
Carbon removal
Imperative in combating climate change
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Carbon removal needed to achieve climate neutrality

To prevent the worst impacts of climate change, the world needs to reach net-negative emissions, the point at which we are actually removing more carbon dioxide from the atmosphere than we are releasing. This will involve deploying methods – both natural and technological – that remove carbon dioxide from the atmosphere and sequester it for long periods.

Both the IPCC's scenarios that are consistent with limiting global warming to 1.5°C and the EU's "Clean Planet for All" scenarios highlight the use of carbon removal in achieving carbon neutrality. Those scenarios have explicitly shown that carbon removal is an essential part of the lowest-cost path towards meeting the Paris Agreement goals.

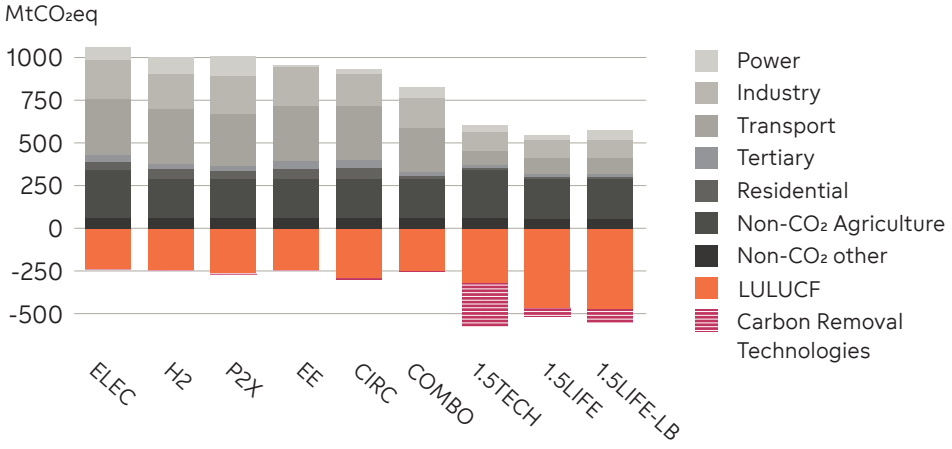
Both natural and technological solutions are needed

Nature-based solutions for carbon removal include oceans and plants, especially forests – at present each sequester approximately one-third (30%) of annual human-derived emissions.

Technological solutions involve capturing carbon dioxide mechanically from the chimney of a power plant or an industrial facility or directly from the air. The captured CO_2 can then be stored underground (CCS), e.g. in offshore subsea storage location, or utilised for different purposes (CCU).

This leaflet deals with technological solutions for carbon removal, especially carbon capture and storage (CCS), in which Fortum has ongoing business development.

EU sectoral greenhouse gas emissions by 2050



Source: The EU Clean Planet for All. All of the scenarios envision some level of non-nature-based removals. The only non-natural removals considered in the scenarios are BECCS and DACCS. The prevalence of technical carbon removal becomes most relevant going from 80% GHG emissions reduction to climate neutrality.

Carbon removal is complementary to emissions reductions

Carbon removal should be complementary to emissions reductions. Rapid emissions reductions are needed, regardless of the level of carbon dioxide removals. In Fortum's opinion, carbon removal accompanied with additional emissions reduction policies should be seen as one tool in a bigger tool box to combat climate change.

Biomass + CCS = negative emissions

Bioenergy with carbon capture and storage (BECCS) is a process that consists of utilising biomass as a feedstock to produce bioenergy (electricity and heat) and capturing the emissions that result from the process. Bioenergy installations are often in the power and heat sector, waste incineration, industrial applications (like pulp and paper), and biogas and ethanol installations.

According to the IPCC's greenhouse calculation rules, bioenergy is considered as a zero-emitting energy source, as these emissions are included in the land use sector. When biomass is burned in an installation with CCS, the process results in negative emissions.

An estimate of the break-even costs for BECCS today is between 50 € and 140 € per tonne of removals[1], indicating that support of this level would incentivise installations to start removing carbon from the atmosphere. The European emission allowance prices were, on average, 24 euros per tonne during 2019.

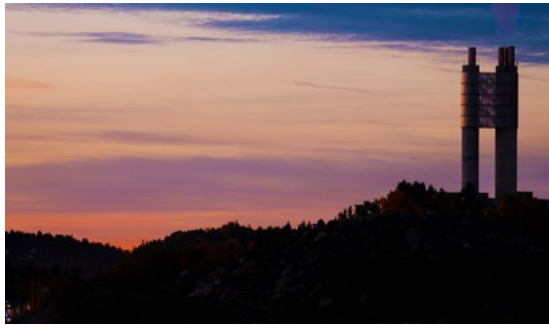
All of the EU scenarios envision BECCS deployment ranging from 4 to 178 Mt annually. As a rule of thumb, the higher the level of decarbonisation, the higher the need for removals. The EU has a lot of potential for BECCS in waste-to-energy plants, the pulp and paper industry, and the district heating sector. The annual biogenic emissions removal potential in the district heating industry is around 30 Mt, in pulp and paper approximately 60 Mt[2], and in waste incineration around 25 to 60 Mt.[3]

Example:

A waste-to-energy installation emitting 400,000 tonnes of CO_2 annually, consisting of approximately 50% of fossil and 50% of biogenic waste with a capture efficiency rate of 90%. Fossil CO2 emissions are 200,000 t/a and biogenic CO2 emissions 200,000 t/a.

180,000 tonnes of the fossil emissions is captured, leaving 20,000 tonnes of fossil emissions. As the biogenic waste has captured the CO_2 from the atmosphere during its lifetime, it is calculated as a zero-emission fuel.

180,000 tonnes of the biogenic emissions is captured. By subtracting the remaining fossil emissions of 20,000 tonnes, this will result in the installation removing 160,000 tonnes of atmospheric CO_2 annually. This is calculated as negative emissions.



[1] Cameron Hepburn and others, 'The Technological and Economic Prospects for CO_2 Utilization and Removal' (2019) 575 Nature 87 <https://search.proquest.com/docview/2315040174>. Breakeven cost meaning taking into account the value of the product i.e. bioenergy.

[2] Anders Hansson and others, Bioenergy With Carbon Capture and Storage: From Global Potentials to Domestic Realities (2017) <http://linkinghub.elsevier.com/retrieve/pii/B9780128054239000041>.

[3] Eurostat, 'Greenhouse Gas Emissions from Waste - Product - Eurostat' (2020) <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200123-1?inheritRedirect=true&redirect=%2Feurostat%2Fweb%2Fwaste%2Fpublications> accessed 7 May 2020.

Legislative framework to be established

Fortum believes that CO_2 removal and negative emission technologies are a key complement to the EU's existing climate change mitigation tools. However, in order to make carbon removal and negative emissions technologies commercially viable and to upscale them, they should be incentivised. They should be better recognised in legislation and, preferably, promoted by market-based tools, like carbon pricing. An appropriately designed EU policy framework can support and incentivise the development of cross-border CO_2 transport and storage networks in Europe.

Financial support and grants will be key to achieving early deployment of the CCS value chain in Europe. In Fortum's view, the current EU Innovation Fund is crucial for financing the first projects and scaling up the technology. The EU and national governments have a big role in providing funding for scaling up the industry. However, public subsidies decided case by case do not provide a longer-term solution and visibility for the industry to emerge.

Therefore, a long-term business model for carbon removals needs to be established. In the longer term, preferably the incentive for carbon removal should be in line with the incentives for emissions reductions to ensure that there will be no market failure of preferring carbon removal over emissions reductions.

CCS as part of the EU recovery package

The EU is currently preparing plans on how to recover from the COVID-19 pandemic and the consequent economic downturn. In Fortum's view, climate change mitigation should be in the core of the EU recovery package. CCS is a proven technology that is necessary in the decarbonisation and safeguarding of European industry and jobs in a low-carbon economy. CCS projects that can rapidly move into implementation should be considered in any economic recovery plan, due to their capacity to deliver quickly in terms of jobs and economic growth while delivering on the EU's emissions reduction targets.

Fortum's proposals for integrating carbon removal into legislation

The revision of the ETS, ESR and LULUCF regulations in 2021 in the framework of the European Green Deal is a key opportunity to establish a legislative framework for carbon removal. We also welcome the Commission's initiative to establish a regulatory framework for the certification of carbon removals in 2023 in connection with the Circular Economy Action Plan.

Under the current legislative framework, integration of technical carbon removal solutions into legislation can be done either based on the EU ETS framework or the effort sharing regulation. In Fortum's opinion, the next regulatory steps should be:

1. As the first step, the EU needs to define what qualifies as carbon removal and storage, and how long the removed CO_2 needs to be sequestered from the atmosphere in order to qualify as removed carbon. Geological storage is an obvious example.
2. Extending the scope of the EU ETS to carbon removals and providing free allocation in the form of emissions allowances or external exchangeable credits to installations removing and storing CO_2. This should be done in a way that ensures that free allocation is taken from existing auctioning volumes to ensure environmental effectiveness.
3. Alternatively to including carbon removals in the EU ETS, they could be incentivised under the ESR. The ESR framework already allows member states to use removals to count towards their AEA obligation; however, the financial incentives for entities to remove CO_2 depend on the national policies of the member states. An EU-level approach would be to allow removals to create individual units that can be sold to all member states for AEA compliance purposes.
4. A third possibility would be to create an all-encompassing, new regulatory framework for CO_2 removals outside the ESR, ETS and LULUCF framework.
5. In addition to the pipeline transportation of CO_2, alternative methods of CO_2 transport, such as ships and trucks, should be recognised in EU legislation, e.g. EU ETS and TEN-E, in order to facilitate a greater range of CO_2 transport solutions in Europe. Similar amendments to the state aid rules for these methods of CO_2 transportation are required.
6. Allowing the simultaneous development of national policies for the promotion of CDRs, including a possible adjustment mechanism to the level of incentive provided from the national scheme. For example, in a case where the EU allowance price if 20 € per tonne and national support is 100 € per tonne, the total compensation for the installation would still be only 100 € per tonne, because free allocation would be deducted from the national support.

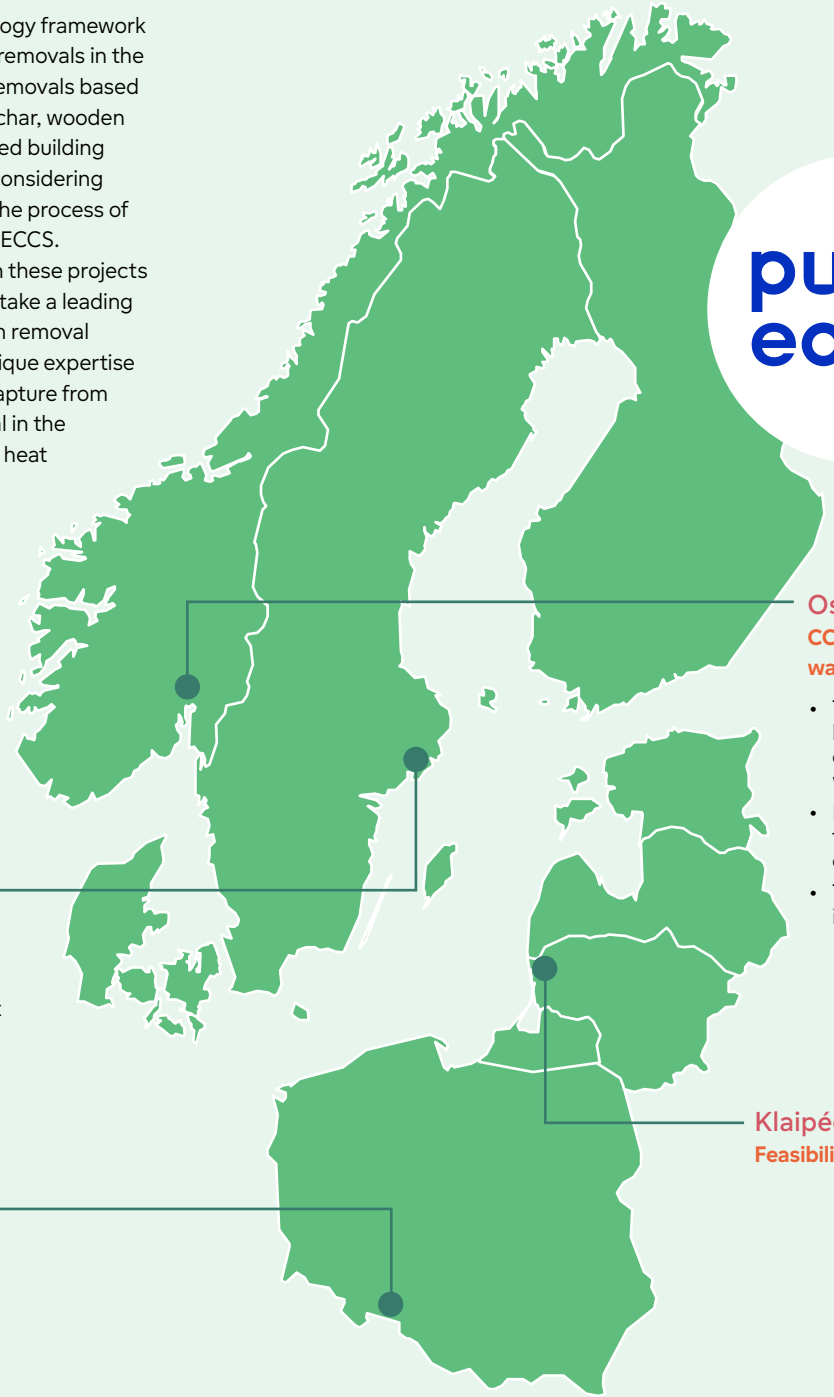
Fortum's carbon removal business development

Fortum is at the forefront of developing carbon capture technology. We have two ongoing projects under development: at **Fortum Oslo Varme**'s waste-to-energy plant in Oslo and at **Stockholm Exergi**'s bio fuelled combined heat and power plant (CHP) in Stockholm. Through the Northern Lights partnership with Shell, Total and Equinor, we aim to safely store the CO_2 under the seabed in the North Sea.

Fortum's two CCS projects can reduce annual CO_2 emissions by 1.2 million tonnes, approximately 1 million tonnes of which are from BECCS, creating negative emissions.

Besides these projects, Fortum's internal startup **Puro** has developed a voluntary marketplace for CO_2 removal certificates. Puro.earth is the first multi-methodology framework for verifying and trading of CO_2 removals in the world. Currently, Puro accepts removals based on storing carbon dioxide in biochar, wooden building elements and carbonated building elements. Puro is continuously considering new methods and currently on the process of developing a methodology for BECCS.

The pioneering work done in these projects enables the Nordic countries to take a leading role in shaping the global carbon removal industry. We can provide the unique expertise the world will need for carbon capture from industries that will remain crucial in the future, like waste treatment and heat production facilities. The world will need waste treatment and heat production also in the future, and we must find ways to make these industries not only carbon neutral, but also carbon negative.



Oslo, Norway

CCS in a waste-to-energy plant

- The CCS pilot in 2019 has confirmed that the chosen capture technology works as intended.
- During the 5,500-hour test period the intended capture rate of 90 per cent was reached
- Target to have the full scale CCS plant in operation 2024

Stockholm, Sweden

CCS in a biomass fired CHP plant

- Long term tests conducted during 2019 and 2020
- Target to have the full scale CCS plant in operation in 2025

Klaipéda, Lithuania

Feasibility studies on CCS

Zabrze, Poland

Feasibility studies on CCS

Fortum is a European energy company with activities in more than 40 countries. We provide our customers with electricity, gas, heating and cooling as well as smart solutions to improve resource efficiency. We want to engage our customers and society to join the change for a cleaner world. Together with our subsidiary Uniper, we are the third largest producer of CO_2-free electricity in Europe. With approximately 19,000 professionals and a combined balance sheet of approximately EUR 69 billion, we have the scale, competence and resources to grow and to drive the energy transition forward. Fortum's share is listed on Nasdaq Helsinki and Uniper's share on the Frankfurt Stock Exchange. www.fortum.com

Abbreviations

AEA	Annual Emission Allocations
BECCS	Bioenergy with Carbon Capture and Storage
CCS	Carbon Capture and Storage
CDR	Carbon Dioxide Removal
ESR	Effort Sharing Regulation
EU ETS	EU Emissions Trading System
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land-use change, and forestry

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