Briefing

The need for a biomass hierarchy

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Summary

In recent years, concerns have grown around the use of biomass (organic material) to decarbonise the economy.

Biomass can come from a range of different sources, such as timber and sawn wood, forestry residues, agricultural or other organic wastes and energy crops. Each have different climate and nature impacts, with some sources, such as forest biomass, posing greater sustainability risks than others.

Using biomass can be a route to decarbonisation for sectors ranging from energy to construction and, in some cases, can generate net negative emissions. But, as demand for it has risen, experts have become concerned about its climate and broader environmental impacts. For example, there is evidence that increased demand is driving forest degradation and there are worries that relying too heavily on certain sources may have unintended consequences, such as encouraging waste production to provide a supply. There are also concerns that, in some cases, using biomass may on balance increase carbon dioxide emissions.

To mitigate these risks, we highlight the need for further research to develop a 'biomass use hierarchy'. We are keen to hear from any organisations that wish to collaborate on this research.

We encourage the government to work with stakeholders in civil society and industry to guide which sectors or uses biomass should be prioritised for. It should consider the following:

- the carbon savings of biomass, compared with fossil fuels or the carbon intensive materials it replaces, and the time taken for it to grow back;
- whether there are other low carbon alternatives readily available;
- the sustainability of the wider supply chain;
- technological readiness;

- costs and value for money wherever government subsidy is required;
- the potential for demand reduction to reduce competition for biomass.

Introduction

There is strong government interest in using biomass to decarbonise the economy. Biomass – which refers to organic material such as wood, straw and organic wastes – can offer a route for many sectors, some of which are otherwise hard to decarbonise, either by directly displacing fossil fuels in heat and energy generation or by replacing materials such as cement and steel which are carbon intensive to produce. Substituting concrete for a cross-laminated timber frame in building design, for example, reduces embodied emissions by 60 per cent, and simultaneously increases carbon storage potential by 400 per cent.[1] Biomass can also be used as a feedstock for chemicals.

In theory, when used as a fuel, biomass is carbon neutral, as it removes an equivalent amount of carbon dioxide from the air during growth as it emits when burnt. If it is used as a material in construction, it acts as a carbon store. Biomass can also be used to create net negative emissions, if the carbon dioxide produced when it is burnt is captured and stored permanently underground. The government's current Net Zero Strategy relies heavily on bioenergy with carbon capture and storage (BECCS) to offset emissions from sectors that are hard to decarbonise, like aviation and agriculture.[2]

However, in recent years, concerns have grown about the environmental impacts of increased biomass use, as well as whether it represents genuine emissions abatement (or removal). A 2022 BBC Panorama programme about Drax power station in Yorkshire revealed how supposedly sustainably sourced biomass is driving logging of primary and old growth forests in British Columbia.[3]

In recognition of these concerns, when the government agreed to extend subsidies to Drax beyond 2027, it introduced a cap roughly halving generation levels, and a condition that stricter sustainability criteria are met.[4] However, these new standards are still considered to be insufficient and the industry is already largely compliant, in part due to the certification standards being fairly broad and very difficult to externally verify.[5,6]

To get around this, the Climate Change Committee's advice specifies that the UK should switch away from imported biomass towards domestically produced feedstocks.[7] But this poses a new set of challenges, as it is likely to involve using more land to grow energy crops, which competes directly with food production.

In 2023, the previous government published a Biomass Strategy pledging to "develop and implement a cross-sectoral common sustainability framework for biomass."[8] While we welcome this commitment, greater guidance is also needed as to where the limited supply of sustainably produced biomass should be used to avoid the risk that it is swallowed up by sectors with better options to decarbonise or where the risks of using biomass outweigh the benefits.

In this briefing we highlight the need for a biomass hierarchy and call on the government to work with stakeholders to produce one. We explore the genuine need for biomass in hard to decarbonise sectors, sustainability and land use constraints, and what other factors a hierarchy should consider.

Sources and uses of biomass

Biomass can come from a variety of sources and has a range of uses, the most traditional being timber used in construction, to make furniture and paper, or it can be directly burnt as a fuel. Possible uses are summarised below:

Sources and uses of biomass

Source	Current and potential uses	Sustainability impacts
Timber and sawn wood	Construction Long lived products like furniture and flooring Bioenergy/ BECCS	Impacts differ, depending on whether it is harvested from plantations, mixed woodland or old growth forests, but it is likely to result in higher carbon emissions than other sources Typically, it is transported long distances
Forestry residues Includes residues left after logging timber (branches, tops, foliage), trees harvested explicitly as a feedstock because they are	Production of paper and pulp Bioenergy/ BECCS Domestic and higher temperature industrial heating Chemical feedstock	May result in higher carbon emissions than other sources. There is limited supply and a risk of encouraging more logging

not suitable for other uses, and residues of wood processing		Excess removal could affect soil health and biodiversity Hard to guarantee that wood is a genuine residue in downstream supply chains Typically, it is transported long distances
Agricultural wastes (eg straw and corn husks, livestock manures)	Compost as a fertiliser Livestock feed Transport biofuels Bioenergy/ BECCS Chemical feedstocks	Limited supply Some needed to maintain soil health Possibility of unintended consequences, such as encouraging larger herd sizes, which would increase emissions Sometimes it is transported long distances
Other organic wastes (eg sewage sludge, used cooking oil, municipal wastes, like food and garden wastes)	Compost as a fertiliser Transport biofuels Bioenergy/ BECCS Chemical feedstocks	Risk of increased resource use by encouraging waste Concerns around contaminants in sewage sludge and authenticity of used cooking oil Sometimes it is transported long distances
Energy crops: non-food crops grown	Transport biofuels Bioenergy/ BECCS	Land-based energy crops compete with food crops and risk displacing food

specifically for biomass It can include both short rotation forestry, like willow, as well as more traditional crops such as wheat, corn and sugarbeet. It can also come from marine sources, such as algae		production to areas of greater nature and carbon storage value Typically transported long distances
Biogas from anaerobic digestion, landfills and sewage[9]	Burnt to generate electricity or heating Chemical feedstocks Gas grid injection	Risk of incentivising production of wastes or locking in intensive animal agriculture

Concerns around the use of biomass

By replacing fossil fuels or carbon intensive materials, biomass can, in theory, offer a route to reduced emissions for a range of sectors, including those such as industrial heat and chemicals that have proved hard to decarbonise. However, the concerns around it are explored below.

Limited supply

There is growing competition between sectors for a limited supply of biomass. Modelling by Material Economics estimates that existing European forests and waste biomass supplies could manage an additional 15 per cent on top of current supplies, but any one of the sectors mentioned above could use all of this.[10] Imports cannot be relied on to meet this demand due to global pressures on land use, and recognition is growing that they cannot be relied on at current levels of use. The UK is already one of world's largest net importers of forest products.[11]

Without regulation, decisions about where biomass is used will be left to the market. Under this scenario, the available supply is likely to end up being monopolised by sectors or businesses most able to pay for it, not necessarily those that need it most. Regulation may be needed to address this.

Competition with other land uses

Growing biomass is a very inefficient use of land. A hectare of solar photovoltaic panels produces up to 100 times more energy than the equivalent area of bioenergy crops.[12] Our analysis has found that under a 'business as usual' scenario, the UK would need to import biomass from an area three times the size of Wales for BECCS simply to offset greenhouse gas emissions from farming.[13]

Higher demand for biomass will place more pressure on land which could lead to habitats being destroyed that are important for nature and climate mitigation, resulting in significantly raised emissions. If these emissions are taken into account, using biomass as a fuel may, in fact, increase emissions further compared to using fossil fuels.[14]

Problems with carbon accounting

Under most carbon accounting frameworks, biomass is assumed to be carbon neutral, as the carbon released into the atmosphere when the biomass is burnt is equivalent to the carbon absorbed when the plants were growing. This assumption encourages the felling of trees that would otherwise store and absorb more carbon if left to continue growing, as the foregone carbon absorption is not taken into account.

To avoid double counting, under the United National Framework Convention on Climate Change (UNFCCC), emissions from biomass are also only counted in the country where it is harvested, not where it is burnt. This is an incentive to burn imported biomass for energy since it does not register as a source of emissions on the UK's carbon balance sheet. Efforts to decarbonise the UK economy with imported biomass could therefore prevent other countries meeting their own climate targets. Experts have also raised concerns that this method of carbon accounting leads to emissions going unaccounted for at the global level.[15]

Climate impacts

Even if burning biomass is theoretically carbon neutral, that does not mean it is neutral in relation to climate change. Burning woody biomass for power and heat releases more carbon dioxide into the atmosphere, per unit of energy generated, than coal.[16] This is only absorbed from the atmosphere once an equivalent tree or crop grows again, which is never guaranteed. This delay, known as the carbon payback period, can be decades or even centuries, raising the risk of crossing irreversible climate tipping points in the meantime. Carbon payback periods are typically complicated to calculate, as they vary in relation to the source of biomass and rely on a counterfactual prediction of what would have otherwise happened to it.[17] As with fossil sources of energy, significant emissions also occur during harvesting, transport and storage.

Modelling has found that using wood biomass in the UK power sector could raise emissions for several decades, compared to a scenario where energy is provided from elsewhere in the grid, due to increased harvesting leading to less carbon stored in forests.[18] For similar reasons, using BECCS to provide removals could increase levels of atmospheric carbon dioxide until approximately 2053, compared to a scenario without BECCS, if wood pellets were supplied by Drax pellet mills in the southern US.[19]

This evidence suggests an urgent need to move away from forest-based feedstocks for bioenergy and power BECCS. We have previously suggested that replacing imported wood pellets from forests with UK-based waste would be a more sustainable option, provided this is done in accordance with the waste hierarchy (ie to prioritise minimising waste first). But Drax is currently not set up to use these feedstocks. Other greenhouse gas removals, such as electrochemical ocean carbon removal and enhanced rock weathering, present good alternatives to BECCS and, with the correct government support, could reach a similar scale, with lower environmental impact.[20] Cost estimates are very uncertain at present, but these options could be equal in cost to BECCS or cheaper.[21]

Broader environmental and health impacts

Growing and harvesting biomass has other negative environmental impacts. Biomass plantations consisting of a single species of fast growing tree or woody crop, such as willow or pine, do not support the same diversity of wildlife as natural, multi-species ecosystems.[22] Fertilisers and pesticides may be used to produce energy crops, which have their own associated emissions during production and application. Logging can negatively impact biodiversity, while removing forestry and agricultural residues can harm soil health, with consequences for future crop growth and water quality.[23] Lifecycle assessments, used to assess environmental burdens, tend not to capture these impacts due to the multi-scale and complex nature of production and supply chains.[24]

Burning biomass can also have an impact on human health. Like with many fossil fuel facilities, processing wood into pellets for burning releases dangerous air pollutants, harming the health of communities nearby.[25] These facilities also tend to be situated in deprived areas.[26]

Unintended consequences

Even sources of biomass which appear, at first glance, to be more sustainable, such as agricultural residues and municipal wastes, can have unintended consequences. For example, their use could encourage farmers to increase livestock herd sizes or discourage resource efficiency. Any policy that provides an incentive to use these sources must account for the waste

hierarchy (ie prioritise minimising waste first) and the 'cascading use principle'.[27]

What a biomass hierarchy should consider

Given the challenges highlighted above, we emphasise the need for a 'biomass hierarchy'. This should lay out priority uses for the limited supply of biomass available, based on the needs of hard to decarbonise sectors, and taking into consideration the sustainability impacts of different biomass sources and end uses. The hierarchy may also want to lay out which uses of biomass should be avoided, apart from in exceptional circumstances.

Below, we outline the criteria that could be used to construct such a hierarchy. While there is some overlap with the principles for biomass use in the government's strategy, as well as the common sustainability framework under development, we believe there is need for an overarching hierarchy that takes all of these different factors – and potentially others – into account. More research is need to determine how much weighting should be given to each of the criteria, and how often the framework should be updated to reflect technological developments.

1. Carbon savings and payback period

For each use of biomass, the greenhouse gas emissions saved by using it instead of traditional fossil fuels or carbon intensive materials, must be considered. This assessment should cover the full lifecycle emissions across the whole biomass supply chain, including resulting changes to land use, both direct and indirect, impacts on soil carbon stocks and emissions relating to the harvesting, processing and transporting feedstocks.

It is critical that a hierarchy takes the carbon payback period into account to encourage the use of sources of biomass with zero or shorter payback periods.

2. The potential to use other low carbon alternatives

The framework should consider whether there are other low carbon alternatives the sector could use instead of biomass. Sectors like construction and chemicals have fewer viable alternatives to replace carbon intensive materials, such as cement, steel and fossil feedstocks. In contrast, electrification is a viable, and often more environmentally appropriate, alternative to power surface transport.

3. Sustainability of the wider supply chain

Sources of biomass, such as waste or timber, and their associated impacts on biodiversity, water pollution, air quality and food production should be considered. This assessment should include whether increasing demand for biomass from a particular source might have unintended consequences, such as incentivising waste production. The government could, for example, implement strict quotas on feedstock which have medium or high risk of increasing the demand for waste.

4. Technological readiness

The framework may need to evolve as technology develops, being wary of the risk of relying on unproven technologies for decarbonisation. For example, while the technology needed to use biomass in construction and power exists, further innovation is needed before it can be used at scale to produce chemicals.

5. Costs to the taxpayer and political impacts

Any costs incurred by the taxpayer should be considered, alongside whether there are more cost effective alternatives to using biomass. For example, there are numerous critiques of the use of taxpayers' money to subsidise Drax, when there are cheaper, more effective alternatives in the form of renewables (for power) and natural carbon sinks, like tree planting, (for carbon removals).[28] The government may also want to consider who the recipients of any subsidy are, and how this aligns with their missions and voter priorities. For example, paying farmers for nature-based carbon removals, which have other benefits such as improving biodiversity and reducing flood risks, while supporting rural economies by boosting the incomes in areas that are less profitable from food production, is likely to go down better with voters than continually subsidising large scale bioenergy businesses.

6. Potential for demand reduction

It is critical that any potential directed allocation of biomass supplies considers the potential for demand reduction, both within a sector and across the wider economy, to reduce dependence on biomass. This is most clearly the case for aviation and energy, but it could also apply to sectors such as chemicals, if more circular practices (reduction, reuse, remanufacturing and recycling) cut the likely demand.

Conclusion

Biomass has an important role to play in reaching net zero carbon emissions, if used well, potentially providing a route to decarbonisation for sectors where alternatives are limited. It could also offer some carbon removals through bioenergy generation with carbon capture and storage (BECCS). But relying too heavily on it to reduce greenhouse gas emissions has substantial risks.

Without a strong governance framework, high demand for biomass could have devastating environmental effects, and it also risks undermining the purpose of using it by raising carbon emissions if it leads to deforestation. In the UK and EU, biomass used for power already causes significant emissions.[29]

To avoid these risks, the government should work with stakeholders in civil society and industry to develop a biomass hierarchy, alongside continuing work on a cross sectoral common sustainability framework promised in the 2023 Biomass Strategy. This would help to ensure the limited supply of biomass available is reserved for sectors where it is most needed, and that sustainability impacts are minimised.

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Endnotes

[1] Climate Change Committee, 2019, Wood construction in the UK: an analysis of carbon abatement potential
[2] Department for Energy Security and Net Zero (DESNZ) (formerly Department for Business, Energy & Industrial Strategy), 2021, 'Net zero strategy'
[3] BBC Panorama, 2022, 'The green energy scandal exposed'
[4] BBC, 10 February 2025, 'Subsidies halved for controversial Drax power station'
[5] Jonathan Brearley, the CEO of Ofgem, recently admitted that standards are difficult to verify in a Public Account Committee hearing; see, Public Accounts Committee, 3 March 2025, 'Oral evidence: The Government's support for biomass'. As a result, the committee have concluded the industry are 'marking their own

homework'; see, Committee of Public Accounts, 2025, *Government's support for biomass*

[6] For more information about the shortcomings of the Sustainable Biomass Program (SBP), the certification scheme co-founded by Drax, see National Resource Defense Council and Dogwood Alliance, 2017, *The sustainable biomass program: smokescreen for forest destruction and corporate non-accountability*. In 2023, there were 272 SBP certificate holders. See Sustainable Biomass Program, 2023, *Annual review 2023*

[7] Climate Change Committee, 2025, 'The seventh carbon budget'

[8] DESNZ, 2023, 'Biomass strategy 2023'

[9] Biogas may not always be technically considered biomass, but for the purposes of this work we consider it a relevant example.

[10] Material Economics, 2021, *EU biomass use in a net-zero economy*

[11] Forest Research, 2023, 'Forestry facts & figures 2023'

[12] RSPB and 3Keel, 2022, *Biomass for energy: a framework for assessing the sustainability of domestic feedstocks*

[13] L Collas and D Benton, 2023, *Shaping UK land use*, Green Alliance

[14] B Seo et al, August 2023, 'Bioenergy in Europe is unlikely to make a timely contribution to climate change targets', *Environmental research letters*

[15] Chatham House, 2017, *Woody biomass for power and heat: impacts on the global climate*

[16] Ibid

[17] Chatham House, 2021, *BECCS deployment - Feedstock choice: Carbon efficiency and carbon debt*.

[18] T Buchholz et al, May 2021, 'When biomass electricity demand prompts thinnings in southern US pine plantations: a forest sector greenhouse gas emissions case study', *Frontiers in forests and global change*

[19] T Buchholz and P Pritchard, 2024, 'Implications for UK net zero of bioenergy with carbon capture and storage (BECCS) utilising southern US sourced biomass', Spatial Informatics Group

[20] J Elliott, February 2024, 'Does the UK need BECCS to reach net zero?', Green Alliance briefing

[21] Ibid

[22] Woodland Trust, 21 July 2020, 'Why are native woods important for biodiversity?'

[23] M De Groot et al, 2016, 'Differential short-term response of functional groups to a change in forest management in a temperate forest', *Forest ecology and management*

[24] RSPB and 3Keel, 2021, op cit

[25] *The Guardian*, 29 May 2023, 'Drax-owned wood pellet plant in US broke air pollution rules again'; Southern Environmental Law Centre, 'Biomass energy hurts our climate, communities, and forests'

[26] S Koester and S Davis, 1 April 2018, 'Siting of wood pellet production facilities in environmental justice communities in the Southeastern United States', *Environmental Justice*

[27] The cascading use principle for woody biomass says the wood should be used, reused and recycled for as long as possible, with burning for energy or disposal being the last act when all other uses have been exhausted.

[28] Our analysis in *Shaping UK land use* (see endnote 13) shows it is much more cost effective to deliver carbon removals through expanding natural carbon sinks, such as woodland, than BECCS.
[29] Chatham House, 2021, *Greenhouse gas emissions from burning US-sourced woody biomass in the EU and UK*