# A Supergen Bioenergy Hub response to the consultation on a common biomass sustainability framework

The Supergen Bioenergy Hub welcomes the opportunity to contribute to this public consultation on a common biomass sustainability framework. The Hub is the UK's flagship bioenergy research consortium, and works with academia, industry, government and societal stakeholders to develop sustainable bioenergy systems that support the UK's transition to an affordable, resilient, low-carbon energy future. This is supported through the Hub's whole system research approach that encompasses all aspects of bioenergy expertise to identify pathways for delivering bioenergy with wider social, economic and environmental benefits.

## Chapter 1 – A Common Sustainability Framework

**1. Do you agree that the initial scope of the framework should be limited to bioenergy that is subject to government incentive schemes? If not, please explain why and provide evidence to support your response.**

While limiting the initial scope of the framework to bioenergy supported through government incentive schemes may enable faster implementation, we believe this approach carries material risks for the wider UK bioeconomy. A more holistic, cross-sectoral framework—extending beyond energy-focused incentives—would better reflect the rapidly expanding role of biological resources across multiple industrial sectors and support coherent sustainability governance.[1]

Focusing solely on bioenergy overlooks the significant growth and strategic importance of the UK bioeconomy, which spans chemicals, materials, biomanufacturing, waste valorisation, agriculture, and emerging engineering biology. The UK bioeconomy is already recognised as a major contributor to national economic growth, job creation, and innovation, underpinning sectors far beyond energy.[2] The UK Government's Modern Industrial Strategy makes notes of work carried

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[1] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

[2] BBSRC. 2022. 'Building the bioeconomy'. [Online] Available from https://www.ukri.org/wp-content/uploads/2022/02/BBSRC-280122-BuildingTheBioeconomy-Presentation.pdf

out by Government Office for Science that identified the role of engineering biology to transform food, chemicals, materials, fuels, health and environmental solutions.[3]

Restricting sustainability standards to only bioenergy under incentive schemes risks creating misaligned sustainability criteria across sectors using similar feedstocks.[4] Without inclusion of the broader biobased sector, there is a clear risk that sustainability expectations for biomass use in other industrial applications will diverge or remain under-regulated, leading to inconsistent biomass governance, supply-chain inefficiencies, and unintended consequences for land-use and resource allocation.

Moreover, without a dedicated UK bioeconomy strategy in place, there is a heightened risk of market distortion. This concern is also reflected in broader policy analyses: limiting scope to specific bioenergy incentive schemes can indeed lead to fragmented regulation and distort market signals, as acknowledged within the 'Case for Intervention' published by the UK Government as part of the current consultation. A sector-siloed approach incentivises biomass flows into subsidised energy pathways even when higher-value or higher-impact uses exist elsewhere in the bioeconomy.

Given the expanding role of biorefineries, biotechnology research programmes, and the existence of bio-based industrial clusters across the UK, which serve as focal points for innovation across multiple bio-based product streams, it is increasingly important that sustainability frameworks reflect the multi-sectoral nature of biomass use.

While the initial narrow scope may offer administrative simplicity, we believe a broader, cross-sectoral approach, covering biomass use in both energy and non-energy biobased sectors, would deliver more robust sustainability outcomes, reduce the risk of fragmented standards, and avoid distortion across biomass markets. A comprehensive framework aligned to a clear UK bioeconomy strategy would help ensure that sustainable biomass use supports the full spectrum of UK economic, environmental, and innovation priorities, not just subsidised energy production.

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[3] Government Office for Science. 2025. 'Engineering Biology Aspirations: Foresight Report'. [Online] Available from: https://www.gov.uk/government/publications/engineering-biology-aspirations-report/engineering-biology-aspirations. [Accessed 24 Feb 2026].

[4] Taylor, D., J. Sparks, K. Chong and M. Röder (2024). "Determining the Benefits of Biomass: Who Wins, and Who Loses?" 14(10): 2350. https://doi.org/10.3390/agronomy14102350.

**2. Do you agree that the common criteria should be delivered as a policy document and implemented through the relevant legislative or contractual frameworks of each individual biomass policy?**

We broadly agree that setting out the common criteria in a policy document is a sensible first step. It creates a shared reference point across different schemes and makes it easier to update or refine the framework as understanding evolves. A policy document also gives departments and delivery bodies something practical to work with in the short term, which is important if the aim is to keep momentum and avoid long delays.

However, relying on policy alone can only take things so far. If the framework is meant to offer long-term clarity and consistency, there needs to be a clear commitment to move toward a legislative and regulatory basis once the groundwork has been tested and proven. Putting the criteria into legislation and regulation would give industry, investors and regulators much greater confidence that sustainability expectations will not shift unpredictably.[5]

Based on our research and stakeholder engagement, we think this transition would benefit from stronger cross-government coordination. A formal governance board, bringing together the departments with a stake in biomass use, could help manage the trade-offs that inevitably arise between energy, land use, industrial development and the wider bioeconomy. Having a single place where these tensions are discussed openly would support more balanced decision-making and help ensure that policy, contractual arrangements and regulation develop in a coherent way rather than drifting apart over time.

**3. Should government consider a legislative route for implementing the common sustainability framework in the future, including expanding for non-subsidised uses? Please provide evidence to support your response.**

We think there is a strong case for the government to consider a legislative route in the future, particularly if the framework is expected to guide both subsidised and non-subsidised biomass uses over the long term. While policy documents can offer flexibility in the early stages, they do not provide the same level of certainty or durability that industry and investors often need when planning around multi-decade biomass supply chains and infrastructure.

[5] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

Past experience in the UK shows that relying on a patchwork of individual schemes and departmental policies has often created unnecessary complexity. Different parts of government have tended to approach biomass through their own priorities, which has made it difficult to build a coherent system.[6] These siloed approaches have, at times, led to overlaps, conflicting incentives, or gaps where no single department holds responsibility.

Moving toward a legislative footing could help resolve some of these longstanding issues. Legislation would provide a common anchor for all departments, ensuring that sustainability expectations apply consistently, regardless of whether biomass is used for heat, power, fuels, materials, chemicals, or other emerging biobased applications. It would also help avoid situations where non-subsidised uses fall outside the scope of sustainability oversight simply because they do not sit within an incentive-driven scheme.

In addition, a legislative route would send a clearer signal to the wider bioeconomy, especially sectors that are growing rapidly but are not currently covered by existing biomass policies. Giving the framework a statutory basis would help ensure that sustainability standards evolve in a more balanced and predictable way, rather than depending on the political or administrative priorities of individual schemes. Over time, this could create a more stable environment for investment and innovation across the full range of biobased industries.

**5. Do you agree that the updated policy guidance document should be published every 5 years? Please provide evidence to support your response or an alternative proposal for review timelines.**

We welcome the proposal to commit to interim updates based on the development of new scientific evidence, or where public concern might warrant a change in policy. However, five years is a long time in a fast-moving area like biomass sustainability, where scientific understanding, market conditions and public attitudes can shift much more quickly. For that reason, we strongly support the proposal to allow for interim update mechanisms when new evidence emerges or when there is a clear signal of public concern.

Building in this flexibility is important. Research by the Supergen Bioenergy Hub[7] indicates that relying on outdated assumptions can

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[6] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

[7] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

weaken both the credibility and the effectiveness of sustainability standards, especially in fields where technologies evolve rapidly and the science around land-use, carbon accounting or environmental impacts is continually improving. Regular, evidence-based updates would help ensure the framework keeps pace with real-world developments rather than lagging behind them.

Frequent touchpoints with the public are equally valuable. Social license is not something that can be established once and then assumed to hold indefinitely. Publishing updates in response to emerging public concerns, such as those raised in forums like the DESNZ Public Dialogue on biomass and net-zero,[8] would demonstrate that government is listening and willing to address contentious issues as they arise, rather than waiting for the next scheduled review period.

To support this, it may be worth creating a 'standing issues log' that tracks questions, criticisms and emerging themes in public debate, along with transparent responses or planned actions. This would help surface issues early, reduce the risk of misinformation gaining traction, and offer a clearer view of where further research or policy clarification might be needed. It would also provide a useful record for the formal five-year reviews, helping to ensure that longer-term updates are informed by consistent, ongoing engagement rather than occasional consultations.

## Chapter 2 – Biomass Feedstock Categories & Definitions

**6. Do you agree with the list of key feedstock categories and their definitions in scope of the common framework? Please provide evidence to support your response.**

We broadly agree with the proposed feedstock categories, but we think the definitions would benefit from further refinement to reflect the real complexity and variability across different biomass types. At present, some of the category boundaries appear too rigid, while others do not fully capture important sustainability considerations that influence how these feedstocks behave in practice. To strengthen the framework, it would be useful to incorporate a few additional clarifications and to revisit some of the assumptions that underpin the categories.

- **Geographical Origin and Supply-Chain Context**

We recommend that feedstock definitions within the framework explicitly recognize the importance of geographical origin and supply-

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[8] DESNZ. 2023. Role of Biomass in Achieving Net Zero: Public Dialogue. [Online] Available at: https://www.gov.uk/government/publications/role-of-biomass-in-achieving-net-zero-public-dialogue. [Accessed 29 Jan 2026].

chain context (mainly for internationally traded biomass). Feedstocks that are similar in type can have very different sustainability implications depending on regional land practices, harvesting methods and transport-based logistics. Incorporating origin-based descriptors alongside feedstock categories would improve traceability. It would also enable more accurate assessment of greenhouse gas (GHG) emissions, land-use risks and broader environmental impacts. This would also be in line with the international sustainability standards and improve transparency where biomass is sourced with differing governance and monitoring capabilities.[9]

- **Perennial Energy Crops and Marginal Land**

We agree with the inclusion of perennial energy crops (Miscanthus, SRC Willow). There is good evidence from Supergen Bioenergy Hub's research that these crops can offer high yields, deliver meaningful carbon sequestration benefits, and avoid direct competition with food production.[10]

The challenge lies in the definition of marginal land itself. Although the term is widely used, it is far less useful in practice. What makes land marginal varies not only between regions but over time, shaped by weather patterns, climate change, soil conditions, waterlogging, access limitations and shifting crop economics. A policy definition risks locking farmers into categories that do not reflect how their land actually behaves, and it may inadvertently exclude those who are already using lower performing fields for perennial energy crops simply because those fields are not officially classified as marginal. For these reasons, we do not think marginal land should be used as a formal category within the framework. Instead, the focus should shift toward the suitability of land for specific crops, assessed on a case-by-case basis and informed by agronomic realities rather than fixed classification schemes. Removing marginal land as a category does not weaken sustainability safeguards, it simply avoids imposing an overly prescriptive and potentially unfair constraint on growers. It also helps ensure that perennial energy crops are deployed where they make most sense environmentally and economically, rather than where a policy label allows them to be planted.

- **Recognition of Chemical Complexities**

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[9] Welfle, Andrew James, Alberto Almena, Muhammad Naveed Arshad, et al. 2023. 'Sustainability of Bioenergy – Mapping the Risks & Benefits to Inform Future Bioenergy Systems'. Biomass and Bioenergy 177: 106919. https://doi.org/10.1016/j.biombioe.2023.106919.

[10] Supergen Bioenergy Hub (2020). Case Studies Report: Developing the UK Bioenergy Sector to Enable the Transition to a Sustainable Bioeconomy. [Online] Available from: https://www.supergen-bioenergy.net/wp-content/uploads/2020/05/Supergen-Bioenergy-Hub-Case-Studies-Report.pdf [Accessed 24 Feb 26].

While the categories like agricultural residues, forestry residues, energy crops etc. are standard, the definitions should more explicitly account for markers such as inorganic ash content and overall chemical composition of the feedstock. Our research has demonstrated that inorganic matter such as potassium and phosphorous in biomass significantly influences the biomass conversion pathways. It also affects the stability of bio-products during thermochemical conversion of biomass.[11]

- **Inclusion of Novel Feedstock**

The framework should be flexible enough to incorporate emerging feedstocks. Examples include gasification char or novel non-food crops such as Virginia Mallow which research by the Supergen Bioenergy Hub has identified as viable energy feedstocks with distinct sustainability capabilities.[12]

The framework should explicitly include marine biomass, such as seaweed, macro- and microalgae, and processed marine residues (e.g., fish and shellfish waste). These feedstocks have significant decarbonisation and circular economy potential but differ ecologically and in supply chain characteristics from terrestrial biomass, and thus require tailored sustainability criteria (e.g., marine ecosystem impact, nutrient cycling, invasive species risk).[13],[14],[15] Including marine biomass ensures the framework reflects a broad and future-facing biomass portfolio that aligns with net-zero and marine overarching objectives.

An expert workshop convened in 2023 by the Supergen Bioenergy Hub identified 27 potential novel crops that could contribute to the sector.[16]

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[11] Banks, Scott W., Daniel J. Nowakowski, and Anthony V. Bridgwater. 2016. 'Impact of Potassium and Phosphorus in Biomass on the Properties of Fast Pyrolysis Bio-Oil'. Energy & Fuels 30 (10): 8009–18. https://doi.org/10.1021/acs.energyfuels.6b01044.

[12] Banks, S. W., M. Śnieg, D. J. Nowakowski, M. Stolarski, and A. V. Bridgwater. 2021. 'Potential of Virginia Mallow as an Energy Feedstock'. *Waste and Biomass Valorization* 12 (5): 2375–88. https://doi.org/10.1007/s12649-020-01183-2.

[13] Onyeaka, Helen, Taghi Miri, KeChrist Obileke, Abarasi Hart, Christian Anumudu, and Zainab T. Al-Sharify. 2021. 'Minimizing Carbon Footprint via Microalgae as a Biological Capture'. Carbon Capture Science & Technology 1: 100007. https://doi.org/10.1016/j.ccst.2021.100007.

[14] Farghali, Mohamed, Israa M. A. Mohamed, Ahmed I. Osman, and David W. Rooney. 2023. 'Seaweed for Climate Mitigation, Wastewater Treatment, Bioenergy, Bioplastic, Biochar, Food, Pharmaceuticals, and Cosmetics: A Review'. Environmental Chemistry Letters 21 (1): 97–152. https://doi.org/10.1007/s10311-022-01520-y.

[15] Bittencourt, Flávio L. F., Márcio F. Martins, Nur F. Munajat, et al. 2025. 'Waste-to-Energy from Marine Biomass and Processing Wastes: A Review'. Biomass and Bioenergy 198 (July): 107835. https://doi.org/10.1016/j.biombioe.2025.107835.

[16] Rowe, Rebecca, Joanna Sparks, and Rebecca Fothergill. 2023. Report from Stakeholder Workshop on Novel Crops and Forestry Species as Sources of Industrial Biomass - Supergen Bioenergy Hub. [Online] Available at: https://www.supergen-bioenergy.net/output/report-from-stakeholder-workshop-on-novel-crops-and-forestry-species-as-sources-of-industrial-biomass/. [Accessed 24 Feb 26].

Peer-reviewed research on many novel biomass crops is limited, with much of the information identified by participants at the 2023 workshop based on personal experience and grey literature. This highlights a key research need to understand and mitigate risks (i.e. around biosecurity) and identify opportunities offered by novel feedstocks.

## Chapter 3 – Land criteria

**7. Do you agree that the agricultural land criteria should continue to include prohibited land categories in line with existing criteria?**

The exclusion of specific agricultural land criteria can have a substantial economic and environmental impact and potentially restrict the ability of farmers to diversify their income. Work using a spatially explicit UK ecosystem service model linked to the UK-TIMES energy system model has demonstrated that the imposition of exclusion zones (including but not limited to specific Agricultural Land Classes) would result in up to an additional £1.33 billion cost of biomass production consistent with CCC scenarios, and could result in some scenarios becoming impossible due to lack of suitable land. Modelling suggests that imposition of exclusion zones could result in biomass production being displaced to lower quality land with lower yield productivity. Such a displacement of biomass production caused by exclusion zones could thus potentially increase the area of land required to meet CCC projections.[17],[18]

**9. Do you agree with the definitions of the highly biodiverse land categories given? If not, please explain why and provide evidence to support your response.**

Broadly speaking these criteria are appropriate. There is some issue with the definition of 'high'. Under global criteria, the few remaining areas of old-growth forest in the UK would not typically be considered to have high biodiversity when compared with ecosystems such as the Brazilian rainforest, which support far greater species richness and ecological complexity at a global scale. This discrepancy highlights that the existing terminology may be too coarse, and that the language should be refined to better reflect spatial variation in biodiversity patterns across the world.

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[17] Delafield, Gemma, Greg S. Smith, Brett Day, Robert A. Holland, et al. 2024. 'Spatial Context Matters: Assessing How Future Renewable Energy Pathways Will Impact Nature and Society'. Renewable Energy 220: 119385. https://doi.org/10.1016/j.renene.2023.119385.

[18] Delafield, Gemma, Greg S. Smith, Brett Day, Robert Holland, and Andrew Lovett. 2024. 'The Financial and Environmental Consequences of Renewable Energy Exclusion Zones'. Environmental and Resource Economics 87 (2): 369–98. https://doi.org/10.1007/s10640-022-00749-z.

**10. Do you agree with the list of protected highly biodiverse land categories where sourcing is not allowed?**

The implication of areas designated for nature protection (one approach to highly biodiverse land categories) requires an appropriate and robust definition of specific land categories. There is a wide array of literature detailing gaps in the coverage of protected areas (PAs). The *Key Biodiversity Area* initiative seeks to identify these gaps through systematic identification of critical sites for global PA expansion.[19] While many of the criteria in the current UK Government consultation align with 2008 as a benchmark year, in terms of conservation status recognition of priority areas for nature conservation in the future to meet mandated targets such as thirty by thirty agreed at in Kunming-Montreal Global Biodiversity Framework[20] is important.

**12. Should other highly biodiverse land categories be added? If yes, what associated sourcing requirements could be included?**

The criteria make no mention of wetland systems, which are dealt with later in the consultation but should be represented here to avoid them being only included as a carbon store. Whilst the argument for protection of these systems primarily focuses on GHG emissions, there is a need for recognition of wetlands as areas that are critically important for global biodiversity. Wetland systems represent around 1% of the earth's surface but contain around 10% of all species and approximately a third of all vertebrates. Furthermore, the criteria do not consider future expansion of the cultivation and/or harvesting of marine algae as a source of biomass. Inshore waters provide critical ecosystem services, including coastal protection, mediated through their high biodiversity compared to open ocean systems.[21] There is limited understanding or capability to understand how expansion of biomass production in these wetland and marine systems could impact biodiversity – but exclusion of marine systems and a sole focus on land based production seems like an important omission.

**15. Do you agree that sourcing should be allowed from peatlands if evidence is provided that the cultivation and harvesting of that raw**

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[19] Kullberg, Peter, Enrico Di Minin, and Atte Moilanen. 2019. 'Using Key Biodiversity Areas to Guide Effective Expansion of the Global Protected Area Network'. Global Ecology and Conservation 20: e00768. https://doi.org/10.1016/j.gecco.2019.e00768.

[20] 'The Kunming-Montreal Global Biodiversity Framework (GBF) Target 3'. 2022. Secretariat of the Convention on Biological Diversity. [Online] Available at: https://www.cbd.int/gbf/targets/3. [Accessed 24 Feb 26].

[21] Tittensor, Derek P., Camilo Mora, Walter Jetz, et al. 2010. 'Global Patterns and Predictors of Marine Biodiversity across Taxa'. Nature 466 (7310): 1098–101. https://doi.org/10.1038/nature09329.

**material does not involve drainage of previously undrained soil?**

Peatlands are the world's largest terrestrial organic carbon stock. Many peatlands however are significantly degraded, releasing carbon into the atmosphere rather than sequestering carbon. Paludiculture, or farming on rewetted peat, is a system of agriculture for wetland crop production under conditions that support the competitive advantage of these crops. In the context of lowland peat soils it is most usually achieved through raising of the water table to achieve wetland conditions.[22] Any sourcing of biomass from peatlands would therefore need to be managed carefully, including options for paludiculture.

## ILUC

**20. How could high ILUC risk feedstocks be identified? Please suggest what factors could be considered and provide evidence to support your response.**

Research by the Supergen Bioenergy Hub has developed a methodology using historical trends and crop price movements, which could be used to assess ILUC caused by UK biomass applications.[23] The methodology when applied to US / Brazil corn-soybean interaction found no evidence that the expansion of corn ethanol production in the US has resulted in significant ILUC in Brazilian soybean cultivation. These findings thus support the classification of corn as a low ILUC-risk feedstock in the US / Brazil production context. However, if ILUC impacts are less significant than previously assumed, there would be a need to reassess the criteria used to define high ILUC-risk feedstocks, particularly within the UK context.

## Agricultural land

**26. Do you have evidence regarding the impact of requiring energy crops to meet the agricultural land criteria? We are particularly interested in potential impacts on planting targets and spatial distribution of energy crops.**

Modelling work examining multiple future pathways of UK bioenergy demand consistent with targets such as those informing the CCC carbon budgets suggest that perverse outcomes can arise from exclusion of energy crops on certain land categories. For example, spatial modelling

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[22] Milner, Jim, and Judith Stuart. 2022. Paludiculture – the future of farming on peat soils?. [Online] Available at: https://naturalengland.blog.gov.uk/2022/09/30/paludiculture-the-future-of-farming-on-peat-soils/. [Accessed 26 Feb 26].

[23] Yesufu and Thornley. 2026. UK bioenergy policies and implications for global land use change [under review].

suggests that exclusion of high-quality agricultural land leads to spatial concentration of dedicated bioenergy crop production in central and eastern England, and that if moderate-quality agricultural land (ALC 3) is also excluded, the expansion of bioenergy becomes technically and economically infeasible for all but the lowest estimates of future bioenergy crop expansion. Based on economic analysis that incorporate both market (i.e. infrastructure, land) and non-market costs (i.e. ecosystems services and biodiversity) the exclusion of moderate quality agricultural land would impose up to £0.5 billion over 25 years in additional costs compared to scenario with no exclusions.[24]

## Forest

**41. Do you agree that forest managers should be required to ensure the management and harvesting activities have a positive impact on local communities in the sourcing area?**

Ensuring that the management and harvesting activities have a positive impact on local communities in the sourcing area is crucial to mobilising public support for biomass harvesting related activities and building social legitimacy.[25] This could be done through a mandate for community benefit and engagement plans which evidence impact on local jobs, skills, and local ecosystem benefits or encouraging participatory engagement in local governance of the harvesting operations.[26]

**42. Are there any other social requirements that should be included in the common framework relating to the sourcing and harvesting of forest biomass? Please explain what these are, how these could be implemented, and the rationale for inclusion.**

Assumptions that the UK will seek to increase the domestic production of biomass through forests and agriculture highlights a key skills gap, which will need to see targeted skills programmes funded to attract and train the next generation of farmers, foresters, and operators to fill the gap and

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[24] Delafield, Gemma, Greg S. Smith, Brett Day, Robert Holland, and Andrew Lovett. 2024. 'The Financial and Environmental Consequences of Renewable Energy Exclusion Zones'. Environmental and Resource Economics 87 (2): 369–98. https://doi.org/10.1007/s10640-022-00749-z.

[25] Taylor, Daniel, Katie Chong, and Mirjam Röder. 2024. 'Designing Biomass Policy: The Political Economy of Renewable Energy for Net Zero'. WIREs Energy and Environment 13 (2): e512. https://doi.org/10.1002/wene.512.

[26] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

unlock jobs in rural communities.[27] A skills gap was also identified at a 2022 workshop with attendees from academia, industry (including biomass suppliers, agricultural consultancies, and end-users), NGOs and government.[28]

**43. Do you agree there should be an explicit requirement for long-term forest carbon stocks to be maintained? What time scale should this assessment consider?**

We strongly agree that there should be an explicit requirement to maintain long-term forest carbon stocks. Forests play a fundamentally different role in the carbon cycle compared to annual crops: while annual crops release and re-absorb carbon within a single growing season, forests accumulate carbon slowly over decades.[29] When that long-term storage is disrupted, the climate consequences can persist for an equally long period. This is why it is essential that any sustainability framework recognise the long-lived nature of forest carbon pools and treat them as strategic assets for climate mitigation.

Given these dynamics, the timescale for assessing forest carbon stocks needs to extend well beyond short-rotation harvest cycles. Research undertaken by Supergen and international forest carbon experts[30] points to the need for evaluating cumulative emissions and removals over multi-decadal to century-scale horizons. These longer timelines align more realistically with net-zero targets and with the modelling approaches commonly used in global climate assessments, many of which project impacts out to 2050, 2100 and beyond.[31] Shorter windows are simply not capable of capturing the full climate consequences of

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[27] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

[28] Rowe, Rebecca, Muhammad Arshad, Andrew Welfle, et al. 2022. Land Use Decision-Making for Biomass Deployment, Bridging the Gap between National Scale Targets and Field Scale Decisions. https://research.manchester.ac.uk/en/publications/land-use-decision-making-for-biomass-deployment-bridging-the-gap-/.

[29] Röder, Mirjam, Evelyne Thiffault, Celia Martínez-Alonso, Fanny Senez-Gagnon, Laurence Paradis, and Patricia Thornley. 2019. 'Understanding the Timing and Variation of Greenhouse Gas Emissions of Forest Bioenergy Systems'. Biomass and Bioenergy 121 (February): 99–114. https://doi.org/10.1016/j.biombioe.2018.12.019.

[30] Röder, Mirjam, Evelyne Thiffault, Celia Martínez-Alonso, Fanny Senez-Gagnon, Laurence Paradis, and Patricia Thornley. 2019. 'Understanding the Timing and Variation of Greenhouse Gas Emissions of Forest Bioenergy Systems'. Biomass and Bioenergy 121 (February): 99–114. https://doi.org/10.1016/j.biombioe.2018.12.019.

[31] Welfle, Andrew, Patricia Thornley, and Mirjam Röder. 2020. 'A Review of the Role of Bioenergy Modelling in Renewable Energy Research & Policy Development'. Biomass and Bioenergy 136: 105542. https://doi.org/10.1016/j.biombioe.2020.105542.

changes in forest management, harvest intensity or feedstock demand.

There is also a practical reason to take this longer view. If forests are managed on very short rotations, or if residues and low-grade wood are removed too aggressively, landscapes can experience long-term reductions in carbon stocks, especially if regeneration is slow or vulnerable to pests, drought or fire. Without safeguards, this can result in a net carbon loss that undermines the very climate benefits that sustainable biomass is meant to deliver. For that reason, it's important that policies explicitly require the maintenance, if not improvement, of long-term forest carbon stocks at the landscape scale, not just at the level of individual stands.

However, it is equally important to recognise that bioenergy and forest management do not have to be at odds. With the right management practices, integrated business models, and careful attention to harvest levels and regeneration rates, it is possible to use forest biomass while still maintaining (or even increasing) the overall carbon stored in the landscape. Many forest systems already operate on multi-decade planning horizons, and sustainable management practices, such as selective harvesting, longer rotation periods, and limits on residue removal, can help ensure that carbon pools remain stable over time rather than drifting toward depletion.

**50. What data could government collect from sourcing regions to monitor management changes? How can government understand the extent to which bioenergy demand may be influencing management changes?**

Government could monitor management changes in biomass sourcing regions by requiring consistent supply-chain reporting such as mean harvested tree age, age-class distributions, growth–drain ratios, residue extraction rates, and data from forest management plans, which the consultation Technical Annex identifies as practical indicators of shifts toward shorter rotations or intensified harvesting. Additional information required should include country of origin, feedstock type, volumes, harvest location at an appropriate resolution, and evidence of sustainable management. Collecting a small set of comparable, outcome-focused indicators from those regions could help to compare and contrast practices. These indicators enable early detection of carbon-risk management changes in sourcing regions. To understand whether such changes are driven by UK bioenergy demand, government should compare these trends over time with UK-linked pellet demand and with similar regions not supplying the UK market, supported by remote sensing and national forest inventory datasets. Confidentiality concerns can be managed through regional aggregation and by redacting commercially sensitive identifiers. Data should also be collected and published using international reporting standards, such as the sustainability and chain-of-custody requirements in EU RED III, which mandate traceability and standardised reporting across feedstock and biofuel supply chains, and the aligned frameworks provided by SBP REDIII normative documents, ISCC EU reporting requirements, and the PEFC RED III chain-of-custody standard.

Aligning with these established standards would ensure comparability across sourcing regions, reduce duplication for operators already complying with RED III, and improve coherence across UK and international biomass markets.

**60. Do you agree that, under the common framework, government should only provide support (where the forest criteria apply) to bioenergy from feedstocks that meet the forest criteria? Please provide evidence to support your response.**

This appears consistent with the National Audit Office recommendations from 2024,[32] which scrutinised government support for biomass through subsidy schemes and included a focus on the sustainability of biomass sourcing from forests. This is crucial to ensuring that taxpayer funds are being used to support the development and protection of forests and minimising the potential for environmental harm from unsustainable sources of biomass.

## Wastes and residues

**70. Do you agree that, unless otherwise stated, wastes and residues should be exempt from the land criteria?**

Yes. In principle, wastes and genuine residues should be exempt from land criteria because they are not the primary driver of land management decisions and generally do not require additional land conversion. This aligns with widely used sustainability concepts that distinguish residues from primary products, where a residue is explicitly defined as not the end product(s) that a production process seeks to produce and the process is not deliberately modified to produce it.[33]

**Marine waste emphasis**: This exemption is particularly important for fish and shellfish processing residues (heads, shells, scales, viscera), which are unavoidable by-products of food supply chains and can be sustainably

[32] National Audit Office. 2024. The Government's Support for Biomass - NAO Report. [Online] Available at: https://www.nao.org.uk/reports/the-governments-support-for-biomass/. [Accessed 26 Feb 26].

[33] ISCC System GmbH. 2023. ISCC EU 202-5 Waste and Residues, version 4.1. [Online] Available at: https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_202-5_Waste_and_Residues-v4.0.pdf. [Accessed 24 Feb 26].

valorised (for energy or materials) without driving land use change.[34]

**71. Do you have evidence that wastes are being purposefully created to produce feedstocks for bioenergy? If yes, please provide evidence.**

No. We work extensively across bioenergy domains and have not seen evidence of this behaviour.

## Novel feedstocks

**72. Are there any emerging or novel biomass feedstocks for which sustainability criteria may need to be developed? If yes, please specify the feedstocks and suggest criteria that would mitigate potential environmental harms arising from the sourcing of the feedstock.**

Yes. The framework needs to be flexible enough to incorporate emerging feedstocks. Examples include gasification char or novel non-food crops like Virginia Mallow which have been identified as viable energy feedstocks with distinct sustainability capabilities in our research.[35],[36],[37],[38] An expert workshop run by the Supergen Bioenergy Hub in 2023 identified 27 novel biomass crops suitable for near-term deployment in the UK. Peer-reviewed research on many of the novel biomass crops is limited, with much of the information identified by participants at the workshop based on personal experience and grey literature.[39] This highlights a key research need to understand and mitigate potential

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[34] Cooney, Ronan, David Baptista de Sousa, Ana Fernández-Ríos, et al. 2023. 'A Circular Economy Framework for Seafood Waste Valorisation to Meet Challenges and Opportunities for Intensive Production and Sustainability'. Journal of Cleaner Production 392 (March): 136283. https://doi.org/10.1016/j.jclepro.2023.136283.

[35] Banks, S. W., Śnieg, M., Nowakowski, D. J., Stolarski, M., & Bridgwater, A. V. (2021). Potential of Virginia mallow as an energy feedstock. Waste and Biomass Valorization, 12(5), 2375-2388. https://link.springer.com/article/10.1007/s12649-020-01183-2.

[36] Welfle, Andrew James, Alberto Almena, Muhammad Naveed Arshad, et al. 2023. 'Sustainability of Bioenergy – Mapping the Risks & Benefits to Inform Future Bioenergy Systems'. Biomass and Bioenergy 177: 106919. https://doi.org/10.1016/j.biombioe.2023.106919.

[37] Welfle, Andrew, and Mirjam Röder. 2020. Supergen Bioenergy Hub Case Studies Report: Developing the UK Bioenergy Sector to Enable the Transition to a Sustainable Bioeconomy and Low-Carbon Future. https://www.supergen-bioenergy.net/wp-content/uploads/2020/05/Supergen-Bioenergy-Hub-Case-Studies-Report.pdf.

[38] Banks, Scott W., Daniel J. Nowakowski, and Anthony V. Bridgwater. 2016. 'Impact of Potassium and Phosphorus in Biomass on the Properties of Fast Pyrolysis Bio-Oil'. Energy & Fuels 30 (10): 8009–18. https://doi.org/10.1021/acs.energyfuels.6b01044.

[39] Rowe, Rebecca, Joanna Sparks, and Rebecca Fothergill. 2023. Report from Stakeholder Workshop on Novel Crops and Forestry Species as Sources of Industrial Biomass - Supergen Bioenergy Hub. [Online] Available at: https://www.supergen-bioenergy.net/output/report-from-stakeholder-workshop-on-novel-crops-and-forestry-species-as-sources-of-industrial-biomass/. [Accessed 26 Feb 26].

harm and identify opportunities.

The framework should explicitly include marine biomass, such as seaweed, macro- and microalgae, and processed marine residues (e.g., fish and shellfish waste). These feedstocks have significant decarbonisation and circular economy potential but differ ecologically and in supply chain characteristics from terrestrial biomass, and thus require tailored sustainability criteria (e.g., marine ecosystem impact, nutrient cycling, invasive species risk). [40],[41],[42] Including them ensures the framework reflects a broad and future-facing biomass portfolio that aligns with net-zero and marine overarching objectives.

## Land criteria to non-bioenergy uses

**73. How would the land criteria, as currently formulated, be applied to biomass feedstocks regardless of their end use (including non-energy uses)?**

Land criteria should be applied based on feedstock origin and production system, not on end use. In practice, this means to apply it at the point of origin of the feedstock (e.g. farm, forest or plantation), biomass should be shown to comply with land criteria, such as not being sourced from protected areas or high-carbon-stock land, in line with the framework. Mechanisms also need to be put in place to ensure that this sustainability status is maintained through the supply chain (e.g. mass balance) and consistent monitoring, reporting and verification.

**Marine emphasis:** For marine biomass (seaweed, macro/microalgae) and marine processing residues, land criteria are often not the right instrument because the primary impacts are in marine ecosystems (spatial planning, habitat effects, nutrient cycling, invasive species risks). So: apply land criteria to terrestrial supply chains and ensure equivalent marine sustainability criteria exist for marine feedstocks so they are not forced into an ill-fitting land-based test.

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[40] Onyeaka, Helen, Taghi Miri, KeChrist Obileke, Abarasi Hart, Christian Anumudu, and Zainab T. Al-Sharify. 2021. 'Minimizing Carbon Footprint via Microalgae as a Biological Capture'. Carbon Capture Science & Technology 1: 100007. https://doi.org/10.1016/j.ccst.2021.100007.

[41] Farghali, Mohamed, Israa M. A. Mohamed, Ahmed I. Osman, and David W. Rooney. 2023. 'Seaweed for Climate Mitigation, Wastewater Treatment, Bioenergy, Bioplastic, Biochar, Food, Pharmaceuticals, and Cosmetics: A Review'. Environmental Chemistry Letters 21 (1): 97–152. https://doi.org/10.1007/s10311-022-01520-y.

[42] Bittencourt, Flávio L. F., Márcio F. Martins, Nur F. Munajat, et al. 2025. 'Waste-to-Energy from Marine Biomass and Processing Wastes: A Review'. Biomass and Bioenergy 198 (July): 107835. https://doi.org/10.1016/j.biombioe.2025.107835.

**76. What environmental or social concerns are there regarding the wider biomass supply chain? Please be specific about their nature and the sectors that these concerns relate to.**

The DESNZ Public Dialogue on the role of biomass in achieving net zero highlighted a concern that biomass might be 'dominated by the profit motives of the energy sector, rather than the need to achieve net zero'.[43] Research by the Supergen Bioenergy Hub shows that this public sentiment is also reflected within the bioenergy sector itself, which demonstrates that the import and use of biomass to generate energy is perceived to contribute towards rising inequality and, controversially, the degradation of natural environments.[44]

**77. Should sector specific policy measures be put in place to mitigate potential risks relating to the wider supply chain or should these be set out at a cross-sector level under the common framework? Please provide detailed evidence on what these could be and how they could be implemented, noting the challenges highlighted above.**

Research by the Supergen Bioenergy Hub demonstrates that 'clawback' mechanisms could be included in performance-based subsidy models, linked to environmental and social indicators, to ensure that money can be reclaimed where biomass sustainability requirements are not met.[45] Clauses in the recent renewal of the Drax subsidy program are an example of such 'clawback' mechanisms from a profitability standpoint, whilst greater stringency on compliance with sustainability requirements is included within the contract terms.[46] Such 'clawback' mechanisms and contract terms for sustainability compliance could be set out at the cross-sectoral level.

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[43] DESNZ. 2023. Role of Biomass in Achieving Net Zero: Public Dialogue. [Online] Available at: https://www.gov.uk/government/publications/role-of-biomass-in-achieving-net-zero-public-dialogue.p5. [Accessed 24 Feb 26].

[44] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

[45] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

[46] DESNZ. 2025. Statement by the Secretary of State for Energy Security and Net Zero. Hansard Written Ministerial Statement, HCWS424, 10 February 2025. [Online} Available at: https://questions-statements.parliament.uk/written-statements/detail/2025-02-10/hcws424. [Accessed 24 Feb 26].

## Chapter 4 – GHG Criteria

**80. Do you agree with the approach on system boundary application? Please provide evidence to support your response, including sector-specific impacts where possible.**

We agree with the principle of applying wider and more comprehensive system boundaries, and we think this is essential if the sustainability framework is to produce credible and policy-relevant outcomes. Evidence from the Supergen Bioenergy Hub has shown repeatedly that when system boundaries are drawn too narrowly, the analysis can produce results that look favourable on paper but fail to reflect what is happening across the whole supply chain.[47],[48],[49],[50],[51],[52],[53],[54],[55] In practice, this can lead to decisions that overlook major emissions sources, ignore important

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[47] Röder, Mirjam, Evelyne Thiffault, Celia Martínez-Alonso, Fanny Senez-Gagnon, Laurence Paradis, and Patricia Thornley. 2019. 'Understanding the Timing and Variation of Greenhouse Gas Emissions of Forest Bioenergy Systems'. Biomass and Bioenergy 121: 99–114. https://doi.org/10.1016/j.biombioe.2018.12.019.

[48] Welfle, Andrew, Patricia Thornley, and Mirjam Röder. 2020. 'A Review of the Role of Bioenergy Modelling in Renewable Energy Research & Policy Development'. Biomass and Bioenergy 136: 105542. https://doi.org/10.1016/j.biombioe.2020.105542.

[49] García-Freites, Samira, Clair Gough, and Mirjam Röder. 2021. 'The Greenhouse Gas Removal Potential of Bioenergy with Carbon Capture and Storage (BECCS) to Support the UK's Net-Zero Emission Target'. Biomass and Bioenergy 151: 106164. https://doi.org/10.1016/j.biombioe.2021.106164.

[50] Welfle, Andrew, and Mirjam Röder. 2022. 'Mapping the Sustainability of Bioenergy to Maximise Benefits, Mitigate Risks and Drive Progress toward the Sustainable Development Goals'. Renewable Energy 191: 493–509. https://doi.org/10.1016/j.renene.2022.03.150.

[51] Almena, Alberto, Patricia Thornley, Katie Chong, and Mirjam Röder. 2022. 'Carbon Dioxide Removal Potential from Decentralised Bioenergy with Carbon Capture and Storage (BECCS) and the Relevance of Operational Choices'. Biomass and Bioenergy 159: 106406. https://doi.org/10.1016/j.biombioe.2022.106406.

[52] Welfle, Andrew James, Alberto Almena, Muhammad Naveed Arshad, et al. 2023. 'Sustainability of Bioenergy – Mapping the Risks & Benefits to Inform Future Bioenergy Systems'. Biomass and Bioenergy 177: 106919. https://doi.org/10.1016/j.biombioe.2023.106919.

[53] Röder, Mirjam, Patricia Thornley, and Craig Jamieson. 2024. 'The Greenhouse Gas Performance and Climate Change Mitigation Potential from Rice Straw Biogas as a Pathway to the UN Sustainable Development Goals'. Biomass and Bioenergy 182: 107072. https://doi.org/10.1016/j.biombioe.2024.107072.

[54] Almena, Alberto, Regina Siu, Katie Chong, Patricia Thornley, and Mirjam Röder. 2024. 'Reducing the Environmental Impact of International Aviation through Sustainable Aviation Fuel with Integrated Carbon Capture and Storage'. Energy Conversion and Management 303: 118186. https://doi.org/10.1016/j.enconman.2024.118186.

[55] Butnar, Isabela, John Lynch, Sylvia Vetter, et al. 2024. 'A Review of Life Cycle Assessment Methods to Inform the Scale-Up of Carbon Dioxide Removal Interventions'. WIREs Energy and Environment 13 (6): e540. https://doi.org/10.1002/wene.540.

trade-offs, or exaggerate the climate benefits of particular biomass pathways.

A more robust approach means looking well beyond the immediate conversion stage. It requires accounting for the entire life cycle of biomass use, from how and where the feedstock is grown, through transportation, processing and combustion, all the way to the performance and infrastructure requirements of carbon capture and storage where relevant. Including these stages helps reveal where the biggest emissions actually occur and where mitigation efforts will have the greatest effect. It also helps distinguish between feedstocks and technologies that look similar within narrow boundaries but behave very differently when viewed across their full lifecycle.

Just as importantly, the system boundary needs to take into account counterfactuals. It is imperative to consider what would happen if the biomass were not used for energy at all, whether it would remain in the forest, be used for other products, decompose on site, or be diverted into other industries. Without this, models risk assuming climate benefits that may not materialise in the real world. Land-use change impacts, alternative management practices, and the displacement of fossil fuels all need to be captured if the final results are to be meaningful.

Sector-specific effects also become clearer when boundaries are expanded. For example, in forestry, changing the level of residue removal or altering harvest cycles can have long-term implications for soil health, carbon stocks and overall landscape resilience. In agriculture, shifting residues from soil incorporation to energy use can affect soil carbon, fertiliser demand and agronomic performance. And in sectors where CCS plays a major role, recognising the energy requirements, infrastructure constraints and capture efficiencies becomes crucial for understanding true system-level emissions.

It is not clear from the consultation document whether end-use is included in the system boundaries for transport fuels. Particularly for the aviation sector, biofuel end-use should be included in the system boundaries as there is evidence to suggest that the use of SAFs (Sustainable Aviation Fuels) could lead to a reduction in contrail formation compared to fossil jet. Contrails, created from airplane vapour, are thought to have the largest single contribution to net global warming from aviation, surpassing $CO_2$ and $NO_x$. Since SAFs usually have a lower aromatic content than conventional jet fuel, they produce fewer soot particles on combustion, leading to reduced contrail formation.[56],[57],[58] This indicates that, in the end-use phase, SAF have a lower global warming impact per MJ fuel burned compared to fossil jet fuel.

Although carbon emissions from SAF combustion are assumed to be offset from the biomass growth stage, if feasible, $NO_x$ emissions from aircraft should be included in the end-use phase as they are separate from the carbon cycle and have a larger global warming impact at higher altitudes,[59] indicating differences between short-haul and long-haul flights per MJ fuel burned. Additionally, the altitude of the flight, location of the flight path, and weather conditions have a significant effect on contrail formation. However, flying at lower altitudes to reduce the impact from contrails and NOx emissions comes with trade-offs such as increased fuel consumption and therefore $CO_2$ emissions.[60], [61] Research in this area is still ongoing.

**87. Do you agree that thresholds under the GHG criteria should be set by individual biomass policies instead of a single cross-sector biomass supply chain threshold?**

We do not think a single, uniform GHG threshold applied across all biomass supply chains would be effective. Research by the Supergen Bioenergy Hub shows that GHG performance varies depending on the type of feedstock being used, the technology involved, and the specific

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[56] Voigt, C., Kleine, J., Sauer, D. et al. Cleaner burning aviation fuels can reduce contrail cloudiness. Commun Earth Environ **2**, 114 (2021). https://doi.org/10.1038/s43247-021-00174-y.

[57] Rubin-Zuzic, M., Bugliaro, L., Marsing, A., Wang, Z., Voigt, C., Simson, C., Kaiser, S., Ziegler, P. Reduced contrail radiative effect for fleets with low soot and water vapour emissions. Atmospheric Environment: X **27**, 100353 (2025). https://doi.org/10.1016/j.aeaoa.2025.100353.

[58] Borrill, E., Koh, S. C. L., Yuan, R. Review of technological developments and LCA applications on biobased SAF conversion processes. Frontiers in Fuels **2**, 1397962 (2024). https://doi.org/10.3389/ffuel.2024.1397962.

[59] Air Transport Action Group. Aviation and climate change Fact sheet 2 (2024). https://atag.org/media/gw5cgzzh/fact-sheet_2_aviation-and-climate-change.pdf.

[60] Teoh, R., Schumann, U., Majumdar, A., Stettler, M. E. J. Mitigating the Climate Forcing of Aircraft Contrails by Small-Scale Diversions and Technology Adoption. Environmental Science & Technology **54**, 5 (2020). https://doi.org/10.1021/acs.est.9b05608.

[61] Williams, V., Noland, R. B., Toumi, R. Reducing the climate change impacts of aviation by restricting cruise altitudes. Transportation Research Part D: Transport and Environment **7**, 6 (2002). https://doi.org/10.1016/S1361-9209(02)00013-5.

management practices applied.[62],[63],[64],[65],[66],[67],[68],[69],[70] Even within the same broad sector, small differences in how biomass is produced, processed or handled can lead to very different emissions outcomes.

For example, seasonal and weather-dependent factors can affect emissions in agricultural systems, while fugitive methane losses and digestate management play a major role in determining the overall GHG profile of anaerobic digestion. In forestry, rotation lengths, harvest intensity, residue management and regeneration rates all influence carbon outcomes over time. Regional differences, such as soil type, climate, and existing land-use patterns, add another layer of variation that a single generic threshold simply cannot capture.

Because of this complexity, applying one cross-sector threshold risks flattening these differences and creating the wrong incentives. High-performing pathways could be penalised unfairly, while pathways

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[62] Röder, Mirjam, Evelyne Thiffault, Celia Martínez-Alonso, Fanny Senez-Gagnon, Laurence Paradis, and Patricia Thornley. 2019. 'Understanding the Timing and Variation of Greenhouse Gas Emissions of Forest Bioenergy Systems'. Biomass and Bioenergy 121: 99–114. https://doi.org/10.1016/j.biombioe.2018.12.019.

[63] Welfle, Andrew, Patricia Thornley, and Mirjam Röder. 2020. 'A Review of the Role of Bioenergy Modelling in Renewable Energy Research & Policy Development'. Biomass and Bioenergy 136: 105542. https://doi.org/10.1016/j.biombioe.2020.105542.

[64] García-Freites, Samira, Clair Gough, and Mirjam Röder. 2021. 'The Greenhouse Gas Removal Potential of Bioenergy with Carbon Capture and Storage (BECCS) to Support the UK's Net-Zero Emission Target'. Biomass and Bioenergy 151: 106164. https://doi.org/10.1016/j.biombioe.2021.106164.

[65] Welfle, Andrew, and Mirjam Röder. 2022. 'Mapping the Sustainability of Bioenergy to Maximise Benefits, Mitigate Risks and Drive Progress toward the Sustainable Development Goals'. Renewable Energy 191: 493–509. https://doi.org/10.1016/j.renene.2022.03.150.

[66] Almena, Alberto, Patricia Thornley, Katie Chong, and Mirjam Röder. 2022. 'Carbon Dioxide Removal Potential from Decentralised Bioenergy with Carbon Capture and Storage (BECCS) and the Relevance of Operational Choices'. Biomass and Bioenergy 159: 106406. https://doi.org/10.1016/j.biombioe.2022.106406.

[67] Welfle, Andrew James, Alberto Almena, Muhammad Naveed Arshad, et al. 2023. 'Sustainability of Bioenergy – Mapping the Risks & Benefits to Inform Future Bioenergy Systems'. Biomass and Bioenergy 177: 106919. https://doi.org/10.1016/j.biombioe.2023.106919.

[68] Röder, Mirjam, Patricia Thornley, and Craig Jamieson. 2024. 'The Greenhouse Gas Performance and Climate Change Mitigation Potential from Rice Straw Biogas as a Pathway to the UN Sustainable Development Goals'. Biomass and Bioenergy 182 (March): 107072. https://doi.org/10.1016/j.biombioe.2024.107072.

[69] Almena, Alberto, Regina Siu, Katie Chong, Patricia Thornley, and Mirjam Röder. 2024. 'Reducing the Environmental Impact of International Aviation through Sustainable Aviation Fuel with Integrated Carbon Capture and Storage'. Energy Conversion and Management 303: 118186. https://doi.org/10.1016/j.enconman.2024.118186.

[70] Butnar, Isabela, John Lynch, Sylvia Vetter, et al. 2024. 'A Review of Life Cycle Assessment Methods to Inform the Scale-Up of Carbon Dioxide Removal Interventions'. WIREs Energy and Environment 13 (6): e540. https://doi.org/10.1002/wene.540.

with weaker climate performance might still pass under an undifferentiated standard. This could also discourage innovation in areas where targeted improvements could deliver significant gains. In the worst cases, a blanket threshold could even steer biomass into uses that look compliant on paper but offer little real-world climate benefit once the full lifecycle is considered.

A more tailored approach, whether sector-specific, feedstock-specific, or technology-specific, would provide a much more realistic picture of actual emissions performance. It would allow thresholds to reflect the genuine sustainability trade-offs within each supply chain and give clearer signals to producers and operators about where improvements are needed. It would also offer policymakers greater confidence that the GHG criteria are driving meaningful change rather than forcing diverse systems into a one-size-fits-all framework.

**91. What are the barriers and challenges (if any) in accounting for GHG emissions from wastes, including mixed wastes?**

The key challenges are already identified in the consultation document, including variable fraction of waste from fossil-derived sources, unknown chemical composition and energy content which impacts conversion efficiency to electricity and fuels, and risk of incentivising unnecessary waste production.

Additional challenges come with the import and export of waste feedstocks for fuel and energy production, as well as accounting for all transport impacts. Care must be taken to ensure that 'waste fraud' is not taking place as the waste certification procedures may not be as rigorous or well-documented in other jurisdictions.[71] If waste is being unnecessarily produced or fraudulently certified, this significantly affects the GHG emissions counting. In particular, waste cooking oil can be sold for higher prices than virgin oil, driving fraudulent practices.[72] Research efforts are still ongoing to develop methods to detect fraudulent waste cooking oil fractions.[73] Similarly, the UK must ensure that any waste

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[71] Transport Environment. 2024. UCO (Unknown Cooking Oil): High hopes on limited and suspicious materials. [Online] Available at: https://www.transportenvironment.org/articles/uco-unknown-cooking-oil-high-hopes-on-limited-and-suspicious-materials#:~:text=Likely%20discrepancy%20between%20collection%20and,being%20mislabelled%20as%20waste%20oils. [Accessed 24 Feb 26].

[72] van Grinsven, A., van den Toorn, E., van der Veen, R., Kampman, B. (2020). Used Cooking Oil (UCO) as biofuel feedstock in the EU. CE Delft 20.200247.144 . https://www.regenwald-statt-palmoel.de/images/pdf/CE_Delft_UCO.pdf

73 Lim, S. Y., Abdul Mutalib, M. S., Khaza'ai, H., & Chang, S. K. (2018). Detection of fresh palm oil adulteration with recycled cooking oil using fatty acid composition and FTIR spectral analysis. International Journal of Food Properties, 21(1), 2428–2451. https://doi.org/10.1080/10942912.2018.1522332.

exports are properly managed to avoid shifting the burden to another nation.[74] Ultimately, the import or export of wastes should be avoided wherever possible to mitigate additional environmental and global warming impacts from transport.

**96. What is your view on the preferred declared or functional unit of expression for LCAs for non-fuel uses of biomass, as an alternative to gCO2e/MJ?**

For non-fuel uses of biomass, g$CO_2$e/MJ is not an appropriate functional unit, as it is energy-specific and does not reflect the function of biomass used in materials, chemicals, or products. Instead, the preferred approach should be based on mass functional units such as g$CO_2$e per kg of biomass input or per kg of final product. These are generally the most transparent and practical for non-fuel applications. They align with how materials and chemicals are produced, traded, and regulated.[75]
In some cases, it may be appropriate to express impacts per functional performance (e.g. per kg of polymer with specified properties, per square meter of material, or per unit of durability), particularly where biomass-based products directly substitute fossil-derived materials.[76],[77] Most importantly, the framework should allow flexibility in functional units while ensuring comparability within product categories, supported by clear guidance on when mass-based versus function-based units should be used.

## Chapter 5 – Monitoring Reporting and Verification

**99. Are there any other improvements to the feedstock type reporting process that should be considered?**

The current reporting on biomass feedstock types would certainly benefit if we moved beyond high-level categorical labels. Instead, adapting a

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74 Puckett, J. (2024). Global and National Instruments to Stop the Export and Dumping of Plastic Wastes. In: Gündoğdu, S. (eds) Plastic Waste Trade. Springer, Cham. https://doi.org/10.1007/978-3-031-51358-9_4.

75 Wang, Kan, Ruiqing Tong, Qiang Zhai, Guomin Lyu, and Yongsheng Li. 2025. 'A Critical Review of Life Cycle Assessments on Bioenergy Technologies: Methodological Choices, Limitations, and Suggestions for Future Studies'. Sustainability 17 (8): 3415. https://doi.org/10.3390/su17083415.

76 Furberg, Anna, Rickard Arvidsson, and Sverker Molander. 2022. 'A Practice-Based Framework for Defining Functional Units in Comparative Life Cycle Assessments of Materials'. Journal of Industrial Ecology 26 (3): 718–30. https://doi.org/10.1111/jiec.13218.

77 Pérez, Reina, Fernando Argüelles, Amanda Laca, and Adriana Laca. 2024. 'Evidencing the Importance of the Functional Unit in Comparative Life Cycle Assessment of Organic Berry Crops'. Environmental Science and Pollution Research 31 (14): 22055–72. https://doi.org/10.1007/s11356-024-32540-6.

smaller number of standardised, physically meaningful descriptors that actually affect sustainability outcomes would prove to be more effective.[78] There is evidence in scientific literature which proves that parameters such as moisture content, ash content, chemical composition can significantly influence GHG emissions.

Thermochemical conversion, such as pyrolysis and gasification, is impacted by biomass characteristics, which in turn have a direct impact on downstream processing that impacts the GHG emissions. Similarly, work from Dolat et al.[79] and Zhang et al.[80] show that feedstock quality and the co-digestion recipes of different feedstocks in anaerobic digestion can impact GHG emission accounting and impacts. For anaerobic digestion, standardised reporting of total solids (TS), volatile solids (VS), biomethane potential (BMP), and carbon to nitrogen ratios can be used to better estimate the global warming potential of the final biogas products, along with seasonal measurements, not annual averages.[81] Reporting these alongside co-digestion blends actually used on site will enable accurate estimates. Further, feedstock availability and storage duration and method of storage are also important to understand whole site emissions.

Including these descriptors by complementing the traditional ones in a harmonised reporting framework would improve comparability across various sectors such as transport fuels, heat, and gaseous fuels for electricity etc. This reporting aligned with international sustainability data formats, such as EU RED III supply-chain reporting frameworks, would reduce our reliance on generic values and better reflect real-world variability in biomass supply chains. This approach aligns with the recommendations in the Supergen Bioenergy Hub's 'Biomass-to-Hydrogen' policy briefing which emphasizes the importance of biomass feedstock characteristics and consistent data for reporting standards.[82]

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[78] Mola-Yudego, Blas, Ioannis Dimitriou, Bruno Gagnon, Jörg Schweinle, and Biljana Kulišić. Priorities for the sustainability criteria of biomass supply chains for energy. Journal of Cleaner Production 434 (2024): 140075 10.1016/j.jclepro.2023.140075.

[79] Dolat, Meshkat, Rohit Murali, Mohammadamin Zarei, et al. 2024. 'Dynamic Feed Scheduling for Optimised Anaerobic Digestion: An Optimisation Approach for Better Decision-Making to Enhance Revenue and Environmental Benefits'. *Digital Chemical Engineering* 13: 100191. https://doi.org/10.1016/j.dche.2024.100191.

[80] Zhang, Ruosi, Jhuma Sadhukhan, Duo Zhang, et al. 2024. 'Novel Life Cycle GHG Formulations of Anaerobic Digestion Systems Aligned with Policy'. SSRN Scholarly Paper No. 4837715. Social Science Research Network. https://doi.org/10.2139/ssrn.4837715.

[81] Dolat, Meshkat, Rohit Murali, Mohammadamin Zarei, et al. 2024. 'Dynamic Feed Scheduling for Optimised Anaerobic Digestion: An Optimisation Approach for Better Decision-Making to Enhance Revenue and Environmental Benefits'. *Digital Chemical Engineering* 13: 100191. https://doi.org/10.1016/j.dche.2024.100191.

[82] Sparks, J, Cooper, S, Okora-Shekwaga, C, Thornley, P, Yuan, R, Skillen, N, Banks, S & Almena, A. 2022. Biomass to hydrogen policy briefing. [Online] Available at: https://www.supergen-bioenergy.net/output/new-biomass-to-hydrogen-policy-briefing/. [Accessed 26 Feb 26].

Overall, these improvements would strengthen transparency and verification and would support more robust assessment of whether specific biomass use delivers genuine climate benefits.

**100. Do you agree with the above proposal on publishing relevant sustainability data? Please provide evidence to support your response.**

Relevant sustainability data should be aggregated and published in a publicly accessible manner as this will aid in the transparency of MRV processes and contribute towards building public trust in supply-chains.[83]

## Conclusion

**128. Do you have any further comments or suggestions across all policy proposals included in this consultation in relation to the objectives (set out above and in chapter 1), including on the costs and practicalities.**

Research by the Supergen Bioenergy Hub, referenced in this consultation response, clearly demonstrates the need for:

1. **A policy framework that incentivises multi-dimensional benefits across sectors:** The framework's objectives should reflect and include reference to building social legitimacy and the equitable distribution of multi-dimensional benefits. Whilst aiming to minimise wider environmental harm associated with unsustainable biomass use is welcome, a focus only on subsidised bioenergy risks market distortion and fragmented standards. A cross-sectoral approach has the potential to unify bio-based sectors, ensuring sustainability expectations develop across all industries and avoid unintended consequences. Such multi-dimensional benefits of bio-based supply chains potentially include jobs in rural communities, ecosystem services, and reliable income streams for farmers and foresters.[84]

2. **A policy framework that reflects the real-world complexities associated with bioenergy supply:** The long-term nature of carbon stocks, whole-system GHG accounting, and varied feedstocks (including marine and novel crops) are important factors that demand a flexible framework that can incorporate emerging scientific evidence through regular, evidence-based reviews. This will ensure the

[83] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

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framework grows with technological advances, environmental science, and public concerns.

3. **A policy framework that develops social legitimacy and public support for biomass**: This legitimisation and benefit distribution will be necessary to sustain and mobilise public confidence across the different bio-based sectors which currently perceive different 'winners' and 'losers' because of biomass related policies.[85] Historically, policy mixes have incentivised bioenergy use to replace coal use at scale principally for carbon benefits. The carbon benefits of bioenergy use are, however, not tangible to the public and therefore do not help to generate public support for bioenergy.[86] Prioritising bioenergy supply-chain outcomes beyond the focus on carbon benefits thus has the potential to deliver greater social legitimacy and public acceptance, both of which the UK bioenergy sector needs to be politically feasible and practically sustainable.[87]

## What next?

The UK Government has the pivotal opportunity to turn a patchwork of biomass rules into a coherent, durable sustainability governance system that industry can build upon and society can trust. A common sustainability framework that begins with subsidised bioenergy is a pragmatic first step; but if a framework were to stop with subsidised bioenergy it would entrench fragmentation, distort markets, and undermine public confidence across the wider bioeconomy. The framework must be developed from day one to scale beyond subsidised uses, with a clear path from policy guidance to legislation and governance to manage trade-offs across land, energy, industry and nature. This approach would deliver investor certainty, alignment with international standards, and credibility domestically and internationally.

The GHG gas performance of bio-based supply chains depends on feedstock, technology, management practice and location. The research of the Supergen Bioenergy Hub shows that sector-, feedstock- and technology-specific GHG thresholds outperform a single cross-sector emission threshold. Whole-system boundaries, including counterfactuals and, where relevant, end-use effects, are essential to avoid overstating

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[87] Taylor, Daniel, and Mirjam Röder. 2026. 'Bringing Biomass out from behind the Scenes: An Alternative Approach to Biomass Policy Design for a Sustainable Transition to Net Zero'. Preprint, Research Square. https://doi.org/10.21203/rs.3.rs-8317572/v1.

climate benefits. The framework should therefore mandate common LCA parameters and sector-specific GHG thresholds that tighten over time, coupled with explicit guidance on counterfactuals. This would ensure that every subsidised pathway is credibly low-carbon in real terms.

Supergen cautions that rigid exclusion zones and poorly defined notions like 'marginal land' raise costs, displace production and, in some scenarios, render deployment infeasible. The better route is suitability-based assessments that protect genuinely high-biodiversity and high-carbon lands while enabling perennial crops where agronomically and environmentally appropriate. The framework should retain strong protections (including for long-term forest carbon stocks), refine biodiversity language to reflect spatial variation.

To allow decisions that are auditable and comparable, MRV needs a modern core dataset, alongside strengthened, benchmarked certification and transparent public reporting. This would improve comparability across sectors, reduce reliance on generic defaults, and build public trust. The consultation's proposals on auditing and data transparency align with this trajectory and should be adopted and further operationalised.

Supergen's work highlights the need for community benefit and engagement plans to ensure that deployment creates visible, local value. Embedding clawback mechanisms for non-compliance will protect taxpayers and reinforce that support is conditional on outcomes, not intent. These measures would convert abstract carbon benefits into tangible public goods and are central to durable consent.

The Supergen Bioenergy Hub is committed to providing the independent scientific data needed to develop an evidence-led biomass sustainability framework that addresses the full potential of the UK bioeconomy, beyond subsidised bioenergy projects. The Hub can help support coordination on biomass policy development, provide the scientific evidence to support informed decision making, alongside fostering collaboration between industry, policy, society, and academia. This will ensure that the UK's bio-based sectors can make a significant contribution to the UK's net zero ambitions, whilst enhancing the long-term climate, environmental, and social benefits of biomass use.

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