24/02/2021

The largest utility companies greater Copenhagen want to work together to capture 3 million tonnes of CO_2 a year – but requires immediate political action

With the C4 cluster, a number of major utility companies in the Copenhagen metropolitan area seek to make carbon capture a crucial element in the green transition in Denmark. CO_2 reductions of around 3 million tonnes per year are possible, if the Danish Parliament has the political will to make it happen.

The climate crisis requires action, now. Therefore several major energy companies in the Copenhagen metropolitan area are becoming engaged in the fight to respond to climate change, with joint efforts in C4 – Carbon Capture Cluster Copenhagen. The collaborative project consists of several large utilities, which together can establish a substantial and durable effect on the green transition.

The objective is to capture CO_2 at a number of large energy plants and save the atmosphere from these CO_2 emissions.

“There is enormous potential in these joint efforts concerning the C4 consortium. We have realistic possibilities to establish CO_2 reductions of around 3 million tonnes per year with carbon capture,” notes CEO Jacob H. Simonsen from ARC, and continues:

”This corresponds to approximately 15% of the total Danish target for reduction of 70% by the year 2030, and could be one of the largest single contributions to the green transition in Denmark.”

Capturing the CO_2 from a number of large energy plants and either storing it or converting it into green fuels will both reduce CO_2 emissions and establish green solutions for sectors that cannot be immediately electrified. These possibilities need to be explored further, to see the extent to which this could become an important contribution to achieving Denmark’s climate goals.

BRIEF FACTS

Those behind the C4 consortium project are ARC, Argo, BIOFOS, Copenhagen Malmö Port (CMP), CTR, HOFOR, Vestforbrænding, VEKS and Ørsted.

Therefore, a consortium

Capturing CO_2 is not sufficient enough. The CO_2 must also be transported and safely stored underground. In the long run CO_2 can be converted into green fuels. The Copenhagen metropolitan area is particularly suitable for establishing carbon capture and storage facilities because there are a number of large energy companies in relatively close proximity to each other, which facilitates better possibilities for a joint infrastructure, to the port on Prøvestenen for instance, from where the CO_2 can be shipped.

The parties in C4 will work to examine and, if possible realise, the vision of capturing and storing/exploiting large amounts of CO_2 in the Copenhagen metropolitan area.

The parties are thus forming the C4 cluster in order to contribute positively to solving the climate change challenge.

The intention is initially to ensure that knowledge and insight into the work relating to carbon capture is shared and utilised mutually, while exploring and cataloguing the possibilities for establishing common solutions. When more stakeholders share the infrastructure, it becomes less expensive, all for the benefit of the green transition. At the same time, significant economies of scale can be reaped from the capture, storage and utilisation of CO_2.

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The way forward

If the C4 consortium's vision for significant reductions of CO_2 in the Copenhagen metropolitan area is to be realised, this requires the requisite determination of the Danish Parliament.

"If we are to attain our goal with the vision relating to CO_2 reductions in the millions, so many stones must be cleared out of the way politically. The future national strategy for the capture, storage and use of CO_2 (The CCUS Strategy) will ensure the requisite funding and address important issues relating to the transport and storage of the CO_2," remarks Jacob H. Simonsen, and says in conclusion:

"In the short term, we would urge the Danish central government to allocate the requisite funds so that GEUS[1] can investigate whether various different Danish formations are feasible for CO_2 storage."

With the right political priorities, it is certainly possible to achieve large reductions in CO_2, at an attractive price. And some C4 consortium members are already up and running. Most recently, Vestforbrænding has announced an ambition to capture 450,000 tonnes of CO_2 per year from the year 2030.

As the C4 consortium becomes better known and we begin to put on our work clothes, we will make a vitally important crucial difference to the green transition in Denmark.

For further information, contact:

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[1] GEUS, an internationally oriented, independent research and advisory institution within the Danish Ministry of Climate, Energy and Utilities, is a geological data centre which conducts surveys, research, consulting and cataloguing primarily in Denmark including Greenland.

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FAQ

Q: What does C4 stand for?

A: C4 stands for Carbon Capture Cluster Copenhagen.

Q: Who is in the C4?

A: Those behind the C4 consortium are ARC, Argo, Avedøreværket, BIOFOS, CMP, CTR, HOFOR, VEKS and Vestforbrænding.

Q: How much CO_2 can C4 save the atmosphere?

A: Together, the C4 consortium can establish CO_2 reductions of around 3 million tonnes per year with carbon capture. More than half of the reductions will be biogenic CO_2 from waste/scrap wood, forestry residues from timber harvesting and old paper, for example. This allows the energy sector in the capital not only to contribute to becoming carbon neutral, but even to eventually becoming carbon negative. This corresponds to about 15% of the total Danish target of a 70% reduction by 2030, and could be one of the largest single contributions to the green transition in Denmark.

Q: Why invest in the capture of CO_2?

A: Carbon capture and storage is an important contribution and, above all, an available technology to meet the Danish climate targets of 70% reduction in CO_2 by year 2030. Carbon capture also contributes to the Paris Agreement's goal of reducing global temperature rises to 1.5^{O}C. UN Intergovernmental Panel on Climate Change, European Commission, International Energy Agency, The Danish Council on Climate Change, and Denmark's green think tank CONCITO, all state that carbon capture is central to achieving the Paris Agreement's goals.

Q: What is carbon capture?

A: Carbon capture is the capture of CO_2 in gaseous form. This is done by a chemical reaction, where the smoke from an industrial chimney, for example, is passed through a liquid that binds with or absorbs the CO_2. The liquid can then be heated to release the CO_2 into a closed container, from which it can be collected. The collected CO_2 can either be stored or used to produce fuel (Power-to-X).

Q: How is it that carbon capture from biogenic sources produce negative emissions?

A: This is due to that biogenic sources have absorbed CO_2 from the atmosphere in its lifetime. This can be, for instance, wood. When biogenic material is burned, releases the same amount of CO_2 into the atmosphere that the material has absorbed during its lifetime in that form. When the majority of the CO_2 is caught in relation to combustion and subsequently stored underground, CO_2 is effectively removed from the atmosphere. More information can be obtained here.

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Q: Is it safe to store CO_2 underground?

A: Yes. According to GEUS, Denmark is blessed with a very favourable underground storage conditions when it comes to storing CO_2. CO_2 storage can be established both on land and at sea, considering that the underground reservoirs are the same. A suitable reservoir has a sealing layer of claystone (a form of mudrock) on top. After the CO_2 is captured, it is converted into a liquid and delivered under pressure into an underground warehouse. GEUS has made the determination that there is virtually no risk associated with underground CO_2 storage, as CO_2 is neither combustible nor explosive. In comparison, natural gas is already stored seamlessly in the Danish underground. Read more here: https://www.danskindustri.dk/di-business/arkiv/nyheder/2020/10/dansk-undergrund-har-plads-til-1.000-ars-co2-udledning/

So as to ensure that the CO_2 does not start to seep back up, care is taken to carefully select reservoirs that have overlying layers of impenetrable rocks. The reservoir should be at a depth of more than 800 metres, as the CO_2 passes to a state that takes up 300 times less due to high pressure and temperature.

You can read more about underground storage of CO_2 here: https://www.geus.dk/udforsk-geologien/fangst-og-lagring-af-co2-ccs

CO_2 storage is also described in this figure: https://view.genial.ly/5ffc127c222af30da764a160

Q: Where does the CO_2 that the C4 consortium wants to capture come from?

A: The C4 consortium consists of a number of large energy plants that supply electricity and district heating to the businesses and households in the Copenhagen metropolitan area by energy - using residual waste, biomass, etc. When the materials are incinerated, CO_2 emissions are created, as with all combustion processes.

Q: Does the C4 consortium have experience with carbon capture?

A: ARC is already working on a project to capture approximately 500,000 tonnes of CO_2 per year from 2025, building skills in the field. You can read more about this project here.

In the period 2004-2009, Ørsted operated a carbon capture project partially funded by the EU that developed, established and conducted tests at Esbjergværket. The sole purpose was to test carbon capture. The project proved effective, showing that it is possible to remove CO_2 – and overall some 4,000 hours of operation was run with analyses of various parameters, including impact on other production in terms of degree of efficiency and maintenance.

Most recently, Vestforbrænding has announced an ambition to capture 450,000 tonnes of CO_2 per year from 2030, which will build up knowledge that the C4 consortium can make good use of.

Q: Why is it obvious to establish the CO_2 cluster C4 in the Copenhagen metropolitan area?

A: Because we can build knowledge together in community, and explore and identify possibilities for solutions, along with jointly demanding facilities for the storage of CO_2 underground. In addition, it is obvious to establish C4 because:

- Our energy plants have extensive operating hours annually, a high CO_2 concentration from the specific sources, long lifespans and significant emissions of CO_2.
- We are all in close proximity to each other, and thus can be connected via a pipeline to, for instance the port on Prøvestenen, from where the CO_2 can be shipped.
- We are connected to the district heating network, to which we can provide the excess heat from the carbon capture.

Q: What is the plan for C4 in terms of timing?

A: There is currently no fixed schedule, as the C4 consortium is in an initial phase of exploring the possibilities for large-scale carbon capture. The implementation depends on the extent of the political will among the politicians in the Danish Parliament. With the right conditions, it is not unlikely that the majority of the potential of around 3 million tonnes of CO_2 reduction/year can be realised within 10-12 years.

Q: What will does it take to succeed with C4?

A: It is an ambitious project that relies on a large number of factors, such as:

- Committed political support is essential – including a national CCUS strategy that establishes the right framework conditions and incentives to capture CO_2
- Financial incentives: The CO_2 reductions benefit the entire Danish climate accounts, and the cost of the CO_2 reductions cannot be borne solely by the circle of owners and customers in the Copenhagen metropolitan area. Therefore there must be financial incentives in the form of support schemes and/or a high carbon tax
- Access to one or more CO_2 storage facilities at a financially attractive price: one can imagine that in the future CCUS strategy, the Danish central government will allow CO_2 emitters to capture the CO_2, and even be responsible for establishing the infrastructure to transport the CO_2 to place for storage – and perhaps also establish one or more Danish storage facilities themselves. This could bring the cost of storing the CO_2 down.
- An important element in the short term is to allocate the necessary funds so that GEUS will have the possibility to investigate whether various Danish formations are usable for CO_2 storage. This is a prerequisite for the development of one or more Danish CO_2 storage facilities as soon as possible.
- Finally, targeted investments in carbon capture research are essential, so that this tool can become more efficient and financially attractive on an ongoing basis.

Q: What is the cost to capture one tonne of CO_2?

A: The financial factors and considerations have not yet been clarified at this point. But preliminarily, ARC expects a price of less than DKK 1,000/tonne CO_2. In other words, somewhat lower than the socio-economic price for CO_2 emissions, which is calculated by The Danish Council on Climate Change to be DKK 1,500/tonne CO_2. (2020).

Q: What is the amount of energy consumed to capture one tonne of CO_2?

A: There are no general precise figures available, as it depends upon the design of the individual carbon capture system. Based on ARC's draft design with heat pumps, there is a total energy consumption of 69 MW to capture 500,000 tonnes of CO_2. On the other hand, we can re-harvest 9 MW for district heating directly from the capture of CO_2 (without heat pumps) and 70 MW of district heating via heat pumps. This means that the capture can be made more than energy neutral using the district heating network.

- Energy consumption (69 MW) is divided into:
    - Approx. 12 MW electricity
    - Low pressure steam equivalent to approximately 37 MW
    - Approx. 20 MW of electricity for the operation of the heat pumps which are inserted strategic locations in the process
- Heat production (79 MW) is divided into
    - Approx. 9 MW district heating directly from the capture process
    - Approx. 70 MW district heating supplied via heat pumps

Q: How much excess heat is generated by capturing 1 tonne of CO_2?

A: There are no general precise figures available, as it depends upon the design of the individual carbon capture system. Based on ARC's draft design with heat pumps, 79 MW of district heating is generated by capturing 500,000 tonnes of CO_2. See also in the answer to the question "What is the amount of energy consumed to capture one tonne of CO2?" above.