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Scottish CO_2 Hub

A unique opportunity for the United Kingdom

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Scottish CO_2 Hub – A unique opportunity for the UK

A Scottish CO_2 Hub can unlock UK and European potential for CCS while creating value through CO_2 utilisation

Development of a Scottish CO_2 Hub can unlock the potential for CCS in the UK and Europe by providing early access for CO_2 captured in the North Sea Region to extensive, well-characterised storage in the Central North Sea (CNS) at low risk, while creating value through CO_2 utilisation.

The unique importance of a Scottish CO_2 Hub is as the 'downstream' component of a Europe-wide CO_2 capture, transport and storage system, complementing the 'upstream' collection and despatch hubs envisaged for mainland Europe, Scandinavia and England by providing access to low risk, high capacity and cost-effective CO_2 storage.

This can be achieved economically and rapidly by re-use of existing on- and offshore transport and storage infrastructure to reduce costs, and potentially through value generation[1] from CO_2 utilisation in CO_2 Enhanced Oil Recovery (CO_2-EOR).[2,3] A flexible shipping solution can transport CO_2 from eastern England and Europe with low initial capital investment and allow sequential, project-by-project expansion of the system.[4]

A CO_2 capture cluster in central and eastern Scotland involving both power and industrial emitters can be established using existing transport and storage infrastructure allowing rapid deployment of the whole-chain CCS system for sequential expansion as import volumes from European and other UK CO_2 hubs become available. Although small by European standards, this capture cluster would be significant for Scottish emissions, realistically able to halve Scottish industrial emissions and reduce total Scottish emissions from all sources by c.20%.[5]

The Central North Sea provides the best CO_2 storage opportunity for northern Europe

CO_2 storage sites in the CNS account for a high proportion of Europe's known storage resource. Accessing CNS storage from northern Europe will require transport over a distance of 600-800 km. This could be accomplished by building new trunk pipelines, or by an alternative solution involving ship transport of liquefied CO_2 using established technology. Trunk pipelines would require a high up-front capital investment while ship transport would involve relatively low initial capital investment at low risk. Shipping can be more cost-effective than pipelines for the distances involved and allows greater flexibility to accommodate CCS deployment through sequential, project-by-project development.[6] Costs would be reduced through sharing and re-use of existing infrastructure including deep-water port facilities, on- and off-shore pipelines and injection platforms, becoming available due to depletion of hydrocarbon fields. The flexibility provided by a ship transport solution also fits well with the CO_2 demand profile of a developing CO_2-EOR programme, which would give a value to CO_2 in use as well as providing long-term storage; this would help offset the costs of CO_2 capture and transport, providing value through CO_2 utilisation.

A Scottish CO_2 transport and storage hub could rapidly deliver large-scale CO_2 storage provision, enabling CO_2 capture and collection in several European member states and delivering benefits to the North Sea Region and the wider EU. These opportunities are available whether or not there is progress on the development of defined anchor projects and industrial capture clusters in central and eastern Scotland.

- CO_2 storage in the CNS is the best understood in Europe following decades of oil and gas activity as well as specific assessments of CO_2 storage requirements.
- Existing pipelines can access storage sites from the Scottish mainland.
- Existing production platforms in the CNS can be converted to CO_2 injection as fields become depleted.
- CO_2 utilisation for EOR can create significant value, extending the productive life of oilfields with a range of benefits, as well as providing long-term CO_2 storage.
- CO_2 import hubs could be developed at existing ports with gas handling facilities: the Firth of Forth (Scotland); Peterhead (Scotland); Teesport (England).
- A high proportion of European emissions would be within range of this CO_2 storage system via ports such as Rotterdam, Le Havre, Antwerp and Hamburg.
- Collection of CO_2 from industrial sources, including that already separated at European ammonia plants, could enable early stage implementation of transport and injection infrastructure.

> Well-characterised storage, reuse of existing infrastructure and shipping of CO_2 provides an opportunity for early-stage injection and rapid deployment of CO_2 transport and storage in the CNS.

CO_2 storage sites in the UK Central and Northern North Sea are the best understood in Europe

CO_2 storage sites in the UK Central and Northern North Sea are the best understood in Europe with an estimated total storage capacity of 54,000 Mt CO_2 [7] (several decades-worth of potential storage requirement for the whole of the EU). The Captain Sandstone aquifer alone has a potential storage capacity of over 1,600 Mt.[8] The Goldeneye depleted gas field was evaluated in the Longannet FEED study[9] and intended for use by the Peterhead CCS Project.[10] Investment in characterising Goldeneye for CO_2 storage has exceeded £60 M and this is in addition to the knowledge and experience gained from developing and operating it for gas production.[11]

Existing pipelines can access storage sites from the Scottish mainland: the Goldeneye pipeline has capacity for 6.5 Mt/yr;[12] the parallel and larger Miller pipeline can access potential storage sites further into the CNS. There is good understanding from a recent study of the potential for multiple injection points into the Captain Sandstone, allowing cost-effective and flexible use of the large storage capacity. This study also demonstrated that aquifer storage-site evaluation can be undertaken rapidly (c. 2 years) in existing hydrocarbon provinces where legacy data is available, in contrast to c. 10 years for aquifers in less-well explored areas. This will allow storage development in the CNS to respond quickly and flexibly to changing demands.[13]

Learning from studies in Scotland opens the way to storage in the CNS for the entire North Sea Region through a shipping import solution

The beginnings of an integrated CCS system have been developing in eastern Scotland with the Peterhead CCS Project FEED study, a proposed second phase anchor project being planned (Caledonia Clean Energy Project) and work to form an industrial CCS cluster in Central Scotland being initiated by Scottish Enterprise. These projects could use existing onshore and offshore pipelines for transport of CO_2 to storage sites in the CNS and could be established by the early 2020's. (See Box 1).

Whether or not these capture projects and cluster developments proceed further, the learning from them opens up the way for CO_2 captured in the entire North Sea Region and northern Europe to access large storage capacity in the CNS in the mid-term. A shipping import solution bringing CO_2 to a transport hub linked to the existing pipelines is envisaged, complementary to proposals for CO_2 collection networks in northern Europe and an export hub at Rotterdam.[14] This would allow early expansion, project-by-project, of initial national CCS developments in the North Sea Region, for both power and industry, through access to well-characterised, large capacity storage sites with relatively low capital investment. In turn, in the longer term, when larger CO_2 transport volumes become established, new trunk pipelines could sequentially replace shipping routes.

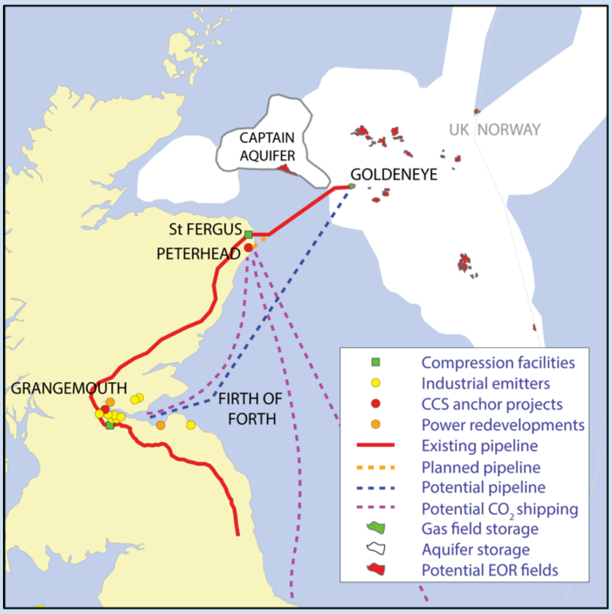
Import hubs in eastern Scotland can link to storage sites via existing pipelines

A CO_2 import hub could be located at various points with access to the existing pipeline infrastructure in eastern Scotland.

- The Firth of Forth has a number of tanker berths with short-route pipeline corridors that could allow easy links to the existing No.10 Feeder, identified as available for CO_2 transport to St Fergus terminal in the North East.[15]
- Peterhead Port has already been positively assessed as a CO_2 import terminal[16] and is keen to expand use of its deep-water tanker berth. The proposed pipeline link from the Peterhead CCS Project is sized to match the Goldeneye pipeline (so, oversized for the project's purpose) and could be redesigned to transport CO_2 directly from the port facilities.
- Further afield, one transport and storage option proposed for the Teesside Collective project is a new offshore pipeline accessing CNS storage sites. This would allow an import hub to be developed at Teesport where there is already experience of liquid CO_2 handling at Yara International's CO_2 shipping terminal.

Box 1 Scottish CCS Cluster

The majority of Scotland's industrial point-source CO_2 emissions (80%, 7.8 Mt in 2012) are located around the Firth of Forth, particularly in the Grangemouth area.[17] This area is close to Feeder 10, a high-pressure natural gas pipeline linking to the St Fergus gas terminal, which has been evaluated in detail and can be made available for CO_2 transport at relatively low cost.[18]



The Grangemouth refinery and petrochemicals complex is ideally located to take advantage of existing infrastructure for CO_2 transport. Realistic capture volumes from major unit processes (CHP, FCC-catalyst regeneration, hydrogen production) could combine to >2 Mt/yr CO_2. A short new pipeline (10 km), following existing transport corridors, would connect to Feeder 10.[19] Other major industrial emitters in the Forth area could connect sequentially by extending the network, bringing the total potential CO_2 capture to around 4 Mt/yr, approaching half of Scotland's industrial emissions. Existing and proposed biomass conversion industries in the area could tie-in to the network introducing a carbon-negative element to the CCS cluster.

Two anchor projects are under consideration in the region. The Peterhead CCS Project could capture 1 Mt/yr CO_2 from a gas-fuelled power station and transport it by tying in to an existing subsea pipeline for storage in the Goldeneye field.[20] The Caledonia Clean Energy Project intends to build a new coal-fuelled IGCC power station at Grangemouth. This could separate 3.8 Mt/yr CO_2 and redevelop existing pipelines for its transport to St Fergus and then offshore to either storage in the Captain Sandstone or for CO_2-EOR use.[21]

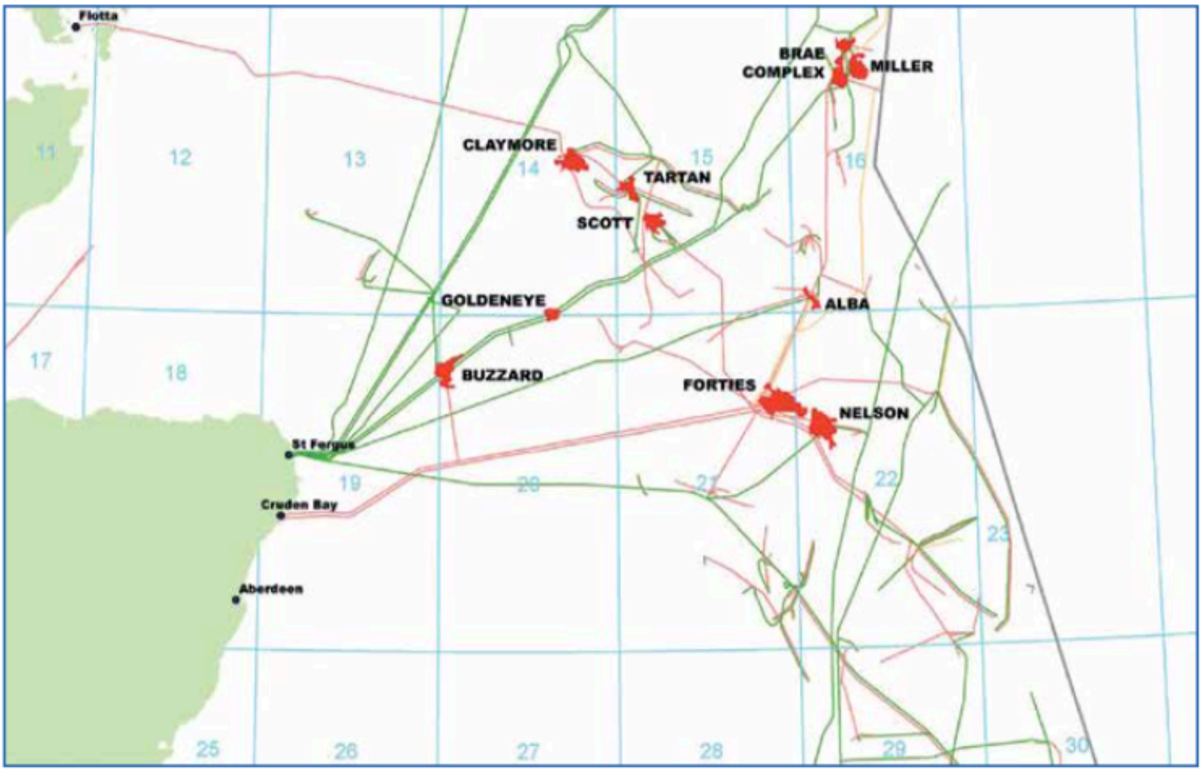
Offshore offloading hubs can allow rapid expansion and flexibility

In the future, as CO_2 capture volumes grow and if capacity in existing pipelines for transfer between a shore-based hub and storage sites were to become limiting, an offshore offloading hub could be developed close to storage sites, reducing the need for new sub-sea pipelines. This might also be a preferred solution for development of CO_2 Enhanced Oil Recovery in the CNS owing to the limited project lifetimes involved and the flexibility that a moveable offshore CO_2 offloading, storage and conditioning facility would allow.

CO_2-EOR can offset costs by valuing CO_2 in use

CO_2-EOR developments could extend the life of oil fields for up to fifteen years, delivering a range of benefits including additional domestic oil revenues, delayed decommissioning, and job retention.[22] The potential return on Government support has been estimated as an economic multiplier of over seven times, roughly twice that of offshore wind power.[23] At the same time, with the correct post-production management strategy, CO_2-EOR can provide a route to a rapid expansion of CO_2 storage at low cost, while achieving long-term, overall net CO_2 storage.[24]

In cases where existing pipelines cannot be used, a ship transport solution combined with a moveable offshore offloading hub can give the flexibility required for CO_2-EOR, where injection profiles may require varied CO_2 supply rates and project lifetimes may be too short to justify investment in new pipelines.[25]



CNS oilfields with significant CO_2-EOR potential, existing gas (green) and oil (red) pipelines[26]

A high proportion of point-source emissions in northern Europe would be within range of this system

Shipping routes are likely to be cost-competitive or -beneficial compared to pipeline transport for CO_2 for distances greater than about 5-700km.[27] This distance would include London, the north coasts of France, Belgium, Netherlands and Germany, and the Baltic region. From previous studies of capture clusters a total potential capture volume in the order of 300 Mt CO_2/yr from this region may be estimated.[28]

Consolidated shipping of liquefied CO_2 in larger shuttle carriers from a hub at Rotterdam, for example, might lead to some economies of scale. But given the flexibility allowed by shipping, collection from liquefaction facilities at other ports – Le Havre, Thames, Antwerp, Hamburg – would be feasible. Using inland waterways and coastal shipping to collect CO_2 by barge from industrial/power clusters to transport hubs at major ports would allow a high proportion of point-source emissions in northern Europe to be within range of this system.

Collection of CO_2 already separated at ammonia plants, and capture from other high concentration industrial emissions could enable early stage implementation of transport and injection infrastructure. CO_2 captured and released from ammonia manufacture amounts to 6-7 Mt CO_2/yr in Europe and the majority of this is close to North Sea ports.[29]

Summary

Storage sites in the CNS are well characterised and existing pipeline infrastructure can be converted to CO_2 use at lower capital cost than the building of new pipelines. CO_2 utilisation in EOR gives a value to stored CO_2, offsetting costs and providing a range of further benefits. Shipping enables rapid development of CO_2 transport whilst being cost-competitive with pipeline for initial CO_2 volumes over North Sea distances.

The combination of shipping and re-use of pipelines not only enables low entry costs but also adds system flexibility, important to CO_2-EOR, and allows sequential, project-by-project development across the full range of plant emission scales. While re-evaluation and consideration of options for deployment of CCS in the UK is underway, it is essential that no decommissioning of potentially relevant pipelines, boreholes, or other offshore facilities is agreed by Government or its agencies.

Opportunities for development of CO_2 transport infrastructure and shipping in the CNS, potentially supported by CO_2-EOR value generation, can enable early-stage, high volume storage of Europe's CO_2 emissions.

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