CCS EII Implementation Plan 2010-2012

Zep
Zero emissions platform

European Technology Platform for
Zero Emission Fossil Fuel Power Plants

1. OBJECTIVE OF THE CCS EU

As proposed in the CCS EII Technology Roadmap and agreed in October 2009 at the CCS EII workshop in Stockholm the strategic objective of the CCS EII is twofold: to enable the cost competitive deployment of CCS after 2020 and to further develop the technologies to allow application in all carbon intensive industrial sectors.

The SET Plan recognises that these objectives can be best delivered through a coherent overall effort by Industry, the European Commission and Member States.

Activities for the achievement of these objectives are already ongoing, at varying levels of progress. The added value of the CCS EII will be to drive and accelerate the required changes in policy, technology and financing at all levels of governance to ensure delivery in an efficient manner and on time. It will be the task of the EII partners to frequently assess if these are sufficient to achieve the strategic objective within the timeline or if more needs to be done and what.

Specific tasks of the EII include: identification of priority actions; synchronisation of agendas through coordination of timeline and actions; identification and management of synergies between ongoing activities and possible interdependencies on risks between activities; monitoring and reporting of progress to stakeholders in reaching EII objectives.

Although industry- driven, the CCS EII will build on the comparative strengths of each of the partners (Industry, MS, EC, research organisations, NGOs).

- Industry: to manage technology and market risk; to deliver on technology and cost objectives etc.

- Member States: to ensure regulatory compliance by way of providing a clear regulatory framework at national level; to provide financial support as needed taking into account the favourable State Aid rules for CCS; to take into account the agreed CCS EII R&D&D priorities in their national R&D&D Programmes etc.

- EC: to provide guidance as necessary in relation to regulatory framework; to provide clarity over applicable EU law and policy and how these may affect business decisions; to coordinate CCS demonstration at EU level through the Project Network and provide support through the EEPR and the NER etc.

- Research organisations and EERA: to undertake necessary research activities complementing those of Industry and therefore deliver required breakthrough research at least cost and on time.

- NGOs: to promote understanding and raise awareness of the advantages of CCS in civil society and to advise on actions as appropriate.

An effective organisational structure in line with the governance structure agreed at the Steering Group meeting on March 5, 2010, will be decided jointly by all partners and reviewed periodically to ensure it remains efficient throughout.

2. IMPLEMENTATION ACTIONS 2010- 2012

This chapter only includes activities that need to be addressed until 2012. Additional activities will be needed past that date. These will be addressed within the EII and included in the 2013-2015 implementation plan and in subsequent plans. The following intermediate, operational objectives (implementation actions) must be achieved by 2012:

2.1. CCS Demonstration:

- Final Investment Decisions (FIDs) for up to 12 CCS demonstration projects to work towards the EU objective of up to 12 CCS demonstration projects by 2015. In that respect Industry has given an outline on the nature and cost of CCS demonstration in the document "EU Demonstration Programme for CO2 Capture and Storage (CCS)"[1].

- Populate the EU CCS Project Network (https://www.ccsnetwork.eu) with active participation of all the early large-scale CCS demonstration projects. This includes a programme of knowledge-sharing between projects, and from projects to stakeholders, as a key task of the Network. The first members of the Network will be all 6 EEPR projects but additional projects that also aim at being operational by 2015 are expected to join in 2010.

2.2. CCS R&D actions towards deployment

Coordination of R&D activities with a clear European added value on different aspects of CCS. Projects should aim to realise commercial availability of new technologies/concepts by 2020-2025.

- Capture: improve and develop new capture concepts to reduce the cost of capture technologies; improve combustion/gasification processes to work towards reducing the efficiency penalty; improve the integration of capture technologies into industrial installations, increase purity of the CO_2 stream as required to manage risks to transport and storage infrastructure. Projects should aim at demonstration at pilot scale for all three main technology routes: post combustion, pre-combustion and oxyfuel.

- Transport: develop a concept for a core trans-European CO_2 network and develop transport concepts further to increase operational reliability and safety (both pipeline and ship).

- Storage: verify storage potential within the EU territory including in deep saline aquifers, depleted oil and gas fields and unmineable coal layers;

[1] http://www.zeroemissionsplatform.eu/library.html/publication/2-eu-demonstration-programme-co2-capture-storage

validate storage monitoring technologies and reporting procedures; agree a consistent methodology or standards for classification of storage reserves/capacity; establish an open database including CO_2 emission sources and potential storage sites; map potential pipeline trajectories connecting sources and sinks.

- Support projects in third countries in order to accelerate the development of CCS.

2.3. Policy/Regulatory:

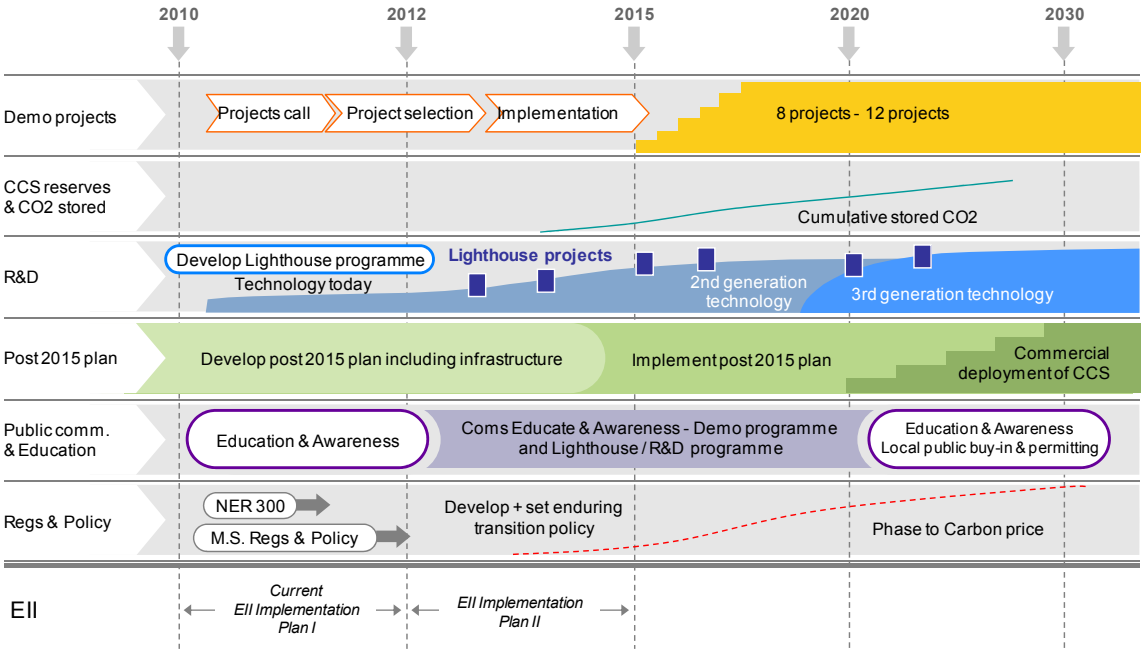
- Contribution –if and as necessary- to the work of the Information Exchange Group under the CCS Directive in order to ensure the transposition of the CCS Directive into national law by the end of 2010.

- Looking beyond 2012 and planning actions for 2012-20 and beyond. This includes identification of the future market needs for CCS wide scale deployment.

- Information exchange on public awareness and support[2].

- International cooperation: target countries and international organisations.

Figure 1, forward view on CCS implementation



[2] This may result in improved targeted local approaches but may also result in a multi-stakeholder communications and outreach programme on CCS technology - as part of the broader EU low- and zero-carbon technology portfolio - tailored to build public awareness and knowledge at both local and national/pan-European levels in order to ensure widescale deployment.

3. PRIORITY PROJECTS AND ITS FINANCING

The total cost for the actions outlined in chapter 2 is estimated to be € 8 - 14 billion of which € 7 -12 billion is required for the CCS demonstration programme. These expenses would need to be committed by 2012. Analytical work on assessing accurately the costs of CCS will continue.

3.1. CCS Demonstration

At present, with the caveat that the exact level of support from the ETS NER300 for CCS is yet to be determined, secured financing for CCS demonstration at EU level is as follows:

1. EEPR- on 9 December 2009 € 1 billion was awarded to 6 CCS demonstration projects in 6 MS: UK, DE, NL, IT, PL, ES.

2. NER300 total revenues could be in the range of € 4.5 – 9 billion. The exact share for CCS projects will be determined during the project selection process. While a call for proposals will be launched in summer 2010, funding decision are expected to be made at the end of 2011.

3. € 3 million for managing the activities of the European CCS Project Network is available for 2009-2012. A call for proposal for the continuation of this network until 2015 will be launched in July 2010.

Depending on the size, the technology used, the distance to the storage location, the geological formation foreseen for storage and the nature of the commercial arrangements across the full chain, incremental investment costs for a single CCS demonstration project can be estimated to be between €500 million and approx. €1.2 billion. The operating costs will greatly depend on the price of coal and Emission Unit Allowances under the ETS.

The demonstration projects that receive funding from the EEPR for the initial phase of the project are shown in the following table. It is noted that there is still a big financing gap to close in order to achieve operationality of both these and additional projects by 2015. In addition to the EEPR projects there are also CCS demonstration projects in Norway and the UK that are receiving national public funding, in the case of the UK projects for the Front End Engineering Design (FEED)stage.

Project	EEPR	NER 300 (to be awarded late 2011)	Other / National Funding	Industry Commitment
Germany, Jaenschwalde	180 million			
Porto Tolle, Italy	100 million			
Rotterdam, Netherlands	180 million			
Hatfield, UK	180 million			
Belchatow, Poland	180 million			
Compostilla, Spain	180 million			
Longannet, UK			Funding of FEED study	
Kingsnorth, UK			Funding of FEED study	
CO2 Technology Center Mongstad,			State Funding: 3.8 BNOK	1.3 BNOK

3.2. CCS R&D

On a European level, financing has been secured for an R&D programme, a feasibility study for CO2 infrastructure and cooperation with emerging economies:

(a) FP7 funding for CCS and CCT topics to date is around € 115 million and a further € 250 million is expected to be made available until 2013 through FP7.

(b) € 300.000 for a feasibility study on CO_2 infrastructure to feed in the revision of TEN-E guidelines in November 2010.

(c) EC has earmarked €60 million for cooperation on cleaner coal technologies and CCS with emerging economies. It is planned to use most of this finance for the design and construction of a CCS demonstration project in China (NZEC project). A small proportion of this funding (ca. €3 million in 2009) will be used to build capacity for CCS and other cleaner coal technologies in other emerging economies.

While funding has already been allocated to the development of CO2 infrastructure and cooperation with emerging economies, the following concrete R&D areas need to be addressed, where possible through larger pilot installations ("lighthouse projects")[3]:

[3] More detailed R&D have been reported in the document: ZEP report on long term CCS R&D, http://www.zeroemissionsplatform.eu/library.html/publication/95-zep-report-on-long-term-ccs-rad

1) Precombustion

- improving CO-shift and CO2-Capture with new adsorption media, new catalysts, by combining CO-shift and CO2-capture, by optimizing process integration

2) Post combustion

- Improve first generation solvents via catalysts and chemical modifications to improve loading, efficiency, solvent loss, and environmental impacts
- Develop second generation solvents combining CO2 and SO2 removal
- Develop third generation capture process based on phase change solvents (precipitation / Phase separation), ionic liquids, anhydrase processes and adsorption based processes
- Carbonate Looping, Enzyme enhanced carbonate looping, CaO-Looping
- Cyrogenic CO2-capture
- Flue gas recirculation to increase CO2-content in the flue gas
- Fuel cells for CO2-capture

3) Oxyfuel

- Chemical Looping to replace Oxyfuel boiler
- Advanced turbine with direct Oxyfuel combustion
- Oxyfuel retrofit
- Reduction of energy penalty for oxygen production

4) Compression

- New compressor design combining high mass flow capability of axial compressors with high pressure capability of centrifugal compressors

5) Transportation

- Development of concepts for transportation network in challenging environments (e.g. highly populated areas)
- Modeling of the flow of CO2 mixtures

6) Storage

- Onshore: storage complex characterization, modeling, risk assessment, well technology, monitoring, storage model verification, public awareness and support
- Offshore underground migration and leakage monitoring
- Offshore storage complex characterization modeling, monitoring, and storage model verification
- CO2 storage in coal sequences

7) Flexibility

- Integrating excess energy from renewables into fossil fuel / biomass power generation / SNG production

The R&D priorities for improving the performance of CCS during the period 2012-2016 as listed above require an estimated budget of €950 million (based on call for expression of the Zero Emissions Platform, ZEP). We expect that further improvement in the performance of CCS can be achieved in the period 2016 - 2020 for a similar budget, bringing the total required budget for R&D priorities at approximately €1.900 million. We emphasize that this relates to R&D priorities, the long term R&D plan of ZEP goes significantly beyond R&D priorities and will therefore require additional funding

3.3. Financing from industry

More than 20 CCS demonstration projects are at various stages of development in the EU. Most have not yet secured public support either at EU or national level without which they will not be implemented.

The total planned industry investment in CCS powerplants until 2015 equal €11,159 billion. However, this figure dates back from 2008 and is likely to be signicantly higher at present.

Total investment in CCS R&D of companies represented in ZEP for the period of 2003- 2008 amount to approx. € 635 million.

4. INDICATIVE KEY PERFORMANCE INDICATORS (KPIS)

4.1. Monitoring and review methodology

A KPI-based methodology for monitoring and reviewing progress of CCS technologies that will be achieved with the implementation of the CCS-EII has already been discussed and agreed in principle between the industry, the Member States and the European Commission's Information System of the SET-Plan (SETIS). Discussions are ongoing within the CCS EII Team, led and facilitated by SETIS, with the aim to finalise the set of KPIs and valuate these to allow for the timely implementation of the EII. The key elements of the methodology are summarised below.

The KPIs have been defined taking stock of the CCS Technology Roadmap, as adopted by the European Commission in 2009. A set of overarching KPIs will be used to monitor the progress of the EII as a whole, while second-tier KPIs will be used for monitoring progress of the EII actions and individual projects. The precise overarching cost KPIs and the methodology to calculate them will be agreed during summer 2010.

Subsequently, KPIs have been defined for each reference system to enable the calculation of the overarching KPIs as well as to monitor progress in EII activities beyond the demonstration and lighthouse projects included in the EII. These KPIs will be linked with one or more EII actions, and can be grouped as follows:

KPIs for the demonstration and lighthouse projects

- Cumulative number of Final Investment decisions (FID) taken
- Gross installed cumulative capacity of CCS projects across Europe
- Specific capital investment
- Fixed and variable operating costs
- Availability
- Construction time
- Plant efficiency
- CO2 capture rate
- CO2 avoided
- CO2 stream composition

CO2 transport and storage

- Length of pipeline network built
- Number of FIDs
- Assessment of European storage potential
- Amount of CO2 stored

Public awareness and support

- Eurobarometer pole

Health Safety, Environmental and Knowledge Sharing KPIs

- Number of permits to CCS projects
- Number of projects in the Project Network

Before the implementation of the EII, the KPIs will be quantified based on the current stage of knowledge; and the impact of the actions of the EIIs on the KPIs will be predicted, thus allowing for the forecast of the overarching KPIs for the duration of the EII. In the course of execution of the EII projects, and at the end of each reporting period, the actual KPI values will be monitored and compared to the predicted values to allow the assessment of progress of the projects and of the EII as a whole.

4.2. Detailed KPIs and target values

Overarching KPIs, with target values where already estimated

- Cost of CO2 abated for CCS equipped power plants
- Cost of CO2 abated for CCS equipped industrial installation

KPIs for the demonstration and lighthouse projects

- Cumulative number of FIDs
  - 2012: 6
  - 2014: 8
  - 2016: 10

- Gross installed cumulative capacity of CCS projects across Europe (*GW*)

Realistic installed target 2020	IEA installed target 2020
8 power plants ≥ 2,0 GW 2 industry projects	9 power plants ≥ 5,5 GW 5 industry projects

- FID (Final Investment Decision) taken for CCS projects across Europe (GW)

Realistic FID's taken by 2020	IEA FID taken by 2020
8 + 6 power plants ≥ 3,5 GW 2 + 2 industry projects	9 + 12 power plants ≥ 14,3 GW 5 + 8 industry projects

- Specific capital investment

- Fixed and Variable Operating costs

- Time availability of CCS systems
  - First year of operation: ≥ 40%
  - Second year of operation: ≥ 60%
  - After the first two years of operation: ≥ 80%

- Construction time
  - 2015: x years (tbd)
  - 2020: y years (tbd)

- Net efficiency of coal fired power plants without CCS ordered before 2020
  - PC: 46% LHV for hard coal
  - IGCC: 46% LHV for hard coal

- Net efficiency of coal fired power plants without CCS ordered after 2020
  - PC: 50% LHV for hard coal
  - IGCC: 48% LHV for hard coal

- Net efficiency of coal fired power plants equipped with CCS
  - for all capture technologies ordered before 2020 < 10 percentage points efficiency losses
  - for all capture technologies ordered after 2020 < 8 percentage points efficiency losses

- CO_2 capture rate, measured as: $\frac{\text{CO2 stored}}{\text{CO2 entering the capture facility}}$
  - > 50% on annual basis in 2016
  - ≥ 90% on annual basis in 2020

- Overall system performance - CO_2 avoided measured as

$$1 - \left[\frac{\text{Total CO2 emitted}_{\text{with CCS}}}{\text{Total MWh produced}_{\text{with CCS}}} \Big/ \frac{\text{Total CO2 emitted}_{\text{without CCS}}}{\text{Total MWh produced}_{\text{without CCS}}} \right]$$

  - > 40% on annual basis in 2016
  - ≥ 75% on annual basis in 2020
  - ≥ 90 % on annual basis in 2025

- For each demonstration project, composition / purity of stream gases sent to the pipelines for storage.
  - CO_2: ≥95% (%Vol)
  - SOx: ≤100ppm (%Vol)
  - H_2S: ≤200ppm (%Vol)

Transport and Storage KPI's

- Length of pipeline network built

- Number of FIDs for transportation/storage networks and cluster projects
  - By 2015≥ 1 project
  - By 2020 more than 2 projects

- Assessment of European storage potential
  - By 2011, the CO_2 Storage Directive is translated into Member State legislation and clear CO_2 storage regulation is in place at Member State level for onshore and offshore storage permitting, monitoring and liability transfer
  - By 2012, main potential on and offshore CO_2 storage reserves confirmed
  - By 2013 develop a unified approach to report CO_2 storage capacity
  - By 2013 and each year thereafter report the number of fields that have confirmed CO_2 storage potential as determined by the unified approach
  - From 2015 and every year thereafter report the CO_2 storage reserves known available in Europe, based on the unified approach

- Amount of CO2 stored by CCS demonstration projects
  - By 2016 > 2 Mt CO_2/y
  - By 2018 > 6 Mt CO_2/y
  - By 2020 > 8 Mt CO_2/y

Public awareness and support

- Eurobarometer pole

Health Safety, Environmental and Knowledge Sharing KPI's

- Number of permits, environmental and storage issued to CCS projects
- CO_2 releases that are out with permit rules.
- CCS demonstration projects included in the knowledge sharing of the European CCS Project Network

5. LINKS WITH EERA

The CCS EII will focus on industrial lead R&D, testing technologies to be commercially available in 2020 or shortly thereafter. EERA draws up annual/ multi-annual Research and Demonstration priorities with a focus on long term research. While these two programmes may not be always linked, the CCS EII and EERA will coordinate their activities.