UK and Global Bioenergy Resource Model (UKGBRM)

QA Review

May 2024

UK Government

CS-NOW

Climate services for a net zero resilient world

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Publication date	28/05/2024
Version	1.1

About CS NOW

Commissioned by the UK Department for Energy Security and Net Zero (DESNZ), Climate Services for a Net Zero Resilient World (CS-N0W) is a 4-year, £5 million research programme, that will use the latest scientific knowledge to inform UK climate policy and help us meet our global decarbonisation ambitions.

CS-N0W aims to enhance the scientific understanding of climate impacts, decarbonisation and climate action, and improve accessibility to the UK's climate data. It will contribute to evidence-based climate policy in the UK and internationally, and strengthen the climate resilience of UK infrastructure, housing and communities.

The programme is delivered by a consortium of world leading research institutions from across the UK, on behalf of DESNZ. The CS-N0W consortium is led by Ricardo and includes research **partners Tyndall Centre for Climate Change Research**, including the Universities of East Anglia (UEA), Manchester (UoM) and Newcastle (NU); institutes supported by the **Natural Environment Research Council (NERC)**, including the British Antarctic Survey (BAS), British Geological Survey (BGS), National Centre for Atmospheric Science (NCAS), National Centre for Earth Observation (NCEO), National Oceanography Centre (NOC), Plymouth Marine Laboratory (PML) and UK Centre for Ecology & Hydrology (UKCEH); and **University College London (UCL)**.

1. Introduction

The UK and Global Bioenergy Resource Model (UKGBRM) has been used to inform UK government biomass strategy since it was originally developed in 2011 to support the 2012 Bioenergy Strategy. UKGBRM was updated and expanded in 2015/2016 to include sustainability, land availability and an expanded range of feedstock. A further iteration of the model in 2022-2024 was developed following a review and determination of methodological developments and improvement in the representation of key sensitivities; updated evidence and improved methodologies; revised representation of domestic feedstock (more granular detail at ITL1 level of detail); and future proofing to allow for the incorporation of new evidence as it emerges. An interim version of the 2024 UKGBRM was used to inform the 2023 Biomass Strategy. As part of the DESNZ CS-NOW programme, WP6 aims to review and quality assure the draft final version of the 2022-23 UKGBRM.

The UK and Global Bioenergy Resource Model (UKGBRM) has been reviewed by three independent bioenergy experts to determine whether the model is robust and produces reasonable outputs. The model and its documentation have been scrutinised to test concept, logic, use of methods, and data quality and transparency. Model use was also tested through building and comparing several scenarios of biomass availability. Overall, the model was found to be robust, with up-to-date methods and well documented data sources Due to the significant quantity of data available in the model and limited review time, the data sources could only be partially checked. Several issues raised in the peer review document reflect the complexity of modelling biomass availability, but also raise issues about the parametrisation of the model and assumptions made. Whilst some of the issues were fixed in the latest, published version of the report, i.e. better documentation of model assumptions, clarification of the sustainability claims and some base year modelled values, other recommended improvements were delayed to future model updates. These pending updates do not undermine the validity of the model and its outputs. Whilst the model was tested in extreme scenarios to determine and discuss model sensitivities (see detailed report review), the responsibility of building sensible scenarios, appropriately communicating results, and using these to inform decision making ultimately rests with the user. In general, the model was found to be fit-for-purpose, with the understanding that on-going iterations will be required as a process of continuous improvement as updated data and evidence become available. Independent peer review is a part of that process and the following were identified as outputs for the review of this version of the model. The Quality Assurers provided this report to support the review, and model amendments were undertaken as an outcome.

2. Errors Log

The expert peer review has been documented and made available to DESNZ (in an excel spreadsheet), detailing the findings of the Quality Assurers for the Biomass Feedstock Availability model, and the supporting spreadsheets and international forestry model, providing comments and prioritising errors, lack of clarity and general observations. Colour coding was applied to this list: Red - denoting important items that the reviewers believe need to be discussed and potential amendments made prior to publication of the model; Amber – denoting further important items worthy of discussion, albeit potentially tasks for further rounds of model development, and; Black – items identified by the reviewers that should be discussed and potentially addressed prior to publication where possible.

3. Scenario Analysis

The biomass strategy considers biomass availability based on 2 scenarios of ambitious supply and restricted biomass supply, whereby most of the assumptions in the model remain the same, except imported levels of biomass (openly available market of overseas biomass in the ambitious scenario vs. 20% available biomass for global trade for the restricted biomass supply, as the result of countries making use of their own biomass for bioenergy applications) and higher energy crop planting in the UK ambitious supply scenario (17kha/yr from 2038) and lower but still increased energy crop planting in the restricted biomass scenario (9kha/yr). Modelled scenarios considered the manipulation of a number of additional parameters to test the robustness of the model, and the outcomes reported beyond the 2 scenarios. Where errors were identified, these have been provided to Ricardo, for further scrutiny.

In particular, the following errors affect one or both Biomass Strategy scenarios, and should be addressed before the model is released:

- The base year (2020) UK domestic values are changing with the scenario runs, e.g. going from 325.7PJ under all low UK resource availability to 379.3PJ when all domestic resources are maxed out. This could be misleading the user, as change of domestic UK resource availability over time is usually reported from the base year.

- The base year (2020) values change for the international biomass supply to the UK as well, misleading the interpretation of change in imported biomass availability over time. E.g. changing from Global resource surplus to Global resource production mode increases the 2020 global resource imports from 93.2 to 123.8PJ.
- Some scenario runs suggest zero availability of imported processing residues in 2020, jumping to 283 PJ in 2025 and almost back to zero again by 2035 (25.2PJ). This suggests there is a disconnect in the modelling between current data (2020) and the first calculated scenario time (2025).
- The functions estimating the amount of carbon captured when CCS is deployed are broken for some biomass uses, e.g. Changing imported Agricultural processing residues (and/or Sawmill residues) allocation from Power generation (pellets) to Power generation with CCS (pellets) from 2030 does not result in any carbon captured.

4. Schematic Systems Map

The model was tested and a number of different input parameters were changed, to test the robustness of the model and the reported outcomes. Several issues were raised in the peer review document which reflect the complexity of modelling biomass availability but also raise issues about the parametrisation of the model and assumptions made.

The model has several levers which can be adjusted to explore biomass feedstock availability under different futures. The user has the option to explore both UK and international settings by changing the assumptions on particular feedstock availability in the user input sheet and feedstock allocation sheets. The most sensitive factors identified in this review are:

1) Land availability for energy crop expansion in the UK. Setting all the other UK levers but land availability to maximum results in 464.2PJ domestic biomass available in 2050. Relaxing the constraints on land, i.e. assuming 1.3Mha become available, takes the UK domestic potential to 862.7PJ by 2050, with SRC and Miscanthus providing 55% of the UK resource. Whilst this seems relatively easy to do in the model, there are several factors influencing both land availability and farmer uptake of energy crops, see Discussion below.
2) International policies on biomass feedstock trading. A change from the global surplus to global production mode quadruples biomass feedstock potentially available to the UK.

Note that this estimation does not include biomass cost fluctuations due to international conditions, limitation which is further discussed in section 6 below.

3) International policies on waste utilisation for biofuels. Even in conditions of limited biomass imports available to the UK, the model still allows for significant imports of road or aviation fuels from waste fractions. Noting that while source countries do not seem to have similar policies in the UK, the model assumes that prioritising waste resources for biofuel production will be policy elsewhere, and that those biofuels are exportable.

Besides biomass resource availability exploration, the model also allows estimation of carbon captured by BECCS technologies available in the model. For BECCS to be considered negative emission technology, it needs to deliver removals over the full life cycle including emissions from harvesting, e.g. soil carbon changes dues to forestry residue harvest. Careful consideration of all the life cycle emission could result in BECCS removal efficiencies of less than 40% of the carbon initially sequestered by biomass, see e.g. Broad et al, 2021. More importantly, as UKGBRM is exploring future carbon sequestration, comparison to a counterfactual becomes a must, to ensure that pathways without BECCS which could deliver more removal are not overlooked.

5. Review Parameterisation

The model was reviewed to identify areas in which the assumptions or methodologies used in the current model are not appropriate or the literature reviewed was substantially incomplete or has been misinterpreted and highlight where improvements could be made, suggesting additional trusted sources of data that could be used by the model.

In general, it was found that there was a lack of transparency about assumptions made and why they were assumed (no references given). Examples have been given in the Excel reviewers log, highlighting discrepancies between related assumptions and unsubstantiated assumptions.

6. Discussion

To identify any significant factors that would impact biomass supply that are not transparently included in the model and provide a discussion of their potential impact on the sustainable biomass feedstock available to the UK.

6.1.1 Sustainability & Biomass Models

The Sustainability Assessment elements of the UKGBRM are limited to carbon and life cycle emissions. Although performance of these is important, 'sustainability' goes far beyond carbon. Literature demonstrates that many of the uncertainties that have historically overshadowed bioenergy projects have been reduced through a growing foundation of research and knowledge, thus the focus of bioenergy sustainability assessments should potentially evolve to ensure that current leading risks continue to be mitigated and benefits are maximised (Welfle et al., 2023).

- We strongly recommend relevant UKGBRM are re-labelled to reflect the focus of the analyses, and that future iterations of the model consider wider sustainability indicators.

Sustainability of bioenergy covers far more issues than those targeted within legislation – where land, carbon and biodiversity are prioritised (BEIS, 2021). Legislation also focuses on preventing the perceived greatest risks, however UK research has repeatedly demonstrated how bioenergy can generate widespread sustainable benefits for people, development, natural systems and the climate. There is a strong argument to also develop frameworks and models that identify, promote and maximise potential benefits (Welfle & Röder, 2022b). For example assuming a project delivers emissions reductions, there is an argument that projects should also be supported/ promoted and replicated based on the ecosystem services and/or economic stimulation they may deliver (Welfle et al., 2023).

Bioenergy is also intrinsically linked to the United Nation's Sustainable Development Goals (SDGs), more so than other renewable technologies. There is a strong argument for these relationships to be further explored and included within policy frameworks and models, as bioenergy could become a real mechanism for achieving targets of the SDGs (Welfle & Röder, 2022b).

- Models such as the Supergen Bioenergy Hub's Bioeconomy Sustainability Indicator Model (BSIM) provide an existing framework that could be adopted for mapping the full sustainability performance of bio- projects (Welfle & Röder, 2022a).
- Through application of the BSIM, Supergen have identified the leading persistent sustainability risks and benefits associated with use of different feedstocks, technologies etc, that could be integrated within models such as the UKGBRM (Welfle et al., 2023).

- Ensuring the sustainability of imported biomass should remain a high priority in UK biomass policy development. Supply chain traceability and country specific legislation on the harvesting of sensitive forest biomass should also continue to be a major factor in defining sustainable biomass use in the UK, and imported biomass should be held to the same standards as the legislation proposes.

6.1.2 Human Actors & Biomass Models

While bioenergy plays a critical role in many future scenarios that meet climate ambitions, deployment of dedicated bioenergy crops in the UK has so far been slow. There is a substantial challenge in translating results from bioresource modelling into the real world (Welfle, et al., 2020). UK research has found that it is essential that human and institutional actors are incentivised and empowered to implement the individual components of bioenergy systems (resource growth, supply chain aggregation, conversion and energy delivery) to deliver sustainable bioenergy systems in the long term. Also policy measures need to consider how they affect individual actors within their own sphere of choice if they are to be effective (Rowe et al., 2022).

- We suggest future work is required to better understand how field/site scale dynamics influence production/mobilisation of biomass resource and how constraints influence deployment of bioenergy technology, so they may be better represented in models.

6.1.3 Competition for Resource & Biomass Models

Bioenergy is a key renewable energy technology targeted to provide options for decarbonising heat, power and transport energy in the UK. In addition, development of the bio-economy is a core element of the UK's industrial strategy. The availability of any given biomass resource over a timeframe will likely be highly dynamic given the equally dynamic competition for that resource over the same timeline by wider sectors (and potentially other countries!).

- How competition and changing demands are analysed within many of the bioresource models is weak, adding layers of uncertainty and risk in outputs generated. Models including the UKGBRM apply relatively static availability percentages as a means of accounting for competition.
- There is a strong argument for further research that would build a better understanding of the current competing uses for the major categories of biomass and lands. This

would be enhanced by also spatially mapping locations of key resources and that of major competing industries.

There are further potential knowledge gaps when considering 'the best uses' of different categories of biomass, as these may be very different when considering the wider economic, environmental and social performance indicators (Welfle et al., 2020).

6.1.4 Natural Capital & Biomass Models

Given the growing focus on natural capital and ecosystem services within the key policies such as the UK's 25 Year Environment Plan, and the potential for biomass systems to deliver these, there is a strong argument for incorporating such analyses within biomass models (Holland et al., 2018).

- It is recommended that work should be carried out to improve our understanding of the role that bioenergy feedstocks can play in the provision of ecosystem goods and services recognising that natural capital is central to human wellbeing, and that there are significant policy drivers in this area.

6.1.5 The Policy Factor

The development of the UK bioenergy sector and bio-economy will be limited by or will flourish upon a secure sustainable supply of feedstocks. The UK's future supply of feedstocks will be dependent upon the extents that resources are grown, produced and mobilised. Establishing robust supply chains will be aided or restricted by the design of policy framework – policies ideally being developed to require or incentivise the use of targeted biomass resources for energy end uses.

  - The current model is significant in its scope and undertaking to inform biomass policy, based on future projections of biomass availability in the UK and globally. Areas of improvement suggested in this report should be part of the on-going process of improving the model to understand future projections of biomass availability. The outcomes of the current model are consistent with the parameters and data used to inform the model, and suggested improvements do not undermine the validity of the current version of the model.
- To ensure policies are developed that prioritize sustainable and cost-effective bioenergy systems, we strongly recommend that policy relating to bioenergy in different sectors and

government departments is reviewed and coordinated across government departments, since bioenergy is so inextricably linked to land, people, industry processes and interactions between these as well as energy.

7. References

BEIS. (2021). *Biomass Policy Statement*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1031057/biomass-policy-statement.pdf

Broad O., Butnar I., and Watson J., 2021. The role of bioenergy with carbon capture and storage (BECCS) in the UK's net-zero pathway. Report for the European Climate Foundation. https://www.ucl.ac.uk/bartlett/sustainable/files/ecfbeccsfinalreportpdf

Holland, R. A., Beaumont, N., Hooper, T., Austen, M., Gross, R. J. K., Heptonstall, P. J., Ketsopoulou, I., Winskel, M., Watson, J., & Taylor, G. (2018). Incorporating ecosystem services into the design of future energy systems. *Applied Energy*, *222*, 812–822. https://doi.org/10.1016/J.APENERGY.2018.04.022

Rowe, R., Arshad, N., Welfle, A., Holland, R., Yuan, R., Sparks, J., Heaton, C., & Fothergill, R. (2022). *Land use decision-making for biomass deployment, bridging the gap between national scale targets and field scale decisions*. https://www.supergen-bioenergy.net/news/workshop-report-published-on-land-use-decision-making-for-biomass-deployment/

Welfle, A. J., Almena, A., Arshad, M. N., Banks, S. W., Butnar, I., Chong, K. J., Cooper, S. G., Daly, H., Garcia Freites, S., Güleç, F., Hardacre, C., Holland, R., Lan, L., Lee, C. S., Robertson, P., Rowe, R., Shepherd, A., Skillen, N., Tedesco, S., … Röder, M. (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

Welfle, A. J., Holland, R., Donnision, I., & Thornley, P. (2020). *UK Biomass Availability Modelling*. https://www.supergen-bioenergy.net/wp-content/uploads/2020/10/Supergen-Bioenergy-Hub-UK-Biomass-Availability-Modelling-Scoping-Report-Published-Final.pdf

Welfle, A. J., Holland, R., Donnison, I., & Thornley, P. (2020). *UK Biomass Availability Modelling: Scoping Report*. www.supergen-bioenergy.net/outputs

Welfle, A. J., & Röder, M. (2022a). *Bioeconomy Sustainability Indicator Model* (22). UK Supergen Bioenergy Hub.

Welfle, A. J., & Röder, M. (2022b). 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

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