An Executable Plan for enabling CCS in Europe

September 2015

Executive Summary

Emitting CO_2 to the atmosphere is currently much cheaper than storing it safely underground. Emitters can pay an 'ETS wergild[1]' and are divorced from all the consequences of their actions, yet if they try to sequester CO_2 they risk taking on liability for decades under the CO_2 Storage Directive. Those factors serve, along with the lack of a near-term business case, to prolong the current inertia on CCS in the EU. Urgent action is now required to deliver CO_2 storage projects and enabling infrastructure in preparation for commercial deployment. This requires an Executable Plan, owned by the European Commission.

This note sketches the contours of such a plan, describing how the Commission can effectively and rapidly aid wide uptake of CCS in Europe; delivering additional CCS projects in power and industry; progressing the development of CCS hubs in Europe; and supporting the appraisal of storage capacity required for commercial CCS deployment.

The Executable Plan has been prepared in response to discussion of the 5 Point Action Plan (ANNEX 1) for CCS, presented by ZEP to the Vice-President on 22 May and the Commissioner on 29 April. It draws solely on existing policies and public financing opportunities, with the aim to enable their most efficient and effective use. It is designed to feed into the SET Plan preparation and next steps on the Energy Union Strategy.

The proposed plan builds on ZEP's insights into the principles for development of CCS in Europe, in particular the need to: decouple the capture of CO_2 from transport and storage (T&S) (section II); develop CCS in phases through (expanding) infrastructure hubs (section I and II); optimise available funding and create mechanisms to commercialise CCS (sections II and III); and engage MS though 2050

Why CCS?

Carbon Capture and Storage (CCS) is an indispensable component of national and global decarbonisation pathways of the IPCC, the IEA, and the European Commission. The EU 2050 Energy Roadmap relies heavily on the deployment of CCS to meet EU-wide decarbonisation targets.[1] CCS deployment provides a huge opportunity for Europe to meet its energy, climate and societal goals. In particular to achieve its GHG emissions reduction targets at lower cost, while satisfying energy security concerns, where the benefit to Europe is estimated at € 2-4 trillion up to 2050 for the energy sector alone[2]. In addition several core industries (e.g. steel, cement, chemicals) cannot decarbonise without CCS. Success requires having large-scale storage and transport infrastructure in place and a CCS industry prepared. The EU has a key role to play in facilitating Member State (MS) action and enabling cost-efficient deployment. This includes enabling the delivery of CO_2 Transport & Storage infrastructure, and timely appraisal of storage capacity in the vicinity of major CO_2 emission concentrations.

[1] 2050 Energy Strategy, European Commission DG ENER (2011)

[2] CCS and the Electricity Market, ZEP (2014)

[1] In ancient Germanic law, the amount of compensation paid by a person committing an offense to the injured party

decarbonisation plans to enable the development of T&S infrastructure (section IV).

The plan would allow the European Commission (and MS) to have a more thoughtful systematic and sustainable way to deploy CCS. This will allow more proactive engagement in international collaboration to deploy this key mitigation technology, not least in the context of the upcoming COP21 in Paris, but more broadly in bilateral learning-sharing and project cooperation with leading countries like Canada, South Korea, China and the United States. While future EU CCS uptake would benefit greatly from such international cooperation, storage capacity and infrastructure for CCS must rapidly be developed by the EU itself to avoid a future competitive disadvantage for EU industries vis-à-vis other major world economies.

The key elements of the executable plan:

- Ensuring that CCS projects currently in development are completed and contribute to laying a foundation for the initial European CCS infrastructure, with a view to expansion into strategic CO_2 hubs;

- Maximising strategic CCS deployment from proposed EU funds for infrastructure, innovation and modernisation, designing the allocation criteria for feasibility funding and capital allocation to favour those infrastructure and storage hubs which provide the most fertile ground for wide CCS uptake;

- Facilitate key MS to put in place a framework that enables the construction of required T&S infrastructure on a commercial basis. The shape and form of such framework should be tailored to MS specific circumstances, one way to achieve this is to enable `market makers' to invest in CO_2 transport and storage infrastructure and de-risk this for emitters who wish to capture CO_2 from their facilities;

- Said framework may include mechanisms through which MS underwrite operational storage risk in the pre-commercial phase, and enable commercial entities to work in the CCS value chain where they have the appropriate skills and risk appetite;

- Facilitate timely investment in appraising (some of) the geological storage capacity that has been identified by various national authorities in Europe. This will provide additional certainty that the required CO_2 storage capacity will be available when needed;

- Enabling cross-border cooperation on CO_2 hubs for MS lacking accessible storage space;

- Engaging MS on their 2030 emissions reduction plans, in particular on the need for CCS to achieve these targets, and whether said plans are compatible with the long-term emission reduction trajectory toward 2050;

I. Seeing key European CCS projects across the finish line

While progress in deployment has been slower than expected, the last decade of experience with CCS has provided the EU CCS community with crucial insights into how CCS deployment can be organised effectively.

CCS projects are generally large in scale, in terms of both their impact on CO_2 emissions but also the required initial investment. Successful first CCS projects require many coordinated steps: funding for feasibility expenditure (FEASEX), capital expenditure (CAPEX), operating expenditure (OPEX) and storage site decommissioning, as well as alignment of a number of stakeholders. Deploying CCS at scale requires construction of CO_2 capture facilities, T&S infrastructure development, and timely characterisation of storage capacity. This requires long lead times and substantial investments to enable timely scale-up of all parts of the chain at the appropriate pace.[2]

Commercial CCS deployment needs to evolve through the three following phases:

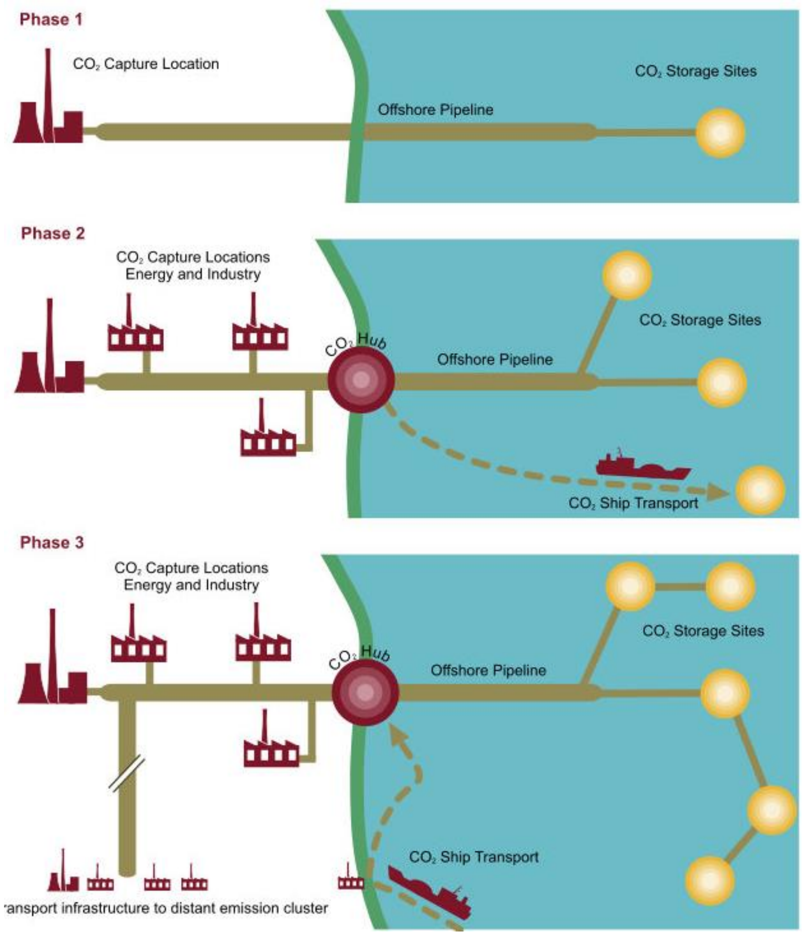

Figure 1 Concept of infrastructure and cluster/hub concept

Phase 1
Deliver existing single source/ sink CCS demonstration projects in prime locations which can be expanded into strategic European CO_2 hubs;

Phase 2
Start sourcing CO_2 from nearby emitters to create CCS hubs, i.e. clustering additional CCS projects near the ground-breaking CO_2 transport infrastructure. Ensure that the storage capacity identified, usually distributed over several depleted oil/gas fields or deep saline formations, is appraised well in advance of its need, driven by hub expansion;

Phase 3
Expand the hub over a wider region and potentially across neighbouring countries.

The first phase means ensuring that projects still progressing are brought to a positive investment decision and become the foundation for the early EU CCS

[2] Scaling the CO2 storage industry: A study and a tool, Bellona Europa (2014)

infrastructure. This concerns the Dutch ROAD capture project with store NL P18; the UK White Rose and Don Valley projects, as well as the industrial cluster project at Teesside with store UK 5/42; and the UK Peterhead project with the Goldeneye store.

It should be underlined that in strategic regions where CCS projects are currently not yet underway (e.g. the Baltic Sea Region and the East Balkans), directly introducing a clusters-and-hubs approach would allow these regions to accelerate deployment of strategic infrastructure. CCS projects may be clustered with other emission sources in their vicinity and linked up to large scale CO_2 network hubs, in turn connected to multiple storage sites. This will enable economies of scale and the development of sustainable European industrial clusters.

This approach significantly reduces risks associated with first-of-a-kind projects, assuming that confidence has been established in the availability of sufficient storage capacity through studies and timely appraisal of the capacity that has been targeted for early use.

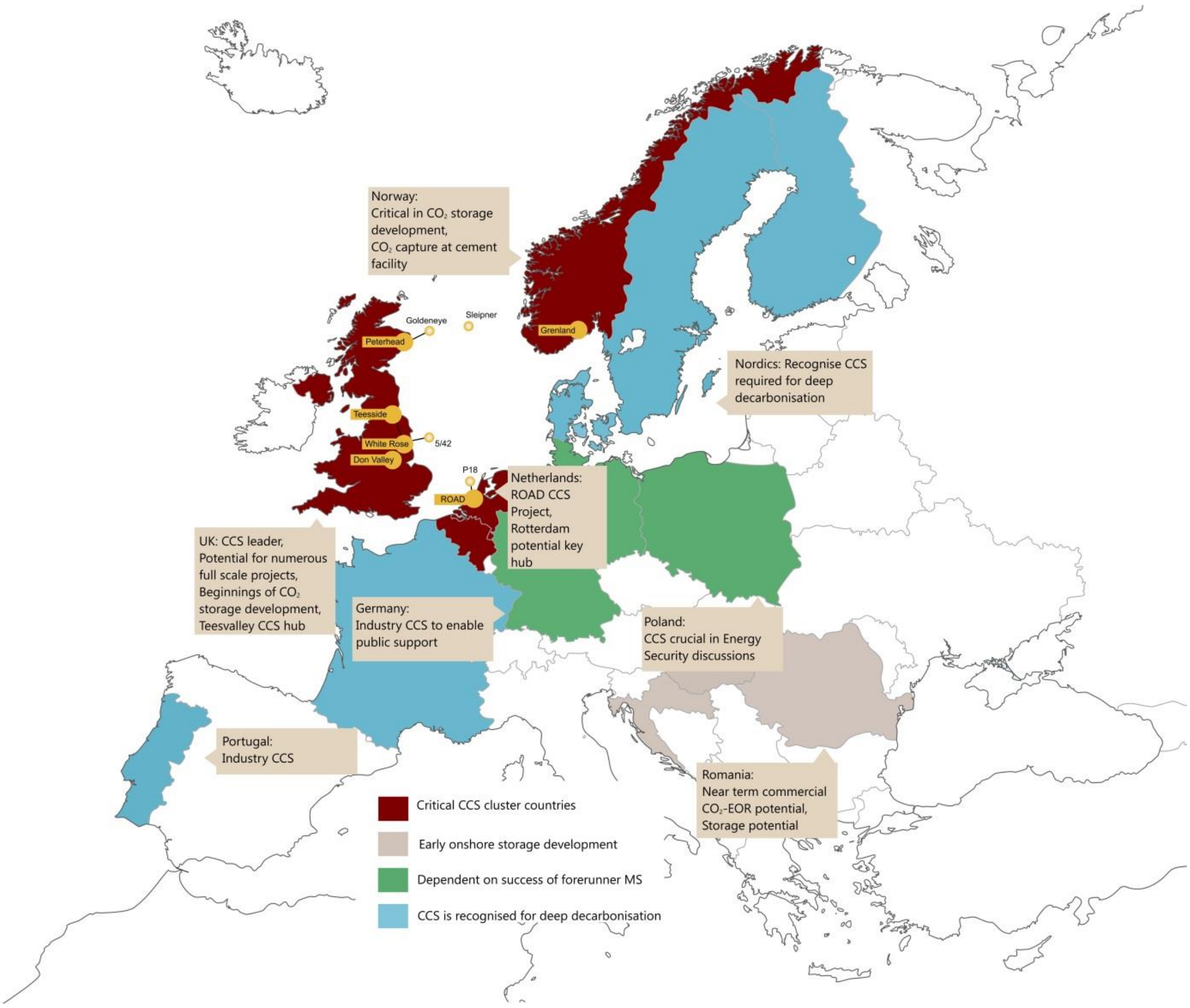

Figure 2 Areas that could be well suited to early deployment of CCS

The development of coastal hubs such as the Port of Rotterdam may unlock CCS uptake from emitter clusters in surrounding regions which lack accessible storage, both through possible onshore pipeline extensions inland and through the use of e.g. river barges in the shorter term.

For regions such as the heavily industrialised German Ruhr area, access to such hubs is necessary to allow the preparation for post-2030 deep decarbonisation.

Transporting CO_2 by ship provides flexibility in an early start-up phase when there might be uncertainties as to how much CO_2 will need to be transported by which routes over which time period. Ship transport can get the CCS chain up and running earlier than a pipeline-only scenario.

II. The role of the European Commission in facilitating CCS commercialisation

Decouple CO_2 capture from transport and storage

The first few CCS demonstration projects (Sleipner, Snøhvit, ROAD, Don Valley, White Rose, Peterhead) have generally been developed linking the CO_2 source and sink into a single value chain. In order to grow into a cluster, any emitter who captures CO_2 must be able to easily connect to the CO_2 infrastructure established by these first-of-a-kind projects. This ensures that all parties in a cluster/hubs model benefit from economies of scale.

General understanding of geological storage is lacking among most of the emitters who wish to capture their CO_2, and they are wary of liabilities. The business model and liability provisions for CO_2 capture and CO_2 transport/storage are very different. Hence, current incentives for power generators to capture CO_2 will not stimulate market conditions for storage. Decoupling capture from transport and storage will address these issues.

Establish viable strategic CCS hubs/clusters

By achieving economies of scale, the focussed development of strategic CO_2 clusters offers significant commercial and deliverability advantages over the proliferation of isolated and commercially more challenging source-to-sink projects. In addition, targeted investment in hubs

A `market maker' model

The 2014 ZEP report, *Business Models for Commercial CO_2 Transport and Storage*[1] assessed the current commercial opportunity for CO_2 storage and concluded that a 'Market Maker'-approach could be an effective and cost-effective mechanism for accelerating CCS deployment in the EU, whilst acknowledging that there will be MS and regional specific requirements and/or preferences and solutions to commercialise CCS must be tailored to local needs.

The idea is that market makers, enabled by a price on transport and storage of CO_2, would do the following:

1) Develop the required storage and transport infrastructure;
2) Transport and store the CO_2 captured by emitters on a commercial contract basis, and;
3) Take the operational storage risk.

Market makers in Europe would be enabled to purchase, on an added-cost[2] basis, CO_2 for transport and storage from power & industrial facilities. The price may be set by the regulator, or alternatively be established/agreed through a commercial tender procedure. The CO_2 will initially be purchased from emitters near the hub infrastructure, covering a mix of CO_2 sources to encourage adoption, innovation and cost-reduction. The market maker should attempt to make accessible CO_2 storage in line with expected/desired future CO_2 capture needs with timely storage and infrastructure development. Market makers could develop into regional storage providers contributing to a pan-European enabling infrastructure.

In addition to the ETS-induced 'push' by incentivising CO_2-emitters to reduce their emissions, the market maker model will create the market 'pull' or demand for (captured) CO_2, rewarding early movers thus allowing the timely physical appraisal of large-scale geological storage.

[1] Business Models for Commercial CO_2 Transport & Storage, ZEP (2014)

[2] The additional production cost due to CO_2 capture, adjusted for the EUA price

can optimise the appraisal of CO_2 storage capacity by early projects. This will require establishing the viability of such early hubs, including confidence in the ability to link up the sources of CO_2 with sufficient sinks.

EU emission sources are well mapped and whilst various national authorities in Europe have also mapped the available storage capacity it will be important to establish a framework for timely appraisal of targeted capacity in strategic CCS hubs and clusters. The Commission can take on a leading role in ensuring this will happen through improving the economics of CCS within the EU by prioritising support for delivering strategic CO_2 transport infrastructure and storage capacity inventories.

The mechanism proposed here will correct for the fact that – currently – paying a penalty for emitting CO_2 into the atmosphere is less costly and easier than capturing and storing the CO_2.

Deploy existing policies and public financing opportunities for targeted EU CCS support mechanisms, which will:

- Target the cheapest (to capture) emissions first, e.g. high-purity CO_2 streams from bio-ethanol production, ammonia and hydrogen manufacturing, etc.
- Benefit a wide range of industries (not specific to any one source – avoids clash with MS competence on sources of energy supply)
- Enable smaller scale CO_2 emissions to be captured and stored through the use of existing infrastructure (lowering the commercial barrier)
- Ensure sufficient means to timely appraise storage space required for commercial CCS deployment post 2030
- Over time, allow MS for whom CO_2 storage is not an easy option to make use of the opportunity that CCS brings through storage in neighbouring countries
- Be compatible with the EU ETS as it is naturally self-limiting: the payments would reduce over time as the price of EUAs increases
- Allow and operate in tandem with the creation of clean power/product markets, for example the UK's CfD mechanism
- Eliminate over time the need for capital grants from European Funds and/or individual MS which are required for Phase 1 demonstration projects
- Ensure that the purchase of CO_2 is not seen as "paying to pollute", rather it is paying to permanently remove CO_2 that would otherwise be emitted to into the atmosphere, and in doing so developing the large-scale storage sites that society will depend on for deep decarbonisation
- As opportunities for industrial commercial utilisation of CO_2 (CCU) emerge, allow for tandem use and storage of CO_2, especially in the vicinity of CO_2 hubs to aid their expansion

CO_2 Capture and Utilisation (CCU)

CCU is a collective description of technologies for commercial industrial utilisation of captured CO_2 for various products and purpose, dissimilar to CCS which, through the permanent geological storage, avoids emissions of CO_2 to the atmosphere with a view to prevent disastrous climate change.

As long as venting CO_2 to the atmosphere remains substantially cheaper than abating the emissions, CCU does have the potential to recuperate some of the costs of industrial decarbonisation by deriving value from CO_2. When discussing CCU in a decarbonisation context it is however vital to discriminate between CCU technologies: some may stop emissions of CO_2 to the atmosphere permanently, while others only delay the CO_2 emissions. There is a wide range of utilisation options, many still at a technologically immature stage, and due to their scale of operation, all likely to play a very modest role for climate mitigation. Each CCU option will need to be assessed individually as life-cycle emissions and environmental impacts are highly diverse.[1]

The inclusion of CO_2 into plastics or synfuel is an example of short cycle utilisation processes: CO_2 will generally be emitted within a few years or even months upon combustion – unless CCS is applied to incinerators and fuel combustion. Inclusion of CO_2 into e.g. building products has the potential for longer term storage, assuming that the products will be in place for many decades or even centuries.

The use of CO_2 in enhanced oil recovery or enhanced gas recovery (EOR/EGR) can be viewed as largely analogous with geological storage of CO_2, with possible dual use of infrastructure and development of relevant skills. Although EOR can in itself only provide limited CO_2 storage capacity, such operations may cost-efficiently contribute to developing CO_2 transport networks and large-scale storage sites. CO_2 EOR is a mature industry in the USA, with millions of tonnes of CO_2 injected each year, and experience already exists in Central and Eastern Europe. Notwithstanding, it will be dwarfed by the required CO_2 storage to reach decarbonisation goals.[2] [3]

In short, CCU is no alternative to developing large-scale geological storage, but may complement its development by supporting the evolution of a CO_2 market, notably at CO_2 hubs.

The adoption of a 'Market Maker' model could potentially facilitate the development of CCU by helping to provide a secure and reliable source of CO_2, which can then give investors the confidence to pursue projects such as CO_2 EOR and use of CO_2 in products. As utilisation can be an irregular or seasonal activity, transport and storage infrastructure will help ensure that clean industrial products and power can still be produced even if a CCU facility is not running. If a market maker could (re)sell CO_2 for utilisation there could potentially be a reduction in the unit cost of storage for plants capturing CO_2. This is an example of how industrial symbiosis with CCS might be encouraged.

[1] What lies in store for CCS? IEA (2014), Chapter 5

[2] Climate Change 2014: Mitigation of Climate Change. IPCC (2014).

[3] Technology Roadmap: Carbon Capture and Storage 2013 IEA (2013)

III. Optimising use of EU funding arrangements

Both MS and the Commission play important roles in enabling and financing CCS infrastructure. The Commission can accelerate CCS progress by providing fit-for-purpose funding for CCS infrastructure development through the proposed Innovation and Energy Modernisation Funds, through regional and structural funds, through Horizon 2020 and through the Connecting Europe Facility (CEF). Calls for proposals under these existing funding streams should, with due consideration for EU state aid rules, include targeted actions aiming to support the development of early strategic infrastructure investments.

Targeted development of CO_2 storage and CCS hubs is well suited to EU support mechanisms and moreover provides a clear justification for EU-level engagement. Such an approach can avoid negative co-dependencies that have made large source-to-sink CCS investments

challenging. EU support for the development of CO_2 hubs can unlink the different investment timelines of capture and storage, a key commercial failure of the past EU CCS strategy[3].
The **Connecting Europe Facility (CEF)** opens for CO_2 transport infrastructure to be accepted as a **Project of Common Interest (PCI)**. The assessment criteria should be sufficiently flexible to allow 1st deployment phase projects with strategic expansion potential into other MS to be deemed compliant. Ongoing DG ENER work in this context is welcomed by ZEP and should be followed by consultation with key stakeholders on the draft criteria for future CEF calls.

The **Innovation Fund** allows funding for both capital and operational expenditure (CAPEX/OPEX). Care must be taken to ensure that the structure is sufficiently flexible to make strategic transport and storage hub development eligible for funding. The assessment of a project should include judging its merit in terms of contribution to strategic CCS infrastructure.

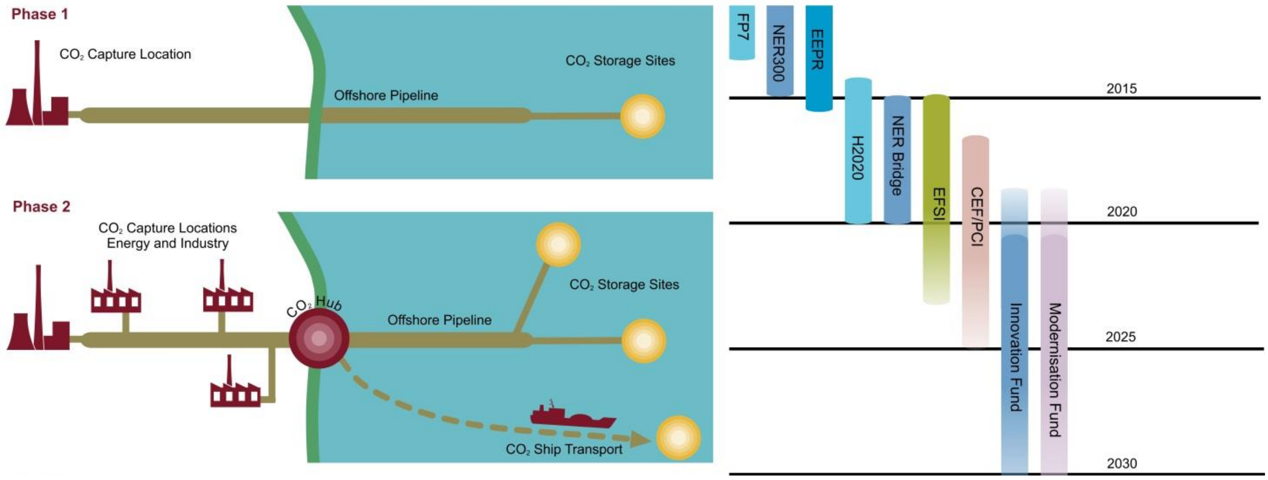

Figure 3 Available funding mechanisms for CCS and when they come into play

Capital grants will be essential to provide prospective operators with the funds required to undertake the development risk of early storage capacity. Expanding on this, a part of the Innovation Fund could be used to create a CO_2 purchase budget with which to develop strategic transport and storage hubs. This budget could target the most cost-efficient CO_2 sources in strategic CCS deployment regions on an added-cost[4] principle. This operational support would provide sufficient CO_2 supply for timely additional storage appraisal. This could be achieved through a 'market maker' model (see inset page 5), if and when such model fits the specific MS needs and policies.

The **European Fund for Strategic Investment (EFSI)** might appear unlikely as a funding option for CCS due to the requirement to provide a return on investment in an uncertain commercial environment. However, any framework that would enable large-scale investments in CO_2 transport and/or storage facilities could alter this situation by creating a commercial market, albeit limited in scope. If a market maker model or equivalent is adopted, then the EFSI could provide valuable upfront capital funding.

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[3] Business Models for Commercial CO_2 Transport & Storage, ZEP (2014)

[4] The additional cost for production of power or the industrial product in question induced by the CO_2 capture, adjusted for the price of the EUAs that would otherwise have to be surrendered for emitting the same CO_2

IV. Engaging MS on CCS through 2050 decarbonisation plans

In the lead up to COP21 in Paris later this year, the EU can demonstrate its commitment to deep CO_2 emissions reductions by supporting CCS as an integral component of the EU's future emissions reductions strategy. This will require clear political signals from the European Commission and EU Member States to industry and investors that there is a future market for CCS in Europe. The ongoing implementation of the EU 2030 Framework for Energy and Climate and the Energy Union provide well-timed opportunities for highlighting this aspect. Governance mechanisms will be critical to stimulate MS action on CCS and monitoring progress towards the EU 2050 Low-Carbon Roadmap.

To increase the speed and scale of CCS deployment within the EU, the Commission can make three key interventions with MS within existing policy initiatives:

1) Require MS to demonstrate the pathway to achieving 2030 objectives in a manner consistent with the EU 2050 Low-Carbon Roadmap via the Governance Mechanisms for the 2030 Framework and the Energy Union. Where CCS is not envisioned, MS should be required to demonstrate alternative means to deeply reduce CO_2 emissions across their economies;

2) Encourage the development of regional partnerships where MS with limited accessible storage capacity collaborate with neighbouring countries that do have storage opportunities. The Commission should moreover help remove any legal hurdles for such cross-border collaboration in order to optimise the use of infrastructure;

3) Assess MS against the following **critical success factors** for CCS deployment:

   Political and Legislative:

   - To what extent have the MS quantified the CCS contribution to the 2030 and 2050 targets?
   - Have MS developed a national plan/roadmap for CCS delivery?
   - Have MS created the marginal abatement cost curve as part of the national plan? Where does CCS sit on this? Before or after the 2030 target? Do abatement strategies include core national industries, e.g. steel, cement, refineries, chemicals, pulp and paper?
   - Do MS have a support mechanism for clean power and clean industry to transition energy and industry systems to when carbon price is sufficiently high?
   - Do MS have a section of government assigned to CCS – with deep understanding ranging from energy markets to storage capacity maturation?
   - Do MS have a feel for public support and acceptance? Are they able to articulate the vision for sustainable cities and sustainable industry?

   Technical and Practical:

   - Do MS have a specific transport and storage plan for CO_2?
   - Are CO_2 sources and CO_2 sinks mapped? Do the MS know the longevity of sources and the mix of industry and power?
   - Have MS got CCS and CO_2 storage regulations in place? To what extent are the different business models elements present for CO_2 storage development?
   - Have MS established a long term liability management mechanism for stored CO_2?
   - Have MS ratified international conventions on transboundary transport of CO_2 by ships and pipelines?

Cooperate on identifying CO_2 storage potential and managing data transfer

Substantial work has been done to date to map EU CO_2 storage capacity, much of it with the support of EU research funding. The Commission could maximise on those projects by taking on a coordinating role in sharing of knowledge and data on geological storage capacity. On this basis, it could make available an EU storage atlas, which would support market makers or equivalent bodies in prospecting clusters.

In the case of depleting/depleted hydrocarbon fields, substantial data is already available for several MS. Once these production licences are returned to the MS, with due respect to confidentiality agreements, such data, reports and models should be made available to aid the development of key CO_2 infrastructure.

For the case of aquifers, by far the largest potential storage formations, such data often does not exist. The creation of regional or MS bodies to characterise these stores will be required.

The role of EU CCS RD&D

The EU has successfully delivered a number of highly-effective R&D programmes relating to CCS and continues to play an important role in supporting academia, research institutions and industry to deliver further improvements. Given the significance of CCS under the RD&I pillar of the Energy Union, the Commission has an opportunity to increase support for CCS RD&D and deliver progress by transitioning towards a more delivery-focused model.

CCS should be viewed not as an innovation challenge but as an implementation and commercialisation challenge, recognising that projects and the development of new commercial arrangements between project participants is needed to deliver progress. In the UK, for example, the Energy Technologies Institute estimates that CCS can reduce the costs of decarbonisation by over £100 billion to consumers *with existing technologies*. In recognition of this, EU RD&D funding should focus on delivering commercial scale projects as much as phase 2 and 3 technology R&D.

Future calls under Horizon 2020 should enable large-scale demonstration projects to be supported as a key strand of the EU RD&D agenda. This would also open up EU Regional and Structural funds as a source of funding for infrastructure development.

ANNEX 1) ZEP 5-point CCS Action Plan

ANNEX 2) Country List/Map

ANNEX 3) EU CCS funding overview

ANNEX 4) Contributors:

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