Candidate PCI projects in cross-border carbon dioxide (CO2) transport networks

in view of preparing the 4th PCI list

This document includes information regarding all cross-border carbon dioxide transport networks projects submitted by projects promoters between 27 November 2018 and 2 March 2019 in view of assessment and preparation of the fourth Union list of Projects of Common Interest, to be adopted in October 2019.

1 ERVIA Cork CCUS

This project will involve the development of the necessary infrastructure to transport captured CO2 from a CCUS cluster of heavy industry (oil refinery) and two gas fired CCGTs to enable the CO2 to be transported either to local geological store or if unavailable to another store managed by another CCUS project developer. The import infrastructure and geological store will also be made available as a backup storage facility to other CCUS developments. The infrastructural development for transportation of CO2 element of the project will require the following:

1. The acceptance of a common set of CO2 compression & conditioning standards for the international transport of CO2

2. The development of facilities for the import/export of CO2 at the Ervia Cork CCUS project to include:

- CO2 transportation pipeline to port facilities
- Appropriate port facilities to enable the import and export of CO2 such as

  i. Condensation & evaporation plant

  ii. Buffer storage at the port to aid the logistics of transport

  iii. Compression and expansion facilities for loading and unloading of CO2

In addition the overall objectives of the CCUS cluster project are to:

 Provide a low carbon source of electricity to support the increase in renewable electricity generation from non-synchronous generation such as wind & solar by providing a low carbon dispatchable and secure supply of electricity

 Create CO2 transport & storage infrastructure with import/export facilities by ship to enable additional national clusters to be developed, to mitigate cross chain default risk and to provide market pressure on off-take contracts

 Develop an anchor project which will enable further additional heavy industry to begin to avail of the CO2 transport & storage infrastructure

 Enable the ability to achieve negative emissions from the storing of CO2 produced from the combustion of biogas

 Enhance the potential for the EU CCUS transport and storage network by working in line with other project developers to create a coordinated approach to developing a CO2 transportation project

Volume of CO2 transported to point of storage

The projected maximum volume of CO2 to the point of storage is circa 300 MT/CO2 within the Kinsale Head gas field and the volume of CO2 transported to this storage point will be to the limit of the capacity of this store. The amount sent to the backup stores will vary depending on store availability but it is anticipated not to exceed 10% of the storage capacity of the project which is 30MT CO2.

Volume of CO2 transported to point of usage

The usage is up to 37,000 T/CO2/year

2 CO2TransPorts

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

• Establishing a Project of Common Interest initiative as a platform for clear dialogue and coordination between the Port Authorities of Rotterdam and Antwerp, and North Sea Port, as well as national gas infrastructure entities and CO2 storage authorities, concerning the efficient and timely development of CO2 transport infrastructure in the region.

• Through a physical cross-border connection, providing Belgium with access to safe and suitable CO2 storage sites on the Dutch Continental Shelf.

• Sending a clear message to industry in the region that access to transport and storage infrastructure is being actively planned for by port authorities.

• Managing the financial risk to public and private investors by implementing a carefully planned phased approach, increasing the transport capacity incrementally as demand from industry arises.

• Aligning with the directions of Member States in the vicinity of the North Sea, through a recognition of the "sensible locations for initial infrastructure development" as established by the North Sea Basin Task Force (2017).

• In advanced phases of the plan, including possibilities for expansion of infrastructure beyond the needs of the represented Member States for potential transport and storage of CO2 from or in third-party Member States.

CO2TransPorts will be developed in 3 phases, listed below. Phases 1 and 2 will provide CO2 transport infrastructure for up to 10 MtCO2/year. However, existing studies indicate that extra capacity may be needed. This will be investigated in Phase 3.

• • **Phase 1 (202310):** This phase is focused on the development of CO2 transport and storage infrastructure at the Port of Rotterdam. This involves the development of an onshore pipeline through the Port of Rotterdam, a compressor station, and an offshore pipeline to access the P18 gas fields for CO2 storage. Due to enter FEED stage Q2 2019.

- **Phase 2 (2026):** In this phase a cross border CO2 pipeline will link the ports of Antwerp and Rotterdam. A CO2 pipeline collection network will be developed in Antwerp and North Sea Port. Through an interconnection between North Sea Port and Port of Antwerp, the CO2 sources in the south will be connected to Rotterdam. This infrastructure provides access to CO2 storage sites in the North Sea for Dutch and Belgian sources; however, to achieve this, additional offshore pipelines must be developed. Currently in feasibility stage.

- **Phase 3 (2030+):** The CO2TransPorts consortium has identified that under certain, reliable economic and regulatory conditions, the total CO2 transport demand from the 3 regions may exceed the maximum design capacity of Phases 1 and 2 of 10 Mt/year. Furthermore, demand for CO2 transport may arise from third-party countries needing access to offshore storage sites. In order to prepare the necessary capacity (pipelines and storage), this will start with a pre-feasibility study. The results will be input for decisions on pipeline dimensioning and storage capacity within Phases 1 and 2. Realisation of Phase 3 is expected from 2030.

This timeline is based on the (operation of) pipeline infrastructure. For each phase studies on (pre-)feasibility and/or FEED studies will be done during the PCI period 2019 – 2021.

3 CO2 SAPLING TRANSPORT INFRASTRUCTURE PROJECT

The CO2 SAPLING project is the transportation infrastructure component of the Acorn full chain Carbon Capture and Storage (CCS) project and its subsequent national and international build out programme. It is the international carbon dioxide (CO2) transportation network that will grow out of the Acorn CCS project.

The CO2 SAPLING project will use existing North Sea gas pipelines that are no longer required for petroleum use as a dedicated transportation infrastructure for captured CO2 (Pale Blue Dot Energy, 2018). This will significantly decrease the financial cost of the Acorn CCS project and other CCS projects attached to the network from around the North Sea Basin. It will extend the useful lives of key infrastructure and defer the financial cost to the oil and gas industry and the social cost of environmental impact associated with the decommissioning of such pipelines.

Previous studies have demonstrated that this re-use approach is a cost effective means of developing CCS projects (Shell UK, 2015a) (Energy Technologies Institute, 2016) and this was re-confirmed in the recent Accelerating CCS Technologies (ACT) Acorn Project work on infrastructure re-use (Pale Blue Dot Energy, 2018) and Connecting Europe Facility (CEF) funding Action 12.2-0001-UKNL-S-M-18 for CO2-SAPLING.

These pipelines will be re-used solely for the transport of anthropogenic CO2 to permanent storage sites in the North Sea. This will be an efficient use of resources as multiple emission sources, and storage sinks, can be connected to the transportation network. This will be initiated using a low-cost existing CO2 source and storage site in the UK before it is expanded to connect with sources around the North Sea Basin and across the EU via tanker shipping between the UK, Netherlands and Norway. Incremental storage and EOR opportunities within the Norwegian North Sea can also be linked using pipeline extensions of less than 80km.

Significant progress has been made since the previous CO2 SAPLING Proposal for Application, made for the 3rd Project of Common Interest (PCI) list in April 2017. Award of the 3rd PCI listing status has been instrumental in progressing the Acorn CCS Project and has directly enabled the project to secure four main sources of funding, with matched funding from UK Government, Scottish Government and industry. These four sources provide funding for the complete feasibility and Front End Engineering Design (FEED) for the project, with complete integration and no overlaps of scope between any of the funding packages. This will enable the Acorn CCS Project, and therefore CO2-SAPLING, to progress to the Final Investment Decision (FID) for Phase 1 in 2020.

4 Northern Lights

The Northern Lights PCI is intended to be a 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.

The preferred concept uses a transport and storage solution where CO2 is collected by ship from industrial sites in Europe and is offloaded at an onshore location on the west coast of Norway. At the offloading location CO2 will be buffered in tanks, conditioned and sent by pipeline (approx. 110 km) offshore to a subsea template where the CO2 will be injected in the Aurora formation (south of the Troll field), a part of the geological structure Johansen, approximately 3000 meters below the seabed. Equinor was awarded an exploitation permit for CO2 storage in Aurora on 11 January 2019. The Northern Lights project is expected to have significant spare capacity for volumes beyond the design capacity for phase 1 and 2 (see below), which is to store at least 100 MT of CO2 over 20 years.

The current project design is based on Phase 1, with flexibility to include additional volumes in Phase 2 subject to incremental investments for increased capacity. Below is a description of both phases of the project:

Phase 1: Concept capacity to transport, inject and store up to 1.5 MTPA of CO2. Given a positive final investment decision from the Norwegian State and the project partners in 2020, Phase 1 is planned to be operational in 2023.

Phase 2: Should markets support it, and partners take a positive final investment decision, development of Phase 2 could be realised under the condition that the CO2 transport capacity in Phase 1 is filled. Phase 2 would include capacity to receive, inject and store an additional 3.5 MTPA of CO2, adding up to a total of 5 MTPA of CO2.

Three critical factors for the total 5 MTPA of CO2 capacity will be included already in phase 1, namely the basic functionality of the receiving terminal, offshore pipeline, and the umbilical to the offshore template. Both phases will offer flexibility to receive additional volumes from European CO2 sources, beyond the 800,000 TPA of CO2 which would come from Norway if both of the initial Norwegian projects are realised (Fortum Oslo Varme and Norcem, each with 400,000 TPA). Capture initiatives listed below could use Northern Lights as their primary transport and storage solution. The total potential volumes of CO2 from these sites add up to considerably more than 5 MTPA. Further expansion phases could be considered by project partners subject to market conditions and final investment decision.

5 ATHOS

This project entails the development of a large-scale, open-access interoperable high-volume CO2 transportation infrastructure from mainland Europe and Ireland to CO2 storage locations in the Dutch section of the North-Sea to enable emission reduction for industrial CO2 emitters in the NZKG (and potentially from the Irish capture plants (located at the Aghada & Whitegate CCGTs and the Irving Oil refinery) and the Ruhr area of Germany.

Customers are planned to be large emitters from the NZKG area.

The NZKG area is a highly suitable location for a CO2 transportation and storage gateway for two reasons:

• It has large industrial clusters in close proximity, both in the Netherlands (the IJmuiden-Alkmaar-Amsterdam triangle, the Rotterdam area and in the hinterland the cluster near Sittard-Geleen) and across the border (the industrial cluster near Antwerp, Belgium and the heavy and chemical industry of the Ruhr area, Germany). Within a

radius of 200 km these CO2 emission sources stemming from the power and industrial sectors of Rotterdam, Antwerp and North Rhine-Westphalia accumulate approximately 260 Mton/a CO2.

• It has easy access to abundant CO2 storage capacity in the North Sea, i.e. depleted natural gas fields.