2020-IP21: Virtual Workshop on CO_2 Infrastructure and Industrial Clusters organised by the Carbon Sequestration Leadership Forum with Gassnova, the Research Council of Norway, the OGCI and IEAGHG

October 15, 2020.

The momentum of Carbon Capture and Storage (CCS) from single demonstration projects to interlinked capture, transportation and storage from multiple sites is gathering pace. There are now a series of CCS hubs and industrial clusters in advanced planning stages with the very real prospect of linked CCS projects in operation by the mid 2020s. Progress with a number of cluster developments was the subject of a recent workshop jointly organised by The Carbon Sequestration Leadership Forum (CSLF), Gassnova, the Research Council of Norway, the Oil and Gas Climate Initiative (OGCI) and IEAGHG. Originally the workshop was to be held in Porsgrunn, southern Norway in March 2020, but the global COVID-19 pandemic meant that the event had to be rearranged as a virtual workshop hosted by the Research Council of Norway.

The workshop was opened by Trude Sundset the CEO of Gassnova who acted as moderator for the event. Trude began proceedings by giving a short summary of the entire Longship Project which includes full-scale CCS capture, transport and storage. This introduction was followed by a presentation from Kjetil Wilhelmsen of Shell on the storage element, the Northern Lights, which is the most advanced offshore project that includes linked CO_2 capture and sea tanker transport. The Northern Lights is a joint venture by Equinor, Shall and Total. The project will take CO_2 captured from the Norcem cement plant in Brevik and, provided some additional funding can be sourced, from the waste-to-energy plant Fortum Oslo Varme in Oslo. CO_2 will then be shipped by tanker to a terminal within Naturgassparken industrial area in the municipality of Øygarden in western Norway. It will then be piped to subsea facilities at the Aurora saline aquifer south of the Troll gas field and then injected into the reservoir. The subsea facilities will receive power from Equinor's Oseberg A Platform in the North Sea.

The scheme is a gateway for other potential industrial CO_2 sources now seeking offshore storage opportunities. Kjetil highlighted the extent of European CO_2 emissions from a variety of industrial sources which amounts to approximately 1,500 million tonnes per year. 580 million tonnes per year comes from sources less than 1,500 km from Naturgassparken. The Northern Lights project is already active across most of northern Europe with nine MOUs already signed with industrial partners. In addition to the Fortum (Finland) and Heildeberg (Germany) Groups, other leading industrial companies include Ervia, (Ireland), Air Liquide (Belgium/France), Stockholm Exergi (Sweden), ArcelorMittal (Luxembourg/Belgium), Preem (Sweden) and the latest Microsoft. This impressive group of companies acts as a bridge for others planning a genuine low-carbon future. The final investment decision (FID) by the Longship industrial partners to proceed was taken earlier this year. Once final approval has been reached by the Norwegian Parliament Phase 1 should start in 2024 with further expansion by 2026. It is possible that by 2050 75 million tonnes per year could be permanently stored.

Many large industrial sources of CO_2 are either based on or near to the North Sea, Atlantic and the Baltic which lends itself to sea-born CO_2 tanker transport. The significance of establishing such a hub and cluster network has also been recognized by the European Commission who can offer support via a designated Project of Common Interest (PCI). Northern Lights has been approved as a PCI.

The second hub and cluster example was presented by Ian Hunter from BP who are leading Net Zero Teesside. This heavily industrialised region on the coast of north-east England has a large number of large CO_2 emission sources from, power, petrochemical, steel and other sources. The location also benefits from the relatively close proximity of deep saline aquifers beneath the North Sea including the Endurance prospect with an estimated 500 million tonne capacity. In addition to strong local political and industrial support this zero carbon industrial hub could benefit from relatively low cost CO_2 from industrial hydrogen production and fertilizer plants. Dispatchable power from gas-fired power plants are also prime targets plus CO_2 from bioenergy and energy from waste plants offering negative carbon electricity. The link to gas-fired generation is significant because these power sources offer flexible generation with renewable sources of energy, notably offshore wind. Future expansion into offshore depleted gas fields is also contemplated possibly with imported CO_2 from external (to Teesside) sources.

Current UK policy is to develop CCUS (carbon capture utilization and storage) within industrial clusters. However, CCUS in the UK failed after previous competitions in 2011 and 2015. Significantly, the UK Government has now set a net zero target by 2050 with new emphasis on a collaborative approach by Government and industry. In contrast to former CCUS proposals, Net Zero Teesside has developed three separate business models (electricity generation with CCUS, industrial production with CCUS and hydrogen with CCUS) for CO_2 capture based on Contract-for-Difference (CfD). This concept has been very successful for the development of renewable energy in the UK and now offers a potential mechanism for CCUS. There would be separate financial arrangements for transport and storage. The inclusion of a power generator acts as an anchor point by providing a long-term CO_2 supply and concomitant revenue stream.

Possibly the largest hub, and certainly the biggest port in Europe, Rotterdam, was the subject of another exciting hub and cluster development, Porthos (Port of Rotterdam CO_2 Transport Hub and Offshore Storage). Mark Driessen, from the Port of Rotterdam, highlighted the benefits of establishing a CCS hub in this area which is responsible for ~16% of the Netherland emissions. It is a relatively compact area in close proximity to many depleted gas fields off the Dutch coast. The country is now committed to a 49% CO_2 reduction by 2030 compare with 1990 levels. CO_2 from major point sources would be pumped via a pipeline within a pre-existing pipeline corridor to P18-A which is a depleted gas field. The new dedicated offshore pipeline will have a capacity of 10 million tonnes per year. It is oversized to accommodate future projected increases in captured CO_2. Porthos customers include Air Liquide, Air Products, ExxonMobil and Shell. Collectively they would supply 2.5 million tonnes per year. CAPEX for the first phase of the project is €450 – 500 million and operations could begin by 2024. EC support from the €102 million funding from PCI will help to establish key demonstration projects like Porthos. Industry will still need to contribute and the project needs to be future proofed. Further hurdles include 7 FIDs, risk and liability assessments, contracts with industrial customers and wider stakeholder support. Risks and liabilities need to be fully resolved. The FID is expected by late 2021 or early 2022. The Dutch Government is currently working on the long-term liability of CO_2 storage. There is a national subsidy scheme for renewable energy which has been expanded to include CO_2 emissions abatement from power generators.

In addition to the technical overviews of the hub and cluster projects, Catherine Lyster, who is a senior advisor to the Norwegian Ministry of Petroleum and Energy presented the national and international legal aspects of CCUS. These aspects of the Longship (Langskip) project are covered in a white paper which will be published in English in a few weeks. Catherine highlighted the significance of the cross-border transport of CO_2 across international borders for permanent geological storage. She also explained that the ETS regulations don't include ship transport, but international law can cover CO_2 transhipment and transfers in event of losses. The EU's CCS Directive does cover the requirements for the transfer of responsibility, operation during storage.

The first of the two panel sessions raised a number of questions from the audience. The panel of presenters made a number of responses:

- The Northern Lights storage reservoir is in a deep saline aquifer as opposed to a depleted gas field because it avoids liabilities of legacy wells. The reservoir formation has a large capacity that has been confirmed by a characterization well drilled in 2019. This investment has helped to prove reservoir storage properties.
- Because of their close proximity to the Dutch coast depleted gas fields are the preferred option for the Porthos cluster. As former gas fields they have proven retention of fluids over millions of years.
- Long-term monitoring will be applied and based on established best practices used in CCS worldwide. Weyburn was mentioned as an example of a demonstration project that clearly shows CO_2 can be safely secured. Learning by sharing experience from technical experts elsewhere, notably through publications, conferences and networks such as the IEAGHG's Monitoring Network have been highly beneficial.
- Long-term liability is covered by EU's CCS directive and Norwegian national legislation. The storage site will be returned to the state when injection stops. CO_2 must be shown to be safely contained. Model predictions must be compared to monitored evidence of CO_2 distribution.
- The cost of the Porthos project is €400 – 500 million, but this only covers the transport and storage. The industry partners must invest in capture.
- The planned capacity for the Northern Lights reservoir is 5 million tonnes per year. The 1.5 million tonnes is a conservative start to prove the concept before scale up. However, Phase 2 work streams are already in progress with Phase 3 also envisaged.
- Successful demonstration will stimulate replication of other cluster / hubs elsewhere. Approaches to development in other countries are likely to vary. They might, for example, depend on tax credits or company to company contracts. Cluster developments look most likely where there are multiple partners.
- The name Longship, or Langskip in Norwegian, comes from the Norwegian word for viking ships, was chosen because these vessels were sleek and innovative designs for their time. The name shows that Norway is a forward looking driver of CCS technology.
- The biggest hurdles that remain are getting contracts between industrial CO_2 suppliers and hub developers. Volatile political climate, and related attitudes, have the potential to derail CCS. For example biofuels development has been brought to a halt in the Netherland for this reason. Public perception is critical especially for a technology like CCS where it is harder to explain its benefits especially at a local level. Fortunately CCS has broad support across the Norwegian political spectrum.
- The discussion concluded with a unanimous view that there will be more than 10 full scale CCS projects in Europe by 2030.

The second session opened with a presentation by Karl Smyth from Drax on Zero Carbon Humber. This cluster will link a number of large CO_2 emission sources centered on or close to the Humber Estuary in eastern England. Collectively they emit 12.4 million tonnes per year. Drax operates the largest power plant in the UK which is in transition from coal to biomass fuel enabling negative CO_2 emission abatement. By the mid 2020s it is possible that up to 4 million tonnes a year could fall into this category. Another nod to the future, within this cluster, is Equinor's hydrogen plant, the largest in UK, which could supply 30 million tonnes a year in 20 years' time.

The diversity of hub and cluster development was reflected in the CO_2 Hub Nordland, presented by Jan Gabor, from Mo Industripark AS. In contrast with the relatively compact hubs and clusters in the UK and the Netherlands, this project includes a number of companies dispersed across the Norwegian county of Nordland in northern Norway. Individual sites emit between 50,000 and 500,000 tonnes per year and include cement, lime, aluminium, ferrosilicon, silicon, ferromanganese and steel. In total these sites emit 2.1 million tonnes per year. These key industries for Norway produce materials for a variety of different markets. They also face the challenge of CO_2 capture from different industrial processes with related cost implications. The demonstration phase has already begun with a budget of 9.8 million Norwegian Kroner (€890,000). Planning involves the mapping of harbours and the specification for suitable storage sites. Logistic options for the transport and size of intermediate storage need to be calculated. The scale of ships and frequency of voyages form part of this cluster design. Further detail will be presented in a paper at the forthcoming GHGT-15 conference in March 2021.

A more advanced infrastructure development, the Alberta Carbon Trunk Line (ACTL), was included in the programme. This 240 km, high pressure, open access pipeline links a number of industrial emitters in the Canadian province of Alberta. These include power generators, refineries, petrochemicals, fertilizer and hydrogen production. Over $1 billion has already been invested in this infrastructure making it the world's largest first dedicated pipeline system for CO_2 from industrial sources. 1.6 million tonnes per year is already sequestered for enhanced oil recovery (EOR) with a projected capacity of 14.6 million tonnes per year. It has been developed in an integrated manner. Proponents have jointly secured Government funding. Capital grants have enabled financing and linkage to the pipeline. EOR and provincial resource royalties underpin commercial agreements.

The workshop concluded with a further panel session with questions from the audience. The panel discussion also addressed the benefits of cluster development particularly the opportunity to share knowledge and physical resources like energy for capture process. There are also operational benefits with these linked networks, for example, there is no single point of failure if a supplier drops out. If new infrastructure can be built, as in case of Alberta, new companies can invest in capture knowing storage is possible. The prospect of relatively small emitters can also be opened up. Increasing the number of partners leads to economies of scale. Common standards across installations need to be agreed for example the level of CO_2 purity. In Alberta the specification is driven by the demands from EOR operators.

Increasing the pace of hub and cluster development of in the UK was raised. This is partly influenced by the UK Government which has been working on business models for CCUS over last 18 months – 2 years. The UK Government now as a stated aim of establishing two clusters by 2030. There is also a call for evidence for negative emission technologies which will influence government thinking on this abatement route including BECCS.

The workshop concluded on an upbeat note with panelists observing that sequential cluster development generates learning by doing. Once transport infrastructure is in place new emitters can be attracted, especially where there is demand for CO_2 utilisation. Capture technologies are now quite mature although interfaces are variable depending on the industry. Cost reduction in solvent solutions is ongoing but it is a longer term process. Strong support from local authorities is also clearly evident given the benefits of secure employment.

The workshop ended with the optimistic prospect that by 2030 there would be 20 full-scale hub and cluster projects worldwide.

The steering committee for this event was:

Lars Ingolf Eide, Research Council of Norway (Chair)
Åse Slagtern, Research Council of Norway
Hans Jorgen Vinje, Gassnova
Mark Crombie, OGCI
James Craig, IEAGHG

James Craig
17th November 2020