Process for the 1st Union list of Projects of Common Interest (PCIs) and Projects of Mutual Interest (PMIs) under the revised TEN-E Regulation[1]

Description of the candidate projects in the thematic area of cross-border carbon dioxide transport and storage networks[2]

This document includes information regarding cross-border carbon dioxide (CO2) transport networks projects submitted between 17 October 2022 and 15 December 2022 in view of assessment and preparation of the first Union's List of Projects of Common Interest and Projects of Mutual Interest under the revised TEN-E, to be adopted in November 2023.

1. CO2TransPorts – applying for PCI status

Related website: CO2 reduction through storage under the North Sea - Porthos (porthosco2.nl)

Involved Member States: Belgium, the Netherlands.

Coordinating applicant: Port of Rotterdam.

The overall objective of CO2TransPorts is to establish the necessary infrastructure to facilitate the large-scale capture, transport and storage of CO2 from three of the most important ports of Europe and their hinterland. CO2TransPorts will provide an 'open access' CO2 transportation service for CO2 capture sites in the Port of Rotterdam, Antwerp and the North Sea Port partnership and the hinterland in Belgium. It will be developed and operated by capable and trusted parties, in close cooperation with the port authorities and supported by national governments.

The port of Rotterdam (as coordinating applicant), port of Antwerp and North Sea Port are cooperating together along with the two pipeline developers Fluxys (Belgium) and Gasunie (Netherlands) to explore potential synergies in the development of CCS in each of the three regions. The organizations are specifically focused on the development of a national and international CO2 transportation and storage infrastructure.

CO2TransPorts will be developed in two main phases, listed below (with an indicative timeline) with the potential for a third phase beyond 2030. Phases 1 will provide the initial local collection pipeline in the Rotterdam and Antwerp regions and Phase 2 will develop the cross-border CO2 transport pipeline infrastructure for up to a maximum of 5 million tonnes of CO2 annually (Mtpa) to the Netherlands from Belgium. This will be developed alongside shipping potential in the region, as being developed in other CCUS projects in the region. Existing studies indicate that extra capacity (both via pipeline and shipping) will be needed and this will also be investigated as part of a longer-term vision in 'Phase 3'.

[1] Regulation (EU) 2022/869

[2] Prepared based solely on the information received in the applications. The European Commission shall not be held responsible for any inconsistency. Any statements about the importance of the projects are views of the applicants, not the Commission.

- Phase 1 (up to 2026): This phase is focused on the development of local collection networks for CO2 transport at each of the ports. In Phase 1 Porthos will become operational which will require the development of an onshore pipeline through the port of Rotterdam, a compressor station, and an offshore pipeline to access the P18 gas fields for CO2 storage. FEED studies are now finalised and a final investment decision (FID) is expected in 2023. Based on a positive FID outcome, the Phase 1 Rotterdam infrastructure is expected to begin construction in 2023/2024 and become operational in 2025/2026. The local CO2 collection pipelines in Antwerp is also expected to be operational by 2025/2026 and are currently undergoing FEED.

- Phase 2 (2027+): This phase will focus on the development of the international pipeline connection between Belgium and the Netherlands, which will connect the local collection networks that were created in Phase 1 (in Rotterdam and Antwerp). Alongside this a Belgian backbone pipeline will start to be developed in Phase 2 which will provide an interconnection between industrial clusters in the south of Belgium towards Antwerp. The capacity for the international interconnecting pipeline is estimated at 5 Mtpa CO2 and the Belgian Backbone is still in the early stages of development.

  Alongside this, the Aramis project will also be progressed in parallel, developing a pipeline connection from Rotterdam to additional offshore storage capacity in the Dutch Continental Shelf. This extension of the offshore transport network is a pre-condition for developing the interconnecting pipeline between Antwerp and Rotterdam as more storage (beyond that provided by Porthos_ will be required to accommodate the extra 5 Mtpa CO2. Potentially, the North Sea Port (Ghent, Terneuzen and Vlissingen) will be connected to Rotterdam either via shipping by the Carbon Connect Delta project (through a separate candidate PCI) and/or via shipping to Northern Lights (trough a separate candidate PCI) and/or via pipeline connection to Antwerp and the interconnecting pipeline to Rotterdam by CO2TransPorts. The pipeline connection is dependent on the capacity needed for transport of CO2.

- Long-term vision (2030+) 'Phase 3': This phase focusses on creating more hinterland connections in Belgium to enable more emitters to connect to the CO2 transport and storage network. This hinterland connecting pipeline system will continue to be developed from 2030 onwards by Fluxys. The CO2TransPorts consortium has identified that under certain, reliable economic and regulatory conditions, the total CO2 transport demand from the three regions may exceed the maximum design capacity of the 5 Mtpa of CO2 expected in Phases 1 and 2. The results of an ongoing pre-feasibility study will be input for decisions on pipeline dimensioning, shipping and storage capacity within Phases 1 and 2. Realisation of Phase 3 is expected from 2030 onwards.

This timeline is based on the (operation of) pipeline infrastructure. During the current period 2021-2023 FEED studies have been conducted for Phase 1, feasibility studies have been conducted for Phase 2, and Phase 3 is currently in the pre-feasibility stage.

2. N-LiTES – applying for PMI status

Related website: Northern Lights designated a Project of Common Interest by the European Union - Northern Lights (norlights.com)

Involved Member States / third countries: Belgium, France, Germany, the Netherlands, Sweden // Norway, United Kingdom.

Coordinating applicant: Northern Lights JV.

The N-LiTES (Northern Lights European CO2 Transport EcoSystem, coordinated by Northern Lights Joint Venture) project aims to collect and transport anthropogenic CO2 from multiple sources (single or cluster industrial installations) for the purpose of permanent geological storage under the seabed in the Aurora license in Norway. To this end, the project supports the simultaneous maturation of EU capture initiatives, the CO2 export components and the N-LiTES transport and storage services in a full-chain approach, with a focus on the development of the needed CO2 transport infrastructure.

The N-LiTES project aims at contributing to the reduction of CO2 emissions in energy-intensive industries and hard-to-abate sectors and at deploying BECCS and DACCS technologies to help achieving negative emissions and reach the "Fit for 55" targets set by the EU. The planned connections to the involved emitters and emitting clusters pave the way for substantial expansion of CCS in North-West Europe. The project includes 16 promoters that represent a large part of energy intensive industries including cement, chemical production, energy, steel making, hydrogen production and refining. Many of these entities operate in multiple countries and may consider future investments on the CCS sector if they successfully transport their captured CO2 emissions within this project.

N-LiTES comprises the connection of CCS infrastructure among 5 EU member states (Belgium, Germnay, France, Sweden and the Netherlands), UK and Norway with an offshore storage site located in the Norwegian Continental Shelf.

The N-LiTES project includes and addresses the development of the main components of the CO2 handling and transport chain, which are CO2 loading terminals (CO2 collection, transmission pipeline networks as well as the sea export terminals, including liquefaction, intermediate storage), a CO2 receiving terminal, transport from the receiving terminal to the storage site via pipeline, and permanent storage of CO2 including surface and injection facilities associated with infrastructure within a geological formation offshore in Norway

The Northern Lights offshore infrastructure for **Phase 1 is currently under construction** and includes an 108km offshore pipeline from the CO2 receiving terminal to the geological storage site, a subsea facility controlling the subsea wells and providing power and signals back to the onshore control room, two subsea structures supporting the equipment to control and monitor the CO2 injection, an umbilical between the platform and the two subsea structures, a power cable between the platform and the two subsea structures to provide power to the subsea facility, and finally two injection wells for permanent injection of the liquid CO2 in the underground aquifer.

Sequential to Phase 1, **Phase 2 is currently undergoing FEED study** that corresponds to the expansion of the Phase 1 infrastructure to bring the total average abatement capacity from 1.5Mtpa CO2 in Phase 1 to a total of 5.2Mtpa CO2 in Phase 2. Indeed, the scope of the project is to transport anthropogenic CO2 captured in industrial facilities located in 5 Member States and 2 third countries to Øygarden receiving terminal in Norway for the subsequent permanent storage of CO2 offshore, in the Aurora formation. This PMI application includes 16 project promoters from: Belgium, France, Germany, The Netherlands, United Kingdom, Norway, and Sweden.

In January 2021, the construction of Phase 1 components at Øygarden started with the aim of reaching a storage capacity of up to 1.5 Mtpa CO2. Civil preparations works were completed in February 2022, and the site is ready for the next phase of the development in order to be ready for operations by 2024.

Phase 2 will expand the total capacity up to 5.2Mtpa CO2, with entry into operations planned early 2026. The concept study for Phase 2 expansion commenced in October 2020 and was completed in August 2021. FEED studies for all Phase 2 components started in May 2022 and the completion of the FEED study is expected by Q4 2022, and will allow for the beginning of Phase 2 works in Q1 2023.

The Phase 2 expansion is expected to accommodate captured volumes from an additional 4-8 emitters. It should be noted that the total annual capture potential of initiatives currently linked to N-LiTES PMI, which account for a total 35Mtpa CO2 of capture potential by 2030, already surpass the predicted capacity of Phase 2, and the volume of CO2 expected to be captured in the next years in the whole Europe is tremendous. Consequently, a further expansion beyond Phase 2 capacity (Phase 3) is already under consideration.

3. ARAMIS – applying for PCI status

Related website: Aramis CCS | Homepage (aramis-ccs.com)

Involved Member States: Belgium, France, Germany, the Netherlands.

Coordinating applicant: Aramis CCS C.V.

The Aramis project - an open access cross-border CO2 transport and storage project (intake from emitters in the hinterland of Rotterdam harbour area and storage to location on the Dutch continental shelf) – is a public&private partnership between Shell Gas & Power Developments, TotalEnergies SE, EBN capital and Nederlandse Gasunie.

The main focus of the Aramis project is the construction of CO2 transport infrastructure, consisting of a trunkline system (~230 km) which is connected to a shipping terminal and compression facilities. The Aramis project envisages a new high-capacity trunkline (22 Mtpa) to transport CO2 from the Port of Rotterdam to the geological storage sites that are located on the Dutch Continental Shelf (mainly located in the offshore K&L license blocks).

A phase I development is expected to be in the order of 5 Mtpa. Most likely anchor customers for Phase I come from North Sea Port and Rotterdam area and are targeting Dutch National SDE++ applications (done in August 2022). For future development phases it is expected that liquified CO2 will be shipped from Belgium (Antwerp, Ghent, river Maas), France (Le Havre, Dunkirk, Saint Nazaire) and Germany (river Rhine). Additional compressed CO2 can be delivered from new infrastructure connecting Rotterdam with Belgium and Germany. The overall Aramis Project development is expected to transport and store 22 Mtpa of CO2 and might be expanded in the future.

To realize a successful full CO2 chain from CO2 capture to CO2 storage, for the Aramis project this means:

- Closer collaboration with the CO2next project that will construct a new, expandable shipping terminal: liquid phase CO2 will be transported by ship (coaster or barge) or truck (considered) from different industrial clusters to a centrally located receiving terminal containing tanks for buffer storage of CO2 and a high-pressure pumping station. At least 2 out of the planned 5 Mtpa in the Aramis launching phase will be transported via the CO2next terminal. The main aim for the Aramis and CO2next cooperation is to optimise the activities and infrastructure needed for an efficient and sustainable carbon capture storage framework.

- Collaboration with the Porthos project (part of PCI 12.3 under the 5th PCI List) for the construction of additional compression facilities, thereby further optimizing the existing Porthos project: gas phase CO2, transported via the onshore Porthos project pipeline coming from emitters in Rotterdam and its hinterland, will be further compressed and combined with the above-mentioned liquid CO2. It is planned that 3 Mtpa will be transported to the Port of Rotterdam via the onshore Porthos project pipeline. The Aramis project will strongly leverage the infrastructure of the Porthos project.

- Collaboration with the L10 CCS Project where 2.5 Mtpa CO2 will be transported via the Aramis pipeline to the L10 facilities that comprise a spur-line for further transportation of CO2 and the L10 injection facilities. The latter consists of a platform hub and a satellite where the CO2 is injected into the L10 reservoir complex for permanent and safe storage.

- Establishment of an offshore CO2 injection network: once the CO2 reaches the offshore platforms it will be injected through wells that connect to geological stores located at 3 to 4 km depth below the seabed. The system can be expanded by connecting platforms from different storage operators through a network of pipelines (new build and re-use of existing gas pipelines and assets are being investigated) to cater for the expected increase in demand for geological storage.

The project is currently in the (pre-) Front-End Engineering Design (FEED) phase after completion of the concept select phase and preliminary feasibility studies in which key design considerations per project component have been explored.

The construction phases is scheduled to start in 2025 for phase I. The end date of the construction for phase I is foreseen in 2027.

4. NAUTILUS – applying for PMI status

Related website: not provided.

Involved Member States / third countries: France, Germany / Norway.

Coordinating applicant: Air Liquide France Industrie.

The Nautilus project aims to collect, transport and permanently store anthropogenic CO2 in the North Sea. The project brings together actors along the full Carbon Capture and Storage (CCS) value chain. CO2 is collected from various industrial emitters in 3 clusters:

- Le Havre in France: also named ECO2Normandy (part of the "Northern Lights" PCI in the 5th list).
    - It aims at contributing to the decarbonation of the Seine basin industry cluster, 3rd biggest French industrial CO2 emitter. This objective will be achieved by implementing capture facilities in the promoters' plants (out of the scope of this candidate PMI), then transporting the CO2 to a shipping terminal in Le Havre, where it will be conditioned (liquefied) and loaded on ships that will carry it to storage infrastructure, located in the North Sea.
    - In total, it is expected to capture about 3 Mtpa of CO2 from 2036. The project will be developed in a staged approach: ● Phase 1 (expected in 2028): ~1.2 Mtpa CO2 collected ● Phase 2 (2031): ~1.2 Mtpa CO2 added ● Phase 3 (2036): additional 0.65 Mtpa CO2.

- Dunkirk in France: also named D'Artagnan (a standalone PCI in the 5th list)
    - It aims at implementing open access CO2 primary infrastructures. CO2 will be collected from various emitters' sites in the Dunkirk harbour (France) and its hinterland, liquefied, and collected in intermediate storages prior to its export by ship to permanent storage locations in the North Sea. An export by pipeline towards import terminals/ storages in the North Sea area could also be developed in later phases of the project. The CO2 liquefaction, storage and ship loading facilities will be located in Dunkirk's harbour. The emitter sites in the Dunkirk area will have dedicated capture units.
    - In total, it is expected to capture about 3 Mtpa of CO2 by the end 2027, 4.4 Mtpa of CO2 by 2031, and further expand later on.

- Duisburg in Germany: also named C Zero (new hub in development).
    - This Hub collects CO2 from industrial emitters in the region and transports it up the Rhine to the CO2 projects in Rotterdam, including CO2next. From there, the CO2 is transported by ship to sinks in the North Sea.
    - The project will be developed in 3 phases:
        - Phase 1: up to 1.2 Mtpa of CO2 transported. Dominant method of transportation to the hub: truck, train and barge. Dominant method of transportation to Rotterdam: barge

- Phase 2: up to 2.4 Mtpa of CO2 transported. Dominant method of transportation to the hub: truck, train, barge and local pipelines. Dominant method of transportation to Rotterdam: barge
- Anticipated later phases of development: >3 Mtpa of CO2 transported. Dominant method of transportation to the hub: truck, train, barge and pipeline. Dominant method of transportation to Rotterdam or Wilhelmshaven: large pipeline and barges.

- Storage: the CO2 is collected from these 3 clusters and stored in a variety of sinks in the North Sea. The permanent storage of CO2 developed off the south west Norwegian coast by Horisont Energi (HE) and Neptune Energy (NE) is included in the scope of this candidate project.
    - Nautilus includes several storage locations: (i) a storage complex in Norway of an aquifer type (export from the onshore terminal to the offshore storage will be through a pipeline); (ii) a storage in a saline aquifer offshore in Norway (iii) a mineral storage terminal in Iceland; (iv) an onshore carbon storage in Danish subsoil and a depleted gas field and saline aquifer, both in Denmark.

The Nautilus project applies for PMI status under the coordination of Air Liquide France Industrie. The PMI includes 14 project promoters from France, Germany and Norway. In addition the project includes affiliated organisations from: France, Germany, The Netherlands, Iceland and Denmark.

The expected construction timeline differs depending on the infrastructure component. In France, the construction is planned to begin in early 2025, after the Final Investment Decision, and to last until the end 2027. In Germany, detailed engineering, procurement and construction are projected to last from Q1 2025 to end 2027. Placing the order for the CO2 Storage is the critical path for the schedule and overall schedule for total Engineering Purchasing and Construction (EPC) phase is around 30 months.

Regarding the CO2 storage, construction is planned to begin in Q1 2024, after the Final Investment Decision, and to last until Q2 2026.

5. EU2NSEA – applying for PCI status

Related website: not provided

Involved Member States / third countries: Belgium, Denmark, France, Germany, Latvia, the Netherlands, Poland, Sweden / Switzerland, Norway.

Coordinating applicant: Equinor.

The EU2NSEA (EU to North Sea) project [*CO2 transport & storage infrastructure for large-scale decarbonization of North-West Europe*] is designed to enable the transport and storage of anthropogenic and biogenic CO2 from North-West Europe to the North Sea, to provide resilience and security of CO2 transport, whilst enabling significant cost reductions and expediting

deployment of CO2 capture, transport and storage networks at European scale. The Norwegian energy company Equinor (as coordinator for the application for the PCI status), the Belgian energy infrastructure operator Fluxys and German energy company Wintershall Dea, together with a dedicated group of affiliated companies joined forces in combinedly developing a project to establish a major cross-border CO2 network infrastructure called the EU2NSEA project.

The scope of the EU2NSEA project includes open infrastructural components along the entire CO2 capture, transport and storage chain:

1. Capture at industrial emission sites in 8 EU member states (Belgium, Denmark, France, Germany, Latvia, The Netherlands, Poland, Sweden), with fixed facilities to make the CO2 ready for its further transportation.
2. CO2 collection networks and hubs in 5 EU member states and 1 third country (BE, DK, FR, GE, NL and CH), linking industrial emission sites to 2 central CO2 transhipment hubs/conditioning export terminals; including inland pipelines interconnecting industrial CO2 emission clusters to the CO2 collection hubs, and facilities for receiving liquid CO2 by ship, barge or train, and further pre-conditioning, compression, and liquefaction equipment for cross-border transport.
3. CO2 transhipment hubs/conditioning export terminals in Zeebrugge (BE) and Wilhelmshaven (GE) for collection, receiving, preconditioning, compression, and liquefaction equipment of CO2 for further cross-border transport.
4. Dedicated high-pressure CO2 transport pipeline infrastructure from export terminals in Zeebrugge (BE) and Wilhelmshaven (GE) to storage sites in the North Sea (NO).
5. Storage sites in the North Sea (NO) for the permanent safe geological storage of CO2, comprising sub-sea infrastructure and infrastructure within the geological formation

This cross-border transport pipeline network solution will carry CO2 captured from emitters and CO2 collection hubs located in North-West Europe to permanent geological storage complexes more than 1500 meters below the seabed in the North Sea.

The project consists in first set-up of two central CO2 collection hubs in Belgium (Zeebrugge) and in Germany (Wilhelmshaven), which will act as the central CO2 collection and transhipment hubs. Onshore pipelines, along with other transport modes such as rail and ship, will carry the CO2 from emitters in Belgium, France, Germany, Latvia, Netherlands, Poland, Sweden, Switzerland, from CO2 collection hubs in France (Dunkirk), Netherlands (Eemshaven), Germany (Rostock), Denmark (Copenhagen) and affiliated sites to the two central transhipment hubs. Two dedicated pipelines (spur lines) will be connecting the two central export terminals to the main trunkline crossing the North Sea basin, arriving to the Smeaheia and Luna storage sites in Norway for injection in the subsurface geological reservoirs.

The setup of the project will allow for flexible future expansions with additional CO2 sources, increasing the handling capacity of the CO2 collection hubs or connecting additional CO2 collection hubs and other CO2 storage sites, supporting emitters in the whole of North-West Europe to decarbonise their processes on a large scale before the end of this decade.

One of the infrastructure items to be build includes a ~700 km CO2 transport network that aims to collect CO2 emitted in the Southern part of Germany for phase 1 linking to the German Carbon

Transport Grid candidate project. Expansion and connection with neighbouring countries (a.o. Belgium) is considered for phase 2.

The project location, the North Sea Basin, is proven to be highly suitable for storing CO2. Moreover, a significant part of the European CO2 emissions is generated by emitters located on the coasts of this basin. Nonetheless, the geographical reach of the project is much larger, as CO2 can be shipped in from neighbouring hubs, or transported from inland continental emission locations via pipeline, truck, rail, barge or ship and connected to the CO2 collection hubs. This will offer emitters in the whole North-West Europe and the Baltics a robust and flexible solution for large-scale decarbonisation before the end of this decade.

The pipeline network solution aims to provide resilience and security of CO2 transport by having a dedicated, high-capacity pipeline infrastructure (20-40 Mtpa CO2) in place that can operate with high regularity. This solution provides much needed essential evacuation capacity of CO2 from industrial emitters in North-West Europe and is planned to be operational from 2029. It is estimated that up to 612 million tonnes of CO2 will be transported and stored over 21 years during of operations. The two initial geological storage sites will have capacity of 25 Mtpa CO2 in full operation.

As stated by the applicant, the emission reductions associated with this project would directly contribute towards the national targets in 8 EU Member States, 1 third country and to EU wide targets.

6. NORNE – applying for PCI status

Related website: not provided

Involved Member States / third countries: Belgium, Denmark, Sweden / United Kingdom.

Coordinating applicant: Capio Danmark.

Project Norne is a cross-border CO2 transportation and storage spoke and hubs network, which includes infrastructure items related to all categories listed in EU 869/2022. The scope and ownership under Project Norne will include infrastructure downstream of carbon capture/purification units including, but not limited to, CO2 compression facilities, dedicated pipelines, liquefied CO2 (“LCO2”) ship receiving facilities, LCO2 storage facilities, and CO2 injection and monitoring wells.

Project Norne seeks to build an anthropogenic CO2 transportation and storage network using CO2 pipeline infrastructure that enables LCO2 ships to transport third-party CO2 from emitters in Europe to onshore geologic formations in Denmark for permanent storage. The initial project scope is expected to cover different Member States Denmark, Sweden, and Belgium and – as a “third country” – the United Kingdom, but the project can benefit any country with the capability of exporting LCO2 by ship.

A third-party CO2 network with onshore storage facilities creates a cost-effective decarbonization solution by spreading high capital costs across many emitters reducing storage costs. This project provides an opportunity for hard-to-abate industries to avoid carbon tax penalties, achieve emissions reductions, and continue operations. This cost-effective solution abates CO2 emissions while maintaining security of supply by reducing the risk of discontinued operations and the movement of industries to regions less expensive to operate in due to carbon costs.

Project Norne will implement proven technologies and standards of best practices that minimize energy intensity and maximize future expansion opportunity. As the first project of its kind in the region, future projects and extensions can be built upon the Project's principles, ensuring the development of a resilient and secure transportation and storage network.

The initial scope of Project Norne will include the development of two separate storage facilities: Project Fyrkat and Project Trelleborg. Project Fyrkat includes a storage facility at the Gassum Structure located in Northern Jutland, its associated pipeline infrastructure, and an LCO2 reception facility at the Port of Aalborg. Project Trelleborg includes a storage facility at the Havnsø Structure located in Western Zealand, its associated pipeline infrastructure, and an LCO2 reception facility at the Port of Kalundborg. Both structures are confined geologic structures within the Gassum Formation.

The Havnsø Structure is located close to the Stenlille Structure, where a pilot CCS project is being developed; the proximity of the two projects creates the potential opportunity to develop shared transportation and storage infrastructure together and flex between storage locations for downtime mitigation and CO2 surge capacity. One of the proposed future expansions of Project Norne will include a union of these separate networks to optimize the usage rates of storage structures.

No existing infrastructure will be used for this project as Capio Danmark, the coordinating applicant, will construct purpose-built, CO2-dedicated infrastructure for transportation and injection.

The planned infrastructure, which is subject to change from commercial commitments under the scope of Project Norne, includes:

1. LCO2 reception facilities located at the Port of Aalborg and the Port of Kalundborg, each with an initial capacity of 4 Mtpa, with a planned expansion at the Port of Kalundborg for Project Trelleborg for an additional 4 Mtpa CO2 bringing the aggregate reception facility capacity of Project Norne to a total of 12 Mtpa CO2 capacity by 2030. Commercial negotiations regarding additional volumes from emitters may drive a need to expand the reception facility at the Port of Aalborg to 8 Mtpa CO2. This expansion will be incorporated into Project Norne upon the successful completion of those negotiations.
2. Intermediary storage in the form of horizontal storage bullets at the reception facilities.
3. High-pressure compression equipment at the reception facilities and pipeline tie-ins where the CO2 stream requires additional compression to enter the pipeline.
4. An 80 km trunkline with 508 mm nominal diameter from the Port of Aalborg to the Gassum Structure with local emitter tie-ins along the route.

5. A 20 km trunkline with 406 mm nominal diameter from the Port of Kalundborg to the Havnsø Structure with local emitter tie-ins along the route.

Project Norne plans to provide a currently planned 12 Mpta of LCO2 reception capacity and 10 Mtpa transportation capacity per trunkline via to injection wells with an estimated 0.75 to 1 Mtpa injection rate per well, drilling new wells as necessary for scale.

Project Norne's initial scope will store 2.3 Mtpa by 2026 and 18.7 Mtpa by 2030 based on dialogue with current emitters.

7. DELTA RHYNE CORRIDOR – applying to PCI status

Related website: Delta corridor links industry with clean H2 and offshore CCS solutions | Shell Netherlands

Involved Member States: Germany, the Netherlands (potentially Belgium).

Coordinating applicant: Shell New Energies NL.

The Delta Rhine Corridor project aims to develop a bundle of underground pipelines for underground transport of sustainable energy carriers and CO2 between Rotterdam, Moerdijk, Venlo Chemelot and Cologne/Wesseling, Duisburg and Gelsenkirchen in North Rhine-Westphalia and Ludwigshafen in Rhineland-Palatinate. Furthermore, there is the opportunity to establish a connection between Moerdijk and Antwerp in Flanders. The initiative for the Delta Rhine Corridor project lies within the private sector, its application to the PCI status is coordinated by Shell New Energies. Business cases are being developed for each specific pipeline (CO2, H2, and potentially NH3) and an overall business case to capture the synergy and benefits of constructing multiple pipelines at once.

The integration of hydrogen and carbon capture and storages technologies within common value chains can contribute to the effective decarbonization of the energy system and hard-to-abate sectors where electrification may not be technically possible or cost effective. Hence, the combined H2-CCS chain is a strategic value chain in the process towards a low carbon and increasingly integrated energy system. The Delta Rhine Corridor is the first pipeline that strives towards successfully creating integrated chains at relevant industrial clusters. This project, Delta Rhine Corridor_CO2 addresses the development of the CO2 pipeline, whereas the development of the H2 pipeline is covered in a PCI application named Delta Rhine Corridor_H2 submitted to ENTSOG.

Specific needs for the proposed cross border CO2 transport network:

- The proposed CO2 transport network together with transport of clean hydrogen in the opposite direction is key to improve the resilience, the energy independence, diversity and security of supply of hinterland industry clusters.
- The hinterland industry clusters, specifically Chemelot and the German Rhineland, Ruhr and Rhineland-Palatinate regions, do not have access to offshore CO2 storage sites via

seaport facilities such as those currently being developed in Rotterdam as part of the Aramis (and Porthos).

- Connection to CO2 storage facilities offers inland industries an opportunity aiming to achieve the climate targets through CCS and EU economic growth and competitiveness.
- Transport of CO2 per barge or train is not a viable alternative considering the expected large volumes. There is insufficient rail freight capacity and inland waterway transport may encounter seasonal limitations (Rhine low water level). Pipeline transport offers a safe, efficient, secure and reliable way of transport.

The total volume of CO2 transported through the main Delta Rhine Corridor pipeline is equal to 14.9 Mtpa of CO2, half of which would stem from Germany. The transported CO2 is aimed to be stored within depleted gas field in the North Sea. The storage of CO2 is outside scope of this candidate PCI.

The Delta Rhine Corridor project is currently in the feasibility stage. In 2023 the project will start the pre-FEED stage, where the MER/permit applications will be done. In 2024, the final design of the project will be made and Delta Rhine Corridor will be waiting for the approval of the permit applications. After this, FID is expected to be taken in Q4 2024. In Q1 2025 the construction of the pipelines will start and will be completed in Q1 2027. After commissioning the pipelines are ready for operation in Q4 2027.

8. GERMAN CARBON TRANSPORT GRID – applying for PMI status

Related website: CO_2-Netz | CO2 Netz (co2-netz.de)

Involved Member States / third countries: Belgium, Germany, the Netherlands / Switzerland, Norway.

Coordinating applicant: Open Grid Europe.

The proposed project, coordinated by Open Grid Europe (OGE), aims at providing the necessary infrastructure for the energy transitions by implementing a CO2 grid in Germany which will be connected to the planned networks in Switzerland, Belgium, the Netherland, and thereby to the offshore permanent storage facility Smeaheia of Equinor and Luna of Wintershall Dea beneath the seabed on the Norwegian continental shelf.

The main result of the proposed project is the implementation of the CO2 pipeline starting in Wilhelmshaven, Germany, to connect industrial CO2 emitters in Germany with the hub and other export options in Wilhelmshaven. The construction and implementation of the hub is propounded in a separate proposal WH2V (eNG Hub phase 1).

The project German Carbon Transport Grid is embedded in a Global Project which contains next to the pipeline also the project W2V (eNG Hub phase 1). Additionally, the proposed project is connected to a number of CO2 pipeline projects across Europe:

1. To an offshore pipeline project connecting Wilhelmshaven, Germany, with a permanent storage facility beneath the seabed on the Norwegian continental shelf, called Smeaheia;
2. To an onshore pipeline project in Belgium which collects CO2 from industries across Belgium and transfers it to Zeebrugge, Belgium and connects with an offshore pipeline project connecting Zeebrugge with permanent storage facilities in Norway, and
3. Delta Rhine Corridor, connecting CO2 source with the Port of Rotterdam to import hydrogen and export CO2.

The implementation status is: completed feasibility and a pre-FID phase. The Front-End Engineering-Design is currently executed leading to the FID at the end 2023 – beginning 2024. The start of operations is indicated by the handover of the pipeline to the operator, which will take place in 2028. After the implementation of the final development stage, the pipeline will transport 25.8 Mtpa of CO2.

9. WH2V (eNG Hub phase 1) – applying for PMI

Related website: TES Hydrogen for life — Wilhelmshaven Green Energy Hub (tes-h2.com)

Involved Member States / third countries: Belgium, Germany, the Netherlands / Switzerland, United States of America.

Coordinating applicant: Tree Energy Solutions.

The proposed project 'WH2V' is embedded in a Global Project which contains next to the energy hub developed by Tree Energy Solutions (TES) and also the CO2 pipeline proposal 'German Carbon Transport Grid' developed by Open Grid Europe (OGE) and TES. EU climate neutrality objectives create the core motivation for the implementation of the energy hub in Wilhelmshaven which, in its final development stage, fulfils a number of services to support the German and European energy transition:

(1) unavoidable CO2 emission will be transported via the hub to sunbelt countries to be transformed to synthetic methane (syn. methane or CH4) by joining the CO2 with green hydrogen,
(2) the reimported syn. methane will be used to provided energy to businesses across Europe, either as green electricity (with CCU), as green hydrogen (CO2 being only the carrier medium), or as green syn. methane if so needed.

The proposed project 'WH2V' provides the necessary export facilities for CO2 to areas for which an offshore pipeline is not a feasible solution, as Iceland or USA for instance, and by its direct connection to CO2 sources in Germany, Switzerland, Belgium and the Netherlands. The sources in each country are connected to the project via the pipeline proposal 'German Carbon Transport Grid'.

Furthermore, the captured CO2 can also be used as a carrier to reimport green hydrogen which will further promote the European energy transition towards climate neutrality in 2050.

Additionally, the CO2 can also be used as a storage medium for hydrogen ensuring energy security.

The involved third countries, being Switzerland and the United States of America, which are connected to the proposed project either via the connected pipeline proposal 'German Carbon Transport Grid' or via a maritime link from Wilhelmshaven to Texas, USA. Texas being part of the Sunbelt is one of the areas where green hydrogen will be produced for setting the carbon cycle in motion. Further sunbelt countries are taken into consideration as the United Arab Emirates for instance. Switzerland is involved as one region providing CO2 sources to be delivered via the pipeline to Wilhelmshaven where the CO2 is then either shipped off to sequestration facilities in Norway, Denmark, United Kingdom, USA or Iceland, or enters the carbon loop to become a carrier medium for importing green hydrogen. Additional sequestration facilities to permanently store the CO2 might be taken into consideration. Due to using maritime transport, a great flexibility in destination is available. The proposed project will not hamper the local energy transition in each involved third country.

The involved third countries, Switzerland and the United States, have a high level of convergence of their individual policy frameworks to the European Union, thereby supporting the Union policy objectives.

The proposed project aims at providing the German and thereby also the European energy market with green hydrogen. To achieve that, an innovative approach was developed. In connection to the proposed project 'German Carbon Transport Grid', captured CO2 arrives at the energy hub in Wilhelmshaven, loaded onto multi-gas carriers, exported to solar belt countries with an abundance of renewable energy sources (e.g., solar power in Texas, USA), transformed into syn. methane using green hydrogen, and finally reimported to Wilhelmshaven. The key here is that the hydrogen is thereby safe for transport using a well-known transportation technology of liquefied gas.

Additionally, the German Carbon Transport Grid is connected to a number of CO2 pipeline projects across Europe: (1) to an offshore pipeline project connecting Zeebrugge, Belgium with a permanent storage facility under the seabed on the Norwegian continental shelf; (2) to an onshore pipeline project in Belgium which collects CO2 from industries across Belgium and transfers it to Zeebrugge; and (3) Delta Rhine Corridor connecting CO2 sources with the port of Rotterdam to import hydrogen and export CO2.

The proposed energy hub will lead to 10 million tons of CO2 to be permanently stored each year and 10 million tons of CO2 available for the closed CO2 loop. The storage facilities in Norway, Denmark, United Kingdom, USA or Iceland are not part of the proposed project.

The proposed project is currently in a Front-End-Engineering-Design phase. The expected start date for the construction of the terminals as applied for is 02.2023. The construction phase shall be completed in 2029.

10. NOORDKAAP – applying for PMI status

Related website: not provided.

Involved Member States / third countries: the Netherlands / Norway (Stage 1). Belgium, France, Germany, Sweden (Stage 2).

Coordinating applicant: Cape Omega AS.

The NoordKaap project will establish cost-effective, scalable infrastructure to facilitate large-scale terminaling, transport and storage of CO2. NoordKaap will connect emitter clusters and single emitters along the North Sea coast to cross-border storage locations, accelerating decarbonization of industrial activities through Carbon Capture and Storage (CCS). Its application for the PMI status is coordinated by CapeOmega.

The NoordKaap Stage 1 project involves the Netherlands and Norway, with Stage 2 expansion to additional countries accessing multiple industrial clusters (the Netherlands, Belgium, Germany, Sweden).

The NoordKaap project complements already existing projects by deploying CO2 ship transport technology offering ambient Direct Offshore Injection (DOI) at storage locations as the most cost-effective, fastest, and logistically most efficient CCS transport & storage solution. NoordKaap will develop and provide open access, multi-client CO2 terminal facilities accommodating liquefaction, transport with loading/unloading services for transport to multi-client storage sites.

The overall objective of NoordKaap is to establish cost-effective, scalable infrastructure facilitating large-scale, flexible CO2 transport and storage from multiple industrial emitters' clusters. The NoordKaap project will deliver:

- Low-cost solutions for emitters not directly adjacent to pipeline infrastructure, enabling them to accelerate decarbonization of industrial activities through CCS;
- Deployment of CO2 ship transport technology that offers ambient DOI at storage locations as the most cost-effective, fastest, and logistically most efficient CCS solution;
- Flexible ambient CO2 offloading options allowing for both DOI as well as offloading at terminal hubs (e.g., Northern Lights, CO2next), providing additional flexibility and redundancy of storage capacity creating a robust and resilient framework for emitters and actors in the CCS value chain;
- Open-access, multi-client CO2 terminal facilities accommodating liquefaction, buffer storage and transport with loading/unloading services.

The NoordKaap project offers CCS solutions to industrial clusters where ship transport is the primary, or earliest, export mode: this is the case for the Eemshaven/Delfzijl industrial area, the Netherlands, which has a CO2 footprint up to 15 Mtpa CO2; for some industrial clusters in Belgium and the north of France, with more than 20 Mtpa CO2 combined; as well as for the Wilhelmshaven area in Germany, emitting approximately 8-15 Mtpa CO2. Whereas the NoordKaap project targets CO2 offloading directly at offshore injection sites, the ship transport can also be directed to offload at CO2 terminals, such as Northern Lights, Norway, and the planned project CO2next in Rotterdam, Netherlands.

The NoordKaap project comprises 2 Stages of development:

Stage 1 (from 2028+) – Establishing cross-border CO2 transport and storage from Eemshaven port

- Connects the industrial cluster in Eemshaven/Delfzijl, Netherlands, to offshore storage locations in the Dutch and Norwegian continental shelf. During Stage 1, up to 12 Mtpa CO2 from Eemshaven/Delfzijl emitters, including up to 8 Mtpa CO2 from biomass combustion, will be captured and transported for storage with DOI on the Dutch and Norwegian continental shelf in Neptune and CapeOmega license areas. The start of CCS operations and subsequent ramp-up will be sourced by RWE's 8 Mtpa CO2 feed, following which other emitters in the Eemshaven/Delfzijl industrial cluster will be connected to the terminal facilities in the Groningen Seaports for CO2 sequestration.

Stage 2 (from 2030+) – Extending offshore storage solutions to multiple clusters:

- Expands the transport routing to industrial clusters in Antwerp, North Sea Port, Wilhelmshaven, Dunkirk, Le Havre, and the Stockholm/Gotland region and unlocks further offshore storage sites not connected to pipeline infrastructure. Stage 2 development will direct CO2 ship transport to offshore storage locations of CO2 in the Dutch and Norwegian offshore, or, alternatively, to terminal sites for offloading in buffer storage and onward transport through pipeline.

11. BIFROST – applying for PCI

Related website: Bifrost | EUDP

Involved Member States: Denmark, Germany, Poland, Sweden.

Coordinating applicant: TotalEnergies SE.

Project Bifrost is a cross-border CO2 transport and storage project aiming to develop open access infrastructure to connect European industrial hubs to offshore underground storage in the Danish North Sea.

The candidate project, which application to the PCI status is coordinated by TotalEnergies, aims at transporting hard-to-abate CO2 collected from industrial emitters and permanently storing up to 260 million metric tons of CO2 over 25 years of operations. It is estimated that 10-15% of this capacity may initially be counted as negative emissions, with anticipated growth as a greater percentage of industries increase their use of biogenic fuel sources. As stated by the applicant, with storage operations start-up scheduled in 2029-2030, the project aims to make a major contribution towards the EU target of climate neutrality towards 2050.

Project Bifrost will leverage the substantial geological storage potential in the Danish North Sea by using storage capacity of both depleted oil & gas fields and saline aquifer structures. Analysis of the Danish subsoil by GEUS2 estimated this capacity to be in the range of 12-22 billion tonnes, the majority identified as being in saline aquifer structures, but also in existing depleted oil and gas reservoirs. The project intends to repurpose existing oil and gas infrastructure where possible, such as offshore facilities (e.g. platforms, interconnections) and the offshore gas transportation

system. The retrofitting of existing infrastructure is a sustainable design element from both a financial and ecological perspective and a key value point of this project. Newly built infrastructure will be developed where infrastructure does not exist yet, as well where existing infrastructure cannot be converted for safety and technical reasons or is in use for other purposes such as gas or hydrogen transport.

Project Bifrost will utilise a combination of new-built and existing infrastructure to transport CO2 from key emitters clusters primarily located in Denmark, Germany, Poland and Sweden to offshore underground storage located in the Danish North Sea.

It will be developed in two phases:

- Phase 1 focuses on the development of 2-3 Mtpa CO2 of transportation and storage capacity from 2029-2030. This phase will rely on the delivery of CO2 from emitters' sites located in Denmark, Poland and/or Sweden, to the storage sites via ships. CO2 will be offloaded either directly offshore to the Harald platform using a floating storage and injection unit that provides intermediate storage, conditioning and injection facilities, or via an onshore terminal including marine and buffer storage facilities from where the CO2 will then be transported to the Harald platform via an offshore pipeline.
- Phase 2 focuses on the expansion of the system to add up to 10 Mtpa CO2 of transportation and storage capacities from 2030-2032 by developing a national and cross-border pipeline network to connect main industrial clusters in Denmark and Germany on the main Leipzig/Hamburg backbone route to additional storage capacities offshore Denmark.

The status of the project and collected interest from market enquiries indicate that a project of a size of 10 to 15 Mtpa CO2 is a feasible market size. This open-access infrastructure will be developed with continual market consultation to ensure that the ultimate capacity of the network corresponds to the demand, including as well potential expansion for marine transport. This taking into consideration both CO2 transported for permanent storage and CO2 transported for utilisation projects.

12. ECO2CEE – applying to PCI status

Related website: not provided.

Involved Member States: Lithuania, Poland.

Coordinating applicant: Air Liquide Polska.

ECO2CEE (its predecessor listed under the name "Poland - EU CCS Interconnector" in the 5th PCI list as PCI 12.91) is a project of an open access multi-modal liquid CO2 (LCO2) import - export terminal in the Polish Gdańsk Hub as well as related CO2 transport infrastructure from the facilities of Polish and Lithuanian emitters to European CO2 transport and storage network in the basin of the North Sea (and the Baltic Sea basin in the future) with a use of transport via roads, railways, pipelines and ships (in the future, also possible by river with inland barges). It application to the PCI status is coordinated by Air Liquide.

ECO2CEE has an ambition to establish an open access multi-modal CO2 import - export terminal ('CO2 Hub') in the Polish Gdańsk Hub with related CO2 transport infrastructure as well as linking the biggest Lithuanian emitters to the planned multi-modal export terminal in the Lithuanian port of Klaipeda. The Project will create a common area on the Southern Baltic coast from which CO2 can be shipped to storage sites in the North Sea basin and the Baltic Sea basin in the future. The Project will rely on 4 key promoters as well as several affiliated. The project objective is to connect the main industrial CO2 emitters in Poland and Lithuania to the CCS chain (under development in the North Sea) for permanent storage.

The infrastructures establishment on both ends of the CCS chain: in Poland and Lithuania, close to CO2 emitters and in the permanent storage location of the North Sea basin consecutively are essential to establish an effective and efficient cross border CCS network and value chain with an European stamp.

Thus, developing capacities on both ends of the CCS value chain will benefit all actors along the value chain, by reducing costs through the economy of scale and through the improvement of the reliability and the robustness of the European CCS value chain as a whole, enabling Polish and Lithuanian industries and sectors experiencing difficulties to abate CO2, to access the North Sea CCS network through liquid CO2 shipping and a world class CO2 export infrastructure.

The strategic objective of the project is to build infrustructure in Poland and Lithuania which will enable connecting large Polish and Lithuanian CO2 emitters with the CCS hub emerging in the North-Sea basin. This inter-regional CCS initiative will be a step towards reaching the climate targets of Poland and Lithuania with use of emerging measures of carbon storage in the North Sea basin.

As a part of ECO2CEE project following infrastructure is planned to be constructed:

1. a multi-modal Liquid CO2 import-export Terminal in Poland,
2. pipeline to transport CO2 from the industrial plants located in the vicinity of the planned CO2 Hub in Poland,
3. primary export infrastructures to provide industries located in the hinterland of Poland access to the Terminal in Poland via railcars shuttle, trucks, inland waterways, or pipeline,
4. primary infrastructure to provide Lithuanian CO2 emitters access to the planned terminal in the Lithuanian Klaipeda harbour via autotrucks, railcars shuttle, or in the future, pipeline.

The project is scheduled to transport 2.5Mtpa CO2 between 2027-2030 period reaching 8.7 million tonnes of CO2 between 2031-2032 period and up to 9 million tonnes of CO2 from 2033 leading to a significant impact in global warming prevention. 8.7 million tonnes of CO2 will come from Poland and around 350 kt of CO2 will come from Lithuania.

13. CCS BALTIC CONSTIUM – applying for PCI status

Related website: not provided

Involved Member States: Latvia, Lithuania

Coordinating applicant: Klaipėdos Nafta AB.

The main objective of the CCS Baltic Consortium project is to develop a comprehensive CCS value chain in the Baltic region and achieve substantial GHG emission reductions in the connected industrial installations operating in the hard-to-abate sector. The project applies for the PCI status under the coordination of Klaipėdos Nafta AB.

The Project will develop the first cross-border CO2 infrastructure in Lithuania and Latvia, accessible also by entities operating in neighbouring countries, thus filling a missing coverage of the common EU-wide CO2 network. Project promoters cover specific parts of the CCS value chain in order to create a robust, effective and sustainable infrastructure.

The CCS Baltic Consortium project addresses the existing need to develop a complex CCS infrastructure in Baltics, which is scalable, offering sufficient storage capacities, offering the possibility of using multiple modes of transport, and contributing to the resilience and security of transport and storage of CO2.

The multimodal terminal's currently projected maximum handling capacity is 4Mtpa of CO2. Around 62,5% of this capacity can be utilised by biggest potential emitters from the region.

The developed CCS infrastructure will provide sufficient storage capacities to accommodate emissions of connected cement plants. The expected storage capacity potential of the terminal in Klaipėda significantly exceeds (more than six times) the capacity requirements of cement plants, therefore being able to absorb the increased storage demand in case additional emitters decide to join the network. For sequestration, several permanent storage sites in the North Sea and Baltic Sea are being considered. The final location will be selected before the start of value chain operation in 2030 based on storage sites availability.

Project promoters are in active contact with other two candidate projects EU2SNEA (DE, BE, NO) and ECO2CEE (PL) to establish cooperation and strengthen connectivity and scalability of the European CCS infrastructure. The multimodal terminal in Klaipėda will provide connectivity for rail transport, road transport, as well as ships. Moreover, there is an existing gas pipeline infrastructure connection to Klaipėda. Pipeline infrastructure will not be currently utilised in the applicant project. The location of the multimodal terminal allows favourable transport accessibility from Baltic region (Lithuania, Latvia, Estonia and Poland) and also to permanent geological storage sites in the North Sea and Baltic Sea. By filling the infrastructure coverage gap, the interconnectivity of the EU CCS infrastructure will be strengthened. It will enable the utilisation of different variations of transport routes within the CCS infrastructure in case of overload, congestion, or failure of part of the transport route in the neighbouring countries. Interconnectivity will respond to the need to increase the resilience and security of CCS Baltic infrastructure as well as entire EU CCS infrastructure.

New multimodal liquid CO2 (LCO2) export/import terminal will be built at Klaipėda (LT) as part of the applicant project. Existing rail infrastructure will be used for onshore transportation between emitters and the multimodal LCO2 terminal at Klaipėda. Smaller volumes of LCO2 may be transported by road using existing infrastructure connections between cement plants and the multimodal terminal. Ships will be used for transporting LCO2 to the offshore storage site. Since CO2 storage is prohibited in both Lithuania and Latvia, it was necessary to find a connection to a storage site outside the territory of these countries. Storage sites in the North Sea are considered as a prime candidate due to their validity and reasonable distance from Klaipėda. Creation and operation of a permanent storage site is not part of the CCS Baltic Consortium project.

The construction phase of the applicant project shall start in 2024 and is expected to end in 2030.

14. GEOTHERMAL CCS CROATIA – applying for PCI status

Related website: not provided.

Involved Member States: Croatia, Hungary.

Coordinating applicant: Hydrocarbons Agency Croatia.

The Croatian Hydrocarbon Agency, which is coordinating this project, has prepared a study on the possibilities of permanent CO2 storage in the Republic of Croatia. The study showed that the potential of the Republic of Croatia in this area is considerable. In addition to the permanent storage of CO2 in depleted oil and gas fields, there is also the possibility of permanent storage in deep saline aquifers. The Bockovac site was selected as optimal for accessing a geological structure suitable for permanent CO2 storage.

The transported CO2 will be liquefied in the injection station and injected into geological structures:

- Infrastructure in Hungary: The route of the new pipelines from a cement factory in Beremend to the border with Croatia at Baranjski Petrovi Selo is being built.

- Infrastructure in Croatia:
    - From the border, the route of the new pipeline continues to Beničanci, making a total of 42 km of new pipelines.
    - The second route will run from a cement plant in Našice to Beničanci, totalling 25 km. From Beničanci to Bockovac where the CO2 will be discharged, a new 13 km pipeline will be built.
    - Two wells.
    - CO2 injection plant, production.
    - Drilling a well for geothermal water production - and the construction of a power plant that would meet the project's electricity needs.

The results of the simulations and calculations showed that it is possible to permanently collect 15.77 million tons of CO2 over a 25-year period at the site in question, while the total capacity is calculated at over 26 million tons. After a detailed analysis, we brought the partners together and started implementing the project.

The next phase of the project is the Feasibility study. Based on its results, the project would move on to the Front-end engineering and design study, Pilot project and Large-scale project.

Expected timeline:

- Start of construction 2025.
- End of construction 2031.

15. PYCASSO – applying for PCI status

Related website: PYCASSO project (pycasso-project.eu)

Involved Member States: France, Spain.

Coordinating applicant: Terega SA.

The PYCASSO project (PYrenean CO2 Abatement through Sustainable Sequestration Operations) applies for PCI status, under the coordination of Terega, as it relates to the transport and storage of anthropogenic CO2 emissions originating from industrial installations in south-western France and northern Spain. These installations include cement, steel, glassware, waste, refinery, pulp and paper, cardboard, energy production (cogeneration from biomass, Combined Cycle Gas Turbine-CCGT, bioethanol) lime and cand tires industries. The majority of the CO2 will be transported via purpose built new pipelines, connecting directly to groups of emitters or with segments of CO2 transport by ship and by rail. The emissions from both member states will be transported to be stored in depleted natural gas reservoirs located in south-western France.

PYCASSO proposes two sequential phases for the project scope, with Phase 1 starting operations in 2030 and Phase 2 in 2035. Both phases enable capture of CO2 emissions in France and Spain.

PYCASSO comprises a cross border network of carbon transport segments, collecting carbon emissions from industrial installations in France and Spain, and storage infrastructure in France. The transport infrastructure is comprised of 4 segments (dedicated transport pipelines, with some connections to further shipping and rail extensions), 1 export terminal and 1 import terminal. The storage infrastructure is comprised of surface and injection facilities.

The different infrastructure components by phase of the project are explained in brief here:

- Phase 1 of the project, due to start operations in 2030, includes emitters from the Lacq Area, as well as emitters and pipelines coming from the east and the west of the storage platform. The corresponding infrastructures are described below:

- The use of existing injection wells and building of new injection wells at the Lacq storage site.
- The pipeline infrastructure required to capture local industrial emissions in the area directly surrounding the storage site in Lacq.
- The shared Eastern pipeline, collecting emissions from cement, waste and biogenic emitters in France, east of Lacq.
- The Western pipeline, linking the storage site in Lacq with the purpose-built Bayonne import terminal, which in turn will receive carbon emissions from steel industrial emitters in Northern Spain, shipped from the purpose-built Gijon terminal. The Bayonne terminal may also receive carbon emissions by ship from other CCUS hubs in France or in Spain. For instance, strong interest has been shown by French hubs under development either in Saint Nazaire or in Fos. The related export terminals do not feature in the PYCASSO Project.

- Phase 2 of the PYCASSO project, due to start operations in 2035, extends to the emitters located north and south of the storage platform. The corresponding infrastructures are described below:
  - a Northern pipeline, to transport carbon from industrial emitters north of Lacq,
  - a Cross-Border pipeline to transport carbon from industrial installations in San Sebastian and outer Bilbao in Northern Spain.

In the case of phase 1, up to 2.5 Mtpa of CO2 will be transported from 2030 to 2034 and in the case of Phase 2, 3.4 Mtpa of CO2 will be additionally transported as of 2035.

16. Callisto Mediterranean CO2 Network – applying for PCI status

Related website: not provided

Involved Member States: France, Italy.

Coordinating applicant: Air Liquide France Industrie.

The CALLISTO (CArbon LIquefaction transportation and STOrage) Mediterranean CO2 Network project aims at kicking off the development of the first industrial CCS chain in the South of Europe and in particular in the Mediterranean. More precisely, CALLISTO Mediterranean CO2 Network will focus on the development of open access multi-modal CO2 Hubs in the Mediterranean, supported by dedicated onshore transport infrastructures, with the purpose of enabling decarbonization of various industrial emitter clusters through CO2 capture, aggregation, transportation and permanent storage of CO2. All the participants included in project (coordinated by Air Liquide France Industrie for French CO2 gathering and by Eni S.p.A. as operator in Italy of Ravenna CCS Project) have a strong interest in decarbonising their activities and/or territories and are acting now to deploy CCS at industrial scale in Europe.

In its main scheme, the candidate PCI CALLISTO Mediterranean CO2 Network includes:

- Collection of CO2 from Emitters clusters in Italy and France.
- Two main CO2 Hubs, located in Italy and France:
    - In France, the Fos - Marseille Hub will gather the CO2 coming from Rhône Valley and Fos - Marseille emitter zone clusters, to be then transported, by ship, to the Ravenna Hub. Collection and transport of the CO2 from Rhône Valley and Fos - Marseille zones emitters clusters to Fos - Marseille Hub is based on the repurposing and extension of existing pipeline network and the extension of the activities of an existing Liquefied Natural Gas terminal of ELENGY to CO2.
    - In Italy, the Ravenna Hub is designed to receive CO2 both from gas pipelines and from ships in liquid phase. The CO2 comes from Marghera, Ferrara and Ravenna emitter clusters and from the Fos-Marseille Hub and connects the permanent geological storage, located offshore the Adriatic Sea. The Ravenna CCS Project, operated by Eni S.p.A, includes the Ravenna Hub and the offshore geological storage located in the Adriatic Sea. The onshore gas pipeline transport, within the Italian boundaries, will be developed and operated by Snam using a dedicated pipelines network that connects the main emission clusters to the Casalborsetti Compression Plant. The Main Scheme to transport the CO2 from Italian emitters to Ravenna Hub is via new pipelines.
- The Surface and injection facilities of the offshore geological storage of Ravenna CCS in Italy linked to the Ravenna Hub. CO2 collected in Ravenna Hub is conveyed via pipeline up to this final storage site in the Adriatic Sea.

The development of the facilities is planned in 2 phases, the amount of CO2 emissions by country handled by the facilities along these 2 phases is summarised below:

- Phase 1 2027-2032: Total 3.6 Mtpa CO2.
- Phase 2 2033 – 2050: Total 6.4 Mtpa CO2.

This project will contribute to remove emissions by enabling the transport and geological storage of captured CO2 from industrial emission points to an offshore storage site. It is estimated that more than 130 MT of CO2 will be transported to the permanent storage in Ravenna in over 23 years during the lifetime of operations of this project.

In France, for the transportation infrastructures, the construction is planned between 2027 and 2029. In Italy, construction starting date for Ravenna Hub is foreseen from 2025 and ending in 2027 for the gas phase, while the construction of all facilities for liquid phase will end by 2029.

17. AUGUSTA C2 – applying for PCI status

Related website: not provided.

Involved Member States: Greece, Italy.

Coordinating applicant: Buzzi Unicem Spa.

The geographical focus of Augusta-C2 is Southern Europe, more specifically Southern Italy and Greece. A number of circumstances makes such area particularly suitable to innovation actions for

deployment CCUS: (a) unexploited off-shore CO2 storage capacity; (b) large industrial concentrations with massive CO2 emissions; (c) optimum conditions for CCUS project due to large availability of renewable energy plants.

Augusta–C2 aim at installing at a cement plant in Sicily (1.2 Mtpa cement capacity) the following equipment's:

- CO2 capture plant able to capture at least 200 kton of emitted CO2
- CO2 Buffer storage at Buzzi Unicem Augusta plant dock located at the plant property
- Facility for CO2 transport to the Energean Prinos (Greece) geological CO2 storage site
- A 5MW electrolyser using local produced renewable electricity for producing green H2 to be used for demonstrating the CO2 conversion to CH4 (utilisation of CO2) is also considered.
- Part of the Augusta-C2 project are also the development of a Safety assessment for transport & storage and the involvement of Local stakeholder engagement

As explained by the applicant, Buzzi Unicem, the captured CO2 will be temporary stored in a local buffer installed within the plant perimeter and then shipped using loading transport container (barges) to the Prinos CO2 Storage site in Greece. This project will see a facility with a notional capacity of 1 mln tonnes per year of CO2 developed before end 2025.

The location of Augusta makes the Prinos CO2 storage very convenient from logistic point of view being the CO2 captured directly at seashore and the CO2 storage site located offshore at approximately 1.000 km of sea distance.

The CO2 capture at Augusta plant will significant support the CO2 storage site in Prinos with a contribution of 200.000 ton of CO2 per year. The estimated start of operation of the Augusta-C2 plant is 2029.

18. PRINOS CO2 STORAGE – applying for PCI status

Related website: not provided.

Involved Member States: Bulgaria, Cyprus, Croatia, Greece, Italy, Slovenia.

Coordinating applicant: Energean.

The Prinos CO2 Storage Project, located in the North of Greece will represent the first CO2 storage hub at industrial/commercial scale in the Mediterranean. It aims to serve CO2 produced by local sources (around Kavala GR industrialized area, including own emissions) and remote sources from those hard-to-abate emitters.

The proposed CO2 project, subject to further technical and economic assessment may be developed to a size adequate to service a large number of hard to abate industries in Greece, and also in the region e.g. Italy, Croatia and Bulgaria. Cyprus and Slovenia are listed as well by the coordinating applicant, Energean, as Member States involved in the project.

Central to this project is the notion of scalability and efficient use of infrastructure. To this end the Prinos CO2 Storage is proposed to be developed in stages to meet increasing demand and address technical challenges. Further, hard to abate emitters in regions such as Attica or Thessaloniki may be serviced through a single local transmission network and common liquefaction plant(s).

The objective of this project is the development of a CO2 storage hub in an area of well-known underground structures suitable to this purpose. The hub aims to provide commercial CO2 storage services. Project objectives in details:

- Decarbonize local Kavala collecting CO2 from the nearby industrial park and own emissions
- Operate as a storage facility open to third party access and thus offer services both to Greek more remote and other regional hard to abate emitters. CO2 is expected to be received in chilled liquid and transported to Kavala via CO2 cargo vessels (LP conditions). Dense phase CO2 may also be received from Bulgaria and the Balkan region. Other ways of transport, i.e. in compressed cylinders on trains maybe also be considered.

The project is envisaged to be initially developed in two phases:

- Phase 1 – Upgrade the existing Prinos Sigma plant (onshore) to separate / compress / reinject acid gas, provide tie-ins and manifolds to local CO2 sources (dense phase), offshore dedicated pipelines from Sigma plant to Beta WHP (about 20km offshore), brownfield modifications at Beta WHP to accommodate CO2 injection facilities, and repurposing of two existing wells to inject dense CO2 into Prinos aquifer layers. Phase 1 aims at a capacity up to 1.0 MTPA. The ambition is to complete it by Q4-2025, in line with requirements of the Recovery and Resilience Fund (RRF). This phase of the project is already eligible for support under the RRF.
- Phase 2 – Phase 2 will be all about LCO2 coming from remote emitters from several countries (details on emitters, origin, and CO2 sequestered quantities are listed in this document). The Prinos Sigma Plant will be retrofitted with an offshore offloading facility to serve carriers of the order of 10.000 Nm3 CO2 (to be further specified subject to final demand and route optimisation), onshore storage tank farm, CO2 injection facility, offshore platform (WHP1) bridge-linked to Beta WHP to enable the injection of up to 2.0 MTPA of CO2 and handle the produced water from the formation, to be disposed. Phase 2 is expected to become operational by Q4-2027. Additional Phases may be considered subject to technical feasibility and market interest.

The proposed infrastructure shall be of capacity in the rage of 3-4 Mtpa infrastructure capacity to cover potential need for CO2 transportation across Attica players (project focus) of length in the range of 60-150km depending on facilities included. Liquefaction and temporary storage facilities matching capacity need (3-4Mtpa) and potentially located in Elefsina area.

The project constitutes of two phases with two different start-up milestone and handover to operations, this is to cope with CO2 project complexity but also to align with the project advancement of the various emitters in Greece and cross-border:

- Phase 1 (1.0 MTPA capacity facilities) by end of Q4 2025
- Phase 2 (overall 2.0 MTPA capacity facilities) by end of Q4 2027.