



European
Commission

INNOVATION FUND

Driving clean innovative technologies towards the market

ANRAV-CCUS - an innovative stakeholder supported CCUS value chain to realize the first CCUS cluster in Eastern Europe, supporting the Balkan region to reach its climate goals by 2030

The Innovation Fund is 100% funded by the EU Emissions Trading System

All images © ANRAV-CCUS



Project summary

The ANRAV project aims to be the first complete carbon capture, utilisation and storage (CCUS) value chain project in Eastern Europe. It will link CO₂ capture facilities at the Devnya Cement Plant in Bulgaria, a subsidiary of Heidelberg Materials, with CO₂ storage in a depleted gas field in the Black Sea, through an onshore and offshore pipeline system. The objective is to maximize the percentage of CO₂ that is captured from the cement kiln, reaching a maximum CO₂ purity level, whilst achieving minimal energy usage and reducing technical risks. The demonstration project will take place within an existing kiln line to ensure high retrofit capability. This will result in the avoidance of 95% of the greenhouse gas (GHG) emissions that would otherwise have occurred in the absence of the project, during the first ten years of operation.

COORDINATOR

Devnya Cement JSC

BENEFICIARIES

Devnya Cement JSC, Petroceltic Bulgaria EOOD

LOCATION

Devnya, Bulgaria

SECTOR

Cement and Lime

GHG EMISSION AVOIDANCE

7.8 Mt CO₂ eq

AMOUNT OF THE INNOVATION FUND GRANT

EUR 189 694 949

STARTING DATE

1 January 2023

PLANNED DATE OF ENTRY INTO OPERATION

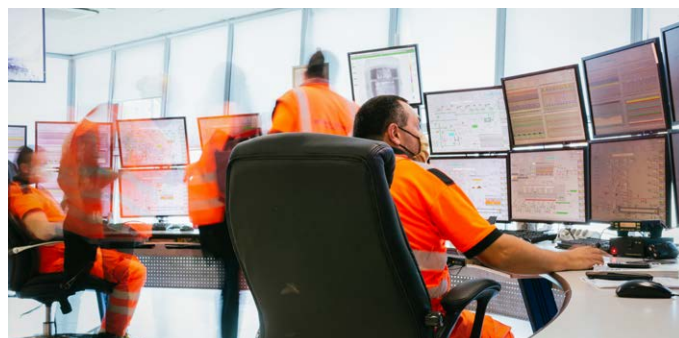
1 April 2028

Ultra-efficient innovative hybrid capture technology

ANRAV will demonstrate an innovative capture technology by merging oxyfuel and amine in a unique way. The cement produced will be low-carbon as the CO₂ emissions from Devnya plant will be sequestered with 99% efficient capture. This will result in an emission avoidance of 7.8 Mt CO₂ equivalent over the first ten years of operation, which represents approximately 13% of Bulgarian emissions over one year.

The unique characteristic of the hybrid and staged oxyfuel/amine concept is that it combines a very high capture efficiency with the ability to retrofit existing kiln lines. The CO₂ from the oxyfuel calciner is going to a CO₂ Processing Unit (CPU). Each CPU unit has some CO₂ losses, which normally are not recovered. However, with this innovative hybrid approach, the losses (the so-called CPU slipstream CO₂) are sent to the amine capture unit. Thus, the amine capture unit will deal with two CO₂ input streams: the flue-gas of the kiln itself and the slipstream of the CPU from the oxyfuel calciner.

This staged and hybrid approach finally results in 99% capture efficiency. Due to this innovative hybrid concept, the cement plant can maintain the same burning conditions of the main burner during the critical phase of the clinker production as for traditional kilns. This eliminates the risk of changing or deteriorating the clinker quality, which is of paramount importance from a business perspective.



A solution for carbon neutrality and achieving the Fit for 55 targets

Decarbonising cement production is necessary to achieve the EU objective of climate neutrality by 2050 and to address climate change. The ANRAV solution will be a flagship project for the cement industry in Eastern Europe and is consistent with the modernisation and decarbonisation objectives of the European Industrial Strategy.

Further, ANRAV is in line with energy efficiency policy instruments in Europe, as it reduces the additional thermal energy requirement from 65% to only 5%, in comparison with a reference kiln with amine capture.

CCUS cluster development in Eastern Europe

The project will be key in supporting the development of a strategically important CCUS cluster in the industrial zone of Devnya and beyond. The project will provide an invaluable opportunity to gain competence in the innovative hybrid oxyfuel/amine capture technology for the deployment in other existing kiln lines and to encourage a CCUS cluster development in a densely industrial area. The ANRAV Capture Unit at Devnya Cement Plant will safely store up to 0.8 Mt CO₂ equivalent per year in the depleted Galata gas field. Further scalability is achieved by constructing a pipeline with a planned annual capacity of 1.5 Mt CO₂ equivalent connecting other industrial emitters in the region to the open-access infrastructure.

Update April 2022



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Beccs Stockholm: Bio Energy Carbon Capture and Storage by Stockholm Exergi

The Innovation Fund is 100% funded by the EU Emissions Trading System

All images © BECCS Stockholm



Project summary

The Beccs Stockholm project will create a world-class, full-scale Bio-Energy Carbon Capture and Storage (BECCS) facility at its existing heat and power biomass plant in Stockholm. The project will combine CO₂ capture with heat recovery, making the process much more energy-efficient than the process in a conventional Carbon Capture Storage (CCS) plant. It will capture and permanently store large quantities of biogenic CO₂, leading to carbon removals from the atmosphere, also called negative emissions. The Beccs Stockholm project has a potential to remove around 7.0 Mt CO₂eq over the first ten years of operation. Net carbon removals are seen as an increasingly important technology-based solution to climate mitigation, indispensable to reach climate neutrality in 2050. The project will also be a catalyst for paving the way for a new market of net carbon removals. Besides the actual negative emissions achieved, Beccs Stockholm will also have a positive impact on the balance for renewable heat and electricity, resulting in additional reduction of around 0,8 Mt CO₂eq over the same period.

COORDINATOR

Stockholm Exergi

LOCATION

Stockholm, Sweden

SECTOR

Bio-electricity

AMOUNT OF INNOVATION FUND GRANT

EUR 180 000 000

RELEVANT COSTS

EUR 608 863 394

CAPEX

EUR 455 661 141

TOTAL PROJECT COSTS

EUR 2 707 453 271

GHG EMISSION AVOIDANCE

7.8 Mt CO₂eq

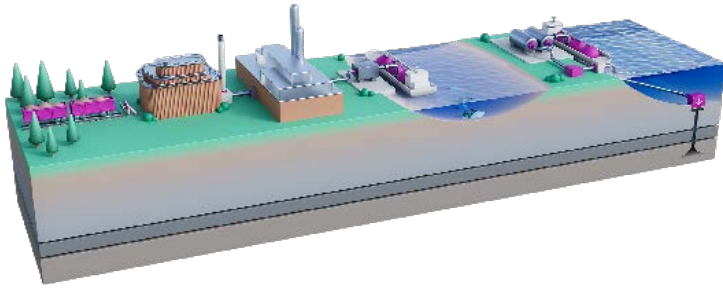
STARTING DATE

01 July 2021

PLANNED DATE OF ENTRY INTO OPERATION

Q3 2026

Climate Action



A world-class, full-scale Bio-Energy Carbon Capture and Storage (BECCS) plant

Beccs Stockholm will make use of a novel combination of existing technologies (Hot Potassium Carbonate for CCS and bio-fueled CHP) on a new scale, to develop the first, large commercial BECCS plant in Europe. The HPC-technology is well proven with multiple installations over the years. Its application with flue-gases from a bio-fueled CHP-plant is, however, not tested in full scale. Therefore, Stockholm Exergi has designed, constructed and now operates a smaller-scale R&D facility at the plant site with support from the Swedish Energy Agency with the objective to gain practical experience and results before designing the full scale plant. The Beccs Stockholm implementation will represent the first-of-a-kind global integration of CO₂ capture in an existing combined heat and power (CHP) plant that uses biomass-based fuels. By using the excess heat of the CO₂ capture facility to supply Stockholm's district heating network, the extra energy required for the CCS process (i.e. the energy penalty) will be greatly reduced. This energy penalty is normally in the range of 15-29%, of the energy produced, while Beccs Stockholm will reduce it to a mere 2%. Importantly, 90% of the CO₂ in the flue gas will be captured by use of the HPC technology. Stockholm Exergi selected this CO₂ absorption technology based on several advantages, such as its non-toxicity, the high selectivity for CO₂ and as a result high purity of captured CO₂, its low regeneration heat; and, the compact lay out of the technology in comparison to other CO₂ absorption solutions. After liquefaction and buffering, the CO₂ will be transported by ship to an underground storage site in the North Sea (although being part of relevant cost-calculation, this part of the technology chain is not part of the project).

Beccs Stockholm actively supports the climate neutrality goal and multiple European strategies

The scaling up of carbon removal solutions that capture CO₂ from the atmosphere and store it for the long term is vital to achieve the EU objective of economy-wide Climate Neutrality by 2050¹. Beccs Stockholm will support the achievement of this climate goal by capturing and storing almost 800 000 tonnes of biogenic CO₂ per year, with the aim to further improve the technology in the future. CCS, as well as bioenergy – the building blocks of the project – are among the ten main priority actions of the European Strategic Energy Technology Plan (SET Plan) to accelerate the energy system's transformation. In particular, the SET Plan highlights

that CCS needs to become a cost-competitive technology and gain public acceptance, to be eventually commercially deployed.

Beccs Stockholm will remove/avoid the emissions of 7.8 Mt CO₂eq of absolute GHG emissions during its first ten years of operation. This is the equivalent to more than the 2018 GHG emissions from public electricity and heat production in Sweden². From the overall emissions removed/avoided, 90% will come from CO₂ capture and storage (removal), and 10% will be associated with renewable electricity and heat generation from a renewable source.

At site-level, the project will implement solutions in line with the Circular Economy Action Plan, using locally-sourced biomass waste, as a feedstock in the electricity and heat generating plant, reusing process water to eliminate or diminish the use of fresh water, and with the opportunity to supply sustainably managed forests with fly ash coming from the co-incineration of the current biomass waste with phosphorous-rich sludge, with the potential to increase Swedish forest sequestration of carbon by 0.45 Mt CO₂eq per year. In line with the EU recovery ambition, the project will also create direct jobs locally and outside Sweden, acting as a springboard for many more highly-skilled engineering, construction and operation-related jobs throughout the CCS value chain.

Measures taken during the preparation phase increased the support of the project among citizens, living as close as 140 metres from the facility. For Stockholm Exergi, nurturing a strong and transparent relation with citizens, is and has always been a priority. One example of this, was the launch of a public acceptance survey at an early stage in the project's planning. This is an essential prerequisite for successful implementation within the boundaries of a populated city. Stockholm Exergi, which is already active in the field, will continue its efforts to establish a market for net CO₂ removals as a novel product. This will make the net carbon removals at Beccs Stockholm profitable for a CHP plant, paving the way for other actors to join.

Strategic location to support scalability and technology transfer

The Beccs Stockholm technology can be replicated in other sites. For example, two locations have already been identified in the region where the solution could be implemented by 2030. These two sites have the potential to avoid 1.1 Mt CO₂eq per year, of which 0.8 Mt from biogenic sources, thereby contributing to the necessary net carbon removals foreseen by relevant scenarios reaching climate neutrality.

The solution also has the potential to be scaled up across the economy, by replicating the technology in other industries, such as the pulp and paper industry, waste incinerators and heat plants.

The project overall will help to establish a new European market for net carbon removals. By contributing to the establishment of all necessary links in the CCS value chain in Northern Europe, including transport by ship of the CO₂ for storage in saline aquifers or depleted gas-/oil-fields in the North Sea basin, Beccs Stockholm is one of the important early adopters that will lead many other CCS projects to follow suit, both in the region and further afield.

1 Communication from the Commission to the European Parliament and the Council on Sustainable Carbon Cycles: https://ec.europa.eu/clima/system/files/2021-12/com_2021_800_en_0.pdf

2 The public electricity and heat production sector in Sweden produced 7.08 Mt CO₂eq in 2018. <https://climate-energy.eea.europa.eu/topics/climate-change-mitigation/greenhouse-gas-emissions-inventory/intro>



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CalCC – First industrial-scale carbon capture for lime production integrated with transport of CO₂ to coastal hub and shipping to geological storage in the North Sea

The Innovation Fund is 100% funded by the EU Emissions Trading System

All images © Lhoist



Project summary

The CalCC project will showcase a pathway for decarbonisation in the European lime industry. The project is capturing and permanently storing CO₂ emitted during lime production at Lhoist Group's Réty site in France. This innovative project will cover the full CO₂ value chain: capture, pipeline transport, liquefaction, shipping, and offshore geological storage. For the carbon capture aspect of the project, Air Liquide will build the first Cryocap™ FG unit in a lime plant at industrial scale. The Cryocap™ technology uses cryogenic temperatures to separate gases and creates a 99.99% pure CO₂ stream needed for CO₂ transport and geological storage. The project plans to achieve 87% relative greenhouse gas (GHG) emission avoidance compared to the reference scenario.

COORDINATOR

Chaux et Dolomies du Boulonnais (FR)
(affiliate of Lhoist Group)

BENEFICIARY

Air Liquide France Industrie (FR)

LOCATION

Réty, France

SECTOR

Cement and lime

GHG EMISSION AVOIDANCE

5.8 Mt CO₂ eq

AMOUNT OF THE INNOVATION FUND GRANT

EUR 125 198 197

RELEVANT COSTS

EUR 208 663 662

TOTAL PROJECT COSTS

EUR 3 036 929 288

ESTIMATED CAPEX

EUR 198 444 191

STARTING DATE

1 January 2023

PLANNED DATE OF ENTRY INTO OPERATION

31 December 2027

The first low-carbon intensity lime on the market

The lime industry is one of the “hard-to-abate” industries, as lime production generates CO₂ from decomposition of limestone. These so-called “process emissions” cannot be avoided by switching to zero-carbon fuels. Thanks to the CalCC project, Lhoist will be able to reduce the CO₂ emissions of its site in Réty by more than 600 000 tonnes per year¹, starting in 2028. This is equivalent to the annual emissions of about 90 000 people in Europe². This first-of-its-kind project will support local and other European lime users from various industries, such as water treatment, chemicals, paper and steel manufacturing, in their path to carbon neutrality, by providing the first low-carbon lime on the market.

Leveraging its know-how and unique expertise in CO₂ capture technologies, Air Liquide will build and operate a unit of its innovative and proprietary Cryocap™ FG (Flue Gas) technology. This will capture and purify 95% of the CO₂ from Lhoist’s existing lime production unit in the Hauts-de-France region. The cryogenic carbon capture technology is 100% electrical and will be used for the first time in Europe to decarbonise the lime sector.

The deployment of a low-carbon industrial ecosystem

The CalCC project is a further step in creating a low-carbon industrial ecosystem in the broader Dunkirk area. The captured CO₂ is planned to be transported via a CO₂ dense phase pipeline, which will run for roughly 50 km and be shared with other industrial streams in order to increase savings and achieve synergies. The CO₂ terminal in the Port of Dunkirk, including the subcooling / liquefaction unit, will be implemented as shared infrastructure with nearby hard-to-abate cement and steel industries. These synergies position the Hauts-de-France region as a driver in the development of integrated CCS logistic solutions.

The liquified CO₂ will be shipped in specially adapted vessels, to be safely and permanently stored in subsea geological formations, in the North Sea.

A solution to support the EU’s carbon neutrality objective

This innovative project will bring together all the elements of the carbon capture and storage (CCS) chain, solving potential interface issues and demonstrating the full value chain for the first time on a lime plant.

The project will pave the way for other emitters, as it shows a high scalability potential on existing plants both at sector level (cement and lime industry), and on an economy-wide level across sectors and across countries. CalCC will share its experiences to support industries in their efforts to contribute to the EU’s objective of achieving climate neutrality by 2050.



¹ Approximately 87% of the CO₂ generated by the operation of the project will not be emitted to the atmosphere.

² Considering Eurostat’s estimate: the total carbon footprint of EU-27 in 2019 was equal to 6.8 tonnes of CO₂ per person.



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Coda Terminal

The Innovation Fund is 100% funded by the EU Emissions Trading System

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Project summary

The Coda Terminal will be the world's first carbon mineral storage terminal, providing a new, safe and scalable method of permanent CO₂ storage. Coda will establish the full carbon capture and storage (CCS) value chain, using sustainable propulsion to ship CO₂ to Iceland for injection into basaltic rocks and permanent storage as carbonate minerals. Coda is a novel, low-cost CCS solution and a crucial contribution to achieving the EU's long-term climate targets, planning to achieve 91% relative greenhouse gas (GHG) emission avoidance over the first ten years of operation.

COORDINATOR

Carbfix

BENEFICIARY

Dan-UnityCO₂ A/S

LOCATION

Straumsvik, Hafnarfjordur, Iceland

SECTOR

CO₂ Transport and Storage

GHG EMISSION AVOIDANCE

21.1 Mt CO₂ eq

AMOUNT OF INNOVATION FUND GRANT

EUR 115 000 000

RELEVANT COSTS

EUR 336 768 000

ESTIMATED CAPEX

EUR 400 157 000

TOTAL PROJECT COSTS

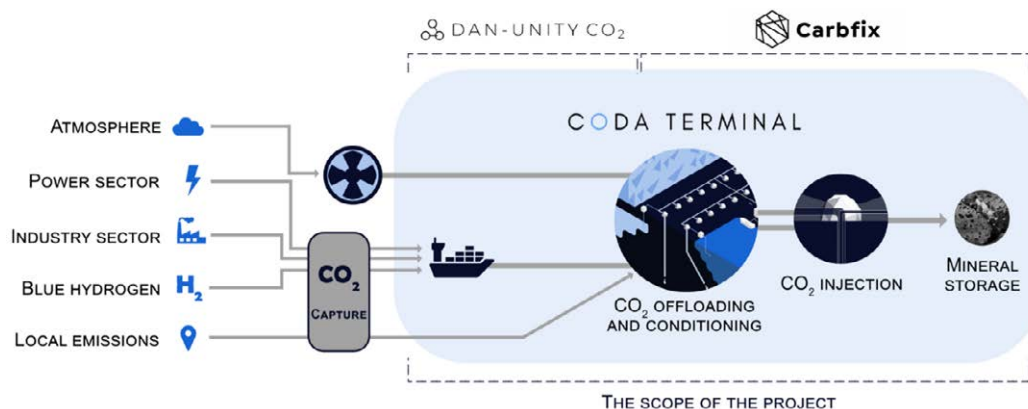
EUR 601 000 000

STARTING DATE

1 January 2023

PLANNED DATE OF ENTRY INTO OPERATION

1 April 2026



The world's first CO₂ mineral storage terminal

The Coda Terminal will substantially alter the costs associated with CO₂ transport and storage, by building a highly scalable onshore carbon mineral storage terminal. While CCS projects have traditionally overlooked basaltic formations, these rocks have been proven as reliable reservoirs for permanent CO₂ storage. With an estimated storage cost of 13 €/tCO₂, Coda will drastically reduce the cost of CO₂ storage.

Coda relies on the Carbfix technology, in which captured CO₂ is dissolved in water and injected into basalts. Robust monitoring and verification methods will be used to validate the rapid mineralisation of CO₂. Dan-Unity CO₂ (a specific shipping entity) will manage maritime transportation to the Coda Terminal. Innovative solutions in low-pressure tank design and ship propulsion will be used to minimise the carbon footprint of CO₂ transport.

The port and storage site will be located in Straumsvik, SW Iceland, where there are geologically young basaltic rock formations and ample supply of renewable energy and water. Coda will geologically store, and thereby avoid, 21 Mt of CO₂ equivalent emissions over the first ten years of operation. This annually equates to over half of Iceland's yearly emissions and approximately 2.5% of reductions required across the EU by 2030.

Key policy contributions

For the EU to meet its 2050 climate neutrality ambition, large-scale deployment of CCS is

needed. The Coda Terminal offers a scalable, cross-border CO₂ transport and onshore mineral storage solution that mainly requires water and favourable rock formations for operations. Coda will offer the most cost-efficient European CO₂ transport and storage service on the market. The project will also directly contribute to policy targets in energy efficiency, circular economy, and renewable electricity.

Scaling up a new climate-friendly industry

The Coda Terminal provides the foundation for a new climate-friendly industry. During the project's lifetime, Coda will create between 130 and 260 local jobs on site, and 85 (crew) and 5 (ashore) for transportation. In addition, indirectly 400 (shipyard) jobs will be created.

Coda has an exceptional scale-up potential. Local opportunities include expansion of the terminal, replication sites and coupling with local sectors, such as geothermal, heavy industry, waste management and direct air capture. In this respect, it should be noted that the project, during its lifetime, will use a mere 3% of the estimated capacity of the site to mineralise CO₂, which highlights the technology's scalability.

Globally, mineral storage terminals can be built in strategic locations favourable for mineral storage, receiving CO₂ regardless of sector or origin. Planned capture projects in Europe far outnumber storage sites currently in development, meaning demand for reliable storage is high.



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GO4ECOPLANET - KUJAWY

Go4ECOPLANET project, Carbon Capture and Storage project in Kujawy Cement Plant in Poland

The Innovation Fund is 100% funded by the EU Emissions Trading System

All images © Lafarge Cement S.A.



Project summary

The Go4ECOPLANET project aims to fully decarbonise cement production at the Lafarge (Holcim Group member) plant in Kujawy (Poland) and thus to contribute to decarbonising the construction industry. The project involves a globally-unique technology for capturing and liquefying CO₂. The solution will capture 100% of the plant's CO₂ emissions, which will be transported to storage areas in the North Sea. The project is a key part of Holcim Group's decarbonisation roadmap to meet its Net Zero Pledge. Negative emissions linked to the fuel containing biogenic carbon (considered as carbon neutral) allows the project to obtain 105% relative greenhouse gas (GHG) emissions avoidance compared to the reference scenario.

COORDINATOR

Lafarge Cement S.A.

BENEFICIARY

Lafarge Cement S.A.

LOCATION

Bielawy, Poland

SECTOR

Cement and lime

GHG EMISSION AVOIDANCE

10 MT CO₂ eq

AMOUNT OF THE INNOVATION FUND GRANT

EUR 228 210 004

RELEVANT COSTS

EUR 380 350 000

TOTAL PROJECT COSTS

EUR 4 744 483 158

ESTIMATED CAPEX

EUR 264 632 772

STARTING DATE

1 April 2022

PLANNED DATE OF ENTRY INTO OPERATION

30 April 2027

One of the first net zero-emission cement plants in Europe

Lafarge's Go4ECOPlanet project will create a full CCS chain, starting from CO₂ capture at the Kujawy site to offshore storage in the North Sea. The vision is to be a net-zero plant by 2027, producing green cement for the European market. This will be possible thanks to Air Liquide's innovative CryoCap™ FG emission capture technology, which is helping to develop highly replicable and complete carbon capture solutions to drive decarbonisation of materials for the building sector. The ambitious project schedule assumes a significant medium-term effect, as 10% of the cement sector emissions in Poland are expected to be captured by 2027.

In the first phase, it is assumed that 2 800 tonnes of CO₂ will be transported daily by train from the Kujawy Cement Plant to the Port of Gdańsk. The CO₂ will then be taken by ship to the North Sea, where it will be injected into depleted oil or gas fields for permanent storage. In total, this one CCS installation will eliminate 10.2 Mt of CO₂ equivalent over ten years of operation.

The transportation and storage of CO₂ will be possible thanks to cooperation with Air Liquide, PKN Orlen, Lafarge and the Port of Gdańsk through a separate Project of Common Interest (PCI), which is independent from the Kujawy Go4ECOPlanet project and not covered by the EU Innovation Fund programme.

The investment will create 39 new jobs at Lafarge Cement S.A. and approximately 200 additional positions in companies all along the value chain.

Driving the cement sector decarbonisation in Poland

The cement industry in Poland is amongst the most modern of any region – not only in Europe, but globally, and has made significant progress in decarbonisation of its energy use. Furthermore, the Polish cement industry is one of the European leaders in the use of alternative fuels (replacing fossil fuels) and mineral additives in cement production, in order to reduce the consumption of high-emission clinker and save natural resources.

Still, innovative technologies such as emissions capture and storage are indispensable to tackle the process emissions, notably from decomposition of calcium carbonate in the production of cement clinker.

The Kujawy Go4ECOPlanet project is aligned with the Polish Energy Strategy up to 2040 as well as with the European Green Deal and related EU actions and legislation to achieve climate neutrality by 2050, including the intermediate target of at least 55% reduction in greenhouse gas emissions by 2030. There is a huge potential to replicate the carbon capture technology used in the project due to the presence of numerous energy intensive industries in Poland. For all of these actors, Kujawy Go4ECOPlanet will serve as a showcase example of an effective decarbonisation strategy.



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Update April 2022



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K6 PROGRAM

The Innovation Fund is 100% funded by
the EU Emissions Trading System

© K6 PROGRAM



Project summary

The K6 Program will transform one of the oldest and strategic cement plants in Europe (located in the Hauts de France region in France) and will make it the first cement plant in Europe to take a large step towards carbon neutrality. The K6 Program aims to produce the first carbon neutral cement in Europe, becoming a representative project for the cement industry worldwide and supporting the green transition of a hard-to-abate sector. The plant has a capacity of more than 800 000 tonnes of cement and uses 145 000 tonnes of local waste per year. It also provides nearly 400 direct and indirect jobs, and supplies construction materials to an extensive regional market that ranges from Dunkirk to Paris.

The project will deploy a first-of-a-kind industrial-scale combination of an airtight kiln and cryogenic carbon capture technology. The captured CO₂, otherwise emitted to the atmosphere, will be finally stored in a permanent storage site in the North Sea (this part of the technology chain falls outside the Innovation Fund project boundary). The project will result in the avoidance of 8.1 Mt CO₂eq emissions over its first ten years of operation. The integration of the K6 Program with the nearby Port of Dunkirk will foster the development of the port as a future European CO₂ hub.

COORDINATOR

EQIOM (FR)

BENEFICIARIES

AIR LIQUIDE (FR), AIR LIQUIDE GLOBAL
E&C SOLUTIONS FRANCE (FR)

LOCATION

Lumbres, Hauts de France, France

SECTOR

Cement and lime

AMOUNT OF INNOVATION FUND GRANT

EUR 153 386 598

RELEVANT COSTS

EUR 255 644 331

GHG EMISSIONS AVOIDANCE

8.1 MtCO₂eq

STARTING DATE

April 2022

PLANNED DATE OF ENTRY INTO OPERATION

Q1 2028

Climate Action

A first-of-a-kind carbon neutral cement

The K6 Program plans to modernize a current cement production site. The project will integrate the rotary kiln system - the central unit of the cement clinker production process - with a very efficient CO₂ capture system to produce the first carbon neutral cement in Europe. It will also put in place a complete chain of carbon capture, liquefaction, transport and storage at full industrial scale.

The main innovation of the project is the installation of the most energy efficient Oxyfuel technology in a cement plant at full scale, in combination with the cryogenic capture and membrane separation technology developed by Air Liquide (Cryocap™). The Oxyfuel technology uses pure oxygen instead air for the combustion in the cement kiln. The airtightness of the system enables a high concentration of the CO₂ from both the combustion and limestone decarbonation in the flue gas and therefore allows direct and efficient capture.

This innovative process has been applied twice at a pilot scale (<100 TPD) in the coal power plant industry and is expected to achieve a CO₂ capture rate of 95 - 98%.

The K6 Program is going to implement technologies to enhance the energy efficiency of the standard cement production subprocesses (going beyond the state of the art).

The plant traditionally uses waste-derived fuels with varying percentage shares of biomass in its clinker manufacturing process. Thus, the overall CO₂ emissions balance per ton of clinker will be slightly negative, i.e. the fraction coming from the biological fuel will balance the remaining actual emissions and lead to net carbon removal.

The captured CO₂ will then be transported to the Dunkirk port and onwards to a permanent underground storage site in the North Sea¹.

A solution for the green transition and carbon neutrality of a hard-to-abate sector

The project will result in an avoidance of 8.1 Mt CO₂e emissions over the first ten years of operation. The absolute emissions avoidance includes around 14% of net carbon removal based on the capture, transport and storage of CO₂ from biogenic fuels (such as waste woods and

impregnated sawdust). Net carbon removal is necessary to achieve the EU objective of EU-wide climate neutrality by 2050².

The K6 Program solution will be a flagship project for the cement industry worldwide and is consistent with the “modernisation and decarbonisation process” of the New Industrial Strategy for Europe. The project also supports the development of the Carbon Capture Utilisation and Storage sector, one of the main priority objectives of the European Strategic Technology Plan (SET Plan).

The K6 Program is in line with the new Circular Economy Action Plan in Europe, as it will reduce the water use. The K6 process will reduce water consumption by 250 000 to 400 000 m³ per year in the area, which that corresponds to the volume of fresh water consumed by 3 000 households in one year³.

A solution to support a Carbon Capture & Storage (CCS) cross-border value chain in Northern Europe

At sector level, the technology of the novel kiln combined with CO₂ capture has the potential to be implemented in both existing and new cement plants. The transfer of the technology to other sectors of the economy will allow for additional avoidance of CO₂ emissions, for example in the steel, ceramics, glass and chemical fertiliser industries.

The project will be key in supporting the development of a strategically important CO₂ export hub in the port of Dunkirk located 54 kilometres away from the Lumbres cement plant. The CO₂ hub in Dunkirk will be developed in the frame of the so-called D’artagnan Project of Common Interest (PCI). The K6 project is the CO₂ capture building block of a full CCS value chain relying on the Northern Lights and D’Artagnan (PCI): being located in such a strategic industrial area, the project could help to develop and expand a value chain and logistic solution for a large number of existing industries. Several existing factories in France & Belgium emitting more than 100 000 tCO₂eq per year could be connected to the CO₂ hub by train or pipeline. In total, 71 cement plants (out of 213) in Europe, UK and Norway, are located close to the coast, and could also be connected by ship. Finally, the project could support the generation and reinforcement of downstream supply chains for the capture, transportation and storage of large amounts of CO₂ in Europe.

¹ This part of the technology chain falls outside the Innovation Fund project boundary.

² Communication from the Commission to the European Parliament and the Council on Sustainable Carbon Cycles: https://ec.europa.eu/clima/system/files/2021-12/com_2021_800_en_0.pdf

³ Considering 144 litres per person per day supplied in Europe and average household’s size of 2.36 people.

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Kairos@C: Building strong momentum for massive decarbonisation in the EU through a unique end-to-end CCS project

The Innovation Fund is 100% funded by the EU Emissions Trading System

© Kairos@C Port of Antwerp view



Project summary

The main objective of the Kairos@C project is to create the first and largest cross-border carbon capture and storage (CCS) value chain to capture, liquefy, ship and permanently store CO₂. Located in the Port of Antwerp, Kairos@C will establish a regional hub for innovative energy and carbon value chains. Kairos@C will develop a full industrial-scale CCS project that will encompass the CO₂ capture from various industrial sources on the Zandvliet industrial platform, the CO₂ transport by a local pipeline within the port of Antwerp to the liquefaction and export terminal located in the same port, the shipping towards CO₂ subsea storages in the North Sea and the permanent sequestration of the CO₂ in these storages. The infrastructures in the Port of Antwerp will be built in a phased approach and will be operated on an open access basis. Kairos@C will be the kick-starter of these shared infrastructures.

Kairos@C will enable the deployment of several pioneering technologies that together have the potential to avoid the emission into the atmosphere of 14 Mt CO₂eq over its first ten years of operation. Among the project innovations are: a cryogenic CO₂ capture process at industrial scale; an energy efficient CO₂ liquefaction plant, with ten times the capacity of the largest CO₂ liquefaction unit in operation today; and the development of a major functioning cross-border shipping and storage CCS chain.

COORDINATOR

Air Liquide Large Industry SA (AL)

BENEFICIARIES

BASF Antwerpen NV (BASF)

LOCATION

Antwerpen, Belgium

SECTOR

CO₂ transport and storage

AMOUNT OF INNOVATION FUND GRANT

EUR 356 900 000

GHG EMISSION AVOIDANCE

13.96 Mt CO₂eq

STARTING DATE

November 2020

PLANNED DATE OF ENTRY INTO OPERATION

Q3 2025

Three first-of-its-kind innovations embedded across the project

The first major innovation is the deployment of Cryocap™, a cryogenic CO₂ capture process, at industrial scale. This process enables the transition to a zero-carbon energy system as it consumes mainly electricity and it can use renewable electricity. The integrated multi-feed capture scheme will integrate CO₂ capture and purification from five different sources located on the Zandvliet industrial complex: two hydrogen (H₂) plants, two ethylene oxide (EO) plants, and one ammonia (NH₃) plant. The project will focus first on the more concentrated CO₂ emissions in the process streams, i.e. those generated as a by-product in a chemical process (ammonia and ethylene oxide) for which no alternative or cost-effective low-carbon technology is available. This is a very cost-effective phased approach (vs full capture upfront investment), starting with the more concentrated emissions in the process streams and allowing integration of future expansions at a later stage.

The second innovative element of the project is the use of an energy efficient liquefaction plant at a scale not realized before (ten times the capacity of the largest CO₂ liquefaction unit in operation today) and tailored to the needs of the Antwerp port.

The third innovative element is the development of liquid CO₂ vessels on a hitherto unavailable scale, whereby the main innovation lies in an appropriate design and steel grade able to withstand both the pressure and weight of liquefied CO₂.

Developing a regional CCS hub to support decarbonisation and industrial competitiveness

Kairos@C is a prominent example of Sustainable Energy Technology (SET) Plan strategy implementation, which looks for clusters and hubs linking a range of carbon and energy intensive industries to increase synergies. The project will support the Port of Antwerp in becoming a regional hub for innovative energy and carbon value chains. The project will also contribute to maintaining and reinforcing European industry's

global competitiveness, in line with the EU Industrial Strategy.

Kairos@C will be the first and largest reference for a cross-border liquid CO₂ value chain in a multi-user environment due to a series of factors. First, Antwerp is the second largest European port (after Rotterdam) and fourth largest European industrial cluster. In addition, the BASF site located in the Port of Antwerp is the largest integrated chemical production complex in Belgium, where Air Liquide owns and operates two world scale hydrogen production units on which capture units will be added. Kairos@C will benefit from the synergies with the Antwerp@C initiative, such as the use of shared CO₂ infrastructure within the port of Antwerp.

Kairos@C is also a flagship project in terms of supporting decarbonisation of hard-to-abate sectors to help achieve the goal of making Europe climate neutral by 2050. Overall, the project will result in an avoidance of 14 Mt CO₂eq emissions over the first ten years of operation. This represents more than the 2019 GHG emissions of the entire chemical industry in Belgium. As such, CCS deployment in the Port of Antwerp, with Kairos@C as an anchor project, will become the cornerstone of the decarbonisation roadmap of Flanders and Belgium.

Strategic location to support scalability and technology transfer

The infrastructure in the Port of Antwerp will be built in a phased approach and will create cost effective scalability towards new industrial customers.

Kairos@C will be a key milestone for Air Liquide and BASF to accelerate the deployment of CCS at their other sites, since many of them are ideally located in industrial clusters within close proximity to carbon storage infrastructure.

The Cryocap™ technology can also be applied in other energy-intensive sectors for CO₂ streams with a CO₂ concentration range between 15% and 95%, such as in oxy-combustion in the power sector or in cement manufacturing, with strong replication potential throughout the industry.

Antwerp at C CO2 Hub 12.4-BE-W-M-22

01/01/2023 - 31/12/2027

CONNECTING EUROPE FACILITY FUNDING: 144.616.403 EUR (awarded- Grant Agreement remains to be signed)

The Antwerp@C CO2 Export Hub project aims at developing a world-scale open-access modular infrastructure for the transport, liquefaction, and export of CO2 captured by industries in the Antwerp port area. The project is one of the capture initiatives of the N-LiTES PCI, which focuses on developing the infrastructure to transport and permanently store CO2 in the Norwegian continental shelf. The project will be finalized in June 2027 and consists of:

- A 2.5 Mtpa CO2 export terminal which includes an innovative liquefaction process (first-of-its-kind and 10 times larger than the current state of the art), buffer storage facilities to temporarily hold liquid CO2, and marine loading facilities to export CO2 via vessels (ships and barges) (terminal).
- A circa 22 km-long CO2 pipeline backbone connecting CO2 emitters, users and export facilities, with a 10 Mtpa total capacity, already future proof for handling future additional demand (backbone).
- Quay infrastructure dedicated to berthing liquid CO2 vessels (quay).

Future phases will progressively increase the infrastructure's capacity and geographical reach, with the ambition to expand to 10 Mtpa of CO2 by 2030. It will also catalyse the development of CC(U)S initiatives in the port of Antwerp.

The Antwerp@C CO2 export Hub project has the potential to reduce the CO₂ emissions in the port of Antwerp by more than 50% by 2030 while ensuring the long-term competitiveness of one of Europe's main economic centres.

BENEFICIARIES:

AIR LIQUIDE INDUSTRIES BELGIUM (Coordinator)

HAVEN VAN ANTWERPEN-BRUGGE

FLUXYS BELGIUM SA



Project of common interest:

12.7

PCI fiche

CATEGORY
Carbon Dioxide

CLUSTER
n/a: n/a

COUNTRIES CONCERNED
Belgium(BE)
Germany(DE)
France(FR)
Netherlands(NL)

PROMOTERS
Aramis CCS C.V.

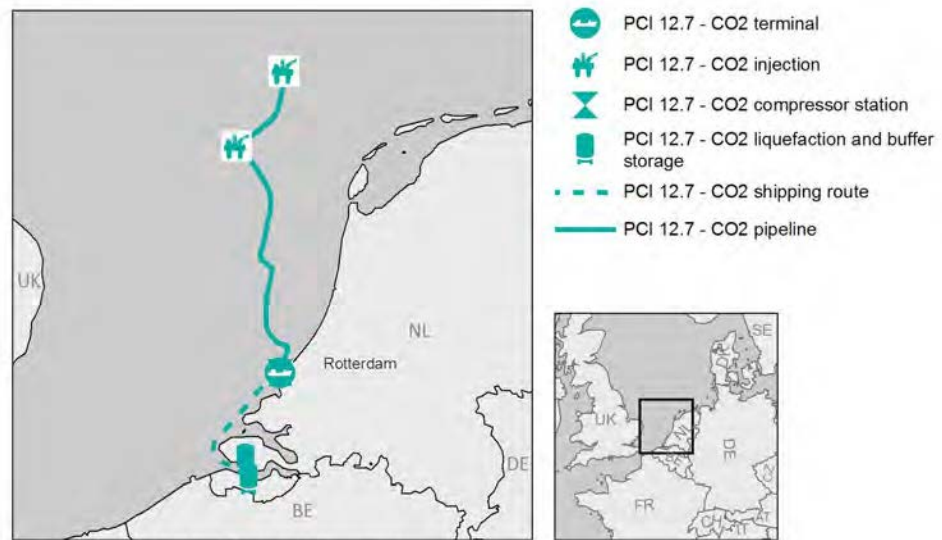
PCI WEBSITE(S)
www.aramis-ccs.com

LOCATION
Rotterdam (NL)

COMMISSIONING DATE
2027

Aramis – 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)

Cross-border carbon dioxide network



Source: PLATTS, GISCO, European Commission

Technical description

The Aramis project foresees to establish connections with industrial clusters in Belgium (Antwerp and Ghent), Germany (Nordrhein Westfalen and Leuna), France (Dunkirk and Le Havre) considering the construction of liquefaction facilities and export terminals. The Aramis launching phase will focus on:

- A new receiving shipping terminal (~3 Mtpa): liquid CO2 will be transported by coaster/barge from different industrial clusters located in the region to a new receiving terminal and temporary storage in an onshore hub located at the Maasvlakte near Rotterdam.
- A compressor station (~2 Mtpa): Compressed (gas phase) CO2 volumes coming by onshore pipeline from Rotterdam and its hinterlands will be further compressed in a compressor station and combined with the above-mentioned liquid CO2 for transport through a new high-pressure, ambient temperature offshore trunkline to the receiving offshore platforms.
- An offshore trunkline (150-200km): The Aramis Project envisages a new high-capacity trunkline (>20Mtpa) to transport the compressed and cryogenic CO2 from the receiving terminal and compressor station to the geological storage sites, located in the offshore K&L blocks. Further, an offshore tie-in to connect third-party infrastructure (Athos) from IJmuiden will be designed and developed.
- An offshore interfield pipeline network: Once the CO2 reaches the central platforms in the K&L blocks it will be injected through wells that connect to the geological sinks located at 3-4km depth. The system can be expanded by distributing CO2 to other nearby facilities through a network of interfield pipelines (new and/or re-use of existing gas pipelines are being investigated) to cater to the expected increase in demand for geological storage.



*Project of common
interest:*

12.7

PCI fiche

LAST UPDATE
March 2023

Aramis – 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)

Cross-border carbon dioxide network

Energy

Note: In line with the provisions of the TEN-E Regulation, the content of this document relies on information provided by the promoter(s) of the Project of Common Interest and CINEA does not guarantee its accuracy. The European Commission and CINEA accept no responsibility or liability whatsoever with regard to the information contained therein.

D'Artagnan Dunkirk CO2 Hub: pre-FEED and FEED Studies 12.8-FR-S-M-22

01/10/2022 - 31/03/2024

CONNECTING EUROPE FACILITY FUNDING: 4.797.552 EUR (awarded - Grant Agreement remains to be signed)

The project contributes to the implementation of the Project of Common Interest (PCI) 12.8 'D'Artagnan - CO2 export Multimodal HUB from Dunkirk and its hinterland', which aims at developing CO2 open access primary infrastructures. The PCI will allow to collect CO2 from various emitter sites in the Dunkirk harbour (north of France) and its hinterland; liquefy, and store it in intermediate storages, before exporting it by ship to permanent storage locations in the North Sea. D'Artagnan project is related to the development of the CO2 hub for an initial capacity of approx. 2 million tonnes of CO2 per year, for the CO2 captured in three main hard-to-abate emitter sites, i.e. EQIOM Lumbres cement plant, Lhoist Réty lime plant and ArcelorMittal Dunkirk steelmaking facilities.

The objective of this project is to carry out preparatory studies and engineering works, i.e. pre-FEED (Front End Engineering Design) and FEED studies for the CO2 Export Terminal and the dense phase CO2 pipelines between the hinterland emitter sites and the terminal; as well as the preparation of the necessary project documentation for the permitting application, and an economic assessment of the CO2 hub. By delivering the FEED of the D'Artagnan CO2 hub, the project will enable to prepare a sound conditional Final Investment Decision for the D'Artagnan CO2 hub, subject to financial availability or subsequent funding. The hub is expected to be operational by the end of 2027.

By interconnecting the north of France with the North Sea sites for permanent CO2 geological storage, the D'Artagnan PCI will contribute to establish a European CO2 network, to help achieve the CO2 reduction objectives of the EU and France, and further contribute to creating a fluid CCS market in Europe.

BENEFICIARIES:

AIR LIQUIDE FRANCE INDUSTRIE (Coordinator)

AL E&C - AIR LIQUIDE GLOBAL E&C SOLUTIONS FRANCE

AL MARITIME - AIR LIQUIDE MARITIME SAS

Ghent Carbon Hub Studies - 12.4-BE-S-M-22-GCH

02/09/2022 -31/12/2025

CONNECTING EUROPE FACILITY FUNDING: 9.588.430 EUR (awarded- Grant Agreement remains to be signed)

The project 'Ghent Carbon Hub Studies' aims to contribute to the advancement of the Project of Common Interest (PCI) 12.4 'N-LITES', which concerns the development of an open-access infrastructure for commercial CO₂ transportation and storage between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and the storage site on the Norwegian Continental Shelf.

The 'Ghent Carbon Hub Studies' project in particular concerns the following open-access infrastructure: approximately 140 km of pipeline network to collect captured CO₂ from emitters in Belgium (Ghent cluster in the North Sea Port and inland Hainaut cluster); a dedicated CO₂ terminal at Rodenhuize Dock North, Ghent, ensuring CO₂ liquefaction, purification, intermediate storage and loading facilities; and a set of maritime infrastructures to allow loading CO₂ on the ships and ensure their safe manoeuvring.

The 'Ghent Carbon Hub Studies' cover technical/economic feasibility studies up to Front-End Engineering Design (FEED), and will deliver Environmental Impact Assessments, engineering documents and relevant building permits. The Action will address market analysis, deliver a Cost-Benefit Analysis (CBA) and define the related contracts for the GCH services that relate to CO₂ pipeline collection and liquefaction.

The realization of this project will result in a Final Investment Decision (FID) taken for the commencement of Ghent Carbon Hub works phase of the concerned part of the PCI and will deliver the final proposals for subsequent Engineering, Procurement and Construction contracts.

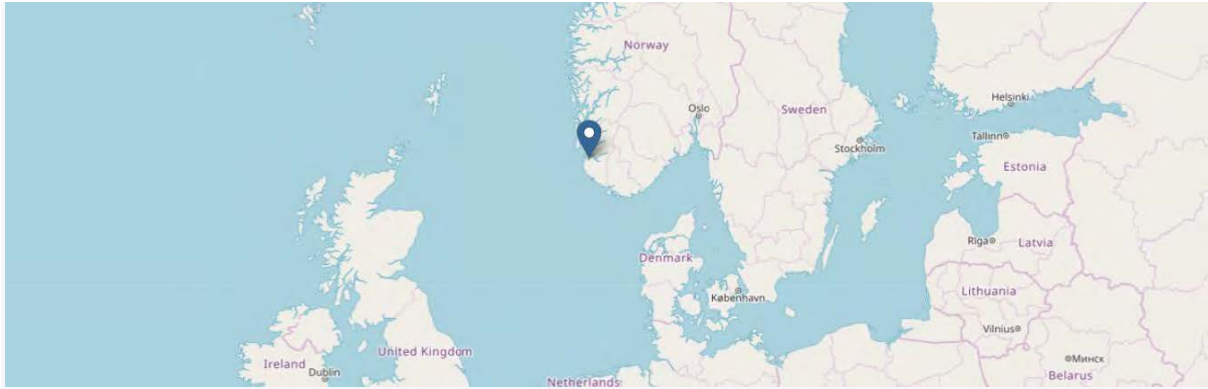
In its final phase, this project will allow to evacuate for permanent storage up to 6 Mtpa of captured CO₂.

BENEFICIARIES:

FLUXYS BELGIUM SA (Coordinator)

North Sea Port Flanders

ARCELORMITTAL BELGIUM NV



Northern Lights Phase 2 Expansion Studies

Project information

Acronym

12.4-S-M-21-NL P2 studies

Project ID

101069502

Status

Active

Start date

01 November 2021

End date

31 October 2023

Coordinated by [EQUINOR ASA](#)

Funded under

Connecting Europe Facility (CEF)

Fact sheet

Coordinator

EQUINOR ASA

Address

**FORUSBEEN 50
4035 STAVANGER
Norway**

Organisation Type

Private for profit organisation

Website

<https://www.equinor.com>

Objective

The project contributes to the implementation of Project of Common Interest 12.4 Northern Lights (NL), which aims to transport CO₂ from 10 capture initiatives to Aurora, a geological storage site in the Norwegian continental shelf. The NL Initiative (NLI), developed and managed by 3 PCI promoters, namely Equinor, Shell and TotalEnergies, includes the transport and storage components, and is currently being developed in 2 phases: • Phase 1 (P1): Concept capacity to transport, inject and store up to 1.5 million tons per annum (Mtpa) of CO₂. A positive final investment decision (FID) by the NLI partners and by the Norwegian Parliament was taken in 2020. Construction work started in January 2021. • Phase 2 (P2): Additional demand by expanding the initial CO₂ storage capacity to 5 Mtpa and beyond. The deliverables of the project

will comprise technical studies for the onshore and the offshore infrastructure, Front-End Engineering Design studies (FEED studies), including cost and schedule estimates as well as permitting and procurement. As part of this project, a final investment decision (FID) for the execution of P2 is foreseen. The FEED will define technical requirements and identify design parameters for the PCI, which will provide greater certainty on overall costs and key risks. The project will also include a cost estimate and the establishment of an economically viable business case. This project will cover the following specific objectives: maturing the NL CO2 transport P2 business case for an investment decision; further define the technical characteristics of the onshore and offshore CO2 transport components selected in the concept studies, mature the design and engineering of the technical components up to FEED level, create awareness and engage with relevant stakeholders, prepare for P2 works. The activities of this project will be carried out by external and internal resources. For the purpose of the implementation of this action the granting authority approves costs and contributions for activities that take place in other than eligible or target countries.

CO2 transport infrastructure expansion, detailed engineering, cost estimation, permitting, procurement

Programme(s)

[Connecting Europe Facility \(CEF\)-undefined](#)

Topic(s)

[CEF-E-2021-PCI-STUDIES](#)

Type of action

CEF Project Grants

Participants

Organisation

[EQUINOR ASA](#) (999939827)

Private for profit organisation

FORUSBEEN 50

4035 STAVANGER

<https://www.equinor.com>

Type

Coordinator

Country

Norway

EU Contribution

€3,733,132.00



Project of common interest:

12.4

PCI fiche

Northern lights project – a commercial CO₂ cross-border transport connection project between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and transport the captured CO₂ by ship to a storage site on the Norwegian continental shelf

Cross-border carbon dioxide network

CATEGORY
Carbon Dioxide

CLUSTER
n/a: n/a

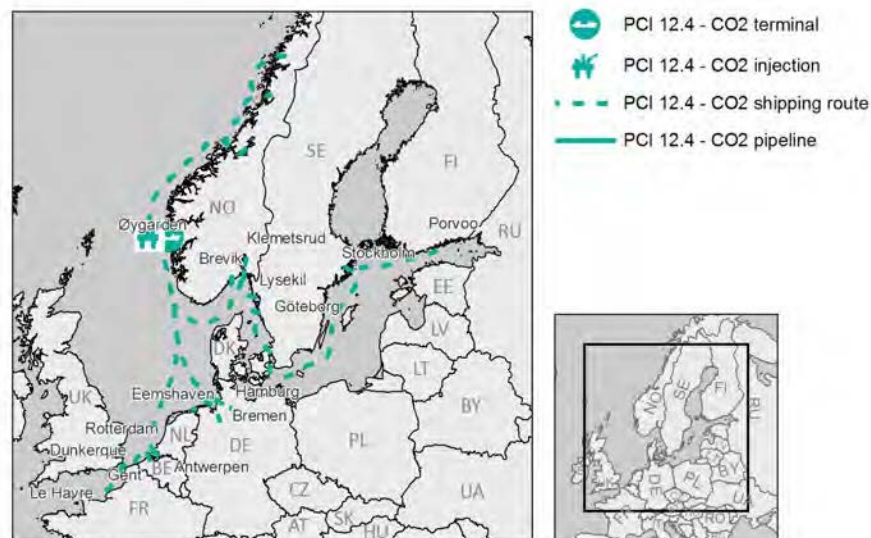
COUNTRIES CONCERNED
Finland(FI)
Netherlands(NL)
Norway(NO)
Belgium(BE)
France(FR)
Sweden(SE)
Germany(DE)

PROMOTERS
Northern Lights JV DA (NL)
AirLiquide Industries France (FR)
ArcelorMittal Belgium (BE)
ArcelorMittal GmbH Hamburg (DE)
ArcelorMittal GmbH Bremen (DE)
Esso Raffinage SAS (FR)
Fluxys Belgium SA/NV (BE)
Havenbedrijf Antwerpen (Antwerp Port Authority) (BE)
Neste Oyi (FI)
Norcem AS (NO)
Shell Global Solutions International B.V. (NL)
Total S.E. (FR/BE)
YARA France SAS (FR)
Air Liquide Industries Belgium (BE)
Preem (SE)
Stockholm Exergi (SE)
Havenbedrijf Antwerpen NV van publiek recht (BE)
Equinor ASA (NO)

PCI WEBSITE(S)
<https://northernlightsccs.com/>

LOCATION
Øygarden (NO)

COMMISSIONING DATE
2026



Source: PLATTS, GISCO, European Commission

Technical description

Commercial CO₂ transport connection project between several European capture initiatives and the storage site on the Norwegian Continental Shelf, as well as providing alternative storage to other CCS projects.

This PCI is located across Europe with promoters in Norway and several Member States (France, Belgium, Netherlands, Germany, Sweden, and Finland). The N-LITES storage site is located offshore Norway, and the CO₂ receiving terminal is at the Energy Park located in the Øygarden municipality, west of Bergen, Norway. The pipeline from the CO₂ receiving terminal to the storage site is about 100 km long. The design of the pipeline includes tie-in options to allow for connection to future wells or pipelines. The shipping routes for CO₂ from port-based facilities to the CO₂ receiving terminal need to be defined. The final shipping logistics will be determined on a per-emitter or emitting cluster basis dependent on buffer storage capacity, capture rate, geographic location and overall shipping optimisation.

The project is developed in two stages:

- Phase 1: Capacity to transport, inject and store up to 1.5 Mtpa CO₂, where ca. 800 ktpa reserved for the two capture projects in the Longship. Construction of both on- and offshore facilities commenced in 2021, and Phase 1 is planned to be operational in 2024.
- Phase 2: This phase will allow for expansion of the CO₂ receiving terminal to up to 5 Mtpa in line with the market development. Part of the Phase 1 infrastructure has already been designed at a 5 Mtpa capacity, this includes the offshore pipeline, and the umbilical to the offshore template.



Project of common interest:

12.4

PCI fiche

Northern lights project – a commercial CO₂ cross-border transport connection project between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and transport the captured CO₂ by ship to a storage site on the Norwegian continental shelf

Cross-border carbon dioxide network

CEF funding

12.4-0010-BE-S-M-20: Awarded CEF co-funding: 3,187,500 EUR

https://ec.europa.eu/assets/cinea/project_fiches/cef/cef_energy/12.4-0010-BE-S-M-20.pdf

12.4-BE-S-M-22-GCH: Awarded CEF co-funding: 9,588,430 EUR

12.4-BE-W-M-22-Antwerp at C CO₂ Hub: Awarded CEF co-funding: 144,616,403.42 EUR

12.4-S-M-21-NL P2 studies: Awarded CEF co-funding: 4,252,340 EUR

<https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/projects-details/43251567/101069502/CEF2027>



Project of common interest:

12.4

PCI fiche

LAST UPDATE
March 2023

Northern lights project – a commercial CO₂ cross-border transport connection project between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and transport the captured CO₂ by ship to a storage site on the Norwegian continental shelf

Cross-border carbon dioxide network

Energy

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Project of common interest:

12.9

PCI fiche

Poland – EU CCS Interconnector (emitters from the industrial cluster in the area around Gdansk, Poland with storage where available in the North Sea country territories)

Cross-border carbon dioxide network

CATEGORY
Carbon Dioxide

CLUSTER
n/a: n/a

COUNTRIES CONCERNED
France(FR)
Netherlands(NL)
Poland(PL)
Norway(NO)

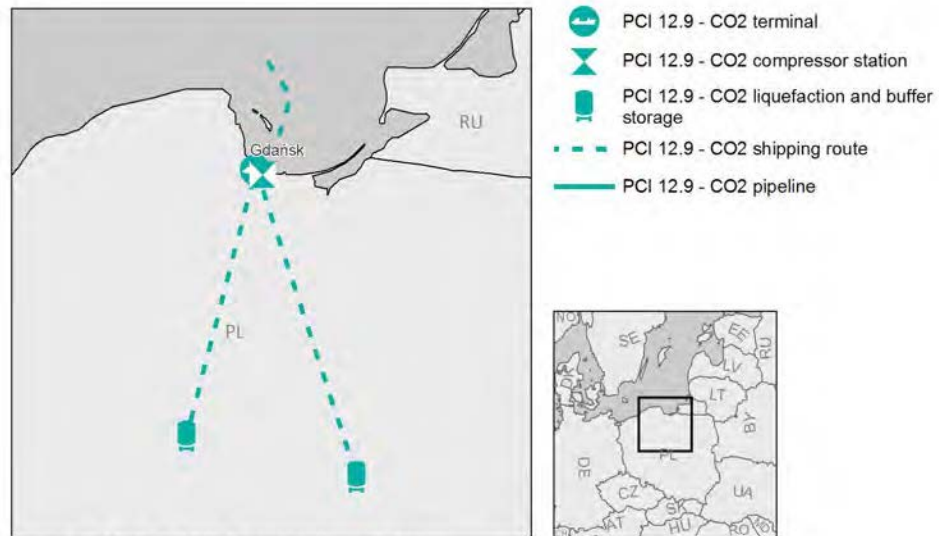
PROMOTERS
Air Liquide Polska Sp. z o.o. (PL)
Zarząd Morskiego Portu Gdansk S.A. (PL)
Polski Koncern Naftowy ORLEN S.A. (PL)
Lafarge Cement S.A. (PL)
Sogestran Shipping (FR)

PCI WEBSITE(S)
<https://www.airliquide.com/pl/polska>

LOCATION
Gdansk (PL)

COMMISSIONING DATE
01/07/2026

LAST UPDATE
March 2023



Source: PLATTS, GISCO, European Commission

Technical description

Open access multi-modal liquid CO₂ (LCO₂) import-export terminal in Port of Gdansk with related CO₂ transport infrastructure from the facilities of emitters to European CO₂ transport and storage network in the basin of North Sea with a use of transport via roads, railways, pipelines and ships. The project is scheduled to transport 2.7M Ton of CO₂ per year between 2025-2030 period reaching 8.7M Ton of CO₂ between 2030-2035 period. The CCS interconnector will consist primarily of the following infrastructures: a multi-modal Liquid CO₂ Export Terminal in Gdansk, a CO₂ collector backbone in the Port of Gdansk, to provide industries in the vicinity of the Port with effective access to the Terminal and a primary export infrastructures in the Gdansk hinterland to provide industries located in the hinterland of Poland to access the Terminal via railcars shuttle, trucks, inland waterways, or pipeline.

Energy

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PORTHOS CO2 transport network

Programme:
CEF Energy

Call year:
2020

Location of the Action:
Netherlands

Implementation schedule:
July 2020 to December 2024

Maximum EU contribution:
€102,135,856

Total eligible costs:
€255,339,640

Percentage of EU support:
40%

Beneficiaries:
Havenbedrijf Rotterdam N.V. (Netherlands) N.V. Nederlandse Gasunie (Netherlands)
EBN B.V. (Netherlands) Porthos Development CV (Netherlands)

Status:
Ongoing

Energy corridor:
Cross-border carbon dioxide network

Energy sector:
CO2

Project(s) of Common Interest:
12.3

Additional information:
European Commission, DG ENER<http://ec.europa.eu/energy/en/topics/infrastructure>

Last modified:
April 2022

Action 12.3-0022-NL-W-M-20



The Action is part of the Project of Common Interest (PCI) 12.3 CO₂ TransPorts. The PCI consists of the development of an open access cross-border CO₂ transport network for the transport of CO₂ from industrial sources in the ports of Rotterdam, Antwerp and North Sea Port (Ghent) to offshore storage locations in depleted gas fields in the North Sea. The PCI foresees three phases of implementation. The current Action implements the first phase, consisting on the realisation of the Port of Rotterdam CO₂ Transport Hub and Offshore Storage (Porthos) until 2024.

The main objective of the Action is the construction of a CO₂ transport backbone in the port of Rotterdam area able to transport CO₂ to the depleted gas fields in the North Sea via the P18A offshore platform. It includes the construction and commissioning of a 33 km onshore pipeline connecting industrial emitters in the port of Rotterdam, a 20 MW compressor station and a 20 km offshore pipeline transporting the compressed captured CO₂ for storage in the Dutch section of the North Sea. In the first operational phase, the pipelines will have a capacity of 5 MtCO₂/year, with provisions to upgrade the capacity to 10 MtCO₂/year.

The Action will result in the realisation of the Porthos CO₂ transport network, fully achieving the first phase in the PCI implementation.



Carbfix

Carbfix – A rock-solid solution for climate

Carbfix captures CO₂ and turns it into stone underground in less than two years through proprietary technology that imitates and accelerates natural processes, providing a permanent and safe carbon storage solution. This cost-effective carbon capture and mineral storage technology has successfully reduced over 70,000 tons of CO₂ emissions and is ripe for dramatic upscaling, both in Iceland, where it was developed, and worldwide.



The technology is applicable to both avoiding CO₂ emissions as well as removing CO₂ already emitted to the atmosphere, both of which are vital at scale if climate goals are to be met.

The Carbfix technology is:

- **Safe.** Any risk of leakage is fully eliminated by dissolving CO₂ in water.
- **Cheaper** than alternative CCS solutions and involves lower up-front capital costs and risk.
- **Environmentally friendly** as it imitates and accelerates nature's way of storing CO₂ in rocks. No added chemicals are needed, only electricity and water.
- **Permanent.** CO₂-bearing minerals which form are stable for thousands of years, limiting the need for long-term monitoring.
- Built on firm **scientific** foundation. Over 100 scientific papers have been published and robust monitoring campaigns demonstrate transformation of CO₂ to minerals.
- Highly **flexible** and **modular** with respect to capture technology, injection strategy and up-scaling.
- **Accepted** by the public as has repeatedly been confirmed by surveys.

The potential for applying CO₂ mineral storage in basalts around the globe is enormous, far greater than ever needed for climate action. The technology furthermore unlocks large regions that have previously not been considered as candidates for CO₂ storage.

Carbfix is working on various fronts for scaling up CO₂ mineral storage on a global level as well as further developing the Carbfix technology to maximize its potential impact with the objective of reaching the gigaton scale in storage capacity in coming years.

Carbfix and Direct Air Capture

On the 8th September 2021, Carbfix started injecting CO₂ captured Climeworks' Orca plant constituting the world's first commercial direct air capture and storage chain.

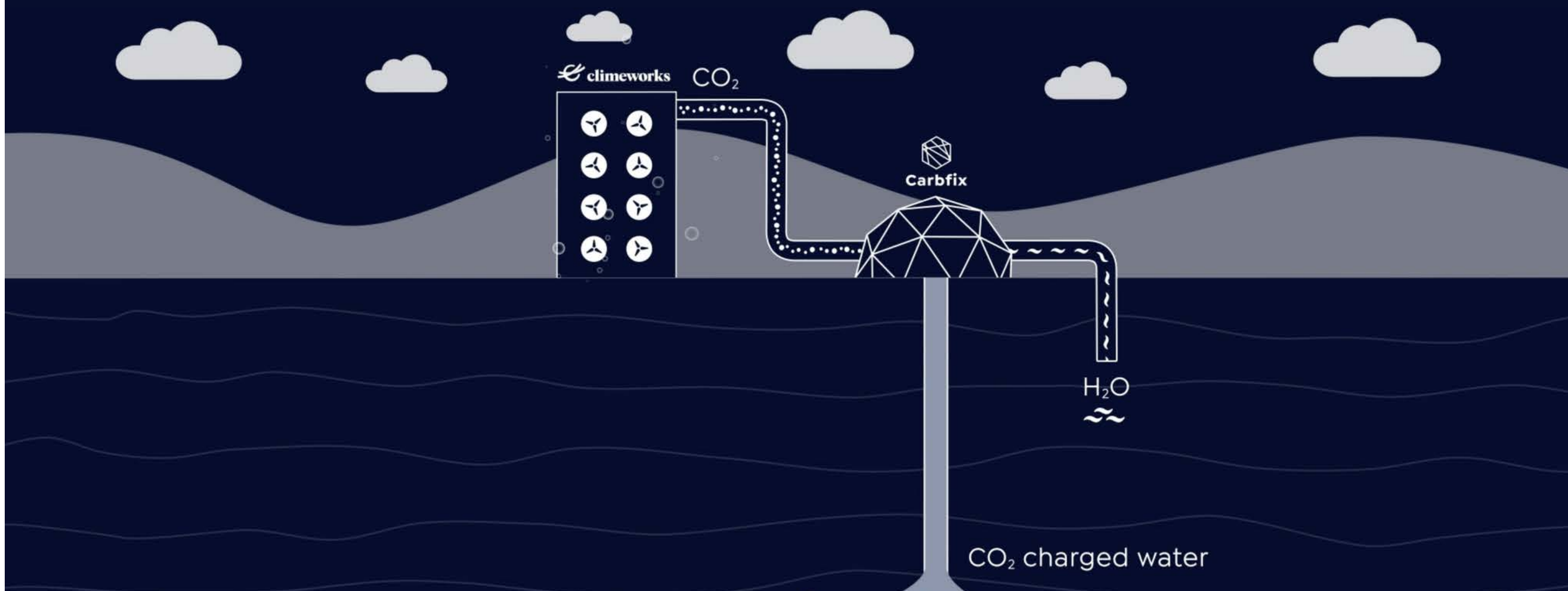
Over four years of successful collaboration, Carbfix and Climeworks has moved direct air capture and storage from pilot scale to commercial scale. The Orca installation has the capacity of capturing 4,000 tons of CO₂ per year, which is injected by Carbfix into nearby basaltic formations to be permanently turned into stone.

The Climeworks CO₂ collectors selectively capture CO₂ via a two-step process, where CO₂ is captured on a highly selective filter within a fan and released at higher temperatures for the collection of a high-purity CO₂ gas.

Iceland is a favorable host for DAC technologies, owing to both

Abundance of renewable energy resources needed to power direct air capture plants.

Highly reactive and porous rocks, which provide a cheap and permanent carbon storage solution.





A CO₂ mineral storage hub in Iceland

Climate goals will not be met without CO₂ emission reductions. This includes CO₂ capture and injection into feasible geological formation for permanent storage, preventing it from entering the atmosphere. Large scale CO₂ Capture and Storage (CCS) is particularly needed for the hard-to-abate sectors such as the production of steel and cement.

CO₂ storage terminals will provide facilities for industries to store CO₂ when they are located in areas where carbon storage is not feasible on-site. CO₂ is captured at the industrial source and then transported to a location where it can be safely stored. CO₂ storage terminals significantly reduce the cost of CO₂ transport and storage through economies of scale and provide multiple sources of CO₂ with access to shared infrastructure.

At the Coda Terminal in Straumsvík, the Carbfix technology will make use of the vast storage capacity of the basaltic rocks at the site for safe and permanent mineral storage. The Carbfix technology has been under development since 2007 as a joint effort between industry and academia. It involves dissolving CO₂ in water and injecting it deep into basaltic formations where the injected CO₂ is rapidly turned into stone. The technology has been proven to be an effective and environmentally friendly climate solution through its 10 years of operational history.

Infrastructure that will be constructed for Coda Terminal operations include storage tanks for CO₂ in the vicinity of the harbour, regasification equipment, pipelines and injection wells. The CO₂ will be captured from the European hard to abate industry and transported to Iceland by specifically designed ships capable of operating on sustainable fuel. The Coda Terminal will also be able to inject CO₂ captured from nearby industrial emissions as well as directly from the atmosphere using direct air capture technology (DAC).

The Coda Terminal will be constructed in three stages and will have the capacity to store 3 million tonnes of CO₂ annually at full scale, thereby significantly supporting Iceland's and the EU's goal of 55% reduction in emissions before 2030. Preparations began in 2021 on the front-end engineering design and licencing processes. Pilot Injection will commence in 2023, operations will then start in 2026 with a 500ktCO₂/yr capacity and full-scale operations are expected to be reached in 2031.

The Coda Terminal lays the foundation for a new, climate-friendly industry that can become a new pillar of the Icelandic economy.

Carbfix technology:

- Safe, effective and flexible
- Permanent and natural
- Firm scientific background
- Almost unlimited storage capacity



**Funded by
the European Union**

*The name, Coda comes from music and refers to a concluding passage that brings the musical piece to a satisfactory close.

Background Information

The RUBY Project by CarbonCuts

Our Company

CarbonCuts is a Danish start-up company, which was established in 2022 as a spin-off from Noreco; Norwegian Energy Company ASA.

The company was founded in the wake of the Danish Climate Act of 2020, which stipulates that CCUS shall be instrumental in reaching Denmark's long-term goals of becoming a carbon neutral society. Denmark is looking to deploy CCUS as a significant part of its portfolio of climate measures and are investing €5 billion in CCUS over the coming decade.

CarbonCuts is committed to contribute to this CCUS acceleration, by building and operating a deep geological onshore storage site in Denmark.

Our Heritage

CarbonCuts is a company founded on deep technical knowhow.

Our executive management have decades of experience in building and operating major subsurface projects in Denmark and abroad, and have spent their working life in Noreco, Shell, Hess, Ørsted and Maersk.

Our board of directors have a strong commercial and financial background from the energy industry and bring along more than 25 years of research and innovation within subsurface and thermodynamics.

Our investor is partner in the Bifrost project, which is a CO₂ transport and storage project which is currently under development in the Danish sector of the North Sea.

Our Priorities

Partnering with the local community

CarbonCuts are working closely with the local community where we plan to build the storage site. We are liaising with the municipality about regulatory matters and about how our storage site will fit into the rest of the existing and planned local energy- and transport infrastructure.

Carboncuts are in dialogue with local emitters to facilitate that the CO₂ which they may capture in the future can be stored with us. Moreover, CarbonCuts are engaging with the people who live and work in the region where our storage site will be. We are building public accept by sharing as much information as we can about the project,

and we are delighted to experience that the local community is meeting our project with a pull, rather than a push.

Collaboration and sector coupling

CarbonCuts is working closely with the Danish regulator, the Danish state geologists, and the municipality to ensure that our storage site will generate synergies with other local and national projects and infrastructure. We are committed to support the future local Power-to-X plants, by collaborating about sourcing the CO₂ and ensuring that our storage site can act as a buffer.

Innovation and development

CarbonCuts are actively engaging with other CCS operators and with leading Danish CCS research institutions to ensure that we learn from each other.

Our Investor

CarbonCuts is financed as a spin-off from Noreco – Norwegian energy Company ASA (noreco.com). Noreco is listed on the Oslo stock exchange and has a strong interest in Denmark with a 36.8% equity share of the Danish Underground Consortium (DUC), acquired through a USD 1.9 bln transaction with Shell in 2019. DUC is a joint venture involving Total Energies, Noreco and Nordsøfonten. The consortium is responsible for exploration and operation of 13 producing fields in the Danish sector of the North Sea, and thus contributes the largest share by far of the Danish hydrocarbon production.

In addition to CarbonCuts, Noreco is investing in CCS via the major Bifrost project offshore Denmark: <https://bifrost-ccs.com>.

Our Project - Ruby

The geological structure

CarbonCuts plan to build a deep geological storage site in the southern part of Denmark, in the so-called Rødby structure. The Rødby structure is one of eight onshore/nearshore geological structures which have been selected by the regulator as potential future CO₂ storage sites.

The structure is already thoroughly explored. It was penetrated by two wells in the 1950'es, by an oil company who were exploring for oil, but instead found a saline aquifer. Over the years several seismic acquisition campaigns have further de-risked the structure. And in the summer of 2023, some 100 km of new high quality seismic will be acquired over the structure.

Storage capacity

CarbonCuts plan to store CO₂ in the **Bunter** formation. This is a regionally widespread sandstone which was deposited more than 200 million years ago, and now buried some 1200 meters below surface. The Bunter sandstone is overlain by thick sealing

caprock (Fjerritslev formation), and a second seal is formed by the thick carbonate and chalk package.

The official storage capacity in the Rødby structure is communicated by the state geologists (GEUS) to be in excess of 300 Million tons CO₂.

The infrastructure

The Rødby structure is an onshore structure, near a harbor which can receive CO₂ by sea transport.



We are planning to store CO₂ from local emitters and from international emitters in proximity to the Baltic Sea. An import option by rail is being investigated. CarbonCuts is in the process of securing a location for the plant and wells.

The timeline

We anticipate injection from 2027 with an injection capacity of 1 Mt CO₂/year increasing to 5-10 MtCO₂/year by 2030.

The economics

CarbonCuts will invest significant capital in the storage site. The price range for storing CO₂ in our site depends on which commitments can be agreed regarding timing, volume, and other commercial conditions. We are flexible towards discussing future scenarios and are ready to explore the possibility of signing Letters of Intent with selected emitters.

Contact information: contact@carboncuts.dk

Homepage: <https://www.carboncuts.dk/>



Equinor contribution - The emerging EU CO₂ transport and storage market

Equinor – 25 years of successful offshore CO₂ storage in Norway

Equinor is a broad energy company headquartered in Norway with 22,000 employees in 30 countries. We're committed to climate neutrality by 2050 and our strategy is to be a leading company in the energy transition. We believe our energy solutions, such as offshore wind, CCS and hydrogen, will contribute to the low-carbon Europe of the future.

Equinor has been developing and using CCS technology for more than 25 years in the Norwegian North Sea, safely storing nearly 25 Mt of CO₂ since 1996 at the Sleipner field, the first offshore CCS project ever. Further contributing to maturing CCS value chains and markets is one of the strategic pillars of our energy transition plan. We have an ambition to develop a CO₂ transport and storage capacity of 5-10 Mtpa by 2030 and 15-30 Mtpa by 2035 (Equinor equity).

Together with Shell and TotalEnergies, we are developing an open-source CO₂ transport and storage infrastructure on the Norwegian Continental Shelf, the Northern Lights Project, which will start storing CO₂ from European sources in 2024. In 2022, Northern Lights signed the first commercial agreement with a customer for CO₂ storage and is the process with other potential customers who are relevant for EU funding.

Equinor has ambitions to develop further CO₂ storage in the North Sea in the coming years with the aim of building a common infrastructure that can contribute to substantial cost reductions for the CCS value chains and connect large emissions in Europe with storage opportunities in Norway.

The Smeaheia CO₂ license

Equinor was awarded in April 2022 the operatorship for the development of the CO₂ geological storage site 'Smeaheia' in the North Sea. Only few months after award, 3D seismic was collected to further improve the case for rapid scale up of CO₂ injection at Smeaheia. The licence is an important building block for developing the Norwegian continental shelf into a leading province for CO₂ storage in Europe.

Smeaheia can become the biggest CO₂ storage solution in Europe. In its application, Equinor has submitted plans to develop the CO₂ storage capacity at Smeaheia to 20 million tonnes annually, which entails a sharp increase in CO₂ storage capacity on a commercial basis on the Norwegian continental shelf. The storage site could provide total permanent and safe storage of >500 million tonnes of CO₂.

The Smeaheia Fault Block is located 30-50 km from shore on the west coast of Norway, east of the Troll gas field and North-East of the Northern Lights CO₂ storage licence. The project plans for investment decision in 2025 and start-up of offshore CO₂ storage in 2028.

The Smeaheia project will contribute to a large reduction of national and European emissions by enabling the transport of captured CO₂ from industrial emission points to offshore geological storage sites.



A European CO₂ pipeline anchored by Smeaheia

EU2NSEA, a major cross-border carbon capture and storage project, involving ten countries, has recently applied for Project of Common Interest (PCI) Status to the European Commission. As part of the project, Equinor, together with partners, aims to develop a major offshore pipeline infrastructure network, enabling the transport and storage of anthropogenic and biogenic CO₂ from North-West Europe to the North Sea.

The large-scale pipeline transmission solution offers businesses an easy-to-use logistics chain from capture to storage. It is both efficient and economical for large volumes of CO₂ and allows for ample operational flexibility

The pipeline network solution aims to provide resilience and security of CO₂ transport by having a dedicated, high-capacity pipeline infrastructure (20-40 Mt CO₂/year) in place that can operate with high regularity. Moreover, the solution can enable significant cost reductions by offering volume and operational efficiency. 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.



Norne Carbon Storage Hub

CCS Market Workshop – Background Materials



30. March 2023

Table of contents

	Section	Page
1	About Fidelis New Energy	3
2	The Norne Carbon Storage Hub	6

A scenic landscape photograph of a mountain range with snow-capped peaks and a turquoise lake in the foreground. The sky is blue with scattered white clouds. A large, semi-transparent teal graphic with curved lines is overlaid on the right side of the image.

About Fidelis New Energy

Fidelis New Energy Snapshot



Our Mission

To address energy security and climate challenges through the deployment of Climate GigaSystems™⁽¹⁾

Fidelis New Energy develops, finances, and operates energy transition and carbon management infrastructure



Core Themes

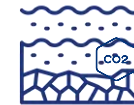
- **Safety, Culture and Values:** Integrated first priority of “safety, values, and culture” driving a “high reliability organization” across the life-cycle of projects (inception, development, delivery, and operations)
- **RACER™⁽¹⁾:** All encompassing, ESG-focused framework that guides all firm activities
- **Downside protection from stable revenue sources:** Revenue contracts, tax credits and/or regulatory incentives / framework
- **First Mover Advantage without First of a Kind Risk:** Only proven technologies, strategies, etc.
- **Utilize Economies of Scale in Infrastructure:** Lowering costs and impacts
- **“Design One, Build Many”:** Design, engineering, fabrication/modularization, supply chain, and construction efficiencies
- **Innovation through Integration:** Combining proven technologies in valuable and novel ways

1. GigaSystem and RACER are trademarks of Fidelis New Energy, LLC and should not be reused without the written permission of Fidelis New Energy, LLC



Assets and Activities

Carbon Management (CCS)



Carbon Negative Power



Hydrogen/Hydrogen Derivatives



Renewable Fuels



Innovation and Technology Licensing



About Fidelis New Energy

A climate positive, carbon negative company focused on creating large-scale climate impact infrastructure

Company mission

To address climate challenges and energy security through rapid development, delivery, and operation of economically rational decarbonized fuels, energy and materials, and decarbonization services.

Fidelis New Energy description

- Fidelis New Energy, LLC (“Fidelis”) was established by Daniel Shapiro and Bengt Jarlsjo. Fidelis develops climate impact infrastructure within renewable transport fuels, carbon management, carbon negative power, clean hydrogen and hydrogen derivatives, and climate impact technologies.
- Fidelis’ CCS value chain experience has been gained partly through Fidelis’ furthest developed project, the Grön Fuels GigaSystem™ and extensive experience developing infrastructure in the oil, gas, and wastewater injection sectors via previous work experiences. Norne’s development benefits from this deep experience.
- Project Norne’s strategic objective was to provide decarbonization infrastructure to Denmark and the EU by leveraging Fidelis’ global expertise.
- Fidelis New Energy has offices in Houston, Baton Rouge, and Copenhagen.
- The core team of experienced energy industry experts have backgrounds in both traditional, transition, and renewable energy infrastructure, including chemicals production facilities, power production (ranging from solar to wind to hydrocarbons to nuclear), extensive pipeline and power transmission infrastructure development, financing, construction, ownership, and operational experiences.

The Norne team of Fidelis New Energy

 = Chief Executive Office
 = Corporate Development
 = Technical Capacity
 = Fidelis Europe

The Norne Carbon Storage Hub

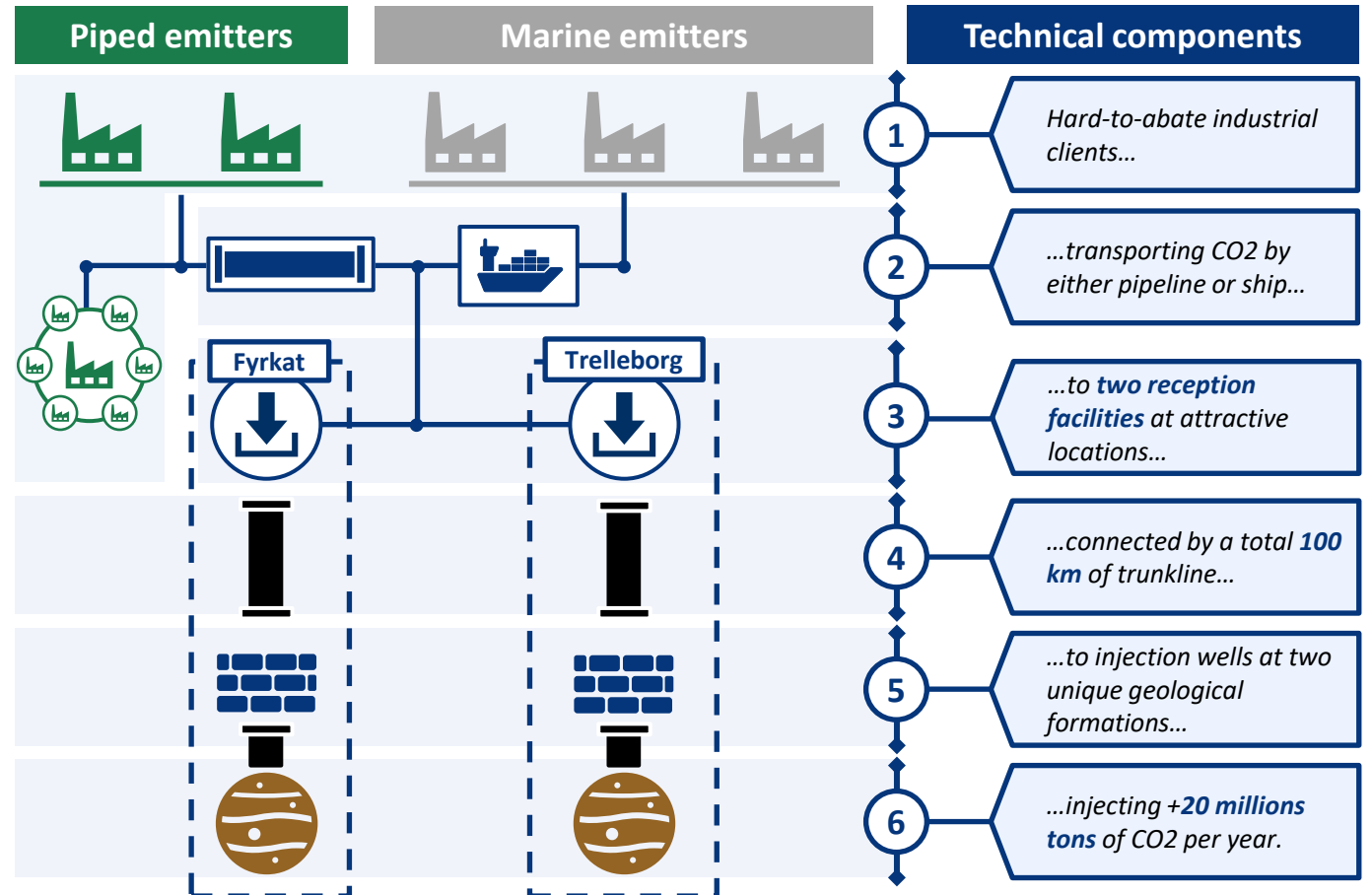
Project Norne, A Northern European Onshore Carbon Storage Hub

Norne is to enable emission reductions from European and local emitters at scale through permanent CO2 storage onshore in Denmark

Norne overview

- Cost efficient CO2 storage
- First regional on-shore large scale storage facility
- Utilizing Denmark's excellent geology
- Storage of local and international Co2
- '26 Operational target date end 2026
- Storage of 18.7 mtpa by 2030 and capacity to grow to 28 mtpa

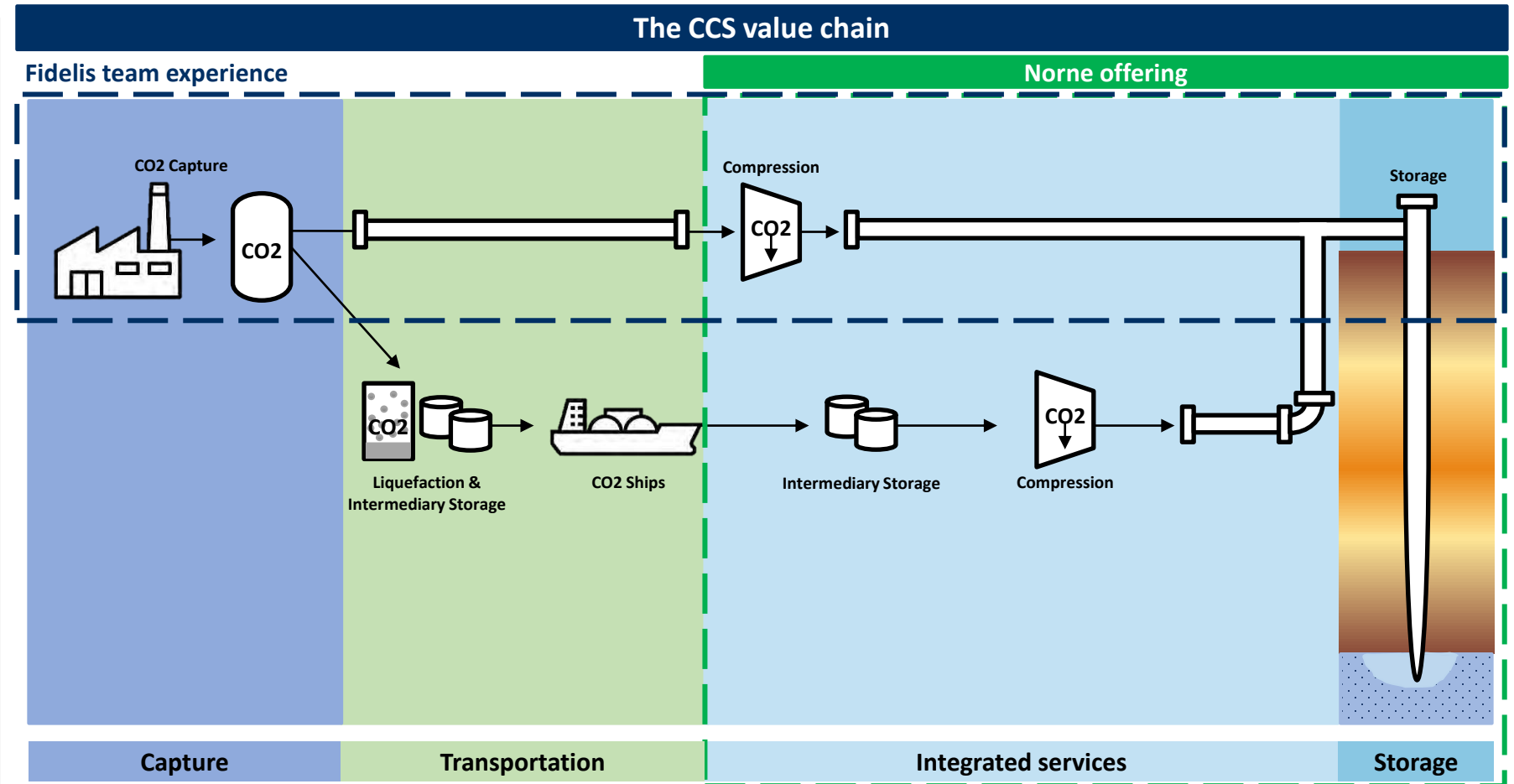
A cross-border storage network with significant impact



Norne's unique value proposition to emitters

Norne focuses on the integrated services of reception, compression, integrated transportation, and storage of the CCS value-chain










- The full CCS value-chain encompasses:
 - CO2 capture at a point-source emitter
 - Transportation of the CO2 from the emitter to an injection site
 - Injection of CO2 deep into the earth with injection wells.
- Emitters are responsible for the capture and transportation to Norne
- Norne takes care of the rest



Current project development progress

Fidelis is developing the first cross-region, cross-border CO2 storage network utilizing Denmark's geology suitable for large-scale CO2 storage

- Supported by DK/EU climate strategy
- Initiated in summer 2021
- **Advanced progress on all major development milestones for the Norne onshore CO2 storage project**

Key milestones of onshore CO2 storage project development	
	Assembly of highly experienced team
	Public process for tendering of exploration and storage licenses as well as relevant strategic environmental impact assessment
	Stakeholder discussions
	Preliminary geological screening
	Establishing valuable partnerships
	Secure infrastructure availability
	Understanding potential “Not-in-my-back-yard” challenges
	Initiate basic design
	Permitting process

CCS is an ideal tool to deliver true climate impact

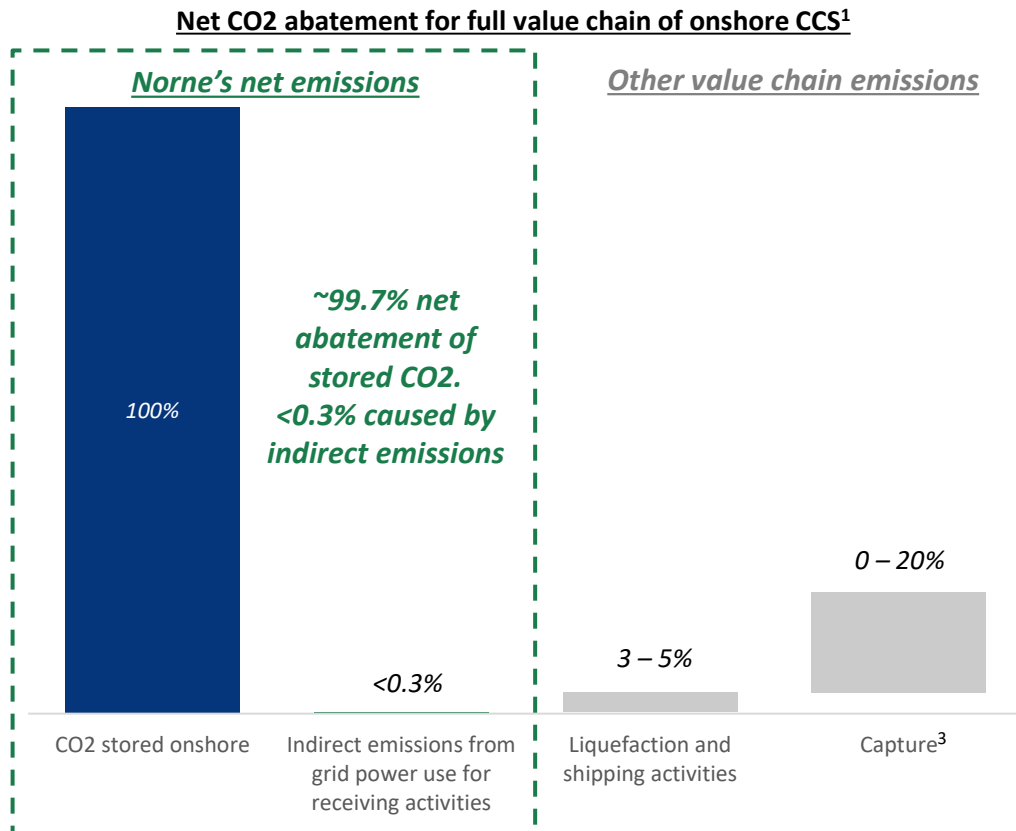
CCS is the only proven solution that can be added to current infrastructure facilities and bring significant emissions reduction impact

Carbon storage is proven and permanent

✓ CCS utilizes **proven capture, transportation, and injection infrastructure technologies** that are widely-used in the oil & gas and chemical industries

✓ CCS is **applicable to existing and new production infrastructure** and is thus ideal for bringing down emissions of processes without an electric alternative

Net abatement for onshore CCS effectively reduces emissions



- **Norne has no direct emissions**, other than negligible fugitive emissions, and its only **indirect emissions are attributed to grid power usage** for receiving activities
- **Conservative estimates of potential CO2 fugitive emissions leakage is 0.02%²** of the transported CO2 across the Norne storage network, an order of magnitude less than the EU taxonomy definition of 0.5%
- Possible to achieve **net CO2 abatement of 97%** of the CO2 captured across the onshore CCS value chain when accounting for all indirect emissions from energy consumption needed and direct emissions from transportation via ship to receiving facilities
- **Clean Danish grid power improves net reduction impact.** All renewable power sources would result in further impact.
- **Biogenic carbon removal can help offset unavoidable emissions that otherwise cannot be viably abated**, helping progress emission reductions towards climate goals

1) Calculations based on Norne CCS value chain and encompasses various capture scenarios. No associated emissions with injection activities due to onsite renewable ancillary power for minimal needs. 2) Conservative fugitive emissions calculations from: <https://www.epa.gov/sites/default/files/2014-02/documents/ldarguide.pdf> and <https://www3.epa.gov/ttnchie1/efdocs/equiplks.pdf> 3) Capture scheme energy requirements, and compression power requirements depend on CO2 stream disposition and concentration. CCS can be configured various ways and can be powered by 100% renewable power, depending on the scale and cost, thus, associated emissions varies considerably.

ON-SHORE CO2 STORAGE

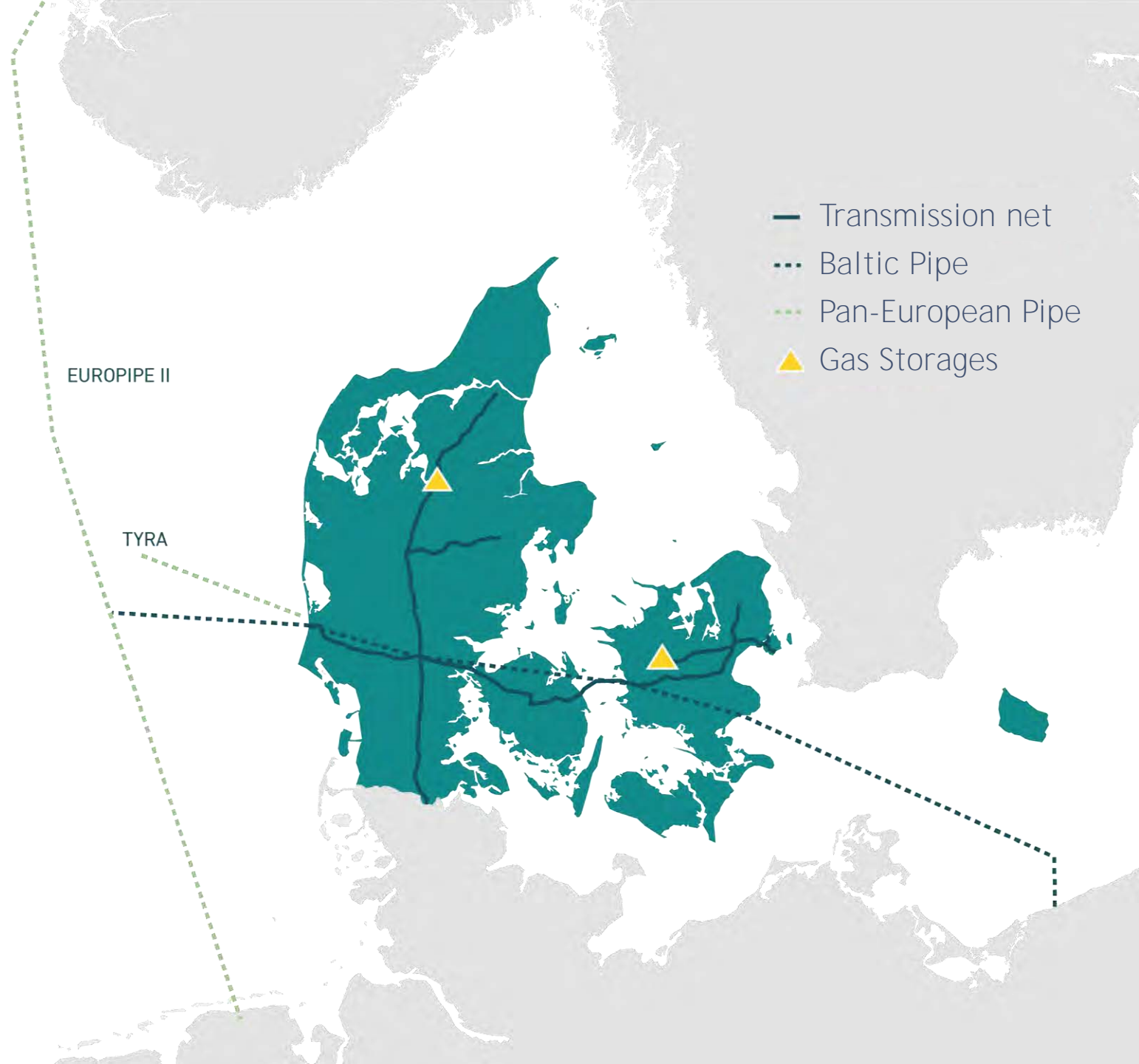
— GAS STORAGE DENMARK —

Simon Sehested,
New Business Senior Manager
Email: svh@gasstorage.dk
Mobile: +45 9390 9392



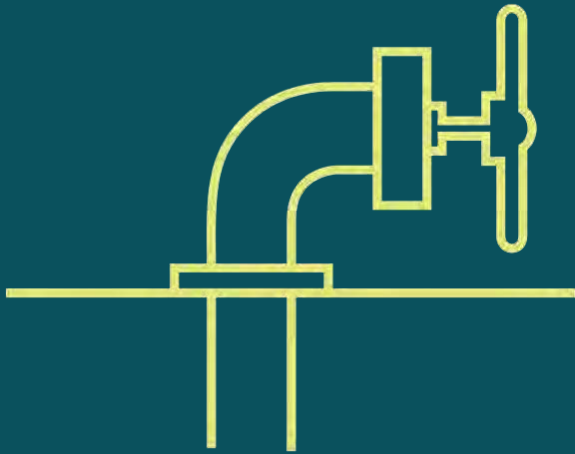
GAS STORAGE DENMARK

- Security of supply
- System services
- Storage and balancing products



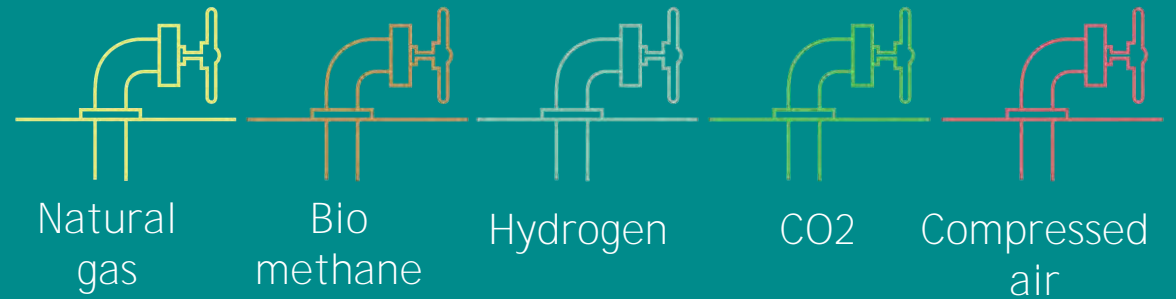
STRATEGIC RESPONSE – NEW BUSINESS LOGIC

Single commodity natural gas storage



Economy-of-scale

Multi commodity energy storage



Economy-of-scope

POLITICAL AND LEGISLATION FOUNDATION

Agreements across parliament, June 2022
”...**parties** agree that GSD can prepare the pilot project for **CO2 storage in Stenlille...**”

Law legislation in place
d.22. december 2022
”...**Energinet and GSD Energinet** can handle activities regarding **CO2 transportation and Storage**”



WHY ARE WE STORING CO2 IN STENLILLE?

Experience

- More than 30 years of operation, with safety, monitoring, communication and good relations with neighbours.

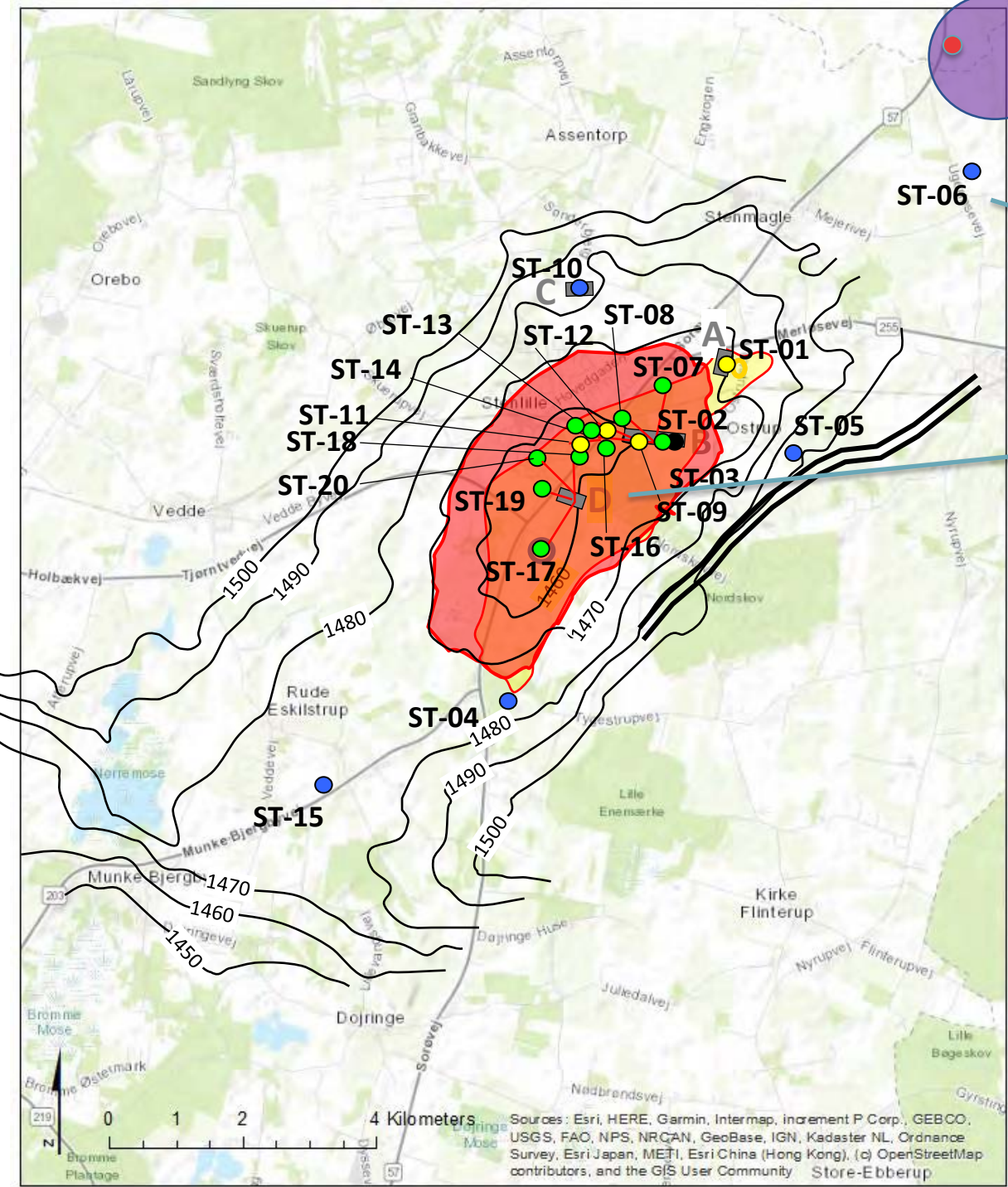
Speed

- Existing infrastructure and organisation enables relatively fast establishing of large-scale operation

Acceleration

- With the pilot project, GSD can actively work together with partners in the industry to reduce risk, optimise setup, and improve timelines for CCS projects in Denmark in general .
-





New wells

Existing well

Natural gas storage

- Total capacity: 8+Mton
- Yearly injection: 0.5 Mton/year
- Lifetime: 20+ years
- First injection planned 2025

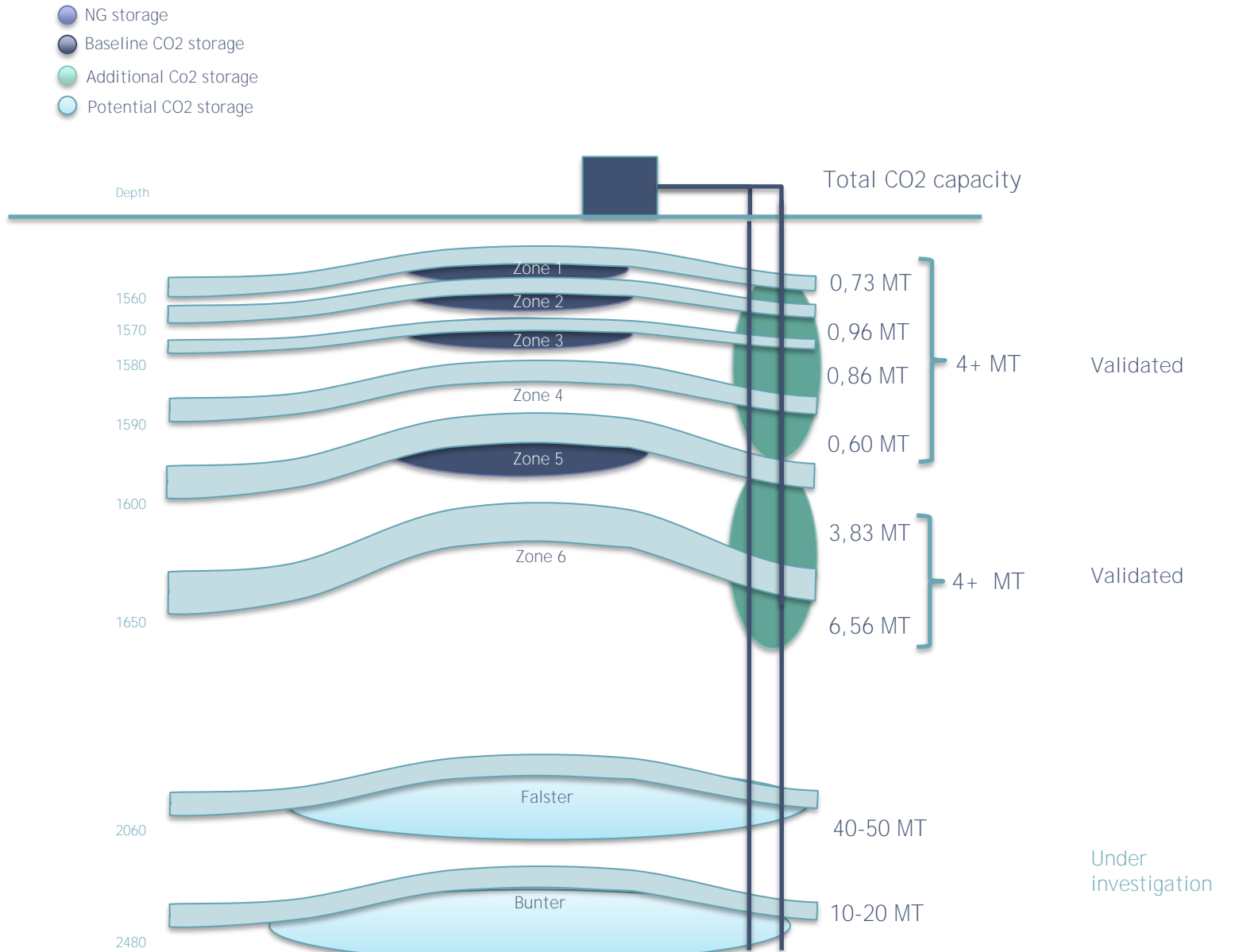
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community Store-Ebberup.

STENLILLE CO2 CAPACITY

- 4+M in Baseline for Zone 1-4
 - Smaller reservoir
 - Low permeabilitet

- 4+M in baseline for Zone 5-6
 - Larger reservoir
 - Higher permeabilitet

- Significant potential in lower layers
 - Very few core samples
 - Limited seismic surveys
 - No operating experience



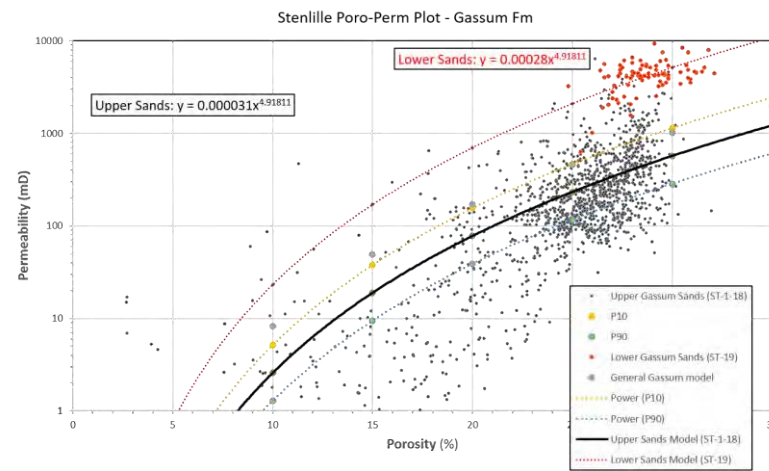
CO2 STORAGE SIMULATION

Key parameters

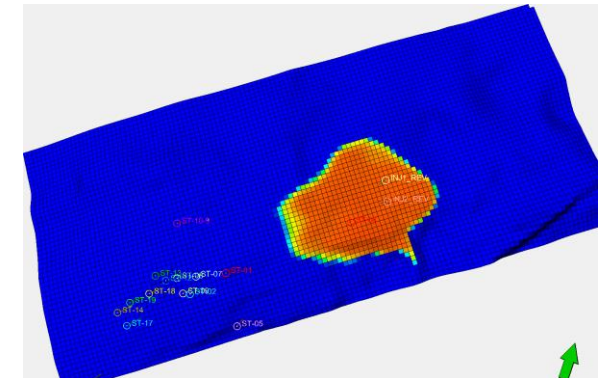
- Based on core samples and experiences
- Simulation of injection profiles
- Monitoring over +100 år

Boundary conditions:

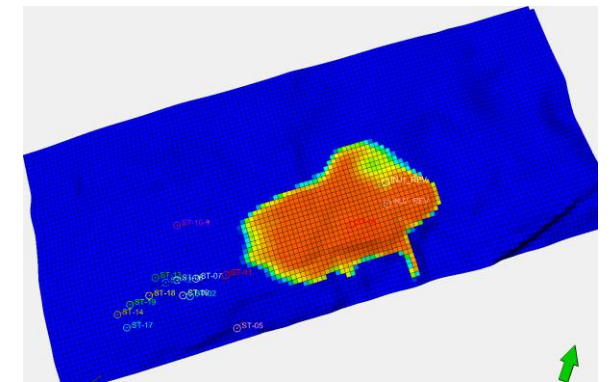
- Safety distance to existing storage
- Seismic and geological conditions
- Avoid saddle points



Base Case. 50 years



Base case. 100 years



POTENTIAL CO₂-INFRASTRUKTUR ON ZEALAND

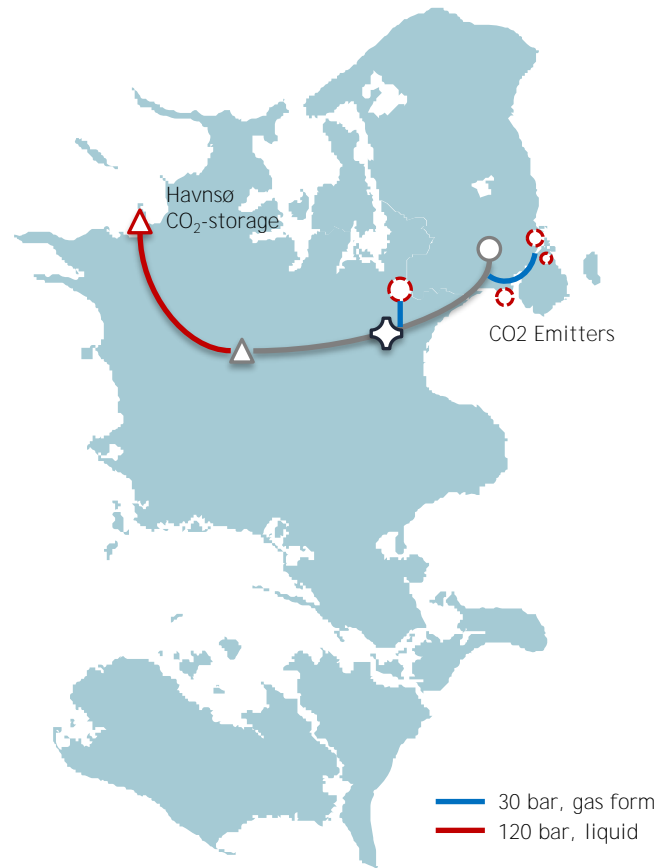


Phase 1



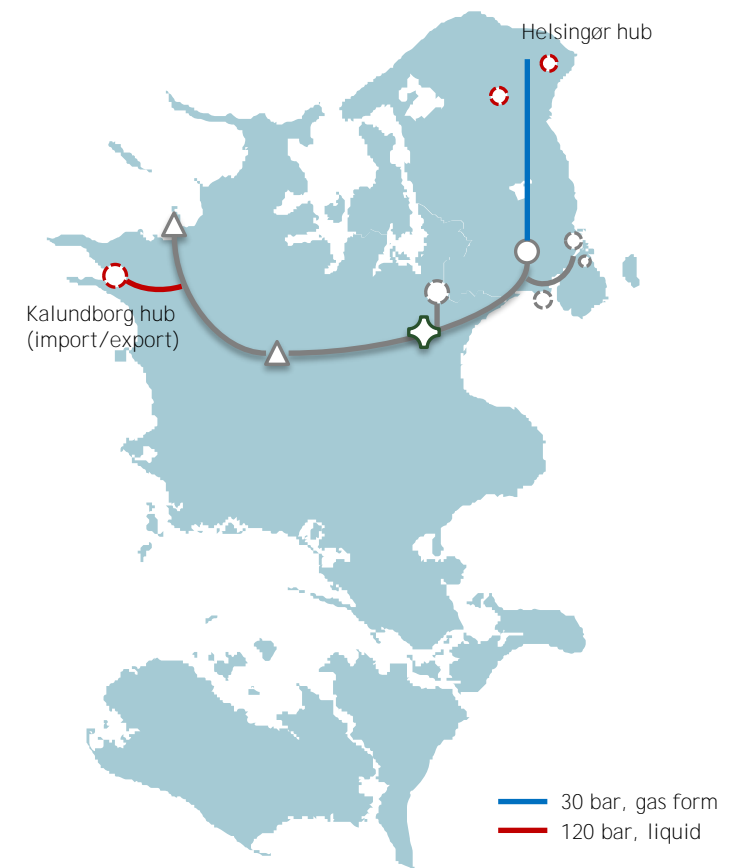
≈ 0,4 mio. tons CO₂/år

Phase 2










≈ 2,75 mio. tons CO₂/år

Phase 3



≈ 2,75+ mio. tons CO₂/år

EXPECTED DEVELOPMENT OF ON-SHORE CO2 STORAGE

	Operation	Capacity [ton]		Cost [EUR]	EUR/ton CO2*	Transport Options
		Yearly	Total			
Stenlille pilot	2025	Ca. 0.5M	8.0M	50-150 mil.	25-50	  
Stenlille CO2	2026	1-2M	+10M	100-200 mil.	10-20	 
Havnsø	2027/8	2-5M+	+200M	0,4-0,8 bil.	7-10	 

* Cost divided on total volumen, inkl. operation og basic return on investment

INEOS Energy



INEOS Energy Corporate Presentation 2023



INEOS Overview

INEOS Group overview



\$65 bn Sales



25,000 employees



39 Businesses



66 million tons of chemicals capacity



17 million tons of refinery products
(360,000 bbls/day)



10 million boe per annum

183
sites worldwide

31 Countries

89 sites
in Europe

36 sites
in Asia

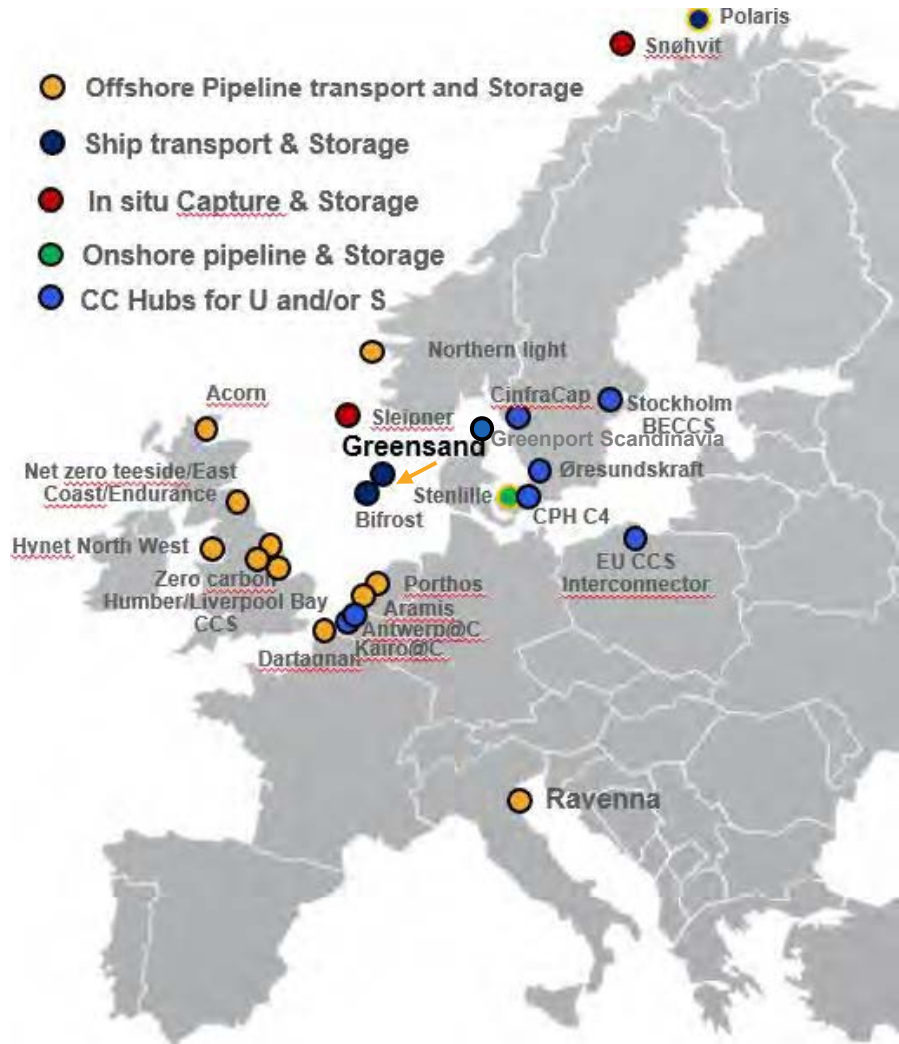
58 sites
in Americas



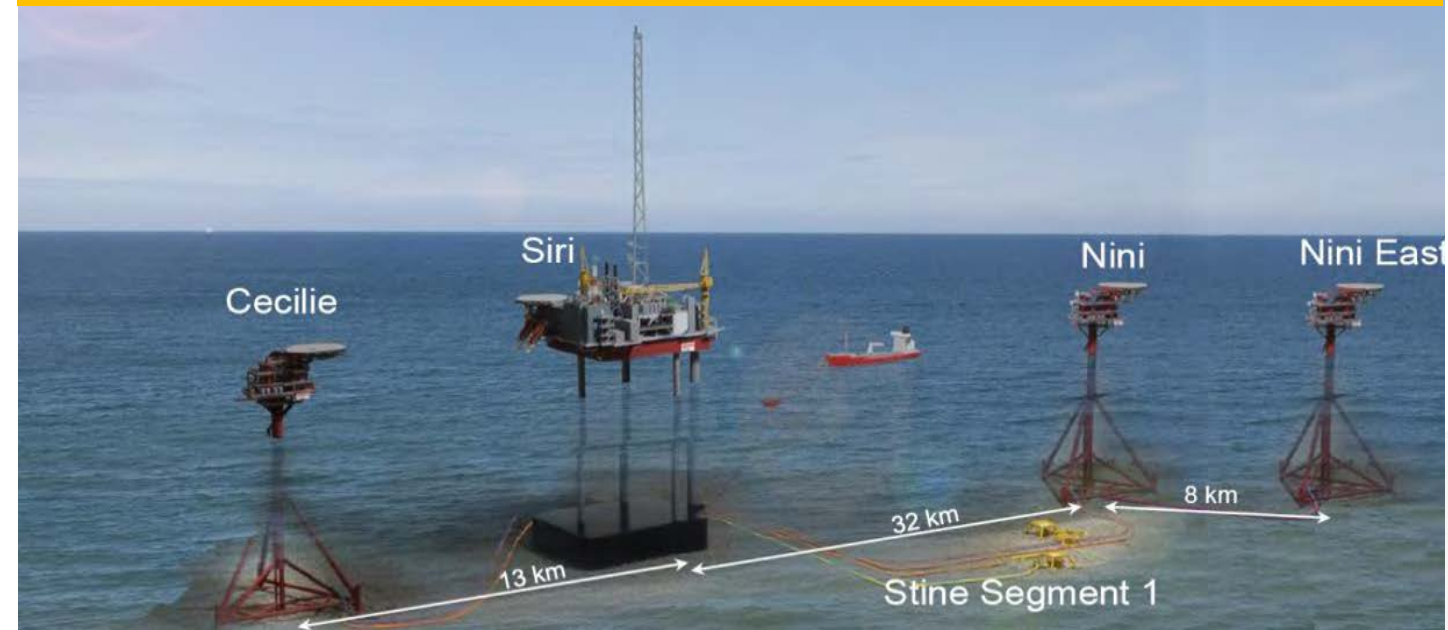
Greensand CO₂ Transport and Storage Project

A CCS project by INEOS Energy, WinterShall Dea and NSF (Danish State)

INEOS in the CCUS space - Greensand Project Overview



Turning the Siri area into a CO₂ storage hub



INEOS CCUS project involvements:

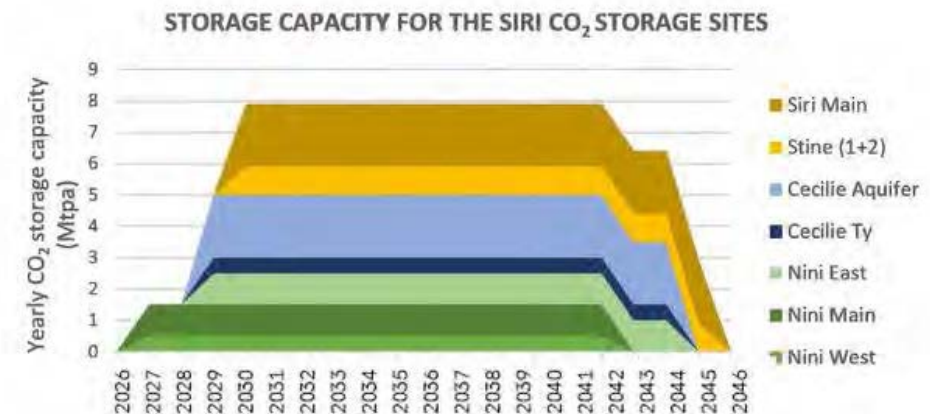
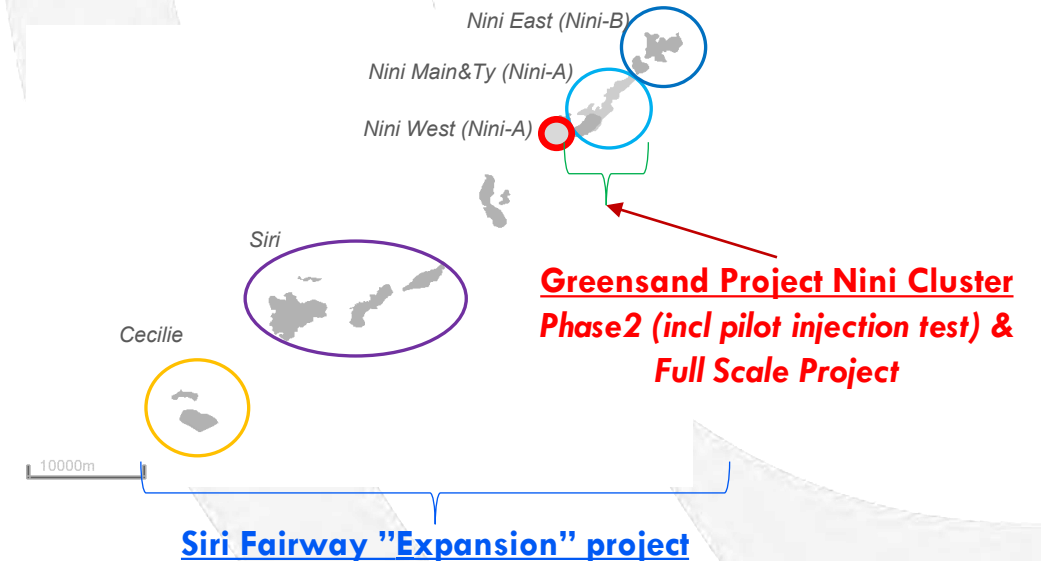
- Greensand
- Acorn
- Zero Carbon Humber
- HyNet
- Antwerp@C

Greensand Project – Transport and Storage of CO₂

Overview



- Use of Siri Area for CO₂ storage
INEOS has experience and huge data set from exploration and production activities in Siri Area over more than 20 years
- Phase 2** Initial Greensand work focused on CO₂ storage in Nini West
 - Offshore CO₂ CCS value chain pilot and monitoring technology testing
 - Material testing, certification, subsurface modelling, etc
- Nini Full scale** project includes Nini Main & West delivering 1.5 MTPA in 2026
- Expansion project** includes remaining Siri area suitable reservoirs – potential 8 MTPA by 2030
- Further upside** potential exist but immature at this point

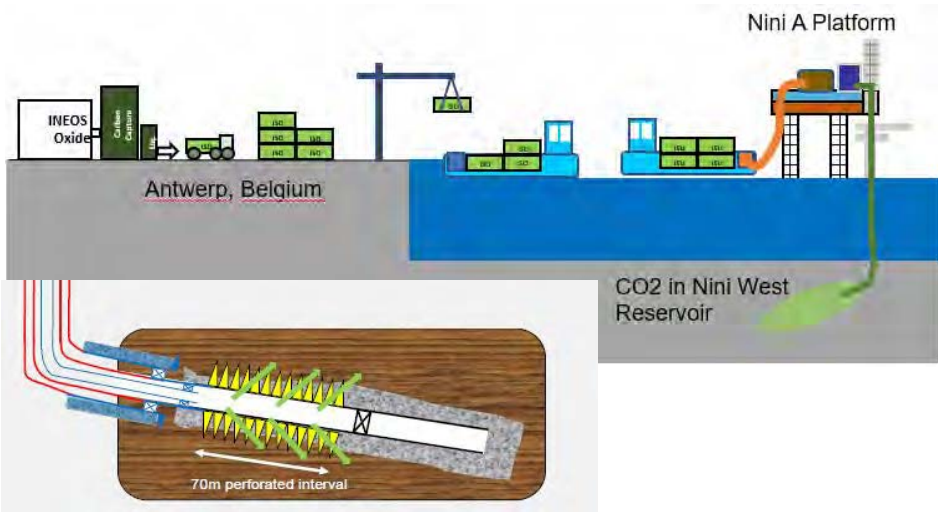


Greensand Project

Phase 2 – Pilot CCS value chain, monitoring testing and further maturation

EUDP O
 Det Energiteknologiske Udviklings- og Demonstrationsprogram
 Government funding of 197 MMDKK received from EUDP in Dec 2021 to support **Phase 2** activities in 2022/23

Pilot Injection Sequence



Strong Phase 2 Consortium of 23 Companies



Key Objectives:

- Test reservoir injectivity (rate/cyclicality)
- Develop pilot full value chain and learn!
- Verify applicability of monitoring technology
- Establish and kick-off full scale maturation process

Siri "green" Sandstone

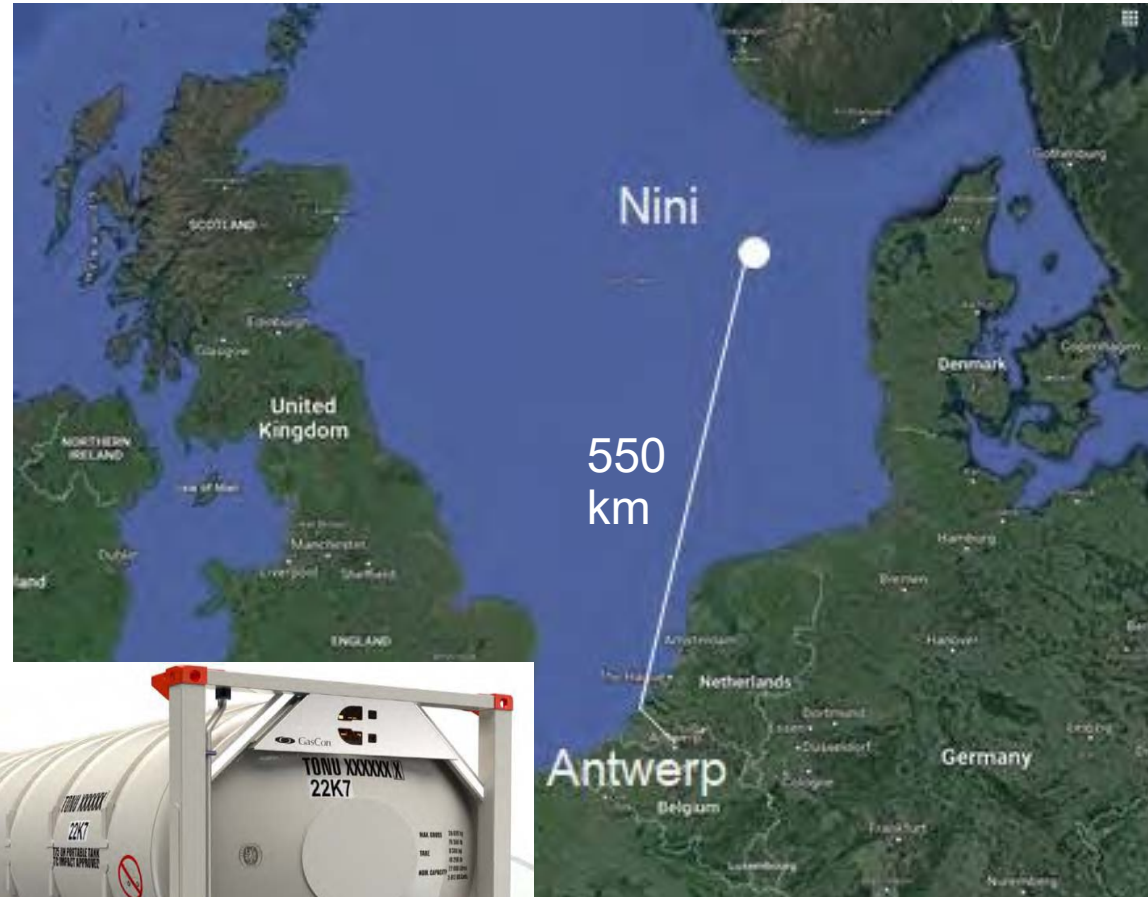


Claystone Chalkstone Sandstone

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Storage Capacity
Phase 1	█											Up to 1.5 MTPA
Phase 2 - Pilot (Nini West) - Offshore injection period			█									
Full Scale (Nini West/Main)							▶ Start Storage					
Siri Fairway Expansion Project											▶	

Greensand Project Phase 2

Injection pilot – the CO₂ journey



Parameter	Value
Liquid CO ₂ conditions	-31°C @ 14 bar to -40°C @ 10 bar (initial vs empty conditions)
Payload	19.6 t
Holding time	30 to 50 days



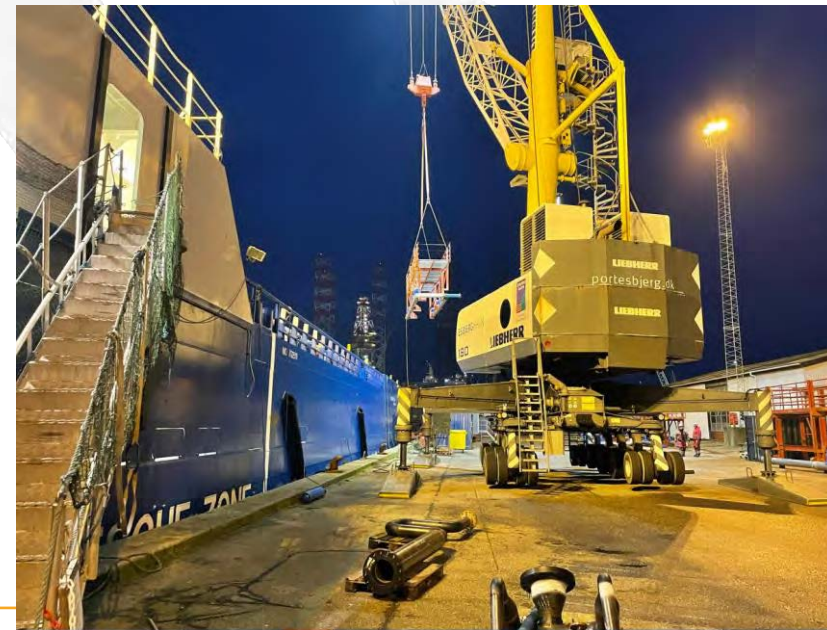
Greensand Phase 2

PSV, Jack-up and monitoring vessel in Esbjerg Harbour (Nov 2022)

- Grillage on PSV to enable safe transport and pumping of CO₂ onboard rig
- Rig to be equipped with HP pump, Heater, CO₂ monitoring and Coil Tubing to facilitate injection into Nini West
- Onshore scope completed
- Moving offshore within short
 - Finalise hook-up of equipment
 - Commence injection and monitoring operations



Greensand Phase 2 Installation activities



Greensand Phase 2

CO2 Loading terminal in Antwerp, Belgium – 3 full ISO tanks shipped for trial testing in Esbjerg



Greensand Phase 2

PSV ship grillage installed - ISO tank trial fitting and testing



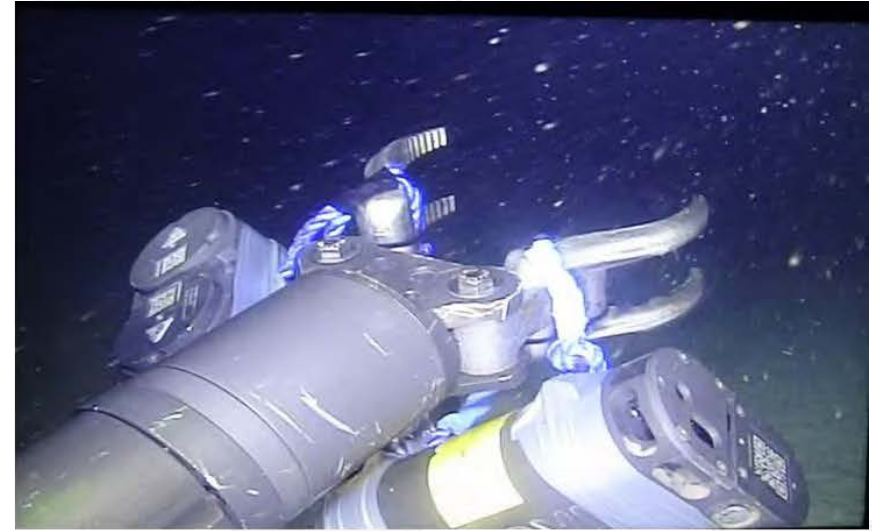
Greensand Phase 2

CO2 loaded on the ship – ready to sail to the Greensand injection site



Greensand Phase 2

Seismic monitoring required to understand the CO2 behavior in the reservoir



Greensand Phase 2

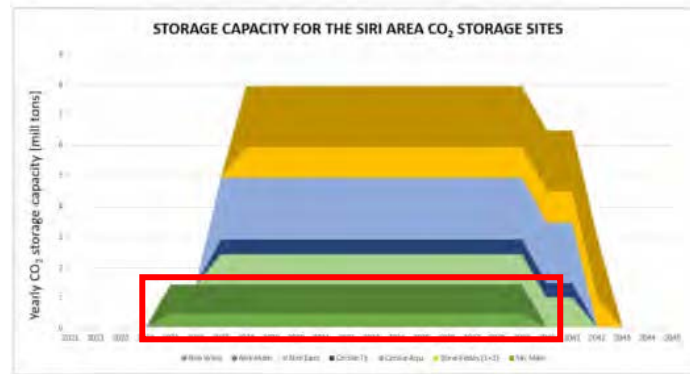
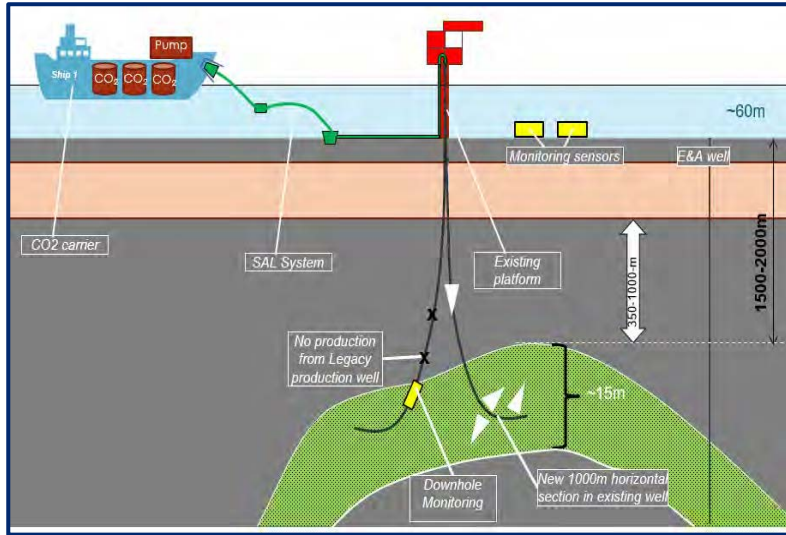
First Storage Event in Esbjerg on March 8th



Greensand Full Scale Project

Starting with a 1.5 MTPA capacity

Full Scale (Nini West/Main) Conceptual Set-up



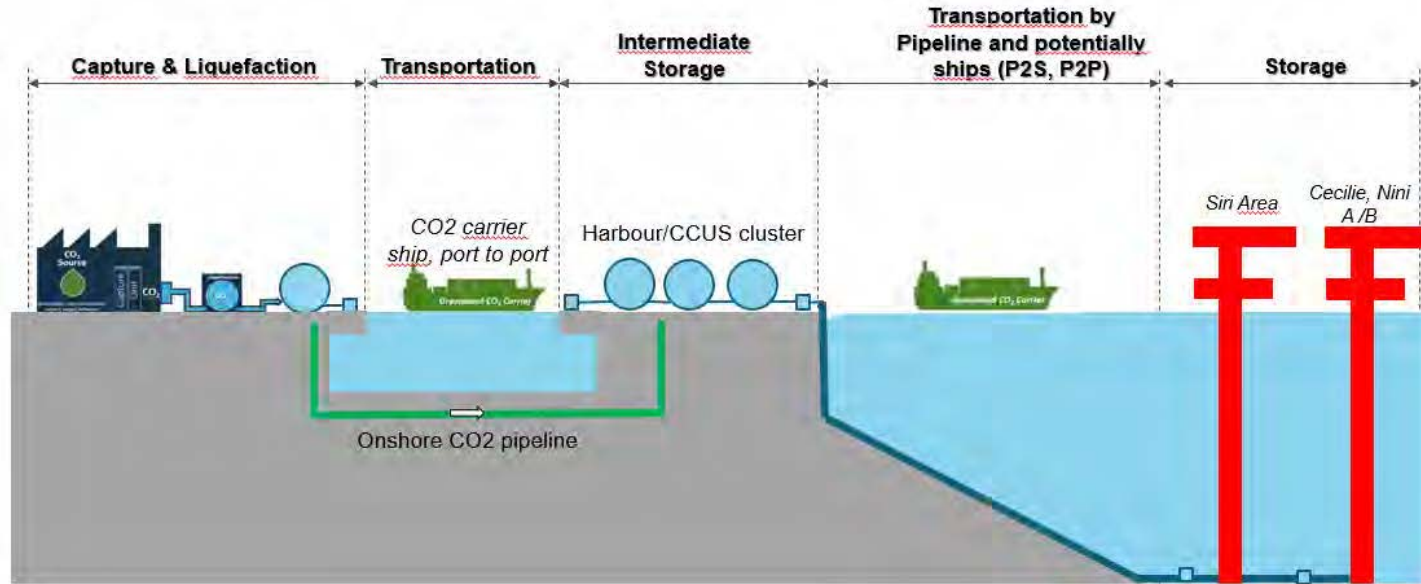
Key activities:

- Mature Nini Main reservoirs
- Mature Development concept
 - Ship design
 - Offloading/Transfer system
 - CO2 injection wells
 - Monitoring set-up
- Establish logistical & commercial model
- Authority approvals
- DnV Storage Site & Site Development CoC's

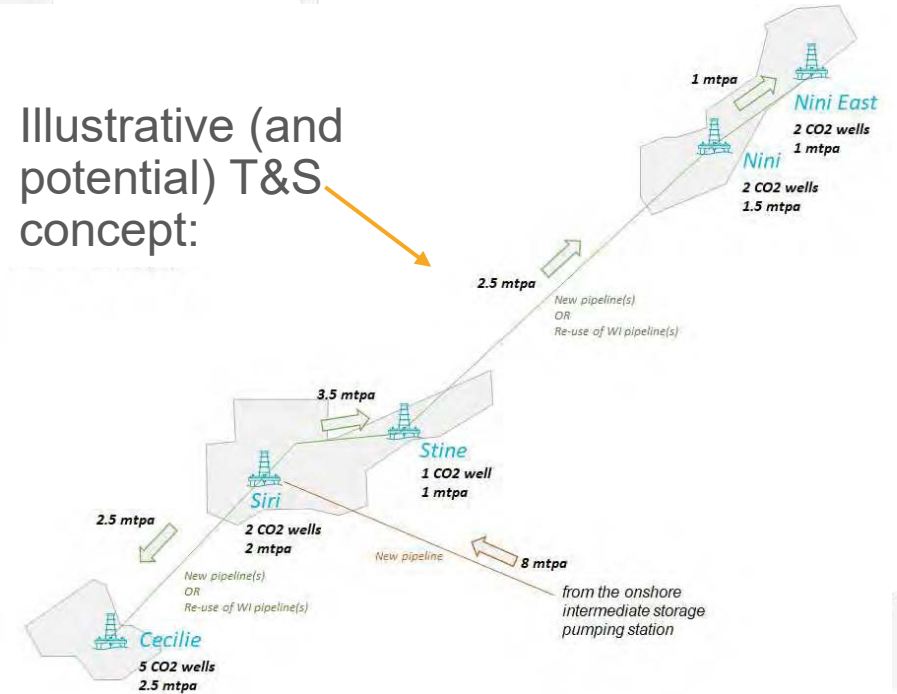
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Storage Capacity
Phase 1	█											Up to 1.5 MTPA
Phase 2 - Pilot (Nini West) - Offshore injection period		█										
Full Scale (Nini West/Main)			█				Start Storage					
Siri Fairway Expansion Project							█					

Greensand – Expanding beyond Full Scale capacity of 1.5 MTPA

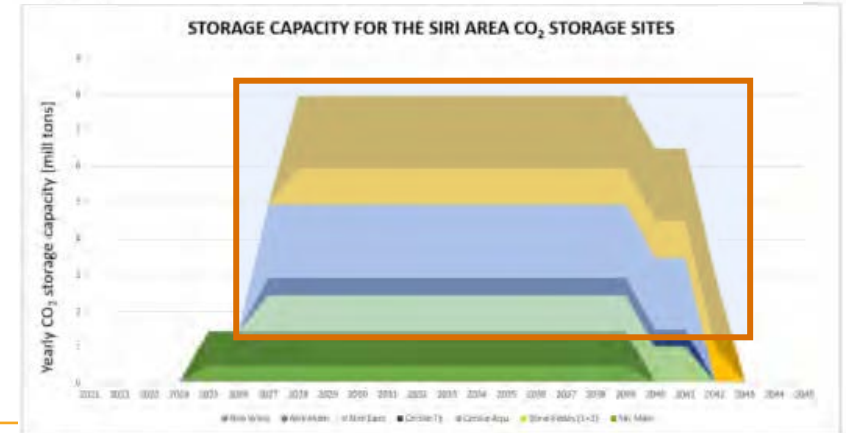
Delivering up to 8 MTPA capacity in existing Oil fields – Siri Hub case



Illustrative (and potential) T&S concept:



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Storage Capacity
Phase 1	█											
Phase 2 - Pilot (Nini West) - Offshore injection period			█									
Full Scale (Nini West/Main)			█			Start Storage						Up to 1.5 MTPA
Siri Fairway Expansion Project						█					Up to 8 MTPA	





About Neptune Energy

Neptune Energy is an independent energy company with operations across Europe, North Africa and Asia Pacific. Neptune aims to store more carbon than is emitted from its own operations and the use of its sold products by 2030. The business had a production of 135,000 net barrels of oil equivalent per day in 2022 and 2P reserves on 31st December 2022 of 552 million barrels of oil equivalent.

Neptune has significant experience with CCS, having carried out a 14-year project in collaboration with TNO on our K12-B platform offshore in the Netherlands, reinjecting CO₂ into the gas field. In addition to that, Neptune is partner in the Norwegian Snøhvit field, which has been reinjecting CO₂ since 2008 and through its other affiliates, Neptune Energy, together with other partners is engaged in the development of several CO₂ storage initiatives for CCS in the Netherlands, Norway and the UK.

www.neptuneenergy.com

<https://www.neptuneenergy.com/media/press-releases/year/2023/neptune-energy-partners-sval-and-storegga-co2-storage-licence>

<https://www.neptuneenergy.com/media/press-releases/year/2023/capeomega-neptune-announce-cross-border-co2-transport-storage>

<https://www.neptuneenergy.com/media/press-releases/year/2023/horison-energi-neptune-energy-and-eon-sign-mou-european-ccs-value>

<https://www.neptuneenergy.com/media/press-releases/year/2023/project-errai-terminal-intermediate-storage-co2-selected>

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L10 CCS project

Neptune Energy is developing a large-scale CO₂ storage project in the L10 area on the Dutch Continental Shelf of the North Sea. CO₂ will be injected in the depleted L10 reservoir complex in the Neptune Energy operated L10/L11 concession. The L10 CCS project has the potential to store 5 million tonnes of CO₂ annually for industrial customers with a total capacity of 120 to 150 million tonnes. It represents the first stage in the potential development of the greater L10 area as a large-volume CO₂ storage reservoir. This first stage is developed together with XTO Netherlands, Tenaz Energy and EBN.

The CO₂ will be transported through the Porthos pipeline or by ships to the CO₂next terminal in Maasvlakte near Rotterdam for onward transportation via the Aramis trunkline to the L10 facilities. L10 injection facilities will be connected via a spur-line to Aramis. The L10 injection facilities consist of a platform hub and a satellite where the CO₂ is injected into the L10 reservoir complex for permanent and safe storage.

The development of the CO₂ injection wells will be phased over the years, such that a constant injection profile of 5 million tonnes per annum for a period of 15 years can be maintained. The spur-line will be oversized to facilitate future developments.

The project plans to start Front End Engineering (FEED) in mid-2023. Neptune Energy aims to submit the storage license in Q2 2023. The L10 CCS Project plans to take an investment decision year end 2024 and start-up year end 2027. Final timeline will be influenced by Aramis trunkline timeline.

A second phase of the L10 CCS area development aims to establish direct offshore injection capabilities whereby a vessel transporting CO₂ can directly inject the CO₂ from the vessel into the reservoir. Neptune Energy collaborates with CapeOmega on this initiative, which is called NoordKaap. The overall objective of NoordKaap is to provide cost-effective, scalable infrastructure solutions to facilitate large-scale, flexible CO₂ transport and storage from multiple industrial emitters clusters.

NoordKaap aims to offer CCS solutions to industrial clusters where ship transport is the primary or earliest available export option. It would provide access to CO₂ subsurface storage sites offshore the Netherlands and Norway.

This subsequent phase will have a minimum capacity of 4 million tonnes of CO₂ per year, initially in the Dutch then Norwegian continental shelf and operations are expected to start from 2028.

The lifetime of the L10 CO₂ reservoirs is estimated to be 20 to 35 years.



Trudvang CCS project

The Trudvang CCS project plans to design, develop, and operate a permanent, geological carbon storage facility in the southern part of the Norwegian Continental Shelf (NCS). The Trudvang project is centred around an offshore CO₂ permanent storage in a saline aquifer. The base case plan is to develop the store through clusters of injection wells connected to an onshore liquid CO₂ receiving terminal on the West coast of Norway. The cryogenic CO₂ can be shipped to the terminal by vessels. A dedicated CO₂ pipeline from the terminal to the geological store is envisaged to be built and owned by the Trudvang project.

The Trudvang project aims to store up to 9 million tons of CO₂ per annum after starting injection in 2029.

The Trudvang project was initiated by Sval and Storegga and Neptune joined the cooperation in September 2022. The Trudvang project has applied for a storage licence with the Norwegian authorities end February 2023.