CCUS SET-PLAN

Deliverable 3.2

RECOMMENDATIONS ON THE STEPS REQUIRED TO DELIVER THE R&I ACTIVITY 2: DELIVERY OF REGIONAL HUBS AND CLUSTERS

JANUARY 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 842214

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+32 2 880 3651 impacts9@ccsassociation.org www.ccus-setplan.eu

CONTACT DETAILS

Carbon Capture & Storage Association
Rue de la Science 14b
B-1040 Brussels
Belgium

CO_2 Value Europe AISBL
Avenue de Tervueren 188A
B-1150 Brussels
Belgium

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+32 2 880 3651 impacts9@ccsassociation.org www.ccus-setplan.eu

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Carbon Capture & Storage Association
Rue de la Science 14b
B-1040 Brussels
Belgium

CO_2 Value Europe AISBL
Avenue de Tervueren 188A
B-1150 Brussels
Belgium

Introduction on SET-Plan, CCUS SET-Plan and European Green Deal

The European Strategic Energy Technology Plan (SET-Plan) aims to accelerate the deployment of low-carbon technologies, improve new technologies and bring down costs by coordinating national research efforts. The SET-Plan brings together EU countries, the European Commission, industries, and research institutions. The SET-Plan defined ten priority areas, covering a wide range of sectors including CCUS, wind, solar, geothermal, renewable heating and cooling, biofuels, etc. The Implementation Working Group 9 (CCUS SET-Plan) has been established to help the progress of Research and Innovation (R&I) activities required to achieve the 2020 targets for CCS and CCU agreed by the European Commission, SET-Plan countries, and industry.

The CCUS SET-Plan is composed of 11 SET-Plan countries (Czechia, France, Germany, Hungary, Italy, Norway, The Netherlands, Turkey, Spain, Sweden and the UK), industrial stakeholders, non-governmental organisations, and research institutions. The work is chaired by the Netherlands, Norway, and the Zero Emissions Platform.

Reaching climate neutrality by 2050 will require major efforts from all economic sectors and European society. Higher climate goals mean that all low-carbon technologies under the European Commission's SET-Plan will be crucial in contributing to the transition to a climate neutral economy by 2050 and to accelerate knowledge development as well as technology transfer and up-take. CCS and CCU will play an important role in the delivery of climate neutrality by 2050, enabling a cost-efficient trajectory towards a low-carbon economy with EU's climate objectives.

As part of the European Green Deal workplan, the European Commission has announced new initiatives – such as the European Climate Law, the Hydrogen strategy, the Industrial strategy – and intends to revise existing pieces of legislation, such as the EU ETS directive and TEN-E regulation. All these initiatives are key to ensure that more CCS and CCU projects are deployed in Europe, overcoming current barriers and securing more announcements such as the Longship project and funding awarded through the Connecting Europe Facility for Energy (CEF) programme to European CCS and CCU projects (Porthos, Athos, Antwerp CO2, Acorn Sapling, Ervia).

The European Green Deal, Europe's new growth strategy, set the legally binding target of net-zero greenhouse gas emissions by 2050, formally adopted in the European Climate Law. All economic sectors and member states will need to make strong efforts to reduce greenhouse gas emissions. This means that all low-carbon technologies with a scientifically proven role in achieving climate change mitigation should be developed and deployed. In this context, carbon capture technologies have been highlighted as necessary in order for Europe to reach climate-neutrality in all credible Integrated Assessment Models and scenarios (including the 1.5 degrees IPCC report and the European Commission Clean Planet for all, long-term strategy).

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Belgium

CO_2 Value Europe AISBL
Avenue de Tervueren 188A
B-1150 Brussels
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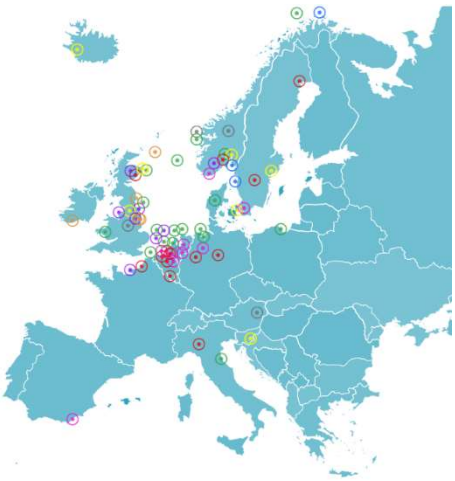
Presentation of hubs and clusters – status, progress, funding, timeline



A European overview of the hubs and clusters under development will be included. Hubs and clusters will be presented, then the report will highlight the status of the development, the partners involved, funding and timeline for operations. Focus will be put on hubs and clusters that have applied for the PCI status (4th and upcoming 5th list), and other cluster will be mentioned and briefly described.

Recently, the concept of developing industrial CCUS clusters as a mechanism to decarbonise coastal industrial hubs has progressed rapidly. This marks a shift away from a single project CCUS value chain with one emitter and one storage site. Clustering CCS projects from industrial applications and linking them with CO_2 transport and storage infrastructure (including cross-border) constitutes an essential basis for development of CCS and CCU projects in Europe. Industrial clusters represent a real opportunity to exploit shared infrastructure that many parties can use, therefore benefiting and reducing cost for multiple (and especially smaller) emitters.

Both at European, regional and national level, there has been acknowledgement that using CCUS to decarbonise industrial hubs is a cost-effective method, and, with regional authority support, many projects have progressed to predicted development timelines.

The development of CO_2 transport and storage infrastructure to connect industrial 'clusters' with other CO_2 capture sites and finally to permanent CO_2 storage or utilisation sites and across international borders, is key to progress CCS and CCU in Europe. Such CO_2 transport infrastructure can serve as the backbone for industrial decarbonisation, delivering carbon dioxide removals (remove CO_2 already in the atmosphere) and enabling the delivery of early, large quantities of clean hydrogen from reformed natural gas with CCS.

- France – Marseille, Le Havre, Dunkirk
- Netherlands – Rotterdam, Amsterdam, Ijmuiden, Den Helder, Eemshaven
- Belgium – Port of Antwerp
- Germany – Hamburg, Bremen, Ruhr Region
- Eastern Europe and Danube region – Poland, Romania
- Sweden – Port of Goteborg
- Denmark – C4: Carbon Capture Cluster Copenhagen
- Italy – Port of Ravenna

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B-1040 Brussels
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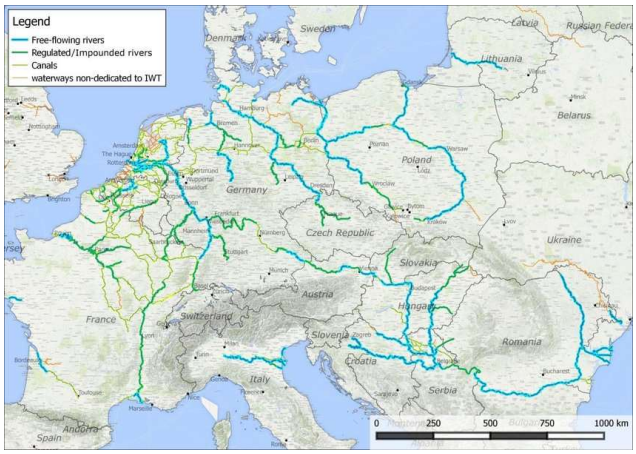
CO_2 Value Europe AISBL
Avenue de Tervueren 188A
B-1150 Brussels
Belgium

It is now crucial that the pipeline of proposed CCUS cluster projects, including the five cross-border CO_2 transport projects on the PCI list, are supported through to full scale operation. Doing so will result in the construction of CO_2 transport and storage infrastructure, which can encourage the development of additional EU wide CO_2 storage projects. For example, CO_2 infrastructure in North-West Europe can encourage CO_2 transport using navigable waterways of the Rhine, Seine, Rhône and Danube, thus connecting many industrial CO_2 emissions through Central and Southern Europe.

The production of low-carbon hydrogen from natural gas with CCS will be an important component of European decarbonisation, as a fuel switching alternative for energy intensive processes, heating, and transport. The production of low-carbon hydrogen will rely heavily on the availability of cross-border CO_2 infrastructure and need to be planned and deployed in parallel. Development of national hydrogen strategies linked to the EU strategy will be crucial.



This map shows the main waterways in continental Europe, indicating that it will be possible to transport large volumes of CO_2 by barge to seaports where the CO_2 can be transported by pipeline or ship to permanent storage offshore. The first shipping projects in a region will likely be centred on large emitters close to coastal sites – possibly to co-located with other emitter sites in a cluster. Within Europe there are a significant number of low-cost capture opportunities in areas that could be accessed via ship for transport.

In the longer term it may also be possible to aggregate, and transport captured CO_2 from cluster sites using an onshore pipeline gathering system and further expand terminal infrastructure to service the growing demand. In addition, it may be possible to use other non-pipeline transport methods such as river barges, rail, and trucks to transfer CO_2 from less accessible areas, particularly for smaller installations. Specific opportunities will need to be considered through techno-economic analyses on a case-by-case basis at individual sites in the context of supporting business models.

Shipping also offers a flexible opportunity for transboundary transport of CO_2 between emitter and storage projects. Where there are suitable support regimes in place and sufficiently low costs of capture and storage a mechanism could be developed to encourage a transport market. There are currently potentially low-cost

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B-1150 Brussels
Belgium

capture opportunities in Europe without stores, as well as several initial projects developing stores with import potential.

Recent developments such as the amendment to the London Protocol, provisionally allowing CO_2 import/export between countries, is a key enabler but there are many other barriers and variables that need to be overcome and understood for a positive further development.

The revision of the EU Gas Directive and the presentation of the Hydrogen and gas decarbonisation package in December 2021 may offer further opportunities for the transport of CO_2. Recognising CO_2 in the context of CCS and enabling gas infrastructure companies to transport CO_2 can be real enablers for open-access CO_2 infrastructure. National Regulatory Authorities should be enabled to oversee the activity.

By the end of 2020, industrial partners of the *Longship* cluster has taken final investment decision and received government support. Longship, the Norwegian Government's full-scale carbon capture and storage project, is one of the first industrial CCS projects to develop an open access infrastructure with the intent and the capacity to store significant volumes of CO_2 from across the European continent. Longship includes capturing and liquefaction of CO_2 from industrial sources in the Oslo-fjord region (cement and potentially waste-to-energy) and shipping liquid CO_2 from these industrial capture sites to an onshore terminal on the Norwegian west coast. From there, the CO_2 will be transported by pipeline to an offshore storage location subsea in the North Sea, for permanent storage.

There is a strong industrial component, as this project will contribute to the decarbonisation of a waste-to-energy and a cement plant, with the possibility for more European CO_2 emitters to connect to the infrastructure. In March 2021, the Northern Lights JV was launched as the transport and storage component of Longship, the Norwegian Government's full-scale carbon capture and storage project Northern Lights will be a cross-border, open-source CO_2 transport and storage infrastructure network. The aim is to develop an open and flexible infrastructure to transport CO_2 from capture sites by ship to a terminal in western Norway for intermediate storage, before being transported by pipeline for permanent storage in a reservoir 2,600 metres under the seabed. Phase one of the project will be completed mid-2024 with a capacity of up to 1.5 million tonnes of CO_2 per year.

Porthos is developing a project in which CO_2 from industry in the Port of Rotterdam is transported and stored in depleted gas fields beneath the North Sea. CO_2 will be captured by various industrial companies, compressed, transported through an offshore pipeline to a platform in the North Sea, approximately 20 km off the coast and pumped in depleted gas fields. The depleted gas fields are situated in a sealed reservoir of porous sandstone, more than 3 km beneath the seabed.

It is expected that, in its early years, the project will be able to store approximately 2.5 million tonnes of CO_2 per year. The possibility for inland connections – from neighbouring countries to the Netherlands – will be evaluated in a second phase. The project has PCI status as since the 3rd PCI list. Involved parties in this project are the Port of Rotterdam, Shell, ExxonMobil, AirLiquide and Air Products.

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Le Havre and Fos-Berre/Marseille have all completed pre-feasibility studies and are looking to proceed with FEED studies in 2020. Additionally, there has been progress developing industrial CCS and CCU clusters into feasibility and FEED stage in other areas, such as Cork, Antwerp, Amsterdam, NW England, South Wales and Dunkerque.

- France – Dartagnan - CO_2 export Multimodal HUB from Dunkirk and its hinterland (emitters from the industrial cluster in the area of Dunkirk, France with storage where available in the North Sea country territories), also on the 5th PCI list. The 3D project in Dunkirk is composed of a consortium of 11 European stakeholders including ArcelorMittal, Axens, IFP Energies Nouvelles and TotalEnergies, to demonstrate an innovative process for capturing CO_2 from industrial activities.
- Netherlands – the Aramis project aims to develop cross-border CO_2 transport and storage project from emitters in the hinterland of Rotterdam harbour area and storage to location on the Dutch continental shelf and was launched by collaboration between TotalEnergies, Shell Netherlands, Energie Beheer Nederland (EBN) and Gasunie.
- Other Dutch clusters are being developed in Den Helder and Eemshaven.
- Belgium – Kairos@C will develop a complete carbon, capture and storage (CCS) value chain that will avoid ca. 14.2 Mt CO_2 over the first 10 years of operation. Kairos@C will initiate a cross-border CCS value chain and kick-start the Antwerp@C project, which is developing a multi-modal transport infrastructure for CO_2 in the port of Antwerp. The project is promoted by Air Liquide Large Industry SA and BASF.
- Eastern Europe and Danube region – In Poland, the Poland EU CCS interconnector has an ambition to establish an open access multi-modal CO_2 Export Hub from Gdansk and its hinterland. The project objective is to connect the main industrial CO_2 emitters in Gdańsk and hinterland to the CCS chain (under development in the North Sea) for permanent storage.
- Sweden – BECCS@STHLM will create a full-scale Bio-Energy Carbon Capture and Storage facility at its existing heat and power biomass plant in Stockholm. The combination of the CO_2 capture with heat recovery will make the process more efficient. BECCS@STHLM will capture and store large quantities of biogenic CO_2 with a potential to avoid ca. 7.8 Mt CO_2 over the first 10 years of operation. It is a project initiated by Stockholm Exergi.
- Denmark – C4: Carbon Capture Cluster Copenhagen. The C4 cluster wants to work on converting CO_2 into green fuels as well as storing excess carbon off site, for instance in depleted oil and gas fields under the Danish North Sea. The companies have also set out to come up with infrastructural solutions, for instance, a method for transmitting CO_2 further along from carbon-capture centres. Several consortium parties have already set off to establish full-scale CCS plants in 2025. The project

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partners are Ørsted, ARC, Hofor, Vestforbrænding, Argo, Biofos, Copenhagen Malmö Port, CTR and Veks.

- Italy – The CCS Ravenna Hub will capture CO_2 in the North of Italy (Pianura Padana Area) from Industrial Complex (i.e. Ravenna), transport and store it in exhausted natural gas fields, with a storage capacity of between 300 and 500 million tonnes.

UK clusters – status, progress, funding, timeline, map

In November 2020, the UK Government introduced a series of CCUS targets, including an ambition to store at least 10Mt of CO_2 per year by 2030, and have 4 CCUS clusters operational by 2030 (with two operating by the mid-2020s). In order to enable projects to come forward aligning to the timeline above, the UK Government introduced a competitive process known as the 'Cluster Sequencing Process'. The process is progressing cluster development on two 'Tracks', Track-1 is for at least two clusters to be operational by the mid-2020s and Track-2 for two more clusters to be operation by 2030.

The UK Government announced the successful 'Track-1' clusters in October 2021, after which applications for wider emitters to access the chosen infrastructure will opened. Additionally, further detail on the 'Track-2' process have been released.

The successful clusters are:

- The East Coast Cluster – a collaboration between Zero Carbon Humber, Net Zero Teesside and Northern Endurance Partnership, deploying CCUS across Humber and Teesside.
- HyNet North-West – a CCUS and hydrogen energy project which will deliver low carbon hydrogen and CCUS in the North-West of England and North Wales.

In addition, the Scottish Cluster – which is centred around the Acorn CCS project based in the North East of Scotland – was announced as a reserve cluster.

In order to support the development of CCS and CCU, commercial frameworks are currently being developed and are due to be published in 2022. They are expected to be based on a Contracts for Difference model to complement current renewable frameworks.

The Net Zero strategy, published in October 2021, further increases the ambition:

- Increased ambition to 20-30 Mt of CO_2 storage per year in 2030. At least approximately 50 Mt CO_2 capture per year is expected to be reached by the mid-2030s.
- This will include 6 Mt of industrial CO_2 emissions per year by 2030, expected to grow to 9 Mt per year by 2035.
- A target of 5 Mt CO_2 per year by 2030 has been introduced for engineered GHG removals.

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B-1150 Brussels
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A wider description of the UK CCUS clusters is provided below:

- Acorn CCUS & Acorn Hydrogen (Scottish Cluster): The project based at the St Fergus Gas Terminal on the east coast of Scotland is aiming to capture CO_2 predominantly from local refining activities, hydrogen production and directly from the air. Storage will reuse oil & gas pipelines and with eventual storage in the Central North Sea. The project is keenly looking at shipping opportunities and has received past funding from the CEF. The project has the potential to capture and store up to 6.7Mt of local CO_2 per year in 2030, and import ~3Mt of CO_2 per year through shipping in 2030.
- East Coast Cluster (formerly Net Zero Teesside, Northern Endurance Partnership and Zero Carbon Humber): This one cluster consists of three linked projects. The Net Zero Teesside project, the Zero Carbon Humber project and the Northern Endurance Partnership. The two projects in Teesside and Humber cover many capture applications, including power CCUS, hydrogen production, fertilisers, EfW facilities and BECCS. Both projects are developing shared storage in the 'Endurance Partnership' in the Southern North Sea. The project has the potential to capture and store up to 27Mt CO_2 per year by 2030 (up to 10Mt in Teesside and at least 17Mt in Humber)
- V Net Zero (formerly Humber Zero): The V Net Zero project is based in the Humber region and consists of CO_2 capture from the Humber Zero group, capturing CO_2 at refineries, from hydrogen production and from CHP generators. The captured CO_2 would then be stored in the Southern North Sea in the Viking A depleted gas field. The project has the potential to capture and store up to 11Mt of CO_2 per year by 2030.
- HyNet North West: The HyNet project is located in NW England and consists predominantly on hydrogen production with CO_2 capture, CO_2 will also be captured from local EfW facilities, BECCS, refining activities and fertiliser production. The captured CO_2 will be transported and stored in the Hamilton Gas Field in the East Irish Sea. The project has the potential to capture and store 10Mt CO_2 per year by 2030.
- South Wales Industrial Cluster (SWIC): The SWIC is located along the southern 'M4 corridor' along the south coast of Wales. The project is looking to capture CO_2 from refining activities, the Tata Steel plant in Port Talbot, power production and other regional emitters. Hydrogen production is also being considered which may be used to fuel switch instead of using carbon capture facilities. There are no local CO_2 stores, so captured CO_2 would be shipped to other storage locations. The CCUS project will help decarbonise the 16Mt CO_2 emissions the region produces annually.
- Other UK projects: There are other projects in the early stages of development including CCUS and hydrogen hubs in Southampton, South England (Southampton Water project), the Bacton Gas Terminal, East England (Bacton Energy Hub), and on the Isle of Grain, near London (Project Cavendish).

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Horizon Europe: call for hubs and clusters; Funding opportunities for clusters

This chapter will give an overview of the Horizon Europe call on hubs and clusters. The chapter will also highlight other funding opportunities under EU programmes (CEF funding, etc). Under the Horizon Europe work programme for 2021-22, a call to support CCUS hubs and clusters is foreseen. The continuation of investigating CCUS possibilities in hubs and clusters, including knowledge sharing activities, is urgently needed as it could help to identify infrastructure needs.

Furthermore, the call could also lead to identifying potential new CO_2 Projects of Common Interest in the sense of the TEN-E regulation[1]. Early planning will enable and accelerate the roll-out of a CCUS infrastructure consisting of capture points and clusters, intermediate hubs, CO_2 conversion facilities, safe and cost-effective CO_2 transport and storage. Comprehensive information concerning the integration of CCUS in hubs and clusters will facilitate the development of operational sites as from the early 2020s.

For the 2023-2024 work programme, the European Commission will likely include a call on CO_2 transport and storage demo projects, feasibility studies; synergies between projects, to be allocated €60 M. The focus for this call will be to facilitate CO_2 transport by all modalities, including pipeline, and transport of CO_2 by ship, train, truck and barge. Successful proposals will seek to leverage and extend existing projects that are already very well advanced. This could include projects developed for application to the Innovation Fund, other PCIs or projects being developed under national programmes. Proposals focusing on means of transport other than pipeline – e.g., by ship or multimodal transport systems – are expected to deliver results supporting further development of CCS within the lifetime of a typical Horizon Europe project. Such projects are likely to be located in leading countries with a strong concentration in northwest Europe, although it is crucial to support the development of CCS in other parts of Europe.

The Innovation Fund is a key funding opportunity for CCS and CCU. The results of the first call for large-scale projects were published in November 2021, and include projects developing carbon capture, use and storage and supporting the decarbonisation of energy-intensive industries through carbon dioxide removals and low-carbon hydrogen.

The Clean Energy Transition Partnership (CETP) aims to empower the energy transition and contribute from a R&I perspective to the EU's goal of becoming the first climate-neutral continent by 2050. With robust investment in innovation and technology development, the CETP will pool national and regional resources/funding programmes, thus overcoming a fragmented approach. CCS and CCU is one of the areas described in the Strategic Research and Innovation Agenda (SRIA). The design of the first calls is currently undergoing, and the first calls for applications are expected in Q3 2022.

Other opportunities come from national funding programmes, such as:

- Carbon price – Norway
- SDE++ – The Netherlands
- UK contracts for difference

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- Germany CO2WIN and German concept for carbon contracts for difference
- Upcoming Swedish system of reversed auctions for carbon dioxide removals

Connecting Europe Facility for Energy (CEF-E)

For CO_2 infrastructure projects that have gained the status of European Projects of Common Interest (PCIs), funding is made available under the Connecting Europe Facility for Energy. This funding stream is connected to the Multiannual Financial Framework (MFF), and for the 2021-2027 period, the budget available under the CEF-E is €5.84 billion.

Currently, five CO_2 infrastructure projects are included in the 4th PCI list and eight have applied to be on the 5th PCI list, to be presented by the end of 2021. The 5th PCI list is the first one to be adopted with the objective of net zero GHG emissions enshrined in EU law.

ERA-NET Accelerating CCS Technologies

Another main pillar for public funding of CCS and CCU R&I in Europe is the corresponding partnership ERA-NET ACT. With an ever-growing number of partners countries and members, funds have successfully been allocated to CCS projects and evaluations are ongoing.

Important Projects of Common European Interest (IPCEI)

The Important Projects of Common European Interest is a valuable mechanism that allows EU member states to support large-scale transnational projects of pan-European interest beyond State aid rules. IPCEI are based on Strategic Value Chains, two of which are particularly interesting for CCS and CCU, i.e. Hydrogen Technologies and low CO_2-emission industries. For the moment, the Hydrogen IPCEI is ongoing with several member states[1] having already opened an expression of interest or having already identified industrial projects at national scale and starting the process of coordinating European cooperation through these projects.

Way forward: Where can we see new hubs and clusters?

This chapter will highlight the critical role of CO_2 transport – and refer to current legislations that are being revised as part of the European Green Deal. It will stress the importance of deploying all modalities for CO_2 transport. Around the clusters and hubs, shared CO_2 transport and storage infrastructure can be developed. It is important to use the Innovation Fund and the CEF funding available for CO_2 infrastructure projects to set the basis for European CO_2 transport and storage networks, to which polluters can access.

This map shows major CO_2 emitters in Europe. Blue circles show electricity generation source, green circles show industrial sources. The red bars show potential aquifer stores, and the orange bars show depleted oil and gas field stores.

CO_2 transport by ship will become increasingly important for European CCS projects, contributing strongly to equitable access for all member states to CO_2 infrastructure that will enable emitters across Europe to

[1] For example Germany, France, Austria, the Netherlands

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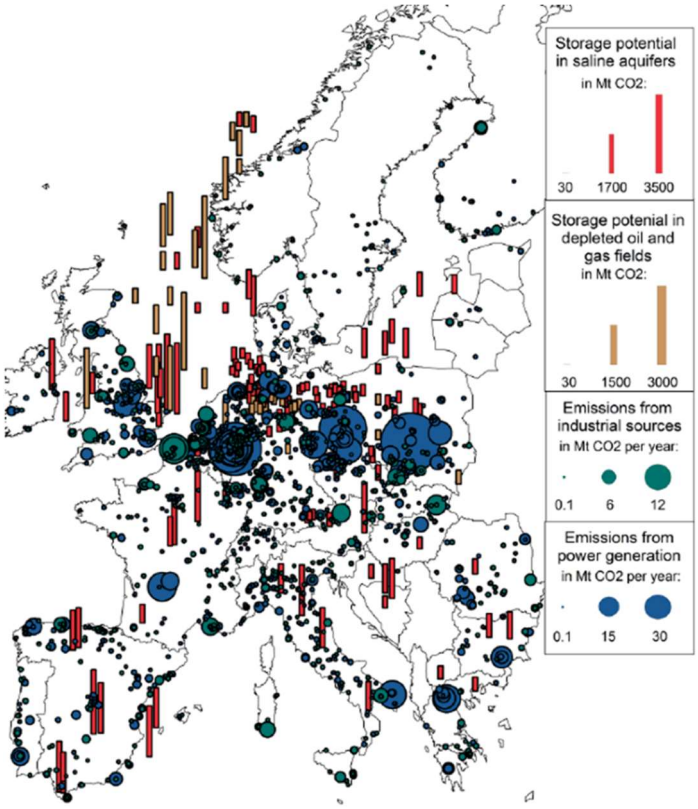
connect to safe and permanent storage. CCS projects, including both cross border European CO_2 infrastructure projects and domestic projects, have identified the need for both inland and maritime shipping solutions. Transporting CO_2 by ship will be crucial for large-scale CCS deployment in Europe.

For CCS projects aiming at transporting CO_2 by ship, interoperability will be very important in order to optimise the development of CO_2 infrastructure. There is a need for standards on CO_2 specifications (composition, pressures, temperatures, etc.), ship design and specifications (e.g., referring to loading and off-loading). As many CCS projects will become operational in the mid-2020s, many new ships for CO_2 transportation will be needed within five years, making these standards urgent and needed.



Further R&I needs

In the past, CCS has largely focussed on power plants as large point sources of CO_2 emissions. Consequently, in many cases the focus for transportation has been on 'point to point' type arrangements, i.e. from the CO_2 source to a storage site.

To meet the net-zero emissions target set in the European Climate Law, the focus across Europe has now shifted to the decarbonisation of large industrial clusters. Capturing, collecting, transporting, utilising and storing CO_2 from such industrial clusters represents new challenges as it involves CO_2 streams with different compositions, flow rates and intermittency and with possibly varying capture technologies requiring the development of safe, resilient and cost-effective CO_2 transportation networks. Given the economies of scale, shared high-pressure pipelines will likely be the backbone of such networks, although gaseous phase transportation at lower pressures and ship transport to and from strategic hubs and to remote offshore storage sites will also have a key role to play.

Facilitating the technical and commercial operation of such networks under clear legal frameworks, along with fully developed business models and regulatory structures, needs to be the focus of further CO_2 transportation development. Success here will accelerate the large-scale role out of CCS and CO_2 infrastructure as investors will be more willing to invest in capture plants and storage sites where there is certainty regarding the availability of viable transportation infrastructure. The feasibility of industrial CO_2

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transport networks needs to be demonstrated as soon as possible to gain technical experience and to strengthen confidence in this solution.

Identifying the appropriate size of the pipelines required for a CO_2 transportation network is a challenging and complex task that has to balance a wide range of factors whilst ensuring assets are not under or over utilised. Important considerations that must be taken into account during the design stage include the inevitable change in the energy supply landscape and further work should address the combination of scenarios relating to changes in future energy supply mix and industrial landscapes alongside the development of CO_2 pipeline transport networks.

Feasibility of hydrogen infrastructure

Launched by the European Commission in July 2020, the European Clean Hydrogen Alliance supports the large-scale deployment of clean hydrogen technologies by 2030 by bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. It aims to promote investments and stimulate the roll-out of clean hydrogen production and use.

During the European Hydrogen Forum in November, the Commission presented the project pipeline coming out of the European Clean Hydrogen Alliance – a list of over 750 projects from all parts of the value chain, including hydrogen production, transmission and distribution and application in industry, transport, energy systems and buildings. The projects are located across Europe, with many set to enter into operation by the end of 2025.

As part of the revision of Regulation 715/2009 on the conditions for access to the natural gas transmission networks, the Hydrogen and decarbonised Gas Package provides an opportunity to expand relevant elements of the existing gas regulatory framework to accommodate the infrastructure networks of the future, as well as the transportation of new gases, including CO_2 in the context of CCS. As stated in the European Hydrogen strategy, low-carbon hydrogen will play a role for the industrial decarbonisation, where direct electrification would be too costly. The Commission should also consider retrofitting and repurposing existing natural gas infrastructure to support the development of dedicated hydrogen infrastructure. In this respect, CO_2 infrastructure should be developed in parallel to hydrogen infrastructure. This will enable the production and transport of early, large-scale volumes of low-carbon hydrogen and limit initial infrastructure costs.

Given the delays for the publication of the publication of the European Commission's delegated act on gas and nuclear of the European Taxonomy, deliverable 3.2 will be updated as soon as more information becomes available

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+32 2 880 3651 impacts9@ccsassociation.org www.ccus-setplan.eu

CONTACT DETAILS

Carbon Capture & Storage Association
Rue de la Science 14b
B-1040 Brussels
Belgium

CO_2 Value Europe AISBL
Avenue de Tervueren 188A
B-1150 Brussels
Belgium

Conclusions

Cross-border CO_2 infrastructure developed around industrial hubs and clusters will be at the basis for the large-scale industrial decarbonisation needed to achieve net-zero GHG emissions by 2050 and higher climate ambitions by 2030.

There is positive development to note in the growing number of CCS hubs and clusters which are planned around Europe. Norway, the United Kingdom and the Netherlands are at the forefront of the development; however, good progress can be noted also around other areas, mostly associated with projects that are seeking funding under the EU ETS Innovation Fund or benefit from the status of Projects of Common Interest.

It is important that cooperation with third-countries continues and is fully taken into account when developing legislation around CO_2 infrastructure and CCS in Europe. R&I activities, both on technical matters and non-technical priorities, will be needed to support the progress on CCS in industrial hubs and clusters. In addition, funding opportunities should be made available and be coherent with the goal of climate neutrality. Finally, it is critical to put in place an enabling policy framework both at the EU and at the national level to develop large-scale, cross-border CO_2 infrastructure.

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