Form 1: General information on the project NER 300 bid with on-shore storage

Prepared by:	Joost Muusze (Essent)
Reviewed by:	Roald van Mastrigt (Essent)
Approved by:	J.Brouwer (CATO-2 Director)

1 Executive Summary

The proposed Carbon Capture Project aims to develop a cost effective 250 MWe CO2 capture facility at the Eemshaven power plant in the North Netherlands (borough of Eemsmond, circa 35km North of Groningen). The proposal covers the full CCS chain and consist of a post-combustion capture unit using amine solvent technology, which will be connected to an onshore depleted gas field by 2015 and aims to store in excess of 7 million tonnes over a ten year period, depending on the – by the Dutch Government – selected storage field.
The differentiating aspect of the proposed project compared to other Post Combustion CCS projects, is the storage facility. Unlike other projects, the proposed project foresees to store the CO2 in an onshore depleted gas field, near the power station in the Province of Groningen. The Groningen area hosts many suitable onshore gas fields, with a combined capacity in excess of 200 Mt. The area provides not only an outlook for future storage, but will also function as a ground breaking demonstration for other areas which have limited access to offshore storage, but do have onshore capacity.

The attached form provides a summary overview of the project, addressing the project objective, anticipated costs, the technical concept from capture to storage and project related concerns.

Distribution List

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Document Change Record

(this section shows the historical versions, with a short description of the updates)

Version	Nr of pages	Short description of change	Pages
See header	1 - 13	First version	

Table of Content

2 Applicable/Reference documents and Abbreviations

2.1 Applicable Documents

(Applicable Documents, including their version, are the "legal" basis to the work performed)

	Title	Doc nr	Version
~~AD-01a~~	~~Beschikking (Subsidieverlening CATO-2 programma verplichtingnummer 1-6843~~	~~ET/ED/9078040~~	~~2009.07.09~~
~~AD-01b~~	~~Wijzigingsaanvraag op subsidieverlening CATO-2 programma verplichtingennr. 1-6843~~	~~CCS/10066253~~	~~2010.05.11~~
~~AD-01c~~	~~Aanvraag uitstel CATO-2a verplichtingennr. 1-6843~~	~~ETM/10128722~~	~~2010.09.02~~
AD-01d	Toezegging CATO-2b	FES10036GXDU	2010.08.05
AD-01f	Besluit wijziging project CATO2b	FES1003AQ1FU	2010.09.21
AD-02a	Consortium Agreement	CATO-2-CA	2009.09.07
AD-02b	CATO-2 Consortium Agreement	CATO-2-CA	2010.09.09
~~AD-03a~~	~~Program Plan 2009~~	~~CATO2-WP0.A-D.03~~	~~2009.09.17~~
~~AD-03b~~	~~Program Plan 2010~~	~~CATO2-WP0.A-D.03~~	~~2010.09.30~~
AD-03c	Program Plan 2011	CATO2-WP0.A-D.03	2010.12.07

2.2 Reference Documents

(Reference Documents are referred to in the document)

	Title	Doc nr	Version

2.3 Abbreviations

(this refers to abbreviations used in this document)

3 Application Form 1: General Information on the Project

General Information on the Project

The purpose of this Application Form is to collect summary information on the proposed Project. Further Application Forms request more detail about the nature of the proposed Project.
This section is to be completed by the Project Sponsor.

A1.1. General Project details

Please complete the following table in respect of the proposed Project.

Table A1.1.1 General Project details

	Question	Response
a	*Technology category/sub category (refer to Annexes 2 & 3 of the Call for Proposals).*	CCS: Power Generation: Post Combustion 250MWe [CCSpos]
b	*Project name*	Eemshaven CCS
c	*Please provide details of Project location(s) and geographical coordinates of all relevant elements of the Project.*	The host site for Essent's carbon capture demonstration will be the Eemshaven power plant on the North Netherlands' coast in the borough of Eemsmond, circa 35 kilometres north of Groningen (Coordinates 53°45'01.36"N, 6°84'54.27"E) The CO2 will be stored onshore in one or more depleted gas fields appointed by the Dutch Government. Three fields are under consideration, namely: • Sebaldeburen: 53°22'49.59"N, 6°29'55.42"E, • Boerakker: 53°19'44.39"N, 6°36'89.16"E, both west of Eemshaven, and • Eleveld: 52°57'25.81"N, 6°34'36.69"E, south of Eemshaven. The Dutch government is expected to select the site for the demo project in Q1 2012. The Project Sponsor developed 4 storage concepts: the 3 fields as stand alone option and the combination of Sebaldeburen and Boerakker. The Project Sponsor has the latter one defined as its base case storage solution. Until the decision of the storage field, two alternative pipeline routes are developed, mostly following existing natural gas

	Question	Response
		pipeline routes: • West route (73 km) to Boerakker/Sebaldeburen • South route (80 km) to Eleveld For Sebaldeburen and Boerakker a combined compressor unit will be constructed at the Grootegast site, 5-7 km from both fields. (Coordinates:53°13'46.68"N, 6°19'37.28"E)
d	*Member State*[1]	Netherlands
e	*Full name of relevant department in Member State/Lead Member State and name of departmental contact.*	The Minister of Economic Affairs, Agriculture and Innovation Attn. mr. drs. P. van Slobbe Acting Project Director CCS of DG Energy, Telecom and Markets of the Ministry of Economic Affairs, Agriculture and Innovation P.O. box 20101 2500 EC The Hague
f	*Is this Project a Trans-boundary Project? (Refer to definition in section 5.4 of the Call for Proposals).*	No
g	*If the response to (f) is yes, please provide details of the other Member States involved (state name and relevant department)*	Not applicable
h	*Total Project cost (over Operation Period)*	Base case*: Capital Expenditures: € 417,380 10-year Operational Expenditures: € 717,686** Total:: € 1,135,248 *all numbers in Real Term 2010 / excl. escalation **Excluding operational benefits
I	*Total Project Relevant Cost for Operation Period (10 years for CCS and 5 years for RES projects)*[2]	n/a

[1] Lead Member State in the case of Trans-boundary projects
[2] Where appropriate, relevant costs to be determined following definition of the reference plant by the Member State as outlined in the Call for Proposals. If the reference plant is not determined at the point of submission of application forms to the Member State, this item should be left blank and completed prior to submission to the EIB in consultation with the Member State.

	Question	Response
j	*Amount of Funding sought under NER 300 (EUR m)*[3]	€ 318,574,000
k	*Project Outputs:* ***CCS projects** – state total CO2 stored over Operation Period [t] and CO2 stored annually [t/year]:*	Project base case: • 9.2 million tonnes over 10 years • On average 920,000 t/year
l	*Proposed date of entry into operation*	13 November 2015
m	*Total Project duration*	10 years

[3] The amount of funding requested from NER 300 will normally depend on the relevant cost determination (see point (i)), which in turn will require, where appropriate, definition of the reference plant by the Member State. If the reference plant is not determined at the point of submission of application forms to the Member State, this item should be left blank and completed prior to submission to the EIB in consultation with the Member State.

A1.2. Please provide a general outline of the Project (additional sheets can be used where necessary).

The Project Sponsor has a 1,560 MW coal fired power station under construction at Eemshaven in the North of the Netherlands (borough of Eemsmond, circa 35 km north of Groningen). The Project Sponsor is part of the RWE group and has an overall objective to reduce its CO2 footprint. CCS has been identified as an important means to realize this target.

The Essent Eemshaven Carbon Capture Project aims to develop a cost effective 250 MWe CO2 capture facility at the Eemshaven power plant. The post-combustion capture unit using amine solvent technology will be connected to a CO2 transport and storage infrastructure.

The plant will be operational by November 2015 and aims to store 9.2 million tonnes over a 10-year period in the base case storage solution: the combined Sebaldeburen/Boerakker storage. In this storage solution injection will start at the Sebaldeburen field and switch to the Boerakker field after Sebaldeburen has been filled up. Depending on the Dutch Government's final field selection, other storage cases will be considered. The Project Sponsor has concluded several Memoranda of Understanding and Cooperation Agreements with contractors and service providers that cover the entire CO2 chain.

The nearly depleted gas fields in the North of the Netherlands together have a potential storage capacity of 7.5 Gigatonnes and can be connected via 2 pipeline routes, one going west and the other one going south. Given that the Eemshaven capture site hosts 1,560 MWe of hard coal-fired generating capacity, there is potential for future expansion.

Objectives

To achieve its overall aim, the project will focus equally on implementing a robust technical solution and on achieving public acceptance for CCS through demonstration of a safe and reliable means of low-carbon electricity generation. In addition, the project aims to share its findings with all relevant stakeholders to maximize the public support for the project.

The following detailed objectives have been identified:

- Technical objectives:
  1. To capture CO2 using an efficient amine-based, post-combustion capture technique
  2. To efficiently transport the CO2 from the capture site to the site of a former gas field
  3. To undertake geological storage of the CO2 in a depleted hydrocarbon reservoir
- Non-technical objectives:
  1. To disseminate generated foreground to all relevant stakeholders
  2. To create public acceptance for this project and CCS in general

The following key features of the project will ensure that these objectives can be met:

- One of the main hurdles to be overcome in order to commercialise CCS technologies is to minimise large, negative impact on the overall power plant efficiency. Most capture techniques are very energy intensive, which is why for this project Essent have selected a technology that aims to be highly efficient and which has been shown in pilot and modelling studies to reduce power plant efficiency by less than 10%-points.

- To transport the captured CO2 to the storage site, transport infrastructure is required. In the Northern Netherlands, as in many parts of mainland Europe, CO2 transport requires the cost effective and safe implementation of pipeline transport. This project will demonstrate the safe and cost effective onshore transport of CO2 through close attention to design, resulting in an optimised solution that takes into account both storage and capture, and by making use of existing natural gas pipeline routes that can ultimately form part of a wider transport infrastructure. For transportation and downstream compression, the Project Sponsor has concluded a Cooperation Agreement with Gasunie and Ocap, which both have extensive expertise in the area of constructing and operating (CO2) pipelines.
- Storage of CO2 in a depleted hydrocarbon field requires careful handling of CO2 to prevent downtime of the entire chain, thereby maximising capture and storage, as well as to ensure both safety of operations and longevity of the storage. In the Eemshaven CCS project the CO2 will be stored in a one or more depleted gas fields that are pre-selected for geological storage by the Dutch Government. The fields are currently still producing gas and operated by NAM. The Project Sponsor has ensured the support from RWE Dea as a consultant in the development phase and as storage Operator for the operational phase. The storage will be monitored closely to establish both verification of the storage and to establish the safety of the entire operation. The Project Sponsor is committed to develop an independent research block which will focus on these issues.
- All relevant technical expertise and experience obtained during the project will be shared with European industry and regulatory stakeholders. This will include dissemination of the technical foreground related to capture, transport and storage of CO2 in a form fully compliant with the EC NER 300 Knowledge Sharing requirements and also additional communication of results and know-how to the wider national and international CCS community.

In addition to the objectives related to the technical realisation of the project and dissemination of result, the success of the project and CCS in general relies on public acceptance. Therefore a specific objective will be to focus on local and more general public acceptance of CCS through a dedicate programme of activities addressing public health, safety and environmental concerns. This programme will be developed in close cooperation with relevant stakeholders.

Essent and the RWE Group have carefully selected a power plant that fulfils the essential criteria for a CCS demonstration, including:

- suitable base power installation (>250 MW, coal-fired)
- high power plant efficiency of 46.85%
- high power plant availability of 8,000 h.
- free space to install the CSS unit
- possibility to create new infrastructure
- suitable nearby storage capacity
- support from national and local authorities
- expansion potential

Essent's Eemshaven development consists of two identical ultra-supercritical ("USC"), hard-coal fired Benson-boilers of state-of-the-art design. The specification of the boilers is as follows:

- Nominal gross power output per unit: 780 MWe (before carbon capture)
- Steam production: 610 kg/s
- Steam pressure: 285 Bar
- Steam temperature: 600°C (after superheater)
- Steam temperature: 610°C (after reheater)

The greenfield site is ideally fitted for a power plant, with ample space for both the demonstration plant and future expansion for additional carbon capture capacity following the successful completion of the project. The high efficiency of seawater cooling is perfectly suited to maximise the efficiency of amine-based post-combustion capture, maximising solvent capacity in the amine absorber. The capture unit will take approximately one third of the flue gas from one of the 780 MWe units. Part of the energy required for the capture will be obtained by heat integration, minimising the use of low-pressure steam from the advanced Siemens steam turbines. The Eemshaven power plant design also features nine-stage preheating, maximum waste heat recovery from the flue gas and optimisation of auxiliary power to improve the overall efficiency of the process. There is also the facility to co-fire up to 10% biomass (thermal basis). A successful demonstration of >85% CO2 capture would therefore pave the way for a truly zero CO2 fossil fuel plant in the future.

Overview of Capture and Storage Concept

Essent's proposal is to implement post-combustion capture, based on the principle of amine scrubbing, to transport the separated, highly purified CO2 in the compressed gas phase to a hydrocarbon reservoir and inject it for permanent storage, verified by a programme of monitoring and safety assessment.

The amine-based CO2-scrubbing process is based on well established gas separation principles employed in the chemical, petroleum, and gas industries for many years, though under process considerable different conditions from the ones in power plants. The innovation in applying this technology to power generating plant is in managing the solvent stability in an oxidising environment, minimising the energy consumption and scaling up the technology to handle the throughput of flue gases required for a full-scale utility boiler.

The process is illustrated in Figure A1.2.1 involves passing the flue gases first through a cooler and then through an SO2 pre-scrubber to optimise the condition of the flue gas prior to contact with amine. The flue gas then passes through a CO2-capture tower containing amine solvent, which selectively absorbs CO2 by formation of a chemical bond. The steps cooling, pre-scrubbing and washing will be combined in one column in the demo plant. The cleaned CO2-lean flue gas is released into the atmosphere via the power plant stack. The solvent flows through the absorption tower in the opposite direction to the flue gases to maintain a constant reaction driving force. The amine-CO2 complex passes in solution to a second solvent regeneration vessel, in which it is heated by steam taken from the power station turbine intermediate pressure to low pressure cross over. The heat breaks the amine-CO2 chemical bond generating free CO2 and the regenerated amine is passed back to the CO2-capture tower for reaction with further flue gas. The CO2 passes through a washing section, to remove traces of amine, and then through a condenser to reduce moisture content, resulting in highly pure CO2. Water content is reduced in the compression/dehydration section by use of a mol sieve.

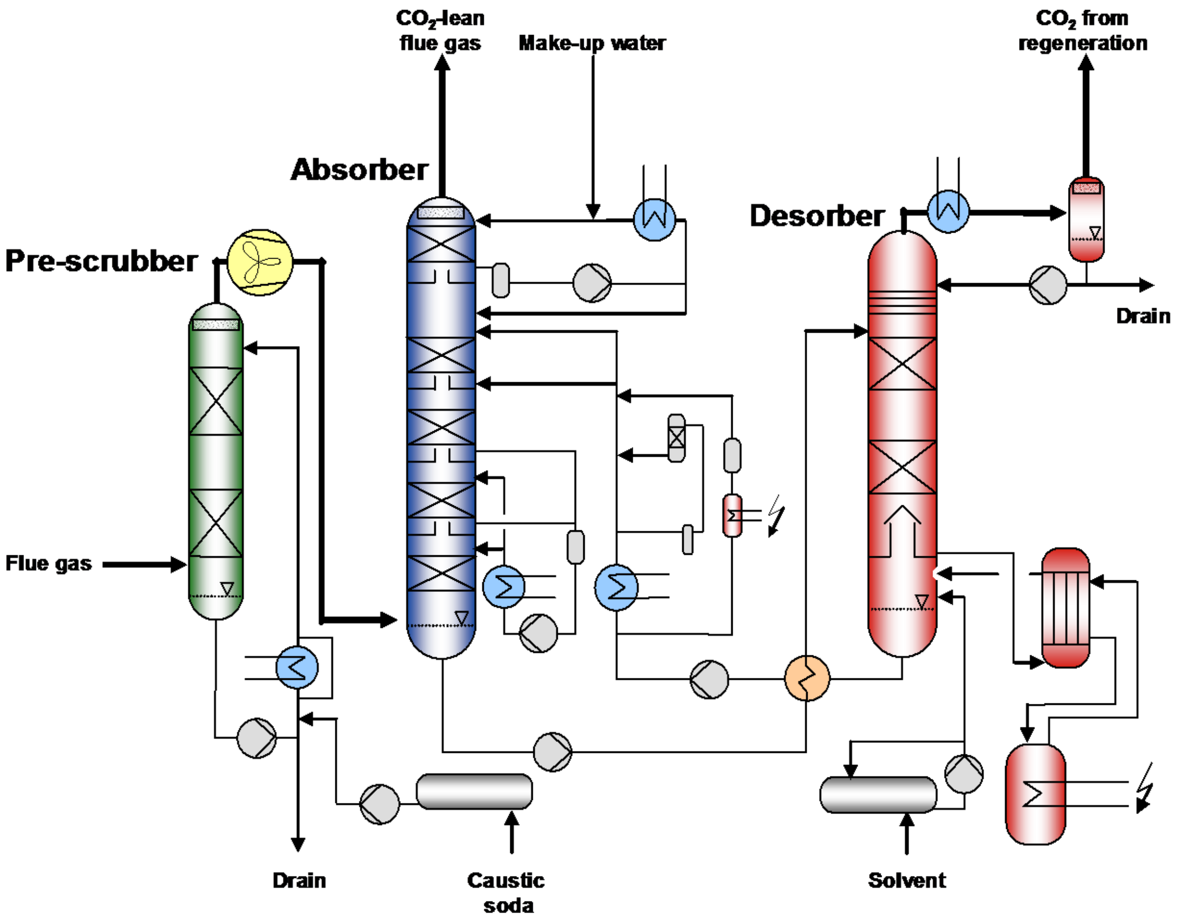

Figure A1.2.1: Schematic of CO2 capture process (pilot plant)

The process includes heat integration within the cycle to ensure that the unreacted amine is as cool as possible when it contacts the flue gas, which promotes the binding of CO2 to the solvent and increases the amount of CO2 carried by the solvent. This reduces energy involved in heating water, which plays no part in the chemical reaction. Also, as the reaction between amine and solvent generates heat, so there is a cross over heat exchanger between the two capture and regenerator vessels to reduce the demand for steam for CO2 regeneration from the turbine.

After separation CO2 needs to be compressed for transport and injection. In the specific Eemshaven application an optimised solution has been developed in which dehydration and initial compression to 40 bar(a) will take place at the capture site. The compressed CO2 will then be transported some 70-80 km from the capture facility to the depleted gas field at this pressure prior to entering a further CO2 compression and injection facility designed specifically to provide optimum performance for the well conditions of the reservoir. In the base case combined Sebaldeburen/Boerakker storage solution, the compressor facility will be built at Grootegast which is located at 5-7 km distance of these fields. Dense phase flow lines will be constructed to transport the CO2 to the injection facilities at the wells.

The specific advantages and innovations of this approach are:

- CO_2 is transported onshore at modest pressures in a very safe gas phase, minimising the risks of problems caused by freezing and blockage of pipes caused by the Joule-Thompson cooling effect on sudden rapid expansion of dense phase CO_2 in the event of physical damage to pipes
- Minimal risk of corrosion of pipes as a result of avoidance of condensation and phase concentration of traces acids and other impurities which might occur with CO_2 transport in the dense phase; this makes CO_2 transport highly suitable for onshore applications and uses existing experience at transporting CO_2 in this form. It also avoids the requirement for more expensive higher grades of pipe material to be used
- An availability of over 7000 hours over the whole chain which can be considered as high for a demonstration project.

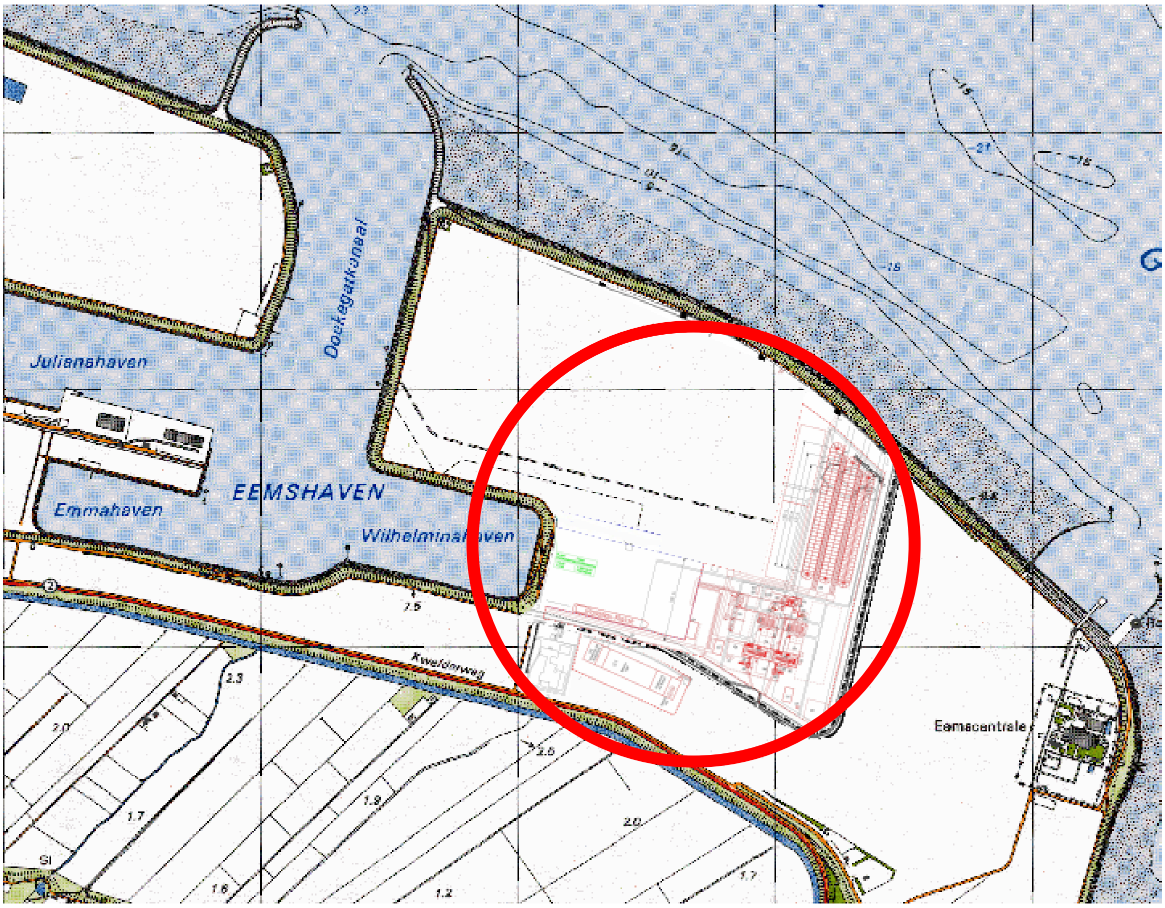

Figure A1.2.2: Location for the demonstration capture plant in the Eemshaven harbour

Three nearly depleted gas fields have been considered by the Dutch Government for storage for the Eemshaven demonstration, of which two, Sebaldeburen and Boerakker, are located to the west of Eemshaven and one, Eleveld, to the south. The west fields require a (shared) pipeline of 73 km from the Eemshaven power plant; the Eleveld field requires an 80 km pipeline to the south. The CO_2 pipeline routes are selected to make use of existing natural gas pipeline routes where possible, which will be beneficial for the purposes of both economics and consenting, though a new dedicated pipeline will need to be laid. All three fields and the intended routing of the pipelines are illustrated in Figure A1.2.3.

The Project sponsor identified 4 storage concepts: the three fields as stand alone solution and a fourth solution as the combined Sebaldeburen/ Boerakker solution. The Project Sponsor defined the latter as the base case solution for reasons of economics and risk mitigation. In this solution CO2 injection will start in Sebaldeburen, fill it up and switch to the Boerakker field after seven years. In case the Sebaldeburen or Boerakker field will be selected, either stand alone or combined, the compression facility will be projected at Grootegast, a location at a distance of some 5-7 km from Sebaldeburen and Boerakker. Dense phase flow lines will transport the CO2 to the injection wells. The compressor at Eleveld will be on the storage site.

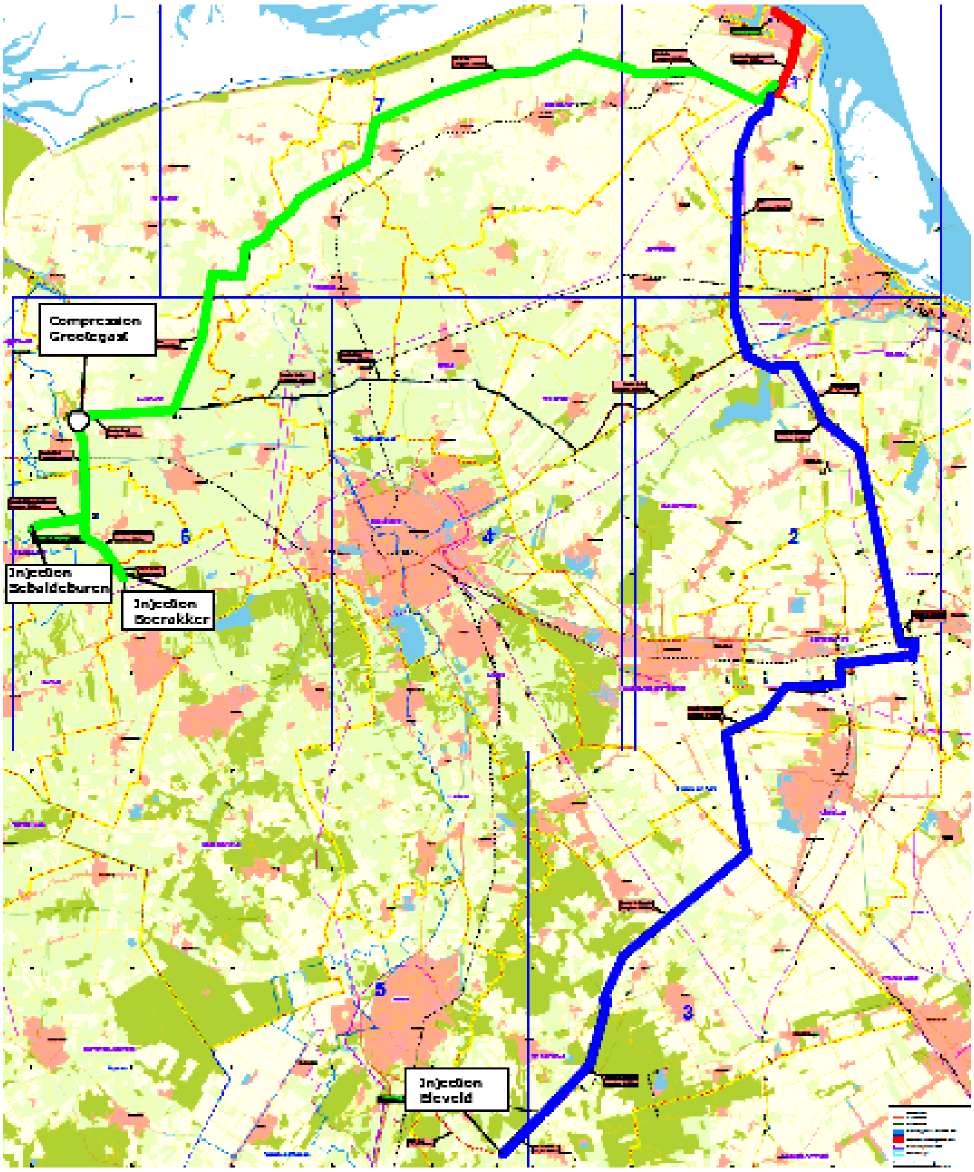

Figure A1.3 1: Storage sites and pipeline routes relative to Eemshaven

There are a large number of CO_2 emitters in the area surrounding the Eemshaven power plant with intentions to capture and store their CO_2, e.g. AkzoNobel, who have expressed their test CO_2 capture on an industrial scale. There are also plans for CO_2 re-use on the chemical park Delfzijl, approximately 15 km from Eemshaven. The Dutch National Government as well as local authorities have expressed their support for the development of a national CO_2 cluster in Northern Netherlands that will make use of the infrastructure to be developed in this project.

A1.3. Where the Proposal is being submitted under paragraph 2 of Article 6 (derogation from paragraph 2 of Article 6 of the Decision), please provide a detailed explanation below.

Not applicable.

A1.4. Please describe any major elements of complexity of the Project (trans-boundary issues, institutional set up, organisation structure, crossing border infrastructure, technology, planning, design, externalities, etc):

The Project Sponsor has identified the following major elements of complexity:

- Integration between the power plant and the capture unit with all the interfaces is a challenge from a technical point of view
- An additional technical complexity will be to achieve optimal energy synergies between the power station and the capture unit
- It will be challenging to keep the emissions within the boundaries of the permits
- The timely selection of the storage sites; this process will be steered by the Dutch government and can to a large extent not be controlled by the Project Sponsor
- The process of the receiving irrevocable environmental permits, where there are many authorities involved with a potential for delays
- An insufficient level of public acceptance may lead to severe resistance to CO_2 pipelines and storage as we have seen in another CO_2 storage project at Barendrecht
- The process of the CO_2 storage license which is very new to the Dutch authorities.