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Carbon Dioxide Transport Plans for Carbon Capture and Storage in the North Sea Region

A summary of existing studies and proposals applicable to the development of Projects of Common Interest

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Authors:

Peter Brownsort, Scientific Research Officer,

Vivian Scott, Policy Research Associate,

Gordon Sim, Business Development Executive.

Sponsor:

Professor Stuart Haszeldine.

Scottish Carbon Capture & Storage
Murchison House, West Mains Road Edinburgh EH9 3LA
Telephone +44 (0)131 650 0270 www.sccs.org.uk

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1. Projects of Common Interest for CO_2 transport

The North Sea region has been identified as the leading European region for the development of carbon capture and storage (CCS) (Pershad and Stewart, 2010). There are CCS projects already operating and under active development in the region with well defined carbon dioxide (CO_2) storage potential. To maximise the value of early CCS demonstration projects it is recognised that they should, where possible, seed the development of CCS networks and clusters through use of shared infrastructures for CO_2 processing, transport and storage where relevant. Studies matching European Union (EU) CO_2 emissions to storage capacity demonstrate the need for trans-boundary transport of CO_2 in order that power and industrial emissions sources in EU countries without domestic CO_2 storage may utilise CCS (Morbee, Serpa and Tzimas, 2010; CO_2Europipe, 2011).

The European Commission has made funding available for identified Projects of Common Interest (PCI) in energy infrastructure through its Connecting Europe Facility (European Commission, 2015a). A Project of Common Interest is a project necessary to implement the energy infrastructure priority corridors and thematic areas defined by the European Parliament; one priority thematic area is cross-border transport of CO_2 for CCS (European Parliament, 2013).

The general criteria a PCI must satisfy are:

- The project must be necessary for at least one of the energy infrastructure priority corridors or thematic areas.
- The potential overall benefits must outweigh the costs.
- The project must be situated, or have significant cross border impact, in at least two EU member states, or one member state and a country of the European Economic Area.

Benefits a PCI may receive include:

- Streamlined and accelerated permitting process.
- Improved regulatory treatment.
- Support from the Connecting Europe Facility – financial instruments and grants may be available, including for studies.

The identification and selection of PCIs for inclusion in the list of supported projects is made by regional or thematic groups consisting of the Commission, relevant Member States and project promoters. A thematic group for CO_2 transport is currently being created (mid-2015), and criteria for project selection are being discussed.

To inform this process the present document gives an overview of CO_2 transport concepts and projects for CCS that have been proposed or assessed to date for the North Sea and wider European region. The focus is primarily on projects that meet most or all of the following criteria:

- Project is greater than a single point-to-point source to storage link.
- Proposals are of demonstration or commercial scale.
- Creation of a CO_2 transport network is envisaged.
- Trans-boundary CO_2 movement is considered by either pipeline or ship.
- Overcapacity is to be built in to the transport network.
- Expansion of use and/or cluster development is enabled.

All levels of study from conceptual to detailed planning, and both active and mothballed projects or proposals are covered as they may include useful data and lessons for the development of PCIs; project status is given where known. References to individual project or study reports and other source material are provided for further detail.

2. North Sea Region CO_2 transport projects, plans or studies

This section describes the projects that have been identified as meeting most of the criteria outlined above. The current status of these projects varies: some are live and looking to progress to the development stage, some are on hold and some have been abandoned; the status is given where known.

2.1. Peterhead-St Fergus hub (UK – North Sea)

A study commissioned by CO_2Deepstore (Giles, 2012) looked into importing CO_2 through port facilities at Peterhead with onward transport to North Sea storage sites by pipeline, using existing assets where possible, via the St Fergus hydrocarbon landing and processing site. This was compared with direct transport by ship and offshore offloading to an existing platform. Costs were estimated for comparison between the four most robust scenarios selected from 25 studied:

1. Onshore/offshore pipeline, maximising use of existing assets.
2. Onshore/offshore pipeline, with liquid-phase transfer.
3. Onshore/offshore pipeline, liquid-phase transfer with reduced CO_2 offloading rate.
4. Shipment direct to offshore offloading at storage site.

The study concluded that CO_2 transport via an import terminal at Peterhead Port is technically feasible and competes favourably on cost with CO_2 shipped direct to the target offshore field, due to the ability to re-use some existing regional infrastructure assets. Re-using assets leads to some constraints, preventing the optimal design of the transport facilities and resulting in marginal capital expenditure increases. The study suggests that social and economic benefits arising through proof of Scotland's potential for commercial scale CCS projects would outweigh these additional costs.

A Front End Engineering Design (FEED) study is currently underway by Shell UK for a project to capture 1 million tonnes per year (Mt/yr) CO_2 at Peterhead gas-fired power station as part of the UK Department of Energy and Climate Change (DECC) CCS Commercialisation Competition. Dense phase CO_2 transport is planned using a short, new offshore pipeline section linking to the existing Goldeneye pipeline for storage in that field (Shell UK, 2015).

The idea of using Peterhead Port as an import terminal is compatible with, indeed enhanced by, the Shell Peterhead CCS Project as the proposed pipeline for this is oversized with capacity for 6.5 Mt per year (Shell UK, 2014).

2.2. Forth Valley CO_2 import hub and network (UK – North Sea)

The majority of Scotland's fixed-source CO_2 emissions are located near to the Firth of Forth in Central Scotland. There is significant and well-characterised geological storage capacity in the Central North Sea (CNS). Existing hydrocarbon infrastructure that, in principle, could be re-used for CO_2 transport links the two areas via the St Fergus landing and processing facility.

A study commissioned by Scottish Enterprise examined the infrastructure required to create a CO_2 capture and collection network in Central and North East Scotland, with transport to a CNS storage hub, including value generation from CO_2-EOR (Element Energy, 2014). This could be linked with international CO_2 import by ship to port facilities either in the Firth of Forth or at Peterhead, generating revenue.

A number of previous studies and current projects fit with this concept and are outlined below:

- Longannet – a FEED study was completed for a DECC CCS Commercialisation Competition proposal to capture CO_2 from one unit of Longannet power station and store it in the Goldeneye field in the CNS. Transport was to be in gas phase to St Fergus re-using an existing 36” natural gas pipeline, Feeder 10, then as dense phase to the storage site re-using the existing Goldeneye pipeline (Scottish Power CCS Consortium, 2011). This project was cancelled in 2011.
- Grangemouth – the planned Caledonia Clean Energy project proposes a new 570 MW coal-fuelled integrated gasification combined cycle (IGCC) power plant at Grangemouth that will capture 90% of CO_2 emissions (3.8Mt per year). A new 20 km pipeline would connect the IGCC plant to the Feeder 10 pipeline, mentioned above. At St Fergus, a new 2 km pipeline would be required to connect Feeder 10 to a new compression facility at Blackhill, near St Fergus. From there, the compressed CO_2 would be transported via the existing 20” Goldeneye natural gas transmission pipeline, which would be redesigned to supply CO_2 for offshore storage. There are possibilities to divert some CO_2 for EOR early in the project's operating life, given the close proximity of fields suitable for CO_2-EOR (Redman, 2014). At the time of writing, this project is due to undertake a feasibility study funded by Scottish and UK Governments (DECC, 2015).
- Grangemouth - the refining and petrochemical complex at Grangemouth emits 9% of Scotland’s total CO_2 emissions and is adjacent to the proposed Caledonia Clean Energy Plant. CO_2 capture at the site has been evaluated in the past (Simmonds, 2002). A short pipeline connection into the Feeder 10 pipeline would allow CO_2 transport to offshore sites as described above.

2.3. Teesside Collective (UK – North Sea)

The Teesside industrial area has a concentration of energy intensive and CO_2-emitting process industries together responsible for 5.6% of UK industrial CO_2 emissions. The local enterprise partnership, Tees Valley Unlimited (TVU) won funding from DECC in 2013 to establish technical feasibility and develop a business case for an industrial CCS network in Teesside; they were also charged with making recommendations for a funding mechanism for industrial CCS. This study is due to report in mid-2015 (Teesside Collective, 2015).

As part of this study four companies, including some of the largest emitters in the area, have expressed interest in early involvement in the CCS network: SSI UK (steelworks), GrowHow (ammonia and fertilisers), BOC (hydrogen) and Lotte Chemicals (polymers). These companies, together with TVU, the North East Process Industry Cluster (NEPIC) and National Grid (as transport system partner) have formed the Teesside Collective project with an intention to progress the study proposals towards deployment.

Engineering assessments in the study have covered designs for capture projects for the four companies, plus a CO_2 collection network and offshore transport pipeline options to two possible storage sites. This work found that the project is technically feasible and has produced costed designs at feasibility level. The storage sites considered are the 5/42 aquifer being developed by National Grid for the Yorkshire/Humber cluster and the Goldeneye depleted gas field being developed for the Peterhead CCS project.

The current project does not include any options for import of CO_2. However, there is an existing CO_2 import/export shipping terminal at Teesport used for food grade and industrial liquefied CO_2. This could be linked to the proposed network and expanded to handle larger import volumes for onward pipeline transport to storage.

2.4. Yorkshire and Humber CCS Project (UK – North Sea)

This project proposes a CO_2 capture cluster and transport network in Yorkshire and Humberside, an area containing several very large power and industrial emitters with total emissions of about 60 Mt/yr CO_2. The development of this network is being driven by the White Rose CCS project, Capture Power's proposed coal-fired oxy-fuel power station, which is currently going through FEED for the DECC CCS Commercialisation Competition (National Grid, 2015).

The project proposes construction of a 67 km cross-country pipeline and a 90 km subsea pipeline delivering CO_2 to the 5/42 storage site for permanent geological sequestration in the Bunter formation beneath the North Sea. This site, currently being appraised, would store CO_2 in a saline aquifer at a depth below 1000m. Provisional estimates suggest a capacity in excess of 200 Mt CO_2; it is suggested that adjacent storage areas could be accessed and developed as required.

The pipeline will be oversized with capacity for 17 Mt/yr CO_2 with junctions available for connection of pipelines carrying CO_2 from future capture projects. The White Rose project, planned to be the first connection, would contribute 2.6 Mt/yr CO_2. A quantity might come from the Don Valley CCS project, now being redeveloped by Sargas, which has been allocated funding from the European Energy Programme for Recovery. A further 9 Mt/yr CO_2 is potentially available from other, primarily industrial, sources.

Earlier studies (Yorkshire Forward, 2008; Hughes, 2013) have proposed an alternative or additional pipeline route along the south shore of the Humber estuary, linking a number of large heavy-industry emitters. As well as allowing transport to other potential storage sites in depleted gas fields, this route allows incorporation of a port facility in the Immingham area for CO_2 import by ship.

2.5. Rotterdam Cluster (NL, BE, DE)

Rotterdam, one of the world's largest seaports, is responsible for around 16% of total emissions in the Netherlands. In 2006 Rotterdam set itself a target of halving CO_2 emissions by 2025 through a combination of energy efficiency, renewable energy and CCS, this led to the formation of the Rotterdam Climate Initiative (RCI) in 2007 (RCI, 2011). Several projects and studies involving CO_2 transport options have been progressed by partners of the RCI.

One piece of CO_2 infrastructure is already in place: the 97 km long OCAP pipeline delivers 0.4 Mt/yr CO_2 from the Shell Pernis refinery and Abengoa bioethanol plant to greenhouses in Holland (OCAP, 2012).

A further major project, ROAD, is awaiting final investment decision. ROAD plans to capture 1.1 Mt/yr CO_2 from the new Maasvlakte 3 coal-fired power plant and transport it by pipeline 25 km offshore for storage in a depleted gas field at the TAQA P18-A platform. The pipeline is designed with capacity to carry initially 1.5 Mt/yr as a warm gas phase – conditions required due to the initial low pressure in the depleted field. Later, transport will be as dense phase, which will increase capacity to 5 Mt/yr, allowing other capture projects to share the pipeline (Uilenreef and Kombrink, 2013).

The original RCI concept envisaged networking all CO_2 sources and users in the Rotterdam area, including ROAD and OCAP. More recently a specific link between these projects has been seen as a way of increasing revenue to ROAD by allowing sales to OCAP (Ros et al, 2014).

The CINTRA conceptual study carried out in 2011 looked at the potential for establishing a CO_2 logistics network with a transport hub at Rotterdam. Proposals included collection networks using pipelines from local and more distant sources and liquid CO_2 transport by barge from upstream/inland sources. Distribution to storage was considered using onshore and offshore pipelines as well as liquid CO_2 shipping. Cost estimates were produced for several different possible CO_2 transport combinations delivering CO_2 from capture site to secure storage (Vermeulen, 2011).

In 2013, the Dutch national CCS project organisation, CATO2, published extensive work relating to transport and storage economics of CCS networks in the Netherlands, particularly in developing the proposed Rotterdam transport CO_2 hub. Twenty-nine different transport and storage scenarios were analysed to support capture projects in the Rotterdam and the Eemshaven areas. CO_2 storage options for the scenarios were based on two potential sites in the Dutch Continental Shelf (P18/P15 depleted gas field and Q1 aquifer) and an EOR opportunity in Denmark (Dan Oilfield). Pipeline and shipping transport (including loading and discharge options) were compared (Loeve, et al, 2013a).

2.6. Antwerp (BE, NL, UK, NL)

Several studies have been commissioned looking at CO_2 transport links for Antwerp. A 2004 SINTEF/Statoil study considered direct ship transport of CO_2 from Antwerp to a generic North Sea storage site (Barrio et al, 2004). This was linked to a study looking to create large scale CO_2 infrastructure for EOR in the Gullfaks field. It considered Antwerp as one potential source of CO_2 and examined both pipeline and shipping options from multiple sources in the area (Berger, Kaarstad and Haugen, 2004).

CATO2 carried out a study of the economics of transport and storage for CCS networks in the Netherlands and Belgium. Several potential cases for transport from Antwerp were included covering both shipping and pipelines direct from Antwerp to storage sites, and shipping and pipeline routes via a hub in Rotterdam. Routes for sources in northern Netherlands (Eemshaven) and using UK hubs (Yorkshire/Humber and St. Fergus) were also included (Loeve et al, 2013b).

Antwerp is the home to the largest integrated chemical and petrochemical cluster in Europe and the Antwerp Port Authority has an interest in creating added value through CO_2 utilisation in these industries. The Authority is currently sponsoring a feasibility study on a CO_2 transport network in its area to provide CO_2 supplies for utilisation as well as for export to CO_2 storage or CO_2-EOR; results of this work remain to be published (Port of Antwerp, 2015).

2.7. Le Havre (FR, BE, NL)

The COCATE project studied feasibility of options for collecting CO_2 from emitters in the Le Havre area of France and transporting it to a hub at Rotterdam for onward transport to North Sea storage sites. A 40 km collection pipeline network was envisaged, linking five capture sites and collecting 13 Mt/yr CO_2. The project examined three potential transport solutions: onshore pipeline; offshore pipeline; or transport of liquid CO_2 using three ships with effective capacities of 30,000 m^3 each. The offshore pipeline was deemed too expensive, at some 30% more than onshore pipeline. The shipping option was only marginally more expensive than onshore pipeline, but with a number of other advantages. The onshore pipeline route proposed passes close to Antwerp (Roussanaly et al, 2013).

2.8. CO_2Europipe (EU-wide)

CO_2Europipe was a large FP7 collaborative project running from 2009 to 2011 that studied the CO_2 transport infrastructure required for deployment of large-scale CCS in Europe. It covered all the important aspects including: existing infrastructure; source-sink matching; stakeholder perceptions; network design and management; CO_2 standards; risk assessment and management; legal, financial and organisational aspects; environmental impacts (CO_2Europipe, 2011).

The collaboration also included a number of significant case studies including:

- Development of large-scale CCS in the North Sea using Rotterdam as a CO_2-hub (Austell et al, 2011).
- Reuse of existing pipelines for CO_2 transport with a focus on the Rhine and Rhur basins (Behrla et al, 2010).
- Transport infrastructure required for North West Germany (Rhine, Rhur, Hamburg, North Sea areas) (Santen et al, 2011).
- Transport by pipeline or ship from the hydrocarbon processing site at Karsto, Norway to the Utsira saline aquifer (Apeland et al, 2011a).

The study of existing infrastructure (Behrla et al, 2010) found that while up to 50,000 km of natural gas pipelines exist in Germany, these were unlikely to be available for CO_2 transport in timescales suitable for CCS deployment.

The case study for North West Germany (Stanten et al, 2011) concluded that the preferred transport method for CO_2 captured in the Rhine and Rhur areas was barge transport downstream to Rotterdam, before onward transport to storage sites by ship or pipeline. For emission clusters further north and east in Germany, such as the Hanover and Leipzig areas, barge transport to the German North Sea coast at Wilhelmshaven and Brunsbuttel was preferred.

The study of transport to Utsira was extended to consider a North Sea network linking Rotterdam and Teesside, as well as Karsto, to the Utsira storage area and including an import terminal at Teesside to take in CO_2 from other areas (Apeland et al, 2011b).

2.9. Other North Sea/EU networks (EU-wide)

The concept of linking the UK and the Netherlands by a CO_2 pipeline has been considered from various viewpoints by a number of studies, including the following:

The One North Sea study, carried out for the North Sea Basin Task-force (NSBTF), outlines a long-term vision of a well-established CO_2 transport and storage infrastructure around the North Sea, with cross-border links in a number of places, including between the UK and the Netherlands. It concludes that while deployment of large-scale, low-cost CO_2 transport infrastructure is technically feasible, and necessary for any 'high CCS' scenarios, this would require a step change in stakeholder co-operation as well as favourable financial conditions (Pershad and Stewart, 2010).

The EC Joint Research Centre looked at how a CO_2 pipeline network might evolve in Europe and what the investment requirements of this would be. Using an optimisation model for pipeline length and cost with assumptions of high CCS deployment in 2050, the study postulated a high-volume CO_2 pipeline backbone linking southern Germany, the Rhine basin and the Netherlands to southern North Sea aquifers, with links also from the UK (Morbee, Serpa and Tzimas, 2010).

A study for the European Commission Directorate-General Energy and Transport undertook a source-sink network analysis looking at Europe-wide transportation networks for low, medium and high CCS deployment levels in 2030 and 2050 (Haszeldine et al, 2010; Stewart et al, 2014). This used network optimisation software to minimise total pipeline-system costs for scenarios with all onshore CO_2 storage available, and only offshore CO_2 storage available utilising data from the FP6 GeoCapacity European storage assessment. In all cases offshore storage in the Southern North Sea is utilised by trans-boundary pipeline networks.

A study under the CATO2 project (mentioned above, Section 2.6) looked at the economics of developing transport infrastructure linking sources in the Netherlands and Belgium with four offshore storage areas including UK areas of the Southern and Central North Sea. Scenarios studied included pipeline transport either directly from Antwerp, or via a collection hub at Rotterdam, to link with the proposed Yorkshire/Humber Hub and storage in the Bunter Sandstone. The conclusions were that sharing transport and storage infrastructure is cost effective, particularly if it is used to maximise injection rates to an individual reservoir, thereby minimising the operating period (Loeve et al, 2013b).

Recent proposals from The Crown Estate pick up on these earlier projects suggesting, in outline, a bi-directional dense phase pipeline between the UK and the Netherlands. The proposed project would link planned developments in the Yorkshire/Humber area with those in the Antwerp/Rotterdam area. It would reduce risks associated with each development area, providing storage back-up and expansion opportunities, and increasing the likelihood of additional CO_2 transport connections to a developing network (Goldthorpe, 2015).

The recently launched (Q2 2015) Horizon 2020 LCE-19 funded GATEWAY project (European Commission, 2015b) coordinated by SINTEF (NO) with partners from NL, DE, UK intends to develop a model for development of a multi-source and sink cross-border European CO_2 infrastructure project.

2.10. BASTOR (SE, FI, LV, EE, LI, PL, DE, DK)

The BASTOR programme is a study of CCS possibilities in the Baltic Sea region. It focuses principally on storage capacity and transport infrastructure options but also covers environmental impact, public awareness, legal and regulatory aspects (Nilsson, 2014). Reports on four work-packages of the pre-feasibility phase (Phase 2) have recently been published but the fifth, covering transport infrastructure, is awaited. The study has established that there is limited CO_2 storage potential in the Swedish sector of the Baltic but more significant potential in the wider region requiring international cooperation and infrastructure development. CO_2 collection networks for a number of emission clusters have been outlined and costed. Options for both pipeline and ship transport have been studied, both for transport from northern Baltic sources to southern Baltic storage areas and, potentially, for transport out of the region to North Sea storages. In most cases shipping costs were found to be lower. This is due to the longer distances and relatively low volumes of CO_2 transported which favour shipping (Nilsson, 2014). The programme has led to formation of a regional CCS expertise network through the Baltic Sea Region Energy Cooperation (BASREC).

2.11. Sleipner (NO – North Sea)

The existing CCS scheme at Sleipner involves separation of a CO_2-rich natural gas stream using an amine-based capture facility on the Sleipner T platform, 240 km west of Stavanger, offshore Norway. The CO_2 is re-injected for storage in the Utsira formation, which lies above the Sleipner East field in the Central North Sea.

A number of studies, some mentioned above, have looked at using the Utsira formation as a storage site for CO_2 from other sources, with transport either by pipeline or ship from a variety of countries around the North Sea (van den Broek et al, 2009; Pershad and Stewart, 2010; Apeland et al, 2011a,b; Loeve et al, 2011b), however, the capability of the existing Sleipner infrastructure for expansion is not known.

2.12. Skagerrak-Kattegat (DK, NO, SE)

Skagerrak and Kattegat are the sea areas between Denmark, Norway and Sweden, which have a number of large industrial and power emitters around their shores. An assessment of potential CO_2 capture and transport networks for the region has been conducted under the INTERREG programme between 2009 and 2011 (Tel-Tek, 2012). The study looked at two capture scenarios, one based on three major industrial clusters with potential capture of around 6 Mt/yr CO_2, the other including all large emitters (>0.3 Mt/yr CO_2) in the area with potential capture of around 14 Mt/yr CO_2. This larger quantity would represent around a quarter of the 2020 emission reduction target for the three countries.

The project considered several aspects of CCS for the region including capture systems, storage options in the Skagerrak and Danish and Norwegian North Sea areas, legal and economic aspects. A number of CO_2 transport options were considered including: a regional pipeline collection network with offshore trunk pipeline to the storage; a system combining collection by ship to a hub with an offshore trunk pipeline (the most cost-effective); and a hybrid system with 'milk round' collection by ship from smaller capture sources but a pipeline network from larger and clustered sources. These were referenced against a case with pipeline transport to a CO_2 transport hub at Mongstad (western Norway) to show the effect on cost of not having a relatively local storage option (Tel-Tek, 2012).

2.13. East Irish Sea Cluster (UK, IE)

A project carried out by Eunomia Research and Consulting Ltd on behalf of Hydrocarbon Resources and Peel Energy looked at a phased development of CCS for six emission clusters around the Irish Sea (SW Scotland, Northern Ireland, Eire, NW England, North and South Wales) with storage in gas fields in Liverpool Bay and Morecambe Bay in the East Irish Sea. Pipeline transport from collection networks at the clusters to storage sites was suggested (Brown et al, 2011, Coulthurst et al, 2011). The project was conceived to provide a regional storage plan, building on the proposed Ayrshire Power Ltd new-build power station CCS demonstration at Hunterston, but has not been followed-up since cancellation of that project.

2.14. Thames cluster (UK)

In 2009 two potential CCS demonstration projects were being considered for new power stations at Kingsnorth and Tilbury, on the Thames estuary. To support these, E.ON carried out a study of CO_2 collection, transport and offshore storage for a proposed Thames CCS cluster comprising eight existing large emitters and the two new power stations, with potential for capture of up to 44 Mt/yr CO_2. Collection and transport of CO_2 by pipeline was proposed with storage offshore in depleted gas fields in the Southern North Sea. Pipeline routes considered included an overland route via the natural gas processing facility at Bacton, north of Great Yarmouth and a 270 km offshore route off the east coast of England; the offshore route was preferred (E.ON, 2009). In 2010 the two CCS demonstration projects were cancelled and there has been no progress on the CCS cluster proposal since.

2.15. Denmark CO_2-EOR (DK, NL, DE, FI)

Maersk Tankers and Maersk Oil undertook studies into the use of shipping to transport CO_2 from sources in the Baltic and Nordic regions to storage in CO_2-EOR operations in the Danish North Sea (Schulze, 2010). They were involved in the Finnish Meri-Pori CCS project, which aimed for inclusion in the EU CCS Demonstration Program but was discontinued in 2010. Little information on Maersk's activity on CO_2 transport appears available in the public domain.

3. Summary and observations

The brief summaries in Section 2 give an indication of the wide variety of previous project proposals and studies of CO_2 transport systems in and around the North Sea region that could help inform the creation and selection of Projects of Common Interest on CO_2 transport. Most of the work summarised here relates to the UK, the Netherlands and the Scandinavian countries reflecting their policies of engagement with CCS generally and their access to offshore CO_2 storage sites in the North Sea.

Collectively, these studies support the following four broad observations for PCI scoping and development:

1. Currently active demonstration projects in the North Sea region are well located to seed subsequent expansion provided their design and build incorporates measures that enable this from the outset.
2. CO_2 transport and storage infrastructures developed in one Member State or region are beneficial to multiple Member States provided connection can be enabled.
3. Trans-boundary CO_2 transport linking to established CO_2 storage is a technically and economically efficient solution for CCS delivery in many Member States, and is also essential for longer-term CCS deployment across the EU.
4. CO_2 transport by ship, both at sea and on inland waterways, is repeatedly identified as an option that may offer advantages over pipelines through flexibility and lower entry costs.

These observations suggest that the study and creation of PCIs in CO_2 transport, preferably involving consideration of both pipeline and ship options, would support the development and deployment of CCS in the North Sea region and subsequently more widely in the EU.

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