Executive summary of the CCS NER 300 bid with on-shore storage

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1 Executive Summary

The proposed Essent Eemshaven CCS bid for the New Entrants Reserve of the European Emissions Trading Scheme for subsidising installations of renewable energy technology and Carbon Capture Storage (CCS), aims to develop a cost effective 250 MWe CO2 capture facility at the Eemshaven power plant in the North Netherlands. The post-combustion capture unit using amine sorbent technology will be connected to an on-shore 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.
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 impact of the project.

The main detailed objectives of the CCS project can be summarised as:

1. Technical objectives:
   - To capture CO2 using an efficient amine-based, post-combustion capture technique
   - To efficiently transport the CO2 from the capture site to the site of a former gas field
   - To undertake geological storage of the CO2 in a depleted hydrocarbon reservoir

2. Non-technical objectives:
   - To disseminate generated foreground to all relevant stakeholders
   - 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:

Optimised capture plant performance. Essent has selected a BASF / Linde technology which has already been successfully tested in the RWE test facility in Niederaussem and which will be further optimised during the development of the proposed CCS project

To transport the captured CO_2 to the storage site, transport infrastructure is required. Essent will effectively make use of the combined Gasunie, OCAP and in-house expertise to demonstrate the safe and cost effective onshore transport of CO_2, taking into account both storage and capture. By making use of existing pipeline routes the transport line can ultimately form part of a wider transport infrastructure.

For the CCS Eemshaven project Essent has reviewed several depleted gas fields with various expert companies, such as TNO and RWE Dea. Besides reviewing the suitability and storage capacity of the potential storage fields, attention has been given to the monitoring of storage in order to establish both verification of the storage and to establish the safety of the entire operation.

A focus on local and more general public acceptance of CCS through a dedicate programme of activities addressing public health, safety and environmental concerns. For this purpose, Essent will develop a specific communication program, tailored to the specific phases of the CCS project.

In view of the number of CO_2 emitters in the Eemshaven area, the intention of the various parties in the area and the proximity of suitable (nearly) depleted gas fields, the Essent CCS proposal provides the necessary potential for future expansion.

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
2011.10.07	1 - 13	First version	
See header	1 - 13	New Executive Summary	2

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

Unique aspects within the post-combustion operational framework of NER300:

- 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.

4 Application Form 3: Project Summary / Specification Post Combustion CCS

Unique aspects within the post-combustion operational framework of NER300:

- Essent its CCS proposal covers the full Carbon Capture Storage chain and has Memoranda of Understanding and Cooperation Agreements with the various expert companies for the further development and realisation of the various steps in the CCS chain:
  - BASF / Linde for the capture unit;
  - Gasunie and OCAP for the development and operation of the transport;
  - RWE Dea for the development and operation of the storage.

- Selecting the main contractors upfront for the various parts of the project, provides the proposed CCS project important advantages:
  1. Selection of capture technology at this early stage allows for extensive testing and further development of the solvent. Adding security towards the stability of the solvent and the energy efficiency;
  2. Each company can contribute its expert know-how to its specific part of expertise, while having the full insight of the overall project, reducing project risks and capital & operational costs;
  3. The selection provides comfort to all stakeholders, regarding the expertise and the professionalism of the involved contractors. The quality and professionalism of the selected contractors ensure timely and cost effective project execution, without compromising on safety and, or quality;
  4. The CCS project is a demonstration unit consisting of several distinct steps. By working closely together from the start of the project, the whole CCS chain can be optimised to the maximum level.

- These advantages are clearly demonstrated by the input from the expert companies as provided throughout the proposal, making the proposal in every aspect a realistic proposition.

5 Application Form 4: Start Date and Implementation Post Combustion CCS

Unique aspects within the post-combustion operational framework of NER300:

- 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.
- The CCS project will be developed in accordance to Essent's 'Ways of Working (WoW)'. This ISO 9001 certified methodology defines distinctive phases, each having a pre-defined list of deliverables, leading to increased accuracy and insight with respect to cost, time, quality and project risks. This systematic approach is based on experience in the industry combined with Essent's know-how and experience in the field. As a result of the Essent WoW, Essent has developed a sound track record in the management of assets from development to realisation and operation, such as the Claus C project (repowering project), the Moerdijk II project (Greenfield CCGT project) and German Epe Cluster (gas storage project).
- Considering the CCS project is a first in kind, Essent has signed a Memorandum of Understanding with several expert companies:
  - RWE Technology GmbH: lead contractor;
  - Linde-KCA-Dresden GmbH: contractor for Engineering, Procurement and Construction Management of the power plant connections and CCS installation, including on-site compression facilities;
  - BASF SE: licensor for the capture process, supply the process solvent;
  - Gasunie/OCAP OCAP (JV of Linde Gas Benelux and Visser & Smit Hanab B.V): consortium for the engineering, supply, installation and commissioning of the CO2 pipeline infrastructure and downstream compression facilities.
  - RWE DEA: technology provider for the preparation of the CO2 storage field and the operator for injection of CO2 during the operational phase.
- These companies have been actively involved in the preparation of the bid and have provided their respective expertise to all aspects of the project. Based on Essent's experience in executing large capital projects, the actual testing of the technology, the engineering work and performed studies with the various specialist companies and research institutions, to date, Essent is confident that it can perform the required services in a timely, cost effective and safe manner, meeting NER 300 objectives, as further described in this Application Form.

6 Application Form 5: Relevant Environmental Assessment and Relevant National Permits

Unique aspects within the post-combustion operational framework of NER300:

- The Eemshaven location was, amongst others, selected for the power plant due to its excellent location regarding the infrastructure for CCS. Depleted gas fields are nearby, as is the expertise needed to successfully integrate the CCS chain
- Thanks to the recent permitting process for the power plant, Essent has a detailed view of all stakeholders involved for the CCS permitting process, the necessary permits and the permit discussions around CCS. Essent also has a clear view on any issue that might arise during the (nature protection) permitting
- The projected CO2 pipeline will mostly follow existing natural gas pipeline trajectories, for which environmental impact assessments have been done by Gasunie
- Essent proactively discusses the plans for CCS with all stakeholders i.e by communication via the Borg Foundation
- The Project Sponsor and partners have broad experience in obtaining all necessary permits in the Netherlands for large-scale projects
- Based on the input and the gained experience from the power plant and the expertise from Gasunie, OCAP and RWE Dea, the project team has prepared a permitting plan. The provided permitting plan indicates that the permits are scheduled to be in place on time for start of operation in 2015.

7 Application Form 7: Confirmation of Location Post Combustion CCS

Unique aspects within the post-combustion operational framework of NER300:

- Three potential locations for CO2 storage are selected: Boerakker, Sebaldeburen and Eleveld and a fourth option the combination of Boerakker and Sebaldeburen.
- As yet no selection of a final storage location for a demo CCS project has taken place. The Dutch government takes an important role in this. The Minister of Economic Affairs, Agriculture & innovation (EL&I) will be responsible for a special environmental impact assessment ('Plan MER") that will ultimately lead to the selection of the storage site. The Minister has started a dialogue with the provincial authorities in the North of the Netherland in order to improve the local support for CCS.
- For the possible acquisition of storage sites the Project Sponsor has concluded a Memorandum of Understanding with the current operator of these fields.
- Depleted gas fields have favourable conditions to store CO2.
- There is potential for further development of CCS due to the abundant availability of CO2 sources and additional depleted gas fields with a combined storage 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 of-shore storage, but do have on-shore capacity.
- Storage location(s) are in close proximity of the power plant. Therefore transportation costs are not excessive.
- The transportation remains onshore which creates no marine related issues.
- Transportation routes do not cross State boundaries; the Project stays within the jurisdiction of the Netherlands.
- CO2 pipeline routing follows existing natural gas pipeline corridors as much as possible which may make the permit procedure easier.
- Pipelines and storage sites are not situated in densely populated areas or in nature conservation areas.

8 Application Form 10: Technical Scope Post Combustion CCS

Unique aspects within the post-combustion operational framework of NER300:

- CO2 will be captured using a novel CO2 capture technology developed in Europe as a result of an intensive development program in cooperation between a power plant operator, a chemical manufacturer and an engineering company.
- The capture unit incorporates a new optimized solvent and absorber design, which has demonstrated excellent energy and solvent consumption characteristics and good materials compatibility.
- The capture technology is tested under real power plant conditions in one of the first capture pilot plants in Europe. It has outstanding retrofit potential, allows very flexible operation and is robust in terms of CO2-product quality and environmental performance (i.e. minimisation of waste streams).
- Pilot trials have been carried out to test and validate the performance of the technology to be employed. The pilot plant will be used in the development phase of the project to assist in the detailed design and testing of additional novel components, including:
  - a waste water treatment process to remove nitrogen-containing species, especially ammonia and amines,
  - a thermal reclaimer, to recover solvent from breakdown products produced during long term operation.
- Heat integration measures are incorporated in the capture component of the chain and the overall process of the CCS chain is optimised for maximum performance
- The CO2 captured and stored will exceed 85% of the CO2 content of the flue gases to which capture is applied, which are equivalent to 250MWe gross before CO2 capture.
- CO2 infrastructure i.e. transportation, compression and storage will be provided by experienced and reputable companies using proven and state of the art technology.
- The gas reservoirs that have been appointed by the Dutch government for CO2 storage provide pressure and temperature conditions to ensure a safe and enduring containment of CO2 in a dense phase at the end of injection. Furthermore, the geological structures that have been trapping natural gas for millions of years ensure a safe and permanent storage of CO2. This is based on in-depth studies by TNO. The Dutch government will select the final storage site.
- Each reservoir has at least one CO2 injection well and a well suitable for monitoring. In addition the Project Sponsor will drill another injection well in each storage solution to ensure a safe and reliable operation.
- The reservoir studies show evidence that the storage solutions have the appropriate injectivity to accept the CO2 flow from the capture unit and that they can permanently contain the total amount of CO2 stored.
- The Project Sponsor and its consultant annex future Operator RWE Dea outlined a monitoring plan focussing on safety of the storage site and potential containment risks and is committed to further develop the monitoring plan in a dialogue with national and international research institutes.
- Most of the CCS chain elements will be newly constructed and fit for purpose. The only existing assets to be used are the wells. No oversizing will take place.

9 Application Form 12: Financing

Unique aspects within the post-combustion operational framework of NER300:

- The Project Sponsor will finance the project from three sources:
  - Project Sponsor's current accounts (or internal reserves) i.e, no project financing is employed
  - Subsidy from the Dutch government
  - Financing from NER sources
- Project financials are based on a post-tax hurdle rate of 6.5%
- The Project Sponsor is prepared to cover a € xx,000,000 gap in the net present value of the project
- Project Sponsor will invest in the capture and storage installations, partner OCAP/Gasunie will invest in the transport and compression installations and charge an annual fee to the Project Sponsor
- A detailed Financial Model is attached in Appendix A12.2

10 Application Form 13: Risk

Unique aspects within the post-combustion operational framework of NER300:

- Essent has a systematic approach for the development of projects. This ISO 9001 certified, systematic approach, as formalised in Essent's 'Ways of Working' (WoW), is based on experience in the industry combined with Essent's know-how and experience in the field. As a result of the Essent WoW, Essent has developed a sound track record in the management of assets from development to realisation and operation.
- Risk management takes a prominent place in the systematic approach as described in the following paragraphs. Already at the beginning of the development of the project, risk management assessment sessions and mitigation actions are defined. The resulting risk log is managed and kept up to date throughout the development of the project.
- In addition to the WoW, Essent has longstanding relationships with the selected suppliers for the project (BASF, Linde, OCAP and Gasunie). These parties have been involved since the start of the initiative and have participated in the various risk management sessions. The involvement of these parties, who possess considerable knowledge, at the early stage of the project significantly reduces the chance that risks are overlooked, or under estimated.
- The Eemshaven project will further benefit from information obtained from the RWE PCC (post combustion capture) development program, which currently has three different PCC pilots in development or operation: Mountaineer (USA), Aberthaw (UK) and Niederaussem-pilot plant (Germ). Other than the information coming from the various pilots, Essent participates in various research programs, such as the CATO-2 program. The information coming from these various programs is incorporated in the risk assessment.
- The Dutch government supports the development of CCS projects, which is demonstrated by the fact that:
  - Government policies are established with CCS as important focus area;
  - by 2030 the Dutch Government expects CCS to be responsible for reducing CO_2 emissions by one third;
  - a dedicated CCS task force has been set up at the Ministry of Economics, Agriculture and Innovation;
  - there is cooperation with local authorities (provinces and municipalities) in the north of the Netherlands to support CCS projects
  - the Dutch Government supports various CCS R&D programmes, such as CATO-2, in which a consortium of nearly 40 partners are cooperating help bring the Government's plans to fruition;
- Essent is developing and implementing a communication plan with the following goals:
  - Encouraging public acceptance for storage (also through the 'Stichting Borg' foundation);
  - Establishing cooperation with local authorities;
  - Increasing awareness of the importance of CCS in reaching the Dutch climate goals;
  - Creating a legal basis (permit, legislation) for CCS.

11 Application Form 14: Operation

Unique aspects within the post-combustion operational framework of NER300:

- The Project Sponsor builds on in-house experience of sister company RWE Power and partners Linde and BASF, operating CO2 capture technology at the pilot plant in Niederaussem, Germany.
- The applied capture technology is result of a powerful development program on optimized post-combustion capture technology for power plants as a cooperation of a power plant operator, a chemical company and an engineering company
- The new technology is tested under real power plant conditions in one of the first capture pilot plants in Europe (and is installed at a coal-fired power plant)
- Project Sponsor's sister E&P company RWE DEA has broad operational experience operating natural gas and oil production sites
- Project Sponsor has years of experience in developing, constructing and operating a natural gas storage facility
- Flexible operation of the power plant is not be restricted by the CCS chain, as the CCS chain can run on full load within the complete range of anticipated power plant loads.
- The Eemshaven power plant will be one of the most efficient coal fired power plants in the region. Hence the projected operational regime and financial performance is sufficiently robust to justify investment in the high specific capital cost CCS technology.
- The average unavailability of the full chain is expected to be 19% (down time for testing purposes excluded), which is considered to be good for a demonstration project. This has been minimised by scheduling essential maintenance during planned outages of the main power plant. As a result the average full load chain will be approximately 7000 hours per annum.
- Together, the Project Sponsor's partners OCAP and Gasunie bring the Netherlands' largest source of experience in developing and operating natural gas and CO2 pipelines in a safe and reliable manner.