CATO event - progress for Dutch carbon capture

The Dutch are making big steps with industrial carbon capture and storage, we learned at a CATO forum in Utrecht, with a new project for the Port of Rotterdam taking CO2 offshore, another project capturing CO2 from steel, three pilot projects to gather CO2 from waste plants.

The Dutch are making big steps with industrial carbon capture, storage and utilisation, we learned at the CATO "Meet the Projects" event in Utrecht, Netherlands, on December 4.

Projects include the PORTHOS plan to build a CO2 transport hub in the Port of Rotterdam, projects to both reduce and capture CO2 at Tata Steel, and a project to build a gas to power with CCS system entirely offshore.

There are planned CO2 capture pilots at waste-to-energy plants run by companies AVR, HVC and Twence, research into inland shipping of liquid CO2, projects to build on existing CO2 sales to greenhouses for fertilising tomatoes and peppers. All three of these projects connect together.

CATO stands for "CO2 Afvang, Transport en Opslag", in English CO2 capture, transport and storage. CATO ran its own research projects from 2004 to 2014, and subsequently worked on CCS programs funded under other Dutch reseach schemes. It hopes to get a CATO-3 program running shortly.

Delegates heard about the latest developments in The Netherlands at the CATO event in Utrecht

PORTHOS – with timescale

The PORTHOS project is perhaps the most exciting development, to build a CO2 pipeline along the Port of Rotterdam connecting multiple CO2 emitters, and then take the CO2 to offshore storage.

The project now has a timescale, with concept selection during 2019, basic engineering by mid-2019, final investment decision in early 2020, detailed engineering in mid-2020, procurement and construction to start in late 2020, with commissioning mid-2023. The system is designed to carry 5,000 tonnes of CO2 per year.

The project is run by the Port of Rotterdam Authority; Gasunie, a Dutch natural gas infrastructure and transportation company; and EBN, a natural gas exploration and production company.

There are various decisions still to make, including the best location for the compressor station, the routing of the pipeline, and the transport and storage fee which will be charged to emitters. Two different storage fields are under consideration

PORTHOS could be considered a follow-up to the ROAD project, which planned to build a carbon capture plant and offshore storage around the Port of Rotterdam. The project was mothballed in 2014 due to funding constraints.

There will be a 36 inch pipeline running 33km along the port, then a compressor on the Maasvlaakte industrial complex at the coast, then an 18 inch offshore pipeline carrying higher pressure gas to offshore empty gas fields.

The pipeline pressure will be up to 35 bar onshore, then compressed to 85 to 120 bar for the offshore part. By the time the gas reaches the bottom of the well, the additional gravity force will increase the pressure to around 200 bar, where it is injected into the reservoir.

One of the main technical issues is flow assurance, making sure that the CO2 does not freeze and block the pipeline. This could happen if there is a sudden drop in pressure, because gas cools as it expands. For example if the pressure at the bottom of the well is much greater than the reservoir pressure, gas will expand quickly.

Further information is at https://rotterdamccus.nl/en/

There were some hints dropped about a similar scheme around the Port of Amsterdam called ATHOS, but no further details provided.

Tata Steel

Tata Steel is involved in two CO2 related research projects, "HIsarna," to make the process of reducing iron ore to iron more efficient and CCS ready, and EVEREST to capture carbon from a standard steelmaking process and make it easier to convert the gaseous products of the blast furnace into useful products.

In a conventional steelmaking process, iron oxide (iron ore) is reacted with coke (containing carbon), to make iron, carbon dioxide and carbon monoxide. The carbon dioxide is vented to the atmosphere. This is why steelmaking has such high CO2 emissions.

The HISarna process sees iron ore reacted directly with oxygen in a cyclone converter furnace. This is more efficient, and means that the reaction product has a higher concentration of CO2, so needs less further separation before going to a CO2 storage facility.

The greater efficiency means that 20 per cent less CO2 is produced (with no carbon capture). The project aims to demonstrate a 35 per cent reduction.

The HIsarna project is run by ULCOS, "Ultra-Low CO2 Steelmaking", a consortium of 48 European companies and organisations from 15 European countries. Around Eur 75m has been invested in reducing CO2 emissions from steelmaking over 10 years.

The environmental performance can be improved by using biomass for fuel, and adding scrap metal to the furnace.

A first "campaign" in 2011 showed the feasibility of the process, producing the first liquid metal. In 2013 it achieved its productivity target. Over 2015-17 there was a major upgrade to the pilot plant with Eur 25m invested. In 2017 it started an "endurance test", and the plant is still running.

There are studies looking at whether the CO2 could be cleaned to become 'food grade' and so used for fizzy drinks, or if it could be used for enhanced oil recovery.

The group would like to build an industrial size demonstration plant, handling 0.5 to 1m tonnes of hot metal per year, but that would need Euro 300m to 350m investment, some of which would probably need to come from public sources, said Jan van der Stel of Tata Steel.

Jacob Limbeek of OCAP, a system to collect CO2 from a Shell refinery and beer fermenting facility, and pipe it to greenhouses to speed up plant growth, said greenhouse operators would typically pay Eur 55 to 60 per tonne for CO2 acquired through combusting natural gas, so could pay an equivalent amount

Steel with carbon capture

Tata is also involved in a project to trial carbon capture on steel making, and also see if the by-products from steelmaking can be used to make napthta and other useful chemicals.

The project is called EVEREST ("Enhancing Value by Emissions Re-use and Emissions Storage"). The main target is to reduce Tata's CO2 emissions by 4m tonnes per year.

To make it possible to make naphtha, hydrogen would be added to the blast furnace, so the gases flowing out would be a mixture of hydrogen, carbon monoxide and carbon dioxide, or 'syngas', the ingredients for the Fischer Tropsch process to create naphtha, a liquid fuel.

This process could also make methanol, acetic acid, kerosene, ammonia or methane. For the overall environmental performance, it would be better if the chemicals were used to make products which are not ultimately combusted, so used for plastics rather than fuels, said Hans van Zutphen of Tata Steel.

For the conventional carbon capture plant, an amine solvent has been chosen. One challenge is that the plant should operate at a high pressure, around 16 bar, because the blast furnace (input gas) is at high pressure, and the destination (perhaps the forthcoming 'ATHOS' CO2 pipeline network) will also be at high pressure. It would be wasteful to depressurise the gas for carbon capture, only to have to compress it again for the pipeline.

Two big challenges are the flows of nitrogen and sulphur compounds in the blast furnace gas, and also the erratic gas flows out of the blast furnace, which could make it hard to connect it to a chemical process which requires a steady flow.

The time scale is to start basic engineering for the carbon capture plant in Q2 2019, open a pilot operation in Gent in Q2 2020, and a second pilot operation in IJmuiden Q4 2021. A separate pilot for the Fischer Tropsch project would start in Q2 2020, with proof of concept in Q3 2021 and basic engineering for the full scale project at the same time, leading to full commercial operation in Q2 2027.

The project partners in the Fischer Tropsch pilot plant are Dow Chemical, Arcelor Mittal, ISPT, University of Gent, ECN and Tata Steel.

CO_2 for greenhouses

The Dutch are perhaps already a world leader in CO_2 utilisation, with the "OCAP" system to collect CO_2 from a Shell refinery and beer fermenting facility, and pipe it to greenhouses, to speed up plant growth. OCAP stands for 'Organic CO_2 for Assimilation by Plants'.

Jacob Limbeek of OCAP, the organisation which runs the pipeline, says that the Netherlands has the highest production of tomatoes, peppers and cucumbers per square kilometre in the world, with its highly optimised greenhouses.

OCAP is a joint venture by gas company Linde and construction company VolkerWessels. It carries around 400,000 tonnes of CO_2 per year, to over 580 greenhouses. Some deliveries are made by truck.

The greenhouse operators burn gas for heating in the winter, and the CO_2 from that is used as a fertiliser. So their main demand for CO_2 from external sources is during the summer. Without a CO_2 supply, they burn gas purely for its CO_2.

Greenhouse operators would typically pay Eur 55 to 60 per tonne for CO_2 acquired through combusting natural gas, so could pay an equivalent amount for CO_2 to be supplied to them, Mr Limbeek said.

The CO_2 in the pipeline from Shell's refinery is still counted as "emitted" under the Emission Trading Scheme, on the basis that the CO_2 will enter the environment eventually.

CO_2 by barge

A research project is underway to explore transport of liquefied CO_2 to greenhouses by barge, since there are many greenhouses close to inland waterways, but not connected to the CO_2 pipeline.

Organisations involved in the research project are Linde Gas, RINA Netherlands, HVC Alkmaar, LTO Glaskracht, Noord BV, Noord-Holland Noord, and Shipco Consultancy.

One approach is to take a vessel for carrying coal (which is no longer needed, due to phasing out of coal power), and convert it to carry CO_2 by installing tanks. The CO_2 will probably be carried at 20 bars pressure and minus 50 degrees C.

Leen Schipper of Shipco said that many more greenhouse operators expressed interest in receiving CO_2 while the research was going on, so the target transportation volume increased from 30,000 tonnes a year to 870,000 tonnes.

One question is why companies don't use intermodal refrigerated tank containers for the CO_2, since there is already an infrastructure to transport them. Mr Schipper replied that the cost would probably be more expensive than using tanks.

Greenhouses typically have a storage tank capable of carrying 300 tonnes, and 250 tonnes can be delivered at once by vessel, thus filling a storage tank which is nearly empty but still with a little CO_2 in reserve.

CO_2 from waste incineration

Three Dutch energy-from-waste companies, AVR, HVC and Twence, are looking for way that CO_2 can be captured from the waste combustion process, and then sold to greenhouses.

AVR has had a pilot project running with Dutch research organisation TNO since 2016, with a carbon capture plant connected to a waste incineration facility. The CO_2 is then sold to gases company Air Liquide.

The carbon capture plant includes a flue gas condensing column, an absorber (amine scrubber) and a stripper. The CO_2 will be cooled to a liquid by air cooled condensers, so it can be easily carried by truck, to customers across the Netherlands. There are and then 4 x 250 tonne CO_2 storage tanks.

Generic MEA solvent will be used, to maintain maximum flexibility in choice of supplier and minimise the number of variables.

Meanwhile energy from waste company HVC has three projects called Ambience, Ambition and Amazing.

The "Ambience" project ("Alkmaar biomass energy carbon capture use) and "Ambition" projects (Alkmaar Bio-Co2 Liquefaction for Greenhouses) run together.

It involves a CO_2 capture plant, built in November 2018, in the BEC Alkmaar waste incineration facility, planning to start operation in January 2019, with a measurement program running until November 2019. It will capture 0.5 tonnes per hour of CO_2 (4,000 tonnes per year).

The absorber and stripper has 12m high columns, and are placed in an existing building for equipment for cleaning flue gas. The CO_2 will be liquefied.

The "Amazing" project ("Alkmaar haalbaarheidsstudie grootschalige demo zuiver CO_2 afvang en vervloeiing") will build a larger scale CO_2 capture plant, producing 75,000 tonnes of liquid CO_2 annually. Currently it is at the feasibility study stage, but with a plan to complete in 2019.

Twence, a third waste processing company in Eastern Netherlands, is planning to build a CO_2 utilisation demonstration plant. The project schedule is for engineering in Q4 2018, procurement in Q1 2019, construction in Q2 2019, and testing the amine solvent in Q3 2019.

The idea is that it can lead to a large scale CO_2 utilisation plant in operation by the second quarter of 2021, said project engineer Andy Roeloffzen.

Reducing solvent degradation

The "Plant One" research project at TNO is looking for ways to reduce the rate of carbon capture amine solvent degradation.

The degradation of the solvent is linked to the amount of oxygen dissolved in the solvent. So by removing dissolved oxygen, the degradation rate can be reduced. Theoretically, no dissolved oxygen means no solvent degradation, said Juliana Monteiro, scientific researcher at TNO.

Higher levels of oxygen are linked to the formation of ammonia in the amine, and increased corrosivity, reduced effectiveness of the solvent and increased waste disposal.

Dutch government perspective

Joëlle Rekers, Senior Policy Advisor Energy with the Dutch Ministry of Economic Affairs, said that there has been a renewed interest in CCS in government over the past few months. The question under consideration is what role government should say in encouraging CCS to be taken forward.

In 2019, the Netherlands plans to spend Eur 10m on CCUS feasibility studies and pilots, she said.

Ms Rekers said that the government's focus is on carbon capture for industry, not carbon capture for electricity, because in the electricity sector renewables have more public support.

In power, "we see CCS as a temporary solution," she said. "It should not stand in the way of more sustainable solutions. She noted that "CCS is still a sensitive topic with NGOs and other partners."

BECCS

There was some discussion about BECCS ("Bioenergy with carbon capture and storage"), a topic of growing interest as a way to make fuel and remove CO_2 from the atmosphere at the same time.

Tom Mikunda, Energy Policy Consultant, TNO, said that BECCS is sometimes talked about as an entirely different technology to CCS, when it is just CCS "with a different fuel". Perhaps some people are keen to differentiate them because they think BECCS is good and CCS is bad, he suggested.

Jon Gibbins, Centre Director of the UK Carbon Capture and Storage Research Centre said that coal plants could be used for burning biomass without any adaption at all. If we envisage a future with a great deal of BECCS, it would make sense to try to keep coal plants open rather than close them down, he said.

One of the biggest problems with biomass projects so far has been getting a large, reliable supply of it, he said.

Circular Energy

Circular Energy (www.circular-energy.nl) is a Dutch start-up company seeking to operate an offshore gas field, combusting the gas to make power offshore and separating CO_2 from the flue gas for immediate sequestration.

Founder Arnold Groot, a former planning and economics practice lead at Shell, calculates that the cost of the project could work out at Eur 6 per tonne of CO_2 stored, so within the current carbon price.

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The project could run on a gas field which is too small to run economically otherwise (and so there is less competition to buy the license to operate it). The gas field would ideally be close to an offshore wind farm, so the power cable to take power to shore is already in place.

The project could then provide back-up to the wind power, only operating when there is a demand for power and the wind farm is unable to operate due to low wind (thereby utilising existing capacity in the power cable).

One challenge is that the CO_2 would be injected into producing reservoirs, which would already be at higher pressure than a depleted gas field or aquifer. The CO_2 would need to be compressed to around 200 bar for it to be injected into the reservoir

By replacing produced methane with injected CO_2, the reservoir pressure could be kept high.

Building a carbon capture plant offshore would be more expensive and complex than building it onshore.

But on the other hand, there would be no need for a long CO_2 pipeline to a sequestration site.

Also there would be advantages to an operator combusting its own gas – it would not need to process the gas to pipeline specification, and there could be taxation advantages, if the tax is calculated based on the gas sales price. In this case, the gas is not sold directly.

The placement of the wells would be critical, to try to avoid CO_2 breakthrough to the production well.

Mr Groot calculates that the weight of the power plant and carbon capture facility would be around 6,000 tonnes, equivalent to the topsides on a typical central Central North Sea platform.

The size of the plant might be more of a challenge than the weight. He envisages using modularised equipment as far as possible to keep the costs down.

More information

Presentations from the event can be downloaded at:

http://bit.ly/CATO18