ZEP: Analysis of funding options for CCS demonstration plants

Supplementary report

November 2007

Climate Change Capital

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Recap of cost estimates

Cost data sources used by CCC

- DOE/NETL
  - DOE / NETL (2007) *Cost and Performance Baseline for Fossil Energy Plants – Volume 1: Bituminous Coal and Natural Gas to Electricity, Final Report*
- IEA GHG R&D Programme
  - IEA GHG R&D Programme (IEA GHG) (2007) *CO_2 Capture Ready Plants*, 2007/4
  - Davison J. (2006) *Performance and costs of power plants with capture and storage of CO_2*, pp. 1163-1176, Energy 32, Elsevier
- IPCC
  - IPCC (2005) *Special Report on Carbon Capture and Storage*, Cambridge University Press

Cost results for EU Flagship Programme (incremental CCS cost only, all technology types)

Cost range for single plant (800MW)	€0.8 bn	-	€1.3 bn
Error range for single plant estimates:	*€0.6 bn*	-	*€1.8 bn*
Cost range for 12 plant (800MW)	€10.3 bn	-	€16.3 bn
Error range for 12 plant estimates:	*€6.8 bn*	-	*€22.2 bn*

Annualised equivalent (for 20 years):

Cost range for single plant (800MW)	€120 m pa	-	€330 m pa
Error range for single plant estimates:	*€90 m pa*	-	*€370 m pa*
Cost range for 12 plant (800MW)	€1.4 bn pa	-	€4.0 bn pa
Error range for 12 plant estimates:	*€1.0 bn pa*	-	*€4.4 bn pa*

Recap of CCS costs summary across technologies

Input assumptions

- **Fuel costs fixed at:**
  - Gas price: 45 ¢/therm
  - Coal price: € 2.25/GJ

  Indexed at 2% p.a.
- **Capex profile:**
  - **3 year construction**
  - **Scheduled 20% in 1st year, 45% in 2nd year, 35% in 3rd year**
- **Plant operating life: 20 years**
- **Plant availability: 85% (ramped up from 70%)**
- **CO2 capture rate: 88%**
- **CO2 transport & storage costs (incl in capex):**
  - **approx € 5-6/tonne**
  - **total capex € 225m**
    - **€ 75m capex**
    - **€ 1.5 m/Km and 100 Km of pipeline length**
- **Financing at 10% WACC**

Average 'central case' estimates from industry studies (low – high range shown in brackets)

For one commercial-scale 800MW plant[1]	Total cost[2]	Capex only[3]	Annual cost[4]	Annual cost per CO2 tonne[5]
	€m	€m	€m p.a.	€/tCO2 p.a.
IGCC with pre-combustion CCS	**861** (566 – 1125)	**566** (464 – 668)	**124** (91 – 153)	**24.90** (18.30 – 30.50)
PC with post-combustion CCS	**1114** (881 – 1418)	**784** (616 – 952)	**153** (124 – 183)	**30.70** (24.70 – 36.70)
PC with oxyfuel CCS	**1364** (945 – 1851)	**891** (538 – 1243)	**186** (131 – 237)	**37.20** (26.30 – 47.40)
CCGT with post-combustion CCS	**1016** (977 – 1150)	**685** (616 – 823)	**334** (324 – 373)	**66.90** (64.70 – 74.70)

Notes

1. These are the incremental costs of CCS (ie excluding power generation costs), assuming a carbon price of €12/tonne fixed for 20 years. Note that all costs could be 30% higher or lower on current estimates. Also note that these are the direct costs of construction and operation – before any allowance for the increased costs arising from being a first-mover.
2. **Total cost** represents an NPV of all incremental capex and opex over 20 years at 10%.
3. **Capex only** excludes incremental operating costs which are 30% - 50% of total costs; therefore capex support alone would be insufficient to deliver CCS deployment.
4. **Annual cost** represents the incremental operating costs and annualised capex assuming 20 year financing at 10%. If paid for 20 years, this is the equivalent of the Total Cost.
5. **Annual cost per CO2 tonne** assumes 800MW coal-fired plant stores 5 million tonnes of CO2 p.a.; gas-fired plant stores approx 35% of coal-fired equivalent

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CCC looked at what carbon price would be necessary to make CCS viable without any form of support

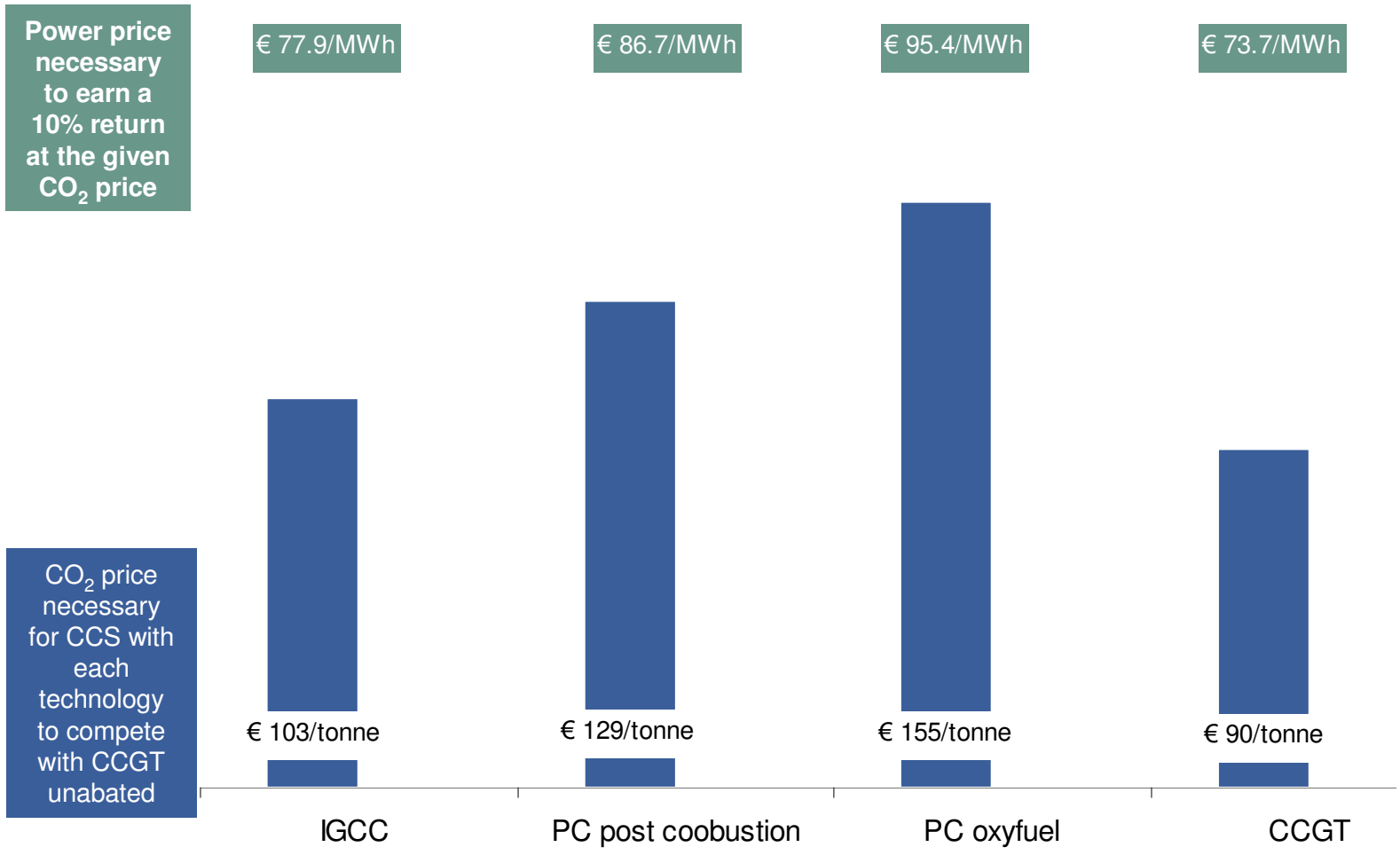
- In the main ZEP report CCC looked at the level of support that different abating technologies would require under different carbon price scenarios
- In the central case scenario (CO_2 trading at €12/tonne) the full CCS chain would require a level of support € 25 – 67 / CO_2 t across the technology types
- CCC has further looked at the carbon price that would be necessary to make the whole CCS chain viable without any form of support, given fuel prices of:
  - Coal price £1.5/GJ
  - Gas price £0.3/therm
- As the carbon price increases CCGT becomes a cheaper power generating option given the low CO_2 emissions associate with gas generation
- Under this scenario, where marginal power prices are set by CCGT, CCC calculated the carbon price that each technology would need to become the lowest entrant price power generation option
  - Coal power generation with CCS would need a carbon price above **€100/tonne** to be competitive with unabated CCGT

When CCGT sets the marginal power price, carbon price for CCS to compete is very high

CCC calculated the carbon price and the corresponding power price at which a generator would be indifferent to invest into CCS technology when CCGT is assumed to be the lowest entrant technology.

When CCGT is the least cost entrant (and thus sets the marginal power price), the carbon price must rise substantially for coal-fired plants because there is not full pass-through of the carbon price into the power price given the lower emissions intensity for CCGT.

The power price for each technology is the necessary revenue required to earn a 10% return with CCS and without, at the given CO2 price.



When CCGT sets marginal power price, the carbon price must rise to over €100 before CCS technology on coal-fired plant can compete

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What will investors look for from the Spring Council?

Investors in CCS will be reluctant to continue CCS project development unless they see…

- Firm commitment to funding for CCS that is:
  - Certain to be delivered
  - Of sufficient scale to deploy commercial-scale plant
  - Sufficient to cover the annual operating losses as well as the increased capital costs, for the life of the plant (eg 20 years)
  - Awarded on merit, not subject to political connections
  - Open to all technology types and geographies

- Policy signal for the longer term future of CCS, to properly mobilise the supply chain beyond just the demonstration phase

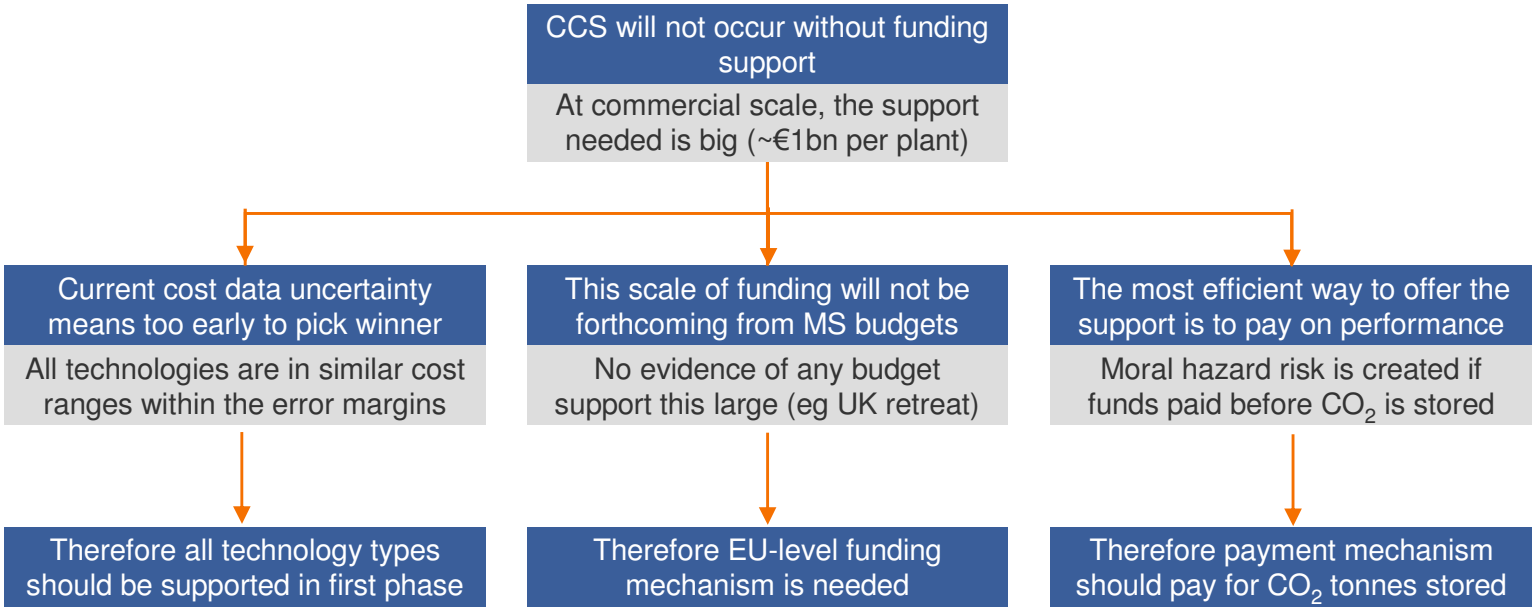
- Timeline for conclusion of the legislative details and commencement of support

- Commitment to meeting previously announced plans (the last Spring Council announcement of the 10-12 commercial-scale CCS plant by 2015) – to ensure investors can rely on future pronouncements from the Spring Council and treat it with credibility

Principles of CCS funding support design

In assessing all funding options for CCS, the following analysis has been undertaken.

These principles can be applied to define the parameters of a funding mechanism, before the details of any mechanism are agreed.



Options for EU-level funding – using EUAs

Source of funds	EU ETS Phase 3 design	■ A reserve of EUAs is set aside from within the cap to be paid to the Flagship Programme plant developers for each CO2 tonne stored
Instrument	Market mechanism	■ Payment is via provision of an asset that can be sold for monetary value equivalent to the support required for CCS: the form of payment is a number of EUAs per tonne of CO2 stored ■ The payment is provided annually for the operating life of the plant (20 years), once performance (storage of the CO2) is verified
Advantages	Policy continuity Controlled at EU-level Market mechanism Size is big enough Applicable to China/India also	■ EUAs are an existing mechanism with which the energy industry is already familiar, and which is seen as the long term driver of CCS investment ■ EUAs are controlled at EU-level which is consistent with the aim of an EU-level program ■ EUAs allow the market to take technology cost risk, consistent with the objectives of EU ETS ■ EU ETS is the only known source large enough to support 10-12 commercial-scale CCS plants ■ Easy to offer EUAs to plant developers in China
Disadvantages	Carbon price risk	■ Due to current policy uncertainty about EU ETS, payment via EUAs requires plant developers to take carbon price risk while it carries policy risk. This includes price upside risk, or 'windfall gain'.

Issues explored – using EUAs as payment

Concerns

1. Exposes project developer to CO_2 price risk

2. Involves risk of windfall gain if CO_2 price rises

3. Inconsistent with Phase 3 objective of 'no free allowances' for power sector

4. EU ETS should be technology neutral; setting aside EUAs to pay for CCS creates a special case

5. What effect will supplying more EUAs have on the EU ETS?

Responses

1. Power plant developers already face CO_2 price risk and will face carbon risk for every future plant built. The number of EUAs paid per tonne (X) can be set to be high enough to provide sufficient return after allowing for volatility in the CO_2 price
   - Price stabilisation contracts can be explored with counterparties such as the EIB

2. Some upside is necessary for first-movers. Any upside will be limited to the demonstration plant only, not the whole market. The demonstrators are performing a risky activity earlier than they would otherwise, to meet public benefit objectives.
   - An upper cap could be set such that the annual payment of EUAs is related to the CO_2 price

3. Issuing EUAs as payment for tonnes stored is not giving free allowances – the 'free allowances' were a permit to pollute; the issuing of EUAs for CCS is not a permit to pollute, it is simply a currency

4. CCS is justifiably a special case. Coal is an abundant, low-cost fossil fuel and its use for power generation is forecast to double by 2030. If coal-fired power plants are built after 2020 without CCS there is virtually no chance of reducing emissions by the 60% - 80% needed by 2050.

5. If 3 EUAs are issued for each CO_2 tonne stored, for 12 800MW plants 180m EUAs would be issued, from a total of over 2 billion EUAs overall (~9%). Total supply will be unaffected if these EUAs are not additional to the cap. These EUAs will be supplied to the market when sold by the CCS developers to monetise their payment.

Issues explored – possible EUA risk management tool

A fixed price long-term EUA forward purchase contract has been proposed to remove price risk

Source of funds	EIB or other institution	■ An institution with AAA credit rating could offer to be an EUA-counterparty on the strength of its balance sheet
Instrument	EUA offtake contract	■ Institution offers CCS plant developer a contract to buy the EUAs paid annually to the CCS plant developer for CO2 storage at a fixed price ■ The institution will sell the EUAs in the EU ETS market and use the proceeds of sale to make the fixed payment to the CCS plant developer ■ Institution makes good any shortfall of sale proceeds from its own balance sheet
Advantages	Removes EUA price risk from CCS developer	■ May reduce the private sector's cost of financing ■ May encourage more/smaller plant developers to compete for demonstration funding ■ If the EU is the institution backing the offtake contract, it places EUA policy risk in the hands of the institution that controls EUA policy
Disadvantages	Balance sheet risk for EUA counter-party (EIB or other institution)	■ Institution needs sufficient funds to make each year's annual payments to the CCS developer in the event of an EUA price crash ■ If the facility was provided to all 12 CCS plant developers, the funds required each year by the counter-party would be €180m for each €1 fall below the contract price (any surplus proceeds from previous years could offset this).

Other options for EU-level funding – auction revenue

EU ETS auction revenue has been proposed as an alternate source of funds to pay for CCS

Source of funds	EU ETS auction revenue	■ An agreed amount from each year's EUA auction revenue proceeds is set aside to pay CCS plant developers in the Flagship Program
Instrument	Annual cash payment	■ A fixed annual payment is made to CCS plant developers from the auction revenue proceeds ■ (The payment need not be fixed – eg it could vary with the varying auction revenue stream – however that would not remove the EUA price risk sought by some proponents of this option)
Advantages	Removes EUA price risk Does not need a special allocation of EUAs	■ If the annual payment is a fixed amount, the CCS plant developer is not exposed to EUA price risk and has a guaranteed revenue stream ■ The allocation of EUAs for Phase 3 of the EU ETS is unaffected by the need to fund CCS; rather a special allocation is required from auction proceeds
Disadvantages	Auction revenue may not be stable EU unlikely to gain full control of auction revenue	■ Auction prices each year will reflect the prevailing EUA prices, and thus are not independent of EUA price risk. Therefore EU will need a reserve fund or to impose a floor price in auctions to ensure sufficient revenue ■ Member States may not give control of the auction revenue to the EU. Some Member States may also refuse to set aside auction proceeds for any special causes (eg UK)

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Policy-making timeframe

Plant Operation

- To achieve the necessary deep cuts by 2050 (60% - 80% below 1990 levels), power plants built from 2020 must have near- zero emissions as they will still be operating in 2050.
  - Therefore CCS must be proven to be operational before 2020.
- To deploy 10-12 demonstration phase commercial-scale CCS plants operating by 2015, construction will need to commence around 2010, and design by 2008/9, therefore financing must be secured in 2008/9. This requires policy certainty as to the revenue for the incremental costs of these demonstration plant to be resolved by 2008.

Policy Timetable

- November 2007 – EU-China Forum held, includes ambition of CCS demo plant in China
- December 2007 – Bali Kyoto-negotiations occur with the aim of setting the parameters for the next global treaty. EU leadership position will be under scrutiny.
- January 2008 – revised publication date of European Commission implementation proposal for the Energy Package, comprising Phase 3 EU ETS design and 2020 targets burden-sharing. The CCS Communication is to be included with this Package.
- March 2008 – EU Spring Council meets to agree Energy Package
- Throughout 2008 – European Council and Parliament consider the Commission's proposed measures on CCS and the broader Energy Policy Package. First-readings in Parliament will occur by end 2008; amendments not possible after this.
- Early 2009 – MEP elections and new Parliament and Commission formed. Uncertainty of continuity of measures not concluded before this.

The opportunity to provide advice to the Commission on CCS is before Jan 2008

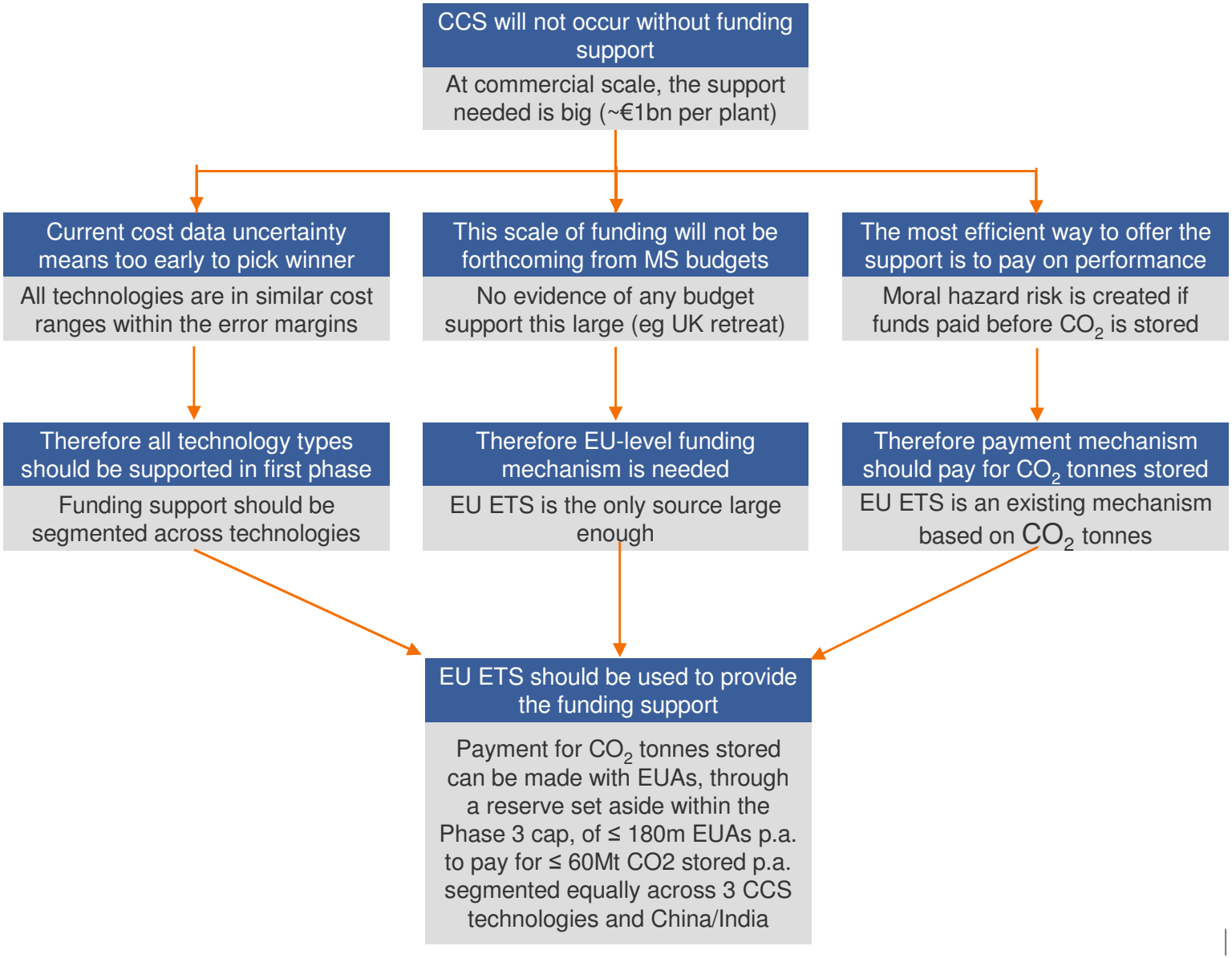
The opportunity to influence the Spring Council is before March 2008

Throughout 2008 the issues move to the political level – MS Governments & MEPs

Decisions for ZEP

	Engagement Strategy	Guiding Principles for Flagship Programme	Recommended Mechanism for CCS Support
Issue	■ Will ZEP provide advice to the EU on the future of the proposed Flagship Programme? ■ If so, when? At what level?	■ Can ZEP advise the EU on key principles of design of a support mechanism that will best achieve the Flagship Programme's objectives?	■ Consistent with the agreed principles, what specific mechanism should be the focus of the EC's implementation plans?
Recommendations	■ EC has asked for industry's clear view on the CCS Flagship Programme ■ ZEP should respond to the EC's request before January 2007, when the EC's paper is to be published ■ ZEP should also engage at the political level in relevant Member States, given the European Council and MEPs can override the Commission	■ Key principles for supporting a successful CCS Flagship Programme include: ▸ Funding must be EU-level ▸ Funding source needs to be large enough to last 20 years and cover 12 plants ▸ Payment should be annual & only when CO2t stored ▸ All technology types should be supported	■ The form of payment most likely to be able to support 10-12 commercial-scale CCS plants is: ▸ Provide EUAs as payment for CO2t stored, as EUAs are readily available at this scale and can be controlled by EC ▸ Set the number of EUAs/t high enough to compensate for first-mover risks as well as direct increased opex and capex costs

Principles and design of CCS support mechanism



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