



**CARBON SEQUESTRATION LEADERSHIP FORUM
TECHNICAL GROUP**

**Task Force on Clusters, Hubs, and Infrastructure and CCS
Update 1, period March 2019 – March 2020**

April 2020

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1. Background

The objective of this document is to report progress and status for the development of CCS hubs, clusters and infrastructure worldwide.

It is an update of the projects described in the Phase “0” report of March 27, 2019 (https://www.cslforum.org/cslf/sites/default/files/documents/Task-Force-on-Clusters-Hubs-and-Infrastructure-and-CCS_Results-and-Recommendations-from-Phase-0-Activities_Draft.pdf). Some text in that report, such as projects in operation by March 2019 is not brought forward in this report.

NOTE 1: Information that relates to before March 2019 and either escaped the Task Force Phase 0 report or was not made public until afterwards, has been included here.

NOTE 2: Only updates that have impact on the investment decisions and full-scale implementation will be reported here (essential information). What is considered normal project activities (meeting, task reports etc.) are not included.

1.2 Some definitions

It is useful to have a common understanding of the concepts discussed in this note. Here follows a repetition of some definitions:

Cluster (From GCCSI, 2016)

- An industry cluster is a geographic concentration of interconnected businesses, suppliers, and associated institutions in a particular field. Clusters can emerge for many different reasons, including proximity to raw materials, to transport options such as ports, to labour supply, and to markets.

Hub (modified from GCCSI, 2016)

- CCS hubs have two meanings:
 - The central collection or distribution points for CO₂. May be common to one or more clusters
 - The storage hub, where CO₂ from the CO₂ from a collection and distribution hub are injected.
- Hubs could be located at the capture end or the storage end of a multi-user pipeline (forming capture/collection or storage hubs), or both.

Network (from GCCSI, 2016)

- A CCS hub and cluster network (network for short) brings together many of the elements along the CCS value chain (CO₂ source, capture, transport, injection, storage) with multiple co-located (clustered) source capture facilities (of the same or different types) supplying CO₂ to a shared ‘oversized’ transport and storage system.

Infrastructure

- The physical parts of the network (single or shared capture facilities; temporary storage facilities; injection facilities, pipelines, ships)

Note that the definitions apply onshore as well as offshore.

Note also that according to these definitions, a plant or facility can be part of network without being part of a cluster.

1.3. Structure of the report

This report will start with some reminders of CSLF recommended targets, task force mandate, and some definitions. It thereafter gives a country-by-country review of progress on the projects reported in the Phase 0 report, as well as brief descriptions of new initiatives, followed by a summary and conclusions and recommendations.

2. CSLF Technology Group recommended target and strategy

The CSLF Technology Roadmap 2017 (TRM) recommends that the CSLF Ministers adopt the following target for CO₂ storage by 2025 to keep the global temperature increase from anthropogenic CO₂ emissions to 2°C or below:

Long-term isolation from the atmosphere of at least 400 megatonnes (Mt) CO₂ per year by 2025 (or have permanently captured and stored of 1,800 Mt CO₂).

To achieve this the TRM recommends ten strategic actions that are deemed necessary, of which the following four are regarded to fall under the Technical Group's responsibilities:

- Facilitate CCS infrastructure development.
- Leverage existing large-scale projects to promote knowledge-exchange opportunities.
- Drive costs down along the whole CCS chain through RD&D.
- Facilitate innovative business models for CCS projects.

For CCS infrastructure the TRM recommends that:

- *Governments and industry should work together to:*
- Towards 2020
 - *Design and initiate large-scale CO₂ hubs that integrate capture, transport, and storage, including matching of sources and sinks.*
 - *Develop commercial models for industrial and power CCS chains.*
- Towards 2025:
 - *Implement the first large-scale (i.e., >10 Mt CO₂/year aggregate throughput) CCS chains in power, industrial, and bio-CCS, in industrial regions that have the potential to share infrastructure,*
 - *Implement initial shared infrastructure for a limited number of plants within industrial clusters.*
- Towards 2035:
 - *Continue progressive rollout and expansion of full-scale CCS chains and clusters in power, industrial, and bio-CCS. This includes large-scale CO₂ transport networks that integrate CO₂ capture, transport, and storage, including matching of sources and sinks.*

The TRM puts obligations on the Technical Group to:

- Monitor the progress in CCS in relation to the Recommended Priority Actions.
- Report the findings at Ministerial meetings.
- Suggest adjustments and updates of the TRM.

3. Task Force objectives and mandate

At the CSLF Technical Group (TG) meeting in Melbourne, Australia, 17 October 2018, it was decided to establish a task force on Clusters, Hubs, and Infrastructure. This task force will conduct only preliminary “Phase 0” activities to review progress made on the topic since the CSLF Technology Roadmap 2017 (TRM) was issued. The task force will present a recommendation on whether or not to continue past the preliminary phase at the next Technical Group meeting.

Task force members for the preliminary phase are Norway (lead), Australia, Brazil, Canada, and the United Kingdom.

Topics that could be addressed by the task force include:

- Brief review of networks, existing or in construction
- Identifying and reviewing projects that have moved forward toward technically and financially
- Identifying and reviewing new studies and concepts
- Identifying and reviewing publications that aim to progress the implementation of CCUS networks

Thus, this note addresses the progress of the first of the strategic actions.

4. Project updates, country by country

4.0. Networks in operation by March 2019

In April 2019 four existing projects were reported:

USA: Three networks were in operation in USA - the Denver City (inception 1985), Gulf Coast (inception 1999), and Rocky Mountain (inception 1986) hubs - all being CO₂-EOR systems where clusters of oilfields are fed by a network of pipelines.

Brazil: The Petrobras project “Offshore Pre-Salt Santos Basin project” with a set of FPSOs unit that incorporates CO₂ separation and injection facilities, specifically, CO₂ capture from natural gas and reinjection system for enhanced oil recovery (EOR) purposes in the Santos Basin Pre-salt formations. In 2019, Petrobras reached the milestone of 14,4 MM tonnes of CO₂ (the CO₂ cumulative injection. During the last year, Petrobras injected 4.6 MM ton of CO₂ at Pre Salt Basin.

4.1. An international hubs initiative

The Oil and Gas Climate Initiative (OGCI) KickStarter initiative is designed to unlock large-scale commercial investment in CCUS, by enabling multiple low-carbon industrial hubs. These hubs capture carbon dioxide from several industrial companies and bring economies of scale by sharing transport and storage infrastructure. The five hubs/clusters included in the KickStarter initiative the are:

Section 4.3: HUB 2: The Full-Scale Open Source CCS Project, Norway

Section 4.4: HUB 3: Rotterdam, The Netherlands

Section 4.5.2: HUB 1: Teesside, UK – Getting to net zero

Section 4.9: HUB 5: Gulf of Mexico, USA

Section 4.10. HUB 4: Xinjiang, China

These hubs and clusters are described in more detail under the respective countries.

4.2. Australia

CarbonNet

This project is investigating the feasibility for a commercial-scale, multi-user CCS network in Gippsland, Victoria, Australia. It is jointly funded by the Australian and Victorian Governments to 2020, with significant research investment from, among others, ANLEC R&D. Feasibility studies have been completed, project development is ongoing with the aim to transit to private sector around 2020/2021. CarbonNet includes plans for hydrogen production in cooperation with Japan.

(<http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/carbon-storage/the-carbonnet-project>;

https://www.cslforum.org/cslf/sites/default/files/documents/Melbourne2018/CarbonNet_Project_Presentation_to_Technical_Group.pdf)

Update:

This project is investigating the feasibility for a commercial-scale, multi-user CCS network in Gippsland, Victoria, Australia. It is jointly funded by the Australian and Victorian Governments to 2020, with significant research investment from, among others, ANLEC R&D. Feasibility studies have been completed, project development is ongoing with the aim to transit to private sector around 2020/2021. CarbonNet includes plans for hydrogen production in cooperation with Japan.

(<https://earthresources.vic.gov.au/projects/carbonnet-project>

https://www.cslforum.org/cslf/sites/default/files/documents/Melbourne2018/CarbonNet_Project_Presentation_to_Technical_Group.pdf)

Update:

CarbonNet successfully completed the drilling operations on CarbonNet's offshore appraisal well at the prospective CO₂ storage site, Pelican. This well was drilled to a depth of approximately 1,500m beneath the sea bed and collected an extensive dataset, including geological formation rock and fluid samples and high-quality wireline formation logs. Along with the data acquired from the 2018 marine seismic survey, this well data will be used to model and assess the suitability of the site for long-term storage of CO₂.

Australia and Japan continue to cooperate on the Hydrogen Energy Supply Chain (HESC) project in Victoria, which is making progress towards establishing the world's first international liquid hydrogen supply chain. CarbonNet's Pelican site forms the target storage site for the CO₂ captured in this process.”

South West Hub

(<http://www.dmp.wa.gov.au/South-West-Hub-CCS-1489.aspx>;

https://www.cslforum.org/cslf/sites/default/files/documents/Melbourne2018/South_West_Hub.pdf)

This is project that so far has focussed on a storage hub in the heart of the industrial area of south west Australia. The South West Hub is a partnership between government and industry. Research into the geo-sequestration is being funded by the Australian Government and the Western Australian Government through the Department of Mines, Industry Regulation and Safety (DMIRS).

Update:

No essential updates found.

4.3. Canada

The Alberta Carbon Trunk Line (ACTL)

Update:

The Alberta Carbon Trunk Line Project (ACTL) is on track to start up in 2020 and collect up to 1.6 million tonnes of CO₂ from the North West Sturgeon Refinery and Nutrien’s fertilizer facility for transport to CO₂-EOR sites. ACTL construction was completed in late 2019, and commissioning of the capture systems at the Nutrien facility and Sturgeon Refinery is underway. These two facilities will use approximately 10% of the pipeline’s design capacity of up to 14.6 million tonnes per year, with the remaining capacity available to connect additional industrial facilities in the future. ACTL was funded by NRCan (\$62.9 million) – to support the initial engineering, design and equipment procurement for CO₂ capture at the two facilities – as well as by the Government of Alberta (\$495 million).

4.4. China

Xinjiang, China.

The Junggar Basin presents key characteristics for CO₂ storage, and is located near important emissions sources. CEM CCUS and OGCI member companies endeavour to collaborate with authorities to set the appropriate regulatory environment and with stakeholders on hubs and project identification and feasibility assessment.

Update/additional information:

The main CO₂ emission sources are coal-fired power plants, coal chemical plants, cement plants, fertiliser plants, steel plants, and other industrial sources. A large number of chemical and coal-fired power plants are in the pipeline

Xinjiang has been included in OGCI KickStarter initiative.

4.5. Europe

4.5.1. Projects of Common Interest (PCIs)

Projects of common interest (PCIs) are key cross border infrastructure projects that link the energy systems of EU countries. They are intended to help the EU achieve its energy policy and climate objectives: affordable, secure and sustainable energy for all citizens, and the long-term decarbonisation of the economy in accordance with the [Paris Agreement](#).

Update:

Several cross-border carbon dioxide transport networks projects promoters submitted documentation between 27 November 2018 and 2 March 2019 in view of assessment and preparation of the fourth Union list of Projects of Common Interest, to be adopted in October 2019. The fourth PCI list included five projects for cross-border CO₂ networks and one “deletion”:

Name	Description	Comments
Ervia Cork	Ervia Cork project aims to repurpose onshore and offshore existing natural gas pipelines and construct new dedicated CO ₂ pipeline to transport captured CO ₂ from CCUS of heavy industry and combined cycle GTs to a storage facility.	New on PCI list
CO2TransPorts	CO2TransPorts aims to establish infrastructure to facilitate large-scale capture, transport and storage of CO ₂ from Rotterdam, Antwerp and the North Sea Port	Porthos (Port of Rotterdam) from third PCI list of 2017 is joined by ports of

		Antwerp and North Sea Ports.
CO2 Sapling Transport and Infrastructure Project	CO2 Sapling Project is the transportation infrastructure component of the Acorn full chain CCS project (United Kingdom, in further phases Netherlands, Norway)	Also on third PCI list of 2017
Northern Lights	Northern lights project – a commercial CO ₂ cross-border transport connection project between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and transport the captured CO ₂ by ship to a storage site on the Norwegian continental shelf	A modified version of CO ₂ cross-border from third PCI list of 2017
Athos	Athos project proposes an infrastructure to transport CO ₂ from industrial areas in the Netherlands and is open to receiving additional CO ₂ from others, such as Ireland and Germany Developing an open-access cross-border interoperable high-volume transportation structure is the idea.	New
Teesside CO ₂ Hub	Now Net Zero Teesside	No longer considered PCI project

These hubs and clusters are described in more detail under the respective countries.

4.5.2. Align – an European Commission Network Project

The [Align](#) project is an ACT (Accelerating CCS Technologies) project funded by the European Commission and led by the Netherlands. Its goal is to transform six European industrial regions into economically robust, low-carbon centres by 2025. A strong focus of the transport work package is ship transport of CO₂.

Update:

June 2019: Align was presented through several papers at the 10th Trondheim CCS Conference (<https://www.alignccus.eu/news/knowledge-sharing-align-ccus-10th-trondheim-ccs-conference>). The ALIGN-CCUS project is building a CCU demonstration plant at RWE's Innovation Centre at Niederaussem, in Germany, with the installation of Asahi-Kasei's alkaline electrolyser.

The demonstrator will produce dimethyl ether, or DME, from carbon dioxide (CO₂), water and renewable electricity. It has been developed over the last two years by ALIGN-CCUS project partners from Germany and the Netherlands. Up to 50kg of DME per day will be produced from 180kg of CO₂ and 22kg hydrogen using an innovative one-step DME synthesis process supplied by Mitsubishi Hitachi Power Systems Europe.

The hydrogen will be provided by a 140kW alkaline electrolyser provided by Asahi-Kasei, and the CO₂ feedstock will be supplied onsite by RWE Niederaussem's existing post-combustion capture plant, which captures CO₂ from the power station's flue gases. Electricity from renewable sources used in the synthesis of the DME will be provided via chemical energy storage, which has a high-energy density.

The end of the commissioning of the DME synthesis plant was planned for mid-November 2019, with the intention that DME will be used as fuel for peak power generation with an electrical output of up to 240 kilowatts from the start of 2020

4.5.3. France

The Dunkirk CO₂ cluster

This network could potentially capture 12 Mt CO₂/year from industrial sources in the Dunkirk area and transport it offshore for storage in depleted gas reservoir or ship it to Kollsnes, the location of the intermediate storage and compression facility of the Norwegian full-scale project. A collection hub at Dunkirk could also receive CO₂ from other sources by ship before being sent to storage.

Update:

As part of the Dunkirk CO₂ Cluster, a consortium coordinated by IFP Energies Nouvelles (IFPEN), and with 11 partners from research and industry from six European countries that include ArcelorMittal, Axens, Total, ACP, Brevik Engineering, CMI, DTU, Gassco, RWTH, and Uetikon, has launched a project to demonstrate the effectiveness of the DMX process on a pilot industrial scale. The Axens-designed pilot—able to capture 0.5 tonnes/hr of CO₂ from steelmaking gases by 2021—may begin construction in 2020 at the ArcelorMittal steelworks site in Dunkirk. The project has received €14.8 million from the European Union, of a total of €19.3 million budget over 4 years (<https://www.total.com/en/media/news/press-releases/launch-innovative-european-3d-project-capture-and-storage-co2-industrial-scale>). The project is part of the more comprehensive study dedicated to the development of a possible European Dunkirk North Sea CCS cluster.

4.5.4. Ireland

The Ervia Cork CCS

The Ervia Cork CCS project plans to capture CO₂ from a number of emission-intensive companies located in Cork, with initial consideration being given to the two modern gas-fired, combined-cycle gas turbine power stations Whitegate and Aghada and Ireland's only oil refining business: Irving Oil Refinery (75,000 barrels per day). The captured CO₂ is planned to be transported via an existing pipe network, which includes 54 kilometres offshore pipeline, to the potential CO₂ storage sites in the Kinsale Gas Field.

Update:

Accepted as European PCI in October 2019.
No other essential updates found,

4.5.5. The Netherlands

PORTHOS and CO₂TransPorts

The Port of Rotterdam CCUS Backbone Initiative (Porthos) aims to develop basic infrastructure to collect captured CO₂ from various industrial sources in the Rotterdam port area and transport it to the North Sea for storage.

The PORTHOS project was granted € 6.5 mill. by the European Commission from the Connectin Europe Fund (CEF) as a Project of Common Interest (PCI) as well as receiving funds from industry.

A feasibility study was completed in April 2018. The project leaders will continue to consolidate the business case and work towards an investment decision in 2021.

Update:

PORTHOS has finalized Feasibility and Concept Select phases and started Define Phase (Front End Engineering and Design).

Following an Expression of Interest process, industry expressed sufficient interest.

On May 2nd 2019, the Netherlands Commission for Environmental Assessment (NCEA) published their advice regarding the Memorandum on Scope and Level of Detail (MSLD) of Porthos. This advice gives clear guidance and further stimulation to start the Environmental Impact Assessment (EIA). Public consultations in Rotterdam Industrial Area have been conducted in connection with start-up of EIA and the EIA work has started.

PORTHOS has been included in OGCI KickStarter initiative.

In spring 2019, the Port of Rotterdam, the Netherlands, the Port of Antwerp, Belgium, and North Sea Port (a 60 km long cross border port area that runs from Vlissingen, the Netherlands to Ghent, Belgium) joined forces to look into the possibilities to construct a CO₂ network in the Port of Rotterdam by 2026 and then spend another four years on a cross-border pipeline to Antwerp and North Sea Port by Ghent, finishing in 2030. Reportedly, a further expansion beyond the initial 10m t is expected after 2030.

The ports submitted a common application to EU for PCI status, which they were awarded in October 2019 as the CO₂TransPorts Project.

In December 2019, four industrial companies have signed contracts to develop capture installations at their sites, intended to deliver CO₂ to the Porthos backbone. These companies are AirProducts, AirLiquide, Shell and ExxonMobil. These parties aim to apply for national funding from the Dutch SDE++ programme (Sustainable Energy Transition Scheme) in September 2020.

ATHOS

This is new project, accepted as a European PCI in October 2019.

ATHOS - Amsterdam-IJmuiden CO₂ Transport Hub & Offshore Storage- is a collaboration between the companies Gasunie, EBN, Port of Amsterdam and Tata Steel, in efforts to research into CO₂ capture, transport, storage and reuse (CCUS, Carbon Capture Utilization and Storage) in the North Sea Canal area, with the aim to show that a CCUS network is technically feasible. In 2020, the consortium plans to obtain expressions of interest from companies that may be interested in using the foreseen ATHOS transport and storage network in order to store captured CO₂ and/or make CO₂ available for usage as a feedstock, or use CO₂ as a feedstock.

In September 2019 ATHOS finished the feasibility study showing the project is feasible at reasonable costs, although a set of technical, legal, financial and social challenges remains to be faced.

4.5.6. Norway

The Northern Lights Project

This is the transport and storage parts of the Norwegian Full-scale Project. The project is executed by a consortium of Equinor, Shell and Total.

Update:

The consortium was granted an exploitation well license in January 2019 (https://static1.squarespace.com/static/574c47228259b5de6737fbfe/t/5d7249cbcd669600018f1045/1567771085420/Halland_Storage+break-out.pdf). Funds for drilling the well were awarded by the Norwegian parliament in spring 2019. The well was spudded in Q4, 2019 and completed in January 2020. The well was drilled down to approximately 3 000 m. Preliminary results are encouraging, including confirmation that there is good shale seal, good quality sandstone in the reservoir and no communications with other formations/reservoirs in the region.

The Northern Lights Project has signed Memorandums of Understanding (MoUs) with several candidates for 3rd party volumes of CO₂ from outside of Norway.

Reports from the Front End Engineering and Design (FEED) phase were submitted to the Norwegian Ministry for Petroleum and Energy Q4, 2019.

The Northern Lights Project was awarded PCI status in October 2019 and is included in the OGCI KickStarter initiative.

4.5.7. United Kingdom

ACORN/CO₂Sapling Transport and Infrastructure Project (<https://pale-blu.com/co2-sapling/>)

Acorn is a full chain CCS project in north east Scotland. Being an infrastructure and storage resource led project, it is specifically designed to make best use of the UK's built and natural assets and initiate CCS in the UK at lowest cost. This is achieved through access to key offshore gas pipelines that are both available now and suitable for reuse for CO₂ transport, as well as to well understood and licensed Acorn CO₂ storage site.

Update:

In summer 2019 ACORN received funds from the UK CCUS Innovation Fund (<https://www.gov.uk/government/publications/call-for-ccus-innovation/ccus-innovation-programme-selected-projects>), and the BEISS CCUS funding is progressing the detailed engineering for this project towards a final investment decision in 2021.

The CO₂Sapling Transport and Infrastructure Project had its status as PCI renewed in October 2019.

Net Zero Teesside (former Clean Gas Project and Teesside Collective)

The Net Zero Teesside project was qualified as EU PCI project, but was not awarded funds in late 2018. However, in June 2019 the £18 millions project was awarded £ 3.8 million by the UK Government's CCUS Innovation Fund. (<https://www.gov.uk/government/publications/call-for-ccus-innovation/ccus-innovation-programme-selected-projects>)

Update:

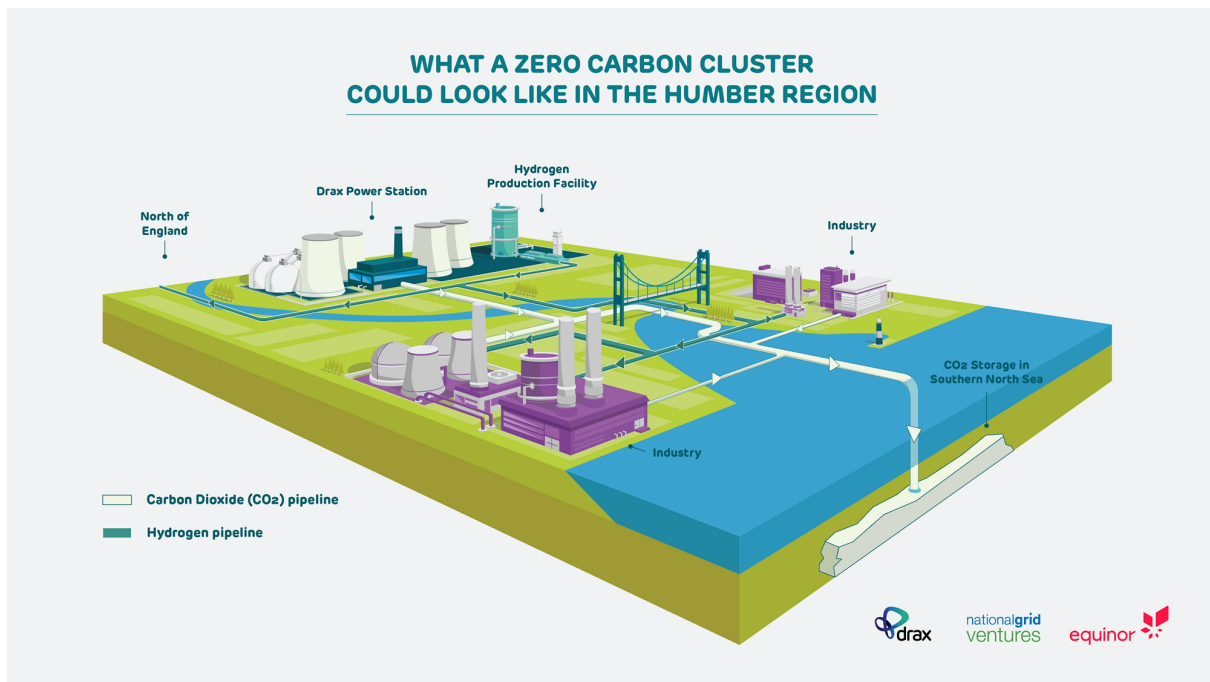
On February 28, 2020, in Teesside, UK, OGCI Climate Investments announced the formation of a consortium of OGCI members – BP, Eni, Equinor, Shell and Total, with BP as operator – to accelerate the development of the Net Zero Teesside project, previously known as the Clean Gas Project. Net Zero Teesside has also signed memorandums of understanding (MoUs) with three existing industrial partners demonstrating the strong local commitment to decarbonising existing local industry. (<https://oilandgasclimateinitiative.com/bp-eni-equinor-shell-and-total-form-consortium-to-develop-the-net-zero-teesside-project-and-accelerate-potential-of-uks-first-zero-carbon-cluster/>).

Net Zero Teesside is included in OGCI KickStarter initiative, but is no longer considered a PCI.

The Humber region zero carbon cluster

New hubs and cluster project.

In late May 2019, the Drax Group, Equinor and National Grid Ventures announced a new zero carbon partnership (https://www.drax.com/press_release/energy-companies-announce-new-zero-carbon-uk-partnership-ccus-hydrogen-beccs-humber-equinor-national-grid/). The commitment marks the first significant response from industry following Committee on Climate Change's *Net Zero* report (<https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/>). The plan could deliver a zero carbon cluster and help position Great Britain at the heart of the global energy revolution.



Graph from https://www.drax.com/press_release/energy-companies-announce-new-zero-carbon-uk-partnership-ccus-hydrogen-beccs-humber-equinor-national-grid/

As seen in the artist's view above of the possible cluster, the Drax Power Station will be part of the network. This power station is already a leading decarbonisation project by having converted two of its three generating units to run on biomass rather than coal. In late June 2019 the company C-Capture and the Drax Group announce that they have secured £ 5 million from the UK Government to further develop the bioenergy and CCS (BECCS) technology at the Drax Power Station over a two year period (https://www.drax.com/press_release/5m-boost-scale-ground-breaking-carbon-capture-pilot-drax-uks-largest-power-station/; <https://bioenergyinternational.com/research-development/c-capture-bags-5-million-boost-to-scale-up-ground-breaking-carbon-capture-pilot-at-drax/>; <https://www.gov.uk/government/publications/call-for-ccus-innovation/ccus-innovation-programme-selected-projects>).

H21 North of England

Although a network for distributing hydrogen, [H21](#) is included here as an example of a new gas network that involves CCS. H21 has launched the first ever testing facility for 100% hydrogen. The site, at the Health and Safety Executive's Science and Research Centre in Buxton, will carry out controlled tests to establish the critical safety evidence proving that a 100% hydrogen gas network is equally as safe as the natural gas grid heating our homes and businesses today. The results will be critical in determining if it is safe to convert millions of homes across the country from natural gas to hydrogen (<https://www.h21.green/news/worlds-first-100-hydrogen-testing-facility-unveiled-h21-project-takes-a-leap-forward-in-making-a-hydrogen-gas-grid-a-reality/>).

Hynet

The HyNet (<https://hynet.co.uk>) consortium of Cadent, Progressive Energy, CF Fertilisers, Essar, Peel, the University of Chester and others, was awarded grant funding under the UK Government's CCUS Innovation Funding earlier this year. This 12-month project to undertake what is known as 'pre-FEED' engineering is now well advanced. It is developing engineering solutions for all parts of the system, and, most importantly, is looking at how the system operates in an integrated.

In summer 2019 Hynet received funds from the UK CCUS Innovation Fund (<https://www.gov.uk/government/publications/call-for-ccus-innovation/ccus-innovation-programme-selected-projects>). Work will conclude in March 2020 with a report that provides far greater granularity on the system cost and how it will operate. At that point, we will seek to launch the next phase of work, called 'FEED', which will last two years and take the project to a Final Investment Decision (FID). **Australia.**

4.6. United Arab Emirates

In Abu Dhabi, the Emirates Steel Industry captures around 800 000 tCO₂/year from steel production for use in EOR operations in an oil field operated by the Abu Dhabi National Oil Company (ADNOC). ADNOC is developing Phase 2 of its efforts to reduce CO₂ emissions, in which it will capture 1.9 to 2.3 Mt CO₂/year from its gas processing plant for EOR. The CO₂ will be stored in the same reservoir as the CO₂ from the steel plant, thus forming a storage hub.

4.7. United States of America

GomCarb

Gulf of Mexico Partnership for Offshore Carbon Storage (GoMCarb) continues its mapping work. Three Texas GoM CO₂ hubs have been identified: La Porte, Texas City, Port Arthur, with a total of > 35 Mt CO₂ per year.

Update:

No other essential updates found.

CarbonSafe

Projects under CarbonSafe was not included in the report April 2019.

Projects in the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative focus on development of geologic storage sites for the storage of 50+ million metric tons (MMT) of carbon dioxide (CO₂) from industrial sources.

The objectives of projects in CarbonSAFE projects includes improved understanding of project screening, site selection, characterization, and baseline monitoring, verification, accounting (MVA), and assessment procedures. Also included is information necessary to submit appropriate permits and design injection and monitoring strategies for commercial-scale projects. More general information can be found at <https://www.netl.doe.gov/coal/carbon-storage/storage-infrastructure/carbonsafe>.

The project list includes 13 pre-feasibility studies and six feasibility projects. Several of the projects include identifying CO₂ sources in the region but focus seems to be on mapping and characterizing storage complexes. in all the project descriptions The 2019 status report from the Global CCS Institute (GCCSI; <https://www.globalccsinstitute.com/resources/global-status-report/>) lists four of the projects with significant development in 2019:

North Dakota, <https://www.netl.doe.gov/project-information?p=FE0029488>.

Illinois Macon County, <https://www.netl.doe.gov/project-information?p=FE0029381>.

Wabash, <https://www.netl.doe.gov/project-information?p=FE0031626>.

Integrated Midcontinent Stacked Carbon Storage Hub, <https://www.netl.doe.gov/project-information?p=FE0029264>.

5. Events, reports, etc. on CO₂ clusters, hubs, and infrastructure since spring 2019.

The importance of CO₂ infrastructure is mentioned in several reports and at several events. It is difficult to state that some are more important or significant than others. Below follow descriptions of two events and one report that are judged more specific than others as separate sub-chapters. In the fourth sub-chapter other reports are briefly summarised with regards to infrastructure.

5.1. Workshop North Rhine Westphalia CO₂ Infrastructure

Representatives from industry, research and politics met on August 22, 2019, in Düsseldorf to discuss the possibilities of establishing a CO₂ infrastructure in North Rhine Westphalia (NRW). Several speakers pointed to the importance of the possibility for industrial clusters to have an infrastructure for transport and storage of CO₂ (<https://bellona.org/news/air-pollution/2019-09-wie-nrw-zum-vorbereiter-einer-klimaneutralen-industrie-in-deutschland-und-europa-wird>).

5.2. European Institute of Innovation and Technology Climate-Knowledge and Innovation Community (EIT Climate-KIC)

On June 13, 2019, industry representatives, regional experts, academics and EU officials held the first public meeting of the research group: “Infrastructure needs of an EU industrial transformation towards deep decarbonisation.” The initiative aims to identify what infrastructure will be needed to meet energy and carbon-intensive industrial areas’ new demands for electricity and hydrogen. The meeting identified specific industrial regions with high concentrations of industries like steel, chemicals and cement. Further, it highlighted that individual regions will probably want to specialise more in renewable energy sources (RES) use or CCS, depending on their local conditions. Ada Marmion, Manager of the Re-Industrialise flagship at EIT Climate-KIC, summed up that the ‘Infrastructure needs of an EU industrial transformation towards deep decarbonisation’ initiative fits into a more global transitioning effort (<https://www.climate-kic.org/news/decarbonising-heavy-industries-by-2050/>)

5.3. UK Committee on Climate Change (CCC): Net Zero: The UK’s contribution to stopping global warming

In this report (<https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/>), the CCC recommends a new emissions target for the UK: net zero greenhouse gases by 2050. The CCC concludes that net zero is necessary, feasible and cost-effective. About CCS and CO₂ infrastructure the CCC says: “Given the large amounts of CCS required by 2050, long lead-times for CO₂ infrastructure (especially CO₂ storage) and infrequent refurbishment rates in industry, developing regional 'cluster'-based infrastructure is on the critical path for achieving net-zero emissions.”

The report is accompanied by the report “Net Zero Technical report” (<https://www.theccc.org.uk/publication/net-zero-technical-report/>), which has an abundance of statements on the necessity of CO₂ infrastructure. Examples are:

- CCS infrastructure required for decarbonisation across the economy.
- Options to use CCS and to switch to hydrogen will be limited by the rate of deployment of infrastructure.
- Achieving deep emissions reductions in the UK's power sector is contingent on CCS infrastructure and deployment support being available by 2030. ^[1]_[SEP]
- Full power sector decarbonisation relies on decarbonising gas generation in the power sector. CCS is key to decarbonising mid-merit power generation and can also play a role in low-carbon

baseload generation. This requires the development of CCS and hydrogen infrastructure, and policy to support their deployment.

- To take full advantage of the potential abatement from industrial CCS, there will need to be adequate CO₂ transport and storage infrastructure. ^[SEP]
- Delayed deployment of hydrogen production and pipeline infrastructure, CO₂ transport and storage infrastructure, or low-carbon heat/combustion technologies, may mean that less decarbonisation of industry is possible and/or a greater role for scrapping of high-carbon assets is required
- CO₂ transport and storage infrastructure should be operational in at least one industrial cluster by 2026 and available to all major industrial clusters soon afterwards, alongside hydrogen for all clusters where it is the best fuel-switching option for some sites.

5.4. Other

Reprt/Source	Reference	Statements
<i>Euractiv</i>	https://www.euractiv.com/section/climate-strategy-2050/news/eu-clarifies-funding-scope-for-co2-capture-technology/	The European Commission has clarified how it intends to support carbon capture and storage (CCS). Future EU funding for CCS is likely to focus on transport infrastructure like CO ₂ pipelines that can collect emissions from several industrial plants
<i>IEA. Transforming Industry through CCUS</i>	https://www.iea.org/publications/reports/TransformingIndustrythroughCCUS/	Recommendation: Facilitate the development of CCUS “hubs” in industrial areas with shared transport and storage infrastructure to reduce costs for facilities incorporating carbon capture into production processes.
<i>Clean Air Task Force (USA). Carbon Capture & Storage in the United States Power Sector</i>	https://www.catf.us/resource/45q-ccs-analysis/	45Q incentives would need to be accompanied by additional policy actions and incentives to increase the pace at which pipelines and injection sites are permitted, financed, and built. Without targeted policies made to remove bottlenecks and enable more rapid development of CO ₂ capture, transport and storage infrastructure, the full impact of 45Q may not be realized.
<i>GCCSI. Policy priorities to incentivise large scale deployment of CCS</i>	https://www.globalccsinstitute.com/resources/publications-reports-research/policy-priorities-to-incentivise-large-scale-deployment-of-ccs/	To reduce the overall cost of CCS, it was found that shared transport and storage networks are an essential component of both risk mitigation and operational cost reductions
<i>International Association of Oil and Gas Producers (IOGP): The potential for CCSA and CCU in Europe</i>	https://ec.europa.eu/info/sites/info/files/iogp_-_report_-_ccs_ccu.pdf	<ul style="list-style-type: none"> • Support Member State initiatives to promote early deployment of CCS and CCU infrastructure • Ensure CO₂ transport by ship and other modes of transport in addition to pipeline • Encourage studies which appraise offshore transport infrastructure to identify infrastructure suitable for reuse.

<p><i>GCCSI Global status of CCS 2019</i></p>	<p>https://www.globalccsinstitute.com/resources/global-status-report/</p>	<p>Hubs and clusters significantly reduce the unit cost of CO₂ storage through economies of scale and offer commercial synergies that reduce the risk of investment. They can play a strategically important role in climate change mitigation.</p> <p>Figure 5 in the report shows a map of hubs and clusters with significant development I 2019. All projects mentioned in this report are included in the figure but this report includes several others as well.</p>
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6. Conclusion and recommendations

The statement "CCUS infrastructure is key to unlocking huge clean growth potential in the UK and can contribute to a cost-effective pathway for reducing UK CO₂ emissions" (UK CCUS Cost Challenge Taskforce Report July 2018) is supported by documents and projects reviewed above. Some positive developments are noted:

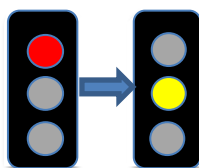
- One project is on track to go online during 2020 (ACTL)
- One project, The Norwegian Full-scale, has submitted FEED documents (FID expected late 2020/early 2021) and drilled an appraisal well
- One other project, CarbonNet, has also drilled an appraisal well
- Some projects have received general funding (the Humber Region/Drax, Clean Gas Project/Teesside, Hynet, ACORN)
 - a. Of these, the Humber Region/Drax is new
- Some projects have received funding for parts of the infrastructure chain, mainly to confirm feasibility of capture technology (Dunkirk, H21) or storage (Northern Lights)
- Infrastructure for CO₂ transportation remains on the EU list of Projects of Common Interest (PCI)
- New as well as continued interest in hubs, clusters and infrastructure is noted through new studies and workshops but all except on project are still in the late pre-FEED phase, at best.

Conclusion 1:

It is still a possibility that at least one infrastructure project may be operational by 2025 (the Norwegian full-scale project¹ and/or PORTHOS²), thus meeting the TRM recommendation for 2025 for infrastructure.

Conclusion 2:

Despite the fact that progress on infrastructure development is lacking behind what is necessary to reach the overall TRM_{storage} target for 2025, the traffic light colour should be changed from red to yellow.



¹ https://www.cslforum.org/cslf/sites/default/files/documents/Chatou2019/Sandberg_Northern-Lights.pdf

² <https://www.cslforum.org/cslf/sites/default/files/documents/Chatou2019/Update-on-Rotterdam-CCUS-Project-Porthos.pdf>

Recommendation 1:

CCUS networks are important to reach the overall target. To this end, decision makers from industry and governments should work together to

- Bring infrastructure projects in advanced stage of development (FEED) to investment decision (FID)
- Develop and implement business models
- Accelerate planning of other infrastructure projects

Recommendation 2:

Arrange a workshop/conference where several of the projects are present to show politicians that industry is ready but needs support. Could be in cooperation with allied organisations or other.

Recommendation 3:

- The Task Force continues to monitor the development of networks for CCUS, including clusters, hubs and infrastructure. The task Force updates this note on an annual basis.