EUROPEAN SUPPLIERS OF WASTE-TO-ENERGY TECHNOLOGY

WASTE-TO-HYDROGEN:

AN INTRODUCTION FOR THE EU POLICY-MAKERS

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1) CONTEXT

Under the European Green Deal, the European Union has agreed to reduce its greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, and to become climate-neutral by 2050. This ambitious goal will require employing all possible and necessary means.

Renewable and low-carbon hydrogen are considered key to the climate objectives, especially in energy-intensive industries and transport.

In this direction, the European Commission adopted the EU hydrogen strategy on 8 July 2020[1], to gather actions in the fields of research, innovation, production, and infrastructure, and to identify the ways the employment of renewable hydrogen can assist the process of decarbonising the EU economy in a cost-effective way.

On its end, the Waste-to-Energy (WtE) sector is now developing Waste-to-Hydrogen solutions to contribute to the decarbonisation in Europe.

2) PRODUCTION AND USE OF HYDROGEN

Hydrogen is an inherently carbon-free energy carrier and is produced from other molecules in a chemical process. Today, hydrogen (H_2) accounts for less than 2% of Europe's energy consumption and is mainly used for the manufacture of chemical products (e.g., plastics and fertilisers).

The vast majority of hydrogen produced comes from natural gas, oil and coal, with 96% coming only from gas, resulting in very high CO_2 emissions. This hydrogen is called "grey". If the majority of the CO_2 emissions from hydrogen plants are captured using Carbon Capture and Storage (CCS) technologies, then the hydrogen is called "blue"[2].

Nevertheless, hydrogen can also be produced from renewable energy sources, including from bio-based feedstocks. This is the "green" or "clean" hydrogen. Only green and blue hydrogen can contribute towards the reduction of CO_2 emissions and the transition to climate neutrality.

Green hydrogen is considered to be of crucial importance to the decarbonisation of many sectors in the economy, especially in transport and energy-intensive industrial processes, where other alternatives might not be viable or affordable[3].

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1 A hydrogen strategy for a climate-neutral Europe - COM/2020/301 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

2 Study requested by the European Parliament's ITRE Committee: Sander de BRUYN, Chris JONGSMA, Bettina KAMPMAN, Benjamin GÖRLACH and Jan-Erik THIE. (July 2020). Energy-intensive industries: Challenges and opportunities in energy transition. Policy Department for Economic, Scientific and Quality of Life Policies Directorate-General for Internal Policies. p. 32, available here: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

3 A hydrogen strategy for a climate-neutral Europe - COM/2020/301 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

The primary challenge for the uptake of hydrogen in the sector with the higher demand, the industry, will be the production of adequate quantities of renewable and low-carbon hydrogen at competitive prices.

Thus, the first necessary step to take advantage of the hydrogen potential is to build the infrastructure for production (electrolysers, etc.) and the technology (networks, pipelines, etc.) for consumption. This will require major infrastructural investments. Then market regulation with certification and standards for the CO_2 footprint of hydrogen must follow.

In order to cover the high demand for hydrogen, Europe might turn to imports from third countries with much better conditions for the production of renewable hydrogen. This practice will be similar to the present import of petroleum products, with many downsides, including excessive costs and emissions just for the relevant infrastructure for the travels of hydrogen.

What is more, this could create new geopolitical and technological dependencies which could hamper other countries' efforts to decarbonise their economies. The EU should be self-sufficiency and depend on the local production of renewable and low-carbon hydrogen first.

3) THE WASTE SECTOR STEPS IN: WASTE-TO-ENERGY OFFERS A RELIABLE LOW-CARBON FUEL FROM WASTE IN EUROPE

In 2019, the EU produced around 39% of its own energy, while 61% was derived from imports. At the same time, renewable energy (including renewable energy from waste) represented only 15% of the energy mix[4]. The growth in electricity generated from renewable energy sources from 2007 to 2017 mostly indicates an increase in three renewable energy sources across the EU, mainly wind power, and then solar power and solid biofuels (including renewable wastes)[5].

It is estimated that Waste-to-Energy plants in Europe account for 2.4% of the EU's total energy supply[6], continuously[7] supplying 18 million residents with electricity and 15.2 million residents with heat[8].

Waste-to-Energy technology is the safest waste treatment option for residual non-recyclable waste, but also an effective alternative energy option to prevent the use of fossil fuels and the consequent CO_2 emissions from traditional power plants producing the same amount of energy[9].

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4 EUROSTAT infographic: https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html?lang=en

5 EUROSTAT. (2019). Energy, transport and environment statistics, p. 51: https://ec.europa.eu/eurostat/documents/3217494/10165279/KS-DK-19-001-EN-N.pdf/76651a29-b817-eed4-f9f2-92bf692e1ed9?t=1571144140000

6 Waste-to-Energy in the EU: The Effects of Plant Ownership, Waste Mobility, and Decentralization on Environmental Outcomes and Welfare: https://www.mdpi.com/2071-1050/12/14/5743

7 Contrary to intermittent renewable sources (such as wind or solar energy), renewable energy from Waste-to-Energy can be provided 24/7, and is thus plannable and reliable.

8 CEWEP FAQ on Waste-to-Energy: https://www.cewep.eu/what-is-waste-to-energy/

9 Depending on the fuel that is replaced (gas, oil, hard coal, lignite), it is estimated that 10 – 49 million tonnes of fossil fuels

The European Commission has already recognised that generating energy from waste which cannot be recycled or reused can contribute to a circular economy and energy diversification, provided full respect of the waste hierarchy. Improving the efficiency in Waste-to-Energy facilities and processes will help to increase energy production and reduce greenhouse gas emissions from the waste sector[10].

Waste-to-Energy covers a wide range of different technologies with proven advantages to the European energy mix, as specified above, but it also has potential with regards to hydrogen production; the combustion of municipal solid waste, half of which is estimated to be of biogenic origin, thus a renewable source of energy, can provide some or all of the energy required for the generation of hydrogen through electrolysis or certain types of gasification. This **low-carbon hydrogen** represents a significant alternative to fossil fuels in powering fuel cell buses in cities, or refuse trucks collecting municipal waste.

Going a step further, Waste-to-Energy plants are not just treating the residual non-recyclable waste and providing "low-carbon" energy, but they have a potential for "negative carbon" contribution towards climate change mitigation targets (i.e., by removing CO_2 from the atmosphere).

Bioenergy with carbon capture and storage (BECCS) in the Waste-to-Energy sector is one of the few abatement technologies that can be **carbon negative**[11]. BECCS involves the utilisation of biomass as an energy source and the capture and permanent storage of the CO_2 produced[12].

The Waste-to-Energy sector has already had successful applications of this technology, for example, in Oslo, Norway, where removing emissions is required to meet the city's goal of 95% emissions reduction (in essence, climate-neutrality) by 2030[13].

Several hundreds of refurbished or new plants treating municipal waste throughout Europe would thus have potential to become as many local sources of green (provided there are CCS technologies in place) or low-carbon hydrogen. Already, promising pilot demonstrations and projects at various stages of development are now taking off in Europe.

A successful example is found in the modern Waste-to-Energy plant of Wuppertal (Germany), where the electricity generated during the thermal treatment of residual waste is used for the production of hydrogen which supplies the city buses with zero-carbon fuel[14].

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emitting 24 – 49 million tonnes of CO_2, would not need to be used by conventional power plants to produce this amount of energy: https://www.cewep.eu/waste-to-energy-cycle/

10 The role of Waste-to-Energy in the circular economy - COM/2017/034 final: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52017DC0034

11 Waste-to-Energy with CCS: A pathway to carbon-negative power generation: https://www.globalccsinstitute.com/wp-content/uploads/2019/10/Waste-to-Energy-Perspective_October-2019-5.pdf

12 The Intergovernmental Panel on Climate Change (IPCC) SR15 report (2018, p. 34) acknowledges that Carbon Dioxide Removal (CDR), including BECCS, is necessary to limit warming to 1.5°C: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf

13 Presentation of the Fortum Oslo Varme CCS project (part of the Longship project): https://www.fortum.com/media/2018/11/full-scale-carbon-capture-and-storage-ccs-project-initiated-norway

14 Article: "How rubbish becomes hydrogen mobility in Wuppertal": https://fuelcellsworks.com/news/how-rubbish-becomes-

4) WHAT IS IN FOR THE EU POLICY: CHALLENGES & OPPORTUNITIES

4.1) Smart Sector Integration Strategy (SSIS)

The Commission's EU Strategy for Energy System Integration or Smart Sector Integration Strategy (SSIS)[15], adopted on 8 July 2020, aims at establishing a "circular" energy system to promote the "energy efficiency first" principle, local energy sources and Waste-to-Energy among others, while offering a greater direct electrification of end-use sectors using more directly electricity produced from local renewable energy sources.

The strategy also supports clean fuels, including renewable hydrogen and sustainable biofuels and biogas. In addition, it works synergistically with the EU hydrogen strategy.

Waste-to-Energy constitutes a **reliable source of continuous energy, partially renewable**, as a complement to intermittent renewable energy sources. It relies on waste directly available in Europe and contributes to the SSIS as well as to the European Green Deal objective of securing affordable renewable energy within the European Union.

Thus, fostering the production of renewable and low-carbon hydrogen from WtE activities is in complete alignment with the requirements of the SSIS.

4.2) Sustainable and Smart Mobility Strategy

The European Commission adopted on 9 December 2020 the EU Sustainable and Smart Mobility Strategy[16]. The EC aims at transforming the EU transport system in line with the European Green Deal, by reducing the dependence of the sector on fossil fuels, by boosting the use of renewable and low-carbon fuels, including hydrogen, and by replacing existing fleets with low- and zero-emission vehicles.

The implementation of the Sustainable Mobility Strategy needs to go together with the EU energy system integration and hydrogen strategies, and encourage the uptake of low-carbon hydrogen produced from waste in sustainable transport.

4.3) Renewable Energy Directive (RED)

The EU legislation on renewable energy sources sets rules for the EU to achieve its 32% renewables target by 2030, a target that is expected to rise to 40% according to the latest proposal from the "Fit for 55" package[17].

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hydrogen-mobility-in-wuppertal/

15 Powering a climate-neutral economy: An EU Strategy for Energy System Integration - COM/2020/299 final: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2020:299:FIN

16 Sustainable And Smart Mobility Strategy – Putting European Transport On Track For The Future - COM/2020/789 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

17 'Fit for 55' press release: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541

This increase in the renewable energy targets will almost double the share of renewables in the EU's energy mix by 2030. The energy sector contributes over 75% of total GHG emissions in the EU, therefore, energy efficiency together with the uptake of renewables are essential to achieve the ambitious 2030 climate targets.

According to the Renewable Energy Directive (RED-II), the biodegradable fraction of municipal and industrial waste is considered biomass, which is a renewable energy source[18]. It is estimated that the renewable energy output from Waste-to-Energy plants is about 50%, contributing substantially to decarbonising the energy systems in Europe, in particular by substituting fossil fuels in the heating and transport sector[19].

Safeguarding the renewable feature of energy produced from biogenic waste and then acknowledging the importance of the renewable energy from this biogenic waste in hydrogen production are vital in order to increase the low-carbon hydrogen supply in Europe.

This is especially important if we consider the increase of the demand for hydrogen, with hydrogen's share in the EU's final energy demand by 2050 projected to reach 24%, providing potentially up to approximately 2,250 terawatt hours (TWh) of energy in the EU by 2050[20].

Biomass contained in waste is an essential renewable source of energy and as such should be strengthened in the revised Renewable Energy Directive (RED-III). This is already the case for some EU Member States, including Germany[21].

4.4) EU Emissions Trading System (EU ETS)

In the context of the European Green Deal and the EU Climate Law, the European Commission presented its proposal for the relevant energy legislation (also referred to as the "Fit for 55 package") in July 2021. This proposal includes the revision of the EU Emissions Trading System (ETS) to extend to new sectors of the economy.

The current proposal does not include Municipal Solid Waste Incineration (MSWI) in the EU ETS[22] and the sector should stay in the Effort Sharing Regulation (ESR), but is yet to be discussed by the EU co-legislators. In this context, several important issues should be taken into consideration.

In particular, any measures under the EU ETS focusing on Waste-to-Energy should be assessed in the context of **wider residual waste management**; undesirable detrimental consequences including increased landfilling or dumping of waste and shipments to countries with lower environmental and social standards should be circumvented.

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18 Renewable Energy Directive, (UE) 2018/2001: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

19 Assessment Of Selected Alternative Fuels And Technologies. p. 9: https://www.dnvgl.com/publications/assessment-of-selected-alternative-fuels-and-technologies-rev-june-2019--116334

20 Hydrogen Roadmap Europe, a sustainable pathway for the European energy transition, p. 8-9: https://www.fch.europa.eu/sites/default/files/Hydrogen%20Roadmap%20Europe_Report.pdf

21 "Decision: Waste becomes green hydrogen": https://www.wtert.net/news/403/DECISION-WASTE-BECOMES-GREEN-HYDROGEN.html based on this document from the Bundestag: https://dserver.bundestag.de/btd/19/298/1929850.pdf

22 "Fit for 55" proposal for the revision of the EU ETS: https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf

Landfills produce methane, a very potent GHG (84-86 times more powerful than CO_2 over a 20-year period[23]), and both landfills and waste exports contribute to marine litter as the wind blows microplastics, from (not sufficiently controlled) landfills to water bodies.

Additionally, as recently reported by Europol[24], making legal waste management services more expensive may result in increased illicit waste management activities impairing human health and the environment. At the same time, this waste would be lost as a resource, be it for electricity, heat or hydrogen production.

The sole inclusion of waste incineration under the EU ETS, with other waste management activities kept under the ESR, would thus run against the logic of the waste hierarchy. According to the waste hierarchy, landfilling should be the last-resort option for waste treatment when there is no alternative left.

Landfill diversion relies on integrated waste management and cannot be achieved without a holistic approach which involves efficient separate collection, waste prevention, reuse, recycling and, when waste cannot be recycled, energy recovery in advanced Waste-to-Energy facilities with a high energy efficiency and low emissions[25].

So far, the European Commission has carried out no impact assessment on the inclusion of WtE in the EU ETS, and it is doubtful that such an inclusion would lead to significant CO_2 emissions reduction if there is no strong preliminary support to CCS implementation[26]. However, it would raise the costs for waste treatment[27] not only in the WtE sector, but in the entire waste management chain, including recycling facilities[28].

These costs would be passed on to municipalities, which could instead spend the resources on supporting the production of hydrogen and carbon capture and storage. At the same time, this approach makes landfilling, for which there is no methane price in place (not to mention that the EU ETS does not consider methane despite recognising that it is a GHG), cheaper and therefore economically more attractive.

Besides, it would add a financial burden on the Waste-to-Energy sector alone (e.g., EU ETS, national incineration tax, and national CO_2 tax).

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23 Methane management challenge: https://unece.org/challenge

24 European Union Serious and Organised Crime Threat Assessment, p.93: https://www.europol.europa.eu/activities-services/main-reports/european-union-serious-and-organised-crime-threat-assessment

25 EP Resolution on the new Circular Economy Action Plan, paragraph 104: https://www.europarl.europa.eu/doceo/document/TA-9-2021-0040_EN.html

26 Though it could be measured in two Member States where municipal waste incineration is already covered under ETS (Sweden, Denmark), the Commission has carried no impact assessment in case of full coverage of the sector, including side-effects on waste management EU-wide. Unlike other industries, the incineration sector cannot switch its fuel for a low-carbon alternative, and it is bound to treat the waste it receives for safe treatment, which it did not produce in the first place. The only option to significantly reduce GHG emissions from incineration plants is to implement Carbon Capture technologies, which can be a challenge for small plants. The implementation of CCS in incineration plants would also require public support in order to ensure economic viability.

27 Unless there is first financial support for the implementation of Carbon Capture in place to make CCS an economically viable solution for WtE plants (no matter their scale). Support to CCS implementation in WtE is necessary as a first step before including the sector under EU ETS.

28 The recycling industry relies on Waste-to-Energy as an alternative to landfills for the treatment of non-recyclable waste rejected by recycling facilities. An increase in the cost of incineration would be passed on to recycling as well. On the relation between recycling and WtE, see for instance this statement of the European recycling industry: https://www.euric-aisbl.eu/position-papers/item/300-statement-on-issues-stemming-from-the-lack-of-capacity-for-ultimate-residual-waste

In order to prevent detrimental side-effects on the environment and competition distortions, it is essential to keep the entire waste management sector under the same legal instrument. Any reform should always carefully evaluate environmental and economic consequences, taking into account the broad impact on the entire waste management chain.

4.5) EU Taxonomy

The European Union is currently setting up a classification system called "taxonomy", which is a list of environmentally sustainable economic activities, in the context of the European Green Deal. The aim of the taxonomy is mainly to direct investments towards sustainable projects and activities.

The EU Taxonomy Regulation, which entered into force on 12 July 2020[29], establishes three overarching conditions that an economic activity has to meet in order to qualify as environmentally sustainable:

[1] An environmentally sustainable economic activity contributes substantially to one or more of the following six environmental objectives: (i) Climate change mitigation, (ii) Climate change adaptation, (iii) Sustainable use and protection of water and marine resources, (iv) Transition to a circular economy, (v) Pollution prevention and control, and (vi) Protection and restoration of biodiversity and ecosystems.

[2] In addition, the activity does not significantly harm ("DNSH") any of the other environmental objectives; and

[3] It is carried out in compliance with Minimum Social Safeguards set out in the Regulation. In order to assess conditions 1 and 2, the Commission is adopting technical screening criteria in the form of delegated acts, with the assistance of the Platform on Sustainable Finance[30].

In order to substantially contribute to climate mitigation and adaptation objectives, the first delegated act of the Taxonomy, which was adopted on 21 April 2021, sets out greenhouse gas thresholds relating to hydrogen production, requiring life-cycle GHG emissions lower than 3tCO2e/tH2[31], and other criteria for other hydrogen-related activities[32].
According to them, green and most probably low-carbon hydrogen will be taxonomy-aligned[33]. Regarding power generation from renewable non-fossil hydrogen, it is considered sustainable if it complies with the threshold of 100 g CO_2 emissions per kWh[34].

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29 Taxonomy on Sustainable Finance Regulation, (UE) 2020/852: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0852

30 These delegated acts are applicable from 1 January 2022 for the two climate-related objectives, and from 1 January 2023 for the other four environmental objectives.

31 EU Taxonomy Climate Delegated Act, Annex I, point 3.10 – Manufacture of hydrogen: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=PI_COM:C(2021)2800

32 EU Taxonomy Climate Delegated Act, Annex I, points 3.2 - Manufacture of equipment for the production and use of hydrogen, and 4.12 - Storage of hydrogen: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=PI_COM:C(2021)2800

33 What does the EU Taxonomy mean for the Hydrogen industry?: https://www.bakermckenzie.com/en/insight/publications/2021/05/eu-taxonomy-hydrogen-industry

34 EU Taxonomy Climate Delegated Act, Annex I, point 4.7 - Electricity generation from renewable non-fossil gaseous and

Therefore, as long as energy from waste biomass is considered renewable and hydrogen from waste meets the thresholds and technical screening criteria, then this hydrogen from WtE should be accepted as taxonomy-aligned.

4.5) Energy and Environmental State Aid Guidelines (EEAG)

At national level, public financial support is important in developing more sustainable waste management solutions and in promoting renewable energy and energy efficiency.

In this direction, it is imperative that the revised guidelines on state aid for environmental protection and energy reiterate that support for energy from renewable sources using waste or support for cogeneration and district heating installations using waste can make a positive contribution to environmental protection as long as it does not hamper the waste hierarchy[35].

This support should also cover the production of hydrogen from Waste-to-Energy plants.

5) CONCLUSIONS

Any forthcoming national or EU-wide climate measure for the Waste-to-Energy sector should take into account the offsets of CO_2 emissions in WtE through Life Cycle Analyses, not just the direct emissions, as well as the potential of the sector in the **hydrogen supply**.

It should also consider the complexities discussed above and ensure that the impact on the environment and human health, in terms of effective GHG emissions' reduction and pollution prevention and control, as well as on competition (level-playing field with the rest of the waste management sector) is carefully evaluated.

In any case, the necessary transition period must be granted, while the polluter-pays principle should be strengthened to make those responsible for waste generation (and not waste treatment) pay for its environmental and climate impacts.

We are running out of time to attain the climate goals; Taking advantage of every available solution is the best way to move faster in decarbonising the European industry and broader economy.

liquid fuels: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=PI_COM:C(2021)2800

35 The role of Waste-to-Energy in the circular economy - COM/2017/034 final, p. 5: : https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52017DC0034

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