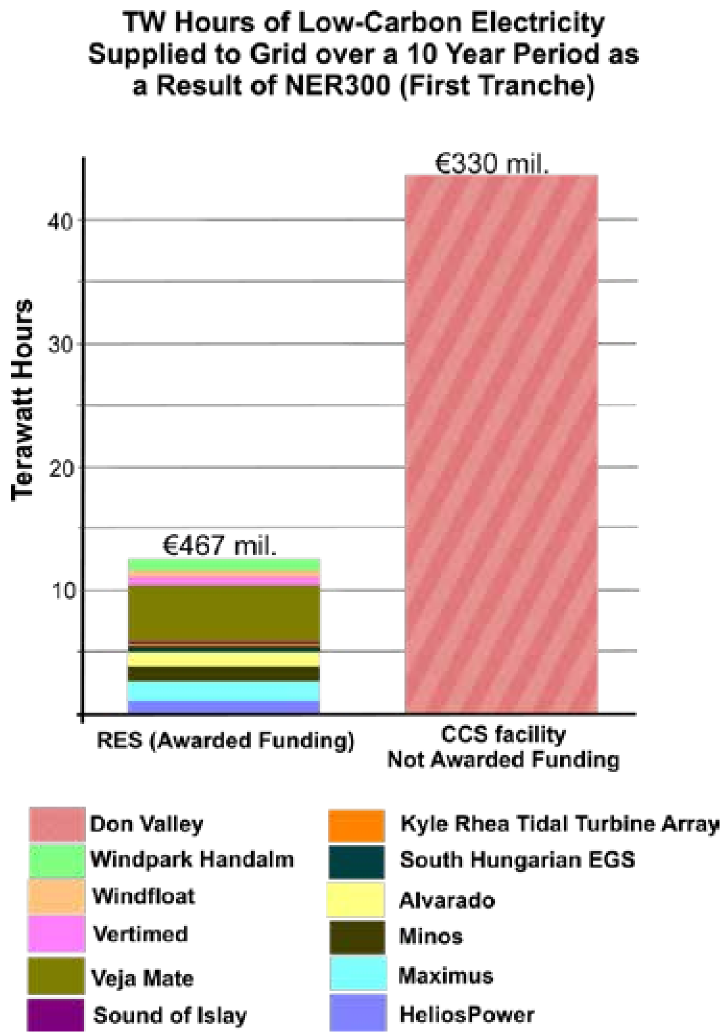


Figure 2: GW hours of low-carbon electricity supplied to the grid over a 10-year period as a result of the NER300 (first tranche). Assumes a capacity factor of 0.25 for solar, ocean and wind and 0.8 for geothermal and CCS. Data: http://europa.eu/rapid/press-release_MEMO-12-999_en.htm.

8 Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community Text with EEA relevance.

9 Commission Decision of 3.11.2010 laying down criteria and measures for the financing of commercial demonstration projects that aim at the environmentally safe capture and geological storage of CO2 as well as demonstration projects of innovative renewable energy technologies under the scheme for greenhouse gas emission allowance trading within the Community established by Directive 2003/87/EC of the European Parliament and of the Council, SEC (2010) 1319, SEC(2010) 1320.

10 Clark (2013) "Europe wobbles on green energy costs", 07/04/2013, Financial Times.

11 With the notable exception of the UK.

12 Forbes (2012) "Policy not technology' the big barrier to carbon storage" European Energy Review http://www.europeanenergyreview.eu/site/pagina.php?id=1565

1.2.3 Summary

In review, the failure of the NER300 was a result of many factors including the initial design of the award process, the funding structure of the award, Member State participation and liability and the way award funds were raised (Table 1). Because CCS lacks other EU- or national-level targeted support schemes (feed in tariffs or binding 2020 targets, for example), most commercial facilities and Member States were unwilling to support the projects. As a result only one Member State agreed to co-finance an NER300 backed demonstration project, but agreed funding from the sponsor facility was not met.[13]

The failure of the NER300 was a result of many factors

Table 1: Factors in NER300 failure to support CCS demonstrations

Funding	Low EUA price and low price forecasts	Failure to raise appropriate levels of funding
		Failure to incentivise participation on the part of industrial and power sectors
Award Structure	Structure of award to Member States	Risk for Member States based on payment only after storage is proven
	CO_2 avoided metric	Disadvantage of industrial and more mature projects
Timeline	Conflict with national CCS competitions	Member states unprepared to support NER project until national competition finalised
	Congested timeframe for securing permits	
Wider Economic Environment	Risk of closure of industrial plants	Result in a forfeit of awarded NER300 award, with all cost liable to Member State
	Member State finances	Lack of available funds or appetite for large projects
Wider Regulatory Environment	Renewables Directive	Additional support such as feed-in for other generation technologies resulted in prioritised investment
	Present short term EU emissions reduction goals	Lower priority for rapid CO2 emissions reductions

13 NER300.com (2013) "ULCOS: a CCS project withdrawn under peculiar circumstances" http://www.ner300.com/?page_id=243

1.3 The barriers to commercial CCS deployment are rising

Notwithstanding the importance of CCS, the first phase of the NER300 has failed to achieve its key goals:

- *Reducing the cost and risk of CCS technology. Reducing the capital and operating costs of CCS at thermal plant and industry settings. Advancing CCS so that it is cost competitive with other low- carbon technologies.*
- *Removing key barriers to the deployment of CCS, through the development of sufficient storage capacity, transport infrastructure and relevant industrial know-how.*

This failure has left many barriers to commercial CCS deployment unaddressed. The absence of full-scale integrated CCS demonstrations will have significant long term repercussions on the development of CCS in Europe, retarding the development of indigenous CCS service providers, jeopardising the timeline for commercial deployment and subsequently reducing the technologies' ability to contribute to CO_2 emissions reductions.[14]

As the timeline for commercial CCS deployment becomes more remote, so too do the learning benefits of hosting a demonstration to the operator.[15] The poor market outlook for CCS equipment and services providers – an essential constituent of the future CCS industry – also increases the opportunity cost of their investments into R&D. To date valuable work has been achieved on CCS that has generated a significant body of research on topics such as the development of advanced CO_2 storage sites characterisation and monitoring methods, along with front-end engineering and design studies.[16] The delay in furnishing an effective policy framework for CCS will result in the costly dissolution of acquired knowledge and skills (Figure 3).

In the absence of renewed projects, professionals will migrate to other sectors resulting in the loss of expertise. Additionally, the continued uncertainty surrounding CCS will further reduce investors' confidence, resulting in short-term planning from energy utilities. The appetite for the risk on behalf of the sponsors is diminishing: they now prefer to pursue more de-risked ventures such as conventional thermal,[17] biomass or other renewables.[18] The construction of such generation is seen as more and more attractive at present, but it has possible damaging effects on both climate policy (due to carbon lock-in) and energy policies such as energy supply security, diversity and price.

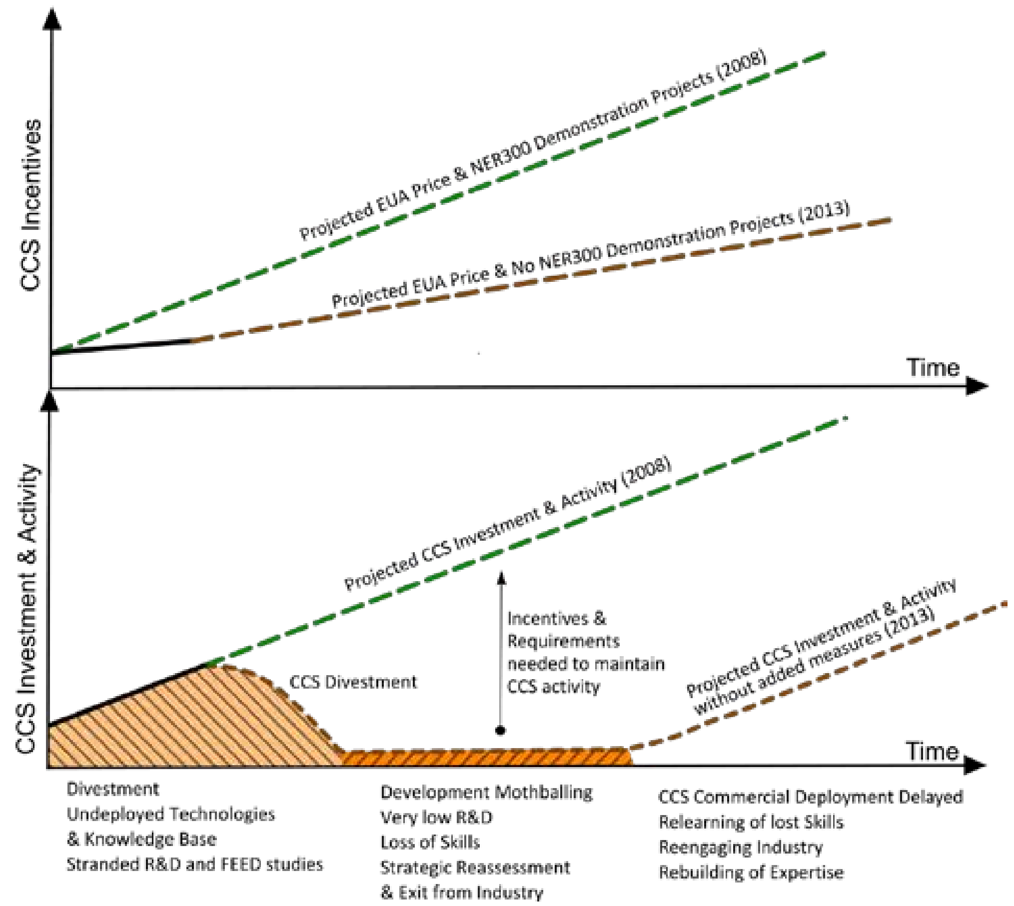


Figure 3: Diminishing incentives and greater uncertainty of projected commercial CCS deployment will have a direct impact on CCS technology development, resulting in divestment and a loss of acquired learning.

14 European Commission (2012) "Energy Roadmap 2050"

15 Eurelectric (2012) "Now or never? The urgent need for CCS demonstration", http://www.eurelectric.org/media/70511/eurelectric_position_ccsdemo_programme.final-2012-170-0006-01-e.pdf.

16 ' 1st Competition: Front End Engineering Design Studies (FEED)', UK Department of Energy and Climate Change, http://webarchive.nationalarchives.gov.uk/20121217150421/http://decc.gov.uk/en/content/cms/emissions/ccs/ukccscomm_prog/feed/feed.aspx

17 Green alliance (2011) "Avoiding gas lock-in: Why a second dash for gas is not in the UK's interest".

18 ecoprog (2012) "Biomass to Energy 2012/2013", http://www.ecoprog.com/en/publications/energy-industry/biomass-to-energy.htm.

A renewed effort on the part of EU institutions, national governments and commercial stakeholders is required to power through this setback and reach the goal of a commercially viable, privately financed, and consumer supported model for CCS. A revised EU demonstration programme will need to address the existing commercial uncertainties by **creating near to medium term incentives on a national and EU level to incubate significant CCS research development and deployment through to competitive commercial deployment.**

> For CCS to be competitive and contribute to climate mitigation a suitable niche must be found in the energy system

1.4 There is a real risk of a lock-in to unabated fossil fuels

Unpredictable developments in energy markets directly affect the 'invest-ability' of different generation technologies. Surprising many analysts, the economic attractiveness of coal in Europe has strongly increased relative to other fossil fuel sources in recent years. This has primarily been the result of plummeting coal prices due to increased exports from the US, a very low penalty for CO_2 emissions and, finally, the maximization of the use of many coal fired plants not compliant with the EU's Large Combustion Plant Directive before their impending retirement at the end of 2015.[19] As such, the amount of electricity generated from coal is rising at annualised rates of as much as 50% in some European countries.[20] Although there is uncertainty as to how long this will continue, the market drivers of this trend – US shale gas production and the low CO_2 price – look set to persist.

In some Member States, such as the United Kingdom, the current combination of legislative or public barriers to new coal capacity, rapidly ageing generation plant and a growing share of intermittent renewables is increasing the attractiveness of Combined Cycle Gas Turbine (CCGT). Under these conditions, such plants offer a low-risk combination of the lowest capital cost of any major generating technology, high flexibility and rapid construction. With existing market structures, they allow utilities to hedge against uncertain and decreasing load factors, capture high prices during times of low generation from intermittent renewables and hedge against modest future increases in the CO_2 price.[21]

It is critical that we develop a system that can provide on-demand low-carbon generation to supplement variable renewable production (Figure 4).[22] This is important as renewable energy, notably wind power, provides a relatively high energy amount, but contributes little to an adequate power system due to its low capacity credit.[23] A decarbonisation trajectory utilising solely renewables and unabated generation will result in a higher cost of abatement, significantly increased stranded assets, and higher costs for consumers while increasing the prospect of carbon lock-in.[24]

Without additional support beyond the current low CO_2 price, CCS in Europe faces a closing window of opportunity and significantly delays in deployment, if not abandonment. Any policy measures to assist the deployment of CCS must also take into account the operational characteristics anticipated for CCS in that energy market. For CCS to be competitive and contribute to climate mitigation a suitable niche must be found in the energy system, providing a load factor to facilitate deployment. Not providing a profitable niche for CCS technologies in the energy sector will result in a locked in development trajectory, with baseload and peaking generation dominated by nuclear and unabated fossil fuel capacity respectively.

19 Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants.
20 The Economist (2013) 'Europe's dirty secret: The unwelcome renaissance', http://www.economist.com/news/briefing/21569039-europes-energy-policy-delivers-worst-all-possible-worlds-unwelcome-renaissance/print.
21 As CCGTs often function as price makers, setting the wholesale price of electricity in European energy markets, rising fuel prices can be passed on to consumers.
22 UK ERP (2011) "The future role for energy storage in the UK Main Report" Technology Report
23 Capacity Credit is a measure of how much electricity any new plant can be depended upon to deliver. Nicolsi, Marco and Fürsch, Michaela. (2009). "The Impact of Increasing the Share of RES-E on the Conventional Power Market - The example of Germany" Zeitschrift fuer Energiewirtschaft 03/2009.
24 Rubbelke, Vogele (2012) "Effects of Carbon Capture and Storage in Germany on European Electricity Exchange and Welfare" Basque Centre for Climate Change

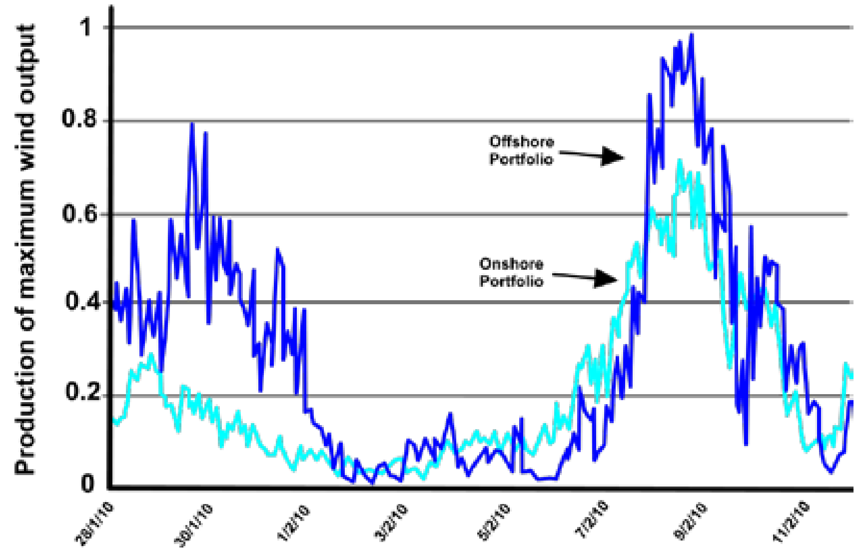


Figure 4: Variability in generation from wind at peak demand showing wind generation as a proportion of total capacity (left hand scale) and average demand for the UK (right hand scale, drops in demand are weekends). With an installed capacity of 30GW and an expected 35% load factor, this would leave a 1TWh gap (or average 9GW), in a period when the total demand was 5.7TWh. (Data from E.ON.)

1.5 The way forward: An overview

A predictable and reliable long term market for CCS must be ensured. Emitters need sufficient signals that CCS will either be profitable or a requirement if they wish to continue to use fossil fuels in power generation and traditional industrial processes. The commercial and regulatory environment needs to reduce uncertainty to both emitters and prospective CCS service providers (Figure 5).

In most Member States, the absence of incentives to operate a CCS demonstration facility severely reduced participation on the part of sponsor facilities. For the technology to be commercially available in a timely manner, support mechanisms need to be put in place now to reward or require emitters to take an active role in the technologies development. Pre-commercial deployment support is necessary to guide the technology through the transitional phase from demonstration to commercialisation. This is critical if CCS is not to be bogged down, its pre-demonstration phase falling prey to the "valley of death". **The key goal is to build effective and complimentary incentive frameworks at both the EU and national levels to facilitate the commercial deployment of CCS, allowing the technology to compete with other low-carbon generation.**

The rest of this report describes and discusses different policy measures aimed at incentivizing CCS. Although these policies have been organized into three sections according to the timeframes in which they would customarily be deployed, it is important for the reader to note that:

- The best timeframe for implementing a policy can vary significantly case to case, and the categorization of policies presented here should therefore be seen as indicative;
- Every EU CCS projects so far has relied upon a tailor-made 'blend' of several mechanism, suggesting that the policy measures described will almost inevitably be deployed in overlap with each other.

The following sections can thus be read as a menu in an eccentric restaurant where diners are encouraged to order two desserts and have them served alongside the main course.

Although there are no hard and fast rules, this report illustrates that different kinds of policies are best implemented by different levels of government. As a general recommendation, all future policies for CCS should therefore be designed to be as complimentary as possible with others in the foreknowledge that any one of them alone will be insufficient to make the commercial case for a prospective investment. This is especially important in the EU, where parallel layers of governance can complicate the design and administration of energy policies, and blur institutional lines of responsibility.

One final comment on the policies examined: Although this report predominantly explains policies with reference to the power sector, eleven of the thirteen policies considered in this paper can be applied to drive CCS deployment in industrial processes such as cement and steel production.[25]

25 The exceptions are capacity auctions (Section 3.2) and priority grid access (Section 3.4).

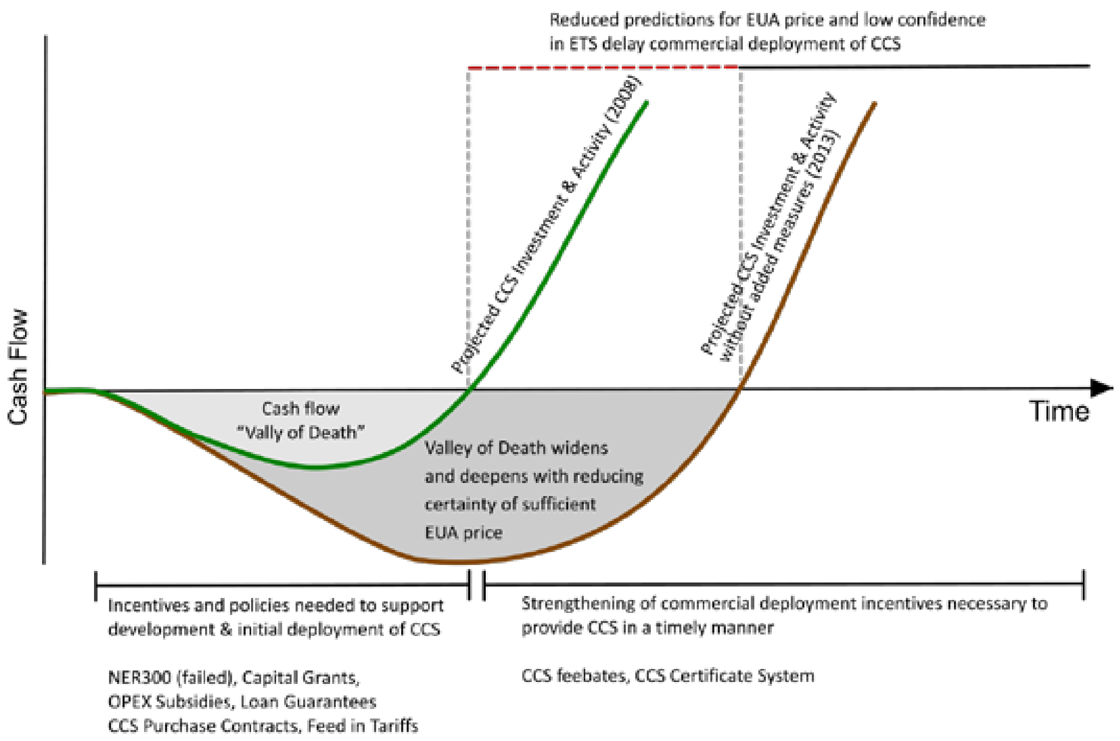


Figure 5: Lack of sufficient Member State and EU wide support frameworks for CCS deployment endangers CCS development

The EU has committed itself to reversing the decline of industry in Europe, aiming to boost its weight from around 16% of GDP today to 20% by 2020.[26] However, this goal is in tension with the Union's ever more stringent climate targets. Commission analysis indicates that, using a 1990 baseline, CO_2 emissions from industry must be reduced by at least 34% by 2030 and 83% by 2050.[27] The application of CCS to industrial processes will therefore become increasingly pressing. Moreover, CO_2 capture from many industrial processes is significantly easier than in the power sector due to the relatively high concentration of CO_2 produced. It therefore represents low hanging fruit for carbon abatement.

The commercial and regulatory environment needs to reduce uncertainty to both emitters and prospective CCS service providers

CO2 emissions from many industrial processes cannot be substantially reduced without CCS.

26 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Stronger European Industry for Growth and Economic Recovery, Industrial Policy Communication Update, COM(2012) 582 final.

27 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions: A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final.

The second round of the NER300 should be administered by an inter-service panel drawn from the DG CLIMA, DG ENER and DG ENTR

2 Kick-Starting EU CCS Projects: The Early Commercial Phase

This subsection addresses policy options for the early stages of CCS deployment. It is primarily aimed at stimulating debate around the most cost effective way to disburse and complement funds from the second round of the NER 300. However, it also discusses whether current levels of grant funding available for CCS demonstration have been sufficient, lessons for future possible CCS grant programmes and other policy measures suitable for 'kick-starting' CCS deployment in the EU.

2.1 Grant schemes

Grants are financial awards given by public authorities to a grantee for a concrete investment activity, usually a specific project. Although grants are non-repayable, almost all require some level of compliance and reporting. Grants offer a means for public authorities to influence investment and the supply of services by various other market actors. They are commonly used to overcome market failures – most notably, to tackle externalities and incentivize the provision of public goods. In the EU energy sector, grants have accordingly been widely deployed to disseminate socially valuable technologies and promote private investment in the development of both market and enterprise. Such grants have been successfully administered by Member States and the EU, and there exists a wealth of institutional knowledge at both levels of government for their use.

Although economic theory suggests that grants can be a good instrument to solve or compensate for market failure, grants are not neutral interventions and can have harmful effects on market development if they are based on erroneous assumptions. For example, grants may be subject to political and ideological preferences that distort markets. Grants awarded to projects that are not technically or financially viable waste public resources. And it makes little sense for policy makers to seek to reduce project risk through the use of grants if policy uncertainty itself is the main source of risk. Provided pitfalls such as these can be avoided, grants have an invaluable place in the policy maker's toolbox.

In the case of CCS, the net marginal benefit to the 'first movers' who take the lead in CCS deployment will be lower than the overall benefit to society. Market conditions therefore render the private provision of CCS unprofitable, which in turn leads to its non-provision. Grants allow public authorities an effective means of redressing this market failure. CCS has accordingly benefitted from European Commission financing under the organization's Seventh Framework Programme for Research and the European Economic Programme for Recovery.

Most notably, CCS is eligible for grants raised by the auctioning of some 300 million emissions allowances from the EU ETS – the NER300 scheme. As narrated earlier, none of the CCS projects which took part in the first round of the scheme succeeded in being awarded any funds. This section looks at the possible ways in which the second round of the NER300 can best be administered in light of the fact that: 1) the unused funds will be carried over and made available for the second call for proposals; and 2) delivery mechanisms can have a dominant impact on the cost-effectiveness of grant schemes.[28]

28 The question of whether funding levels are sufficient, and whether additional instruments would be necessary to realize CCS projects given the low CO_2 price is addressed elsewhere in this report.

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Table 2: NER300 Project Funding Requirements

Requirement	Suggestion
1) *The award of funds shall be dependent upon the verified avoidance of CO_2 emissions. More specifically, disbursement should take place annually, on the basis of the amount of CO_2 stored for CCS demonstration projects.*	Currently, cost-per-unit performance is measured by the requested funds divided by the amount of CO_2 stored. Alternatively, as long as the plant meets certain emissions standards, measuring CCS performance on the basis of the amount of electricity or industrial product generated may be a more suitable metric.
2) *No project shall receive support via the mechanism that exceeds 15 % of the total number of allowances available for this purpose.*	An important question in *ex ante* economic analysis is the optimal grant percentage. Analytically, this should be primarily dependent on the policy objectives and the characteristics of the project itself – not the pool of available funds. Creating binding rules that limit absolute funding levels can reduce the effectiveness of the grant programme, particularly if other rules exists that set a minimum project threshold size (≥250MW in the case of the NER300).
3) *NER300 financing should be reduced by the amount of financing received from the EEPR.*	
4) *Financing is fixed at 50 % of the additional investment costs in land, plant and equipment which are borne by the project due to the application of CCS.*	Depending on the market failure to be corrected and the characteristics of the project, financing could be justified in covering a greater proportion of costs and/or a different share of costs (OPEX, for example). In some cases, a more flexible interpretation of the legislation governing the administration of EU Structural Funds to allow them to support CCS would facilitate this.
5) *Member States must confirm the value and structure of the total public funding contribution.*	Risk sharing may have been skewed, with Member States taking almost all of the investment risk, and the Commission not bearing any risk at all. In light of the uncertain nature of CCS demonstration projects, risks may have to be distributed more evenly across funding bodies.
6) *Award decisions shall be conditional upon all relevant national permits.*	NER 300 projects may have been pushed into a timeframe that was unachievable. Large infrastructure projects (such as the ≥250MW CCS demonstration plants eligible for NER300 funding) face long lead times in many EU Member States due to inclusive and protracted planning processes. As such, the sanctions linked to timelines in the NER 300 may have to be relaxed.
7) *Award decisions shall be conditional upon final investment decisions being reached by the sponsors, within 24 months of adoption of the award decisions.*	

The design and implementation of grant projects can be complex and often requires learning by doing. Implementation modalities have a major impact on their effectiveness and efficiency. Currently, NER 300 project funding is disbursed according to rules set out in Directive 2009/29/EC[29] and Commission Decision C(2010) 7499.[30] The table above looks at several separate requirements that are, *inter alia*, stipulated by the legislation that may merit re-examination in light of the fall in funding levels and other lessons learned. The conclusions are necessarily qualified and impressionistic because business confidential data makes a thorough examination of the NER 300 first round difficult. Nevertheless, successfully addressing these issues would remove many of the problems faced by CCS projects applying for NER300 funding.

Above all, there is a pressing need for further clarification of the circumstances surrounding the first round of the NER300. Although its causes were numerous (see Section 1.2.3), the outcome of the NER300 raised fundamental questions about the underlying willingness of the EU to support CCS. Uncertainty about the way in which the NER300 scheme was designed and administered has fostered uncertainty as to whether an aversion to CCS exists within certain EU Institutions. These doubts have been amplified by a perfunctory report on the first round of the NER300 prepared by DG CLIMA,[31] and will linger until at least the full circumstances surrounding the funding decisions come to light.

29 Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community Text with EEA relevance.

30 Commission Decision of 3.11.2010 laying down criteria and measures for the financing of commercial demonstration projects that aim at the environmentally safe capture and geological storage of CO2 as well as demonstration projects of innovative renewable energy technologies under the scheme for greenhouse gas emission allowance trading within the Community established by Directive 2003/87/EC of the European Parliament and of the Council, SEC (2010) 1319, SEC(2010) 1320.

31 Bellona Press Release, 'NER300 second call to be launched in April, European Commission announced',13.03.2013, http://bellona.org/ccs/ccs-news-events/news/article/ner300-second-call-to-be-launched-in-april-european-commission-announced.html.

An audit by the Commission's Internal Audit Service (IAS) may be the most appropriate means for this. Although each DG has its own audit Unit, the IAS would not be subject to the service perspectives that may cloud an analysis of the relevant issues. Its involvement is justified by the importance of the NER300 and huge social benefit of clear lessons learned emerging from the first round. Such an audit should address both the initial design and the execution of the scheme against its stated political objective:

"to help stimulate the construction and operation of up to 12 commercial demonstration projects that aim at the environmentally safe capture and geological storage (CCS) of CO2 as well as demonstration projects of innovative renewable energy technologies, in the territory of the Union.".[32]

In addition, the relevant Commission services should also candidly reassess their own resources earmarked to implement the scheme. Although a wealth of institutional knowledge on grant scheme administration exists within the Commission, the NER300 was a particularly large and complex competition. A marginal increase in the administration resources (and hence costs) may well be justified in light of reports of miscommunication and slow communication between the European Commission, Member States and grant applicants.

Accordingly, Bellona would recommend that the second round of the NER300 be administered by an inter-service panel drawn from the Directorate General for Climate Action, the Directorate General for Energy and the Directorate General for Enterprise and Industry. The inter-service administration of funds is well established in the European Commission and would be compatible with legislation currently governing the NER300. Such an arrangement would ensure that a greater pool of expertise and resources are available to effectively administer this important call. It would also address concerns that political or ideological preferences may influence funding decisions.

The advantage of a pan-European system of support for CCS deployment is that it is more compatible with the EU's single-market ambitions

32 Directive 2009/29/EC.

2.2 Supplementary funding mechanisms

The European Commission's current view is that the ETS and the NER programme are the primary EU-level tools to drive CCS demonstration. However, it is worth pausing to contemplate if these EU mechanisms alone will be sufficient in light of market developments since their inception. As already mentioned, EU CCS demonstration projects have faced the double blow of low EUA prices increasing their effective OPEX, and the concomitant shrinkage of available funds from the NER 300 increasing their CAPEX requirements. This has created a funding gap that has led to a number of candidate projects failing the selection process for NER 300 funds, the Commission has confirmed.[33] Compounding the matter further, national funding opportunities have also diminished, due to the current global economic climate.

The advantage of a pan-European system of support for CCS deployment is that it is more compatible with the EU's single-market ambitions. As such, the European Commission should consider opening a dialog with Member States and industry to coordinate efforts for identifying and making available alternative sources of financing that are complementary to the forthcoming NER300 second call.

Prime among the alternatives for consideration should be the unlocking of pre-allocated structural funds for CCS demonstration. Aimed at reducing regional disparities in income, wealth and opportunity, EU Structural Funds comprise one of the largest items of the Union's budget. Under European Law, however, structural funds for the period 2014 to 2020 cannot be disbursed to installations falling under ETS. Although the intention of the measure was to support the general shift to renewable energy sources by investing in adequate production capacity, its effect has also been to disqualify low-carbon investments that fall under the ETS, such as CCS.[34] An exemption for CCS demonstration projects may therefore be justified in that it would promote further decarbonisation.

An assessment of whether and how the recycling of funds from the European Economic Programme for Recovery (EEPR) should also take place. Set up in 2009, the EEPR made €4bn available to co-finance projects that made energy supplies cleaner and more reliable in the EU, while simultaneously boosting its economic recovery. Although five out of the original six CCS projects that were awarded funding under the EEPR are still on-going, it seems unlikely that all of them will still be realized in their current forms. Any unused EEPR monies from these, as well as other non-CCS projects awarded EEPR funding, could therefore be re-injected to bolster CCS demonstration in light of the outcome of the NER 300 first round.

And finally, decision makers will need to decide if entirely new EU-level funding mechanisms will be necessary if gaps are still likely to remain after even the most effective use of the existing instruments. Provided that the evidence suggests that additional funding is what is needed, the EU should be frank about the role it could play. Policy makers can be overly fixated on keeping capital costs 'off the books'. However, if European consumers are unable to pay for CCS deployment, then taxpayers must, and because energy use is ubiquitous, these are largely the same people. By failing to commit the necessary funds for effective decarbonisation, the EU has in effect been living beyond its means.

Whatever changes are decided, it is essential that there is a clear shared understanding between the European Commission, Member States and industry on the way in which any new sources of funding are permitted to fit together. Given the strains of the funding application process on all parties, there can be no latitude for interpretation on necessary requirements.

33 Press Release: Questions and Answers on the outcome of the first call for proposals under the NER300 programme, MEMO/12/999, 18/12/2012.

34 Regulation of the European Parliament and of the Council on the Cohesion Fund and repealing Council Regulation (EC) No 1084/2006, COM(2011) 612 final; Regulation of the European Parliament and of the Council on specific provisions concerning the European Regional Development Fund and the Investment for growth and jobs goal and repealing Regulation (EC) No 1080/2006, COM(2011) 614 final.

2.3 Loan guarantees

Due to the higher debt-to-equity ratios of CCS demonstration projects, and the government's lower cost of capital, public loan guarantees with performance or capacity conditions could be a cost-effective way of reducing their capital cost.

Coal and gas fired power stations with CCS are more expensive to build than their unabated equivalents, giving them a higher burden of capital cost to recover over their operating lifetimes, i.e. the interest that must be paid on debt or the cost of equity. This is especially true if there is reluctance or inability on the part of project stakeholders to provide initial equity capital. However it is raised, financing will typically absorb revenue for an extended period of operation, and represent a large share of the revenue from a CCS power plant. Investors will want to ensure that operating conditions can remain profitable throughout this period or demand higher returns to take on the risk.

Whilst CO_2 pricing can create conditions that make investment in CCS more attractive, there are uncertainties associated with future movements in fuel prices, wholesale power prices, EUA prices, and political decisions. These make such projects riskier to investors, which discourages outlay and drives up the cost of capital. The effect may be that investors still prefer to build unabated coal and gas fired power stations even though the CO_2 price may have matched the levellized generating costs of their CCS equivalents.

Government loan guarantees would dramatically reduce the cost of capital by effectively replacing the borrower's risk profile with that of the public authority, greatly lowering the chance that the loan will not be repaid, and therefore reducing the borrowing cost. Because the government bears the responsibility for repayment in the event of default, there is a risk cost associated with each loan that the government guarantees. This is called the credit subsidy cost. The credit subsidy cost for CCS projects in Europe could come from Member States, the sale of Emissions Unit Allowances, or other EU financial instruments. The use of public funds can be justified by the fact that such loan guarantees would correct a market failure whereby individual lenders assume a disproportionate risk for CCS projects that, in fact, provide a valuable public good.

Compared to grants, loan guarantees have the advantage of leveraging government funds by providing support through mainly off-budget channels. This is especially important given the current fiscal situation in Europe, allowing public authorities to support a greater number of projects. Additionally, having accepted a portion of the risk of the project, loan guarantees may also have a feedback effect with policy makers, re-doubling their commitment to the success of CCS. This could, in turn, lead to other more effective policies, further lowering costs to tax-payers.

Perhaps the most notable use of loan guarantees in the energy sector has been by the United States by the Department of Energy. Section 1703 of the Energy Policy Act of 2005 authorized the Secretary of Energy to issue loan guarantees for up to 80% of the value of projects that reduce greenhouse gas emissions and employ new or significantly improved technologies compared to commercial technologies at the time of the guarantee. The threshold for eligibility was only that projects offer a "reasonable prospect of repayment", providing a high level of effective risk subsidization by the US Government.[35] The use of loan guarantees under the 2005 Energy Policy Act was then expanded by American Recovery and Reinvestment Act of 2009, which amended the 2005 law by adding Section 1705, the Temporary Programme for Rapid Deployment of Renewable Energy and Electric Power Transmission Projects. To date, 28 loan guarantees totalling $26.3 billion have been issued by the Section 1703 and 1705 programmes.[36]

Loan guarantees are also a tool already used by EU Institutions to facilitate investment in the energy sector, although not for low-carbon projects specifically. The Union's Trans-European Energy Networks programme has seen numerous European

35 http://www.gpo.gov/fd sys/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf

36 https://lpo.energy.gov/?page_id=45

Investment Fund[37] loan guarantees offered to energy infrastructure projects.[38] The European Investment Bank has also recently signed a €440-million loan guarantee with the Slovenian government for a 600MW lignite plant in the town of Šoštanj.[39] Institutions and expertise therefore exists at the EU level that can be built upon to add-value to CCS deployment.

There are certain limitations to this policy measure. Loan guarantees will not decisively help secure final investment decisions for projects that are currently uneconomic irrespective of the ease of financing. The use of loan guarantees to absorb and manage complex technological risk may also pose significant management challenges for the government authorities administering these loans for the first time. In particular, there may be limited ability to accurately assess and budget for the risk in its loan guarantee portfolio for the novel technologies in question.[40]

Government loan guarantees can dramatically reduce the cost of borrowing

2.4 An EU-wide CCS or 'low-carbon' milestone

Quota or portfolio obligation approaches to promoting low-carbon technologies define targets for the deployment of the technology and oblige a particular party (e. g. public authorities, utilities or consumers) with the fulfilment of these targets. This subsection discusses the purest examples of such an approach, which do not explicitly furnish or specify any additional policy mechanism to facilitate the attainment of set targets, other than a penalty for non-compliance.

For example, the US State of Illinois has introduced a Clean Coal Portfolio Standard Law[41] to drive CCS deployment in the coal producing state. Starting in 2015, the state's power utilities will be legally required to source 5% of their electricity from a 'clean coal' power source, with a target of 25% by 2025. Plants in operation before 2016 qualify as clean coal as long as at least 50% of CO_2 emissions are captured and stored. This requirement rises to 70% for plants expected to commence operating in 2016 or 2017, and to 90% thereafter. The law also authorizes the development of two CCS projects in Illinois: one 500 MW coal-to-electricity power plant and one coal-to-natural gas power plant.

37 Funded 30% by the EU Commission, 30% by banks and other financial institutions and the remaining 30% by the European Investment Bank, the EU's non-profit long-term lending institution.

38 Regulation (EC) No 680/2007 of the European Parliament and of the Council of 20 June 2007 laying down general rules for the granting of Community financial aid in the field of the trans-European transport and energy networks

39 http://www.eib.org/projects/loans/2006/20060319.htm

40 Boroughs et al. (2012) 'Assessing the Value of Loan Guarantees as an Instrument for Supporting the Deployment of New Clean Energy Technology', Center for International Science and Technology Policy. http://www.gwu.edu/~cistp/assets/docs/capstone/2012/Loan%20Guarantees%20Capstone%20Project%20Final.pdf

41 Public Act 095-1027: The Clean Coal Portfolio Standard Law, http://ilga.gov/legislation/publicacts/95/PDF/095-1027.pdf.

Of course, quota or portfolio obligation approaches have also been deployed at the EU-level. The market diffusion of new renewable energy technologies in the EU has increased significantly over the last decade. A major driver of this development has been the host of national support strategies triggered by the EU's 2009 Renewable Energy Directive, which set a binding target of a minimum 20% share of energy consumption from renewable sources in the bloc as a whole by 2020,[42] as well as the non-binding renewables target set by its predecessor, Directive 2001/77/EC.[43]

Similar milestones for CCS could prove equally effective. For example, a legally binding EU requirement for Member States to capture a pre-agreed proportion of their total CO_2 emissions, such that the EU as a whole captures and stores at least 15% of its total CO_2 emissions by 2030 may prove a politically salient and mobilizing target.

As per the Renewable Energy Directive, Member States would be free to decide on the best mechanisms to deploy at the national-level in order to achieve this target: Regional certificate schemes or feed in tariffs could be developed within the overarching objective. Member States could, moreover, have the possibility of making a statistical transfer of a specified amount of CO_2 captured from one Member State to another, allowing Member States who are most able to deploy CCS to make up for (and be reimbursed by) those who are not.

Unlike the Renewable Energy Directive, however, a CCS milestone would also serve to reduce direct emissions from industrial processes, opening the possibility for Member States to meet a significant proportion of their targets through industry, including biomass-based industries like biofuels production. (Biomass uptake has risen sharply in the EU over the last few years in response to the Union's Renewable Energy targets.) Member States would therefore have to adopt a CO_2 capture action plans setting national targets for the shares of capture from transport, electricity and industry, as well as the means to achieve these targets.

As a capture target would only apply to a Member State's remaining CO_2 emissions in the year 2030, it would not jeopardize the development of renewable energy sources. If anything, such a capture target could act as a further incentive to increase the share of renewable energy generation – and not least to increase investments in energy efficiency measures – to reduce the level of energy-related CO_2 emissions that would otherwise have to be captured and stored.

Member States would be free to decide on the best mechanisms to deploy at the national-level in order to achieve this target

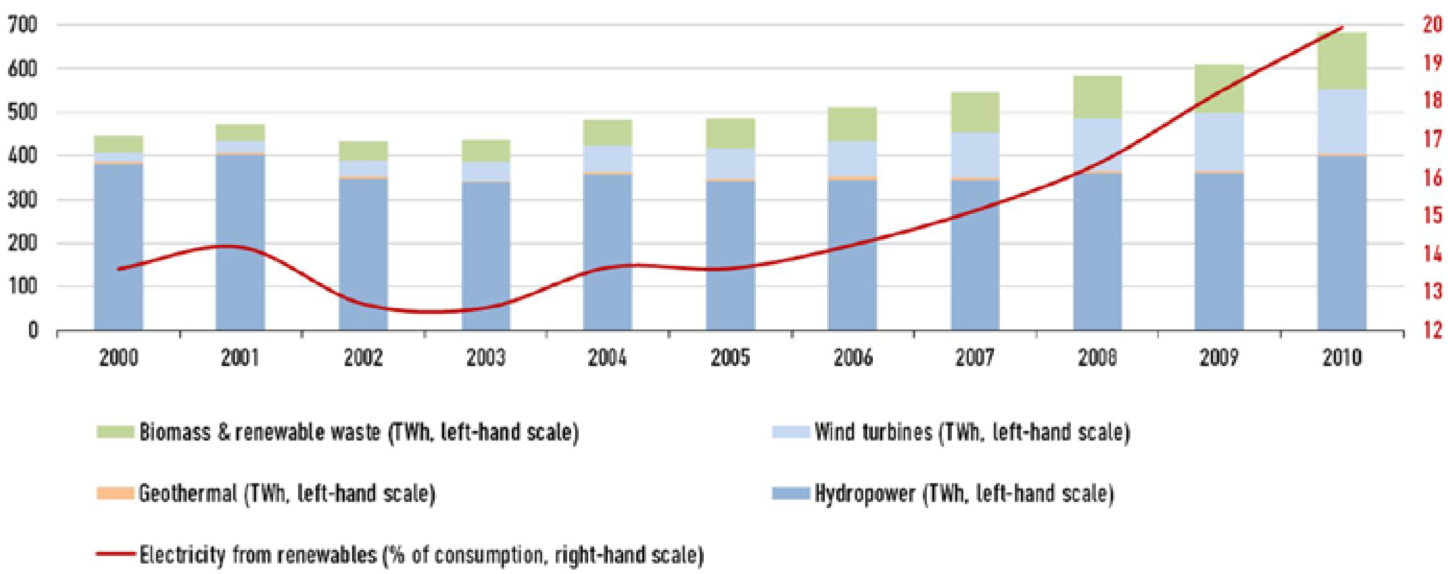
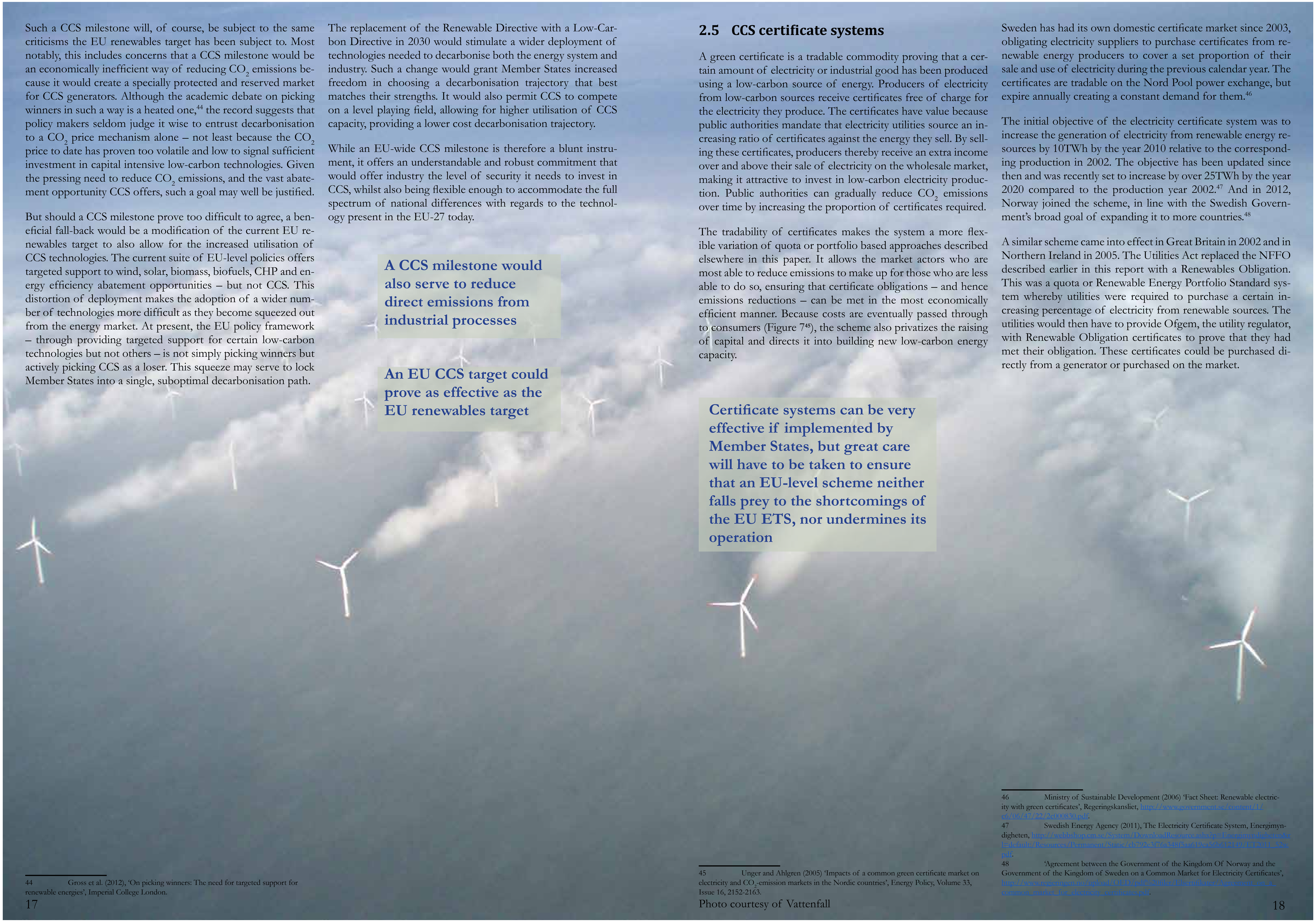


Figure 6: Electricity generated from renewable energy sources, EU-27, 2000-2010. Source: Eurostat

42 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.

43 Directive 2001/77/EC of the European Parliament and of the of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:283:0033:0033:EN:PDF.



Such a CCS milestone will, of course, be subject to the same criticisms the EU renewables target has been subject to. Most notably, this includes concerns that a CCS milestone would be an economically inefficient way of reducing CO_2 emissions because it would create a specially protected and reserved market for CCS generators. Although the academic debate on picking winners in such a way is a heated one,[44] the record suggests that policy makers seldom judge it wise to entrust decarbonisation to a CO_2 price mechanism alone – not least because the CO_2 price to date has proven too volatile and low to signal sufficient investment in capital intensive low-carbon technologies. Given the pressing need to reduce CO_2 emissions, and the vast abatement opportunity CCS offers, such a goal may well be justified.

But should a CCS milestone prove too difficult to agree, a beneficial fall-back would be a modification of the current EU renewables target to also allow for the increased utilisation of CCS technologies. The current suite of EU-level policies offers targeted support to wind, solar, biomass, biofuels, CHP and energy efficiency abatement opportunities – but not CCS. This distortion of deployment makes the adoption of a wider number of technologies more difficult as they become squeezed out from the energy market. At present, the EU policy framework – through providing targeted support for certain low-carbon technologies but not others – is not simply picking winners but actively picking CCS as a loser. This squeeze may serve to lock Member States into a single, suboptimal decarbonisation path.

The replacement of the Renewable Directive with a Low-Carbon Directive in 2030 would stimulate a wider deployment of technologies needed to decarbonise both the energy system and industry. Such a change would grant Member States increased freedom in choosing a decarbonisation trajectory that best matches their strengths. It would also permit CCS to compete on a level playing field, allowing for higher utilisation of CCS capacity, providing a lower cost decarbonisation trajectory.

While an EU-wide CCS milestone is therefore a blunt instrument, it offers an understandable and robust commitment that would offer industry the level of security it needs to invest in CCS, whilst also being flexible enough to accommodate the full spectrum of national differences with regards to the technology present in the EU-27 today.

A CCS milestone would also serve to reduce direct emissions from industrial processes

An EU CCS target could prove as effective as the EU renewables target

44 Gross et al. (2012), 'On picking winners: The need for targeted support for renewable energies', Imperial College London.

2.5 CCS certificate systems

A green certificate is a tradable commodity proving that a certain amount of electricity or industrial good has been produced using a low-carbon source of energy. Producers of electricity from low-carbon sources receive certificates free of charge for the electricity they produce. The certificates have value because public authorities mandate that electricity utilities source an increasing ratio of certificates against the energy they sell. By selling these certificates, producers thereby receive an extra income over and above their sale of electricity on the wholesale market, making it attractive to invest in low-carbon electricity production. Public authorities can gradually reduce CO_2 emissions over time by increasing the proportion of certificates required.

The tradability of certificates makes the system a more flexible variation of quota or portfolio based approaches described elsewhere in this paper. It allows the market actors who are most able to reduce emissions to make up for those who are less able to do so, ensuring that certificate obligations – and hence emissions reductions – can be met in the most economically efficient manner. Because costs are eventually passed through to consumers (Figure 7[45]), the scheme also privatizes the raising of capital and directs it into building new low-carbon energy capacity.

Certificate systems can be very effective if implemented by Member States, but great care will have to be taken to ensure that an EU-level scheme neither falls prey to the shortcomings of the EU ETS, nor undermines its operation

Sweden has had its own domestic certificate market since 2003, obligating electricity suppliers to purchase certificates from renewable energy producers to cover a set proportion of their sale and use of electricity during the previous calendar year. The certificates are tradable on the Nord Pool power exchange, but expire annually creating a constant demand for them.[46]

The initial objective of the electricity certificate system was to increase the generation of electricity from renewable energy resources by 10TWh by the year 2010 relative to the corresponding production in 2002. The objective has been updated since then and was recently set to increase by over 25TWh by the year 2020 compared to the production year 2002.[47] And in 2012, Norway joined the scheme, in line with the Swedish Government's broad goal of expanding it to more countries.[48]

A similar scheme came into effect in Great Britain in 2002 and in Northern Ireland in 2005. The Utilities Act replaced the NFFO described earlier in this report with a Renewables Obligation. This was a quota or Renewable Energy Portfolio Standard system whereby utilities were required to purchase a certain increasing percentage of electricity from renewable sources. The utilities would then have to provide Ofgem, the utility regulator, with Renewable Obligation certificates to prove that they had met their obligation. These certificates could be purchased directly from a generator or purchased on the market.

45 Unger and Ahlgren (2005) 'Impacts of a common green certificate market on electricity and CO_2-emission markets in the Nordic countries', Energy Policy, Volume 33, Issue 16, 2152-2163.

Photo courtesy of Vattenfall

46 Ministry of Sustainable Development (2006) 'Fact Sheet: Renewable electricity with green certificates', Regeringskansliet, http://www.government.se/content/1/c6/06/47/22/2c000830.pdf.

47 Swedish Energy Agency (2011), The Electricity Certificate System, Energimyndigheten, http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/cb792e3f76a348f5aa619ca56b612149/ET2011_52w.pdf.

48 'Agreement between the Government of the Kingdom Of Norway and the Government of the Kingdom of Sweden on a Common Market for Electricity Certificates', http://www.regjeringen.no/upload/OED/pdf%20filer/Elsertifikater/Agreement_on_a_common_market_for_electricity_certificates.pdf.

The Renewables Obligation also included a buyout provision (£36.99 per certificate in 2010/2011), which went into a pool to be redistributed to those utilities that did participate (around £360 million in the same year).[49] As with the Swedish-Norwegian certificate scheme, the mechanism was technology non-specific, such that different renewable technologies competed against each other, however this is now under review.[50]

A certificate system such as those described above could be put in place to drive CCS deployment in the EU, both in the power and non-power sectors. Such a scheme would see the EU issue certificates to CCS power plants for every unit of low-carbon electricity they produce. Electricity utilities would then be required to have a number of EU-issued CCS certificates against their total electricity production (as per the established green certificate model) or their total CO_2 emissions, the latter option placing a greater burden on utilities with larger fossil-fuel portfolios. Utilities would be free to meet this obligation by building and running CCS power plants themselves – thereby receiving certificates directly from the EU – or sourcing certificates from others on the open market.

Industrial CCS applications could also be included in the scheme by issuing CCS-enabled cement, steel or refining plants with certificates for the real-world CO_2 abatement they achieve i.e. their CO_2 savings per tonne of cement, steel or refined product compared with unabated production. The NER300 has shown that extreme care will be needed when deciding precisely how to quantify this. However, provided a fair and accurate metric of real world abatement can be calculated on a sector-by-sector basis, this would improve the economic efficiency of the scheme, allowing CCS to be deployed by the industries most able to do so.

A variation on this theme might see the obligation for purchasing certificates shifted from utilities to suppliers of coal and gas. This would require companies that export coal and gas to Europe, as well as domestic producers, to purchase CCS certificates against the coal and gas they sell in the EU.

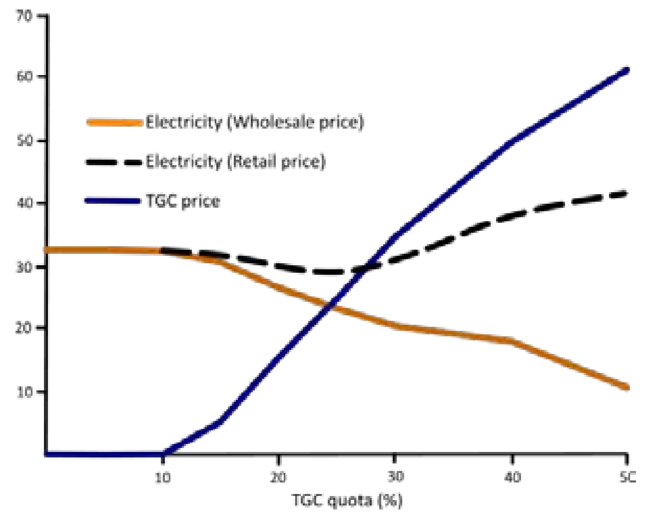


Figure 7: Modelled wholesale electricity, retail electricity and tradable green certificate prices for a hypothetical Nordic market

49 Department of Energy and Climate Change, https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro.

50 Woodman, B. and Mitchell, C. (2011). 'Learning from experience? The development of the Renewables Obligation in England and Wales 2002-2010', Energy Policy, 39(7), 3914-3921.

This might align the costs of CCS deployment more closely with the market actors who have the most to commercially gain from it, making such a scheme politically easier to implement.[51] Moreover, it may more strongly incentivize market actors in the upstream and mining sectors to develop the safe CO_2 storage services necessary to unlock investment in CCS. By doing so, they would be allocated free-of-charge the certificates necessary to secure the continued sale of their products in the EU.

Multilateral negotiations would be necessary to put in place such a system on a pan-European scale. These negotiations would be complicated by the fact that some EU Member States face not only economic but also political obstacles to CCS. However, because of the certificate scheme's inherent flexibility, it will allow Member States who are most able to deploy CCS to make up for those who are not.

Moreover, EU-wide trade would contribute to a more efficient market for CCS certificates with higher liquidity and increased turnover. This would stimulate greater effectiveness and increase downward pressure on CCS generation costs than purely national measures. Any challenges in coming to an EU-level agreement may therefore be handsomely rewarded.

Regarding implementation at the EU-level, two general models could be followed. Use could either be made of the institutional knowledge present in the European Investment Bank to design and manage the issuance, auctioning and trading of certificates. As there would be no need for EU institutions to directly manage revenues (the EU simply controls the scarcity of certificates which indirectly gives these certificates value to the bearers), this would make the scheme be easier to administer and politically agree.

Alternatively, EU legislation could require Member States to issue CCS certificates themselves. This is currently the practice with guarantees of origin for renewable power generation (GoO), which provide proof that a given quantity of electricity was generated from a renewable or CHP source.[52] The GoO precedent suggests how Member States could be mandated to designate an independent national body to supervise the issuance of CCS certificates, as well as to ensure compliance amongst parties required to purchase them.

51 However all certificate schemes eventually pass costs through to consumers.

In closing, CCS certificate schemes offer a theoretically elegant option for CCS deployment in the EU. However, a certificate scheme is a market-based mechanism, and whilst examples have been successfully implemented by EU Member States, great care will have to be taken to ensure that an EU-wide certificate scheme neither falls prey to the shortcomings that have beset the EU ETS (see Section 4.1), nor undermines its operation.

As fossil fuel power stations are already included in the ETS, reduced emissions resulting from a supplementary CCS certificate scheme may lead to lower priced Emissions Unit Allowances, and a therefore reduced net incentive for the plants involved in both schemes to decarbonize.[53] One possible way to avoid this would be to permanently withdraw an 'equivalent' volume of ETS allowances from the market. However, there are strong political sensitivities around this subject (see Section 4.1) and it would be difficult to predict *a priori* exactly how the different schemes would interact.

In light of this, attempting an EU CCS-certificate scheme should be conditional upon a substantial will on the part of both the European Commission and Member States to broaden the EU's mandate and build the competences necessary to effectively and flexibly administer it on a large scale. In the absence of such a commitment, the Union may be better served by tools that are less theoretically elegant but more tried and tested at the EU-level.

52 This system was introduced by the Introduced by the EU's first Renewable Energy Directive, Directive 2001/77/EC of the European Parliament and of the of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:283:0033:0033:EN:PDF.

53 Morthorst (2003) 'A green certificate market combined with a liberalized power market', Energy Policy 31 (2003), 1393-1402; Söderholm (2008) 'The political economy of international green certificate markets', Energy Policy, Volume 36, Issue 6, 2008, 2051-2062.

3 Bridging the Gap: Policy Measures for the Middle Stages of Deployment

Effective support for innovation requires that policy frameworks 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.[54] Following demonstration, targeted support can create early markets for emerging technologies, effectively 'buying down' the cost of generation from these technologies so that they can be deployed more cost effectively in the future.[55] This is because such targeted support has dynamic effects: it fosters innovation, yields increasing returns to adoption and helps low-carbon technologies move along their learning curve (Figure 8[56]).[57] This subsection presents policy options that are suitable for the pre-commercial stage, where targeted support gradually transitions to support that encourages increased competitiveness with other abatement alternatives.

Government support can 'buy down' the costs of CCS

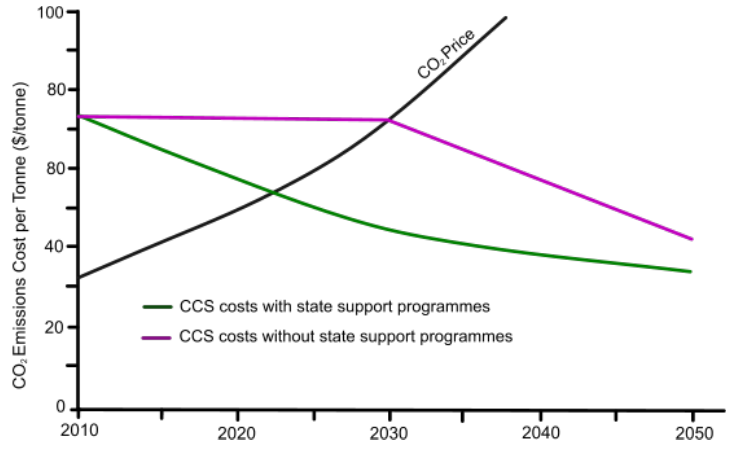


Figure 8: Effect of government support on cost of CCS

54 Foxon, T., Gross, R., Chase, A., Howes, J., Arnall, A., Anderson, D. (2005) Innovation systems for new and renewable energy technologies: drivers, barriers and system failures, Energy Policy, 33, pp. 2123-2137.

55 IEA (2000) 'Learning curves for energy technology policy', International Energy Agency, Paris, France.

56 Mills, R. (2011) *Capturing Carbon: The New Weapon in the War Against Climate Change*, p.237.

57 Gross et al. (2012), 'On picking winners: The need for targeted support for renewable energies', Imperial College London.

3.1 CCS purchase contracts through reverse auctions

In a reverse auction, a buyer advertises a specification for a good or service that it needs. Several sellers then bid to provide this good or service, competing against each other to obtain the buyer's business. Prices will typically decrease, rather than increase, as the sellers seek to undercut each other. This essentially constitutes an auction approach to procurement, also known as a tender in other contexts.

Perhaps most notably within the EU, reverse auctions were used to spur early renewable energy development in the UK through the Non-Fossil Fuel Obligation (NFFO) scheme.[58] Between 1989–1998, reverse auctions were conducted by the UK Government's Non-Fossil Purchasing Agency Limited (NFPA) for electricity generated from wind, hydro, landfill gas, sewer gas, biomass, and wet farm wastes.[59] NFFOs then required Regional Electricity Companies in England and Wales, to purchase all generation offered to them through these reverse auctions. Although they were required to buy the electricity, the companies only had to purchase it at the market price.[60] The difference between the contracted price and the market price was paid by the NFPA out of the funds that came from the Fossil Fuel Levy – a tax on all electricity introduced with the scheme.[61] The NFFO scheme is no longer open to new generators, but existing contracts will continue until the last of them expires in 2019.

To apply reverse auctions to CCS, public authorities could designate an amount of anthropogenic CO_2 to be captured and stored over the next 25 years. This sector-neutral objective would drive CCS deployment in both the power and non-power sectors.

Alternatively a number of MW of generation from a CCS power plant over that same period could be called for. A competitive bidding process would then take place for 20-year purchase contracts to reach either the desired CO_2 volumes or MW (excluding project construction time). Through the use of separate CCS technology bands, such a scheme has the potential for application in both pre- and post-combustion capture. Once bids are solicited, they would be compared with others from within their own technology bands, with the lowest bids selected.

Reverse auctions are attractive to policy makers because they offer one way of letting the competitive market apply downward pressure on CCS costs. For example, one comparative study of reverse auctions shows that tenders were accompanied by a reduction in the domestic price of electricity from renewable sources in the UK, China and Brazil.[62]

And whilst the performance incentive of a reverse auction would help drive CCS generation costs closer to grid parity, purchase contracts would also provide industry with much-needed economic certainty. Once in place, such agreements would ensure projects of a revenue stream that is insulated from price

58 http://www.ofgem.gov.uk/Sustainability/Environment/NFFOSRO/Pages/NFFOSRO.aspx.

59 The original intention was to provide financial support to the UK nuclear power generators, which continued to be state owned following the liberalization of the electricity market in 1989. The proposals were enlarged in scope before the scheme was brought into operation in 1990 to include the renewable energy sector.

60 More specifically, the average Pool Selling Price.

61 Mitchell, C. (2000), 'The England and Wales Non-Fossil Fuel Obligation: History and Lessons', *Annual Review of Energy and the Environment* 25: 285–312.

62 Cozzi (2012) 'Assessing Reverse Auctions as a Policy Tool for Renewable Energy Deployment', Energy, Climate, and Innovation Program, Tufts University.

volatility in the CO_2 and/or electricity markets for a known period of time. The resulting diminished investment risks would, in turn, help to deliver financing and lower capital costs.

Finally, as a demand instrument, purchase contracts could be engineered to be an effective tool in the development of a local market for manufacturing of components. This is a key goal of the pre-commercial phase in the CCS development cycle, and can be ensured by the purchase contract specifying a high local content requirement.

The clearest danger in the design of a reverse auction is that of underbidding. This is because the tendering process incentivizes firms to make 'best-case scenario' bids, which do not allow for potential obstacles or delays such as permitting problems.

Reverse auctions offer one way of letting the competitive market determine the price paid for CCS once a firm political commitment is made to the technology

Design elements therefore need to be incorporated to prevent underbidding and breaches of contract. Another danger is that bidders collude to achieve their common interest of a high price for their services. However auctions can be specifically designed to address these problems.

There is also one last drawback to the schemes described in this subsection. Although competitive at the bidding stage, purchase contracts subsequently isolate generators from the market through their use of must-take contracts for the duration of the specified fixed period. While this certainly does diminish the pressure towards cost-competitiveness when compared with other policy measures, the trade-off can be judged acceptable for the development of CCS in the pre-commercial phase.

A reverse auction doesn't determine either the price or the quantity of low-carbon energy. Instead, it gives public authorities a mandate to source the cheapest generation available from a pre-determined source. Provided that a political commitment can be made to developing a specific technology, reverse auctions help ensure that the development of this technology can be supported in the most cost-effective manner.

Because CCS purchase contracts would involve a substantial financial commitment and may not fit the needs of all EU Member States, decisions on their deployment are most suitably taken at the national rather than EU-level.

Capacity payments for CCS would need to be closely aligned with individual Member States' needs, energy market structures and existing energy policies

3.2 CCS capacity auctions

Capacity mechanisms encompass a variety of policy tools to assist energy planners in ensuring sufficient reliable capacity to cover peak demand, or in simple terms "to keep the lights on". Sufficient resource adequacy is necessary to ensure network robustness in the case of unplanned outages or – of increasing importance in modern generation networks – in times of low renewable generation.[63]

Capacity mechanisms have historically been used to drive investment in peaking capacity by adding economic incentives for capacity deployment. Capacity mechanisms may be necessary to supplement flexible capacity that operates below optimal load factors, and thus would otherwise not be sufficiently rewarded by the market.[64]

In many Member States, capacity payments have been proposed to help ensure the deployment of sufficient fossil backup capacity to renewable generation. It follows that such a mechanism could be used to prioritise the deployment of flexible low-carbon generation such as CCS. In networks with high renewable deployment and low CO_2 prices, it is possible that CCS facilities will operate at low load factors due to competition from low marginal cost renewables. In such circumstances, due to the capital intensity of CCS plant, investors will require some form a capacity mechanism in order to ensure that capital costs are recovered.

The most basic capacity mechanism is the strategic reserve, used in Sweden, Poland and Finland. Capacity is acquired and withheld from the market as a dispatch of last resort. Often the capacity is comprised of old facilities that would otherwise be retired as uneconomical.[65] A strategic reserve operating to these criteria would thus not support the deployment of new-build flexible low-carbon generation such as CCS.

Another form of capacity mechanism is the capacity payment. Here all generators, incumbents and entrants are paid for being available. The payments contribute towards the generators fixed cost with the payment level set administratively. Such a payment system is in place in Ireland, Spain, Portugal and Greece.[66]

63 Finon, Roques (2012) "European Electricity Market Reforms: The visible Hand of Public Coordination".

64 Heptonstall, Gross, Jones (2011) "Carbon Capture and Storage: Realising the Potential? Work Package 3, Task 5 Working Paper Version 2.1" UKERC.

65 Ewi (2012) "Investing into a sustainable electricity market design for Germany" Institute of Energy Economics. University of Cologne

66 Commission for Energy Regulation (2011) "CER Factsheet on the Single Electricity Market" www.cer.ie; Platts (2011) "Spain's government passes decree on 2012 power capacity payments"; NEPP (2011) "Capacity mechanisms: Revived interest in capacity mechanisms throughout Europe in the face of high volumes of intermittent generation" Northern Europe Power Perspectives.

Capacity markets can be constructed in a variety of ways. The UK, through the EMR, will centrally set the net amount of capacity needed to ensure security of supply before a capacity auction. Providers of capacity successful in the auction will enter into capacity agreements, committing to provide electricity or reduce demand for electricity when needed in the delivery years in return for steady capacity payments or face financial penalties. In this way, supply security may be provided through generation and non-generation means, such as demand side response and energy storage.

In the UK EMR, it is not envisioned that low-carbon generators receiving a FiT CfD will be eligible for capacity payments, so as to avoid double payments. Through these current arrangements it is not anticipated a UK capacity market will be provided a significant incentive for the short to medium term deployment of CCS, however in the longer term such a mechanism may supplement the income of low load factor CCS plant. In this way a capacity mechanism of some form to support CCS could serve a positive role in helping to reassure CCS investors concerned about load factor risk in the longer term.[67]

As with FiTs, capacity payments for CCS would need to be closely aligned with individual Member States' needs, energy market structures and existing energy policies. This makes them unsuitable for an EU-level legislative initiative, although they can certainly play an important role when implemented by Member States as part of an EU-wide policy framework.

3.3 Feed-in tariffs

Feed-in Tariff schemes (FiTs) offer targeted subsidies to production, setting total fixed price per unit of electricity for a generation technology or technologies.[68] FiTs are designed to cover the long-term average costs of generation, which means initial capital costs are included in the tariff. Generally the tariff is set for 10 to 20 years to provide transparency, longevity and certainty (TLC) to investors.[69] After this set period, the price returns to market levels. A variation of the fixed price schemes are premium payment schemes. These provide a fixed premium to be paid to the generator on top of the market price for electricity.[70]

In general, FiTs offer investors a significant security of income, reducing uncertainty and correspondingly lowering the cost of capital. However, unlike 'guaranteed rate of return' contracts, the technological risk remains with the developer.[71] This is to say that if the construction and operational cost are greater than expected, these are borne by the developer.

Due to FiT's ability to limit risk to taxpayers while proving very successful in achieving renewable energy deployment, the policy tool has become increasingly popular throughout Europe. As of 2012, 24 Member States had implemented FiTs, with 20 using the instrument as the primary renewable energy support

In the EU, it has been estimated that 85% of all new wind systems and nearly 100% of all new solar PV systems since 1997 have been installed with feed-in tariffs

mechanism.[72] In the EU it has been estimated that 85% of all new wind systems and nearly 100% % of all new solar PV systems since 1997 have been installed with feed-in tariffs.[73] A 2005 Commission study concluded that "well-adapted feed-in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity."[74]

The German model to support renewable deployment – the *Erneuerbare-Energien-Gesetz*, or EEG – is an example of a FiT. It provides renewable generators with a technology specific fixed premium per unit of electricity for a fixed period of time. Technologies with higher costs receive higher premiums. As the generation costs of new capacity decrease due to technological advancement, higher market penetration and learning through deployment, the premium paid to new developments is adjusted accordingly. A formidable 22% of Germany's electricity generation came from renewable sources in 2012.

Their glowing success elsewhere suggests that a tariff scheme for the electricity generated by CCS plants could also successfully drive the deployment of CCS in the EU. Alternatively, a FiT for the volume of CO_2 stored could act as an effective supplement to the electricity market price, making the business case for CCS whilst incentivizing operators to strive for ever greater emissions savings against the electricity produced. This latter approach could also be used to drive CCS deployment at industrial facilities: Eligible sectors, such as steel or cement, would receive a predetermined price for CO_2 stored.

Romania has offered its CCS demonstration project, Getica CCS, a FiT for the electricity it would produce, further demonstrating the applicability of the approach to CCS.

And the UK intends FiTs to be the cornerstone of the proposed Electricity Market Reform (EMR), limiting the existing system of tradable Renewables Obligations (see Section 2.5) in favour of a system wide FiT known as a Contract for Difference (CfD).[75] The CfD is envisioned to be the first European FiT to support low-carbon capital intensive projects such as nuclear and CCS in parallel to providing support to traditional renewable generation. The CfD will function with a technology specific centrally set strike price, offering a guaranteed electricity price for low-carbon generation while capping prices in times of generation scarcity (Figure 9).[76] CfD terms will distinguish between intermittent and baseload low-carbon generation as well as risk profile, such as for early stage CCS projects.[77]

67 Heptonstall, Gross, Jones (2011) "Carbon Capture and Storage: Realising the Potential? Work Package 3, Task 5 Working Paper Version 2.1" UKERC.
68 EPRG (2010) The Efficiency of Policy Instruments for the Deployment of CCS as a Large-sized Technology.
69 Fulton, Capalino (2012) "The German Feed-in Tariff: Recent Policy Changes" DB Climate Change Advisors.
70 Gross (2010) "Is there a route to a UK Feed in Tariff for renewable energy?" ICEPT.
71 Rothwell (2010) "New U.S. Nuclear Generation: 2010–2030" NEPI.

72 Ragwitz, Winkler (2012) "Recent developments of feed-in systems in the EU –A research paper for the International Feed-In Cooperation" A report commissioned by the Ministry for the Environment, Nature Conservation and Nuclear Safety.
73 8th International Feed-in Cooperation Workshop on 18 and 19 November 2010.
74 Communication from the Commission: The support of electricity from renewable energy sources, COM(2005) 627 final.
75 Allen & Overy (2012) "UK Electricity Market Reform: The draft Energy Bill".
76 Department of Energy and Climate change (2011) "Planning our electric future: technical update".
77 Written Ministerial Statement on energy policy (Oct 2010) Commentary on EMR White Paper.

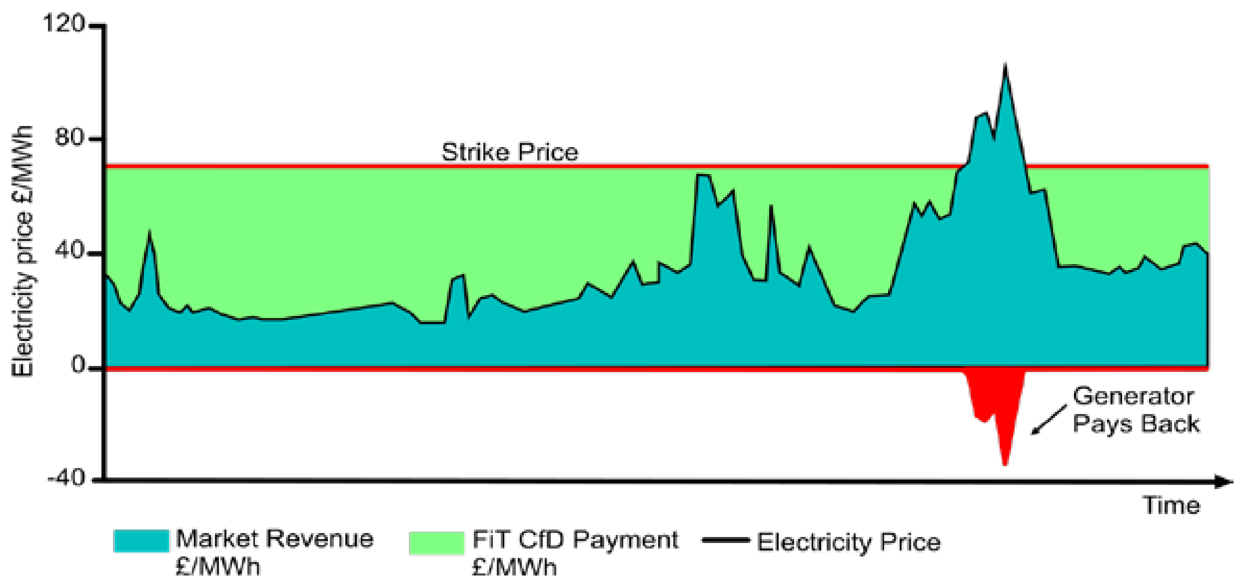


Figure 9: Graphical representation of a generic FiT scheme with a strike price

Whilst the paragraphs above illustrate their potential, FiTs pose a number of design challenges for policymakers. First of all, it is unavoidable that for large capital cost projects with long lead times, FiTs may expose consumers to risk in the case of significant technology or market change by locking in purchases from a technology that may be obsolete or expensive. An example is the 30 year FiT contract to support Rockport coal gasification facility in Indiana USA, resulting in costs for consumers due to the subsequent collapse in US natural gas prices after increases in shale gas production.[78]

Secondly, for a FiT to successfully attract investment to CCS, it is necessary that the level of subsidy provided be just right. Too conservative and the desired technology may not be deployed. Too generous, however, and it would result in an over-allocation of support to developers and oversubscription to the scheme at the expense of consumers and the public.[79] Some have suggested that this has been observed with photovoltaic deployment in Germany and Spain.[80] This can be controlled by revising the policy when installed capacity reaches a set level – in the case of CCS, for a set capacity or number of capture technologies deployed.

Unlike renewables, however, unpredictable changes in the market price of fuels mean that a CCS FiT will need some form of fuel price indexation to act as a hedge against long term fuel price variability. With a static FiT, fluctuating fuel prices would erode the incentive to construct or operate CCS facilities because it would be impossible for CCS operators to get fuel supply contracts to last the lifetime of their plants. This would in turn diminish the long-term security of income provided by the FiT, greatly reducing the scheme's effectiveness. It is for this reason that, as of early 2013, the UK government was considering fuel price indexation for CCS projects in its CfD scheme.[81]

Due to these factors, an efficient FiT would need to be very closely aligned with individual Member States' needs, energy market structures, technological deployment aspirations and long term energy policies. Whilst FiT schemes can therefore be extremely effective when designed and deployed at the national level, the difficulties associated with a one-size-fits-all approach may weaken their effectiveness if achieved through EU-level legislation that is too prescriptive.[82] Moreover, the significant fiscal commitment that comes with binding EU-wide legislation on a CCS FiT would likely make such a scheme politically infeasible.

FiTs arguably offer investors a greater security of income than any other policy measure examined, reducing uncertainty and correspondingly lowering the cost of capital

A FiT for CCS will require some form of fuel price indexation to act as a hedge against long-term changes in fuel prices

78 Indystar.com (2012) "Court ruling may give Indiana lawmakers another swipe at Rockport coal-gas plant".
79 Finon (2010) "The Efficiency of Policy Instruments for the Deployment of CCS as a Large-sized Technology" EPRG.
80 Fulton, Capalino (2012) "The German Feed-in Tariff: Recent Policy Changes" DB Climate Change Advisors.
81 Norton Rose Global (2012) "CfD operational framework - Ten key aspects".

82 A 2008 European Commission report on the harmonization of renewable energy policies reached a similar conclusion. Commission Staff Working Document: The support of electricity from renewable energy sources: Accompanying document to the Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources {COM(2008) 19 final}, SEC(2008) 57, 23.1.2008.

3.4 Priority grid access

The position of a generation technology in the merit order has important implications for the commercial attractiveness of that technology. New plants with high upfront cost such as CCS may require high load factors in order to recoup investments and generate an acceptable return for operators. Uncertainty surrounding the load factor of a facility and thus revenues generated may be a commercial barrier to deployment.[83]

Throughout Member States, electricity is generally dispatched to the grid through a form of 'merit order'. The variable operating cost of various generators – also known as their marginal cost of production – is the key organizing principle that determines which units the power system dispatches to meet electricity demand at any given moment.

Strictly speaking, there is no fixed 'merit order' in liberalized electricity markets such as in the EU: generators are free to trade as they see fit within the constraints of their operating characteristics (such as output ramping rates) and the regulatory framework. However, the term is a useful shorthand to describe what typically happens in the market – i.e. a plant that has high up-front capital costs and low variable operating costs (nuclear power, for example) will normally run whenever it is physically capable of doing so, however low the electricity market price is. Progressively higher variable cost facilities will operate to follow seasonal and daily demand variation, as market prices rise.[84]

It is important to note that this 'conventional' dispatch order does not necessarily reflect the levellized generation costs of various energy sources, their environmental sustainability, nor the long-run costs of the system as a whole.[85] In other words, the disaggregated decisions of individual competing agents in the market may not ensure system-wide optimisation.

Traditionally, low marginal cost fossil plants such as coal and lignite would rank highly on the merit order just behind nuclear, dominating baseload generation and receiving high load factors.[86] Older, less efficient coal plants and combined cycle gas facilities would operate as mid merit, while open cycle gas plants and oil would provide rapid response peaking plant.

However, the traditional merit curve is undergoing change with the deployment of large scale renewable generation incentives by national and EU policy. Renewables such as wind are characterised by high capital cost and very low marginal cost, as the technology has zero fuel costs. As such, whenever the wind is blowing the electricity produced is sold onto the market regardless of the price, receiving the highest dispatch priority. On top of this, the EU requires Member States to give priority access to the grid for renewable energy sources.[87]

The end result is a shifting of the traditional merit curve, with intermittent renewables – whenever available – occupying baseload alongside inflexible low marginal cost nuclear generation. Lignite and coal capacity is displaced, migrating to mid-merit

83 Energy and Climate Change Committee (2012) – "Draft Energy Bill: Pre-legislative Scrutiny Written evidence submitted by Carbon Capture and Storage Association".
84 Heptonstall, Gross, Jones (2011) "Carbon Capture and Storage: Realising the Potential? Work Package 3, Task 5 Working Paper Version 2.1" UKERC.
85 Nicolsi, Marco and Fürsch, Michaela. (2009). "The Impact of Increasing the Share of RES-E on the Conventional Power Market - The example of Germany." Zeitschrift fuer Energiewirtschaft 03/200.
86 Vivideconomics (2011) Productivity Commission Electricity dispatch regimes.
87 RES National Policy Reviews (2013) http://www.erec.org/policy/national-policies.html European Renewable Energy Council.

A reduced load factor for CCS facilities will curtail revenue and dissuade investment

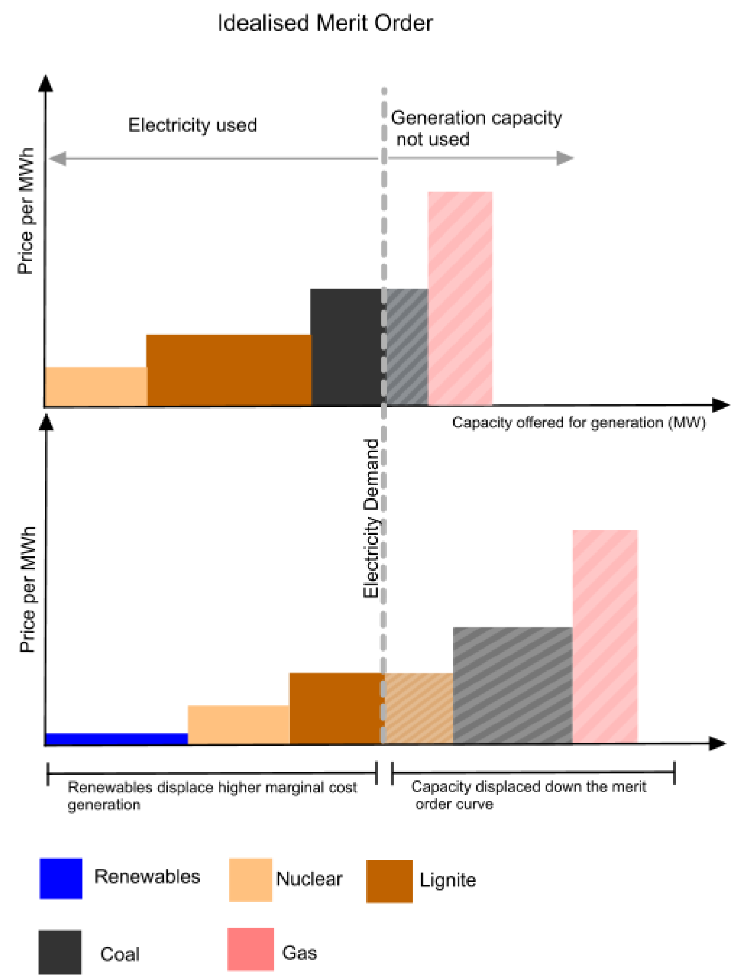


Figure 10: Effect of renewables on electricity market dispatch.

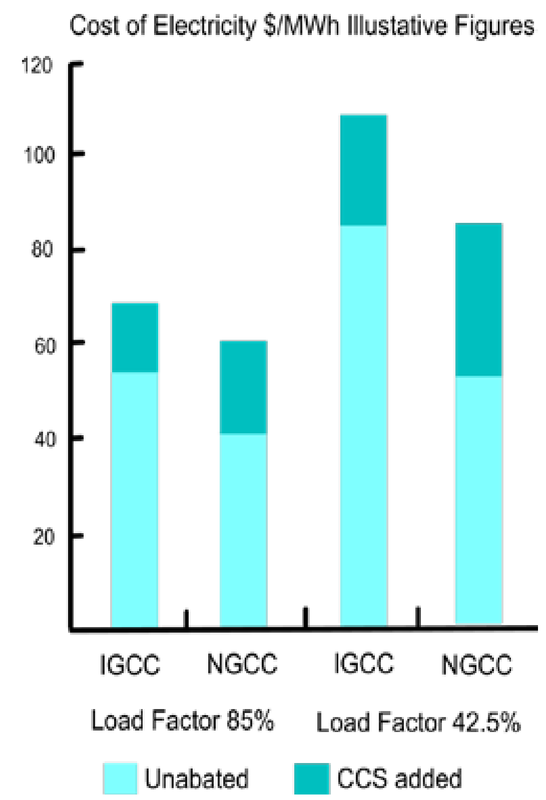


Figure 11: Estimated effect of different load factor on the generating cost from CCS facility

generation due to its relatively high marginal cost (Figure 10). This effect is anticipated to accelerate as the deployment of renewables ramps up.

Currently, the EU electricity market is characterized by conditions of a low CO_2 price combined with high levels of intermittent renewables generation. Under these conditions, the higher marginal cost of CCS generation means that it would have a low position in the merit order. This, in turn, would reduce a CCS facility's load factor, curtailing revenue generation. E.ON anticipates coal CCS load factor in the UK to be in the region of 60-80% to 2025, declining to 45-60% by 2035 with the prevailing market structure.[88]

The lower dispatch of electricity from a capital intensive investment such as a CCS facility will substantially increase the risk to revenues, making it difficult to secure higher shares of debt funding.[89] In this way, uncertainty surrounding expected load factors may be sufficient to dissuade investment in CCS, as much of the risks of this investment would have to be internalized.

Figure 11[90] describes the cost of electricity from an Integrated Gasification Combined Cycle (IGCC) and Natural Gas Combined Cycle (NGCC) fitted with CCS at high (85%) and low (42.5%) load factors. As CCS is anticipated to remain relatively capital intensive in the coming decades, prospective operators will seek high utilisation of their facilities. CCS operating as baseload enables the plant to be operated in the most economically efficient manner. The high capacity credit of CCS facilities is a key benefit of the technology and needs to be taken into account by energy planners.

CCS facilities will also likely be required to operate with a degree of flexibility in order to provide low-carbon system support services.[91] Many techniques exist to further increase the operational flexibility of coal or gas CCS facilities, such as temporarily reducing the rate of capture, storing of amine for post combustion, buffering hydrogen for later use at an IGCC facility or storing oxygen in the case of an oxyfuel plant.[92] However, such modifications may further increase the capital outlay and increase operational cost associated with CO_2 transport and storage.[93]

Within the framework of strong, targeted support for intermittent renewable generation, the load factor of CCS can be increased through displacing unabated generation on the merit order. As the short run marginal cost of unabated coal or gas is the cost of fuel, CO_2 price as well as operation and maintenance costs, this goal can be accomplished through the following policies.[94]

88 E.ON in the UK response to DECC Call for Evidence on 2050 Pathways Analysis, http://www.eon-uk.com/2050_pathways_response.pdf.
89 Houston, Pearce (2011) "Business Model for CCS" Poyry Carbon Capture Journal.
90 Sweeney (2011) "Decarbonising electricity, Why, how, how much? "Presentation to Energy Day Calix.
91 Rodriguez (2011) "Exploring the potential role of CCS in the future low-carbon electricity market" Centre of Environmental Policy, Imperial College London.
92 Ladbrook, Pearce (2010) "Flexible CCS for power generation" Poyry Energy Consulting
93 Lohwasser, Madlener (2009) "Impact of CCS on the Economics of Coal-Fired Power Plants – Why Investment Costs Do and Efficiency Doesn't Matter" E.ON Energy Research Center
94 Seebregs, Deurzen (2010) "Carbon Capture & Storage in power generation and wind energy: flexibility and reliability issues in scenarios for Northwest Europe" Energy Procardia

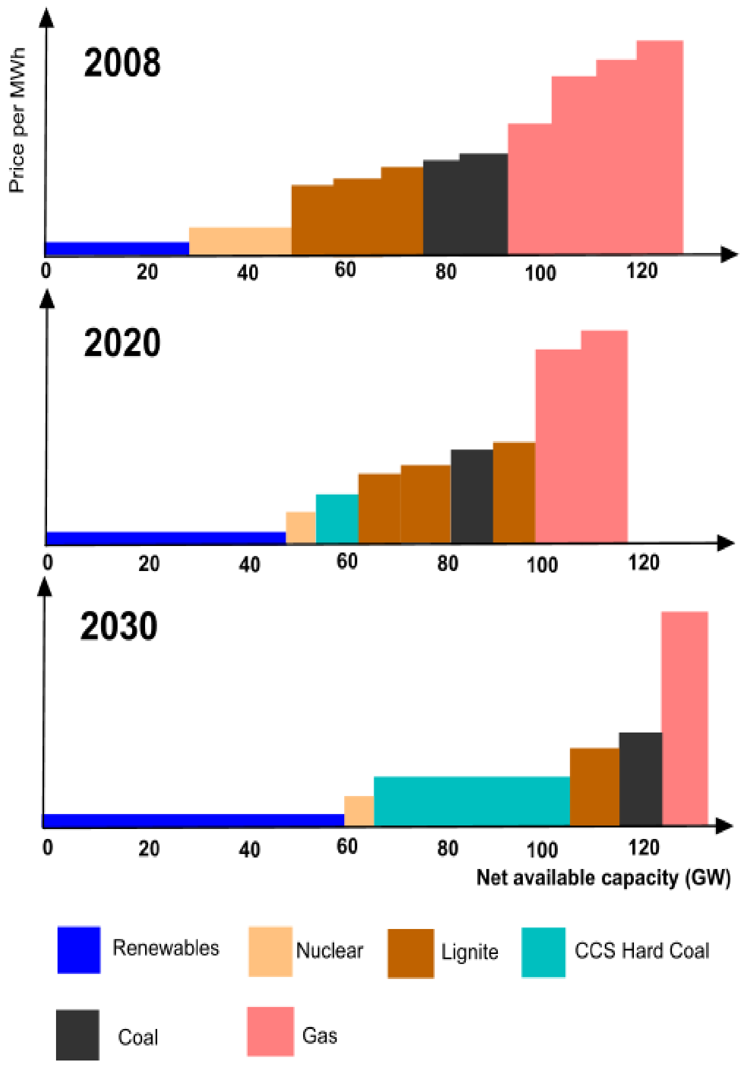


Figure 12: Merit order curve for the Germany/Austria/Switzerland region. At high CO_2 prices, conventional fossil fuel-fired power plants are replaced in the merit order by both renewable energy technologies and CCS capacity across Europe.

1) Significantly increasing the penalty on operating an unabated plant through a CO_2 price (Figure 12[95]).

This measure would increase the marginal cost of unabated generation, requiring operators to purchase carbon allowances or pay a carbon tax. Reducing the competitiveness of unabated capacity relative to CCS capacity would give CCS a place in the mid-merit that would ensure investors of a sufficient return.

Recently, the low EU ETS CO_2 price has meant that a scenario such as that depicted in the figure above has not materialized. More fundamentally, CO_2 price volatility has undermined some CCS investors' beliefs that a high and stable CO_2 price would sustain long enough to deliver an adequate return on capital if CCS is not supported by supplementary policies (see Section 4.1).

2) Directly modifying the electricity dispatch system to reflect the value of low-carbon generation and not just marginal cost alone.

In certain cases, modifying the rules that determine the dispatch order of generation capacity could also be used to increase the load factor of CCS capacity. It is possible to alter the system to preferentially dispatch low-carbon generation 'out of merit'. This would increase CCS utilization by moving CCS plant up the merit order and incentivize CCS deployment as it allows the technology to capture a larger slice of the energy market.

Under conditions where electricity networks are operated as monopolies,[96] modifying the dispatch order is relatively straightforward. For example, China has begun trials on a modified dispatch routine known as Regulation on Energy Conservation Power Generation Dispatching.[97] Seven classes of generation units based on their carbon intensity were created with the intention for units from a more carbon intensive class to only be brought on-line once the lower carbon class is operating at full capacity (Table 3).[98] In such a system, fossil fuelled plant equipped with CCS would rank in class 4.

Table 3: Trial Energy Conservation Power Generation Dispatching in China

1	Wind, solar, ocean and must-run hydro
2	Adjustable hydro, biomass, geothermal and solid waste
3	Nuclear
4	Coal-fired Combined Heat and Power (CHP) units
5	Natural gas and coal gasification-based combined cycle
6	Other coal-fired units including co-generation without head load
7	Oil-based generation units

Whilst the Chinese example seems attractive, its application in the liberalized EU electricity market is troublesome. EU system operators do have some leeway to classify units as running in out-of-merit dispatch so as to provide reactive power to support transmission grids and to hold units as "spinning-reserve". However, the aim of this is to substantially reduce the market clearing price at times when rapidly increasing demand would otherwise cause it to spike. Running large scale CCS generation out of merit would therefore be in tension with some of the basic operating principles of the common liberalized electricity market that the European Commission has worked to attain since 1996.

95 Seebregts (2011) "Screening of the impacts of large scale CCS on the electricity market" CATO-2 Deliverable WP 2.2-D 2.2 01; Lohwasser, Mandlener (2009) Simulation of the European Electricity Market and CCS Development with the HECTOR Model

96 In public ownership, as closely regulated private utility companies, or as local municipal undertakings.

97 Cheung (2011) "Integration of Renewables Status and challenges in China" IEA Working Paper

98 Vivideconomics (2011) Productivity Commission Electricity dispatch regimes

The conventional dispatch order does not necessarily reflect the levelized generation costs of various energy sources, their environmental sustainability, nor the long-run costs of the system as a whole

FiTs offer one way to ensure CCS of priority grid access in the liberalized electricity market

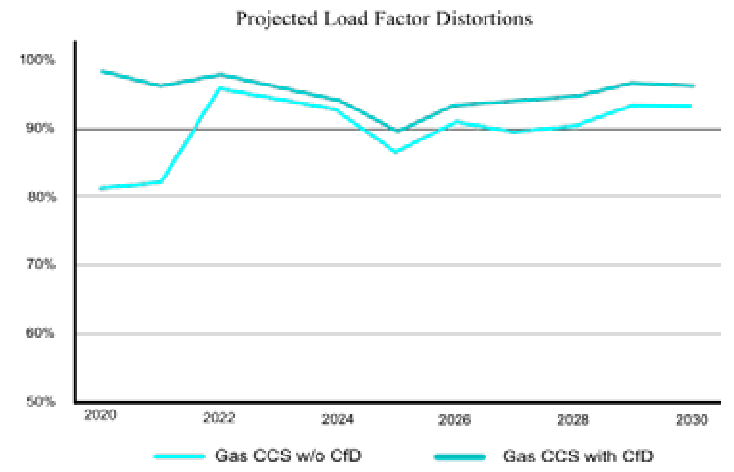


Figure 13 Higher mid-merit – Projected load factor distortions under metered output ("with distortion") and firm volume ("without distortion")

3) Providing a sufficient reward to generate CCS electricity (FiT).

As covered in Section 3.3, the effect of the proposed UK CfD will be to reduce the short-run marginal cost of CCS by the strike price less the reference price.[99] This reduction in marginal cost will, if set correctly, be sufficient for CCS equipped plant to displace unabated facilities in the merit order curve, independent of the prevailing CO_2 price (Figure 13). Not only would fixed-tariffs over a clear timeframe provide certainty of income for investors, it would also further reduce system emissions.[100]

Without a substantial CO_2 price to penalise unabated electricity generation (increasing its marginal cost relative to CCS) or a policy to ensure CCS generation of a high place on the merit order, such as a FiT (decreasing the relative marginal cost of CCS), there can be no business case for CCS. Even if the technology were deployed, there would be no commercial rationale to operate the plant. As such, CCS facilities constructed through a simple deployment mandate would require such additional policies in order to avoid non-operational or 'mothballed' facilities.

It is interesting to note that two EU-level precedents already exist for providing priority dispatch in the electricity market. Renewable energy sources are ensured priority access with the 2009 Renewable Energy Directive[101] and the 2012 Energy Efficiency Directive mandates priority access for high efficiency combined heat and power facilities, albeit with provisos that this does not endanger grid stability.[102] Although it was left to Member States to decide how to implement this priority access, the supplementary income offered by widely-employed FiTs and green certificate schemes for both technologies ensured them priority dispatch without violation of the general economic principle that the lowest marginal cost generation should be dispatched first.

With CO_2 price developments uncertain and direct control of dispatch unrealistic in liberalized electricity markets, FiT schemes present the most attractive option to investors for ensuring CCS of a high enough place on the dispatch curve to limit revenue risks and facilitate investment. An EU Directive giving CCS some degree of privileged access to the grid would likely be fulfilled by the majority of Member States through FiT schemes.

As priority dispatch of renewables and CHP were both previsioned in the 3rd Energy Package's Electricity Directive[103] any new EU legislation granting priority access to CCS may require an amendment to this.

99 LCP (2012) "LCP's assessment of the dispatch distortions under the Feed-in Tariff with Contract for Differences policy."

100 Lohwasser, Mandlener (2009) Simulation of the European Electricity Market and CCS Development with the HECTOR Model

101 Article 16. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance).

102 Article 15. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Text with EEA relevance).

103 Article 15. Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance).

4 Ensuring the Competitiveness of CCS

As covered in Section 2.3, there is a general consensus that the most cost-effective way to facilitate the deployment of new energy technologies is through a combination of targeted support and CO_2 pricing policies.[104] As the IEA highlights, CCS support policies for need to take into account the shifting needs of the technology as it matures, from more specific measures in the early stages to more neutral measures as it approaches commercialization to ensure it becomes competitive with other abatement opportunities.[105]

Neutral CO_2 pricing 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. The result may be to over-reward subsidized generators and transfer wealth from consumers to the industry in question.[106] Moreover, subsidies have the potential to undermine any market based solution in place, effectively penalizing or rewarding different market actors twice.

However, CO_2 markets are far from perfect. First, costs and benefits – for example, CCS allowing a greater penetration of intermittent renewables, by acting as a back-up – are not transparent, making the 'optimal' CO_2 price very difficult to determine.[107] Setting a CO_2 tax (or cap), based upon an analysis of global damage costs weighed against the benefits of unabated fossil generation is therefore problematic. And secondly, numerous non-price market failures exist. Uncertainties associated with wholesale power prices, CO_2 prices, and future political decisions may drive up the cost of capital, and discourage investment in CCS.[108]

The most cost-effective way to facilitate the deployment of CCS is therefore highly contestable, hinging upon whether the notional inefficiencies associated with targeted support for CCS outweigh the real-world inefficiencies of CO_2 caps or taxes in the context of targeted support for other technologies. In light of this uncertainty, this subsection presents a selection of both technology specific, and technology general policies with a view to stimulating debate on this point.

104 Stern, N. (2007) The Economics of Climate Change: The Stern Review, Cambridge University Press, Cambridge, UK; Fischer, C. & Newell, R. G. (2008) Environmental and technology policies for climate mitigation. Journal of Environmental Economics and Management, 55(2), pp. 142–162. UNDP. (2009) Charting A New Low-carbon Route To Development. [Online] United Nations Development Programme, Washington D.C., USA.

105 IEA (2012), 'A Policy Strategy for Carbon Capture and Storage'.

106 Helm, D. (2010) Government failure, rent-seeking, and capture: the design of climate change policy, Oxford Review of Economic Policy 26 (2), pp. 182-196.

107 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. 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. Stern, N. (2007) 'The Economics of Climate Change: The Stern Review', Cambridge University Press, Cambridge, UK; CCC (2008) 'Building a Low-carbon Economy: the UK's Contribution to Tackling Climate Change', Committee on Climate Change, London, UK.

108 Gross et al. (2012), 'On picking winners: The need for targeted support for renewable energies', Imperial College London.

4.1 Reforming the EU emissions trading system

Introduced in 2005, the EU ETS is the bloc's flagship policy to address climate change and the largest carbon market in operation worldwide. Because CCS has not been the beneficiary of significant targeted support schemes to date – feed-in-tariffs or portfolio requirements, for example – its fate is especially dependent on the ETS CO_2 price. As illustrated in Section 1.4, a high CO_2 price would have ensured that the marginal cost of unabated generation would increase, made CCS generation competitive and driven its deployment in the EU.

Unfortunately, the price of CO_2 has not been as robust as originally forecast (see Figure 1). At the time of writing, EUAs were trading at around €4.30/tCO_2. This compared with forecast prices of around €30/t from mid-2008.[109] Moreover, the low price of 10-year CO_2 futures indicates that the market currently does not see the price of EUAs increasing dramatically in this time window. Under these conditions, investors and utilities will not deploy CCS as a matter of course. Whilst some may argue that the low price of CO_2 illustrates that the cap-and-trade system has been effective in lowering EU emissions, there can be no doubt that the ETS in its present form fails to provide a satisfactory price signal – now or projected – to encourage the development and deployment of new low-carbon technologies, such as CCS (see section 1.2.1). In that respect, it has failed to achieve an important policy objective.

In the short- to medium-term, the European Commission's proposal to delay the auctioning of emissions allowances could increase the amount of funds available to fund CCS in the second round of the NER300. In the longer-term, however, significant institutional reform may be necessary to address the following inter-related shortcomings of the EU ETS that prevent it from providing an effective price signal for low-carbon investment.

1) The over-generous allocation of emissions allowances. The political decision making process that gave rise to the ETS Directive resulted in compromises that meant the final form of the legislation was based on a conservative collective understanding of achievable CO_2 emissions reductions. This led to a generous supply of allowances and international credits – in particular, the grandfathering of an excessively large number of allowances to heavily polluting industries in a move that aberrantly resulted in windfalls for many who were able to sell on their unused allowances. These effects were exacerbated by the reduced economic activity caused by the global financial crisis.

2) The lack of a monopoly on policymaking in fields that may have an impact on the scarcity of allowances. Parallel energy policies at both the national- and EU-levels – FiTs, carbon floor prices and the Renewables and Energy Efficiency Directives, for example – have the potential to distort the market price of EUAs (see Section 2.5 for a discussion with regards to green certificate schemes). Because 30 countries share a common pool of allowances, policies enacted by any one of them can have unintended consequences in others. Moreover, the weaker the CO_2 price becomes, the greater the temptation to enact parallel policies that weaken it further.

The ability to reactively adjust the scarcity of allowances would offer the EU a means of addressing both of the abovementioned issues. Currently, adjusting the supply of EUAs requires a proposed amendment to the ETS Directive by the European Commission, which the European Parliament and Council both then need to approve. This is a lengthy and uncertain political process.

Alternatively, a structural reform of the ETS could be performed to put in place governance arrangements for discretionary adjustments to the supply of allowances. This would be a break from the market-based logic of allowing the scarcity of a pre-determined limit on emissions determine the CO_2 price. Many would also view it as a breach of the political mandate granted to the EU on how climate change should be addressed.

However, such a reform would allow the EU Institution with executive responsibility for the system to react to inherently unpredictable changes in CO_2 demand that could lead to excessive price movements affecting the orderly functioning of the market. Effective and transparent criteria for intervention will need to be drawn up and the executive institution will need to be assured of both a strong mandate and the independence to execute this mandate. Providing such arrangements can be politically agreed at the EU-level, the resulting changes would be a great step forward for all low-carbon technologies, including CCS.

Until such change can be realized, however, supplementary targeted support for CCS will be necessary – even into the commercial deployment phase. This 'belt and braces' approach to decarbonisation has been widely employed by EU Member States – as well as by the EU itself. For example, the EU provides direct support to renewable energy sources beyond the ETS by mandating their deployment with the Renewables Directive (see Section 2.4). Member State and private spending of €20 billion per year until 2020 will be required to meet the obligations of the Directive.

109 Energy and Climate Change Committee (2012) "the EU Emissions Trading System: government Response to the Committee's Tenth report of Session 2010-2012

4.2 Emission performance standards

Emissions Performance Standards (EPS) have long been a key tool in achieving desired environmental goals. The concept is simple, in that once implemented it dictates a maximum allowable release of a pollutant (SO_2, NO_x, CO_2) during the production of a commodity such as a tonne of steel or MWh of electricity. This places a clear obligation on the polluter to alter their production process or install pollution abatement technology to reach the mandated performance standard.

EPS are attractive to policy makers due to their simplicity of implementation, predictable results and low direct cost to the state. However, as an EPS may effectively result in a technology mandate depending on what level the EPS is set at. This can be unattractive to policy makers due to a reluctance of governments to be seen to be "picking winners". A side effect of an overly strict EPS in the absence of other supporting policies may be underinvestment, as polluters avoid the development of affected technologies, preferring instead to switch fuel or process with the resulting impacts on energy supply diversity and security.

Emissions performance standards have been implemented to promote CCS deployment in both Canada and the United States

Notable EPSs at thermal power plants include the 1971 New Source Performance Standard in the United States. This created the first effective market demand for SO_2 emissions control technology, encouraged investment in R&D and fabrication of Flue Gas Desulphurisation (FGD) technology and also helped foster the creation of a competitive air cleaning industry.[110] However the legislation and subsequent variants failed to address emissions from existing sources or grandfathering, greatly reducing their effectiveness in reducing SO_2 emissions.

In 1983, West Germany introduced the *Großfeuerungsanlagenverordnung* (GFAVo), imposing swingeing emissions cuts on nearly all existing large coal combustion plants.[111] This EPS could only be met through the application of FGD and was therefore, effectively, a mandate to retrofit the technology. The ambitious GFAVo was ultimately very successful in dramatically reducing SO_2 emissions in a very short time period, but the rapidity of the roll out and the uniformity of the regulations meant that this reduction was achieved at an inflated cost.[112]

In spite of this, German industry quickly modified, perfected and reduced the cost of FGD technology; incentivised by a large and stable local FGD market, very competitive vendor markets and strict performance guarantees demanded by utilities. Due to competitive yet profitable conditions in the domestic market, German vendors were well placed to compete internationally for FGD contracts, capturing the lion's share of the global FGD market. The GFAVo served as the basis of the EU wide 1988 Large Combustion Plant Directive (LCPD), enforcing SO_2 emissions reductions and increasing the market for the air cleaning industry.[113]

Emissions performance standards have been implemented to help promote CCS deployment in both Canada and the United States. In 2012 the Canadian government finalised performance standards affecting coal electricity generation. All new coal facilities post 2015 and existing facilities over 50 years will be mandated to reduce CO_2 emissions to the level of Combine Cycle Gas Turbine (CCGT) (420kg/MWh), requiring the application of CCS. A grace period in achieving the EPS and thus the deployment CCS has been set to 2025.

In the United States, an array of regional and state level performance standards have emerged. California, Oregon and Washington have adopted an EPS for baseload thermal electricity generation, requiring all new build and existing facilities entering into long-term contracts to meet an emissions performance equivalent to CCGT. Montana has implemented an EPS through the planning code, with approval of new coal based generation conditional on meeting an EPS with CCS. In New Mexico, incentives such as tax and cost recovery are provided to coal-fired plants that meet an EPS. The state of Illinois is requiring electric utilities to enter into one or more sourcing agreements with "initial clean coal facilities" (see Section 2.4).[114]

The United States EPA is proposing new source performance standards for emissions of CO_2 for new fossil fuel-fired electric generating units. The proposed standard will limit all new capacity to 454 kg of CO_2/MWh. The draft regulation allows new coal facilities flexibility in meeting the standard, with emissions averaged over a 30 year period. This would result in a maximum unabated operation of 10 years before the installation of CCS at a high capture rate.[115]

In the UK, any new coal capacity is already required to have a minimum of 300 MW fitted with CCS as a condition of planning consent.[116] This is anticipated to expand to a more complete EPS with the passing of the Electricity Market Reform in 2013.[117] The EMR is a series of interdependent and reinforcing policy tools designed with ambition of providing an attractive market for all forms of low-carbon electricity while maintaining supply security and system integrity. In the design of the EMR, an EPS is envisioned to act as: a) insurance against lock-in to high carbon generation technology; b) a transparent framework on government expectations of CO_2 emissions from the electricity sector; c) certainty for investment in low-carbon technology; and d) along with other measures, assist the deployment of CCS. As designed, the EPS will place an annual limit on CO_2 emissions equivalent to 450 Kg/MWh. The EPS will not be retroactive, only applying to new build or extensively modified facilities. In combination with grandfathering, the EPS is set at the current level until 2045 for capacity built within its scope, creating concerns of emissions lock-in resulting from rapid expansion in natural gas generation capacity.

It is unlikely that a basic standalone EPS, isolated from other policy instruments, would deliver near-term CCS deployment in the EU power sector

110 Taylor, Margaret R. The Influence of Government Actions on Innovative Activities in the Development of Environmental Technologies to Control Sulfur Dioxide Emissions from Stationary Sources. Pittsburgh: Carnegie mellon university, 2001.
111 Berkhout, Christiansen, Skea. "Electricity wastes in the UK and West Germany." Energy Policy , 1989: 109-115.
112 BioIntelligence. Case Studey on the Large Combustion Plants Directive. Paris: European Commission, 2006.
113 Peattie, Ringler. "Managment and the Environment in the UK and Germany." European Managment Journal, 1994: Vol 12, 216-225.

114 Simpson, Hausauer & Rao (2010) "Emissions Performance Standards In Selected States" Regulatory Assistance Project, research Brief.
115 Baker & McKenzie (2012) "EPA publishes first-ever carbon dioxide emissions standard for new power plants with future implications for existing sources" http://www.lexology.com/library/detail.aspx?g=e6fc55b3-6de1-401e-99a0-2b2587e07ec9

116 Committee, E. a. C. C., 2010. Emissions Preformance Standards. First Report of Session 2010-11 Volume 1, UK: House of Commons.
117 House of Commons Energy and Climate Change Committee, 2011. Emissions Performance Standards: Government Response to the Committee's First Report of Session 2010–11 , London: Energy and Climate Change Committee.

Table 4: Emissions Performance Standards in selected countries (Proposed or in place)

	UK	Canada	US
EPS Standard (kg/MWh)	450	420	454
New units	Yes	Yes	Yes
Old Units	No	Yes - Facilities > 50 years	No
Fuel	Fossil Fuels	Coal	Fossil Fuels
Flexibility - Emissions Averaging for peaking and part time operation	Yes	Yes	Yes
CCS Application	Exemption for CCS Demonstration Projects	CCS deployment post 2025	Emissions averaged over 30 year basis. Up to 10 year delay in CCS deployment
Implementation	2012	2012	Draft – 2012

It is clear that many governments see an EPS as an effective policy tool to assist the deployment of CCS. EPSs have also been deployed at the EU level: The EU's Large Combustion Plant Directive further tightened SO_2, NO_X and particulate emissions limits, and will have a deep impact on the operation of existing coal-fired plant in the Union when 'opt outs' for its implementation expire at the end of 2015.[118]

The proposal of an EU wide EPS to support CCS at fossil fuel power plants is not new. During the negotiations and development of the NER300 scheme, the European Parliament attempted to add an amendment enacting an Emissions Performance Standard (EPS) of 500g of CO_2/kWh, to come into force in 2015. This would effectively require CCS to be fitted if coal large combustion plants wished to remain in operation. This amendment met with stiff opposition from Member States and failed to pass the European Council of Ministers.[119] The precedent indicates that the political acceptability of an EU-wide EPS ambitious enough to incentivize CCS on its own would be remote.

An EPS can form a valuable part of a suite of policies aimed at energy system decarbonisation. For example, a modest CO_2 EPS could ensure that a transitory surplus in CO_2 allowances does not lead to the most highly polluting generation sources being run. However, because of political acceptance issues, it is unlikely that a basic standalone EPS – one that simply mandates a universal standard for new facilities and isolated from other policy instruments – would deliver near-term CCS deployment in the power sector.[120]

Its application to non-power industries, however, is promising provided that the global competitiveness of these industries can be ensured (see Section 4.4).

4.3 Feebates

Also called a system benefit charge, a feebate can generically be described as a fee imposed by government authorities on socially undesirable activities, the collected revenues from which are applied to fund socially desirable activities. Applied to CCS, authorities could accordingly charge utilities or industry with significant CO_2 emissions to fund a pool that could then be proportionally redistributed to generators with fewer emissions – either through one-time capital expenditure grants or OPEX subsidies. This would reward comparative emissions performance and compensate less polluting plants for their higher capital and operating costs. If designed carefully, therefore, feebates may play a valuable role in CCS deployment, where CO_2 and fossil fuel price volatility results in severe discounting of future OPEX and an investor aversion to generating infrastructure with higher capital costs.

As the chart above illustrates, feebates can be considered a sort of 'soft' EPS, where convergence around a certain emissions standard is financially incentivized rather than directly regulated. Feebates allow for considerable flexibility around a target in terms of the benchmark emission figure, as well as the bonus and malus rates (Figure 14). Although a CO_2 feebate scheme for thermal coal or gas generation would be technology neutral, setting a sufficiently high benchmark CO_2 emission level as well as bonus and malus rates could effectively incentivize CCS deployment.

Feebate schemes can deliver impressive levels of emissions reductions, but the direct management of significant revenues makes them unsuitable for EU-level legislation

118 Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants.

119 Energy and Climate Change Committee (2010) 'First Report: Emissions Performance Standards', UK Parliament, http://www.publications.parliament.uk/pa/cm201011/cmselect/cmenergy/523/52308.htm.

120 Bloomberg New Energy Finance, 2011. Emission Preformance Standards: Impacts of power plant CO_2 emission preformance standards in the context of the European carbon market, s.l.: Bloombeg New Energy Finance.

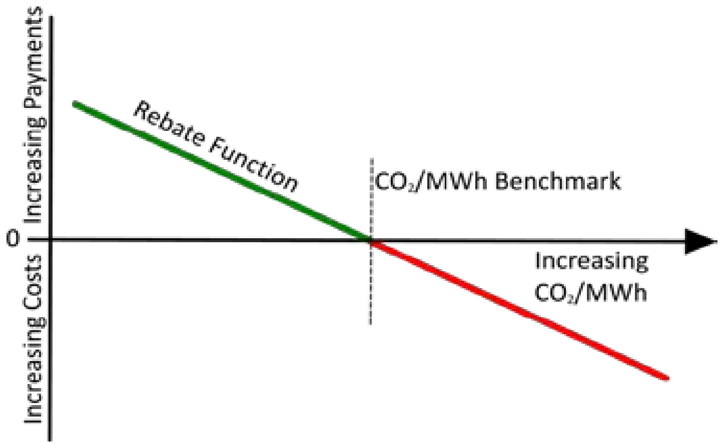


Figure 14: Depiction of a Generic CCS Feebate Programme

However, their inherent flexibility leads to the oft-cited criticism that feebate schemes can be very difficult to administer if the rebate function is made static. For example, although such schemes can theoretically be made revenue-neutral, (the amount of money collected through fees equals the amount paid out in rebates) the difficulty of predicting take up levels makes this difficult in practice.

Political challenges include the scope for lobbying on baseline levels, the fact that funds are vulnerable to distribution according to politicized criteria, and potential budget raids on the collected revenues. The need for public authorities to directly manage significant revenues means the scheme would be easier to coordinate at the national level. And of course, feebate schemes for emissions can be in tension with pre-existing cap and trade systems, such as the ETS, as they may effectively penalize or reward market actors twice.

Careful consideration would also have to be given to how the application of such a scheme in the EU would interact with other CO_2 policies already in place. As market players are already included in the ETS, for example, reduced emissions resulting from a supplementary feebate scheme may lead to a reduced net incentive for plants involved in both schemes to decarbonize.

Nevertheless, sector-specific feebates that only collect and redistribute funds within a particular industry have a perceived fairness that can drive industry buy in. For example, such schemes can be viewed as coal paying for the future of coal in the EU, although they could equally be applied to gas generation as well as the steel or cement industries. Preventing a misalignment of incentives could thus secure greater industrial participation in decarbonisation. Moreover, previous instantiations in EU Member States demonstrate that feebate schemes can deliver impressive levels of emissions reductions.

Perhaps the most relevant example is Sweden's Nitrous Oxide (NOx) Charge, which is directed at the power generation sector and large combustion plants in industry. NOx emissions are one of the main precursors of acid rain, and cause the eutrophication of forestland and seabeds. In 1990, the Swedish Government therefore introduced a tax on NOx emissions from boilers, stationary combustion engines and gas turbines with a useful energy production of at least 25 GWh per year. At roughly €4,500/tonne of NOx, the charge is very high, although almost all of it[121] is then distributed back to the participating plants, in proportion to their production of useful energy. This avoids distorting the pattern of competition between those plants which are subject to the NOx charge and those that are not. It also means that the polluting industry as a whole does not pay anything to society – making the charge more politically feasible.[122]

The scheme has been credited for a drop in NOx emissions from the participating plants of about 40% per unit of energy since it came into force.[123] As the system developed, costs for abatement and metering have fallen, and the criterion for inclusion has been lowered twice: in 1996 plants producing over 40 GWh useful energy per year were included and in 1997 the boundary was lowered to 25 GWh.

4.4 Border carbon adjustment to fund CCS deployment in specific industries

Given that the deployment of CCS in the non-power industry would result in an increase in costs for industrial products, a major concern is the adverse impact that this might have on the global competitiveness of the relevant sectors. Border carbon adjustment (BCA) offers one means of directly addressing this issue.

BCA involves a tax on imported goods and/or a subsidy to exported goods that seeks to make the price of the goods in destination markets reflect the costs they *would have* incurred had they been produced under the destination market's emissions regime. For example, goods imported into a country with a CO_2 tax would be charged for any associated emissions they were not charged for in their country of origin. And goods produced in a country with an emissions charge would receive a rebate for the levied fees upon export to a country without one.

In the absence of a global climate change regime, BCA schemes address the dangers of carbon leakage, making global industrial competition more efficient. Leakage is an increase in CO_2 emissions in foreign jurisdictions that results from climate policies enacted domestically. It occurs when existing economic activity is relocated to countries with lower regulatory costs and through the diversion of investment (see Figure 15[124] below).

Leakage can also happen indirectly, when, for example, a reduction in domestic fossil fuel demand due to emissions charges lowers global prices thereby increasing overseas consumption. However, border carbon adjustment cannot address this.

Notable economists have argued that *not* pricing the global external costs of carbon emissions is a *de facto* domestic subsidy

121 The administration of the charge is carried out by the Swedish Environmental Protection Agency (SEPA), and has been kept at a very low cost, approximately 0.3% of revenues collected. The metering costs are estimated at approximately 3% of total charges paid.

122 SEPA (2006) 'The Swedish charge on nitrogen oxides – Cost-effective emission reduction', Naturvårdsverket, http://www.naturvardsverket.se/Documents/publikationer/620-8245-0.pdf.

123 Lena Höglund-Isaksson (2009) 'Innovation Effects of the Swedish NOx Charge', OECD, http://www.oecd.org/greengrowth/consumption-innovation/43211635.pdf; Millock and Sterner (2004) 'NOx Emissions in France and Sweden: Advance Fee Schemes versus Regulation' in Harrington and Morgenstarn (Eds.) *Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe.*

124 Davis and Caldeira (2010) 'Consumption-based accounting of CO2 emissions', PNAS 107 (12), 5687-5692.

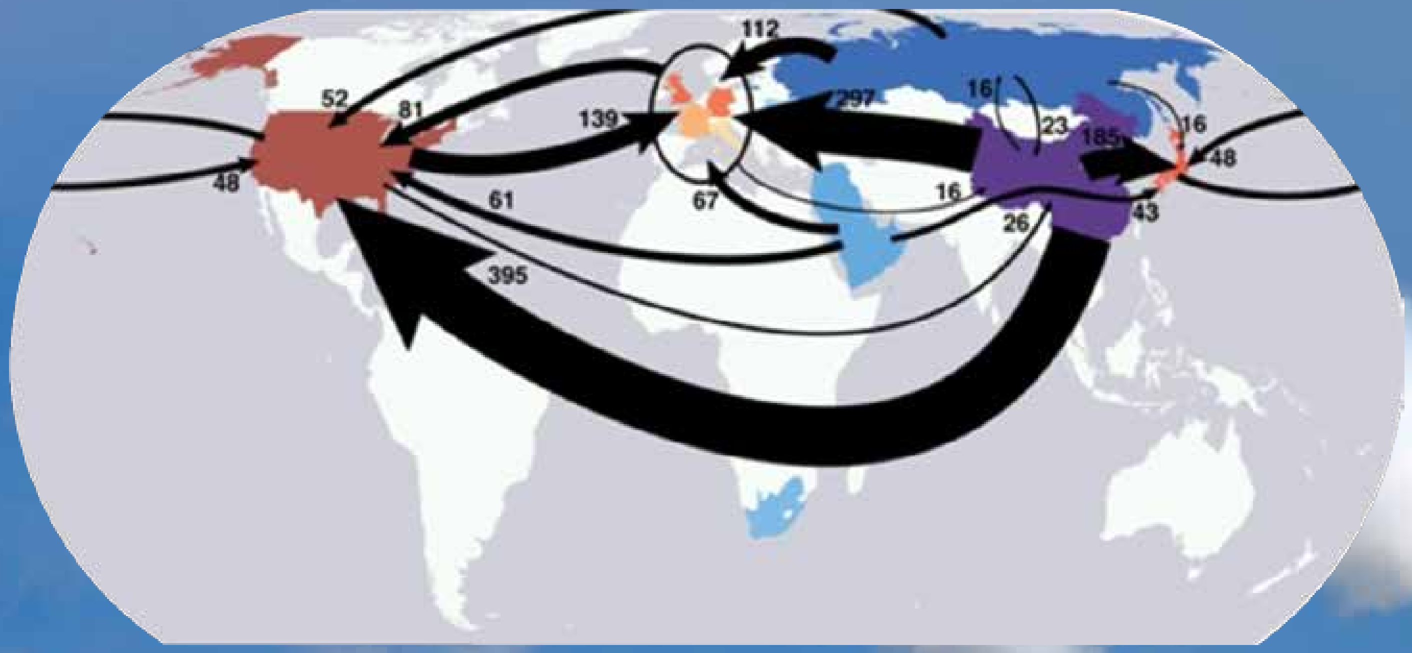


Figure 15: Largest interregional fluxes of emissions embodied in trade (Mt CO_2 y−1) from dominant net exporting countries (blue) to the dominant net importing countries (red)

that justifies countervailing duties. BCA therefore helps to level the playing field in international trade while internalizing the costs of climate damage into prices of goods and services. Indeed, such schemes may be necessary to prevent countries which refuse to agree to, or implement, emission reductions from inflicting harm on the rest of the world.[125]

BCA also incentivizes other countries to adopt policies to reduce GHG emissions, albeit coercively. Domestically charging an equal CO_2 price – preferably, within a multilateral framework – would remove the basis for exported goods being levied. And for additional effectiveness, any collected revenues from import adjustment could also be earmarked for emissions reductions schemes and redistributed back to the charged countries.

The EU is currently mooting the implementation of two policies that closely resemble BCA. First, its aviation emission's levy[126] includes emissions from international aviation in the EU ETS. This charges airlines for the full amount of CO_2 emitted on flights to, from and within the EU. Secondly, the bloc is considering updating its Fuel Quality Directive[127] – which sets minimum environmental standards for a range of imported fuels – to rank oil produced from tar sands oil as more polluting than other fuels, effectively banning it in the EU. In addition, the EU alludes to the implementation of a BCA scheme in its Energy Roadmap 2050[128] as well as its recently published Green Paper entitled "A 2030 framework for energy and climate policies".[129]

An EU BCA scheme could be implemented to drive the industrial deployment of CCS both inside and outside the Union, whilst preserving the Union's competitiveness.

Currently, in order preserve industrial competitiveness under the EU ETS, several sectors deemed to be exposed to a significant risk of carbon leakage receive a higher share of free emissions allowances in the period 2013 and 2020. The highly polluting sectors on the so-called 'leakage list' effectively get a license to continue polluting during this period, leading to a lowest common denominator approach to reconciling the tension between climate change and competitiveness.

Instead of this, a small number of European industries currently on the list – say cement, refining and steel – could be removed and required to meet stringent emissions performance standards. Instead of bearing the full costs of this transition on their own, the industries would be supported by a levy on all imported cement, refined oil and steel products not produced to the same standards. A portion of collected revenues could be returned to exporting nations to fund industrial CCS deployment overseas, thereby helping them to escape the levy in the future and reducing global emissions.

125 Stiglitz (2006) 'A New Agenda for Global Warming', *The Economists' Voice* 3(7). Berkeley Electronic Press, http://heartland.org/sites/all/modules/custom/heartland_migration/files/pdfs/19398.pdf; Helm, Hepburn and Ruta (2012) 'Trade, climate change and the political game theory of border carbon adjustments', Oxford Review of Economic Policy, 28 (2), 368-394.

126 Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community (Text with EEA relevance).

127 Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC (Text with EEA relevance).

128 "Safeguards against carbon leakage will have to be kept under close review in relation to efforts by third countries." Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Energy Roadmap 2050, COM/2011/0885 Final.

129 Specifically, it asks "How could this problem [of carbon leakage] be addressed in the 2030 framework?" European Commission (2013) 'GREEN PAPER: A 2030 framework for climate and energy policies' COM(2013) 169 final, http://ec.europa.eu/energy/consultations/doc/com_2013_0169_green_paper_2030_en.pdf.

In the absence of a global climate change regime, BCA schemes could help specific sectors address the dangers of carbon leakage should they choose to deploy CCS

In spite of the notional elegance of such a scheme, a number of unanswered questions remain. First among these would be its effectiveness. A recent study commissioned by the EU Directorate General for Trade argues that CO_2 leakage due to international trade is very small, and is far outweighed by indirect leakage through the fossil fuel price channel (climate policies in some countries reducing global demand for fossil fuels thereby causing prices to fall and consumption to increase in regions without climate policies). In light of the fact that BCA cannot address leakage through this channel, the study does not recommend the broad deployment of BCA. Nevertheless, the study looked at economy-wide implementation of BCA, admitting that a disaggregated analysis might reveal that BCA could effectively be applied to tackle significant trade leakage from select highly-affected sectors.[130]

A second consideration is the risk of trade disputes. As there would be real competitiveness benefits accruing to EU industry as a result of a BCA scheme, opponents may claim that climate concerns were a pretext to raise protectionist tariffs. This might lead to threats of retaliation – as witnessed with the EU aviation emissions levy – further reducing global trade and welfare. Trade is an exclusive competence of the EU and the Commission's President has publicly emphasized the contribution it can make to boosting growth and jobs in the bloc.[131] Stiff resistance can therefore also be expected from a range of institutional stakeholders and economically liberal Member States.

A closely related third consideration is the scheme's effect on social welfare – particularly in more vulnerable developing countries. In light of the fact that BCA would be pursued not as an end in itself but as a means to prevent further climate change and thereby improve social welfare, the welfare lost as a result of reduced trade would have to be weighed against the welfare gained as a result of mitigation. Even if this can be theoretically demonstrated at the global level,[132] the principle of Common But Differentiated Responsibility states that developed nations should shoulder the burden of the fight against climate change because of their greater capability to do so, and because they gained this capability by past economic exploitation of global commons.

Fourthly, effective and fair regimes for accounting, reporting and verification for BCA will be challenging to design and execute. For example, would such as scheme factor in only direct emissions, or would they include indirect emissions from electricity inputs used to produce the final goods as well? And how would emissions embedded in downstream products be accounted for? A balance will therefore have to be struck between the comprehensiveness of border measures and their administrative costs.

Finally, there is also the substantial possibility of adverse unintended consequences given the complex nature of international trade flows. For example, assume that both Japan and the EU take part in a climate change agreement, but only the EU introduces BCA. Steel exports from countries without a carbon regime would then be redirected from the EU to Japan, with the shortfall in supply to the EU being met by increased Japanese steel imports, which would not incur tariffs. This would raise the price of steel in the EU but would not result in significant global emissions reductions. International coordination will be necessary to reduce the possibility of examples such as this occurring.

BCA schemes are polarizing, but unless substantial global progress on climate change can be made in the coming decades, the EU's ambitious climate targets will make preserving industrial competitiveness an ever more pressing concern for the Union. Whether BCA can achieve this is uncertain.

What is sure is that the EU has an unmatched ability to act in this sphere because international trade is an exclusive competence of the Union and no other Member State is legally able to implement such a scheme separately. Through the Common Customs Tariff, the Community applies the principle that domestic producers should be able to compete fairly and equally on the internal market with manufacturers exporting from other countries.

130 Bollen, Koutsaal and Veenendaal (2011) Trade and Climate Change, CPB Netherlands Bureau for Economic Policy Analysis, http://trade.ec.europa.eu/doclib/docs/2011/may/tradoc_147906.pdf.

131 Letter of President Barroso to the European Council on the contribution of trade to growth and jobs, 05/02/2013, MEMO/13/69, http://europa.eu/rapid/press-release_MEMO-13-69_en.htm.

132 Gros (2009), 'Global welfare implications of carbon border taxes', CEPS working document 315, http://www.ceps.be/ceps/dld/1691/pdf.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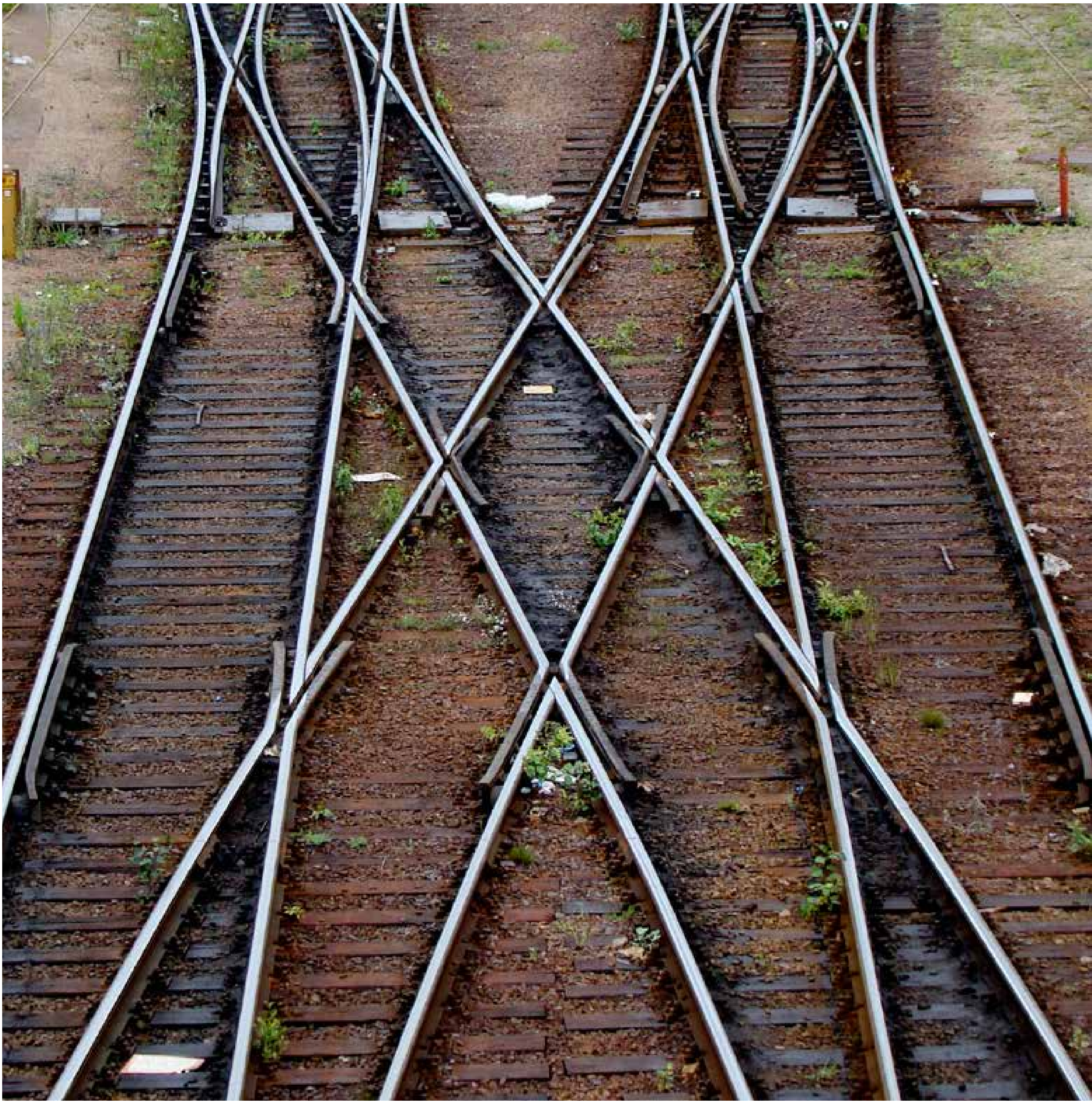

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