Supergen Bioenergy Hub Input to the Environmental Audit Committee Inquiry on Sustainable Timber and Deforestation

2022/2023

Question: Are there sustainable sources of biomass for UK energy generation either from imported or domestically grown wood for pellet or woodchip? And how can future demand be met from sustainable sources?

Bioenergy is integral to the pathways for meeting climate targets laid out by both the Climate Change Committee (CCC) and the Intergovernmental Panel on Climate Change (IPCC) (find references). Non-carbon-based technologies (electrification, renewable energy from solar and wind) should be used where possible, but bioenergy is needed for hard to decarbonise sectors (such as those where electrification is not possible in the near future or where a carbon source or deployable fuel are a necessity) and as a source of negative emissions when coupled with carbon capture and storage [1, 2]. Here we will address three key areas in response to the above question: carbon impacts, wider environmental sustainability, and sustainable resource availability.

Resource

- It is likely that to balance the UK's future biomass demands to support climate targets, a range of domestic biomass resources and some use of imports will be required. A number of different studies have been carried out to quantify the current and potential future availability of different biomass recourses, including from forestry [3-5].
- Ranges of potential availability of UK biomass as reported by Government reports, academic research and from leading resource models are reported in the Supergen Bioenergy Hub 'UK Biomass Availability Modelling' scoping report [4].
- Leading UK biomass resource opportunities for the bioenergy sector are consistently identified as: organic wastes (such as household/ municipal solid wastes); residues from ongoing activities such as agriculture (e.g. straws) or industry processes (e.g. sawdust from wood industries), and; energy crops purposely grown on UK lands for energy end uses [3].

- Forestry biomass for bioenergy can be in the form of harvesting and processing residues, stem wood, and waste wood. Forests are grown for different purposes, mainly to produce wood and timber for products and not for energy purpose. Depending on the geographical region, tree species, forest management and overall forest business model, the basket of forest products will look different for different forests and at the point of harvest. Depending on the forest management system and business model, the availability and amount of harvest (branches, stem cut-offs, low-quality trees) and processing residues (saw dust, chips, cut-offs) will vary significantly [6].
- Short rotation forestry (SRF, where trees are harvested after roughly 20 years) or short rotation coppice (SRC, where plants are cut back and then harvested roughly every 3 years) of fast-growing species like willow and poplar is another source of woody biomass for bioenergy. It should be noted that models often treat SRC in the same category as other

perennial energy crops as miscanthus rather than as a form of forestry biomass.

- Domestic biomass production can be supplied from a diverse range of sources (e.g. see Figure 5 of Welfle *et al*. [3]) including from forests, SRF and SRC. SRF and SRC deployment is low in the UK at present, but modelling indicates that they will be relied upon to meet growing biomass demand [3-5]. Following a stakeholder workshop in 2021, the Supergen Bioenergy Hub published a report that considered how to bridge the gap between national scale targets and field scale decisions for these and other energy crops [7].
- The UK is projected to have significant indigenous biomass resources but to meet bioenergy demand it is likely that imports will be required [3, 4]. If the UK does not significantly expand domestic biomass production, then there will be greater reliance on biomass imports. Imported biomass can be sustainable, but international supply chains do pose additional challenges when it comes to ensuring sustainability and avoiding offshoring of impacts [8, 9].
- The sustainability impacts and benefits of biomass and bioenergy activities are increasingly well understood, and performance criteria for carbon, biodiversity and land sustainability themes are integral to the UK's sustainability regulatory frameworks. There is also a growing number of voluntary sustainability assessment schemes that cover a broader range of issues. Sustainability risks of imported biomass may be reduced through legislation and implementation of sustainability assessment approaches such as chain of custody reporting and monitoring [10].
- Whilst the Drax supply chain demonstrates that low-value and waste-wood can be successfully utilised for bioenergy, there will be a limit to this resource globally, and so greater global demand for biomass may present challenges to the UK.

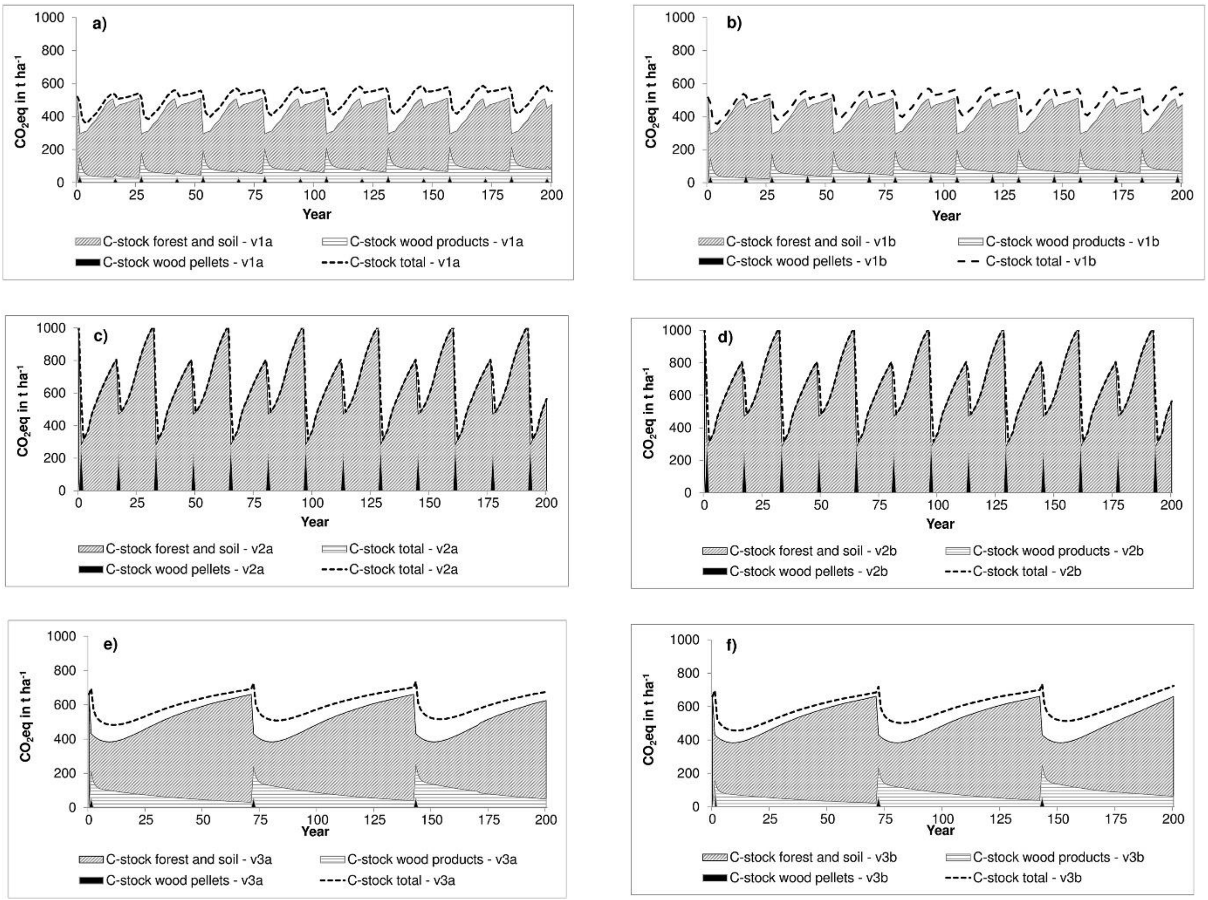
Carbon

- Understanding the carbon impacts of forest bioenergy systems requires Life Cycle Analysis (LCA) which considers the full supply chain emissions [11-13]. LCA has demonstrated that forest bioenergy systems can achieve significant greenhouse gas savings compared to fossil based systems [13, 14]. For example, electricity generated from forestry and sawmill residues imported from the USA to the UK can reduce emissions by more than 80% compared to electricity from coal [14]. However, emissions reductions are not guaranteed and the overall carbon impact is influenced by the forest management and other factors along the supply chain [13, 14].
- There is also a temporal aspect to the carbon impacts of forest bioenergy systems [6, 13, 15]. Trees take time to grow, and debates see questions around the concepts of carbon debt or payback time for forestry bioenergy. However, trees are part of a wider product basket and forest landscape. A forest is normally made of different plots of different age and while one plot of a forest has reached maturity and is harvested the overall carbon budget of the forest will not change. From a carbon budget perspective, it does not make sense to consider just single point emissions when biomass is burned as this is part of the dynamics of the wider forest system. This translates into atmospheric and terrestrial carbon budgets. While biomass burning causes a single point of biogenic emissions, it does not increase the overall atmospheric carbon budget as the wider forest landscapes keeps sequestering carbon at a continuous rate. Compared to fossil fuels, the use of forest biomass does therefore not contribute to the atmospheric carbon budget [13].
- The rate at which trees (and forests) sequester carbon is not linear and varies over lifetime depending on species, agro-ecological zone/climate experienced and forest management regime. As CO_2 is removed from atmosphere to managed trees/forests it is transferred to

different carbon pools: stemwood (which provides most wood products e.g. timber for construction); roundwood and smaller branches (which are of lower value and often used for pulp, fibre and pellet production); roots and soil. Assessment of the contribution of trees and forests to carbon dioxide removal must take account of all of these carbon stores.

- The graphs below [6] show simulations of typical managed forests in different parts of the world with management regimes typical for commercial practice. Figures a and b relate to a U.S. system of Lobolly pine which is clearcut harvested every 25 years; figures c and d a Spanish eucalyptus system on a shorter rotation harvested completely for pellets every 16 years and e, f a Canadian system of balsam fir.

Fig. 1. Carbon stocks of forest, wood products and wood pellets of the three forest systems over 200 years as tonnes of CO2eq mass per hectare



- It is critical to note that for all 3 systems the carbon sequestered and stored is cyclical and the maintenance of a long term carbon stock is dependent on maintaining long term sustainable forestry practices. So, there may be periods of thinning or harvesting every 16, 25 or 75 years; but if the same area of land remains under the same forest regime the cycle will then be repeated: hence **the timber harvesting process is necessary in order to make space for new trees to be planted that will fulfil future material and economic demands.** The timescale in which this takes place may exceed human lifetimes and will often exceed periods considered normal for rates of return on business transactions. So, it may appear to an observer who constrains their time horizon that a particular land area has been "deforested" by clearfelling at a point in the stand lifetime, but what is critical is what happens beyond that harvesting point. This **clearfelling is not deforestation if the harvested area is replanted or naturally regenerated, so that the land continues to sequester carbon at high rates in future decades.**

- The curves above show that when harvest takes place there will be a reduction in the stock of carbon in the stand, but that will be regained in a sustainable forest system. The time periods for that redemption may seem long by human standards: 10, 50 or 75 years in some of the examples above, but this is simply indicative of the fact that forests are long term commitments. If a sustainable long term commitment to keeping an area under forest is maintained the graphs show that land can continue to extract carbon from the atmosphere for 200 or more years, whilst simultaneously delivering wood products for use that contain carbon.

- If short term extraction of carbon from atmosphere is a priority e.g. maximizing the amount of carbon removed per unit area of land by 2050, then it may make sense to give particular priority to certain species and agro-ecological zones (e.g. the Spanish systems considered sequester carbon faster than the Canadian ones). However, this is usually at the expense of other attributes e.g. the biodiversity characteristics may be different, but most importantly the opportunity to produce high commercial value timber is likely to be lower i.e. long rotation broadleaf systems often produce stemwood that has higher market value than that produced by short rotation coniferous systems.
- The cyclical, repeating curves for all of the systems above show that there is no unique “starting” or “reference” point from which we can consider forestry practices to have increased or decreased carbon removed or stored. What actually matters is the long term level of sequestration and storage. So **it does not make sense to talk about “carbon debt” associated with harvesting that takes place as part of a long-term repeated cycle in a sustainable forestry system**, in which the debt is actually repaid within the lifetime of the forest system.
- The key points to note from the U.S. and Canadian systems are that **as the forest stands reach maturity the rate of extraction of carbon from atmosphere (per unit area of land) slows and the carbon stock plateaus. So retaining the same trees beyond that point does not significantly contribute to additional carbon removal from atmosphere. It usually makes more sense to harvest the accumulated carbon at that point to pave the way for new growth.** This allows more carbon to be sequestered in future, but also provides an economic return for the landowner, which contributes to the economic sustainability of the forest cover, increasing the likelihood of it being maintained in the long term.
- **When we look at the forest stands over appropriate time frames of 100 years or more it becomes clear that there is no unique vantage point from which we can argue a “carbon debt” has been incurred.** Carbon increases, then decreases, then increase again. The mean stock is important, but equally important is what is done with the material and carbon that is removed from the system.
- When considering the system contribution to a green taxonomy two concepts are significant: systems that are sustainable because they “do no harm” and those that make positive contributions to climate/sustainability challenges. All of the forestry systems above “do no harm” in that they sequester more carbon than would be expended in their creation and maintenance. However, **maximizing their positive contribution depends very critically on the use that is made of the removed wood products**. If these are simply returned to atmosphere after processing then the process has “done no harm”, since the integral health, functioning and sequestration capacity of the forest system has not been negatively affected by the removal of the wood. If the processing of the wood (e.g. in a biomass power plant) causes a reduction in another harmful activity e.g. reduction in fossil fuel fired power generation then the process has arguably made a positive contribution. This positive contribution can be further enhanced if the removed wood can be put to a use where the carbon is not re-released to atmosphere but instead retains the (originally atmospheric) carbon in the planetary ecosphere. That can be achieved by incorporating the wood into long term uses (such as construction), using it to synthesize essential materials/chemicals or deliberately storing the carbon in reservoirs (such as in depleted oil and gas fields). These (biomass to energy with carbon capture utilization and storage)

applications can therefore deliver net negative emissions. If these are to be achieved it is critical to consider them at the outset of any forest planting programme. Different species not only sequester carbon at different rates, but also produce wood that is useful for different applications e.g. pulp, furniture, construction. So **long term carbon benefits can be maximized by planting the most appropriate species to (a) maximize the amount of carbon sequestered per unit area of land and (b) service the long term market demand** that will result in the carbon sequestered remaining locked up for a long period of time.

- Under the United Nations Framework Convention on Climate Change (UNFCCC), nations are required to report on all their emissions within a series of GHG inventories. The UNFCCC emission accounting framework demands the use of a comprehensive methodology to measure, report and verify emissions from bioenergy, and an overview of how bioenergy system emissions are accounted for can be found in our 2020 policy briefing on the topic [16]. Under the carbon accounting framework bioenergy can prove beneficial for both biomass producing and bioenergy using countries [16].

Sustainability

- Regarding the ecosystem impacts, a growing body of research is exploring the impact of growing non-food bioenergy crops or SRF on land, finding positive ecosystem benefits when grown on agricultural land. Benefits include improved biodiversity, soil health and soil carbon, and flood mitigation (in eastern England in particular). In cultivating these crops and SRF it will be important to choose suitable locations, scales, and management practices, which minimise risks and support ecosystems. Policy makers can facilitate this through incentivising bioenergy crop deployment where ecosystems are supported – such as through the Environmental Land Management Scheme (ELMS). Concerning the risk of indirect land-use change from cultivating these crops, there is concern that their deployment might displace food production and lead to conversion of land elsewhere globally to offset this lost food production, with negative environmental impacts. There are several reasons to suggest this need not happen: increased land-use efficiency in the UK can be driven by increased land productivity as well as dietary shifts away from meat and dairy, freeing up land for bioenergy crop deployment. As UK domestic bioenergy crop deployment expands it will be important to monitor any potential risks of indirect land-use change [10].
- Sustainability concerns here relate to the ecosystem impacts of converting land to this purpose as well as accounting for any indirect consequences of using that land for bioenergy: indirect land-use change.
- It will be important to validate biomass imports to determine their sustainability as well as to use Life-Cycle Analysis to determine full supply chain emissions and the carbon impact of this biomass source.
- Current sustainability criteria for biomass use in the UK (for both domestic and imported biomass), focus on the quantification of GHG emission impacts and encourage biodiversity. So far other environmental, economic and social co-benefits of biomass use are not included in policy. An integration of wider sustainability benefits and risks would allow to move beyond carbon and facility the deployment of wider sustainability standards and support a wider number of sectors and stakeholders [10].

The recent Supergen Bioenergy Hub myth busting paper titled “Does Bioenergy Cause Biodiversity Loss?” may be of interest to those considering the sustainability implications of biomass [17].

Following oral evidence given by Director of the Supergen Bioenergy Hub and the Energy

and Bioproducts Research Institute at Aston University Patricia Thornley on 26 October and 2 November, the committee requested further written input to clarify on certain points. This is included below.

Question: As the UK scales up its use of biomass for bioenergy generation and/or BECCS, what proportion of domestically sourced biomass is expected to be from woody vs. non-woody biomass sources?

Biomass demand could increase substantially as the UK transitions to a net-zero economy. The Committee on Climate Change expects bioenergy to meet 5-15% of the UK's energy demand in 2050, compared to around 7% today (CCC 2018). Biomass demand will depend upon a number of factors including energy demand, reliance on other energy resources, and biomass use for non-bioenergy uses (e.g as a feedstock for chemicals or a construction material) [4].

- In its 'Balanced Net Zero Pathway' scenario, the Committee on Climate Change expect just under 50% of domestic UK biomass in 2050 to be sourced from forest residues and bioenergy crops, including short-rotation forestry (SRF). The more ambitious CCC scenarios of biomass demand requires either an increase in bioenergy crops or an increase in biomass imports. Whilst the biomass supply in 2050 may be balanced between woody and non-woody biomass sources, this assumes ambitious woody biomass planting scenarios which would be required to scale-up in the next decade. Realising these deployment scales will depend on a number of factors including the availability of land, willingness of landowner to plant, and how fast non-food bioenergy crops can be scaled up. As a result of their limited deployment at present, the near-term biomass availability is greatest from waste resources and agricultural crop residues [3]. More recent analysis from the UK and Global Bioenergy Resource Model (developed by Ricardo on behalf of BEIS) found similarly high availability of biomass resources from agricultural and waste resources by 2030, with limited non-food bioenergy crop and forestry potential [5].
- Updated quantitative analysis on current and potential future availability of different domestic and imported biomass resources would support discussion of this question and the next two questions. We were therefore pleased to see that BEIS awarded a contract for work to update the UK and Global Bioenergy Resource Model in 2022 as part of their work on the upcoming Biomass Strategy [18].

Question: Patricia in her oral evidence said in the session that 'we have crunched the numbers on this. I cannot remember the exact figure but a few million tonnes per annum is potentially accessible in a sustainable manner from woodland in the UK.' Could you please point me in the direction of the relevant literature/research?

- Our Supergen modelling of UK biomass availability potential suggests that there is approximately 70 Petajoules (PJ) available from forest resources in 2025, or 9 Million tonnes (Mt) of biomass (at 12.5 Gigajoules/tonne as used by Forest Research [19]), rising to 150 PJ by 2050, or 19 Mt of biomass [4]. To put these figures into context, biomass availability potential from crops, residues, and waste in 2025 are estimated at 56 PJ, 148 PJ, and 219 PJ.

Question: The 2018 CCC Biomass report says that the government should 'Undertake more work to deliver the commitment to bring 67% of England's forests back under active management (from 59% currently), and seek to extend the ambition where the evidence supports this.' Is it therefore expected that active management of the UK woodlands will be the main source of woody biomass for bioenergy/BECCS? Or are other sources including SRF, silvicultural thinning, and waste and residues likely to be significant?

- As stated in our answer above, woody biomass represents around half of the UK's domestic biomass supply under the CCC's 'Balanced Net Zero Pathway' scenario, with approximately half of this supplied by bioenergy crops, including SRF. The Global Bioenergy Resource Model (developed by Ricardo on behalf of BEIS) publishes a breakdown of UK biomass resource availability in 2030. This includes 36 PJ from forestry residues, 23 PJ from stemwood, 31 PJ from sawmill co-products, 51 PJ from arboricultural arisings, and 95 PJ from waste wood. Non-food bioenergy crop potential is estimated at 66-221 PJ, whilst the SRF potential in 2030 is 0, on account of the lack of planting at present. Non-food bioenergy crops include the fast-growing woody crops of poplar and willow - which can grow rapidly and be harvested every 3 years. Whilst the deployment of these crops is low in the UK at present, modelling indicates that they will be relied upon to meet growing biomass demand.

Question: Patricia said: ‘Governance is important, but I think we need to know, we need to be monitoring at the right scale globally, if we are going to go to BECCS, to ensure that we do know what is actually happening.’ I just wanted to clarify what it is that you are suggesting is monitored on a global scale. Is that global biomass consumption?

- The carbon impact (i.e. the net carbon emissions or sequestration associated with its production and sourcing) of biomass imports are not necessarily linear or scalable: if today we are importing 10 Mt per year of forestry material and that is established to have a certain carbon impact, it is not necessarily the case that scaling imports by a factor of 10 will also scale up the overall carbon impact by the same amount. This is because where and how biomass is grown both play a role in determining its carbon impact. To obtain accurate assessments of the carbon impacts the type, species, location, age, and management regime of the individual sources must be considered.

- In addition, there will be a net impact on forest carbon stocks if significant quantities of biomass material are extracted from a particular region or location. That impact is cumulative across all extraction purposes (energy, timber for building etc) and so it can be difficult to attribute emissions or changes in carbon stock to a particular use/consignment/purpose. As a consequence, the only really effective way of establishing the impact of global biomass sourcing is to monitor global movements, locations, practices, and associated forest inventories, as well as carbon stocks. Global statistics will not be able to show that particular supply chains or activities have *caused* particular carbon changes as this will be attributable across economic multiple sectors or could arise through natural processes (i.e. forest fires, disease, etc). However, monitoring of the movement of timber, residues etc. does enable correlations to be observed e.g. it could be observed that carbon stocks in forests in a particular country/agroecological zone decrease over time while at the same time the net export of forest residues from that region also increase. That does not "prove" there is a causal link but provides evidence of an environmental concern that should be carefully studied.

Question: Patricia also mentioned that there may be potential to use land which is currently used for pasture to expand wood production, if there was a change in diet away from meat consumption. I recognise this as something which the CCC say in relation to land-use trade-offs generally. Again, grateful if you could please share the relevant literature or address this in writing.

- The CCC has identified the role that dietary shifts in the UK could perform in freeing agricultural land for bioenergy crop cultivation. There is a broad base of scientific literature showing the high land-use intensity of meat and dairy foods, and that significantly less land is required to produce plant-based foods of the same calorific quantities (e.g. [20, 21]). As well as using arable crops to produce livestock feed, the UK also imports animal feed, reflecting a global footprint attached to UK meat and dairy consumption. The UK Climate

Assembly found support for a 20-40% reduction in meat and dairy consumption in the UK [22], with recent data showing a 17% reduction since 2010 [23]. The reduction of land-use intensity of UK diets is therefore a very realisable outcome, and this would allow more land to be used for other things including forestry and cultivation of bioenergy crops.

Question: Patricia referred to analysis of carbon sequestration potential of forests through different rotation periods in Spain, Canada and Sweden. The Chair asked if you would be able to provide us with this, please.

- The study that was being referred to was one by Röder *et al* [6]. This study looked at different forest rotation periods and explored the carbon 'debt' of using forest biomass to supply bioenergy. As Patricia noted in her oral evidence, the relevant scale here is that of the forest, not the individual tree.
- The recent Supergen Bioenergy Hub myth busting paper titled "Is bioenergy carbon neutral?", which examines the concepts of carbon neutrality and carbon debt for bioenergy, may be of interest to those looking at these topics [24].

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