An analysis of BECCS industries' methodology for certifying industrial carbon removals

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Front cover: The Drax Power Station in North Yorkshire, United Kingdom began piloting carbon capture technology in 2018, but the proposed Drax / Stockholm Exergi methodology does not guarantee genuine removals of carbon dioxide from the atmosphere. Photo by Clare Louise Jackson/Shutterstock

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Summary

This paper analyses the suggested methodology for carbon removals published by Drax and Stockholm Exergi in October 2023. It identifies the following shortcomings:

It does not guarantee that the BECCS project will be genuinely additional, i.e. that the atmospheric concentration of carbon dioxide will be lower than it would have been if the project had not taken place. Where the feedstock is whole trees – as most of it may be – all that the BECCS project will do is transfer carbon stored in one form – the biological pool – to another – the geological pool. For BECCS to be additional, the scheme would need to show additional growth of biomass, but the methodology does nothing to deliver this outcome.

It adopts the assumption that all forest biomass feedstocks are automatically carbon-neutral, and accordingly does nothing to restrict feedstocks to those with the lowest carbon payback periods. Similarly, it ignores emissions from on-site biomass generation used in the carbon capture and storage process.

The proposed sustainability criteria are defective in a number of ways:

- Feedstock sourcing areas are limited to those which show stable or increasing forest carbon stock, but it is possible for such areas to experience increased growth but at a lower rate than they would have seen in the absence of extraction for energy. It is the net impact on the climate compared with the counterfactual, of no extraction for energy, that should underlie the measurement of carbon sequestered.
- The exemption through which biomass may be sourced from areas with declining carbon stocks if this is due to 'planned reductions' such as thinning, could be open to abuse.
- 'Material suitable for use in long-lived wood products, such as sawtimber or veneer within the sourcing area' is excluded from allowable feedstock, but the wording 'within the sourcing area' is unclear and may significantly limit this constraint.
- The list of categories that are suitable for BECCS is wide, including thinning, pulpwood and 'down-graded' wood, even though, in practice, these types of wood can include all trees with no other commercial value and can be, and often are, used for long-lived wood products such as panels and have high carbon and biodiversity value when left in the forest.

There are also a number of issues where more clarity is needed, including the justification for setting a relatively high leakage threshold; limits on sourcing feedstock from highly biodiverse forest; and mitigating corruption.

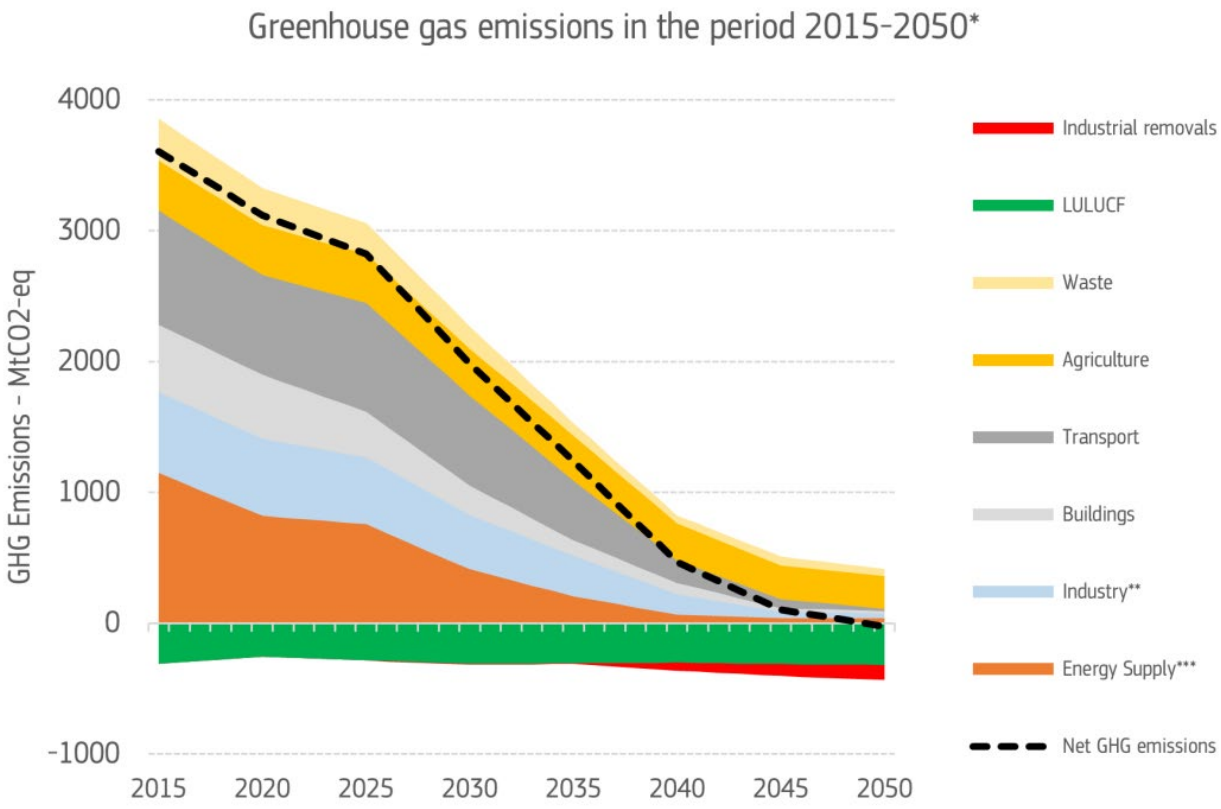
Given the urgency of the climate challenge and the difficulty and cost of mitigation options for the 'hard-to-abate' sectors, robust rules are clearly needed for CDR projects, both nature-based and industrial, including BECCS. In particular, robust sustainability boundaries must be drawn for CDR projects with a major impact on land use. Any attempt to measure accurately the carbon removals deriving from these activities is welcome, and developing this methodology could have been a useful step forward. However, its value is severely limited by the drawbacks identified above, particularly on additionality and the zero-rating of feedstock. In addition, it would be of more value if it can be adapted to deal with more appropriate categories of feedstock, including agricultural residues and wastes, which are likely to be the only suitable feedstocks for BECCS, particularly where they are sourced locally with very short supply chains, but these are excluded from the current version.

1. Background: EU climate goals

On 6 February 2024 the European Commission published its proposal for a 2040 climate target for the EU. After considering three options, in the context of the optimum pathway to reach the EU's existing target of net zero by 2050, the Commission recommended reducing the EU's net greenhouse gas emissions by 90% by 2040, relative to 1990.[1]

All three options analysed included reliance on negative emissions to offset the remaining emissions primarily from the 'hard-to-abate' sectors, mainly agriculture, industry and aviation. While the bulk of these negative emissions were assumed to derive from the Land Use, Land-Use Change and Forestry (LULUCF) sector, a significant proportion needed to be generated from industrial carbon capture processes; see Figures 1 and 2.

Figure 1: Historical and projected EU greenhouse gas emissions, including negative emissions, 2015–50[2]



*Source: PRIMES, GAINS, GLOBIOM
**Excluding non-BECCS industrial removals
***Including Bioenergy with carbon capture and storage (BECCS)

1 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Securing our future – Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society (COM(2024) 63 final, 6 February 2024).*

2 *Source: Commission website at https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2040-climate-target_en*

Figure 2: Estimates of EU negative emissions – industrial and LULUCF removals[3]

	2040			2050
	S1	S2	S3	S3**
Gross GHG emissions (MtCO2-eq)	**1273**	**943**	**748**	**411**
Total Removals (MtCO2-eq)	**-222**	**-365**	**-391**	**-447**
Industrial Removals (MtCO2)	-4	-49	-75	-114
LULUCF net removals (MtCO2-eq)	-218	-316	-317	-333

Note: S1, 2 and 3 are analytical scenarios accompanying the three options considered by the Commission.

Source: PRIMES, GAINS, GLOBIOM

The option the Commission chose (option 3) implies industrial removals of 75 megatonnes of carbon dioxide equivalent (MtCO2) by 2040, from "a large portfolio of options such as BioCCS (carbon capture and storage of biogenic CO2 emissions originated from the combustion of biomass to produce energy (BECCS) or from the processing of biomass in industrial applications), DACCS (Direct Air Capture with Carbon Storage) and possibly other novel approaches".[4] On the same day at its proposals for the 2040 target were launched, the Commission published a further paper setting out the framework for a strategy to create an enabling environment to develop and scale up industrial carbon management approaches.[5]

1.1 The EU's Carbon Removal Certification Framework

Quantifying the carbon dioxide captured by industrial carbon removal processes, and verifying the volumes captured and stored, is a critical part of the process. On 30 November 2022, as part of the European Green Deal, the Commission presented a legislative proposal for an EU certification framework for carbon removals.[6] Provisional agreement between the European Parliament, the European Commission and the Council on an amended text was reached on 20 February 2024, a compromise that was welcomed by Drax and drew criticism from environmental and climate non-governmental organisations.[7, 8, 9]

The proposed framework distinguishes between four types of carbon removals, depending on the length of time the carbon is expected to remain in storage. Permanent carbon removals, such as DACCS and BECCS,

3 *Source: Commission Staff Working Document Impact Assessment Report Part 1, Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Securing our future – Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society (COM(2024) 63 final, 6 February 2024) (SWD(2024) 63 final, 6 February 2024).*

4 *Securing our future, p. 18.*

5 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Towards an ambitious Industrial Carbon Management for the EU (COM(2024) 62 final, 6 February 2024).*

6 *Proposal for a Regulation of the European Parliament and of the Council, establishing a Union certification framework for carbon removals (COM(2022) 672 final, 30 November 2022).*

7 *Commission press release, 'Commission welcomes political agreement on EU-wide certification scheme for carbon removals' (20 February 2024); https://ec.europa.eu/commission/presscorner/detail/en/ip_24_885.*

8 *https://twitter.com/DraxGroup/status/1760982910251765854*

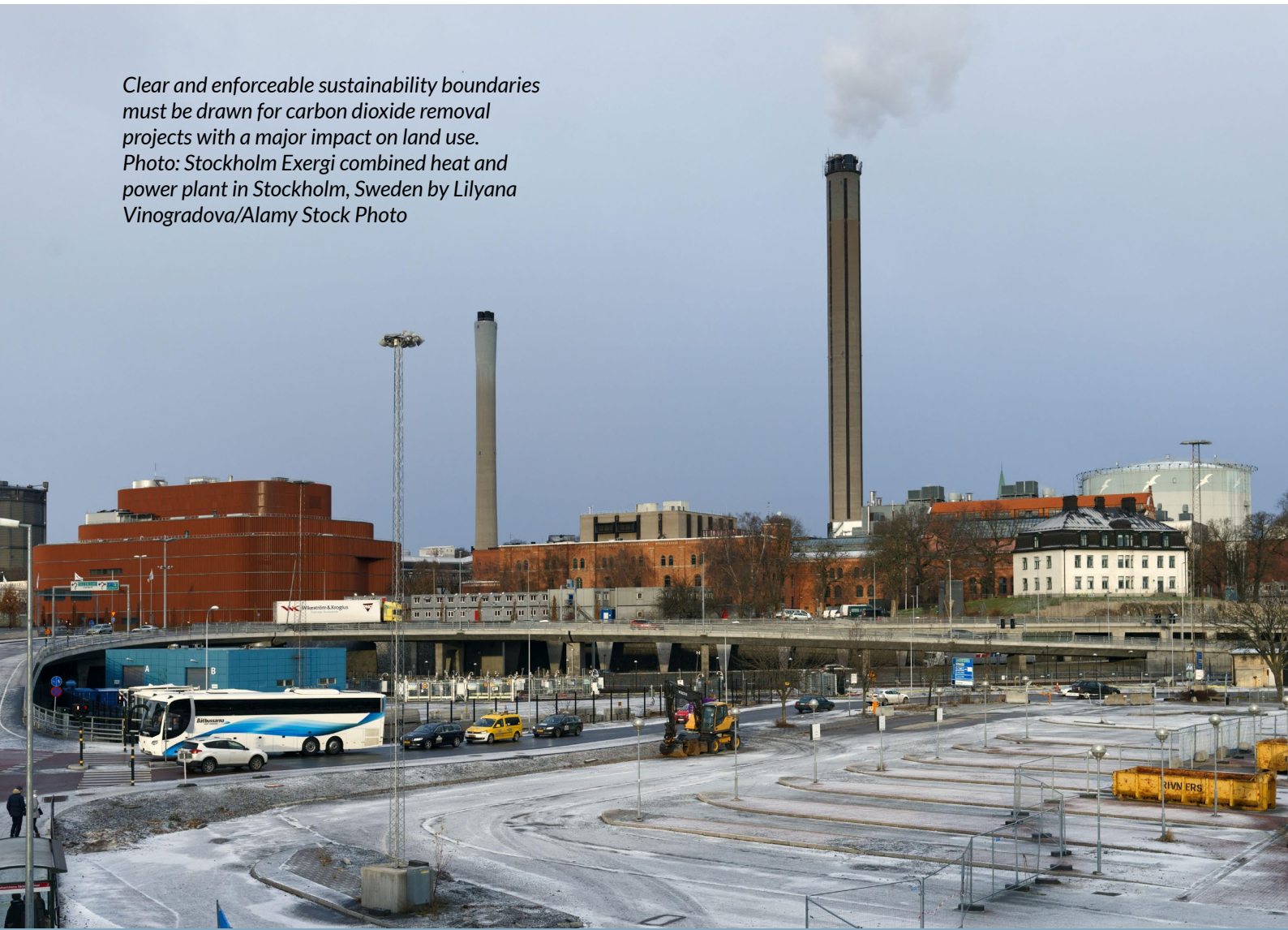
9 *Carbon Market Watch, 'CRCF: The EU's carbon removal certification failure', 20 February 2024, https://carbonmarketwatch.org/2024/02/20/crcf-the-eus-carbon-removal-certification-failure/*

which are assumed to store carbon for several centuries, are treated differently from shorter-lived carbon storage, for example in wood-based construction materials. The Carbon Removals Certification Framework (CRCF) landed on the following guiding criteria: correctly quantified; store carbon for an agreed long-term period (a minimum of 35 years for carbon stored in products); go beyond existing practices and do not just reward the status quo; and contribute to broader sustainability goals.

The CRCF states that any carbon removal activity must have a neutral impact on or generate co-benefits for a range of sustainability objectives, including the sustainable use and protection of water and marine resources, and the protection and restoration of biodiversity and ecosystems. Removals will be subject to monitoring, and operators will be liable to address any cases of reversal, where carbon is accidentally released back into the atmosphere as carbon dioxide.

The draft text sets out the recognised certification bodies and schemes, and the procedures for certification of compliance, reporting, and establishing an EU registry of carbon removals. Although certification is to remain voluntary for the time being, only certified units can be used to meet the EU's climate objectives and Nationally Determined Contributions (NDC) under the Paris Agreement, adopted under the United Nations Framework Convention on Climate Change (UNFCCC).

The next step is for the Commission, supported by the Carbon Removal Expert Group, to continue its work to develop credible and tailored certification methodologies for the different types of carbon removal activities, based on four criteria: quantification, additionality, long-term storage, and sustainability.



Clear and enforceable sustainability boundaries must be drawn for carbon dioxide removal projects with a major impact on land use. Photo: Stockholm Exergi combined heat and power plant in Stockholm, Sweden by Lilyana Vinogradova/Alamy Stock Photo

2. The Drax/Stockholm Exergi proposed methodology

It was in the context of the EU's Carbon Removal Certification Framework that the two energy companies Drax and Stockholm Exergi, together with the consultancy EcoEngineers, published, in October 2023, a suggested methodology for carbon removals.[10] This methodology was presented at the third meeting of the Commission's Carbon Removals Expert Group on 25–26 October.[11] It is labelled as version 0.9, with the first full version (1.0) to be published 'shortly', after consultations, though no further version has yet been made available.

Drax, the last coal station to be built in the UK, is also the largest. Between 2013 and 2018 it converted four of its six units from coal to biomass (the remaining two are now being decommissioned). Drax is now the largest biomass-burning power station in the world, with a capacity of about 2.5 gigawatts, producing about 5% of UK electricity. It burns roughly seven million tonnes of wood pellets a year, almost entirely imported, mostly from the United States (US), Canada and the Baltic states. It began piloting carbon capture technology in 2018, started a second pilot in 2020, and has announced its ambition to geologically sequester 14 million tonnes of carbon a year by 2030.[12]

Stockholm Exergi, a Swedish district energy provider, is currently supported by the EU Innovation Fund to create a BECCS facility at its existing combined heat and power biomass plant in Stockholm. Combining carbon capture with heat recovery, the plant projects it will capture and store around seven million tonnes of carbon dioxide over the first ten years of operation.

The methodology document is intended for use by developers of BECCS projects aimed at generating credits from carbon dioxide removal (CDR), but is also clearly intended to influence the process within the Commission of developing carbon removal certification. It explains that:

> ***"This methodology is built on the principle of conservativeness, calculating the net volume of carbon dioxide (CO2) removed from the atmosphere through BECCS, and containing measures to avoid overstating removals volumes. In addition, this methodology outlines robust quantification approaches and data sources that can be used to verify net removal volumes and in turn produce CDR credits. It also outlines strict eligibility criteria, such as detailed biomass sustainability requirements."***[13]

It covers only BECCS plants using thermal combustion of forest and agricultural biomass (though in fact agricultural feedstocks are not included at this stage) – thus excluding other technologies such as ethanol production or waste combustion – operating in the European Economic Area, the United Kingdom (UK) or the US (it is intended to expand to other jurisdictions in time). At the time of publication it was pending validation by a third party verification body; no further information is available on who this body is or when it might verify the methodology.

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10 EcoEngineers, Methodology for measuring net carbon dioxide removal through bioenergy with carbon capture and storage (BECCS), Vol. 9 (Drax and Stockholm Exergi, October 2023).

11 See https://climate.ec.europa.eu/eu-action/sustainable-carbon-cycles/expert-group-carbon-removals_en.

12 'Drax's BECCS Frontiers: Redefining Energy, Reducing Emissions, and Beyond' (interview with Lewis Rodger, Carbon Markets Development Lead at Drax, 16 January 2024); https://medium.com/@nep.europe23/draxs-beccs-frontiers-redefining-energy-reducing-emissions-and-beyond-5d33942df5e8.

13 Ibid., p. 4.

Under the methodology, BECCS projects must meet the following requirements:[14]

- Only 'sustainable' biomass feedstocks can be used (see Section 2.1 below).
- Captured carbon dioxide must be stored in permanent geological storage meeting applicable regulatory standards, and cannot be used for any other purpose, such as enhanced oil recovery.
- For new-build facilities, projects must have included consultation with relevant stakeholders; for retrofit projects, this is only considered necessary where the physical footprint of the facility increases.[15] A grievance mechanism must also be established.
- The project proponent must confirm that there is no risk of breaching safeguards, or provide a mitigation plan if there is.[16] These safeguards include compliance with national and local laws and human and labour rights; Free, Prior and Informed Consent for Indigenous Peoples and local communities, and respect for their rights; regulatory limits on pollution; avoiding, or where this is not feasible, minimising, forced physical and or economic displacement; avoiding negative impacts on biodiversity and living natural resources; and providing for equal opportunities on the basis of gender.
- The removals generated must be additional, which is defined as meaning they would not have taken place without the incentive created by CDR credits. Projects subject to regulatory requirements to capture carbon dioxide, for example, are not additional, and neither are projects not intended to participate in the voluntary carbon market (projects in receipt of public funding are additional as long as they can demonstrate *some* incentive from carbon market revenues).

The 'boundary' of the project – the processes exclusively initiated by the anticipation of CDR credit revenue – covers the carbon capture, processing, transport and storage components of the BECCS system.[17] Emissions that would have occurred anyway, in the absence of the BECCS project, are considered to be baseline emissions and are excluded from the net removals calculation.[18] Emissions removals are calculated as follows:[19]

- Volume of carbon dioxide permanently removed and stored through the BECCS project.
- *Minus* all direct emissions associated with the construction and operation of the CCS equipment, including from the capture process, liquefaction, transport to permanent storage, injection and storage.
- For existing biomass plant retrofitted with BECCS equipment, this includes emissions from the installation of the CCS equipment and a portion of overall emissions from the plant (calculated according to the amount of electricity needed to operate the CCS activities, including capture, liquefaction and interim storage). For new-build BECCS plants, this includes only the embodied emissions from construction.
- *Minus* operational supply-chain emissions related to the supply of the feedstock, including emissions from the cultivation and harvesting of the biomass used for BECCS, processing (e.g. processing woody biomass into pellets), transport of feedstock, and removing and transporting waste (e.g. removing ash from combustion units).

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14 Methodology for measuring net carbon dioxide removal through BECCS, summary of sections 2 and 4.

15 For more detail see ibid., Appendix E.

16 For more detail see ibid., Appendix F.

17 Ibid., section 3. More detail is included in Appendix G.

18 Ibid., section 5.

19 Ibid., section 7.

- *Minus* indirect emissions from leakage caused by activities within the BECCS value chain – e.g. from any increase in the use of carbon-intensive energy as a result of demand for CCS equipment, or from increased carbon dioxide emissions from wetland soils as result of lowered water levels from increased use of water for biomass feedstocks.[20] However, below a threshold of 2% of gross captured emissions, leakage emissions are considered to be non-material (though no explanation is given as to how the 2% figure was arrived at).

Avoided emissions from biomass displacing 'more carbon intensive forms of generation' are not included in the quantification. If the energy used for CCS derives from on-site biomass power generation, emissions associated with this are not subtracted, as they have already been factored into the supply-chain emissions calculation; this element thus only relates to energy purchased from third parties. Embodied emissions from the chemicals used in the carbon capture process are included.

In line with current public policy frameworks, carbon dioxide emissions from the combustion of the biomass feedstock (as long as it meets sustainability criteria) are not included in the calculation; this applies to emissions from biomass use for energy in the supply chain as well as from the biomass burnt in the BECCS plant. Biomass is 'zero rated' for these purposes because it is assumed, in line with the reporting conventions introduced by the Intergovernmental Panel on Climate Change (IPCC), that all emissions from changes in carbon stocks from the harvest of the biomass are reported in the Agriculture, Forestry and Other Land Use (AFOLU) sector of the national greenhouse gas inventory of the country of origin (see further below, Section 3.2).[21] Emissions of the greenhouse gases methane and nitrous oxide are, however, included.

Each project is required to report data and evidence to a third-party organisation for the purpose of independently assuring project outcomes.[22] The project is validated when it is confirmed that it has adhered to all requirements in the methodology; validation must be renewed at the end of the 15-year crediting period. Project validation signifies the beginning of the crediting period, and all claims of net carbon dioxide removal volumes must be verified by a third party at least once per year.

2.1 Sustainability criteria

In order to be zero-rated, biomass feedstocks must meet sustainability criteria, which includes a number of elements, explained below.[23] (Many of these are adapted from the sustainability criteria for solid biomass included in the EU Renewable Energy Directive 2019, as revised in 2023.)

They must be sourced from areas which show stable or increasing forest carbon stock.

This is to be assessed either at a jurisdictional level, as included in national greenhouse gas emissions reports to the UNFCCC, or at the forest sourcing area level. (For countries larger than five million square kilometres (km2) – i.e. Russia, Canada, US, China, Brazil and Australia – the assessment must be carried out at the sourcing-area level.) Jurisdictional-level assessments are to use an average of the last five years of available UNFCCC data on changes in emissions from forest lands and harvested wood products. Forest-sourcing-area-level assessments are to be conducted based on changes in carbon stock on attributable managed lands within the sourcing region, using an average of the last five years of available data (the term 'region' is not defined).

Biomass may be sourced from areas with declining carbon stocks if it can be shown, and independently verified, that the reduction in stocks is not due to over-harvesting of forests, but derives from natural disturbances (e.g.

20 Ibid., section 6. More detail is included in Appendix D.

21 Ibid., p. 22 and Appendix A.

22 Ibid., section 9. More detail on the data to be reported is included in Appendix I and on monitoring in Appendix J.

23 Ibid., Appendix C.

fire or pests) or planned reductions to stabilise or reverse the decline of future forest carbon stock (e.g. thinning to reduce fire risk) and where a mitigation plan is in place to stabilise or reverse the decline.

The source forests must be sustainably managed.

This criterion require either that the source country has national or sub-national laws applicable in the area of harvest, as well as monitoring and enforcement systems, or that management systems are in place at the forest sourcing area, in each case ensuring that operations are legal, harvested areas are regenerated, protected areas remain protected, harvesting prevents negative impacts on soil quality and biodiversity (e.g. by avoiding harvesting stumps and roots and excessive extraction of deadwood) and harvesting maintains or improves the long-term production capacity of the forest.

- Primary forests and other highly biodiverse ecosystems are not used for sourcing feedstock, though sourcing is allowed from highly biodiverse forests if: "evidence is provided that the harvesting of the biomass does not interfere with those nature protection purposes". There is no explanation of what this evidence should comprise or how it can be concluded that its extraction does not interfere with nature protection.
- High carbon stock lands – wetlands and peatlands – are not used for sourcing feedstock.
- Feedstock must not be sourced from "material suitable for use in long-lived wood products, such as sawtimber or veneer within the sourcing area".[24] Sources "whose characteristics make them unsuitable for use in higher value markets … are eligible. Sources may include thinning, pulpwood, or down-graded wood due to fire, storms, infestation, fungus or fibre that is logistically or otherwise unsuitable for use in long-lived products."
- Feedstock must not be sourced from any country with a Corruption Perception Index less than 50 (on the 2023 Index, these are all developing or former Soviet countries plus Turkey, North Macedonia, Hungary, China, Bulgaria, Romania, Montenegro and Greece; the main current sources of internationally traded forest biomass – US, Canada, the Baltic states, etc. – are rated above 50),[25] except where the supplier can demonstrate adequate mitigation of the risk of corruption – how they are to do this is not explained.

Post-consumer waste feedstocks are exempt from the sustainability criteria. Biomass residues from processing (e.g. sawmill residues) are exempt from the 'stable or increasing forest carbon stock' criterion "on the basis that demand for such biomass has little influence over land management decisions and consequently carbon stock changes".[26]

Biomass must be traceable throughout the value chain, but mass balance is allowed, which means that "biomass with differing sustainability and GHG [greenhouse gas] characteristics" can be mixed, though sustainable biomass must not be mixed with illegally harvested sources.[27] Verification against the sustainability criteria can be conducted either through certification, third-party verification or regulatory verification against national criteria (by a third party or by national authorities). Where the certification or regulatory criteria do not cover all of the criteria set out in the methodology, third-party verification may be used to verify those not included.

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24 Ibid., p. 43.

25 See https://www.transparency.org/en/cpi/2023.

26 Methodology for measuring net carbon dioxide removal through BECCS, p. 43.

27 Ibid., pp. 43–44.

3. Shortcomings

Any contribution to the development of a comprehensive methodology for measuring the possible climate benefit of BECCS projects is of course welcome. However, in its current form the Drax / Stockholm Exergi methodology suffers from several shortcomings, discussed below.

3.1 Additionality of negative emissions

BECCS projects are only of value if they result in genuine removals of carbon dioxide from the atmosphere – i.e. that the atmospheric concentration of carbon dioxide is lower than it would have been if the project had not taken place. The Drax / Stockholm Exergi methodology does not guarantee that this will take place. Where the feedstock is whole trees (as is the case for the majority of Drax's feedstock),all that the BECCS project does is transfer carbon stored in one form – the biological pool – to another – the geological pool, with additional emissions associated with the processing. Treating these emissions as negative would result in double-counting, as the carbon sequestered in the trees has already been included in the national greenhouse gas inventories of the countries of origin. The outcome of the BECCS activity would not have changed the atmospheric concentration of carbon dioxide at all.

Furthermore, the process will not capture 100% of the carbon sequestered in forest biomass; a proportion will be lost at every stage of the process, including harvesting (such as through soil disturbance), processing, transport, combustion, capture, transport of the carbon dioxide and storage.

For robust carbon accounting, only carbon removals relative to a counterfactual baseline that would not have taken place without the BECCS project should be counted as a genuine carbon reduction.[28] As the *Oxford Principles for Net Zero Aligned Carbon Offsetting* comments, "Additionality can be difficult to determine and verify, and ultimately involves some degree of subjectivity since the counterfactual world in which the offsetting activity was not performed cannot be observed directly".[29] In this case, the BECCS project must lead to additional growth of biomass, and associated carbon sequestration, that would not have taken place in the absence of the project. The Drax / Stockholm Exergi methodology does nothing to deliver this outcome; its own definition of 'additionality' relates only to the question of whether the project would have taken place without the incentive created by CDR credits.

This will be a key issue for BECCS projects. In 2022 the Agriculture and Fisheries Council drew attention to the need for high-quality criteria for additionality, among other factors, in the EU's carbon reduction framework.[30] In practice the need for genuine additionality implies that BECCS projects should only be based on new, not existing, sources of feedstock except in cases where the biomass would otherwise be burnt as waste, for example from agricultural processes or municipal organic waste not used for the production of compost, or left to decay and release its stored carbon to the atmosphere (bearing in mind that for harvest residues left in the forest, some of the carbon will be absorbed by forest soils). For both reasons this suggests that BECCS feedstock should be primarily drawn from residues from wood processing outside forests (such as sawmill residues) and waste, and possibly fast-growing energy crops not competing with food production, none of which are covered by this version of the methodology.

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28 As discussed, for example, in Zetterberg L, Johnsson F and Möllersten K (2021) Incentivizing BECCS—A Swedish Case Study. Front. Clim. 3:685227 and Schneider, L., Kollmuss, A., and Lazarus, M. (2014). Addressing the Risk of Double Counting Emission Reductions Under the UN-FCCC. Stockholm Environment Institute.

29 Allen, M. et al, The Oxford Principles for Net Zero Aligned Carbon Offsetting (University of Oxford, September 2020).

30 'Council conclusions on the Commission communication on sustainable carbon cycles in the agricultural and forestry sectors' (7728/22, 4 April 2022).

3.2 Zero-rating of biomass feedstock

Carbon payback periods

Another main shortcoming of the methodology is the assumption that all forest biomass feedstocks meeting the sustainability criteria are automatically carbon-neutral. This follows the EU policy framework, where biomass feedstocks meeting the Renewable Energy Directive's sustainability criteria are zero-rated. However, as has been extensively discussed in many studies, this assumption is not valid.[31] Burning biomass for energy creates a significant initial increase in carbon emissions, which is only balanced by regrowing trees and the displacement of fossil fuels. Depending on the feedstock used and the efficiency of combustion, the net impact is to increase global warming for, at best, a few years and, at worst, several centuries. During this 'carbon payback period' carbon dioxide emissions are higher than they would otherwise have been, even taking into account the fossil fuel use displaced by bioenergy.

Although the carbon dioxide emitted from burning biomass would eventually be absorbed by forest regrowth (assuming this is not affected by climate and biodiversity loss stresses), the elevated levels in the interim are incompatible with the Paris Agreement's aim of peaking global emissions 'as soon as possible', as well as its 1.5°C and, possibly, 2°C targets, and also the EU's own target of net zero by 2050. They also increase the risk of reaching a climate tipping point, when a small rise in global temperature prompts a large and potentially irreversible change in the global climate.

Reviews by the EU's Joint Research Centre, among others, have shown the wide range of payback periods associated with different categories of forest biomass compared to the use of coal or gas, ranging from 10 to 20 years for fine woody residues from forest operations (tops, branches and needles) to more than 50 years for coarse residues with generally slower decay rates (snags, standing dead trees and high stumps).[32] If residues such as these are left to decompose in the forest, they release their carbon to the atmosphere only slowly (depending on site-specific factors such as temperature, moisture levels, biodiversity, tree species, etc.), and a portion enters the forest soil, where the carbon can remain for much longer periods of time.

Feedstock from increased harvesting of whole trees would have longer payback periods, possibly over a century. During 2009–15, such primary woody biomass harvested from forests accounted for up to 51% of the input mix of wood for energy consumed in the EU, according to the Joint Research Centre study; and since 2015 the rate of extraction of wood from EU forests has increased significantly.[33] Similarly, about 50% of US-sourced wood pellets burnt in UK power stations is derived from whole trees, mainly described as thinnings.[34]

Agricultural residues can be burnt to generate electricity, and some very small biomass plants use this feedstock, as well as forest harvesting residues, but forest biomass is significantly cheaper and easier to collect, process and transport (usually as wood pellets) over long distances, which is why it generally accounts for all, or almost all, of the feedstock burnt in larger stations. Furthermore, most existing large biomass plants, either conversions or new build, are optimised for wood pellets or chips and cannot burn agricultural residues, or can do but only in very small proportions, owing to their fouling effect on the machinery. It is likely, then, that forest biomass would remain the major source of feedstock for a converted or expanded BECCS industry, with accompanying impacts on carbon payback periods. Both Drax and Exergi are planning to continue using forest biomass as their feedstock once they have installed CCS equipment at their existing biomass stations.

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31 For overviews, see, for example, Brack D., Birdsey R. and Walker W., Greenhouse gas emissions from burning US-sourced woody biomass in the UK and EU (Chatham House, 2021); Quiggin D., BECCS deployment. The risks of policies forging ahead of the evidence (Chatham House, 2021); EASAC, Forest bioenergy update: BECCS and its role in integrated assessment models (EASAC, 2022).

32 Camia A. et al., The use of woody biomass for energy production in the EU (EU Joint Research Centre, 2021).

33 Turubanova & al, 'Tree canopy extent and height change in Europe, 2001–2021, quantified using Landsat data archive', Remote Sensing of Environment, Vol. 298, 2023.

34 Brack et al., Greenhouse gas emissions from burning US-sourced woody biomass in the UK and EU.

Energy used for carbon capture

The impact of zero-rating of biomass feedstock is exacerbated because the methodology ignores emissions from on-site electricity generation from biomass used in the carbon capture and storage process. This is of course consistent with the zero-rating approach, but it can represent a significant proportion of energy output from the plant, given the need to heat the carbon dioxide absorbent used in the capture cycle to separate the solvent from the captured carbon, and the additional energy required to compress and transport the captured carbon. Trials at the Drax biomass plant in the UK indicate an energy penalty of around 170 megawatts (MW) for each 630 MW turbine, lowering the overall efficiency of the BECCS-to-power facility from 36.2 to 20.9%, relative to the same plant without CCS.35 (However, Exergi is aiming for much higher efficiency by coupling a heat pump to the CCS installation, by which they anticipate reducing the CCS energy penalty to 2%.) The feedstock used for the CCS processes effectively has a higher carbon payback period than the rest of the feedstock, as it cannot replace fossil fuels used for energy elsewhere. Emissions from biomass energy used in the carbon capture and storage process should be deducted from the total stored.

Linkage with reporting in the land-use sector

As noted, a fundamental reason why biomass is zero-rated in policy frameworks is because emissions from biomass consumption for energy are reported not in the energy sector of national reports under the UNFCCC, but in the land-use sector of the country in which the biomass is harvested (in order to avoid double-counting). This approach was adopted for the limited purpose of counting global emissions through reporting, but it has fed through into national accounting – measuring emissions levels against countries' targets under the 1997 Kyoto Protocol, the Paris Agreement or national legislation. This causes a particular problem where the countries producing and consuming the biomass are not the same. When importing countries replace fossil fuels with biomass for heat and power, their emissions totals fall immediately. While the EU's Renewable Energy Directive requires more stringent sustainability verification when importing biomass from a country that does not account for LULUCF emissions, there is no automatic mechanism to ensure that the exporting countries reduce their emissions in other sectors to compensate for the loss of sequestrated carbon.

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35 Quiggin D., BECCS deployment.

BECCS projects must confirm that there is no risk of breaching safeguards, including regulatory limits on pollution. Photo: Drax Power Station in North Yorkshire, United Kingdom by Daniel Heighton/Shutterstock

Attempts to address these issues under the Kyoto Protocol were not wholly successful, and the problem is unlikely to be resolved under the Paris Agreement either. Most NDCs submitted so far under the latter do not contain separate targets for the land-use sector; relatively few anticipate the use of any kind of accounting rules; and where accounting for land-use sector emissions and removals is mentioned, the submitting countries have chosen a variety of accounting methods. As a result, it is not possible to assess the net climate effects of bioenergy simply by comparing the emissions from combustion with those associated with feedstock in the land-use category and supply chain. Therefore, there is no automatic link between falling emissions in countries consuming bioenergy and the need for corresponding action in the countries supplying the feedstock.

In any case, even if the figures could be accurately estimated and the accounting challenges overcome, the point remains that by treating biomass emissions as zero at the point of combustion, a significant incentive is created for consuming countries to burn wood for energy, and/or for BECCS, despite carbon dioxide emissions increasing relative to fossil fuels for a period of decades or centuries as a result.

The incentives are greater still at the industry level. In the UK and most EU Member States, energy companies are paid to burn biomass and face no responsibility to compensate for the associated emissions elsewhere. Reporting of higher land-use emissions by countries of origin would have no bearing on the activities of these companies, and even if some mechanism could be devised to create a linkage with emissions in the country of origin, current policy frameworks in consuming countries would still lead to higher carbon dioxide levels in the atmosphere for the duration of the carbon payback period than would have occurred in the absence of support for burning biomass. The methodology does not, of course, discuss this, as it only dealing with project-level emissions, but it is a fundamental problem underlying bioenergy use, including for BECCS.

3.3 Sustainability criteria

The types of feedstock used for BECCS plants can be constrained through the use of sustainability criteria, which the Drax / Stockholm Exergi methodology includes in some detail. Largely adapted from the sustainability criteria for solid biomass included in the 2019 EU Renewable Energy Directive and its 2023 revision, they are not, however, adequate for the purpose of limiting feedstocks to those with the lowest carbon payback periods.

As summarised above in Section 2.1, the criteria suggested in the methodology limit feedstock sourcing areas to those which show stable or increasing forest carbon stock – but it is of course possible for those areas to experience increased growth but at a lower rate than they would have seen in the absence of extraction for energy. This is particularly true of source countries under the five million km2 threshold (where the changes in forest carbon stock can be assessed at the jurisdictional level), where extraction for energy could lead to a decline in carbon stock in some areas, which would offset, or more than offset, increases in other areas. It is the net impact on the climate compared with the counterfactual, of no extraction for energy, that should underlie the measurement of carbon sequestered, not the crude metric the methodology suggests. This is a critical failing of the proposed methodology.

In addition, the exemption through which biomass may be sourced from areas with declining carbon stocks if this is due to 'planned reductions' such as thinning, could be open to abuse; as discussed above, thinnings are currently a major source of feedstock for large biomass plants, and there is little reason to think these criteria would act as a disincentive.

Other elements of the sustainability criteria are more useful, including in particular the limitation of acceptable categories of feedstock; the criteria exclude "material suitable for use in long-lived wood products, such as sawtimber or veneer within the sourcing area». The wording 'within the sourcing area' is unclear – it seems unlikely that it could mean only wood made into wood products to be used within the sourcing area, as opposed to anywhere else (if this is what it means, it would significantly limit this constraint), but there seems no

other purpose for these words. Also, the list of categories that are suitable for BECCS is quite wide, including thinning, pulpwood and 'down-graded' wood. In practice, these types of wood can include all trees with no other commercial value and can be, and often are, used for wood products such as pulp, paper or panels, some of which, as IPCC guidance observes, may be used in buildings and therefore 'held for decades to over 100 years'.[36]

Finally, sustainability criteria are only useful if they can be monitored and enforced. The track record of enforcement of existing criteria is not encouraging – as demonstrated, for example, in Drax's gaming of the system when sourcing feedstock from British Columbia, revealed in two investigations, by the British and Canadian Broadcasting Corporations, in autumn 2022.[37] Another BBC investigation in 2024 showed extensive sourcing of logs from old-growth primary forest in British Columbia.[38] Drax is currently subject to an investigation by the UK regulator Ofgem into its compliance with its annual profiling reporting requirements.

In January 2024 a report by the UK National Audit Office into the UK's support for biomass observed that: "Our experience from auditing other areas of government shows that to gain the necessary assurance about more stringent rules, DESNZ [Department for Energy Security and Net Zero] will need to commit more resources to monitoring and compliance … The government cannot demonstrate that its current arrangements are adequate to give it confidence industry is meeting sustainability standards".[39] Monitoring of compliance is likely to be particularly challenging when the feedstock is sourced from other countries.

3.4 Lack of clarity in the methodology

In addition to the shortcomings discussed above, there are a number of issues where more clarity is needed. These are identified above in Section 2, and include:

- What is the justification for setting the threshold of 2% of gross captured emissions below which leakage emissions are considered to be non-material? This could still be a significant volume of emissions.
- Sourcing of feedstock is allowed from highly biodiverse forest if: "evidence is provided that the harvesting of the biomass does not interfere with those nature protection purposes". There is no explanation of what this evidence should comprise or how it can be concluded that its extraction does not interfere with nature protection.
- Sourcing is not allowed from any country with a Corruption Perception Index less than 50 except where the supplier can demonstrate adequate mitigation of the risk of corruption – how they are to do this is not explained.

36 2006 IPCC Guidelines, at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP.pdf.

37 'Drax: UK power station owner cuts down primary forests in Canada' (BBC, 3 October 2022); https://www.bbc.co.uk/news/science-environment-63089348; 'Wood from B.C. forests is being burned for electricity billed as green — but critics say that's deceptive' (CBC, 9 October 2022); https://www.cbc.ca/news/canada/wood-pellets-bc-forests-green-energy-1.6606921.

38 'Drax: UK power station still burning rare forest wood' (BBC, 28 February 2024);

39 The government's support for biomass (HC 358, National Audit Office, 24 January 2024), pp 8, 10.

4. Conclusions

Beyond the specific problems with the methodology promoted by Drax and Stockholm Exergi, there are many other drawbacks of proposals for the deployment of BECCS technology, particularly at the scale implied in some integrated assessment models. These include the cost, compared to other CDR options; competing demands for biomass, for example for wood products or biochemicals; requirements for land and the corresponding impacts on food production and other demands for land use; the impacts on biodiversity; and the effects of water and fertiliser use from the expansion of BECCS activities.[40] One would not expect the Drax / Stockholm Exergi methodology to include consideration of all these factors – except possibly the impacts on land use – but they are relevant to national policy-making, particularly in the context of the ongoing work within the European Commission, and also to the integrity of voluntary carbon markets.

Given the urgency of the climate challenge and the difficulty and cost of mitigation options for the 'hard-to-abate' sectors, there is a clear need for robust rules for CDR projects, both nature-based and industrial, including BECCS. In particular, clear and enforceable sustainability boundaries must be drawn for CDR projects with a major impact on land use. Any attempt to measure accurately the possible climate benefit deriving from these activities is welcome, and the development of this methodology could have been a useful step forward. Unfortunately, its value has been severely limited by the drawbacks identified in Section 3, particularly on additionality and the zero-rating of feedstock. In addition, it would be of more value if it can be adapted to deal with more appropriate categories of feedstock, including agricultural residues and wastes, which are likely to be the only suitable feedstocks for BECCS, particularly where they are sourced locally with very short supply chains,[41] but these are excluded from the current version.

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40 Many of these are well summarised in Deprez, A. et al. (2024). Sustainability limits needed for CO2 removal – The true climate mitigation challenge is revealed by considering sustainability impacts. Science 383, 484–486.

41 European Academies Science Advisory Council, Forest bioenergy update: BECCS and its role in integrated assessment models, 28 February 2022 https://easac.eu/publications/details/forest-bioenergy-update-beccs-and-its-role-in-integrated-assessment-models