Written evidence from Chatham House

Submission to Environmental Audit Committee call for evidence on negative emissions technologies: BECCS and forest biomass feedstock

This submission draws on three research papers I have co-authored, published through Chatham House (Royal Institute of International Affairs):

- Duncan Brack, *Woody Biomass for Power and Heat: Impacts on the Global Climate* (2017)
- Duncan Brack, James Hewitt and Tina Marie Marchand, *Woody Biomass for Power and Heat: Demand and Supply in Selected EU Member States* (2018)
- Duncan Brack, Richard Birdsey and Wayne Walker, *Greenhouse gas emissions from burning US-sourced woody biomass in the EU and UK* (with Woodwell Climate Research Center, 2021)

While these papers look mainly at the use of biomass for power and heat in existing power stations, they are relevant to the debates around BECCS. To summarise, I argue here that feedstock sourced from forests is in general unsuitable for use in BECCS plants. In theory some forest feedstock categories could be usable, but their availability is limited and distinguishing between suitable and unsuitable categories is challenging. At the very least, strict sustainability criteria should be put in place to regulate the types of feedstock used in BECCS plants, whether sourced from forests or elsewhere.

Biomass feedstocks

Almost any organic material can be used to generate biomass energy, but the practicalities of harvesting and collection, and the degree of contamination of some categories (e.g. municipal waste) in practice place limits on the feedstocks that are of commercial utility in existing biomass plants. This is why the main categories used for energy are different types of forest biomass, usually originating from sawmill residues, forest residues from logging operations for other wood products or forest management and whole trees harvested for bioenergy. For ease of transport, these different types are commonly transformed into wood pellets, which are increasingly favoured for long-distance transport and storage, as they are denser and contain lower moisture content.

The term 'residue' is often used very loosely, whether in the context of forestry or sawmill residues. It can sometimes include any kind of roundwood not suitable for use in a sawmill for processing for wood products, i.e. not the straight, unblemished and appropriately sized logs that sawmills generally demand. This can include, for example, 'low-value' or 'unmerchantable' or diseased or storm-damaged trees. Regulators' definitions are not always clearly drawn, and often permit whole trees to be classified as 'residues', alongside genuine forestry or sawmill residues. Company reports sometimes include 'low-value wood' in the same category as residues. Thinnings – the selective removal of trees, primarily undertaken to improve the growth rate or health of the remaining trees – can be identified separately, but are also sometimes grouped together with residues.

A recent report from the EU's Joint Research Centre concluded that 37 per cent of wood-based bioenergy production in the EU over the period 2009–15 could be classified as 'primary woody biomass' harvested from forests, but about 14 per cent was uncategorised in the reported statistics, and was likely to be primary wood; this category showed faster growth than the others over the study period.[1] Since 2015, the rate of extraction has increased significantly, meaning that the proportion of primary woody biomass burnt for energy has probably grown in recent years.

Looking more narrowly at US-sourced wood pellets burnt for energy – the largest source of imports of wood pellets to the UK – supply reports from the Drax power station (far and away the single largest user in the UK) over the period 2015–19 indicate that on average almost half of the wood was sourced from sawmill residues (25 per cent) and forest residues (23 per cent), and just over half from whole trees: 21 per cent from 'low-grade roundwood' and 30 per cent from thinnings.

Impacts on the climate: carbon payback periods

The impact on the climate of burning different types of feedstock for energy varies substantially. Burning any kind of wood for electricity or heat will produce more carbon dioxide than if fossil fuels are used to generate the same amount of energy (with a few exceptions for some types of coal). For the same energy output, burning wood releases about 10–15 per cent more carbon dioxide than anthracite and about 100 per cent more than gas (under laboratory conditions, with the complete combustion of the fuel in the presence of oxygen). Biomass stations tend to have lower thermal and electrical efficiencies than coal or gas plants, so the real-world differences will be larger.[2]

Assuming that the harvested trees are replaced by new planting, these carbon emissions will be absorbed over time by forest regrowth, so the net impact on the climate depends on the balance between the level of emissions produced during harvesting, collecting, processing, transporting and burning the biomass and regrowth, and, crucially, what would have happened to the forest or the feedstock in the absence of demand for wood for energy – the counterfactual.

Many attempts have been made to measure the net impact on the atmosphere of using different biomass feedstocks compared to using fossil fuels. The initial combustion, along with the associated life-cycle emissions of the biomass feedstock, create what can be termed a 'carbon debt' – i.e. the additional emissions caused by burning biomass instead of the coal or gas it replaces, plus the emissions absorption forgone from the harvesting of the forest. Over time, regrowth of the harvested forest removes this carbon from the atmosphere, reducing the carbon debt. The period until carbon parity is achieved (i.e. the point at which the net cumulative emissions from biomass use are equivalent to those from a fossil fuel plant generating the same amount of energy) is usually termed the 'carbon payback period'. After this point, as regrowth continues, biomass may begin to yield 'carbon dividends' in the form of atmospheric greenhouse gas levels lower than would have occurred if fossil fuels had been used. Eventually carbon levels in the forest return to the level at which they would have been if they had been left unharvested.

The attempts that have been made to estimate carbon payback periods suggest that they vary substantially, from less than 20 years to many decades, and in some cases centuries, depending on the feedstock used and the efficiency of combustion. As would be expected, the shortest payback periods derive from the use of residues and wastes from forest harvesting or forest industries that imply no additional harvesting, and if otherwise burnt as waste or left to decompose would release carbon to the atmosphere in any case. This includes, in particular, sawmill wastes such as sawdust (unless they are diverted from use for wood products) and black liquor from the pulp and paper industry that would otherwise have to be disposed of.

[1] A. Camia et al, *The use of woody biomass for energy purposes in the EU* (Joint Research Centre, 2021).
[2] See Brack, *Woody Biomass for Power and Heat: Impacts on the Global Climate*, pp. 14–16.

If forest residues are used that would otherwise have been left to decompose in the forest, the impact is complex, as decay rates vary significantly depending on local climatic conditions. Burning slowly decaying forest residues may mean that carbon dioxide levels stay higher in the atmosphere for decades longer than if fossil fuels had been used. In addition, excessive removal may reduce levels of soil carbon and rates of tree growth, and it takes time for the residual trees or new trees to compensate.

The most negative impacts on carbon concentrations in the atmosphere derive from increasing harvest volumes or frequencies in already managed forests, harvesting natural forests or converting natural forests into plantations, or displacing wood from other uses. Where whole trees are harvested and used for energy, not only is the stored carbon in the tree released to the atmosphere immediately, but the future carbon sequestration capacity of the tree is lost.

On the other hand, in the absence of forest management, the rate of net carbon absorption by most forests falls as the incidence of dead and diseased trees increases, and over time the forest may also become more vulnerable to wildfire or other disturbances. There can, therefore, be benefits over the long term from some level of harvesting – though due to the urgency of the need to reduce greenhouse gas emissions, long-term benefits are not as desirable as more immediate ones.

The EU Joint Research Centre's recent report summarised a range of studies to suggest that only the use of fine woody residues from forest operations (tops, branches and needles) had short carbon payback periods (10 – 20 years) compared to the use of coal or gas, while the use of coarse residues (snags, standing dead trees and high stumps), with generally slower decay rates, extended the carbon payback periods to more than 50 years.[3]

Plantation forests have higher growth rates than natural forests and are typically harvested at a relatively young age; naturally regenerated forests tend to be older and have larger trees when harvested. Therefore, more stored carbon is lost when natural forests are harvested, and it takes longer to replace the stored carbon emitted to the atmosphere. The conversion of natural forests to fast-growing plantations will therefore lead to a large release of carbon at the time of conversion plus a lower stock of carbon when trees are harvested; while this may be somewhat offset by faster tree growth rates in the plantation, the net impact on forest carbon storage will be negative. A study looking at this scenario in the US South found that the carbon payback time would be 60–70 years compared to using coal and 120 years for gas.[4] Regular harvesting and clearing of plantations releases stored carbon dioxide back into the atmosphere every 10–20 years.

It is sometimes claimed that the practice of thinning – the removal of selected trees or rows either to allow stronger growth in remaining trees or to reduce fire risk – can increase forest carbon storage. Almost all of the studies on which this claim rests focus on volume growth in remaining trees, conclude that this does not lead to an increase in total stand volume compared with an uncut stand, and do not report statistics about carbon uptake by the ecosystem. More recent studies have shown that the use of thinnings for energy does not reduce net greenhouse gas emissions for years at best, and can, under some circumstances, increase them. In general, intact forests with high tree-species diversity, largely free from human intervention, are the most carbon-rich ecosystems, with higher rates of biological carbon sequestration.

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[3] A. Camia et al, *The use of woody biomass for energy purposes in the EU* (Joint Research Centre, 2021).
[4] John D. Sterman et al, 'Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy', 2018 *Environ. Res. Lett.* 13 015007

Limiting the types of feedstocks that may be burnt for energy can therefore help to ensure that negative impacts on the climate are minimised. This is why the 2017 Chatham House paper concluded that only sawmill residues and post-consumer wood waste should be eligible for subsidy (while fast-decaying forest residues could also be acceptable, the practical challenges of identifying and verifying them are substantial). The JRC paper similarly recommended that the use of coarse woody residues should be strictly constrained, and that biomass produced from plantations established on recently cleared natural forest should not be eligible for support.[5]

Two further points about carbon payback periods are worth noting. First, the use of coal is rapidly being phased out in the UK, and the deployment of other renewables, mainly wind and solar, is increasing. Carbon payback periods measured comparatively to coal or gas are therefore not representative of current fuel mixes; the real payback periods compared to the average UK fuel mix are much longer. Second, even if the carbon payback period is relatively short, there is still an impact on the climate during the years when carbon dioxide emissions are higher than they would otherwise have been. This is incompatible with the aim of the Paris Agreement to: 'reach global peaking of greenhouse gas emissions as soon as possible'.[6] It also raises the possibility of reaching 'climate tipping points', when global temperature rise triggers a possibly irreversible change in the global climate from one stable state to another at a higher temperature.

Implications for BECCS

The implications of this discussion for the use of forest biomass as feedstock for BECCS plants are obvious. The theory behind BECCS rests on the assumption that the burning of biomass is carbon-neutral at the point of combustion; therefore, if the carbon dioxide emitted is captured and stored permanently, the net result is negative emissions. This is a near-universal assumption incorporated in integrated assessment models; a 2015 survey was unable to find a single study that had calculated the potential for negative emissions based on any type of life-cycle greenhouse gas assessment that could have taken into account changes in the forest carbon stock as a result of harvesting for bioenergy.[7]

As discussed above, however, it cannot be assumed that all types of forest biomass are in reality carbon-neutral over the short, medium or even long term. Without strict controls over the types of feedstock used, BECCS plants cannot expect to be anything more than carbon-neutral themselves (i.e. they do not result in negative emissions); and in practice they will not even be that, since there are emissions from the supply chain – from harvesting, processing and transporting the feedstock – that cannot be captured.

Real emissions associated with biomass use for energy

The latest research paper published by Chatham House on this topic aimed to calculate the real impact on the climate of using wood pellets sourced from the US and burnt for energy in the UK and EU. We analysed emissions from combustion of the pellets and their supply chain, forgone removals of carbon dioxide from the atmosphere due to the harvest of live trees and emissions from the

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[5] Camia et al, *The use of woody biomass for energy purposes in the EU*, p. 162.
[6] Paris Agreement, Article 4(1).
[7] Almuth Ernsting and Oliver Munnion, *Last-ditch Climate Option or Wishful Thinking? Bioenergy with carbon capture and storage* (Biofuelwatch, 2015).

decay of roots and unused logging residues left in the forest after harvest; this is a more detailed analysis of bioenergy emissions than has been conducted before.

In 2019, according to this analysis, US-sourced pellets burnt for energy in the UK were responsible for 13 million–16 million tonnes of carbon dioxide emissions, Almost none of these emissions are included in the UK's national greenhouse gas inventory; if they were, this would have added between 22 and 27 per cent to the emissions from total UK electricity generation, or 2.8–3.6 per cent of total UK greenhouse gas emissions in 2019. This volume is equivalent to the annual greenhouse gas emissions from 6 million to 7 million passenger vehicles.

Looking ahead to expected growth in consumption, emissions from US-sourced biomass burnt in the UK are projected to rise to 17 million–20 million tonnes of carbon dioxide a year by 2025. This represents 4.4–5.1 per cent of the average annual greenhouse gas emissions target in the UK's fourth carbon budget (which covers the period 2023–27), making it more difficult to hit a target which the country is currently not on track to achieve in any case.

Sustainability criteria

The current sustainability criteria in the UK that define the categories of biomass feedstock that can be supported and the conditions under which they can be burnt do not take account of the real impacts of different feedstocks on the climate and cannot, accordingly, minimise the impact on biomass use on the climate or ensure that real reductions in emissions take place over anything other than the long term. They are not fit for purpose for use in either current biomass plants or future BECCS plants. Our 2021 paper therefore recommended that UK sustainability criteria be amended as follows:

- Only those categories of feedstock with the lowest carbon payback periods should be eligible for support: sawmill and small forest residues and wastes with no other commercial use whose consumption for energy does not inhibit forest ecosystem health and vitality.
- Much tighter definitions of feedstock categories should be introduced to prevent whole trees being treated in the same way as genuine residues.
- Periodic monitoring of feedstock use and impact should be conducted to ensure that allowable feedstocks are not diverted from other uses – e.g. for wood products.
- Additional criteria should be included to protect particular types of landscape, including primary and highly biodiverse forests, from the extraction of biomass for energy.
- Feedstock for BECCS plants should be subject to at least the same constraints as other biomass plants.

In principle supply-chain controls could be used to separate allowable categories of feedstock from those types that do not fit the proposals set out above. In practice, however, ensuring that these work as intended and are not subject to gaming would be challenging. Furthermore, the categories of feedstock considered to be allowable are limited in availability and may have other uses, for example for burning on-site for energy use in sawmills or in manufactured wood products such as panels. In reality, therefore, the use of forest feedstock for combustion for power and heat, and for use in BECCS plants, is in general undesirable.

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