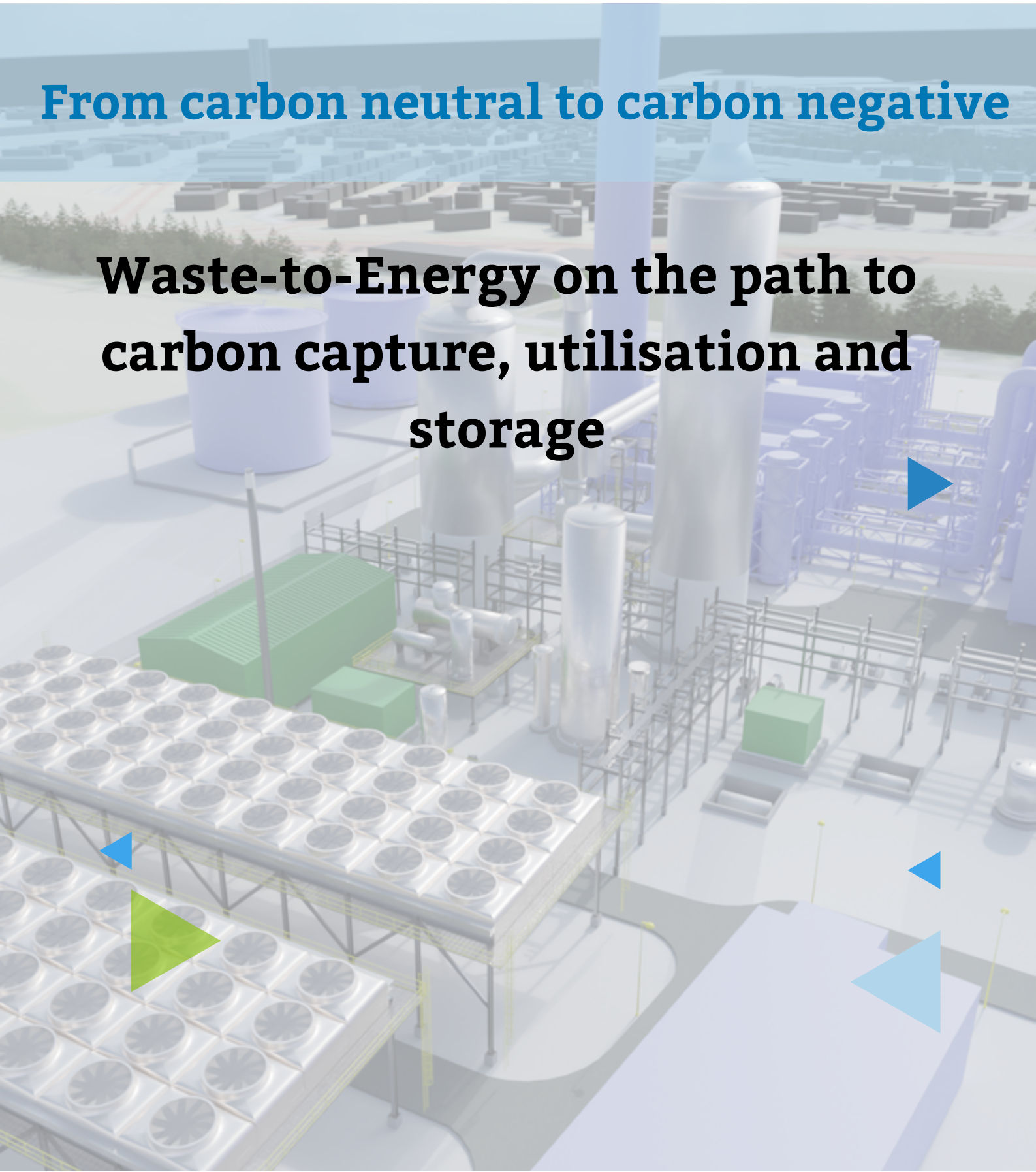
ESWET

European Suppliers of Waste-to-Energy Technology

From carbon neutral to carbon negative

Waste-to-Energy on the path to carbon capture, utilisation and storage



Foreword

In order to limit the impact of climate change, reducing greenhouse gas (GHG) emissions is now widely accepted as a necessity. At the EU level, this priority is at the core of the Green Deal, launched in 2019. The Green Deal, through a series of new regulations and the revision of existing legislation, set the ambitious target of achieving carbon neutrality by 2050.
However, this objective does not mean that no GHG emissions will be emitted by 2050, rather that emissions after 2050 should be balanced via absorption and sequestration through the implementation of Carbon Capture, Utilisation and Storage (CCUS) technologies.

For hard-to-abate sectors such as industries, capturing emissions is the most efficient decarbonisation solution. For Waste-to-Energy (WtE), this may represent the potential to become carbon negative, as thanks to carbon offsets plants are already considered as carbon neutral[1].

Indeed, it is not an option for WtE to switch to another renewable fuel, as it would mean stop treating non-recyclable waste. However, the deployment of CCUS is still at an early stage, and faces many regulatory, technical and financial challenges.

> As recognised by the IPCC in April 2022, "Depending on the origin of the waste used, the integration of WtE and carbon capture and storage could enable waste to be a net zero or even net negative emissions energy source"

IPCC Report, April 2022

1. See for instance CEWEP's Climate roadmap (2022) on the carbon offsets of Waste-to-Energy.

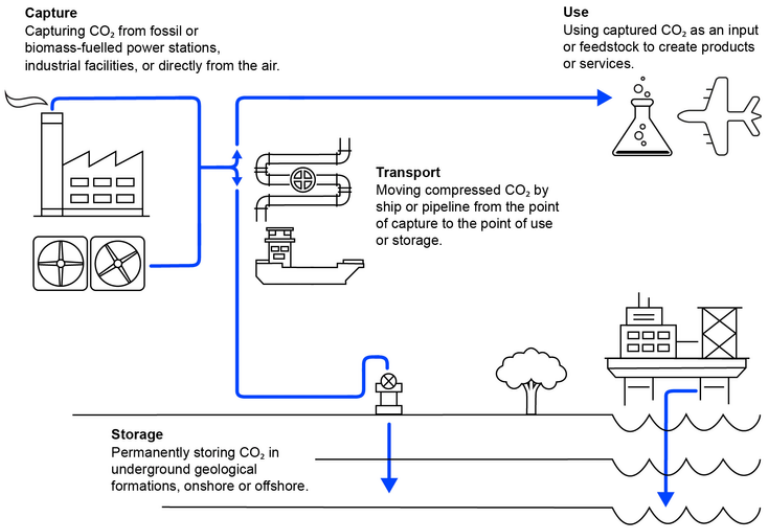
An incomplete policy framework

The implementation of CCUS technologies is one of the solutions to reduce GHG emissions at EU level, and a technology necessary to decarbonise hard-to-abate sectors. However, the regulatory framework is still in development: EU regulation so far covers geological storage and provides incentives to reduce emissions through the EU Emissions Trading System (ETS), but no fully developed scheme to encourage the removal of CO_2 for all economic sectors.

Additionally, the utilisation of carbon, as an alternative to storage, is not recognised by current EU legislation, and the transport to storage sites is hindered by restrictions such as the London Protocol, which makes the transboundary transport of CO_2 nearly impossible[2].

To facilitate the uptake of carbon removals, EU legislation needs to cover all steps of the CCUS value chain – capture, transport, utilisation and storage – as well as provide sufficient financial or regulatory incentives.

As part of this challenge, the European Commission is currently working on a certification scheme which will cover how to account for captured emissions, either fossil, biogenic or atmospheric. The revision of existing legislation is also expected to further encourage industries to capture their emissions, and to use recycled CO_2 as a substitute in the chemicals sector, the production of synthetic fuels, etc.



IEA, 2021

2. The London Protocol, entered into force in 2006, prohibits the dumping of wastes and other matter into the marine environment. This includes CO2 streams from CCS processes for sequestration, but with the first development of CCUS technologies a 2009 amendment made it possible for CO2 to be exported for storage between cooperating countries following specific requirements for permitting. However, the 2009 amendment is not yet in force as it was only ratified by 6 out of the 53 Parties. See IEA GHG **here**

Capturing CO_2

The most mature, commercially available technology today for WtE is post-combustion amine-based capture. But there are other solvents in development with lower TRL that could help to increase the efficiency and lower the cost of carbon capture in the coming years.[3]

Currently, the capture process requires a lot of energy, meaning that it lowers the amount of energy usually supplied for citizens and businesses. There are ways, however, to recover the waste heat from the process that can be then re-injected into the district heating grid and balance this loss[4].

The Amager Bakke plant, currently developing a carbon capture project. Credits: Rasmus Hjortshøj.

3. For an overview of capture technologies, including applicable to WtE, see IEA (2020), CCUS in Clean Energy Transitions, pp. 98 – 103, available **here**

4. See for instance Bisinella V. et al. (2022), Environmental assessment of amending the Amager Bakke incineration plant in Copenhagen with carbon capture and storage, Waste Management & Research, available **here**

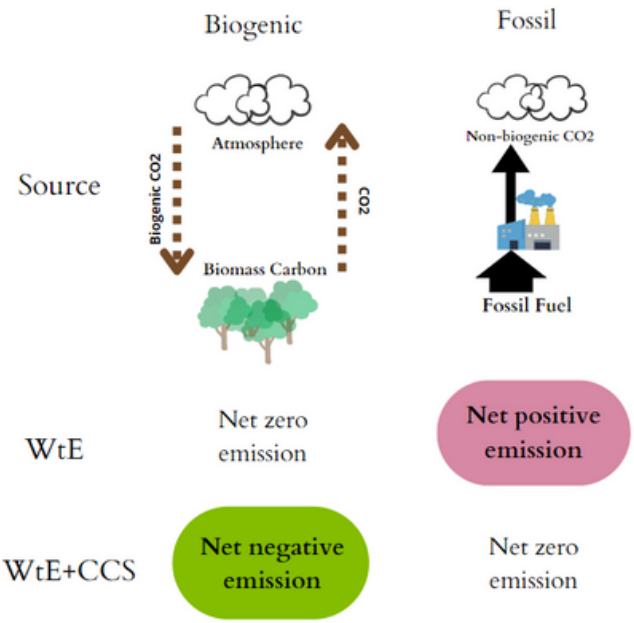
Monitoring Issues

Capturing CO_2 emissions is only the first step. To ensure that carbon is effectively removed from the atmosphere, and to guarantee that allowances are properly attributed, a solid accounting methodology is needed. WtE plants, however, present specificities that make accounting for emissions more complex. Indeed, the rule of thumb in Europe is that about half of CO_2 emissions emitted are of biogenic origin, and half of fossil origin. But this figure can vary depending on the area and the time period, as mixed municipal waste is heterogenous by nature and the fraction of biogenic waste can vary.

Indeed, due to the composition of the waste, plants emit two types of CO_2:

- Fossil CO_2(coming for instance from non-recyclable plastic),
- Biogenic CO_2(coming for instance from contaminated paper).

Biogenic CO_2 is carbon that was originally present in the atmosphere, for example taken up by trees and ending up in thermal treatment as contaminated paper. When emitted, this CO_2 is considered as carbon neutral (see Figure 1 below).



Monitoring Issues

While monitoring requirements are not covered by EU legislation to this day, there are other solutions emerging in third countries. In order to set up a new equivalent of the ETS in the United Kingdom following Brexit, the UK launched a consultation from March to June 2022 aimed at considering the inclusion of WtE[5].

Two options were on the table:

- **Individual plant monitoring:** meaning that plants' operators would have to determine the ratio of fossil and biogenic CO_2 from their plants, using either the 14C method, or a mass balance approach. The 14C method is a well-known may to measure the amount of 14C isotope in a sample, but only two accredited laboratories can provide this analysis (including one in the US, which increases the costs of logistics), which makes the process slow and burdensome.

- **Emissions factor approach:** this methodology is based on an estimate of the composition of waste, either with an average at national or regional level. This is a more practical approach, but one that could give an inaccurate report as waste composition vary over time. To best reflect the actual content of biogenic and fossil waste, an emissions factor should be tailored as close as possible to actual emissions.

While both solutions have their benefits and drawbacks, they show the complexity of designing an accounting methodology suited for WtE. Even if they will not be taken into consideration at EU level, they give a first insight on what a monitoring mechanism could entail for the sector.

5. Consultation and proposals related to the UK ETS, closed in June 2022, available **here**. A first response covering the actions to be implemented by 2023 was published in August, with no decision on WtE yet.

Certifying the removal of CO_2

Monitoring and reporting are essential to guarantee that each ton of captured CO_2 is effectively removed from the atmosphere. To prove this removal, the European Commission has been working on a certification mechanism. The goal is to propose EU-wide rules, including on monitoring, reporting and verifying the authenticity of said removals. A solid certification scheme will also enable the development of the full value chain, including carbon transport, utilisation and storage.

Clear regulation will also provide visibility to investors and facilitate new projects, and safeguard against greenwashing practices. Indeed, as more financial support is needed to ensure the full-scale deployment of infrastructure in Europe and ensure the effectiveness of carbon removals. The certification mechanism will be the basis of the upcoming framework that will cover the full value chain. A legislative proposal is expected in November 2022.

To store or to use

When captured, CO_2 has two routes: storage and utilisation. Storage means the permanent sequestration of carbon, generally in subsurface saline aquifers, geological formations or other reservoirs such as depleted oil fields. However, storage sites tend to be located in specific areas, and not always close and easily accessible for WtE plants or other facilities looking to invest in carbon capture. This means that that the development of a reliable transport infrastructure will be crucial for the full CCUS value chain, but will also allow to achieve economies of scale as a network can bring facilities together.

Utilisation is a more recent solution and still under development, but offers many possibilities and an additional revenue for the plant equipped with carbon capture. One instance in the WtE sector is the direct utilisation of CO_2 in greenhouses to promote plants growth and reduce the use of fossil fuels.

However, the utilisation of CO_2 emissions, such as for synthetic fuels, is closer to a delayed removal than to a permanent removal, as it will then be re-emitted at a later stage. This raises the question of the appropriate credit to be awarded.

2 European WtE plants actively capturing their GHG emissions

- Twence in Hengelo, in the Netherlands, was the first European plant to capture CO_2. Part of the emissions are transformed on-site into sodium bicarbonate to be reinjected into the flue gas cleaning line, and another part is sold to local greenhouses.

- AVR Duiven, in the Netherlands, delivers about 60,000 tons of CO_2 per year to the horticulture industry.

Carbon capture unit at the AVR Duiven plant. Credits: AVR.

2 projects are also in development and are now fairly advanced

- Klemetsrud in Oslo, in Norway, which is part of the large-scale Longship project supported by the Norwegian government. The plant, the largest one in Norway, is planning to capture up 400,000 tonnes of CO_2/year to from 2026. The project recently secured the necessary funding.
- Amager Resource Center in Copenhagen, in Denmark, finished a successful pilot project and is now in need of additional funding to fully implement their carbon capture project [6].

The Dutch government officially recognised the End-of-Waste status of the captured CO_2 from WtE in early 2022: **meaning that this carbon is considered as a product, which help to lessen the administrative burden for operators.**

Another use of carbon is the production of synthetic fuels, considered under EU legislation as 'recycled carbon fuels' or 'renewable fuels of non-biological origin'. In the case of CO_2 from WtE, those fuels would be classified as partly recycled carbon fuels, partly renewable biofuels, due to the specificities of WtE. However, using CO_2 to generate synthetic fuels raises the question of the permanency of removal, as the emissions captured are ultimately re-emitted again when the fuel is burned.

6. For more projects related to WtE, **see the list** from CEWEP on page 19.

The perception of "CO_2 from waste" will not be an issue as the demand for recycled carbon, incentivized by recent legislative changes such as synthetic fuels, is enough to ensure CCU for WtE plants as a viable option[7]. Indeed, with the appropriate filters & cleaning, it will not represent any risk because of its source, and can be used in the chemical industry like any other carbon.

During the Conference on Sustainable Carbon Cycles in January 31, the representant of Unilever indicated that their company was determined in using all sources of CO_2 , and that they considered carbon from waste to be a safe option for their products. See recording of the conference here.

Ensuring the success of CCUS for WtE

While the technical deployment of CCUS is already ongoing, there are still regulatory and financial obstacles to the achievement of its full potential. As such, a comprehensive policy framework tackling issues such as monitoring or the status of carbon utilisation is needed at EU level in the near future. The Waste-to-Energy sector is already working on improving its sustainability, but more clarity and a facilitated access to public funding will help to attain the goal of carbon negativity.

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CGI of potential CCUS plant at Runcorn EfW, UK.