

# CO<sub>2</sub> Capture and Storage (CCS)

Creating a secure environment  
for investment in Europe

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# The Zero Emissions Platform (ZEP)

Founded in 2005, ZEP represents a unique coalition of stakeholders united in their support for CCS as a critical solution for combating climate change. Indeed, CCS is the single biggest lever for reducing CO<sub>2</sub> emissions – providing almost 20% of the global cuts required by 2050 (IEA). Members include European utilities, oil and gas companies, equipment suppliers, national geological surveys, academic institutions and environmental NGOs. The goal: to make CCS commercially available by 2020 and accelerate wide-scale deployment.

[www.zeroemissionsplatform.eu](http://www.zeroemissionsplatform.eu)



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# 1 Why additional economic measures for CCS are essential

## 1.1 EU Energy Roadmap 2050 confirms critical role of CCS in decarbonising Europe cost-effectively

The critical role of CO<sub>2</sub> Capture and Storage (CCS) in meeting European Union (EU) and global climate targets is now indisputable: it can not only abate at least 90% of emissions from the world's largest emitters, but complement the large-scale deployment of intermittent renewable energy sources with low-carbon base-load power generation and balancing capacity.

Indeed, the International Energy Agency (IEA) declares that "The scale of potential future deployment of CCS is enormous, spanning manufacturing, power generation and hydrocarbon extraction worldwide."<sup>1</sup> Combined with sustainable biomass, CCS can even *withdraw* CO<sub>2</sub> from the atmosphere – already recognised as a significant and attractive abatement solution.<sup>2</sup>

The EU Energy Roadmap 2050<sup>3</sup> therefore confirms that "For all fossil fuels, Carbon Capture and Storage will have to be applied from around 2030 onwards in the power sector in order to reach decarbonisation targets". The IEA goes even further, warning that "If CCS is not widely deployed in the 2020s, an extraordinary burden would rest on other low-carbon technologies to deliver lower emissions in line with global climate objectives":<sup>4</sup> the costs of achieving such objectives *without* CCS would be over 70% higher.

The result: Europe will not only enjoy a climate-friendly economy, but new industrial growth – creating jobs and boosting competitiveness – fuelled by a diverse and reliable energy supply.

## 1.2 CCS can deliver – but a weak EUA price threatens demonstration and deployment

The EU has responded swiftly, moving rapidly from development to demonstration on the road to wide deployment: billions of euros have been invested or pledged by industry, funding has been achieved for a CCS demonstration programme and an EU-wide legal framework has been established. As importantly, the ZEP cost reports<sup>5</sup> now give confidence that following a successful demonstration, the current suite of CCS technologies will be cost-competitive<sup>6</sup> with the full range of low-carbon power options, including on-/offshore wind, solar power and nuclear.

In short, there is no doubt that CCS can deliver, as confirmed by international developments where final investment decision (FID) has already been taken on large-scale demonstration projects in Australia, Canada and the U.S.

However, while confidence in the technology remains high, the fall in the price of Emission Unit Allowances (EUAs) could have a severe impact on both CCS demonstration and deployment: not only is significantly less funding available for the "NER 300"<sup>7</sup> scheme, but the long-term business case for CCS has been seriously undermined. It means **CCS has now reached a "tipping point" in Europe and urgent action is needed at EU and Member State level to counteract these developments. As the IEA has declared, "Deploying CCS requires policy action; it is not something the market will do on its own."**

**A successful demonstration of CCS is a precondition for commercial deployment; but without a secure environment for long-term investment, demonstration projects will not happen.**

<sup>1</sup> "A Policy Strategy for Carbon Capture and Storage", 2012: [www.iea.org/papers/2012/policy\\_strategy\\_for\\_ccs.pdf](http://www.iea.org/papers/2012/policy_strategy_for_ccs.pdf)  
<sup>2</sup> "Special Report on Renewable Energy Sources and Climate Change Mitigation", Intergovernmental Panel on Climate Change, 2011: [www.srren.org](http://www.srren.org); "Technology Roadmap – Carbon Capture and Storage in Industrial Applications", 2011: [www.unido.org/fileadmin/user\\_media/News/2011/CCS\\_Industry\\_Roadmap\\_WEB.pdf](http://www.unido.org/fileadmin/user_media/News/2011/CCS_Industry_Roadmap_WEB.pdf)  
<sup>3</sup> December 2011: [http://ec.europa.eu/energy/energy2020/roadmap/doc/com\\_2011\\_8852\\_en.pdf](http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf)  
<sup>4</sup> 2011 World Energy Outlook  
<sup>5</sup> Zero Emissions Platform, July 2011: [www.zeroemissionsplatform.eu/library/publication/165-zep-cost-report-summary.html](http://www.zeroemissionsplatform.eu/library/publication/165-zep-cost-report-summary.html)  
<sup>6</sup> €70-90/MWh for CCS with coal, €70-120/MWh with gas, operating in baseload (7,500 hours equivalent full load each year)  
<sup>7</sup> In 2008, the EU agreed to set aside 300 million Emission Unit Allowances from the New Entrant Reserve under the EU ETS Directive to demonstrate CCS and innovative renewable energy technologies



### 1.3 Correcting the policy framework to give a strong price signal for investment

When the EU set out to establish a CCS demonstration programme, the price of EUAs in the EU Emissions Trading Scheme (ETS) was ~€30. This provided a significant stimulus for action, both directly as a result of the EUA price (which would underpin long-term deployment) and indirectly via the NER 300 (which would therefore have a reserve of ~€9 billion). In addition, with the ETS past the Phase I doldrums and a robust Phase II under way – and the prospect of significant allowance scarcity extending through Phase III – the business case for CCS was both real and sustainable.

However, a variety of factors, including the economic crisis, has depressed the EUA price to ~€8 today and decreasing. As the long-term economic viability of CCS depends on a strong EUA price, it is therefore essential to correct the current policy framework with additional financial incentives – and ensure a level playing field for all low-carbon energy technologies. It also means strengthening the EUA price which is expected to continue to be weak, despite the prospect of deep CO<sub>2</sub> reduction targets: the ETS underpins not only the long-term, but also partly the short-term business model as every CCS project will need to recover its investment over the medium to long term.

### 1.4 Urgent, short-term measures are needed to enable demonstration projects to take FID

However, as this may take some years to deliver and the need to demonstrate and commercialise CCS is a short-term imperative, short-term measures are also urgently needed in order to enable developers of demonstration projects to take FID. National governments are already moving in this direction, underlining the urgency of the situation.

Industry has already demonstrated its willingness to take on a major portion of the costs and risks of investing in CCS technology. However, as the NER 300 may now deliver as little as €2.5 billion in total for CCS and innovative renewable energy technologies, additional financial support from Member States is also vital.<sup>8</sup> It must be remembered that as well as delivering key learnings, technology advances and cost reductions, demonstration projects will be operating for some decades, capturing and storing CO<sub>2</sub> that would otherwise be released into the atmosphere. Their operation must therefore remain economical, at acceptable risk, over a planned life of up to 30 years.

**Timing is crucial: CCS is on the critical path with no margin for delay. Indeed, companies which have invested heavily in CCS demonstration projects must take FID imminently to secure the NER 300 and/or other funding – or the window of opportunity will be missed.**

This report therefore aims to find the right balance between funding support in the short term to drive early deployment and achieve key learnings, while at the same time ensuring that investments can achieve a sufficient level and certainty (predictability) of market-based revenues in order to support investment decisions and ensure actual economic operation of CCS assets. Both are currently highly uncertain and require the immediate attention of policymakers.

The result of in-depth analysis by expert economists,<sup>9</sup> ZEP's proposals are fully in line with the recent work of the IEA (see footnote 1). However, they are unique in that they provide *clear recommendations for action* by both the European Commission and Member State governments.

<sup>8</sup> Even if Member States replicate the contribution of NER 300 funding, a gap of hundreds of millions of euros in incremental costs could remain per project (except under specific conditions such as the use of CO<sub>2</sub> for Enhanced Oil Recovery (EOR))

<sup>9</sup> See Annex

## 2 Key principles

### 2.1 CCS measures should be flexible, but stable

In its recent report, “A Policy Strategy for Carbon Capture and Storage” (see footnote 1), the IEA explains why public incentives for CCS depend on technology maturity and must therefore have the flexibility to adapt, yet be sufficiently stable to provide predictability for investors. It assesses some of the most widely discussed options against a set of criteria, but refrains from ranking them.

ZEP agrees with this general approach and concludes that measures should be targeted at one or several of the following market failures that block the deployment of CCS:

- **Externality:** Primarily, the negative externality of CO<sub>2</sub> emissions at current prices; but also possible, positive externalities of CO<sub>2</sub> transport and storage infrastructure.<sup>10</sup> In a grid with a high proportion of intermittent energy sources, CCS-equipped power plants could provide both low-carbon base-load power generation and balancing capacity, representing a positive externality for the energy system.
- **Public good:** Mainly related to knowledge and innovation, which has wider societal benefits beyond those enjoyed by individual actors paying for the innovation. CCS is still at the start of the learning curve: the technology is proven, but there is still a great deal of potential to drive costs down. Society, too, is still at the start of the learning curve: while it is clear that under the right conditions CO<sub>2</sub>

- storage should be supported by the public, there may be concerns due to lack of experience.
- **Imperfect competition:** Particularly for transport and storage, there is a risk in the short to medium term that in many regions the number of companies will be too few for competition to deliver a socially optimal supply.
- **Information asymmetry and imperfect information:** In the short to medium term, due to unequal distribution of information, capital providers may be unable to distinguish good projects from bad, thereby increasing the cost of capital. Because CCS projects require very capital-intensive investments – around €1 billion each, with potentially corresponding profit and loss margins – most investors will be reluctant to take them on in an uncertain environment.
- **Complementary markets:** A deficient coordination of planning and performance guarantees for CO<sub>2</sub> capture plants, pipelines and storage sites (e.g. due to distinct ownership) introduces substantial risks. The contrasted situation of EOR in the U.S. and Europe testifies to such a market failure.

Different measures should therefore be designed to address each of these market failures and the IEA provides an overview of several potential options, i.e., the ETS, feebate systems and tax incentives. Figure 1 below illustrates how a likely evolution of the various market failures will impact the relative importance of different measures.

Figure 1: Evolving rationale for policy intervention



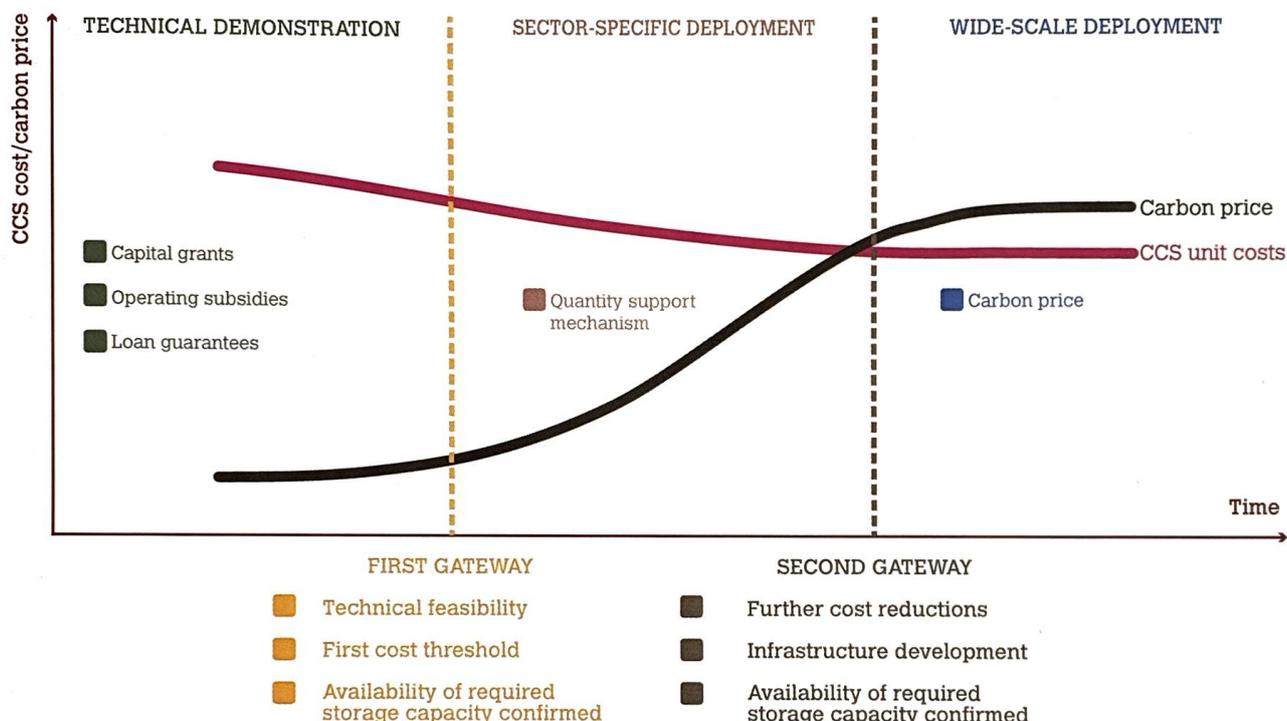
Source: IEA, 2012

<sup>10</sup> The existence of a pipeline and a storage site may have network effects, reducing the costs of CCS for nearby CO<sub>2</sub> sources

It is crucial that measures are designed with clear sunset clauses to phase them out when the market failures they are created to address diminish in

importance as the technology matures. Figure 2 describes how gateways can be defined upfront for these transitions.

Figure 2: Gateways within a CCS policy framework



Source: IEA, 2012

Some argue that additional incentives may be counter-productive because they act to reduce demand for EUAs: if the ETS cap is not adjusted accordingly, non-ETS incentives to support CCS will lead to an EUA price that is lower than it would otherwise have been.<sup>11</sup>

It is possible that some non-ETS measures will be adopted at national level in the short to medium term. ZEP accepts that the resulting uneven playing field for CCS is preferable to the absence of additional incentives. However, the EU should play a coordinating role in phasing out national measures when predefined gateways for CCS are attained.

Given the critical importance of CCS in addressing climate change, ZEP recommends that in the short term (2012-2020) and medium term (2020-2030), the ETS should be adjusted to take the impact of additional, non-ETS measures into account. Together with a clear plan for phasing them out, these adjustments will provide a credible, long-term trend for the EUA price – and a strong signal to investors. ETS adjustments may consist of more ambitious emission reduction targets for the ETS and possibly a more flexible design in order to mitigate the effects of macro-economic volatility on the price. (For further details on the design of the ETS, please see Chapter 3.)

The key imperative for any package of measures is to provide a credible and predictable pathway for the gradual deployment of CCS – from demonstration projects, through to commercial-scale projects, to those that will ultimately replace unabated, fossil fuel alternatives. It means that such measures must be implemented as soon as possible as they will impact the short-, medium- and long-term prospects for CCS.

<sup>11</sup> For an extensive discussion of the effects of interactions of renewable energy and climate policies, see “Interactions of Policies for Renewable Energy and Climate” by the IEA and Cedric Philibert, 2011

## 2.2 Key criteria for the assessment of measures

In order to select the measures, ZEP has established a list of criteria, inspired by the IEA report cited above:

- **Certainty of economic impact on CCS projects** (from investors' point of view)
- **Environmental effectiveness:** how much will the instrument reduce CO<sub>2</sub> emissions?
- **Cost-effectiveness:** what is the cost per tonne of CO<sub>2</sub> abated?
- **Ease of application:** how easily can the instrument be applied?
- **Political acceptability:** how can it gain support from a political majority? This may vary strongly between countries.

ZEP has also formulated its preferences for key categories of measures:

- **Cross-sectoral vs. power only**  
CCS is a key CO<sub>2</sub> mitigation option with significant potential not only in the power sector, but across a range of industrial applications (e.g. iron and steel, chemicals, cement and fuel transformation). Yet to date, most CCS measures have been aimed at the power sector only. ZEP therefore strongly recommends that measures are aimed at all sectors – delivering more CCS learning at a lower

cost. However, different sectors have varying exposure to non-EU markets. As a consequence, the mix of politically feasible “sticks” and “carrots” will need to be tailor-made.

- **Economic incentives vs. regulatory compliance**  
ZEP favours measures that attach monetary value to low-carbon production/CO<sub>2</sub> abatement, as opposed to being based on regulatory compliance/non-compliance. This is particularly important in order to encourage not only CCS for coal, but also for gas, as well as in combination with biomass. Regulatory measures which add significant costs to power generation with CCS, on the other hand, will delay investment in CCS – until the market rewards such costs.
- **EU vs. Member States**  
ZEP favours a global incentive, but in its absence favours one at EU level. However, as long as an EU-level incentive is not strong enough, it welcomes appropriate measures implemented by individual Member States. This may increase overall costs of CCS deployment, but ZEP believes this approach is useful to help break the deadlock in adopting EU-level incentives that will be sufficiently strong for CCS.

## 2.3 Preventing carbon leakage<sup>12</sup>

CCS incentives, like those for any scalable low-carbon technologies, add costs that are proportionally significant and there are few countries where taxpayers will shoulder that bill beyond a few demonstration projects. This means that consumers will have to pay, at least in the medium to long term. Most products from industries where CCS is a potential solution can easily be traded across borders. This raises the risk of leakage of investments and production (carbon leakage) to countries that do not enforce stricter climate protection, thus undercutting prices. In this case, there would be little CCS deployment and simply a movement of production and emissions across borders.

Carbon leakage could occur both between Member States (in the medium term) or between the EU and countries without similarly ambitious climate change policies (in the medium to long term). Compensatory measures are therefore required. Ideally, these should ensure that imported goods or kilowatt-hours

are treated the same way as domestically produced ones (and, conversely, exports are exempted from the climate change policy measures). For electricity, it should therefore be investigated if and how climate policy obligations could be put on electricity *distribution* instead of *generation*. For manufacturing industries, it should similarly be investigated if and how European emission benchmarks could be applied to imports as a default value from which derogations are possible.

However, for electricity-intensive industries, other compensatory measures may be suitable, e.g. state aid, which is already being considered by the European Commission through the elaboration of state aid guidelines for industries affected by ETS-induced price increases. Any such measures must be consistent with EU and World Trade Organization law in order to prevent the fragmentation of the single market or international trade wars.

<sup>12</sup> “Carbon leakage” refers to the relocation of investment in carbon-intensive activities to countries where there are fewer constraints on emissions

## 3 Strategy

### 3.1 Address issues specific to CCS

Clearly, policy for the development and deployment of CCS must be viewed within the wider framework of low-carbon emission reduction policies. However, as described in Section 2.1, CCS is not only influenced by specific market failures, but has unique aspects that must be addressed by specific policy measures:

- CCS requires very large, upfront investments – not only for CO<sub>2</sub> capture, but also CO<sub>2</sub> transport and storage infrastructure. N.B. timelines for individual elements of the CCS value chain differ, with storage requiring much longer lead times (up to 7 years).
- CCS technology is proven, but needs to be scaled up to large integrated projects, with significant potential to drive down costs. Society, too, is at the start of the learning curve: while it is clear that under the right conditions CO<sub>2</sub> storage should be supported by the public, there may be concerns due to lack of experience.
- CCS must play a significant role in the future energy mix if decarbonisation targets are to be met: unlike intermittent renewable energy sources, CCS can deliver both base-load power generation *and* balancing capacity; CCS marginal costs are also highly dependent on fuel costs (fossil fuel or biomass).

### 3.2 Correct the deficiencies of the ETS with temporary, *complementary* measures

The ETS is currently the key instrument for incentivising the reduction of CO<sub>2</sub> emissions in the EU and ZEP believes it should be the principal mechanism for driving long-term deployment:

- The ETS covers power generation and major industry in Europe and through a reducing issuance of EUAs, delivers a carbon price to the economy.
- In principle, the ETS is effective and efficient: it leaves the market to select the most cost-effective abatement options, with the knowledge that the emissions cap will be met. It also encourages the most efficient use of all available resources and technologies – once mature – such as Solar, Offshore Wind and CCS.

However, the ETS also has clear deficiencies:

- In practice, the political and social process that leads to the setting of the ETS cap and its EUA price may not reflect a social optimum.

- Due to the economic downturn since 2008, the EUA price is currently significantly lower than when the cap was set.
- The ETS does not, by itself, address the specific aspects of CCS development and deployment.

For the time being, the ETS therefore provides insufficient investment security and must be strengthened in order to deliver a sound business case for both CCS *and* other key low-carbon energy technologies. With a gradual tightening of the cap, the ETS will ultimately ensure the market conditions for CCS, but until then, additional policy measures are essential.

**Additional, non-ETS measures for CCS should be temporary and complement the ETS in order to accelerate market introduction. The ETS should therefore be adjusted to take these measures into account – either by setting more ambitious targets or via a more flexible ETS design – and a phasing-out plan developed as the technology matures.**

### 3.3 Revise the mix of measures as the technology matures

CCS incentives will vary over time as the technology matures and climate policies evolve:

- **Short term: 2012-2020**

Today, individual components of the CCS value chain are proven, numerous pilot projects are operational worldwide and FID has been taken on large-scale demonstration projects in Australia, Canada and the US. Nevertheless, CCS is still at the early stages of being scaled up to large, integrated projects, with virtually no transport and storage infrastructure in place; little experience in tackling stewardship transfer of storage sites and long-term liability; significant upfront costs for “early movers”; and an uncertain environment for long-term investment.

- **Medium term: 2020-2030**

Once the first CCS demonstration projects have had some operational experience, there will be greater confidence in both costs and performance. Equipment suppliers (and possibly transport and storage operators) will be able to take on these

risks and offer contracts on ordinary commercial terms. There will also be a skeleton of pipelines and storage sites – at least some of which built with the capacity to take on additional CO<sub>2</sub> streams. Unabated fossil fuel power plants will therefore gradually be replaced with new CCS-equipped plants. During this period, non-ETS incentives will still be required and CO<sub>2</sub> transport infrastructure, in particular, may require significant government intervention (on a commercial basis).

- **Long term: 2030+**

At a later stage, the value of EUAs under the ETS will be level with the cost of CO<sub>2</sub> abatement with CCS – at least for new fossil fuel power plants operating in base-load – while CO<sub>2</sub> transport and storage infrastructure will be operated and further developed by private companies under ordinary competition rules. Non-ETS incentives will still be necessary for the development of new technologies, but a level playing field, based on the ETS, is the correct approach once technologies are fully mature and normal competition applies.

## 4 Assessment of available measures

### 4.1 Options for the short, medium and long term

There are several categories of measures which can make CCS more attractive to investors. In the following tables, these are listed and compared against the criteria outlined in Chapter 2. The results are then presented in a semi-quantitative way (using

qualitative assessment and scores of +, 0 and -). The first column examines the strength of the investment incentive for CCS, together with the degree of policy/regulatory risk.

Table 1: An assessment of short-term measures (2012-2020)

Policy tool	Certainty of economic impact	Environmental effectiveness	Cost-effectiveness	Ease of application	Political acceptability	Overall
<b>Capital grants</b> (e.g. structural funds, trust accounts for EUA expenditures)	+	--	0	++	0	+
	Payment over short period of time	No guarantee of operations if uneconomic in current market unless combined with other incentives, or a claw-back clause is included	Should be done competitively; lower cost of capital for government		Claw-back clause for non-performance would enhance acceptability	
<b>Opex grants</b> (e.g. NER 300)	++	++	-	+	-	+
<b>Loan guarantees</b>	++	--	++	++	++	+
		No guarantee of operations if uneconomic in current market unless combined with other incentives, or a claw-back clause is included				
<b>Tax breaks</b>	+	-	0	++	0	0
		Depends on conditions			Claw-back clause for non-performance would enhance acceptability.	
<b>Capacity payments</b>	++	--	0	0	++	+
	Helps to get demo projects started	No guarantee of operations if uneconomic in current market unless combined with other incentives, or a claw-back clause is included	Could be managed through a competitive process	Raises question of how to deal with moral hazard	Already used in electricity markets, but for different purpose	

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Table 1 (continued from previous page)

Policy tool	Certainty of economic impact	Environmental effectiveness	Cost-effectiveness	Ease of application	Political acceptability	Overall
<b>Set aside a volume of EUAs</b>	+ Should be organised as a one-off intervention, adequate in size to cancel impact of Phase II over allocation and economic downturn. Helps to restore scarcity in the market, as originally intended. Could undermine confidence in the market due to increase in regulatory risk as economy is expected to remain volatile.	0 Increases uncertainty in the ETS. Doubts about effectiveness as it is not a permanent measure; and it is not clear what will happen to EUAs set aside. Will only be effective as a first step towards a broader reform of the ETS, including extending the cap from 2020 to 2030.	+ Lowest marginal cost, but increased risk premium on investments.	+ Administratively relatively easy.	++ The instrument has gained considerable political traction. Still questions to address: how many EUAs should be withdrawn? Will they be cancelled or put on the market later? With what justification?	+
<b>Feed-in tariff (€80-€100/MWh)</b>	++ Contract law guarantees feed-in tariff for economic lifetime of project	++ Only payment for actual generation of power with CCS (clarity needed on verification of actual storage)	0 Risk of under- or over-funding, but risk premium of investor very small. No upfront payment increases capital costs. Could be combined with electricity purchase obligation.	+ In demonstration phase, needs to be more project-specific, evolving into a pure feed-in tariff as the technology matures (i.e. in medium-term phase – see below).	++ Already successful for Renewable Energy Sources (RES). Bill can be passed on to electricity consumers or taxpayers (flexible)	++
<b>CCS purchase contracts through reverse auctions</b>	++ Reverse bidding for CCS leading to contract with government has a low political risk.	++ Only payment for actual CO <sub>2</sub> abatement	++ Lowest-cost projects delivered, but sponsors need to take development risk. No upfront payment increases capital costs. Would be enhanced if organised as project contracts with government.	+ In principle easy following cost discovery, provided sufficient competition.	++ Already used for RES. Bill can be passed on to electricity consumers or taxpayers (flexible)	++

- EUA revenue funds for CCS, possibly set up as time-limited company-specific trust accounts, could be an attractive way to provide capex grants.
- CCS purchase contracts combine high certainty of revenues for the economic lifetime of plants and strong performance incentives (as for feed-in tariffs) with the cost-efficiency of competitive processes. Such contracts could also incentivise CCS outside the power sector.
- Feed-in tariffs also score well on economic and environmental impact effectiveness.
- The EUA set-aside would help to remove the current surplus (now ~1.4 billion EUAs) compared to expectations, on the basis of which Phase III of the ETS was adopted. This would help to restore the ambition level, or scarcity in the market, as originally intended.
- Both the Directive on Geological Storage of CO<sub>2</sub><sup>13</sup> and the Industrial Emissions Directive<sup>14</sup> will act as drivers for a new investment cycle in power generation and it is important that Member States implement strict CCS-readiness requirements to reflect this. This can significantly reduce the costs of retrofitting CCS.

<sup>13</sup> 2009/31/EC

<sup>14</sup> 2010/75/EU

Table 2: An assessment of medium-term measures (2020-2030)

Policy tool	Economic impact effectiveness	Environmental effectiveness	Cost-effectiveness	Ease of application	Political acceptability	Overall
<b>Feed-in tariff (€80-€100/MWh)</b>	++ Contract law guarantees feed-in tariff for normal depreciation period of power plants of 20-25 years.	++ Only payment for actual generation of power with CCS (clarity needed on verification of actual storage)	0 Risk of under- or over-funding, but risk premium of investor very small. No upfront payment increases capital costs. Could be combined with electricity purchase obligation.	+	++ Administratively easy, but setting correct level presupposes cost discovery. CCS providing base-load may require more balancing capacity in grid.	++
<b>CCS certificate scheme<sup>15</sup></b>	+	++	+	+	++	+
<b>CCS purchase contracts through reverse auctions</b>	++ Reverse bidding for CCS leading to contract with government has a low political risk.	++ Only payment for actual CO <sub>2</sub> abatement	++ Lowest-cost projects delivered, but sponsors need to take development risk. No upfront payment increases capital costs. Would be enhanced if organised as project contracts with government.	+	++ Already used for RES. Bill can be passed on to electricity consumers or taxpayers (flexible)	++
<b>CO<sub>2</sub> tax (national)</b>	-- Subject to regulatory risk. Benefit depends on coverage and compensatory measures (revenues) to prevent carbon leakage, mitigate impacts on poorer households and create new jobs	+	0	++	+	+/0
<b>National CO<sub>2</sub> Emission Intensity Target for power generation decided at EU level</b>	0 Gives great flexibility for countries to reach targets, so depends on being combined with national instruments; EU legislation reduces risk of reversal	0	0	++	0	+/0
<b>Feebate (bonus-malus) for power sector</b>	+	-	-	0	++	+
<b>Capacity payments</b>	++	+	0	-	++	+

- Feed-in tariffs and CCS purchase contracts score well on economic impact and environmental effectiveness, as well as political acceptability.

<sup>15</sup> Could be set up as a purely national initiative or, more ambitiously, at EU level whereby Member States must achieve an increasing share of CCS-equipped fossil fuel power plants – either domestically or elsewhere in the EU

Table 3: An assessment of long-term measures (2030+)

Policy tool	Economic impact effectiveness	Environmental effectiveness	Cost-effectiveness	Ease of application	Political acceptability	Overall
<b>ETS coupled with auction reserve price</b> (presupposes EUA supply adjustment if needed)	++ Should give investors more certainty. Investors may still question credibility, as it may conflict with other objectives (low energy prices and/or energy security).	+ Ensures CO <sub>2</sub> abatement happens even if the EUA price would be below the auction reserve price. Stabilising the price in itself does not improve environmental effectiveness.	+	0 In principle relatively easy to apply. Ideally, should be set at EU level.	0 May be difficult to justify politically.	+
<b>ETS coupled with carbon central bank:</b> bank can issue and sell EUAs, thus influencing the price.	++ Bank should be independent from government politics. Bank would provide buffer against price volatility and provide investors more certainty.	0 See above. Overshooting of emissions is possible if bank were allowed to print emissions to cap prices.	+	0 Challenging, as new independent institution with a clear mandate would be required, but similarity with monetary central bank may help initial set up.	+	++ Vested interests may lobby against putting EUA supply "at arm's length" from governments.
<b>More ambitious ETS cap:</b> Lower cap for emissions allowances and CO <sub>2</sub> emissions (88%-91% reduction between 2005 and 2050).	++ Lower cap should attract little concerns regarding regulatory risk. Risk of price volatility remains if not combined with additional tools.	++ Emissions can be reduced effectively.	0 Costs are not known in advance, but would be lowest based on a market mechanism for all low-carbon energy technologies.	+	++ Tougher standards are in principle vulnerable to lobbying, but relatively easy to enforce. Will be part of ETS review for post 2020.	++ Already in political agenda. Part of ETS review post 2020.
<b>Emissions Performance Standard at 150g CO<sub>2</sub>/kWh</b> for power plants, with exemptions and transitional periods	- Provides little investment incentive.	0 Effective in controlling emissions, but does not support level playing field.	- Can be costly by setting same standards for all players.	++ Standards are vulnerable to lobbying, but relatively easy to enforce.	++ Would probably be acceptable if technology is mature and cost is low.	0

- Setting more ambitious emission reductions targets for the ETS scores well on economic impact, environmental effectiveness, cost-effectiveness and political acceptability. However, banking of EUAs must be included between different phases and future targets set early so investors can anticipate impacts on EUA prices.
- There is a body of academic literature that argues in favour of combining certain features of both price-based and quantity-based measures to create so-called hybrid policies. According to economic research, policymakers wishing to support EUA prices and limit undesirable fluctuations should look to such hybrid instruments – i.e. trading schemes with price-like features, such as an auction reserve price – to ensure their objectives are met.<sup>16</sup> However, there is also a clear warning that such non-ETS measures could have a damaging effect if not accounted for correctly in the design process. They should therefore take as a starting point the long-term political goal for the ETS cap and model the EUA price evolution accordingly, taking existing policies into account (e.g. on energy efficiency or renewable energy) that will impact on EUA demand.
- A hybrid ETS system coupled with a central carbon bank also scores well on economic impact and cost-effectiveness and could ensure that ETS-damaging effects such as macroeconomic shocks are sufficiently buffered – stabilising the ETS market and lowering EUA price fluctuations. It would require the establishment of an independent new agency – akin to independent central banks with inflation targets. This would make the system independent of political influences.

<sup>16</sup> Samuel Fankhauser, Cameron Hepburn and Jisung Park (2011), "Combining Multiple Climate Policy Instruments: How not to do it," Centre for Climate Change Economics and Policy Working Paper No. 48



- An emissions performance standard (EPS) scores relatively poorly on economic impact, cost-effectiveness and, in some circumstances, environmental effectiveness and would therefore only be considered as part of a package of measures once CCS has been demonstrated. An EPS could potentially provide a forward market signal for future demand for CCS when set sufficiently low and combined with other market incentives. This could be of particular value for those Member States looking to achieve power sector decarbonisation at an accelerated timescale.

When matured CCS technology is available, this will result in new-build and retrofit CCS capacity. It may happen that some old, unabated power plants will be reserved for peak and upper intermediate load range. However, it can be expected that the operational ranking in the merit order will prioritise CCS-equipped plants due to the higher efficiency of new-build and the avoided CO<sub>2</sub> penalty of new-build and retrofitted power plants. An EPS that does not recognise the different operating regimes needed for power supply (peak-, medium- and base-load) will compromise the flexibility of electricity supply.

## 5 Conclusions

### 5.1 Short-term measures (2012-2020)

In the short term, the aim is to build and operate CCS demonstration projects, requiring mainly additional, tailor-made “carrots” for individual projects.

- **Feed-in tariffs** are effective in providing predictable revenues – ZEP recommends a sliding premium scheme which is kept between a floor and a ceiling in order to create predictability for both investors and government. In any case, such contracts should be set for 20 years, funded either by taxpayers via the public treasury (through EUA revenues) or by energy consumers via a levy on tariffs. (N.B. in the demonstration phase, feed-in tariffs need to be more project-specific, evolving into a pure feed-in tariff as the technology matures, i.e. in the medium term.)
- **CCS purchase contracts** would combine the economic certainty of feed-in tariffs with greater cost-efficiency and the potential for application beyond the power sector.
- **An immediate set-aside of a volume of EUAs.**<sup>17</sup> Some say that this would reduce the predictability of the ETS as a precedent for political intervention is set. In order to achieve full impact, it must therefore represent a first step towards a broader reform of the ETS, including setting an ETS cap for 2030.
- Further **capital and operating grants** are needed in the form of long-term contracts negotiated between project sponsors and public authorities based on a certain volume of CO<sub>2</sub> stored. This could either be funded by taxpayers via the public treasury or by energy consumers via a levy on tariffs. Alternatively, EUA revenues from companies could be held in a trust account and released for CCS capital expenditure only, within a certain timeframe (a “use-it-or-lose-it” clause).
- In many markets, there is uncertainty over the role of fossil power generation with or without CCS in the power mix: if it is not called upon to provide base-load capacity, costs increase significantly and investments are discouraged. This could be addressed by **forward contracts for CCS generation capacity**.
- Due to higher debt levels/equity ratios and the government’s lower cost of capital, **public loan guarantees with performance or capacity guarantees** could be a cost-effective way of reducing the capital cost of projects.
- CO<sub>2</sub> capture from power generation or industrial processes for Enhanced Oil Recovery (EOR), Enhanced Gas Recovery (EGR) and Enhanced Coalbed Methane (ECBM) offers a revenue stream from hydrocarbon extraction which is generally taxed at high rates. **Tax breaks for EOR, EGR and ECBM** with anthropogenic CO<sub>2</sub> could be a reasonable and attractive way to incentivise such integrated projects.

<sup>17</sup> As proposed by the Environment Committee of the European Parliament, December 2011

## 5.2 Medium-term measures (2020 - 2030)

In the medium term, general CCS-specific support regimes are recommended, the details of which may need to be set at Member State level. Some type of EU-binding targets could prevent this from creating unequal conditions amongst Member States, e.g. national, effort-sharing targets for the decarbonisation of the power sector. This could replace specific EU policy targets for renewable energy, post-2020. As with any non-ETS measures, it could decrease the overall cost-efficiency of EU climate change policy.

Some second-generation CCS technologies – particularly for CO<sub>2</sub> capture – will not have had demonstration experience and should therefore continue to receive incentives, as described for the short term.

- **Feed-in tariffs** should continue as a sliding premium scheme (as in the short term, see above).

## 5.3 Long-term measures (2030+)

In the long term, non-ETS incentives will still be necessary for the development of new technologies, but a level playing field, based on the ETS, is the correct approach once technologies are fully mature and normal competition applies.

- **A long-term ETS cap for 2050 should be set as early as possible** – well before the end of the preceding phase, with a view to making the EUA price an effective part of the long-term business case for CCS. Banking should continue to be allowed in order to establish a long-term forward market for EUAs. Provided that the risk of carbon leakage is addressed (see page 10), the cap should be based on the scenario outlined in the European Commission's Low-Carbon Economy Roadmap 2050<sup>18</sup> which sets the required emission reduction target at 88%-91% for ETS sectors between 2005 and 2050. This scenario is also the basis for the EU Energy Roadmap 2050, which confirms the critical role of CCS in the energy system towards 2050 (see footnote 3).
- An additional new ETS instrument could also be designed to stabilise ex ante the EUA price in the face of (expected) economic volatility: a **central carbon bank**, to be capitalised by the revenues

- **CCS purchase contracts** could be attractive options for the medium term.
- **The ETS cap should be extended from 2020 to 2030 and 2040** in line with the EU Low-Carbon Economy Roadmap 2050 – a legally binding EU target for reducing the CO<sub>2</sub> intensity of all sectors, including power, is a strong driver for investment by Member States. By increasing the EUA price, it also makes CCS for fossil fuel power plants economically viable. (Measures may be needed to prevent carbon leakage.)
- **Forward contracts for CCS generation capacity** should continue (as in the short term, see above).
- **Public loan guarantees** would continue to lower the overall cost of projects and should therefore also be available. These are indirect debt-financing measures for commercial-scale coal- and gas-fired power plants with CCS.

from EU auctions, with a remit to buy and sell EUAs in order to stabilise the price. Such a bank should be independent of other political entities, such as the Commission, to avoid political interference in the market. However, the influences of the macroeconomy on the ETS system would have to be estimated in advance, in order to link the indicators sufficiently to the cap.

- Credible and predictable **reserve price auctions** would provide investors with long-term security that the EUA price will not fall below a certain level. However, some ZEP members consider that this would not have sufficient impact on the business case for CCS and that it would undermine the fundamentals of the EU ETS – which is a volume-based instrument – as an imposed price would not result in lowest-cost emissions reductions.
- An EPS scores relatively poorly on economic impact, cost-effectiveness and, in some circumstances, environmental effectiveness and would therefore only be considered as part of a package of measures once CCS has been demonstrated. An EPS could potentially provide a forward market signal for future demand for CCS when set sufficiently low and combined with other

<sup>18</sup> SEC(2011) 288 final, p. 54, March 2011

market incentives. It may happen that some old, unabated power plants will be reserved for peak and upper intermediate load range. However, it can be expected that the operational ranking in the merit order will prioritise CCS-equipped plants due to the higher efficiency of new-build and the avoided CO<sub>2</sub> penalty of new-build and retrofitted power plants. An EPS that does not recognise the different operating regimes needed for power supply (peak-, medium- and base-load) will compromise the flexibility of electricity supply.

However, some ZEP members believe an EPS could promote the development of CCS investments if implemented at an earlier juncture. Its potential effectiveness would be strongly impacted by the manner in which it would be applied.

Long-term, advanced warning of emissions regulations is essential to enable industry to prepare for deployment. Other members of ZEP consider that imposing an EPS on new and existing power plants before the technology is fully demonstrated would be injurious to its proper development and timely investments.

While recommendations for policy packages are divided into short, medium and long term, the earlier they are all adopted, the greater the impact on earlier stages due to anticipation effects, e.g. a tight ETS cap adopted in 2020 for 2050 would also encourage CCS investments in the medium term.

## 5.4 Summary table of recommended CCS measures

Recommended options for financial assistance measures for CCS are summarised below:

MEASURE	DESCRIPTION	KEY BENEFITS
<b>Short term, 2012-2020</b>		
<b>Feed-in tariffs</b>	A sliding premium scheme whereby a premium indexed on fuel price is guaranteed above the market price	Provides predictable revenues (in demonstration phase needs to be more project-specific, evolving into a pure feed-in tariff as technology matures, i.e. medium-term phase).
<b>CCS purchase contracts</b>	Government sets an amount of anthropogenic CO <sub>2</sub> to be captured and stored over the next 25 years; competitive bidding process for 20-year CCS contracts to reach the desired volume (excludes project construction time).	Combines contract certainty of feed-in tariffs with competitive and cross-sectoral elements of a CCS certificate scheme.
<b>Set aside a volume of EUAs</b> (as proposed by the Environment Committee of the European Parliament, December 2011)	EUA surplus is not placed into the market in order to restore scarcity as originally intended	One-off measure to help increase EUA price (which places a cost on emissions) which in turn can be avoided through CCS. Will only achieve full impact as a first step towards a broader reform of the ETS, including extending ETS cap to 2030. This measure should be carefully managed to avoid political risk associated with the ETS.
<b>Earmark EUA revenues for CCS capital grants</b>	50% of EUA expenditure of ETS installations is placed in company-specific trust accounts for CCS capex with a 5-10 year "use it or lose it" clause	Simple and predictable for companies and in line with the spirit of the ETS Directive (50% earmarking).
<b>Capacity payments</b>	TSO holds reverse auction for forward CCS-equipped power generation capacity (with set requirements for availability, flexibility etc) – payments are made annually as long as capacity is available (€/MW). The contractual terms for payments should be set for a number of years in advance.	Reduces the risk to return on capex that the trend towards reduced base-load entails for CCS.
<b>Public loan guarantees</b>	Loan guarantees to commercial-scale coal- and gas-fired power plants with CCS	Indirect debt finance measure to help lower the overall cost of CCS projects.
<b>Tax breaks for EOR</b>	Reduction in tax liability for companies operating a CCS asset for EOR projects.	Lowers cost of projects that employ CCS technology.

MEASURE	DESCRIPTION	KEY BENEFITS
<b>Medium term, 2020-2030</b>		
<b>Feed-in tariffs (€80-€100/MWh)</b>	A sliding premium scheme whereby a premium indexed on fuel price is guaranteed above the market price	Provides predictable revenues
<b>CCS purchase contracts</b>	Government sets an amount of anthropogenic CO <sub>2</sub> to be captured and stored over the next 25 years; competitive bidding process for 20-year CCS contracts to reach the desired volume (excludes project construction time).	Combines contract certainty of feed-in tariffs with competitive and cross-sectoral elements of a CCS certificate scheme.
<b>Extend ETS cap from 2020 to 2030 and 2040</b> (in line with EU Low-Carbon Economy Roadmap 2050)	A legally binding EU target for reducing CO <sub>2</sub> intensity of all sectors, including power, is a strong driver for investment by Member States.	Increases EUA price, making CCS for fossil fuel power plants economically viable. (Measures may be needed to prevent carbon leakage.)
<b>Capacity payments</b>	TSO holds reverse auction for forward CCS-equipped power generation capacity (with set requirements for availability, flexibility etc) – payments are made annually as long as capacity is available (€/MW). The contractual terms for payments should be set for a number of years in advance.	Reduces the risk to return on capex that the trend towards reduced base-load entails for CCS.
<b>Public loan guarantees</b>	Loan guarantees to commercial-scale coal- and gas-fired power plants with CCS	Indirect debt finance measure to help lower the overall cost of CCS projects.
<b>Long term, 2030+</b>		
<b>Adjust EUA supply/ETS cap</b>	Reduces the total quantity of CO <sub>2</sub> emissions and equivalent EUAs. Set the cap for 2050 in line with EU Low-Carbon Economy Roadmap 2050; banking should be allowed.	Increases EUA price, making CCS for fossil fuel power plants economically viable. (Measures may be needed to prevent carbon leakage.)
<b>EUA reserve price auction</b>	EUAs are not auctioned below a certain price. A carbon central bank could be a way to achieve this.	Gives the investor greater certainty regarding the EUA price and revenues. (Complementary measures to adjust EUA supply are needed to prevent speculation and eliminate adverse interaction between ETS and non-ETS measures.)

## 5.5 Additional actions required to ensure the timely demonstration and deployment of CCS

Industry has already demonstrated its willingness to take on a major portion of the costs and risks of investing in CCS technology. However, as NER 300 funding will now be significantly reduced, additional financial support for CCS demonstration projects from Member States is vital (see page 7).

In addition to economic measures for CCS, the following actions must therefore also be taken as a matter of urgency in order to enable the *timely* demonstration and deployment of CCS – and deliver the EU Energy Roadmap:

- **Storage site operators need greater clarity – for example, on the precise modalities for site hand-over and financial security** at Member State level. CCS investments need to be de-risked.
- Onshore CO<sub>2</sub> storage is significantly cheaper than offshore and key to the long-term business case for CCS in most Member States. As there may be insufficient demonstration projects with onshore storage, **large R&D pilot projects with CO<sub>2</sub> storage should also be supported**, with a primary focus on onshore.
- **The appraisal and characterisation of CO<sub>2</sub> storage is urgently required** as this is on the critical path for the large-scale roll-out of CCS. Balanced attention should be paid to all storage options (onshore, offshore and EOR) – each has its role to play.
- While applying mainly to commercial CCS deployment, **early strategic planning of large-scale CO<sub>2</sub> infrastructure is key** due to the long lead time and its importance in achieving economies of scale. EU policy should therefore support the development of National CCS Master Plans in which key clusters are identified and a long-term CO<sub>2</sub> pipeline infrastructure plan established. This will necessitate complementary studies and could require financial incentives/ support for “over-sizing” infrastructure. The preferred regulatory regime and business model for CO<sub>2</sub> pipeline infrastructure should also be clarified, including transparent and non-discriminatory rules and tariffs for third party access.
- A disconnect currently exists between Member States engaged in CCS demonstration projects and a public that remains largely unaware of CCS and why it is urgently needed. **Political and legal support for CCS is essential**, focusing on the critical role it has to play in decarbonising Europe – within a portfolio of solutions, including greater energy efficiency and renewable energy; the use of natural mechanisms that have already ‘stored’ CO<sub>2</sub>, oil and gas underground for millions of years; and the decades of relevant experience that already exists within the industry – including successful small-scale demonstrations of CO<sub>2</sub> storage that have been taking place in Europe since 1996.

## Annex: Members of the ZEP Temporary Working Group Market Economics (TWG ME)

Name	Country	Organisation
Heinz Bergmann	Germany	RWE and Chair of ZEP Coordination Group
Christian Bos	The Netherlands	TNO
Christina Hatzilau	Greece	National Technical University of Athens
Peter Heijmans	The Netherlands	Shell and Co-chair of ZEP TWG ME
Eivind Hoff	Belgium	The Bellona Foundation
Emmanuel Kakaras	Greece	CERTH
Hans Knippels	The Netherlands	Rotterdam Climate Initiative
Jean-Francois Leandri	France	Alstom
Goran Lindgren	Sweden	Vattenfall
Guy Maisonnier	France	IFP Energies nouvelles
Emilie Mouren-Renouard	France	Air Liquide
Philippe Opendacker	Belgium	GDF SUEZ
Anca Popescu	Romania	ISPE
Charles Soothill	Switzerland	Alstom and Co-chair of ZEP TWG ME; Vice-Chair of ZEP Advisory Council
Hermione St. Leger	U.K.	Shell, Editor
Bart Stoffer	France	General Electric
Asgeir Tomasgard	Norway	SINTEF
Marc Trotignon	France	EdF
Robert van der Lande	The Netherlands	ZEP Secretariat
Viviana Vitto	Italy	ENEL
Karl-Josef Wolf	Germany	RWE
Gerhard Zimmermann	Germany	Siemens

