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– end-of-pipe solutions dominated by CCS

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Analysis and opinion by Fredrik Lundberg

Cover photo: Bente Stachowske.

Protest at CCS Trade Fair in Hamburg 23 october 2024 by Greenpeace

In front of the world's largest trade fair for CO2 storage, Greenpeace activists are protesting against plans to inject climate-damaging carbon dioxide into the North Sea floor with an oversized, inflatable CO2 cloud. A 5 x 22-metre banner with the demand "Avoid CO2 instead of hiding it" was stretched across the entrance to Messe Hamburg by climbers, with a comic bomb depicted on it symbolizing the risk of the plans supported by business and politics. According to the organizers, the world's largest conference and trade fair for carbon capture, storage and use will take place over two days at the exhibition grounds.

This briefing was prepared for Real Zero Europe (RZE).

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Cover illustration: Sven Ängermark/Monoclick .

Layout: Sven Ängermark/Monoclick

Language consultant: Malcolm Berry, Seven G Translations, UK

Published in October 2024 by the Air Pollution & Climate Secretariat (Reinhold Pape).

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The Secretariat is a joint project by Friends of the Earth Sweden, Nature and Youth Sweden, the Swedish Society for Nature Conservation and the World Wide Fund for Nature Sweden. The report is also available in pdf format at www.airclim.org. The views expressed here are those of the authors and not necessarily those of the publisher.

EU Innovation Fund – end-of-pipe solutions dominated by CCS

The EU Innovation Fund is investing around 40 billion euros, in addition to other funding, with the stated intention of greening industry. However most of this money will support the existing industrial production of cement, plastics and petrochemicals rather than supporting green alternatives. The majority will go to CCS.

The Innovation Fund's goals[1] are to "help businesses invest in clean energy and industry, boost economic growth, create future-proof jobs and reinforce European technological leadership on a global scale."

Looking closer, the Commission's goals appear more limited, as it aims to fund projects focusing on "innovative low-carbon technologies and processes in energy-intensive industries, including products that can substitute carbon-intensive ones", including:

- carbon capture and utilisation CCU
- construction and operation of carbon capture and storage (CCS) facilities
- innovative renewable energy generation
- energy storage

124 projects have been approved so far (September 2024), of which 63 are large-scale. The top 30 of these large-scale projects, ranging from just under €100m upwards, together account for €4774m – more than 70 per cent of all the funding awarded (including small-scale projects that are not analysed in this briefing).

These 30 projects therefore give a fairly good picture of what the EU wants. The classification is based on the project descriptions, and although these are often promotional and short on technical detail, the big picture is clear.

Top 30 Innovation Fund projects, as of September 2024[2]

#	Project	Project location countries	EU contribution M€	CCS, end-of-pipe	Transformative?	Activity
1	Kairos-at-C	Belgium	356.9	x		CO_2 cluster
2	H2GS	Sweden	250.0		x	Green steel
3	IFESTOS	Greece	2340	x		Cement
4	GO4ZERO	Belgium	230.0	x		Cement
5	EVEREST	Germany	228.7	x		Lime
6	GO4ECO-PLANET	Poland	228.2	x		Cement
7	GAP	Norway	203.8		x	Ammonia
8	HOPE	Spain, Germany	200.0		x	Photovoltaics

1 https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/what-innovation-fund_en#financing-rates

2 https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/innovation-fund-projects_en

#	Project	Project location countries	EU contribution M€	CCS, end-of-pipe	Trans-forma-tive?	Activity
9	GeZero	Germany	190.9	x		Cement
10	ANRAV	Bulgaria	189.7	x		Cement
11	BECCS Stockholm	Sweden	180.0	x		BioCCS for CHP
12	BioOstrand	Sweden	166.6		x	biorefinery, green H_2
13	K6	France	153.4	x		Cement
14	HYBRIT	Sweden	143.0		x	Green steel
15	PULSE	Finland	135.0		x	Plastics recycling
16	IRIS	Greece	126.8	x		Refinery
17	CalCC	France	125.2	x		Lime
18	OLYMPUS	Greece	124.3	x		Cement
19	GREEN MEIGA	Spain	1229	x		Methanol, DACCS
20	TANGO	Italy	117.7		x	Photovolta-ics
21	KOdeCO	Croatia	116.9	x		Cement
22	eM-Rhone	France	115.2	x		Cement CO_2 to metha-nol, cluster
23	Coda Ter-minal	Iceland	115.0	x		CCS infra
24	C2B	Germany	109.8	x		Cement CCS infra
25	FUREC	Netherlands	108.0	x		Waste recy-cling H_2
26	ECOPLANTA	Spain	106.4	x		Waste recy-cling fuel
27	Giga Arctic	Norway	100.0		x	Battery fac-tory
28	BBRT	Spain	100.0		x	Battery recycling
29	ELYgator	Netherlands	99.0		x	Electrolyser for H_2
30	AIR	Sweden	97.0	x		Waste-to-methanol CCU

Of the 30 larger projects, 68 percent of the funding goes to 20 projects that require CCS or CCS infrastructure or other end-of-pipe add-ons, while just 10 of them are greener, more transformative projects.

There is a heavy focus on cement and lime, which account for 11 projects; other CCS which accounts for 3 projects; and cluster/infrastructure for CO_2 /CCS account for another 3 projects.

Hub for CCS

The top award of €357m has gone to **Kairos@C** in Antwerp, Belgium. Its objective is to create a hub for CO_2: "to create the first and largest cross-border carbon capture and storage (CCS) value chain to capture, liquefy, ship and permanently store CO_2."

If this sounds big and complex, that is because it is. Projects #4, 9, 13 and 16 are also CO_2 hub projects.

On top of the €357m for Kairos@C there is more EU money[3]: €145m from Connecting Europe Facility (CEF) for *Energy, which* is the EU funding programme for implementing the Trans-European Networks for *Energy* policy. This is intended for the closely connected Antwerp@C. The projects have also received "significant funding"[4] from the Flemish government.

The major players are the companies BASF (petrochemicals and plastics) and Air Liquide, which is involved in 12 CCS projects in Europe[5] alone and 29 around the world. Other companies include fossil giants ExxonMobil and Total, natural gas grid operator Fluxys, petrochemical companies Ineos and Borealis.

Kairos@C claims that it will remove 14 Mt of CO_2 over its first ten years of operation. The project has several parts: carbon capture from two hydrogen plants, two ethylene oxide plants and one ammonia plant; liquefaction of CO_2 by a cryogenic method; and the construction of pipelines and ships.

The 14 Mt figure is calculated by comparison with a reference scenario in which the same volume of product is produced without CCS, and depends on a number of assumptions. One is that the hydrogen would have been produced from natural gas without CCS. In that case, the CCS is expected to remove a lot of CO_2.

An alternative assumption would be that the hydrogen is green hydrogen that is produced by electrolysis using wind and solar power. But if this the case, CCS will not remove a gram of CO_2; on the contrary, some CO_2 will leak and so increase the emissions.

Other questionable assumptions yield questionable results for the ammonia and ethylene oxide plants.

Ammonia could be produced from green hydrogen which would come from project #7. However, it should be mentioned that the EU already uses too much ammonia for agriculture, causing eutrophication on land and in water. This could be reduced by changing agricultural policy.

Ethylene oxide is toxic and carcinogenic, and has been banned in the EU for various applications since 1991, though large quantities are exported from the EU. There are alternatives for at least some of its uses.[6] One of its applications is for oilfield chemicals, which need to be phased out, not produced in even larger quantities.

3 https://cinea.ec.europa.eu/news-events/news/cef-energy-antwerpc-co2-export-hub-receives-1446-million-eu-funding-co2-capture-infrastructure-2023-06-26_en

4 https://hydrogeneurope.eu/wp-content/uploads/2023/03/2023.03_H2Europe_Clean_Ammonia_Report_DIGITAL_FINAL.pdf p44

5 https://www.airliquide.com/stories/industry/capturing-co2-essential-solution-decarbonizing-industry

6 https://novasterilis.com/blog/5-alternatives-to-ethylene-oxide-sterilization/

That view is not shared by fossil fuel companies and the chemical industry, which were granted very large subsidies in Antwerp for keeping business as usual.

CCS requires massive infrastructure

The Kairos project is only meaningful in a context of an enormous apparatus for CCS. It requires other ports that export and import CO_2. It also requires buyers and sellers. A value chain is not a value chain unless there is profit at every step. If enough businesses see opportunities other than CCS, or it simply shrinks as a result of climate policy or market forces, Antwerp will be under-used and left with huge derelict steel structures.

If it succeeds it is just the beginning of what may be the biggest infrastructure programme in global history for transporting and storing CO_2 at a cost of trillions of euros over several decades. It cannot be seen as the bridge to transition; but a dam against that transition.

The Innovation Fund has also awarded €115m (project #23) to an Iceland harbour for receiving CO_2 from ships.

The Porthos CCS project in Rotterdam harbour is also supported by the EU (CEF), and the CO_2 cluster idea is shared by many hopefuls, such as the ports of Gothenburg,[7] Hamburg,[8] and Le Havre.[9]

One problem with this grand plan is that at present there is no CO_2 to transport. There is no large-scale capture going on anywhere in the EU, and precious few projects under construction or firmly planned.

In 2007 the EU Commission introduced the NER300 programme to support CCS development and it set a target of 12 large-scale demonstration plants[10] by 2015. What it clearly had in mind at the time was coal and gas power plants. However, none of these plants materialised. Instead, wind, solar and efficiency measures (heat pumps, better insulation, LED lighting) have replaced coal and gas. Electricity generation from coal, gas and oil decreased from 1556 TWh in 2007 to 841 TWh in 2023, while solar and wind increased from 175 to 727 TWh. Electricity consumption decreased 250 TWh during the same period. It turned out there was no need for 12 large-scale coal power stations with CCS, so they were never built. Not a gram of CO_2 was avoided by the NER300 programme.

Generous funding for cement companies

Cement seems to be the big CCS hope. 13 of the 30 projects (#3, 4, 5, 6, 9, 10, 13, 22, and 24 in the table) are related to cement and lime, which are often said to be "hard-to-abate". The CO_2 is emitted from the limestone itself, and from fossil fuels used to heat it.

In another Briefing in this series, **Carbon emissions from the cement industry can be**

7 https://www.portofgothenburg.com/about/the-port-of-the-future/large-scale-co2-hub/

8 https://www.hafen-hamburg.de/en/port-of-hamburg-magazine/all-purpose-port/logistik-hub-fuer-co2/

9 https://www.globalccsinstitute.com/news-media/latest-news/france-outlines-ccus-trajectory-in-the-countrys-transition-towards-carbon-neutrality-in-updated-national-strategy/

10 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0002:FIN:EN:PDF p6

reduced without CCS, it is shown that in fact there are dozens of methods to cut CO_2 emissions from cement, and that CCS is not very effective. Alternatives to lime are not yet well researched, but there are reasons to believe that other materials and processes could replace lime, or that the use of lime is declining (for example in flue gas desulphurisation and for raising the pH of acidified lakes).

The cement and lime production industry prefers to keep on doing what it has always done, using the machinery it already has, with support from the EU and the Innovation Fund. Two of the largest cement producers in the world are supported by Innovation Fund projects: HolcimLafarge with 4 projects (#4, 6, 21 and 24) and Heidelberg Materials with two (#9 and 10).

"Blue" hydrogen, BECCS and DAC

One option for CCS is known as **blue hydrogen**. Green hydrogen emits no CO_2 if the electricity used to make it is fossil-free. Blue hydrogen is produced from fuels, today usually fossil gas, combined with CCS. If the fuel is mainly biomass, it can claim to be climate neutral or even net negative. Projects #1 and #16 are to produce blue hydrogen.

Bio-CCS is hailed as one potentially large source of CO_2 for transport and storage, and there is a large project in Stockholm for a biofuel combined heat and power plant at number 11 on the list of projects. The supposed beauty of BECCS is that it can produce "negative emissions". This is technically correct, if all biomass combustion is considered carbon neutral, and that is how it is accounted for in the climate convention.

The IEA has very high hopes for BECCS in its World Energy Outlooks, with billions of tonnes captured from more and more biomass.

This vision seems to be shared by the Innovation Fund, but aside from what we think (and most NGOs are against a big bet on biomass), it does not look likely to happen. There are no BECCS plants in operation anywhere in the EU. Stockholm Exergi has not yet made a final investment decision, three years after the announcement of the €180m award.

There is one BECCS project currently underway, Ørsted Kalundborg CO_2 Hub, for a coal power plant earlier converted to biofuel in Denmark, which is supported by the Danish State and by Microsoft, but as yet not by EU money.

Direct Air Capture (DAC) is an economically controversial proposal. It is difficult enough to achieve reasonably economic CCS even with relatively concentrated streams of 18 per cent or so of CO_2 (as in the cement industry). The air we breathe has a concentration of .04 per cent CO_2. Project #19 partly finances DAC, and #23 is related to a DAC project in Iceland, backed by erratic right-wing billionaires such as Peter Thiel and Elon Musk.[11]

DAC is very unlikely to develop anything even close to a relevant technology for the climate. It seems to be a diversion tactic by the fossil industry to avoid actually cutting emissions. Iberdrola, the beneficiary of #23, emitted 10 million tonnes[12] of CO_2 from its power plants 2023.

11 https://www.airclim.org/acidnews/direct-air-capture-billionaires-dream-vacuuming-carbon-out-atmosphere

12 https://www.iberdrola.com/documents/20125/41101/ghg-report-2023.pdf p13

Waste, waste, waste

The potential of BECCS may not be so great, but there is a blurred zone between pure biomass and mixed waste. Stockholm Exergi wants to capture CO_2 from other plants that burn mixed waste[13] and that may be the next big thing for CCS.

Waste consists of essentially two fractions: plastics of fossil origin, which we should be greatly reducing, and biomass which should be put to better use.

There is an enormous unsolved waste problem in every corner of Europe due to household waste and other waste.

But instead of investing in "reduce, reuse and recycle" the current response appears to be to burn everything and use CCS to tackle what the fund calls "non-recyclable solid waste streams".

Even when direct incineration does not take place, as in the waste-to-hydrogen project FUREC in the Netherlands (#25), it amounts to the same thing. Mixed waste production continues, it is chemically processed, and CCS is used to remove the CO_2. It uses several technical systems (collection and transport of waste, pelletisation, dry distillation, CO_2 capture and storage, hydrogen storage and transport) all of which carry an environmental cost and a risk, probably at high cost compared to a systemic change such as a policy to reduce packaging and plastic. But RWE, the largest emitter of CO_2 in the EU, may appreciate all the add-ons and will benefit from the FUREC project.

Project #26, a petrochemical complex in Tarragona, Spain, "uses waste that would otherwise end up in landfill" to produce methanol, with CCS,[14] although the project description does not say so.

Project #30 in Sweden also produces methanol with CCS.

Some good green projects

Not all of the Innovation Fund projects support fossil industries.

Project #2 is for H2 Green Steel in Sweden and #14 is the pioneering HYBRIT. Both projects aim to decarbonise steel production by replacing coal and coke with green hydrogen. The HYBRIT project was set up soon after the Paris agreement, in cooperation between the iron miner LKAB, the steel producer SSAB and power giant Vattenfall. Between them, they have extensive expertise and they began with a realistic schedule (which they even moved forward). They have the ore, harbours, railways and customers. The H2 GreenSteel project came from nowhere and promised production in three years – without ore, harbours, know-how etc. One can only hope for the best.

It is noteworthy that neither of the steel projects need a large hydrogen infrastructure (pipelines or ships) and that there is no steel CCS project among the large-scale projects funded.

Project #7 in Norway is intended to produce green ammonia (fertiliser etc.) with green hydrogen, instead of from fossil gas. Ammonia may be of even greater importance as it may also be used as a hydrogen carrier for ship propulsion.

13 (in Swedish) https://www.stockholmexergi.se/darfor-eldar-man-avfall/koldioxidinfangning-en-del-av-den-framtidens-avfallslosning/

14 https://zeroemissionsplatform.eu/about-ccs-ccu/css-ccu-projects/

Two projects are aimed at battery production (#27) and battery recycling (#28). One is for the manufacture of green hydrogen electrolysers (#29). Two are for solar cell factories (#8 and 20). However, they will all have to compete with the very large, dynamic and innovative Chinese manufacturers, and in the case of electrolysers, with other countries as well.

Project #15, for oil refiner Neste in Finland, centres on the chemical recycling of plastic waste and thus reduces the need for new fossil input and can be said to reduce emissions. Plastics consumption will have to be reduced in a real-zero world, but some plastics will still be needed. If the process works well, it could also work for plastics of biogenic origin.

Some of the projects will fail at some stage, so some of the money will not be spent. If the bona fide green projects fail more frequently than the industry-preservation projects, the final distribution of funding will be even more warped than the current 68 percent allocation to industry preservation.

More opportunities?

So far, most of the Innovation Fund has gone to CCS and other end-of pipe solutions. What has not been funded?

Decarbonising the industry *could* mean things like alternative binders for the cement industry, limitation of single-use packaging and less production of plastics generally, clean aluminium production, less transport and lighter construction materials. There is little support for these alternatives.

Wind power supplies a fifth of EU electricity, and the EU industry has led the world for many years and continues to do so, but competition is sharpening. Among the top 30 projects there is no wind power project, though some can be found further down the list.

Energy efficiency measures, such as better-insulated windows, receive no support. The words "window", "insulation" or "heat pump" do not occur in the (long) project descriptions.

This is the story so far, but most of the Innovation Fund money has yet to be awarded. It is possible that it will be used for more green transformation.

Massive investment pot, on which future?

The EU has no power to levy and collect taxes, so the Innovation Fund gets its money from the European Trading System, for the sale of 530 million ETS allowances. At a price of €75, that means €40 billion to be spent by the Commission, on top of other private and public money, as the Fund usually provides up to 60 per cent of the cost.

The price of emissions rights fluctuates, so nobody knows how much the fund will have to spend, but 40 billion is a reasonable guess. To that should be added perhaps the same amount again from national governments and private investors leveraged by the Innovation Fund.

That is a lot of money to be spent on one of our possible futures.